

The Gulf Military Balance

*Volume II: The Missile and
Nuclear Dimensions*

AUTHORS

Anthony H. Cordesman
Bryan Gold

A Report of the CSIS Burke Chair in Strategy
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Executive Summary

No single aspect of US and Iranian military competition is potentially more dangerous than the missile and nuclear dimensions, and the possibility Iran will deploy long-range, nuclear-armed missiles.

The fact Iran reached an interim agreement in November 2013 with the P5+1 to limit its nuclear activities with the P5+1—which includes the five permanent members of the UN Security Council—United States, Russia, China, United Kingdom, and France—plus Germany—could be a major breakthrough in eliminating this threat and laying the groundwork for broader easing of tensions in the region. It will take years, however, to reach a full and lasting agreement, test Iranian compliance, and move towards a more stable security structure in the Gulf.

Iran has powerful military incentives to pursue nuclear weapons. It also may seek substitutes. These could include developing terminal guidance systems for its conventionally armed missiles if it cannot arm them with nuclear warheads. Highly accurate conventional warheads could attack key point targets in the Gulf and the region – targets like petroleum, power, and water facilities – effectively replace weapons of mass destruction with weapons of mass effectiveness. It has alternative like reviving its chemical weapons program or shifting to a covert program to create biological warheads that could have nuclear levels of lethality.

As a result, the nuclear issue is only one aspect of Iranian military balance. The balance must be assessed in terms of Iran's overall capabilities to deliver weapons of mass destruction and create effective and survivable nuclear forces. It must also be assessed in terms of its ability use conventional missiles and non-nuclear weapons of mass destruction to pressure, deter, and fight the US and other regional power at a time when the Syrian civil war and upheavals in the region create new tensions and risks of conflict, and Islam is caught up in a sometimes violent struggle over the future role of religion in the state, sectarian struggles, and violence with Sunni Islam.

At one level, Iran's current missile and rocket forces help compensate for its lack of effective air power and allow it to pose a threat to its neighbors and US forces that could affect their willingness to strike on Iran if Iran uses its capabilities for asymmetric warfare in the Gulf or against any of its neighbors. At another level, Iran's steady increase in the number, range, and capability of its rocket and missile forces has increased the level of tension in the Gulf, and in other regional states like Turkey, Jordan, and Israel. Iran has also shown that it will transfer long-range rockets to "friendly" or "proxy" forces like the Hezbollah and Hamas.

At a far more threatening level, Iran acquired virtually every element of a nuclear breakout capability except the fissile material needed to make a weapon before it reached a nuclear agreement with the P5+1. This threat has already led to a growing "war of sanctions," and Israeli and US threats of preventive strikes. At the same time, the threat posed by Iran's nuclear programs cannot be separated from the threat posed by Iran's growing capabilities for asymmetric warfare in the Gulf and along all of its borders.

Iran also acquired most of the technology to design a fission warhead or bomb small enough to be carried by a fighter-bomber or long-range missile. This does not mean it has a rapid break out capability to actually deploy a nuclear weapon. It will need to test a basic device, then test weapons designs, and finally actually deploy a weapon.

There is time to determine whether Iran is serious about reaching a meaningful nuclear agreement. Arms control experts would like Iran to lack any nuclear alternatives. From a real

world military viewpoint, however, Iran cannot suddenly rush forward into deploying a meaningful nuclear force or deter preventive strikes with a potential nuclear warfighting capability. The technical challenges involved in creating any form of nuclear weapon are serious, as are safety and reliability. A large gun device is not an effective nuclear weapon, and the ability to create an explosive fissile event does not mean that a national has a reliable implosion weapon or the ability to create an effective nuclear force.

Deploying a reliable weapon could take several years after an initial fissile event - depending on how much technology Iran has developed to date and obtain through sources like North Korea—which seems to have obtained Chinese design data—and other sources like Abdul Qadeer Khan. Some US experts believe Iran has much of the data for a workable fission warhead design.

This gives the US and its allies time to focus on creating a lasting a negotiated solution to Iran's nuclear efforts, and the US has pressed Israel to wait to see if such negotiations can be successful. Nevertheless, Israel's opposition to the interim agreement leaves the risk that Israel might launch preventive strikes against Iran's nuclear programs at some point in the next few years. Moreover, success depends heavily on the willingness of the US and EU to restore and enforce sanctions the moment Iran fails to implement and agreement and t the US must continue to show Iran and the world it will keep helping the Arab Gulf states develop effective deterrent and warfighting capabilities, the US will make good on its offer of extended deterrence and missile defense, and that the US will continue to be ready to exercise a "military option" if Iran does not negotiate an agreement to abide by the terms of the Nuclear Non-Proliferation Treaty.

Putting Iran's Missile and Nuclear Programs in Perspective

At the same time, the US and other power need to be more sensitive to the fact that the nuclear threat is only part of the threat posed by Iran's long-range strike capabilities. Iran already faces pressures from many different directions that might lead it to use its conventionally armed long-range missiles and rockets without nuclear warheads. Iran is coming under steadily greater pressure from sanctions, is seeing a limited US build up in the Gulf, and faces a major build-up by key Southern Gulf States like Saudi Arabia and the UAE that is clearly targeted at Iran.

Iran faces a different kind of competition for influence and control over Iraq, and growing uncertainty over the future of its alliance with the Assad regime in Syria and the Hezbollah in Lebanon. It sees American influence behind all of these steadily growing pressures, and seeks asymmetric means with which to respond to US encroachment in "its" region.

So far, Iran has only talked provocatively about closing the Gulf, denying access to US carriers, and carrying out major exercises targeted against the US and less directly at the GCC states, describing most of its threats and exercises as a response to Israeli or American threats and "aggression". In practice, all sides have been cautious not to take provocative military steps, and limit the risk of military confrontation. US and EU sanctions went into full effect in July 2012, however, and it is not clear that Iran will remain passive if negotiations with the 5+1 do not succeed.

Iran might deliberately try to create a clash in an effort to force more favorable compromises, persuade the Iranian people they do face real foreign enemies, show how serious the impact could be on the global economy, or simply punish other powers.

Wars can also have far less deliberate causes. Tempers can grow short, given units can overreact, situations can be misunderstood, and one nation's view of how to escalate rarely matches

another's once a crisis begins. Moreover, the covert war that Israel and Iran are already fighting, which is reported to entail Israel's assassinations of Iranian nuclear scientists, could escalate and come to include the US and European targets - as well as lead to Iranian or proxy attacks and operations in areas like Iraq and Afghanistan.

If Iran chooses to use conventionally armed missiles, much depends on factors where unclassified sources provide only limited data:

- Iran's testing of such missiles and rockets and their accuracy and reliability, the operational realism of such testing, and Iran's perceptions of its progress versus the reality. Limited tests under "white suit" conditions can produce a greatly exaggerated picture of capability, particularly if success is exaggerated to the political leadership.
- Their warhead and fusing design, and the real world lethality of unitary high explosive warheads under operational conditions, and of any cluster munitions Iran may have for such systems. A unitary conventional missile warhead that relies on a near surface burst can have only 30-60% of the lethality of a bomb with a similar payload because the closing velocity vectors much of the explosive force upwards.
- The relative accuracy of the missile and targeting systems relative to high value targets and the ability to launch or "volley" enough systems to compensate for limited accuracy against point and area targets.
- The quality of US, Gulf, Israeli and other missile defenses.
- Iranian perceptions of the risk of counterstrikes by Gulf and Israeli air forces, and US and Israeli missiles.
- The actual political, psychological, and retaliatory behavior of targeted countries and their allies.

If Iran can actually deploy a nuclear-armed missile, many of the same reliability and accuracy factors still apply, particularly if Iran still have a very limited stockpile of weapons, and if it should fire on a nuclear-armed Israel with a mature counterstrike capability or after the US implements its offer of extended deterrence." Iran does not exist in a "nuclear vacuum." It faces existing Israeli and US nuclear forces and the prospect that it might provoke a Gulf power like Saudi Arabia to seek nuclear-armed missiles from Pakistan.

Iran's nuclear and missile programs do pose what many Israelis see as "existential" risks, although Israel's forces will probably pose a greater existential threat to Iran through 2020. The US sees the situation as less urgent, but President Obama and other senior officials have made it clear that US policy sees Iran's acquisition of nuclear weapons as "unacceptable." Both Israel and the US have repeatedly stated that they are planning and ready for military options that could include preventive strikes on at least Iran's nuclear facilities and, and that US strikes might cover a much wider range of missile facilities and other targets.

A preventive war might trigger a direct military confrontation or conflict in the Gulf with little warning. It might also lead to at least symbolic Iranian missile strikes on US basing facilities, GCC targets or Israel. At the same time, it could lead to much more serious covert and proxy operations in Lebanon, Iraq, Afghanistan, the rest of the Gulf, and other areas.

Furthermore, unless preventive strikes were reinforced by a lasting regime of follow-on strikes, they could trigger a much stronger Iranian effort to actually acquire and deploy nuclear weapons and/or Iranian rejection of the Nuclear Non-Proliferation Treaty (NPT) and negotiations. The US, in contrast, might see it had no choice other than to maintain a military overwatch and restrike capability to ensure Iran could not carry out such a program and rebuild its nuclear capabilities or any other capabilities that were attacked.

The end result is that Israel, the US, and Arab states cannot choose between preventive war and containment. Unless Iran fundamentally changes its present course, the choice is between preventive strike and containment, or containment alone. Preventive strikes may be able to delay Iran for a given period of time, but if Iran seeks to rebuild its nuclear capabilities, the Israel, the US, and Arab will have to strengthen their missile and other defenses, develop great retaliatory capabilities and/or restrike every new Iranian effort to move towards nuclear weapons.

At the same time, containment cannot affect the fact that a nuclear arms race already exists between Israel and Iran - albeit one where only Israel now has a nuclear strike capability. The practical problem this raises for Iran - and for stabilizing this arms race - is that it will face a possible Israeli first strike option until it can secure its nuclear armed forces. This pushes it towards a concealed or breakout deployment, and an initial phase where it would have to launch on warning or under attack until it has a survivable force. It then must compete with powers with far larger stockpiles and boosted and thermonuclear weapons until it can create a more sophisticated force of its own. The options will result in a high-risk arms race, particularly during its initial years, for all sides and do so regardless of the level of containment.

The Near-Term Impact of the Iranian Missile Threat

Iran's existing missile forces give it the capability to attack targets in the Gulf and near its border with conventionally armed long-range missiles and rockets, and Iran can attack targets in Israel, throughout the region, and beyond with its longest-range ballistic missiles. However, the short-term risks posed by Iran's current conventionally armed rockets and missiles should not be exaggerated. Most are relatively short-range systems, and have limited accuracy and lethality. They can be used as artillery, limited substitutes for air power, or as weapons of terror or intimidation. They are not accurate enough to play a substantial role in a conventional war, despite Iran's efforts to upgrade them.

In the near-term, Iran would either be limited to the tactical use of shorter range systems as artillery against area targets, to volleys of shorter ranged missiles and rockets against nearby area targets (tactics it has not yet seriously practiced), or to longer-range missile strikes designed more for psychological or "terror" purposes than military combat. The seriousness of even these threats would depend in part on Iran's ability to launch rockets and missiles in salvos, and in "stacked threats" of different types that complicated the use of missile defenses and suppressive strikes.

The limited lethality of Iran's current warheads, the severe limits to their accuracy, and the uncertain reliability of Iran's longer-range systems all combine to limit the impact of such strikes to almost random hits somewhere in a large area with casualties that would most probably be limited to those resulting from a single 1,000 pound unguided bomb.

Nevertheless, Iran could still use conventionally or chemically armed missiles and long-range rockets as terror weapons, striking against large area targets like cities. It might escalate to the use of such systems because of a conventional war in the Gulf, in reaction to any military threat to its ruling regime, as a response to covert action against the state, or as a method of resolving domestic fissures.

Moreover, Iran's missile and rocket forces may well become far more effective even if Iran does not get nuclear weapons. Today's missile designs would be more effective if they could be equipped with conventional or chemical cluster munitions although they would still be limited by

range-payload limits, “fusing” issues, and a lack of accuracy, and even substantial volleys against area targets would be more terror strikes than ones capable of hitting and destroying key point target.

If Iran is to make a major advance in lethality using missiles and rockets without nuclear weapons, it would have to make advances in one of two other areas: Precision guidance and terminal homing and biological weapons. Iran has already said it is seeking to provide its missiles and rockets with precision guidance and terminal homing warheads, and with countermeasures to ballistic missile defenses. It has also claimed to have shown it has a near precision strike capability although satellite photos of the target area indicate it simulated missile hits by using explosive devices at the scene.

A reliable precision strike capability capable of targeting key military, petroleum, power, and water facilities with enough accuracy to destroy them with a credible conventional payload would radically alter the lethality of Iran’s longer-range systems against high-value military targets and civil targets like key oil product facilities and desalination plants—creating the equivalent of “weapons of mass effectiveness.” There is no evidence as yet that Iran has such capabilities and no clear indicators that it can acquire them in the near future. Iran has, however, made claims that imply it already has such accuracy, and a number of Israel experts believe it is developing such systems.

Deploying chemical or biological warheads would give Iranian missile more lethality, but it is easy to exaggerate the lethality of chemical missile warhead under real world operational conditions. Dispersing an agent effectively is a major challenge, and chemical cluster weapons present serious timing and height of burst problems. It might well take a substantial volley to have a major effect, and such a strike could remove all limits to a conflict and might still produce limited damage to critical targets.

Biological weapons can theoretically be as - or more - lethal than fission weapons and Iran has all of the need technology. Effective dispersal is, however, even more difficult than with chemical weapons, and developing and testing such a warhead presents both serious technical problems and the problem that the threat is not credible until capability is proven, but the very threat could trigger massive preventive strikes and use would eliminate any barriers to counterstrikes with nuclear weapons.

The Mid and Longer Term Risk of an Iranian Nuclear Weapon and a Nuclear-Armed Missile Threat

It has been the prospect of combined Iranian missile and nuclear threat, however, that has posed risks that have affected every aspect of US, Arab, Israeli and other military competition with Iran. By 2012, Iran had made enough progress towards a nuclear weapons capability so that there was a very real prospect that Iran would acquire nuclear weapons and arm its missiles and aircraft with such weapons within the next three to five years..

This is why the US and other members of the P5+1 have pressed so hard to end this threat through negotiations. It was also possible that such a threat could be deterred or contained by military means. The practical problem, however, is that a nuclear armed Iran would still have far more negotiating leverage over its neighbors, and had a far more powerful deterrent to any US or allied escalation in response to Iran’s use of its forces for asymmetric warfare.

A nuclear-armed Iran could destroy any military target or city in the region, and pose an “existential” threat to many states. A regional war could have a far more radical and lasting impact on the global economy, which gets some 20% of the world’s oil supply through the Gulf, and while few experts feel Iran’s leaders would act irrationally or without regard to the risks, the history of war and diplomacy is often the history of mistakes, miscalculations, and unintended conflicts. One needs to remember for all of the talk of a stable pattern of mutual assured destruction during the Cold War, the US went from no more than six nuclear weapons at the end of 1945 to a peak of over 31,000 in 1967, while the Soviet Union went from none before 1949 to a peak of nearly 41,000 in 1987.

The very risk of nuclear-armed missiles becoming an Iranian reality has already led Israel to increase the range of its nuclear-armed missiles to cover all targets in Iran. It has triggered the start of a nuclear arms race in the region.

It has already led the US and Israel to research and develop missile defenses, and the US to work with friendly Arab states to purchase new missile defenses. It has also led to steady increase in the long-range strike capabilities of rival states. Saudi Arabia first acquired long-range conventionally armed ballistic missiles because of the threat from Iraq but has retained them because of the threat from Iran.

The US and Gulf Arab countries have also increased the strike capabilities of their air forces and, the US has carried out exercises that demonstrate it could make extensive use of conventionally armed cruise missiles. It has also offered friendly states in the region some form of “extended deterrence” in the form of US attacks on Iran if Iran should strike - although it has never clarified whether this would only apply to Iranian nuclear strikes, and would involve US conventional or nuclear-armed systems.

The Uncertain Prospects for Effective Negotiations, Agreements, and Verifiable Arms Control

War and preventive strikes are scarcely a desirable option, and containment and deterrence pose major continuing risks that are likely to be exacerbated by a steadily intensifying nuclear arms race. At the same time, the risks involved in the agreements Iran and the P5+1 reach in November 2013 and any broader arms control agreement also to be assessed as realistically as possible. Far too much of the analysis of confrontation between Iran and the US and other members of the P5+1 has focused on the arms control aspects of keeping Iran from having any nuclear weapons. It has decoupled Iran’s nuclear programs from an analysis of how the military balance in the region

There has been little focus on the risk that Iran will seek other weapons of mass destruction. Iran has had an active chemical weapons program, and likely could quickly redevelop and redeploy such weapons. It has all of the technology and industrial base to produce advanced genetically engineered biological weapons if it chose to do so. Iran is developing a variety of cluster munitions and warheads with advanced detonation and munitions dispersal systems that will allow its ballistic weapons to carry chemical and potentially biological weapons.

There has been little focus on the risk that Iran may eventually be able to acquire terminal guidance systems for its long and medium-range ballistic and cruise missiles - making them “weapons of mass effectiveness” when targeted against critical infrastructure targets like the

Gulf desalination plants. The Missile Technology Control Regime (MCTR) was designed to prevent states like Iran from constructing advanced ballistic missiles, but Iran has progressed nonetheless, indigenously producing a missile capable of reaching southeastern Europe. It is pushing ahead in guidance, warhead design, range-payload, and numbers, creating a missile force that can be turned to any number of destabilizing purposes.

Moreover, it is not clear how realistic the negotiations that shape the November 2013 agreement will prove to be in ensuring adequate verification and enforcement even if an agreement is reached. They seem to have focused on Iran's current debates with the IAEA, its known facilities, and on enrichment rather than on the risk Iran could continue to develop steadily more advanced centrifuges and capability to manufacture them.

They generally assumed very high levels of enriched weapons grade material are needed - based on earlier weapons designs - and do not examine the full range of nuclear weapons design options. They take account of Iranian activities at Parchin, but do not seem to posit credible barriers to other ways Iran could covertly develop nuclear weapons designs using simulated weapons that would be extremely difficult to detect.

At a different level, there has been little public focus on how Iran could make the shift from creating enough fissile material to build a device to testing a fissile explosion or "event" to creating effective bombs and missile warheads to deploying nuclear armed forces.

The process of weaponization poses as many challenges for arms control as creating a "breakout" capability, but it is unclear that the IAEA has fully examined these challenges and other arms control efforts have largely ignored them.

At another level, North Korea's third test has demonstrated that it could seal the test off well enough to eliminate more than faint traces of the character of the explosion. If Iran follows in this path, it might be able to conceal much of its progress in design efforts, any shift from Uranium to Plutonium, tests of boosted weapons, yield, etc. This would complicate any post-test arms control efforts.

A related focus on a Weapons of Mass Destruction Free Zone (WMDFZ) seems well-intentioned, but ignores the realities of Israel's commitment to nuclear armed-long range missiles, the political upheavals that could make any agreement suddenly useless, the fact Arab states like Syria have extensive stocks of chemical weapons (which Iran could develop), and the risks posed by biological weapons and "weapons of mass effectiveness." This does not mean a

WMDFZ is not worth pursuing, but it does indicate it has a low probability of success, and that current efforts do not begin to effectively address the problem and risks involved.

The Uncertain Prospects for Containment

As has been touched upon earlier, containment poses a different set of risks. The US has said it will not accept containment as an alternative to Iranian efforts to acquire and deploy nuclear weapons. It has not set deadlines or defined its red lines in operational terms, but it is clear it has developed the contingency capabilities for a wide range of strike options. Israel is more limited in conventional capability, but it is important to remember that it is already a nuclear power that poses an "existential" threat to Iran.

This may help explain why President Obama publically rejected containment as an option in the fall of 2011 - although this rejection may have been more a matter of campaign rhetoric than

real. It is still possible that both the US and Israel might accept a reliance on containment if Iran does proceed to develop and deploy nuclear weapons because of the costs and risks of preventive strikes.

This could lead the US to work with the Gulf States, other regional power, and Israel to develop greatly enhanced air defenses, wide area theater missile defenses, and some form of “extended deterrence” - nuclear or conventional-to support its allies. The end result could be a regional nuclear arms race that would most logically take on the form of mutual deterrence, but one where miscalculation or the escalation of lower levels of conflict could trigger a progressively more dangerous struggle at any time over the next decade and beyond.

As for a living with nuclear arms race in the region, it is again worth pointing out that one already exists. Israel almost certainly acquired nuclear-armed missiles that can target every major population center in Iran years ago. While Iran might have serious problems in creating safe, stable, reliable fission warheads and bombs that have predictable yields and reliably can be deployed on missiles and aircraft, Israel almost certainly has “boosted” fission weapons, and may well have thermonuclear weapons.

In practice, Israel now poses a more serious existential threat to Iran than Iran can pose to Israel in the near term. This does not mean that Iran could not achieve massive political and economic damage to Israel or any Gulf state simply by exploding even the crudest gun type nuclear device on a cargo or other civilian ship. It does not mean that Israel or Iran would never engage in such a nuclear exchange or use nuclear weapons at all. Iran’s more extreme rhetoric and threat to Israel seem designed as much to cloak its build-up of military capabilities directed at the Arab states and US as anything else. It does mean, however, that Israel acquired a major lead in a nuclear arms race on region long ago, and that both sides are likely to pursue that race far more intensely - possibly with a Gulf state like Saudi Arabia joining in.

Such an arms race might also push Iran into high-risk nuclear missile deployment options early in its deployment efforts - involving mobile and silo-based nuclear armed system ties to warning and command and control system for either launch on warning (LOW) or launch under perceived attack (LUA). It would give Iran strong incentives to go from simple fissile weapons to the largest boosted and thermonuclear weapons it could design and build. Iran’s conventional command and control approach of giving autonomy to local commanders would provide an effective deterrent for a ground invasion or first strike, but it would also increase the risk of an accidental launch or an unwanted nuclear exchange.

This race could drive both Iran and Israel to acquire as many nuclear-armed delivery systems missile as possible - including submarines and cruise missiles - and to try to offset any perceived nuclear advantage on the other side by deploying biological weapons as well. This could be further complicated by US efforts to provide some form of extended deterrence, and a nuclear umbrella to cover the Arab Gulf States and Israel similar to the one it provide its ANATO allies during the Cold War.

Looking Beyond Negotiations

US and allied competition with Iran over Iran’s nuclear and missile programs affect the entire region and the world. Given the importance of the Gulf in global energy security, Iran’s goals of becoming a regional power, and socio-political instability in the Middle East, military

competition between the US and Iran will either force some form of negotiation or continue to intensify.

Iran has already managed to trigger a nuclear arms race without even having a nuclear weapon. Israel long ago extended the range of its nuclear-armed land-based missiles, probably now targets Iran with thermonuclear weapons, and is examining options for sea launched cruise missiles. The region faces a future that could go from possibly 100+ Israeli nuclear weapons and a potential Iranian weapon to a broad regional arms race accelerating year-by-year for the indefinite future.

There is also a matching race in missile and air defenses defense where the US, its Gulf allies, and Israel so far have an advantage over Iran. The US is deploying advanced missile defense ships with wide area theater missile and air defense capabilities. The Arab Gulf States are buying the PAC-3 and THAAD. Israel has the Arrow and PAC 3, and is working with the US to develop a far more advanced Arrow 3.

The US is also selling modern attack aircraft with stand off precision strike capabilities that offer regional states a counterweight to Iran's conventionally armed missiles, and has the ability to deploy major air strike assets of its own – including stealth bombers and strike fighters. It can deploy carrier-based aircraft and a wide range of precision cruise missiles. The Arab Gulf states also have the option of creating integrated missile defenses with US aid and access to US missile warning and tracking systems.

Iran is countering with efforts to develop penetration aids and countermeasures for its missiles, but so far has been unable to buy or indigenously develop any form of modern surface-to-air missile or missile defenses. Iran's efforts to develop or purchase anti-missile assets is also likely to further stoke fears in Tel Aviv, particularly if Israel believes that its retaliatory power is being eroded and may no longer function as a credible deterrent.

The Key Provisions of the November 2013 interim Agreement

The key issue, however, is how much the interim agreement and any lasting agreement will actually limit Iran's progress in acquiring and deploying nuclear weapons. The interim agreement certainly appears to limit such activities in every important dimension. The agreement has the following key provisions:

A Six-Month Interim Agreement Will Roll Back the Most Critical Parts of the Threat

The initial, six month step includes significant limits on Iran's nuclear program and begins to address our most urgent concerns including Iran's enrichment capabilities; its existing stockpiles of enriched uranium; the number and capabilities of its centrifuges; and its ability to produce weapons-grade plutonium using the Arak reactor.

The concessions Iran has committed to make as part of this first step will also provide us with increased transparency and intrusive monitoring of its nuclear program. In the past, the concern has been expressed that Iran will use negotiations to buy time to advance their program. Taken together, these first step measures will help prevent Iran from using the cover of negotiations to continue advancing its nuclear program as we seek to negotiate a long-term, comprehensive solution that addresses all of the international community's concerns.

In return, as part of this initial step, the P5+1 will provide limited, temporary, targeted, and reversible relief to Iran. This relief is structured so that the overwhelming majority of the sanctions regime, including the key oil, banking, and financial sanctions architecture, remains in place. The P5+1 will continue to enforce

these sanctions vigorously. If Iran fails to meet its commitments, we will revoke the limited relief and impose additional sanctions on Iran.

The interim agreement is the prelude to a lasting general agreement that would require Iran to fully comply with all the terms and concerns of the IAEA

The P5+1 and Iran also discussed the general parameters of a comprehensive solution that would constrain Iran's nuclear program over the long term, provide verifiable assurances to the international community that Iran's nuclear activities will be exclusively peaceful, and ensure that any attempt by Iran to pursue a nuclear weapon would be promptly detected.

The set of understandings also includes an acknowledgment by Iran that it must address all United Nations Security Council resolutions – which Iran has long claimed are illegal – as well as past and present issues with Iran's nuclear program that have been identified by the International Atomic Energy Agency (IAEA).

This would include resolution of questions concerning the possible military dimension of Iran's nuclear program, including Iran's activities at Parchin.

As part of a comprehensive solution, Iran must also come into full compliance with its obligations under the Non-Proliferation Treaty (NPT) and its obligations to the IAEA. With respect to the comprehensive solution, nothing is agreed until everything is agreed. Put simply, this first step expires in six months, and does not represent an acceptable end state to the United States or our P5+1 partners.

The agreement would halt the progress of Iran's program and roll back key elements in every meaningful area of Uranium enrichment

Iran committed to halt enrichment above 5%:

- Halt all enrichment above 5% and dismantle the technical connections required to enrich above 5%.

Iran committed to neutralize its stockpile of near-20% uranium:

- Dilute below 5% or convert to a form not suitable for further enrichment its entire stockpile of near-20% enriched uranium before the end of the initial phase.

Iran committed to halt progress on its enrichment capacity:

- Not install additional centrifuges of any type.
- Not install or use any next-generation centrifuges to enrich uranium.
- Leave inoperable roughly half of installed centrifuges at Natanz and three-quarters of installed centrifuges at Fordow, so they cannot be used to enrich uranium.
- Limit its centrifuge production to those needed to replace damaged machines, so Iran cannot use the six months to stockpile centrifuges.
- Not construct additional enrichment facilities.

Iran committed to halt progress on the growth of its 3.5% stockpile:

- Not increase its stockpile of 3.5% low enriched uranium, so that the amount is not greater at the end of the six months than it is at the beginning, and any newly enriched 3.5% enriched uranium is converted into oxide.

Iran committed to making no further advances of its activities at Arak and to halt progress on its plutonium track:

- *Not commission the Arak reactor.*
- Not fuel the Arak reactor.
- Halt the production of fuel for the Arak reactor.
- No additional testing of fuel for the Arak reactor.
- Not install any additional reactor components at Arak.

- Not transfer fuel and heavy water to the reactor site.
- Not construct a facility capable of reprocessing. Without reprocessing, Iran cannot separate plutonium from spent fuel.

Iran committed to unprecedented transparency and intrusive monitoring of Iran’s nuclear program:

- Provide daily access by IAEA inspectors at Natanz and Fordow. This daily access will permit inspectors to review surveillance camera footage to ensure comprehensive monitoring. This access will provide even greater transparency into enrichment at these sites and shorten detection time for any non-compliance.
- Provide IAEA access to centrifuge assembly facilities.
- Provide IAEA access to centrifuge rotor component production and storage facilities.
- Provide IAEA access to uranium mines and mills.
- Provide long-sought design information for the Arak reactor. This will provide critical insight into the reactor that has not previously been available.
- Provide more frequent inspector access to the Arak reactor.
- Provide certain key data and information called for in the Additional Protocol to Iran’s IAEA Safeguards Agreement and Modified Code 3.1.

Iran committed to an effective IAEA Verification Mechanism

The IAEA will be called upon to perform many of these verification steps, consistent with their ongoing inspection role in Iran. In addition, the P5+1 and Iran have committed to establishing a Joint Commission to work with the IAEA to monitor implementation and address issues that may arise. The Joint Commission will also work with the IAEA to facilitate resolution of past and present concerns with respect to Iran’s nuclear program, including the possible military dimension of Iran’s nuclear program and Iran’s activities at Parchin.

As this list of features shows, full and lasting enforcement of such an agreement would probably mean Iran could not successfully deploy a significant number of nuclear bombs and missile warheads. The agreement covers virtually every aspect of Iranian weapons-related nuclear activity and requires Iran to halt or roll back such activity. Everything does, however, depend on successful further negotiations, full Iranian compliance, and demanding verification and enforcement indefinitely into the future.

Enforcement, Verification and Iranian Compliance

At the same time, the past history of negotiating efforts is one of ongoing failures in years of P5+1 talks with Iran, and the failure of the Iranian regime to react to sanctions, will be repeated in the future. Iran has long used negotiations as a cover for continued nuclear programs, but the option of negotiations is still available.

Future years of negotiating efforts may prove to be ones in which negotiations continue to fail to prevent Iran from moving forward. The end result may be that Iran will either cross the nuclear threshold in terms of some form of test, or be so close to the edge of making nuclear weapons that the US, the Arab Gulf states, other regional power, and the European members of the 5+1 will have to react in military terms.

Moreover, Iran’s *red lines* have already shifted to the point where they must take account of the fact Iran is now at the nuclear breakout and IRBM stage of development, and Iran can move towards the following new red lines: fissile grade enrichment, “cold” or passive nuclear weapons testing, creation of new dispersed or sheltered facilities with more advanced centrifuges, testing an

actual nuclear device, and arming its missiles with an untested nuclear warhead – a risk that sounds extreme until one remembers the reliability and accuracy of US nuclear-armed systems like Jupiter and the M-4/MGM-18 Lacrosse.

There is no reliable way to predict the timing and nature of such Iranian actions in advance. There is no unclassified way to know how much design and test data Iran has received from the outside, and how well it can hide its efforts and leap frog to some form of weapons deployment. Moreover Iran's actions are only likely to become real world "red lines" in terms of any action by the US and other outside powers when Iran actually crosses them *and* Iran's actions have been detected.

US Enforcement Capabilities and Israel Threats

There also is no way to know exactly how the US would react when and if Iran actually crosses such a "red line," and how much international support it would get. Gulf leaders, for example, talk privately about such support but many are remarkably silent when the subject of supporting and basing US preventive strikes is raised in any open forum that even hints at public commitment. At the same time, key Saudi figures not only talk about the need to take preventive action, but a credible Saudi voice like Prince Turki has stated that Saudi Arabia is examining its own nuclear options.

Moreover, there is no way to know how Israel will react. At this point, its nuclear efforts are so tightly concealed that there is no public debate over its nuclear weapons holding, missile forces, and possible addition of sea or air-launched systems. The US has made it clear that it does not want Israeli preventive strikes, but has never publically said it would ride out any Israel effort and let Israel take the consequences. Israel may or may not be able to hit at all of Iran's current major publically known nuclear enrichment facilities. The hardening of Natanz and Fordow raise questions for a force of fighter-bombers using conventional earth penetrators (although nuclear-armed penetrators would be a very different story). It seems likely that Israel will only strike if it feels there is no credible US alternative – but there scarcely are any guarantees that this will be the case.

As a result, the key uncertainties affecting international action in dealing with the Iranian missile and nuclear threat now lie in whether the US will conduct preventive strikes or rely on containment, and the level of Arab and other regional support it will receive. The US has said that an Iranian nuclear force is "unacceptable." Like the word "no," however, "unacceptable" is far more difficult to define in practice than in the dictionary.

Preventive strikes also have consequences. Strikes by either the US or Israel can trigger a far more intensive Iranian nuclear effort, withdrawal from the NNPT with claim the act is "defensive," and a wide range of low level military acts in the Gulf or effort to use proxies and surrogates in Lebanon, Iraq, and the Gaza. Sustaining even a major US strike requires sustain support from the Arab Gulf states for restrikes, as well as willingness to counter Iranian asymmetric and even missile strikes.

At the same time, the US cannot afford to underreact. If some argue that Iran should learn from Libya, the US should definitely learn from North Korea. Brazil, South Africa and Argentina are not the models for dealing with Iran. Once Iran has become an active military power, it is likely to move forward toward more and more nuclear weapons, boosted and thermonuclear weapons designs, and combinations of launch on warning, launch under attack and then dispersed and

shelter forces. Pressure from Israel, Saudi (and possibly Turkish) nuclear and missile forces will add to the resulting arms race.

The US has to consider the tradeoff between all of the risks and costs of preventive strikes and the costs and risks of nuclear exchanges or the use of extended deterrence if the US does not act. Arms control negotiations, sanctions, clearly defined redlines and public analysis of the cost to Iran of a nuclear exchange are all interim steps that might eliminate the need for preventive strikes, *but some red lines are deadlines and make it time to act.*

Once Iran crosses “red lines” that include clear evidence of weapons production, an actual test of a fissile device, or preparing to arm its missiles with nuclear warheads, the key US military choices become preventive strikes and follow-on containment or containment without preventive strikes. Other possible “red lines” like weapons grade enrichment, “cold” or passive nuclear weapons testing, and creation of new dispersed or sheltered facilities with more advanced centrifuges would present massive problems in terms of US credibility given the US false alarms in Iraq. The US cannot afford to underreact, but it also cannot afford to be seen as over-reacting and neither can its allies.

If Iran does cross the more critical “red lines,” however, there will then be a strong case for preventive strikes/. Such strikes are also real world options for the US. Senior US military figures have made it clear that the US is steadily refining and improving its military strike options and has kept them very real. The US can hit at the full mix of suspect sites – including research and centrifuge production, take out much of Iran’s defenses and missile capabilities, and has access to Gulf bases. The US can also restrike from the Gulf region if Iran tries to recreate its facilities.

These also are capabilities Israel probably lacks -- although several factors may have eased its may have eased its penetration and refueling problems, including Israel’s quasi-rapprochement with Turkey, Syria’s civil war, and Iraq’s problems in getting advanced fighters and weapons from the US. It is also important to note that US rhetoric about refusing to rely on “containment” is more rhetoric than reality since the US would have to rely on containment after preventive strikes and has no credible options to invade Iran or force Iranian regime change on its own.

If the US does not choose to carry out such preventive strikes, it should at least strengthen containment by deploying some tangible form of the “extended deterrence” that Secretary Clinton has already offered the US allies in the region.

- The most “quiet” or discrete extended deterrence option would be nuclear armed, submarine or surface launched cruise missiles backed with the deployment of conventionally armed cruise or ballistic missiles with terminal guidance systems capable of point attacks on Iran’s most valuable civil and military assets.
- The most decisive extended deterrence options would be the equivalent of the combination of Pershing II and GLCMs that were land based, had US operating crews both deep inside the Arab Gulf and other regional states and in or near key major cities, and had both nuclear and precision conventional warheads. Iran would be faced with the inability to strike at key Arab population centers without striking at US forces and still see mobile US nuclear armed forces in reserve. It also could not use conventional warheads without facing a more accurate and reliable US strike force in return.

Finally, it is important for the US and its allies – *as well as Iran* -- to consider the “unthinkable” in terms of what a nuclear war in the region might become if Iran continues to threaten Israel, actually deploys nuclear weapons, and any form of nuclear exchange takes place. . Even today, it

is possible to think of some Iranian covert nuclear attack on Israel or a Gulf state using a gun device hidden in a ship – or less credibly – given to a proxy like the Hezbollah.

The end result of any Iranian nuclear attack on Israel would probably be nuclear missile strikes involving ground bursts on Iranian cities – a far greater “existential threat” to Iran than the kind of attack Iran will be able to launch again Israel during the first years of its nuclear forces. Israel would have no reason to limit the scale of its retaliation, and outside states would have no strategic reason to urge such restraint.

Horrible as a nuclear exchange of any kind could be in humanitarian terms, the grim logic of strategic realism does not place any restraints on Israeli retaliatory attacks on Iran. The outside world may need Iranian oil – although that is now questionable given developments in shale oil and gas and other sources of energy and liquid fuels. No one needs Iranians and no one needs an Iranian regime with any chance of recovering nuclear capability.

Iran's Missile Programs and Their Impact on the Gulf and Regional Military Balance

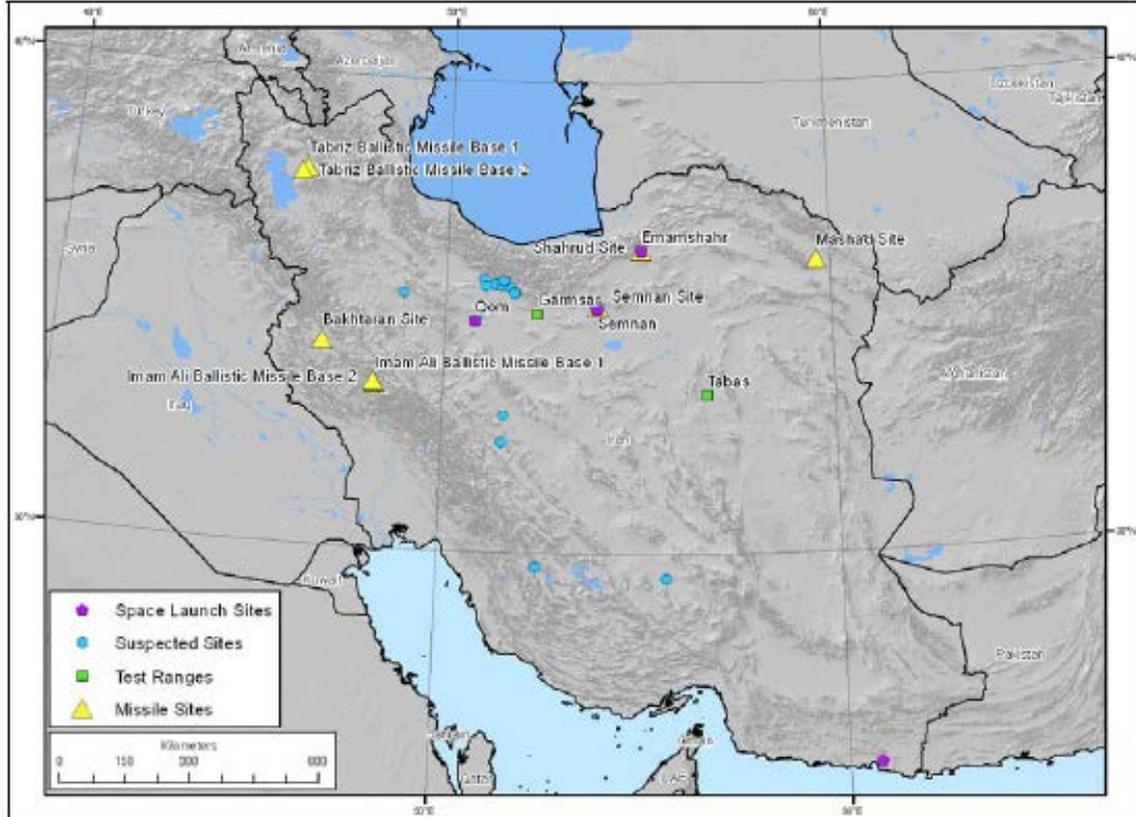
Iran's missile programs are both an independent element of the military balance and a key to Iran's nuclear efforts. US, European, Gulf, and Israeli policymakers and experts agree that Iran possesses a large and growing rocket missile force, with a growing number of missiles capable of hitting Israel and Europe. They agree that Iran has begun developing longer range and solid fuel missiles, and already possesses a sufficient number to pose an economic and psychological threat to Gulf States.

Figure 1 draws on work by Steven A. Hildreth of the Congressional Research Service to provide a rough indication of the scale of Iran's missile effort. Few reliable unclassified data are available on the specifics of Iran's missile R&D, production, test and other effort, but it is clear that Iran has put major resources into these efforts for several decades and that they are national in scale.¹ The scale of Iran's effort is also reflected in the number of missile systems that Iran deploys. A rough estimate of the technical details and even rougher estimate of the number of Iran's missiles is provided in **Figure 2**.

Iran has been developing ballistic missile capabilities based on Russian, North Korean, and Chinese technology or weapons systems since the early 1980s. Iran currently possesses the largest ballistic missile inventory in the Middle East, and the country's military and scientific establishments are working to increase the sophistication, scale, and reach of its missiles.²

Iran almost certainly sees its longer-range missile capabilities as a way to compensate for its shortcomings in conventional forces, as well as a means to strike at high-value targets with little warning, such as population centers and Western and Western-backed forces in the region, including US bases in the Gulf. As such, ballistic missiles play an integral role in Iran's asymmetric warfare doctrine. Given the emphasis Iran places on its missile program, it is clear that Iran considers its ballistic missile arsenal among its most important assets as both a deterrent to attackers and leverage over other regional players.

Figure 1: Iran's Ballistic Missile and Space Launch Complex



Source: Steven A. Hildreth, *Iran's Ballistic Missile and Space Launch Programs*, Congressional Research Service R42849, December 6, 2012, p. 15.

US Assessments of Iran's Missile Programs

The US Department of Defense made it clear in its 2010 and 2012 reports on the Iranian threat that it took Iran's missile capabilities very seriously. The 2010 report made it clear that Iran's focus on missiles was now some three decades old, and included a mix of tactical and short to medium range conventional systems, as well as serving as potential platforms for nuclear warheads,³

Over the past two decades, Iran has placed a significant emphasis on developing and fielding ballistic missiles to counter perceived threats from Israel and coalition forces in the Middle East and to project power in the region. Iran actively began acquisition and production programs in the 1980s during the Iran-Iraq war to address its inability to counter Iraqi missile attacks. In developing and expanding its missile program, Iran has received assistance from North Korea and China. At present, Iran is assessed to have the largest deployed ballistic missile force in the Middle East with approximately 1000 missiles that range from 90-1200 miles. To demonstrate its missile capabilities; Iran has conducted a total of four highly publicized exercises ("Noble Prophet"), since 2006.

Short-range ballistic missiles provide Tehran with an effective mobile capability to strike coalition forces in the region. Iran continues to improve the survivability of these systems through technological advances, such as solid propellant and the use of antimissile defense tactics.

Iran has also developed medium-range ballistic missiles to target Israel and continues to increase the range, lethality, and accuracy of these systems. For example, the Shahab 3, based on the North Korean No Dong,

can reach all of Israel. The Ashura or “Sejil” is an indigenous, two-stage missile that is in development. It uses solid-propellant technology, which reduces the launch preparation time and footprint.

...Coastal defense cruise missiles (CDCMs) are an important layer in Iran’s defense of or denial of access to the Gulf and Strait of Hormuz. Iran can attack targeted ships with anti-ship cruise missiles (ASCMs) from its own shores, islands, and oil platforms using relatively small mobile launchers.

The C801/802 is Iran’s primary CDCM, first imported from China in 1995. The C801/802 is capable of engaging targets at a range of six nautical miles, and has greater accuracy, a lower cruising altitude, and a faster set-up time than the Seersucker missile Iran used during the Iran-Iraq War. The C801/802 allows Iran to target any point within the Strait of Hormuz and much of the Persian Gulf and Gulf of Oman. Iran has also worked with China to develop shorter-range missiles, including the C701, for deployment in narrow geographic environments.

Iran can readily deploy its mobile CDCM launchers anywhere along its coast. These systems have auto control and radar homing guidance systems, and some can target using a remote air link. Mobile CDCMs, combined with multiple rocket launchers (MRLs), coastal artillery, and ballistic missiles, Iran hopes to overwhelm enemy air defenses.

The 2012 report focused on Iran’s ballistic missile program and stated that,⁴

Regular Iranian ballistic missile training continues throughout the country. Iran continues to develop ballistic missiles that can range regional adversaries, Israel, and Eastern Europe, including an extended-range variant of the Shahab-3 and a 2,000-km medium-range ballistic missile, the Ashura.

Beyond steady growth in its missile and rocket inventories, Iran has boosted the lethality and effectiveness of existing systems with accuracy improvements and new submunition payloads.

Iran’s missile force consists chiefly of mobile missile launchers that are not tethered to specific physical launch positions.

Iran may be technically capable of flight-testing an intercontinental ballistic missile by 2015.

During the last 20 years, Iran has placed significant emphasis on developing and fielding ballistic missiles to counter perceived threats from Israel and Coalition forces in the Middle East and to project power in the region.

In 2011, Iran launched several missiles during the Noble Prophet 6 exercise, including a multiple missile salvo.

Short-range ballistic missiles provide Tehran with an effective mobile capability to strike partner forces in the region. Iran continues to improve the survivability of these systems against missile defenses.

It is also developing and claims to have deployed short-range ballistic missiles with seekers that enable the missile to identify and maneuver toward ships during flight. This technology also may be capable of striking land-based targets.

Iran also has developed medium-range ballistic missiles to target Israel and continues to increase the range, lethality, and accuracy of these systems.

Since 2008, Iran has launched multistage space launch vehicles that could serve as a test bed for developing long-range ballistic missile technologies.

The Iranian missile program does remain in constant flux and many of Iran’s missile systems are still in a development phase where their range, accuracy, warhead, and reliability are impossible to predict. There is no agreement on the reliability and accuracy of Iran’s missiles under operational conditions. There is no agreement as to when Iran may acquire missiles with homing warheads and the kind of terminal guidance that can hit point targets effectively with conventional warheads. And, there is no agreement on Iran’s ability to deploy systems with countermeasures to missile defenses. Finally, there is no agreement on whether Iran yet has

mastered production techniques for ballistic missiles, allowing it to further build and refine its force even without additional technology proliferation.

At the same time, there is doubt that the Department of Defense is correct in stressing their importance and that Iran’s family of missiles are not tied to any given mission or concept of war fighting. Iran’s missiles supplement its land force rockets, and play a key role in substituting for Iran’s lack of modern airpower.

These are – addressed in depth in *The Gulf Military Balance, Volume I: The Conventional and Asymmetric Dimensions*. Missiles are Iran’s most likely platforms for the delivery of nuclear weapons, but their conventional capabilities – and US and Arab Gulf capabilities to deter and defend against their use in regional asymmetric and conventional warfare are just as important.

Figure 2: Iranian Missile Technical Details

	Shahab-1	Shahab-2	Shahab-3	Ghadir-1	Sejjil-2	Khalij Fars	Fateh-110	Zelzal-1/2/3
Range (km)	300-315	375-700	800-1300	1100-2500	1800+	300	200-400	125/200/ 150-400
Payload (kg)	1000	1000-730	1000	1000-750	1000	650	500	600
CEP (m)	450-1000	50-700	190-2500	1000	Unknown	<50	100-300	100-3000
Number in Service	200-300	100-200	25-100	25-300	Unknown	Unknown	Unknown; likely in hundreds	Unknown; likely in thousands
Launchers	18	18 (same as Shahab-1)	6-20	6-20 (same as Shahab- 3)	Unknown	Unknown	Unknown	Unknown
Fuel	Liquid	Liquid	Liquid	Liquid	Solid	Solid	Solid	Solid

Iran’s Shorter Range Missile and Rocket Programs

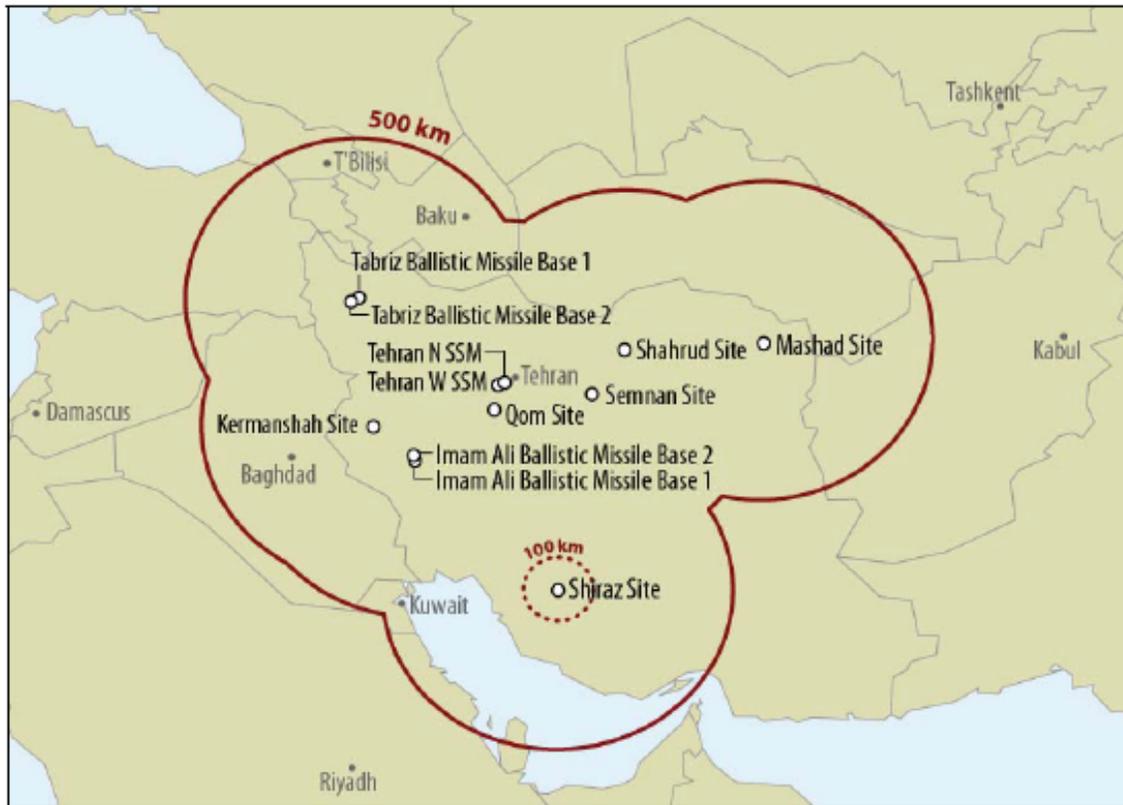
Iran’s efforts in developing short-range missile systems – defined here as weapons with a range from under 400 km to up to 1,000 km, most of which are unable to reach beyond the Gulf littoral. As work by Steven A. Hildreth notes, “A precise, public accounting of Iran’s SRBM force is not available. Official U.S. sources often cite the figure of “hundreds of SRBMs” with perhaps 50-100 launchers (a launcher can be reused to fire additional missiles). There is no further breakdown of these numbers.⁵

Hildreth also provides a rough map of the location of these forces that is shown in **Figure 3**, and states that,⁶

Other good public sources cite figures of perhaps 200-300 Shahab-1 and Shahab-2 SRBMs (with as few as 18-20 launchers or up to around 50 launchers). ..These latter sources cite additional, different named SRBMs in Iran's inventory, which this report does not attempt to deconflict. This section provides a brief overview of Iran's SRBM missiles and programs.

Finally, imagery obtained through the Library of Congress shows what appear to be a number of short-range missile bunkers in western Iran around Kermanshah and what a SRBM missile base might look like.

Figure 3: Iranian SRBM Sites and Ranges



Source: Steven A. Hildreth, *Iran's Ballistic Missile and Space Launch Programs*, Congressional Research Service R42849, December 6, 2012, p. 16.

Iran's development of these missiles has served several purposes. The research, served a dual purpose. The research, production, maintenance, and upgrading of these weapons has led Iran to build its knowledge of the critical components of ballistic missiles, underpinning research on longer-range ballistic missiles. Without the experience garnered through these weaker systems, Iranian scientists would have faced severe challenges constructing such missiles as the Sejil-2.

Like Iran's artillery rockets, which are analyzed in Part I of this report, these weapons serve a more immediate purpose in Iran's conventional military strategy. Their relatively short range and imprecise targeting could be partially compensated for by firing sheer numbers. In the event of a ground war, they could supplement Iran's artillery holdings, with the mobile missiles hidden and used for hit-and-run strikes.

Iran's short-range rockets and missiles are less lethal, versatile, and effective than US and Arab Gulf strike aircraft: They have limited individual lethality, accuracy, and range. However, they allow Iran to strike at area targets without exposing its aircraft to air-to-air combat or surface-to-air missiles, and dispersed launchers/fire units or groups of launchers/fire units are hard to target and attack.

While Iran has not yet exercised such attacks at levels where it is possible to characterize Iran's effectiveness with any accuracy, Iran could fire some such rockets and missiles in relatively large numbers or salvos. It could mix different types - and mix short and longer-range systems - in a "stacked threat" to saturate missile defenses.

Experts note that Iran does exercise or simulate attacks threats from "stacked arrays" of different missiles in both surface-to-surface and anti-ship exercises - although Iran generally does not hold demanding missile firing exercises in terms of showing their effectiveness against given target arrays and the readiness of combat units to conduct such attacks in the field - versus "white suit," well planned and technically supported firings - is uncertain.

Shorter-range rockets and missiles can also be valuable as exports to proxies. As is discussed later, reports indicate that Iran has supplied them to Syria and the Hezbollah. The range limitations of such weapons become far less important once they are deployed in the Levant. Zelzals and Fateh-110s are able to reach Tel Aviv and Jerusalem from Lebanon. Such exports not only serve to distract Israel and provide Iran with credibility on the Arab street, but also further Hezbollah's and other allies' dependence on Iran.

Iran's Shortest Range Missiles

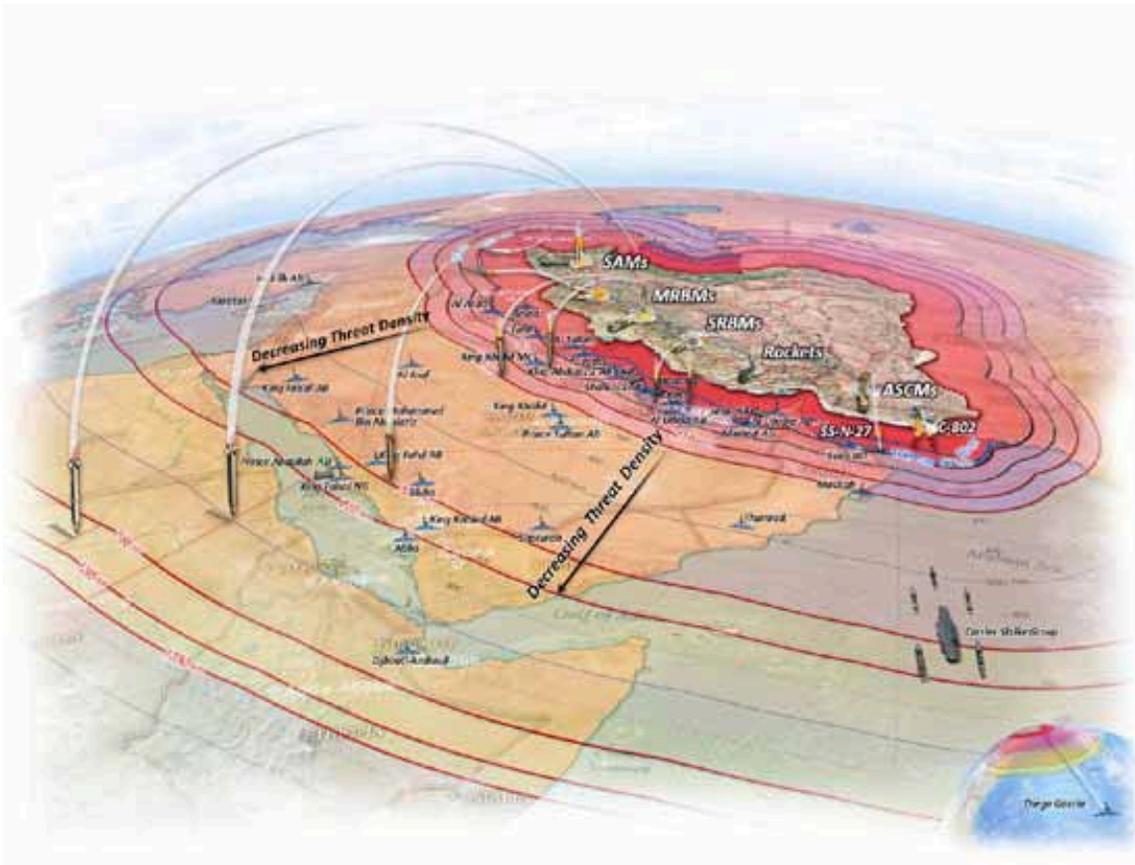
Iran's shortest-range systems are among the best-understood elements of the Iranian ballistic stockpile, and their potential to be used in volleys is shown in **Figure 4**. Many of these missiles are based on systems that saw service in the Iran-Iraq War, and many have been repeatedly fired and tested since then. What is not clear is how far Iran has gone in upgrading their performance (given its tendency to exaggerate all of its weapons performance claims) and how many missiles and rockets of each type it actually has.

The older models of these systems pose a limited threat to targets in the region, due to a poor CEP and restricted range. Iranian mass production was only valuable if the weapons could reach targets; the ranges of Zelzal-1 and -2 meant they only posed a threat at certain chokepoints, and were relevant only in the context of a ground campaign.

If Iran has upgraded its short-range missiles, the method of upgrading will also matter. A strap-on kit that boosts range and/or improves accuracy will allow Iran to easily retrofit its old stocks of missiles, quickly and cheaply improving their overall effectiveness. If the upgrade requires new production rather than converting old systems, then recent improvements will take years to percolate through the missile force.

As long as these weapons have a CEP that is still measured in kilometers or hundreds of meters, and use conventional warheads, these weapons are of limited military utility. While Iran has certainly made improvements in their accuracy and will continue to boost precision as its engineers gain expertise, experts question whether Iran's short-range missiles are capable of doing anything more than area bombardment.

Figure 4: Iran Missile Strike Capability: Density Relative to Range



Source: Adapted from Mark Gunzinger and Christopher Dougherty, *Outside-In Operating from Range to Defeat Iran's Anti-Access and Area-Denial Threats*, CBSA, Washington DC, 2011.

Iran has unknown numbers of older short-range solid fuel missiles - primarily Shahin, Fajir, and Nazeat - and the condition and current capabilities of these weapons are unclear. While they may be used in the event of a ground war in Iran - and some are probably under the control of Iranian proxies - all are based on twenty-year-old designs and have likely been heavily upgraded.

Other missiles, like the more recent Zelzal and Fateh-110, are highly mobile, easy to conceal, and easy to fire. However, they are also inaccurate, short ranged, and difficult to upgrade to advanced munitions.

Zelzal (Meteor or Shooting Star)

The Zelzal program grew out of the Nazeat and other Iranian short-range solid-fuel ballistic programs during the Iran-Iraq war. These weapons, for the most part, were limited to less than 100 km, with only the Nazeat going 150 km (at the cost of 90 kg warhead). The Zelzals seem to be a product of Iran's familiarity with solid fuels and missile design, along with limited North Korean Chinese support.

Describing the system is difficult because the Zelzal name has been seen at least three distinct iterations. According to contradictory reports, some later models were spin-stabilized, with

external rockets firing shortly after launch to reduce deviations in accuracy. Unclassified sources provide a wide range of different data on each variant. Typical estimates are shown below:

- The Zelzal 1 is a solid fueled-artillery rocket that seems to be a modification of the old Russian FROG artillery rocket, and has a maximum range of 150 KM (93 miles) and a 600-kilogram (1,200 pound) warhead. Its CEP is no better than 0.5 to 1 kilometer depending on range. The original system was designed primarily to carry a nuclear warhead. Reports of chemical and cluster warheads are not confirmed.
- The Zelzal 2 is a somewhat longer-range, and has a maximum range of 210 KM (130 miles). It too seems to have a 600-kilogram (1,200 pound) warhead. Its CEP too is no better than 0.5 to 1 kilometer depending on range. The original system was designed primarily to carry a nuclear warhead. Reports of chemical and cluster warheads are not confirmed.
- The Zelzal 3 is sometimes used as a name for the Shahab 3, which is a much longer range MRBM based on the North Korean No Dong. If it is actually deployed as a fully functioning system, exists, it is an extended range version of the basic Zelzal design with a range of 150-400 kilometers. According to *Missile Threat*, the Zelzal-3 capable of reaching 400 km only with additional propellant strapped on (an as-yet unconfirmed capability). Its CEP is estimated to be several kilometers; although Iran has made claims that the CEP of its newest upgrade could have been cut to 50-100 meters.

It should be noted, however, that such estimates of CEP are based largely on the theoretical accuracy of the rocket and not the reliability and real world accuracy of the actual missile fire under operation conditions. CEP also only applies to 50% of the systems - with no estimate of the distribution of the strikes from other missiles, applies to a missile or rocket that functions perfectly in flight, and only applies to perfectly located targets.

Since the shorter-range version of the system has been in production roughly since 1998, some sources assume that Iran has built hundreds of Zelzals, but there are no credible estimates in the public domain. Given the large number extant and their relative cheapness, Iran has reportedly attempted to improve their accuracy.

The IRGC claimed that it had developed a strap-on guidance kit that reduces the CEP to 50 m, enough to make the system a viable military option.⁷ So far, there has been no independent confirmation of this increase in ability, and given Iran's tendency toward bombast in public pronouncements, it is unlikely Iran has so dramatically increased the Zelzal's precision. Given the US's ability to create precision munitions with guidance packages, though, some evolution in unguided Iranian munitions is possible.

All Zelzals are reported to carry a 600 kg warhead. According to *Missile Threat*, their ranges are estimated at 125 km, 200 km, and 150-400 km, respectively, with the Zelzal-3 capable of reaching 400 km only with additional propellant strapped on (an as-yet unconfirmed capability). Its CEP is estimated to be several kilometers; although Iran's newest upgrade may have cut it to 50-100 m.

Fateh-110 (Conqueror)

Iran's basic Fateh-110 missile was developed as an improved version of the Zelzal, with additional guidance from an onboard set of gyroscopes. Instead of relying on spin-stabilization, the Fateh-110 used a set of instruments and fins to maintain a preprogrammed angle during the launch phase. While not a true precision system - the missile still is subject to uncorrected changes of direction during unpowered flight - it does provide a more precise weapon.

Iran seems to have had Chinese support in designing and producing the system. Missile threat reports that, "In 2006 the US Department of the Treasury accused Great Wall Industry, a Chinese

Corporation and its partners for playing a lead role in the development of the Fateh missile system.”

Unfortunately, little is known about the operational accuracy and deployed numbers of this system. The system is believed to have entered full-scale production in 2004, with several hundred emplaced on mobile launchers. It is believed to have entered test production in 2002, full production in 2004, and gone through at least two modifications, with newer varieties using inertial guidance and capable of carrying slightly larger warheads over marginally longer distances. At least 10 tests have been reported, but no details are available, and most to have been from fixed sites and conducted unit by technical teams rather than under operational conditions, but some video coverage exists of tests using TEL launchers.

Estimates place the range of Fateh 110 variants at between 200 and 400 km - with the third generation the longest-ranged of the three - and a warhead payload of around 500 kg for all variants. Some sources report chemical and cluster warheads, and some form of cluster warhead option seems to exist. Iran reported the development of an improved system in 2010, and made claims that implied it might have electro-optical terminal or GPS guidance. This is not confirmed. The newest guidance system is reported to give it a CEP of 100-300 meters. Experts believe the system is significantly less accurate in reality.

Hildreth provides the following estimate:

The Fateh-110 is a solid-fuel, road-mobile battlefield or tactical ballistic missile with a range of about 200 km. Its development probably started around 1995 and its first test flight reported in 2001. There may be three versions of the Fateh-110 in service; one is apparently called the Khalij-Fasr....An upgraded version of the Fateh-110 reportedly was tested in early August 2012. Iran claimed it was the fourth generation of the Fateh, and equipped with a new guidance system capable of striking targets up to 300 km away with high accuracy.⁶³ Experts such as Elleman find the Iranian assertion dubious; the missile has a maximum range of only 200-250 km, and claims of high accuracy are questionable.⁸

Khalij Fars and Guided Ballistic Missiles

As has just been noted, Iran claims that it has developed a modification of the Fateh-110 called the Khalij Fars, and developed a long-range, passive radar covering a 1,100km-radius. It says this missile has a speed of Mach 3, a range of up to 300 kilometers, a 450-650 kilogram explosive warhead, missile defense countermeasures, and an anti-ship homing warhead.⁹ The Khalij Fars is reported to have entered service in early 2011, although Iran claims it was finished in 2008. It is also reported to have a CEP in the lower double digits.^{10 11}

Experts believe there is no evidence Iran actually has such capabilities to target missiles against ships at long ranges. They feel Iran is at least 5-10 years away from giving its ballistic missiles any form of true homing, TERCOM, or other forms of precision guidance. At present, Iran rarely practices firing shorter range systems like its C-700 and C-800 series of anti-ship cruise missiles against moving ships, and unguided ballistic missiles have no practical utility against even static ships.

If Iran did develop an effective precision strike and targeting system, however, ships would be vulnerable to such ballistic missiles, particularly if they are beyond the missile defense envelope of US Navy Aegis or other missile defense systems. Just as salvos of conventional missiles could penetrate anti-missile systems on land, the mass-production of long-range ballistic missiles with suitable guidance and targeting systems could represent a significant threat to even anti-missile

equipped American and GCC naval forces. They could be used in such a role if Iran tried to “close the Gulf” by other naval means - small-boat harassment or mine warfare - as ballistic missiles could target military vessels trying to counter these smaller threats.

The possibility Iran could eventually make good on its claims is another reason for the Gulf states to acquire missile defenses. Such weapons could represent the Islamic Republic’s first real opportunity to target the war-making capabilities of its Gulf opponents. Although the Gulf States are protected for now, their relative lack of strategic depth means that Bahrain, Qatar, and the UAE will all be vulnerable to missiles with a range of 400 km - a number that Iran may be able to achieve with boosted Zelzal-3s, and likely with its next generation of missiles. As Iran further improves and builds its short-range fleet, it will gradually play a major denial role for the GCC.

Such developments would, however, be more likely to push the US towards missile defense than close the region to US use of Southern Gulf and other regional bases. There are too many airfields, depots, ports, and staging ports for Iran to close them all, and improvements in missile defense will continue to reduce the number of expected surviving missiles.

The Shahab 1 and Shahab 2

Unclassified sources provide a wide range of useful data on Iran’s more capable short-range ballistic missiles; but the data are best on technical performance rather than numbers, force structure, command and control, and readiness. Some performance data, however, are based on data comparable systems - SCUD-B for Shahab-1, SCUD-C for Shahab-2, and Nodong for Shahab-3 - but these sources do not take into account further upgrades Iran may have done to its store of missiles, or the impact of local weather, age, and maintenance by unfamiliar technicians on their electronics, guidance systems, and propulsion.

More importantly, these estimates do not take into account local conditions. Launching a weapon from a sanitized testing facility bears little relation to doing so under the stress and confusion of battle. While factors such as storage conditions, improper fueling, and local engineering will affect the range and maximum payload, mistakes by the launching crew - as well as mechanical defects - are likely to reduce the accuracy of the weapon.

Shahab-1 (Meteor 1)

The Shahab-1 is the Iranian version of the SCUD-B missile, a weapon designed by the Soviet Union in the 1960s and later exported to over 20 countries. It was used by Iran and Iraq in the War of the Cities during the Iran-Iraq War, and was used to target Coalition bases and Israeli cities during the first Persian Gulf War. Designed as a tactical nuclear missile, it has since become the most widely copied ballistic missile, with its ease of construction and launch making up for deficiencies in accuracy.

There is broad agreement on some details of the system’s performance. According to a Joint Threat Analysis produced by Dr. Postol, with a 1000 kg warhead the Shahab-1 has a range of approximately 315 km. This agrees with the Federation of America Scientists’ (FAS)¹² assessment that its range is 285 to 330 km, similar to the US Department of Defense’s estimate of 185 mi (300 km). Both *Missile Threat*¹³ and FAS give the Shahab-1 a CEP¹⁴ of 450 m; IISS gives 450 as its best-case number, but suggests 1000 m is more likely.¹⁵ The system is liquid-fueled, and requires approximately one hour to fuel and to prepare for launch (and can only be kept in a launch-ready state for a limited period of time).

Experience from the Gulf War and other conflicts demonstrate that these missiles are far too inaccurate to be used to hit point targets. The roughly 90 SCUD-Bs fired by Iraq caused approximately 30 direct casualties, most of which were caused by the missile strike on the US base at Dhahran. While terror-induced strokes and heart attacks increased the total, barring considerable luck or improvements in accuracy, this weapon armed with a conventional warhead has limited military utility. As **Figure 3** shows, the best-case scenario means several hundred Shahab-1 would be necessary to hit a single target with lethal accuracy.

The force numbers are far less clear. According to a 1995 *Jane's Intelligence Review - Special Report No. 6* Iran has 15 transport-erector-launchers (TEL) and 250-300 Shahab-1 missiles, along with the capacity to manufacture more. It is not clear how the force has evolved over time. Assertions that Iran can manufacture all the components of Shahab-1 engines are disputed by IISS in a recent briefing, which agrees that Iran only possesses approximately 200-300 Shahab-1.¹⁶ The UN Panel of Experts on Iran Sanctions supports either interpretation, stating:

“With assistance from the Democratic People’s Republic of Korea, Iran has likely established Shahab missile assembly facilities, which can produce these missiles using imported components.

Iran claims that it produces Shahab 1 and 2 missiles indigenously, for both domestic use and export. Its production of the Shahab 3 however requires some imported components including guidance systems, liquid-propellant engines and telemetry equipment. Experts also note that the performance of the Shahab 1, for example, mirrors closely its Soviet-era Scud counterpart, indicating that it may continue to rely upon imported engines and critical components. Iran currently is not said to possess a fully indigenous liquid-propellant engine production line.”¹⁷

It is interesting that Iran fired a Shahab 1 from a ship in the Caspian in 1988 - presenting the possibility it could use a ship like a freighter or tanker to fire such a system from a distance off the coast of Israel or the US.¹⁸

Shahab-2

The Shahab-2 is the Iranian designation for the SCUD-C. The SCUD-C was developed by the Soviet Union as a longer-range version of SCUD-B, using more fuel, a more efficient design, and potentially a smaller warhead. Widely exported, like the SCUD-B it was allegedly obtained by Iran from North Korea, and is liquid fueled and road-mobile.

There is much less agreement on the performance of the system, and much of the data that do exist as based on a nominal warhead rather than its actual payload. According to Dr. Postol’s analysis, the Shahab-2, armed with a 1000 kg warhead, has a range of approximately 375 km, while the 2010 DOD report gives 310 mi (500 km) and FAS and *Missile Threat* estimates 500-700 km. Dr. Elleman from IISS suggests that its range is 500 km when armed with a 730 kg warhead. Appraisals of the Shahab-2’s accuracy diverge by an order of magnitude, with FAS estimating the CEP at 50 meters and Shifrinson and Priebe citing 700 m.¹⁹

The number of active Shahab-2 missiles and TELs is also unclear. FAS states that Iran’s total Shahab-1 and 2 holdings are between 200 and 450 missiles (which, given FAS estimates for Shahab-1 holdings, leaves Iran with between 0 and 200 Shahab-2), with a March 2006 Air Force report placing the aggregate number of TELs at under 100. *Missile Threat* states that Iran purchased between 150 and 200 SCUD-Cs from North Korea by 1994; after testing and possible reverse engineering, it suggests Iran has between 300 and 400 Shahab-1 and 2 today.

Hildreth provides the following summary of the capabilities of both the Shahab 1 and Shahab 2.¹²

Both the Shahab-1 and the Shahab-2 are road-mobile systems that can be moved to any number of pre-surveyed launch sites. Wartime experiences, such as in Iraq, show these missiles tend to operate within a radius of about 100 km or less from their bases because of the need to ensure operational security and to be able to maintain key logistics support. A notional operating area of these missiles is shown in **Figure 3** based on locations around Shiraz in southwestern Iran. The Shahab-1 has a range estimated of about 300 km, while the Shahab-2, which carries a lighter conventional warhead, has a range estimated at about 500 km. Iran has an unspecified number of Shahab-1 and Shahab-2 SRBMs, but they likely number on the order of a few hundred.

Hildreth also mentions the possibility that Iran has a more modern variant of the Shahab 2 called the Qiam. He notes, however, that,¹³

The only reported test of this ballistic missile in the media was in August 2010. A UN Report said a Member State “assessed the Qiam to be based on the Shahab-2, with a range between 500 and 1,000 kilometers. Some experts have raised questions about the missile’s lack of apparent testing...” “Missiles are known to require extensive flight testing before they can be fully operational.”...The status of the Qiam is unclear. According to a Hezbollah (Lebanese) media source, the Qiam 1 was delivered to the Aerospace Force of the IRGC in late May 2010.⁶¹ Iran’s Islamic Republic

News Agency quoted Defense Minister BG Vahdi as saying the Qiam is harder to detect than older models and that mass production of the Qiam missile, the country’s first missile without stabilizer fins, demonstrates Iran’s self-sufficiency in producing various types of missiles. Gen. Vahdi added that the Qiam’s design reduces the possibility of being detected by enemy anti-missile systems and the omission of its fins increases the missile’s speed enabling it to hit its targets with high precision. According to the same Hezbollah source, IRGC Commander Mohammed Ali Jafari, told reporters earlier in 2010 “these new missiles enjoy supersonic speed and cannot be tracked or intercepted by the enemy.”¹⁴ (Add endnote: Steven A. Hildreth, *Iran’s Ballistic Missile and Space Launch Programs*, Congressional Research Service R42849, December 6, 2012, pp. 18-19)

Military Potential and Effectiveness

Iran's shorter-range rocket and missile programs missile program are an integral part of both its Conventional and asymmetric strategy. They help compensate for the Islamic Republic's weakness in conventional airpower, but it also gives it other forms of war fighting capabilities that greatly complicate US and Gulf Arab missile defenses, and gives Iran a way of arming the Hezbollah and working with Syria in ways that threaten Israel.

Current Combat Role

Their limitations in range and lethality limit their effectiveness in conventional combat, particularly since Iran's beyond visual range and targeting capability remains limited and it has no effective over-the-horizon targeting capability that could survive in combat. While some experts feel such systems could be upgraded to precision guidance over the next five to ten years, open source evidence suggests that Iranian doctrine now calls for them to be fired in volleys and that such volleys would still have limited real-world lethality but could have a major impact in terms of psychological and political warfare if used against Arab Gulf area targets or US, British, and France forces and basing facilities.

They are relatively cheap, mobile, easy-to-use systems that can be used independent of any central command. Unlike longer-range missiles - particularly those emplaced in silos - aiming and firing these weapons is done on the initiative of lower-echelon commanders. Accordingly, they could be valuable in both political intimidation and deterrence.

Dispersed forces would be hard to target and destroy, and the destruction of Iranian command and control facilities would not eliminate missile-launching capabilities, although it could weaken their effectiveness in a major attack because their lack of precision and the need for massed volleys demands a coordinated C³I. It also is unclear from unclassified reporting whether recent ground-war exercises in Iran included large numbers of Zelzals and Fateh-110s, or whether the IRGC intends to not even push centralized command and control and totally separate them from conventional forces.

Such weapons could also play a role in any Iranian effort to threaten or attack Iraq and Kuwait. While these systems currently can only target the Gulf littoral, all of populated Kuwait lies within range. While the other GCC states (excepting Bahrain) have some strategic depth and are out of range unless the Zelzal and Fateh-110s hit maximum range, Kuwait is within easy missile range and must send its tankers close to Iran for every oil shipment.

Kuwait's vulnerability was demonstrated during the Tanker War, when Kuwait was the first Gulf state to request US assistance in securing its oil exports, and despite new Patriot missiles Iran likely views Kuwait as the most vulnerable state. Iraq has greater strategic depth than any GCC state, but it lacks either anti-missile systems or the retaliatory capability to deter Iranian missile strikes. In any military or diplomatic confrontation, Iran could use or threaten to use its short-range systems, for which Iraq has no proportional response.

Attacks Across the Gulf

The Gulf is only 300 km wide at its widest point, and only 50 km wide at the Strait of Hormuz. With maximum ranges in 200-400 km range, the Zelzal and Fateh-110 have limited utility in attacking land target across the Gulf, particularly since the accuracy of such missiles is poor and deteriorates further at long ranges.

The longer-range versions are able to target Gulf coastal cities, however, and some significant Gulf infrastructure, given Iran's presumed large stocks. They also could be fired in volleys along with longer-range missiles - potentially complicating, saturating, or exhausting the reload capability of missile defenses. It is uncertain whether a combination of the offensive strike and missile defense capabilities of the US and Gulf States could fully protect this region from multiple volleys. This is particularly critical given Iran's island holdings in the Gulf, which allow it to emplace missiles close to GCC states' coastline.¹⁵

Saudi Arabia has three desalination plants on the Gulf, including the intake stations for Riyadh, and Qatar, Bahrain, and the United Arab Emirates all rely on desalination for 99%, 30% (with wastewater reuse - and its attendant vulnerable infrastructure - making up another 30%), and 40% of their water, respectively. All of these are large, unhardened complexes, and might require on the order of 50-75 missiles to damage them with 50% confidence (more to ensure the damage is serious).

All the Gulf States have a substantial portion of their petroleum infrastructure located on the Gulf coast. The vast majority of GCC oil fields are located on or near the Gulf, with most major infrastructure - for production, refining, and transportation - within 100 km of the coast.

This places them within the range of Iran's Shahab-1 and 2, and the shorter-range Zelzals and Fateh-110s as well in the case of Kuwait, the UAE's and Qatar. While Iran could likely only target four to ten critical pieces of infrastructure with its Shahabs, using large numbers of the shorter range Zelzals and Fatehs would give it the ability to strike dozens of area targets with a 50% confidence of success. This still might not hit critical or long lead components but it would have a major impact on any cities, could damage infrastructure facilities long enough to have a political impact, and might hit a truly critical target by luck in the process.

The most vulnerable state is the UAE, with Dubai probably within range of Zelzal-2s and Fateh-110s. If Iran can base missiles off its islands in the Gulf, it will be able to target all the petroleum and desalination facilities that provide roughly a quarter of the UAE's GDP, along with a portion of Saudi Arabia's northeastern oil fields. While launchers on Gulf islands would be vulnerable to airstrikes, they provide Iran with the possibility of at least one volley of direct attacks on its Gulf neighbors.

The UAE is uniquely vulnerable among the Gulf States as its territory is vulnerable to attack even without Iran emplacing missiles on its islands. Mobile launchers inland are more likely to survive and launch additional volleys of strikes, meaning the Emirates may face the most sustained missile campaign should hostilities break out.

Such missiles potentially allow Iran to overwhelm Kuwait's anti-missile defenses and target the main port, desalination plants, military bases, petroleum facilities, and other crucial pieces of infrastructure. At such close range, and with so many targets to choose from, Iran is able to threaten Kuwait with severe economic damage while Kuwait lacks the SSM capacity to respond and SAM/TBM capacity to defend itself. Should Iran seek to pressure Kuwait, these short-range systems will be the primary component of its threat. Under these circumstances, Kuwait is obliged to rely on external partners to guarantee its security, both to upgrade its anti-ballistic defenses and provide retaliatory capabilities.

Iraq is also a potential for target of these systems. Baghdad, Basra, other cities near the border, and much of the agricultural heartland of southern Iraq are vulnerable to Zelzal and Fateh-110

missiles. Iraq lacks both the anti-ballistic missiles and retaliatory systems to combat this threat, and most Iraq policy makers likely recall the devastation and panic that fewer Iranian missiles caused during the War of the Cities. While such an attack would probably prompt US and GCC support of Iraq, as well as substantially undermine popular support for Iran in Iraq, it remains an obscured threat to Baghdad in all dealings with Tehran.

With the exception of US bases in Kuwait, Zelzals and Fateh-110s do not pose a threat to US forces in the region. Their reach is too short to penetrate deeply beyond the littoral, and only the al Dhafra air base and some positions in Saudi Arabia would be vulnerable to missiles launched from Iran's Gulf islands. The same is true for the GCC's militaries - despite their relative lack of strategic depth (except in the case of Saudi Arabia), their bases are for the most part too distant from mainland Iran to be vulnerable to multiple volleys of missile fire from the more numerous Zelzals and Fateh-110s.

Iran's Potential War Fighting Capabilities

These assessments, however, are based on the view of experts who believe there is no evidence Iran actually has the capability to target even its shorter-range missiles against ships at long ranges. They feel Iran is at least 5-10 years away from giving any of its ballistic missiles any form of true homing, TERCOM, or other forms of precision guidance. At present, Iran rarely practices firing shorter range systems like its C-700 and C-800 series of anti-ship cruise missiles against moving ships, and unguided ballistic missiles have no practical utility against even static ships.

If Iran did develop an effective precision strike and targeting system, however, ships would be vulnerable to such ballistic missiles, particularly if they are beyond the missile defense envelope of US Navy Aegis or other missile defense systems. Just as salvos of conventional missiles could penetrate anti-missile systems on land, the mass-production of long-range ballistic missiles with suitable guidance and targeting systems could represent a significant threat to even anti-missile equipped American and GCC naval forces. They could be used in such a role if Iran tried to "close the Gulf" by other naval means - small-boat harassment or mine warfare - as ballistic missiles could target military vessels trying to counter these smaller threats.

The possibility Iran could eventually make good on its claims is another reason for the Gulf states to acquire missile defenses. Such weapons could represent the Islamic Republic's first real opportunity to target the war-making capabilities of its Gulf opponents. Although the Gulf States are protected for now, their relative lack of strategic depth means that Bahrain, Qatar, and the UAE will all be vulnerable to missiles with a range of 400 km - a number that Iran may be able to achieve with boosted Zelzal-3s, and likely with its next generation of missiles. As Iran further improves and builds its short-range fleet, it will gradually play a major denial role for the GCC.

Such developments would, however, be more likely to push the US towards missile defense than close the region to US use of Southern Gulf and other regional bases. There are too many airfields, depots, ports, and staging ports for Iran to close them all, and improvements in missile defense will continue to reduce the number of expected surviving missiles.

Iran's Medium and Long-Range Missile Programs

The trends in Iran's current medium and long-range missile efforts were summarized in the declassified version of a report the US Secretary of Defense sent to Congress in April 2012,¹⁶

Regular Iranian ballistic missile training program continues throughout the country. Iran continues to develop ballistic missiles that can range regional adversaries, Israel, and Eastern Europe, including an extended-range variant of the Shahab-3 and a 2,000-km medium-range ballistic missile, the Ashura. Beyond the steady growth in its missile and rocket inventories, Iran has boosted the lethality and effectiveness of existing systems by improving accuracy and developing new submunition payloads.

During the last two decades, Iran has placed significant emphasis on developing and fielding ballistic missiles to counter perceived threats from Israel and Coalition forces in the Middle East and to project power in the region. With sufficient foreign assistance, Iran may be capable of flight-testing an intercontinental ballistic missile by 2015.

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During the last 20 years, Iran has placed significant emphasis on developing and fielding ballistic missiles to counter perceived threats from Israel and Coalition forces in the Middle East and to project power in the region. In 2011, Iran launched several missiles during the NOBLE PROPHET 6 exercise, including a multiple missile salvo.

Short-range ballistic missiles provide Tehran with an effective mobility to strike partner forces in the region. Iran continues to improve the survivability of these systems against missile defenses. It is also developing and claims to have deployed short-range ballistic missiles with seekers that enable the missile to identify and maneuver towards ships during flight. This technology also may be capable of striking land-based targets.

Iran has also developed medium-range ballistic missiles to target Israel and continues to increase the range, lethality, and accuracy of these systems.

A RAND analysis summarized the utility of Iran's current systems and the improvements Iran is likely to seek in the near future as follows:

Iran's short- and intermediate-range conventional ballistic missiles confront the United States and its allies with the threat of retaliatory strikes against key regional targets in the event of a conflict. However, given the relatively limited capabilities of Iran's conventional missile program, particularly the relative inaccuracy of the SCUD-based models, and even the Shahab-3 and its variants, these systems are likely to play two operational roles. First, these missiles may be launched against large U.S. bases—including Ali Al Salem in Kuwait, Al-Udeid in Qatar, AL-Dhafra in the UAE, and perhaps Incirlik in Turkey—in order to disrupt U.S. air operations....Additionally, Iran's missiles may be utilized in a punitive counter-value campaign against population centers in the region, and perhaps oil production infrastructure in Saudi Arabia and the Gulf States, to intimidate opposing regimes and perhaps limit cooperation with U.S. forces. ...The limited technical capabilities of the Iranian missile systems, particularly their relative inaccuracy and reliance on primitive conventional warheads, are unlikely to provide Iran with a capacity to execute a highly coordinated first-strike against high-value U.S. and allied military targets in the region.²⁴ While a preventive or preemptive missile strike launched in the midst of an intense diplomatic crisis cannot be ruled out, the inherent technical limitations of these missiles undermine their military effectiveness and would seem to make their employment as anything other than retaliatory weapons improbable.

U.S. forward bases and installations will be at far greater risk of damage or destruction from nuclear-armed, intermediate-range missiles. However, without a significant enhancement of Iranian air defense capabilities, fighter aircraft, or both, the United States would still be expected to achieve air superiority in a conflict and able to strike high-value targets, including Iranian missile forces, even if responding from European bases or U.S. aircraft carriers.¹⁷

James R. Clapper, the US Director of National Intelligence, described the nature of the Iranian missile threat as follows in his annual *Statement for the Record Worldwide Threat Assessment of the US Intelligence Community* to the Senate Select Committee on Intelligence on March 123, 2013 (p. 7)

Iran already has the largest inventory of ballistic missiles in the Middle East, and it is expanding the scale, reach, and sophistication of its ballistic missile arsenal. Iran's growing ballistic missile inventory and its domestic production of anti-ship cruise missiles (ASCM) and development of its first long-range land attack cruise missile provide capabilities to enhance its power projection. Tehran views its conventionally armed missiles as an integral part of its strategy to deter—and if necessary retaliate against—forces in the region, including US forces.

Key Uncertainties in Making an Assessment

It is not easy to provide a clear picture of Iran's diverse and constantly changing programs. While the following data are unclassified and many aspects of their details are uncertain or based on conflicting nominal estimates, they still illustrate significant real-world capabilities:

Figure 5 shows some of the current estimates of the ranges of Iran's ballistic missiles. While Iran does not yet possess missiles with a range of 3,000 km, the possibility exists that Iran may soon produce missiles with such a capability given the scale of R&D into its ballistic missile program.

Figure 6 provides a more conservative estimate for the range of Iran's current missile forces. According to the BPC's estimate, Iranian missiles could potentially strike Athens, Bucharest, or Moscow.

Figure 7 reflects key developments in Iran's ballistic missile program in the last several years. Key points include the possibility that Iran could produce an intercontinental ballistic missile by 2015, and indicators that Iran is developing a nuclear warhead for its Shahab-3 intermediate range ballistic missile.

Figure 8 provides a table that indicates the names, fuel types, estimated ranges, and likely payloads of the missiles in Iran's arsenal.

Figure 9 provides range-payload graphs for Iran's current missiles and a comparison of its current missiles and potential new systems.

Figure 10 shows Iran's "erector set" of missiles, allowing a visual frame of reference and demonstrating the technological similarities between the weapons.

It is obvious from these different estimates that unclassified sources do not provide a clear basis for estimating how effective Iran's medium and longer-range systems really are. Accurate data are difficult to obtain. While the performance of shorter range systems like unmodified versions of the Scud B is well known, many aspects of Iran's longer-range and more developmental programs are not. Iran has not conducted the kind of extensive, realistic missile tests at operational ranges and carried through to strikes on target with the same configuration of its modified or Iranian-produced missiles to make reliable estimates of their war fighting capability or give any estimate of their performance.

A Council on Foreign Relations report on Iran's ballistic missile program notes that:

Defense analysts say despite Iran's public pronouncements and frequently publicized test firings, assessments of Iranian hardware are largely speculative. Indeed, many Western reports offer contradictory findings, with different missile names, ranges, inventory numbers, and other characteristics for even the most commonly cited systems. The Federation of American Scientists, an advocacy group that promotes disarmament, for instance, estimates the maximum range of the liquid-fueled workhorse of the Iranian arsenal, the Shahab-3 medium-range missile, at 1,500 kilometers, while Missilethreat.com, a project of the conservative Claremont Institute, puts the maximum range at 2,500 kilometers.¹⁸

Iran also has a tendency to introduce similar missiles under different names, exaggerate qualities of missiles and the number used in tests, and actively doctor evidence such that unclassified reports are often contradictory and provide a very limited understanding of new classes of Iranian missiles.

The technical literature on such systems also has serious limitations. Many unclassified range estimates use a nominal payload that may bear no relation to the actual payload, and this casts serious doubt on both the range-payload data and any estimate of warhead lethality. **Figure 9** attempts to correct this with estimated range-payload charts, showing the trade-off between warhead size and distance, but these are based on technical analysis and guesstimates, not hard test data.

Experts note that to date, Iran has rarely fired missiles at maximum range - although two Shahab 3s were fired into the Indian Ocean, evidently more as a test of range than as part of a well-structured effort to determine accuracy. Iran also tends to fire off its older missiles, rather than its latest inventory. Experts indicate, for example that Iran's newer, longer-range versions of the Shahab 3 seem to be much improved over its earliest deployed versions.

A number of past tests ended in the missile being destroyed before it hits a land target, and Iran does not conduct anything like the number of tests to establish reliability or accuracy using a derived aim point rather than a theoretical engineering estimate of CEP.

The lack of large-scale testing eliminates Iran's ability to calibrate the accuracy of its systems using a derived aim point versus an engineering estimate, compensate for the earth's rotation and irregularities in its shape. It presents difficulties for the Iranian engineers trying to improve their missiles' performance. While Iranian scientists can compare the actual flight path to the expected route - an option not available to foreigners - they lose out on data about the missile's final approach to its target. Iranian engineers have also faced difficulty addressing natural factors, as flights over the Indian Ocean have encountered weather and geological complications that have restricted useful test data.

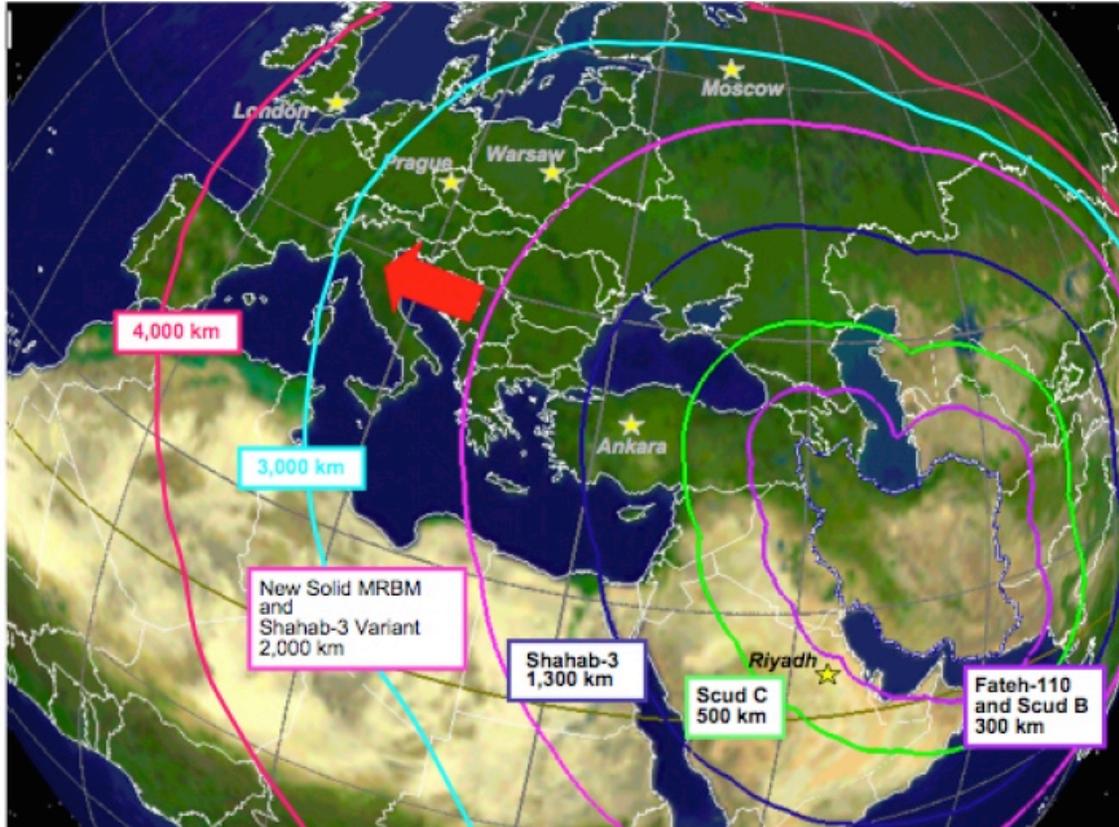
Experts estimate that Iran relies largely on unitary warheads - which generally limit the lethality of missile warheads to about one-third of the impact of a bomb with similar weight of explosive because of the upward vectoring of the explosion as the missile hits at high velocities. They feel does not have chemical warheads for such missiles or effective submunitions.

There are no reliable unclassified sources on the details of Iranian developments in submunitions and missile accuracy, however, both of which could increase lethality. These data problems are particularly important in light of events like the Qayim-1 launches in July 2012, where Iran may have demonstrated a superior warhead and improved guidance systems - or, potentially, claimed much but changed little. Experts do say on background, however, that they have not seen evidence of advanced or highly effective high explosive or chemical cluster munitions, guided or homing submunitions, or effective fusing and dispersal systems

Iran also keeps changing key aspects of its longer-range systems as it moves towards long ranges systems with payloads large enough to either hold a CBRN weapon or more sophisticated conventional warhead. While Iran's Shahab-1 and Shahab-2 short range ballistic missiles (SRBM) approach the status of a mature force with a defined command structure and established launching positions, even the unclassified data on the extended range Shahabs consists largely of estimates. Both its Shahab and Sejil program seem to undergo constant evolution even though a

force is already deployed, and Iran is so busy testing new designs that it demonstrates at least one new missile every year - although the new weapon is sometimes an old artillery rocket with a better warhead.

Figure 5: Estimated Range of Iranian Long-Range Missile Forces



Source: NASIC, B&CM Threat 2006, Jacoby Testimony, March 2005.

Figure 6: Estimated Range of Iranian Long-Range Missile Forces – Part I



Source: Bipartisan Policy Center, “Meeting the Challenge: Stopping the Clock,” February 2012.
<http://www.bipartisanpolicy.org/sites/default/files/BPC%20Iran%20Report.pdf>.

Figure 6: Estimated Range of Iranian Long-Range Missile Forces – Part II



Source: Steven A. Hildreth, *Iran's Ballistic Missile and Space Launch Programs*, Congressional Research Service R42849, December 6, 2012.

Figure 7: Iran’s Longer Range Ballistic Missile Arsenal

Shahab-3 (“Meteor”)	800-mile range. The Defense Department report of April 2010, cited earlier, has the missiles as “deployed.” Still, several of its tests (July 1998, July 2000, and September 2000) reportedly were unsuccessful or partially successful, and US experts say the missile is not completely reliable. Iran tested several of the missiles on September 28, 2009, in advance of the October 1 meeting with the P5+1.
Shahab-3 “Variant”/Sejjil	1,200-1,500-mile range. The April 2010 Defense Department report has the liquid fueled Shahab-3 “variant” as “possibly deployed.” The solid fuel version, called the Sejjil, is considered “not” deployed by the Defense Department. The Sejjil is alternatively called the “Ashoura.” These missiles potentially put large portions of the Near East and Southeastern Europe in range, including US bases in Turkey.
BM-25	1,500-mile range. On April 27, 2006, Israel’s military intelligence chief said that Iran had received a shipment of North Korean-supplied BM-25 missiles. Missile said to be capable of carrying nuclear warheads. The <i>Washington Times</i> appeared to corroborate this reporting in a July 6, 2006 story, which asserted that the North Korean-supplied missile is based on a Soviet-era “SS-N-6” missile. Press accounts in December 2010 indicate that Iran may have received components but not the entire BM-25 missile from North Korea.
ICBM	US officials believe Iran might be capable of developing an intercontinental ballistic missile (3,000 mile range) by 2015, a time frame reiterated by the April 2010 DOD report.
Other Missiles	On September 6, 2002, Iran said it successfully tested a 200-mile range “Fateh-110” missile (solid propellant), and Iran said in late September 2002 that it had begun production. Iran also possesses a few hundred short-range ballistic missiles, including the <i>Shahab-1</i> (Scud-B), the <i>Shahab-2</i> (Scud-C), and the <i>Tondar-69</i> (CSS-8). In January 2009, Iran claimed to have tested a new air-to-air missile. On March 7, 2010, Iran claimed it was now producing short-range cruise missiles that it claimed are highly accurate and can destroy heavy targets. At a February 8, 2011 press conference, IRGC chief Mohammed Ali Jafari announced that Iran had developed the <i>Khalij Fars</i> (“Persian Gulf”), a “smart” anti-ship ballistic missile based on the Fateh-110 that is allegedly able to hit high-value targets throughout the Gulf.
Space Vehicle	In February 2008, Iran claimed to have launched a probe into space, suggesting its missile technology might be improving to the point where an Iranian ICBM is realistic. Following an August 2008 failure, in early February 2009, Iran successfully launched a small, low-earth satellite on a <i>Safir-2</i> rocket (range about 155 miles). The Pentagon said the launch was “clearly a concern of ours” because “there are dual-use capabilities here which could be applied toward the development of long-range missiles.” Additionally, Iran has embarked on an ambitious satellite launch program since early-mid 2011.
Warheads	A <i>Wall Street Journal</i> report of September 14, 2005, said that US intelligence believes Iran is working to adapt the Shahab-3 to deliver a nuclear warhead. Subsequent press reports say that US intelligence captured an Iranian computer in mid-2004 showing plans to construct a nuclear warhead for the Shahab. The IAEA is seeking additional information from Iran.

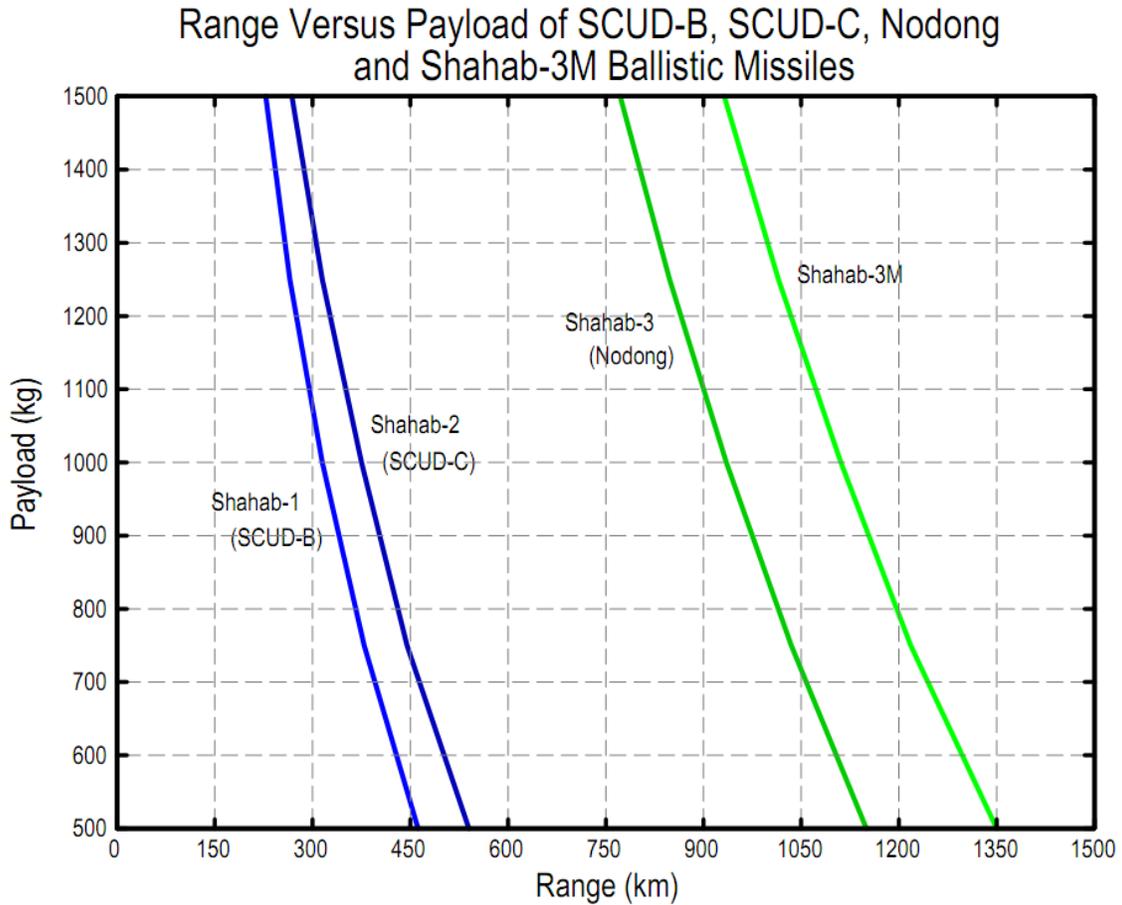
Sources: Kenneth Katzman, “Iran: US Concerns and Policy Responses,” US Congressional Research Service, February 14, 2011; Iranian reporting.

Figure 8: Iranian Rockets and Missiles

Missile	Translation	Fuel Type	Estimated Range	Payload
Fajr-3	<i>Dawn-3</i>	Solid	45 km	45 kg
Fajr-5	<i>Dawn-5</i>	Solid	75 km	90 kg
Fateh-110	<i>Victorious</i>	Solid	20 km	500 kg
Ghadr-1	<i>Powerful-1</i>	Liquid	1600 km	750 kg
Iran-130/Nazeat	<i>Removal</i>	Solid	90-120 km	150 kg
Kh-55		Liquid	2500-3000 km	400-450 kg
Nazeat-6	<i>Removal-6</i>	Solid	100 km	150 kg
Nazeat-10	<i>Removal-10</i>	Solid	140-150 km	250 kg
Oghab	<i>Eagle</i>	Solid	40 km	70 kg
Sajjil-2	<i>Baked Clay-2</i>	Solid	2200-2400 km	750 kg
Shahab-1	<i>Meteor-1</i>	Liquid	300 km	1000 kg
Shahab-2	<i>Meteor-2</i>	Liquid	500 km	730 kg
Shahab-3	<i>Meteor-3</i>	Liquid	800-1000 km	760-1100 kg
Shahin-1	<i>Hawk-1</i>	Solid	13 km	
Shahin-2	<i>Hawk-2</i>	Solid	20 km	
Zelzal-1	<i>Earthquake-1</i>	Solid	125 km	600 kg
Zelzal-2	<i>Earthquake-2</i>	Solid	200 km	600 kg

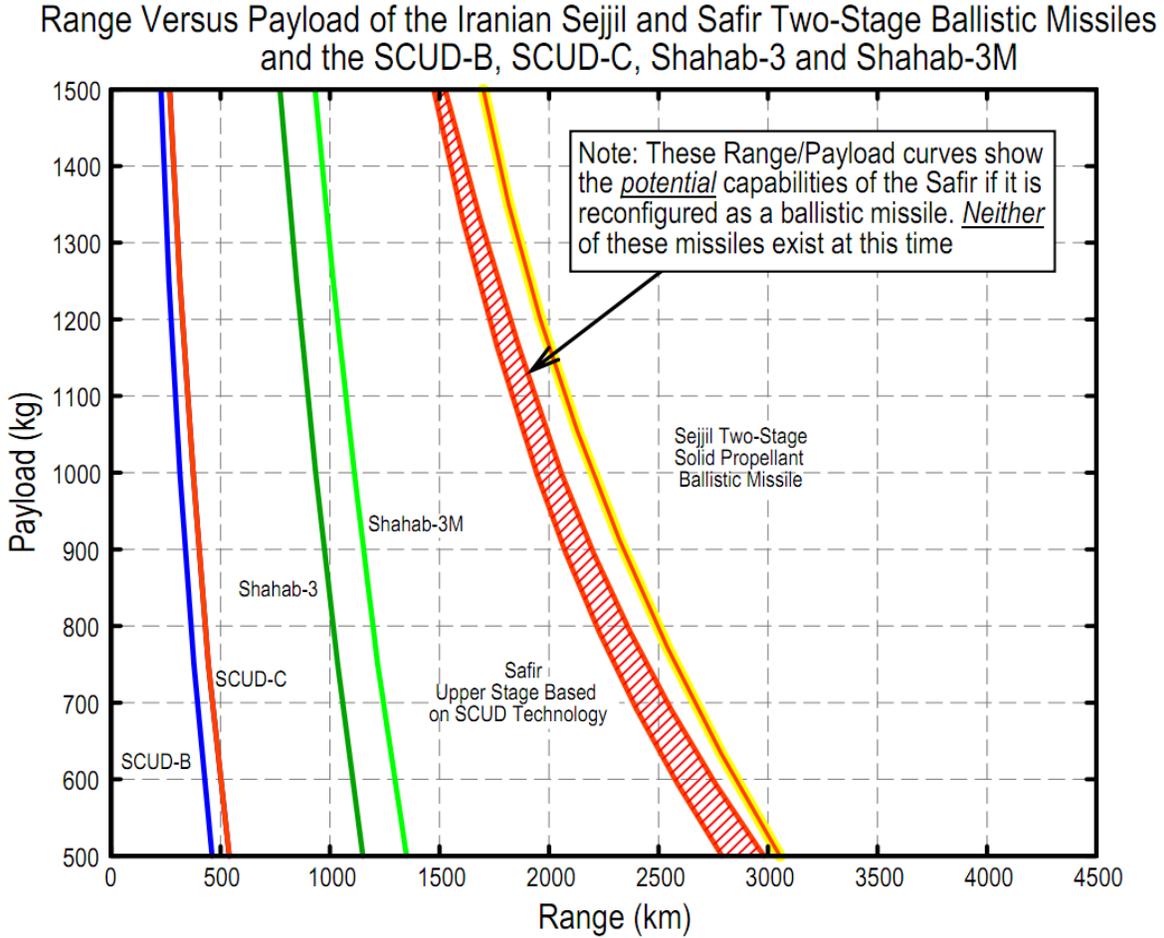
Source: 2010 IISS Iran's Ballistic Missile Capabilities: A Net Assessment.

Figure 9: Range-Payload Relationship for Active Iranian Missiles - Part I



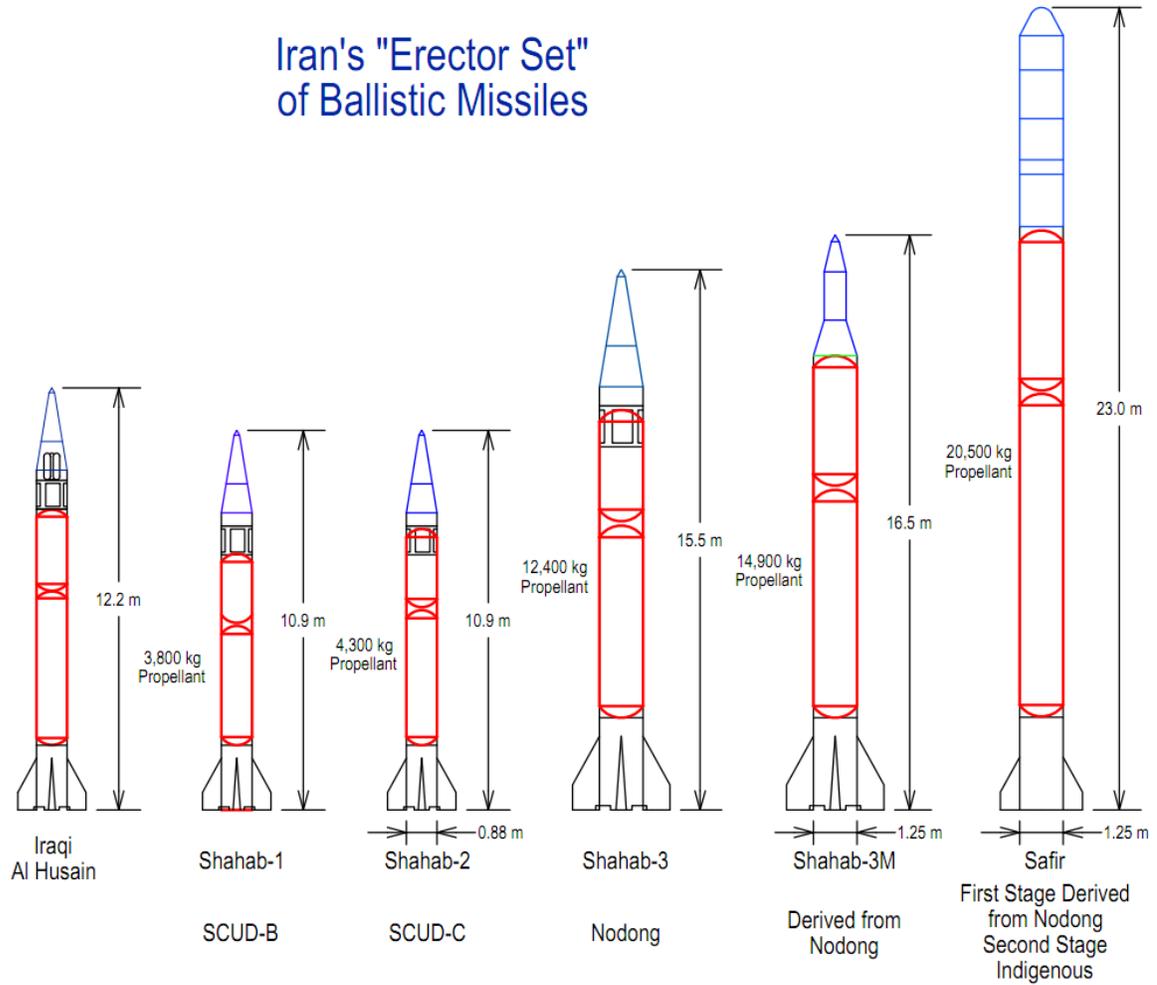
Source: Theodore Postol, *A Technical Assessment of Iran's Ballistic Missile Program*, from "Technical Addendum to the Joint Threat Assessment on the Iran's Nuclear and Missile Potential." (JTA) May 6, 2009.

Figure 9: Range-Payload Relationship for Active Iranian Missiles - Part II



Source: Theodore Postol, *A Technical Assessment of Iran's Ballistic Missile Program*, from "Technical Addendum to the Joint Threat Assessment on the Iran's Nuclear and Missile Potential." (JTA) May 6, 2009.

Figure 10: Iran's "Erector Set" of Ballistic Missiles



Source: Theodore Postol, *A Technical Assessment of Iran's Ballistic Missile Program*, from "Technical Addendum to the Joint Threat Assessment on the Iran's Nuclear and Missile Potential." (JTA) May 6, 2009.

Medium-Range Ballistic Missiles

Unclassified sources provide a wide range of useful data on Iran's shorter-range ballistic missiles; although the data are best on technical performance rather than numbers, force structure, command and control, and readiness. Some performance data also are based on data comparable systems - SCUD-B for Shahab-1, SCUD-C for Shahab-2, and Nodong for Shahab-3 - but these sources do not take into account further upgrades Iran may have done to its store of missiles, or the impact of local weather, age, and maintenance by unfamiliar technicians on their electronics, guidance systems, and propulsion.

More importantly, these estimates do not take into account local conditions. Launching a weapon from a sanitized testing facility bears little relation to doing so under the stress and confusion of battle. While factors such as storage conditions, improper fueling, and local engineering will affect the range and maximum payload, mistakes by the launching crew - as well as mechanical defects - are likely to reduce the accuracy of the weapon.

Shahab-1 (Meteor 1)

The Shahab-1 is the Iranian version of the SCUD-B missile, a weapon designed by the Soviet Union in the 1960s and later exported to over 20 countries. It was used by Iran and Iraq in the War of the Cities during the Iran-Iraq War, and was used to target Coalition bases and Israeli cities during the first Persian Gulf War. Designed as a tactical nuclear missile, it has since become the most widely copied ballistic missile, with its ease of construction and launch making up for deficiencies in accuracy.

There is broad agreement on some details of the system's performance. According to a Joint Threat Analysis produced by Dr. Postol, with a 1000 kg warhead the Shahab-1 has a range of approximately 315 km. This agrees with the Federation of America Scientists' (FAS)¹⁹ assessment that its range is 285 to 330 km, similar to the US Department of Defense's estimate of 185 mi (300 km). Both *Missile Threat*²⁰ and FAS give the Shahab-1 a CEP²¹ of 450 m; IISS gives 450 as its best-case number, but suggests 1000 m is more likely.²² The system is liquid-fueled, and requires approximately one hour to fuel and to prepare for launch (and can only be kept in a launch-ready state for a limited period of time).

Experience from the Gulf War and other conflicts demonstrate that these missiles are far too inaccurate to be used to hit point targets. The roughly 90 SCUD-Bs fired by Iraq caused approximately 30 direct casualties, most of which were caused by the missile strike on the US base at Dhahran. While terror-induced strokes and heart attacks increased the total, barring considerable luck or improvements in accuracy, this weapon armed with a conventional warhead has limited military utility. As **Figure 3** shows, the best-case scenario means several hundred Shahab-1 would be necessary to hit a single target with lethal accuracy.

The force numbers are far less clear. According to a 1995 *Jane's Intelligence Review - Special Report No. 6* Iran has 15 transport-erector-launchers (TEL) and 250-300 Shahab-1 missiles, along with the capacity to manufacture more. It is not clear how the force has evolved over time. Assertions that Iran can manufacture all the components of Shahab-1 engines are disputed by IISS in a recent briefing, which agrees that Iran only possesses approximately 200-300 Shahab-1.²³ The UN Panel of Experts on Iran Sanctions supports either interpretation, stating:

“With assistance from the Democratic People's Republic of Korea, Iran has likely established Shahab missile assembly facilities, which can produce these missiles using imported components.

Iran claims that it produces Shahab 1 and 2 missiles indigenously, for both domestic use and export. Its production of the Shahab 3 however requires some imported components including guidance systems, liquid-propellant engines and telemetry equipment. Experts also note that the performance of the Shahab 1, for example, mirrors closely its Soviet-era Scud counterpart, indicating that it may continue to rely upon imported engines and critical components. Iran currently is not said to possess a fully indigenous liquid-propellant engine production line.²⁴

It is interesting that Iran fired a Shahab 1 from a ship in the Caspian in 1988 - presenting the possibility it could use a ship like a freighter or tanker to fire such a system from a distance off the coast of Israel or the US.²⁵

Shahab-2

The Shahab-2 is the Iranian designation for the SCUD-C. The SCUD-C was developed by the Soviet Union as a longer-range version of SCUD-B, using more fuel, a more efficient design, and potentially a smaller warhead. Widely exported, like the SCUD-B it was allegedly obtained by Iran from North Korea, and is liquid fueled and road-mobile.

There is much less agreement on the performance of the system, and much of the data that do exist as based on a nominal warhead rather than its actual payload. According to Dr. Postol's analysis, the Shahab-2, armed with a 1000 kg warhead, has a range of approximately 375 km, while the 2010 DOD report gives 310 mi (500 km) and FAS and *Missile Threat* estimates 500-700 km. Dr. Elleman from IISS suggests that its range is 500 km when armed with a 730 kg warhead. Appraisals of the Shahab-2's accuracy diverge by an order of magnitude, with FAS estimating the CEP at 50 meters and Shifrinson and Priebe citing 700 m.²⁶

The number of active Shahab-2 missiles and TELs is also unclear. FAS states that Iran's total Shahab-1 and 2 holdings are between 200 and 450 missiles (which, given FAS estimates for Shahab-1 holdings, leaves Iran with between 0 and 200 Shahab-2), with a March 2006 Air Force report placing the aggregate number of TELs at under 100. *Missile Threat* states that Iran purchased between 150 and 200 SCUD-Cs from North Korea by 1994; after testing and possible reverse engineering, it suggests Iran has between 300 and 400 Shahab-1 and 2 today.

Longer Range MRBM/IRBMs

As **Figure 5** to **Figure 10** show, Iran possesses longer-range ballistic missiles, and substantial ability to launch even its longest-range missiles from dispersed mobile launchers. Of particular note are Iran's medium-range ballistic missiles (MRBMs), which include the Shahab-3, its longer-range variants, and the Sejil. Based on the North Korean Nodong-1, the Shahab-3 has a range of roughly 1,000 km, and can potentially reach targets throughout the Middle East, while Iran's other MRBMs can reach up to 2000 km.²⁷

The Shahab-3 has been upgraded by Tehran to increase its range and, potentially, the versatility of its warhead. These versions - which may include the Shahab-3A, Shahab-3B, Shahab-4, and Ghadr-1 - may all be similar versions of the same missile, incremental improvements of which only the latest has entered production, or distinct weapons for different missions.

Iran is also developing additional MRBMs - most importantly the Sejil - that could form the backbone of a strategic missile force that would allow Iran to conduct more effective strikes against population centers and area targets throughout the region, and deliver CBN weapons on distant targets. Future development in the MRBM/IRBM (Intermediate Range Ballistic Missiles) field is likely to be concentrated in solid-fueled designs.²⁸

Iran has made such programs a key propaganda issue. For example, FARS announced shortly after Iran and the P5+1 reached an agreement on nuclear weapons in November 2013, that Brigadier General Hossein Salami, the lieutenant commander of Iran's elite Islamic Revolutionary Guard Corps (IRGC), had stated that, "Iran is among the only three world countries enjoying an indigenous ballistic missile technology...Many countries may have access to cruise missiles technology, but when it comes to ballistic missiles, I am confident that only the U.S. and the [former] Soviet Union could master this technology, and now we can announce that we own this technology as well".²⁹

The IRGC leader claimed that Iran was also developing other advanced systems, "While we did not have any knowledge about drones, we have developed and acquired drones that travel 2,000 kilometers, conduct their operations, and then land in our desirable regions." At nearly the same time, General Ramezan Sharif, Head of the IRGC's Public Relations Department, stated that, "The U.S. has double-standards towards social issues of nations and the language that Americans understands is the language of force...U.S. power is growing weaker every year...The pillars of the U.S. strength have become seriously shaky in the world, especially in the Middle-East."³⁰

Shahab-3

Despite the similarity in nomenclature, the Shahab-3 is a very different weapon than the Shahab-1 and 2. Although liquid-fueled and road-mobile, it is derived from the North Korean No dong, which some experts believe is derived from Soviet submarine-launched ballistic missiles. Designed as a medium-range ballistic missile, its exterior is essentially a SCUD-B that has been stretched by a factor of 1.4 in every dimension with an advanced engine based off the Soviet SS-N-4 SLBM.³¹ Its increased range, greater payload capacity, and Iran's sizeable collection make it the most formidable ballistic missile class currently deployed by Iran for Middle East operations.

Again, sources differ and often used a nominal payload and optimal guidance data rather than real-world performance, meaning that this weapon is less dangerous in a war zone than the statistics would suggest.

According to Dr. Postol, a Shahab-3 with a 1000 kg warhead has a range of 930 km, while the 2010 DOD report and FAS suggest 800 mi (1290 km), *Missile Threat* estimates 800 to 1300 km, and Dr. Elleman, for a 1000 kg warhead, gives the range as 800-1000 km.

Missile Threat recognizes these problems in what seems to be one of the most accurate summaries of the variants in the Shahab 3 program:

The lack of reliable information, especially when combined with the confusing list of alternate names, has made the separate specifications for the Shahab 3 variants almost impossible to sort out. Photos have confirmed the existence of variants and observing test launches of externally modified Shahab 3 missiles, but which project/missile name belongs to each specific modification is less clear.

Based upon known tests and photographs, the Shahab 3 has undergone the following modifications:

- Size reduction of rear fins.
- Material replacement of fuselage (aluminum in place of steel) to reduce weight.
- Overall reduction of warhead mass.
- Lengthening of airframe to allow for longer fuel tanks (and additional fuel).
- Replacement of navigation and guidance systems.

- Redesign of the RV/warhead unit, giving the nose cone a “baby bottle” shape that allows for a higher re-entry velocity and possibly an airburst detonation (necessary for EMP).

Known and supposed modifications have led experts to suggest that the newer missiles have a range of 1,500 to 1,800 km...Some sources suggest that later versions are capable of reaching 2,500 km...Of course, the additional range bears a heavy cost on payload, and most experts place the maximum payload of Shahab 3 variants around 800 kg...Given RV design requirements, an 800 kg payload could be expected to carry a 500 kg warhead. The combination of reduced fuselage weight and increased fuel capacity provide the Shahab 3 variants with about the same launch weight as the original Shahab 3. The increased fuel may increase overall launch weight by as much as 1,000 kg, but the extra ten seconds or so of burn-time give the missile a significantly increased range...

The original Shahab 3 had a separating RV-unit that gave the missile a standard, conical nose cone. The Shahab 3 variants employ a modified RV that gives the missiles a baby bottle-shaped nose cone. More exactly, the RV consists of a small cone attached to a cylinder that connects to the body of the missile (the single stage engine) with metal skirting.

The new design is probably capable of faster re-entry speeds, thus making it more difficult to target with anti-ballistic missile systems. The changed design may also make it possible for the warhead to detonate high above a target...Though an airburst detonation may improve a ballistic missile’s ability to disburse chemical or biological weapons, its most effective use is with a nuclear warhead. A nuclear warhead, when detonated high in the atmosphere, creates an EMP that is potentially more devastating than a conventionally employed nuclear warhead.

Some reports have suggested that the newest variants of the Shahab 3 employ solid fuel...Such a modification would represent a great improvement to the overall Shahab 3 program and an incredible development in Iranian missile technology. Solid fuel allows missiles to be stored and transported while fully fueled and ready to launch; thus the missiles can be quickly and easily launched. Less secure launch locations - on the border of Iran and Iraq, for example - also become more feasible as the decreased launch time lessens the time that a launch crew is vulnerable to enemy fire. Since a solid-fuelled missile requires no pre-launch fueling, the size of a launch crew is also greatly reduced, as fuelling vehicles and fire-safety equipment are no longer necessary.

The Shahab 3 missiles were tested in July 2002, August 2002, and July 2003 may have been Shahab 3 variants. Since that time, Shahab 3 variants have been tested in August 2004, September 2004, October 2004, January 2006, March 2006 (possible), May 2006, and November 2006...It is believed that the earliest Shahab 3 variants reached operational status in 2007. The Iranian space program, which appears to use Shahab 3 missiles or Shahab 3 technology, tested rockets in February 2007 (probably a failure), February 2008, and August 2008. In February 2009, Iran successfully placed a satellite in space aboard the Safir-1. Though the space program represents significant advances in the Iranian program, the rocket used in the 2009 launch is not capable of delivering a warhead at ICBM range (unlike the Russian rocket used to put Sputnik in space).³²

Hildreth describes the Shahab 3 and possible variants as follows:³³

The Shahab-3 is a ballistic missile imported from the DPRK and based on the No-dong 1. Iran may have “purchased a production line for these missiles in the early 1990s and is now manufacturing them rapidly,” according to one expert....The Shahab-3 has been given various names by Iran and others over time. There reportedly have been several different versions of this liquid-fueled missile flight tested with various other modifications made to it, perhaps providing the Shahab-3 with ranges varying from about 800 – 1,000 km.

...Because the range of the Shahab-3 lies at the low end of an MRBM, Iran has sought to develop, test and deploy a much longer-range ballistic missile.... It has sought to do this with both liquid-fueled missile programs based off the Shahab-3, such as the Ghadr-1 or Kadr (or Kadr F), and a separate solid-fuel missile such as the Sejil or Ashura.

Iran first pursued a number of efforts to extend the range of the Shahab-3 with mixed test results. One expert wrote that “there are indications that perhaps as many as one-half of them [Shahab-3 tests] failed.”⁷¹ Some have variously referred to this as an extended range or modified Shahab-3 Ghadar-1. Range estimates for this missile vary widely, from 1,000 km to 2,000 km. Such range differences could in large part be

explained in terms of ranges associated with payloads of different weights.

This missile reportedly carries a smaller payload than the Shahab-3, includes a lighter airframe for greater distances, and has “an improved guidance system and uses a triconic aeroshell geometry that provides greater aerodynamic stability.”...The Ghadar-1 design, “almost certainly includes a separating warhead,” could provide the capacity “to carry airburst warheads, or warheads containing submunition packages.”... It was reported in 2006 that some Western intelligence experts believed Iran had been able to modify the nose cone or reentry vehicle (RV) of the Shahab-3 with Russian and Chinese assistance. An identical RV was twice displayed on No Dong missiles in North Korean parades, so it may have been designed by North Korea.

One source says that “instead of the single cone normally attached to this type of missile, the new Shahab has three cones, or a triconic, warhead. A triconic warhead allows the missile to accommodate a nuclear device and this type of warhead is normally found only in nuclear weapons.”...But others have suggested the triconic RV may be less suitable for a nuclear payload than the previous conical RV associated with the older Shahab 3, and may instead be designed for higher accuracy that may indicate a nonnuclear mission. But none of this has been officially confirmed in Iran. U.S. and other intelligence reports indicate that Iran apparently has not made the decision to develop a nuclear weapon, but developments such as these cause concern among many decision makers and observers.

Tests of the Shahab have often been announced with little real data on its performance or purpose. There are exceptions: Arms Control Today reported in June 2013 that Iranian Defense Minister Ali Shamkhani stated on May 26 that Iran had successfully completed a fourth test of the Shahab-3 medium-range ballistic missile in mid-May, 2013. The IRNA report also quoted Shamkhani as stating that Iran would continue its missile program “in order to promote the power and precision of the Shahab-3 missile,” and that the tests were carried out “to upgrade the missile and are not regarded as a new production or step toward increasing its range.” He added that despite the test’s success, Iran “is not intending to build new missiles under the names of Shahab-4 or Shahab-5, as claimed by the Americans.” However, Shamkhani had previously called for development of a Shahab-4 with space-launch potential and has mentioned plans for a longer-range Shahab-5 missile.³⁴

Arms Control Today reported that. “With a range of 1,300 kilometers when equipped with a 700-kilogram payload, the liquid-fueled, road-mobile Shahab-3 can potentially target all of Israel with weapons of mass destruction....” A US State Department spokesman had said earlier on May 16th that the administration continues to have “serious concerns” about the missile program, and that the United States viewed “Iran’s efforts to further develop its missile capabilities, including flight testing of missiles, as a threat to the region and to U.S. interests” and said that Washington will “continue to actively pursue extensive efforts to stop the proliferation of missile technology and equipment to Iran.”

Reports of tests of the Shahab 3 continued through 2013, although little is known about the exact nature of such tests. Syrian news showed launches of the Shahab 1,2, and 3 on February 23, 2013.³⁵ Other sources reported new tests of the Shahab 3 and Ghadir 1 in May and November 2013, but did not provide clear details.

The uncertainties in the unclassified data on the Shahab’s performance and that of its possible variants illustrate both the difficulties in dealing with a key Iranian system and illustrate both the difficulties in dealing with a key Iranian system and the broader problems in analyzing the Iranian missile effort. There have been too few tests for Iran to have a credible picture of accuracy and reliability based on empirical data and derived aim points. The Shahab has been in

development since well before 1998, when it was first shown in public. It only had four tests before it was declared ready for deployment in November 2004 – none of which have been described reliably in unclassified literature.

Since that time, Iran has only conducted a limited number of tests and firings that have become public. The images of the Shahab also show steady changes configuration that may have led to the development of more accurate Shahab 3B with enhanced penetration capability described later in this report, and other reports of variants that go as high as a “Shahab 6.” Iran claimed in 2006 that these included cluster warheads with over 1,000 (1,400?) submunitions.

Unclassified sources make it clear that Iran has made progress in developing the capability to fire “volleys” of missile in a short period of time – although it has only done so in exercises where it could prepare for such firings long in advance. Similarly, there is unclassified imagery showing an Iranian attack on a mock-up of a US air base where missiles and or rockets hit the base with reasonable accuracy – but some sources indicate that the “hits” may have been faked with preset explosives and the hits would still have not been accurate enough to do serious damage.

Similarly, Iran has suddenly fired “tests” of the Shahabs that were a political response to missile tests by Israel without any clear technical purpose. It has also made many claims about improved missile performance but some are known to be false, including TV images of multiple firings that turned out to be faked.

Perhaps the most reliable perspective is the one the Department of Defense provided in the unclassified version of its 2012 report to Congress on the Iranian threat. It stated that Iran’s missile and rockets had become more accurate, and some had submunitions.³⁶

Iran continues to develop ballistic missiles that can range regional adversaries, Israel, and Eastern Europe, including an extended-range variant of the Shahab-3 and a 2,000-km medium-range ballistic missile, the Ashura.

Beyond steady growth in its missile and rocket inventories, Iran has boosted the lethality and effectiveness of existing systems by improving accuracy and developing new submunition payloads.

During the last two decades, Iran has placed significant emphasis on developing and fielding ballistic missiles to counter perceived threats from Israel and Coalition forces in the Middle East and to project power in the region.

With sufficient foreign assistance, Iran may be technically capable of flight-testing an intercontinental ballistic missile by 2015.

US experts later made it clear, however, that these improvements did not give Iran anything like a precision strike capability or capability to carry out anything like the attacks Iranian officials and officers threaten.

Iranian officers have made claims a far more advanced a precision strike capability – although these have not been clearly tied to the Shahab 3 or any specific type of Iranian missile. After the series of tests in July 2012, Iranian state media reported that,³⁷

“Within 10 minutes, a considerable number of missiles were fired at a single target. The achievement, called high firing density, makes it impossible for anti-missile systems to intercept and destroy them. In the end, the target is definitely hit”

An AP report following the July 2012 tests quoted Ismaeil Kowsari, a former Revolutionary Guard commander and member of the Majlis, as saying that,³⁸

“Our missiles are more accurate and lethal than ever... These achievements send clear signals to the West that Iran is a formidable force, making enemies think twice before making any decision to attack us.

At the same time, some Iranian claims reached the point of absurdity – such as those of General Amir Ali Hajizadeh, the head of IRGC’s Aerospace Division. Hajizadeh claimed in July 2012 Israel would “disappear from the Earth” if it attacked Iran, and “warned that 35 American military bases in the Middle East are within Iran’s missile range and would be destroyed within seconds after any U.S. attack on Iran.”³⁹

The quantitative unclassified estimates, of the Shahab’s accuracy as even more suspect and again illustrate the general problems in assessing Iran’s progress and capabilities. The FAS reports the Shahab’s CEP as 190 meters - noting that Iran appears to have improved the accuracy over the past few years). Shiffrinson and Priebe place the CEP between 1850 and 2500 m and *Global Security* cites a Jane’s Report that the CEP was 3 km for a series of tests in 2000. These latter estimates seem more likely to be accurate, and it should be noted that CEP only delineates the accuracy of 50% of the missiles, and does not take targeting and reliability factors into account.

There is no agreement on estimates of the number of Shahab-3 missiles. FAS believes that Iran has 20 Shahab-3 launchers, while *Global Security* estimates that Iran 300 Shahab-3 and Ghadir-1 missiles. *Missile Threat* says that Iran may have begun production of 12-15 missiles each year as early as 1998 (an assertion Dr. Elleman disagrees with⁴⁰), potentially giving Iran 25-100 Shahab-3 in operation today, while Shiffrinson and Priebe only estimate the number as being greater than 30. IISS estimates the numbers of TELs at 6, while other sources provide no information. Iran does have silos that are capable of launching Shahab-3, although the number of operational sites is unknown.

Ghadir-1

The Ghadir-1 - also called the Shahab-3b, the Shahab-3M, and the Shahab-4 - seems to be an indigenously improved version of the Shahab-3. Technical data are harder to establish for these weapons due to Iran’s tendency to ascribe new names to the same weapons system, wide range in estimates on technical specifications for new launches, and to deliberately obfuscate technical details of some of its most important weapons programs. Although the variants of the Shahab-3 will be termed Ghadir-1 throughout this chapter, this weapon (or, more accurately, system of weapons) is closely related to the Shahab-3 and at this time should be treated as a similar missile.

The Ghadir-1 is primarily distinguished from its predecessor by a longer body and a reshaped warhead. The elongated body uses the additional thrust from the SS-N-4’s engines to carry more fuel, increasing the systems’ range. The results of design changes in the nosecone are less certain.

While technical analysis estimates that the triconic shape will improve the stability of the reentry vehicle with a higher payload, reducing the CEP,⁴¹ it is unclear whether the improved design will allow Iran to upgrade the type of warhead (i.e. facilitate the usage of cluster munitions or a CBRN device). *Missile Threat* also suggests that Shahab-3 variants incorporate changes in fin design, lighter materials in construction of the body, and an overhaul of the navigation system, overall increasing the range and slightly boosting the accuracy.

According to Dr. Postol, armed with a 1000 kg warhead, the Ghadir-1 has a range of 1100 km. The 2010 DOD report proposes a maximum range of 1200+ mi (1930+ km), while *Missile Threat* estimates between 1500 and 2500 km and Dr. Elleman suggests 1600 km with a 750 kg

warhead. CEP is estimated to be slightly improved from the Shahab-3 original, with *Missile Threat* estimating 1000 m. No other unclassified estimates are available at this time.

There are no meaningful estimates of Ghadr-1 stockpiles; *Global Security's* estimate of 300 and *Missile Threat's* estimate of 25-100 Shahab-3 and Ghadr-1 seem to be little more than guesstimates. *Missile Threat* does, however, provide an interesting summary of the Ghadr 1's possible history and the uncertainties surrounding it:

The Ghadr-1 appears to be an improved variant of the Shahab-3A, also referred to as the Ghadr-101 and the Ghadr-110. There are mixed reports regarding the new missile. In 2004, it was believed to have a liquid-fuel first stage and a solid-fuel second stage...According to *Jane's Strategic Weapon Systems*, this would allow it to have a range of 1950 km. The length is thought to be 15.86 m, with a launch weight of about 19,000 kg. If reports regarding the Ghadr-1 accuracy are correct, then it would be a significant improvement of the Shahab 3 (2,500 CEP). A December 2008 report noted an CEP of 300 for the Ghadr-1. Reports also indicate the possibility that Ghadr could be designed to carry a nuclear payload. This possibility is raised with uncertainty as the Ghadr appears to be comparable to the Shahab system, whose apparent goal is to obtain such a payload.

The Ghadr-1 is also believed to have a higher maneuverability than the Shahab-3. While some sources believe that it is the same missile as the Shahab 4, the higher maneuverability as well as the 30-minute set-up time, provide sufficient evidence to consider this a separate missile. Additionally, sources from 2007 report that the Ghadr 1 may have a significantly shorter stated range than originally projected in 2004. It remains classified as an MRBM and is now considered distinct from its shorter range, Shahab-3, and longer-range, Shahab-4, counterparts. Sources also indicate that the Ghadr-1 is being manufactured entirely in Iran at the top-secret Hemmat Missile Industries Complex....An article from December 2007, though, cites interaction between the German Intelligence agencies and Iranian nationals within German borders. The report states that on more than one occasion Iranian nationals have been held in conjunction with the smuggling of "dual use goods." These items are usually converted for their secondary use, military needs, in Iran after their transit from Germany. Reports indicate that these dual use goods were used in the development of the Ghadr-1 missile system...

In December of 2004 the National Council of Resistance of Iran claimed ongoing research and ground testing of the Ghadr-1....In March 2006, the Paris-based Iranian opposition group, the National Council of Resistance of Iran (NCRI), claimed that Iran had ramped up its development of the Ghadr-1, allegedly 70 percent complete at the time. The NCRI added that the new missile was expected to be entirely complete in one year's time....Reports from October 2007 indicate that Teheran unveiled the Ghadr whose shape was very similar to that of the Shahab-3 MRBM...⁴²

Missile Threat is also careful to qualify reports of a Shahab 4:

The Shahab 4 has been mentioned in many media and intelligence reports over the last ten years. Unfortunately, those reports have frequently been contradictory and their sum does not provide a clear picture of the Shahab 4 missile project. The program, in fact, may not actually exist. Assuming that the missile is in development, it would probably borrow from the technologies of the Shahab 3 while improving performance characteristics to allow for greater range, a heavier payload, and increased accuracy.

Though Iranian missile development has progressed dramatically in the last 15 years, many experts believe that the Shahab 4 borrows from foreign missile design. In keeping with the North Korea-Pakistan-Iran missile relationship, some speculate that the Shahab 4 is based off of the North Korean No Dong 2 or Taepo Dong 1 missiles or the Pakistani Hatf 5A. Other sources suggest that the Shahab 4 is based on defunct Russian technology from the SS-4 or SS-N-6....

The No Dong 2 and the Hatf 5A are obvious comparisons with the Shahab 4. The Shahab 3 was based upon the same technology as the No Dong 1 and the Hatf 5, so it makes some sense that the improved versions of those missiles would form the basis of the newer Shahab missile. Of course, Iran has already greatly improved upon the Shahab 3, as discussed in the Shahab 3 variants entry. If the Shahab 4 is based upon the No Dong 2 and Hatf 5A, then it is probably one of the many Shahab 3 variants and not a separate project.

Given the tendency of Iranian officials to name and rename projects, this conclusion is likely accurate.

The SS-4 was 22.8 m long with a diameter of 1.65 m and a launch weight of 42,000 kg. Its 1,600 kg payload contained a single separating warhead. It used a single-stage liquid propellant engine and an inertial guidance system. The SS-4 had a range of 2,000 km (1,243 miles) and an abysmal accuracy of 2,400 m CEP. Depending on the similarity between the Shahab 4 and the SS-4, these figures may not be relevant. It is believed that the Shahab 4 will have an accuracy of between 2,500 and 3,500 m CEP and a range of between 2,000 and 3,000 km (1,243 to 1,864 miles)...

The Soviet SS-N-6 bears similar specifications to the SS-4 and the projected specifications for Shahab 4, but with increased accuracy (1,000m CEP), greater range (2,500-4,000 km), and a lighter payload (1,200kg). Originally submarine launched, the SS-N-6 is believed to have been modified by North Korean, and finally adjusted and assembled by Iran for use as a land-based missile. At the fall of the Soviet Union, many of these SLBMs remained in operational condition. Reports indicate that one or more of these weapons made their way to North Korea before North Korea delivered some of these missiles to Iran...

In 2003 Iran announced that it would close the Shahab 4 program in favor of an SLV program (Satellite Launch Vehicle)...Since that time, Iran has had some success with a domestic space program that has successfully put a small satellite into orbit. Regardless of the space program, however, talk of a Shahab 4 has not completely quieted and many believe that a missile with this designator is still in development. The Shahab 3 and its variants can hardly meet many conceivable range and payload objectives, so it seems reasonable to expect that a new missile is in development.

If the Shahab 4's reported range of 2,000 km range is correct, the missile will have the capability to target all of Israel, as well as Turkey, much of India, and US forces stationed in Iraq, Afghanistan, or the Persian Gulf. The missile could substantially increase the political and military leverage held by the Iranian government, especially if Iran develops a nuclear warhead.

An additional threat is the possibility that Iran will give or sell its missile technology to rogue nations or terrorist organizations antagonistic toward the U.S. At present, Iran's missiles are stored and operated in underground sites under the complete control of the Islamic Revolutionary Guard Corps, which enjoys little outside supervision within Iran. General Mahmud Chahar Baghi of the IRGC stated in 2008 that any act of Israeli aggression would be retorted by the launching of 11,000 missiles within the first minute...

The Iranian missile program has been shrouded in secrecy, deception, and the unknown. Iran obtains weapons of various design and origin, and frequently retains a single name and reclassifies its physical missile assets, which adds to the confusion. According to Defense Minister Najjar, when asked about the testing of the Shahab 4, "Names and titles are not important in this regard. The important point, though, is that we are proceeding according to our defense doctrine"...At present the future of the Iranian missile program is uncertain, but the existence of these missiles proves that ballistic missiles are no longer the purview of first world nations. If the US and its allies are to remain safe, they must deploy missile defense systems capable of undermining the effectiveness of these now ubiquitous offensive system⁴³

So is Hildreth,⁴⁴

Various reports of a Shahab-4 surfaced in the 1990s and those missile designations are still used or mentioned on occasion. It appears, however, that whatever was intended originally, any "Shahab-4" missile effort likely led to the development of the extended-range Shahab-3 MRBMs or the Ghadr-1.

In the late 1990s and early 2000s, other reports said Iran was developing a solid- or liquid-fueled, two- or three-stage MRBM or space launch vehicle. It is possible they once had a designation of Shahab-5 and Shahab-6, which continues to cause some confusion today. But, more likely these programs led to other ballistic missile and space launch programs in Iran today. One may have become or led to the Ashura/Sejil and the other may have become or led to the Safir space launch vehicle...When asked in a lengthy and seemingly rather open interview in 2006 about Iranian military exercises ('Great Prophet' IV) and Iranian ballistic missiles, then IRGC Commander Gen. Safavi said, "I'd prefer not to answer," whether there were Shahab-4 and Shahab-5 missiles.

It is likely that the functional operational accuracy of all the Shahab-3 variants - as distinguished from their technical CEP - is over a thousand meters, meaning that its conventional significance

is limited. While Iranian sources regularly talk about the precision of the system, Iranian officials generally call all missile “precise” or “accurate,” and there are no hard data to suggest that the guidance packages have been substantially improved.

*Sejjil-2/Ashura*⁴⁵

The Sejjil-2 (also called the Ashura, Ashoura, Sajil, Sejjil) ballistic missile was first tested on May 20, 2009, and represented Iran’s first solid-propellant two-stage ballistic missile. Built with two identical stages - the sole distinction being that the second has less fuel - the missile is very different from the Safir, the recently tested liquid fueled two-stage satellite launcher. With an estimated range of 2000 to 2200 km, this MRBM allows Iran to target Israel.

This new class was reportedly developed by Shahid Bagheri Industrial Group (SBIG) under the Sanam Industrial Group (Department 140), which is a subsidiary of the Defense Industries Organization (DIO) of Iran, with expertise developed in work on both solid- and liquid-fueled missiles.⁴⁶ Unconfirmed sources suggest that the warhead closed more quickly than that of the Shahab and had a special coating to reduce detection by the radar of missile defense systems. Iran reported other launches in 2010 and 2011, but with little detail.⁴⁷

Little is known about the technical details of this weapon. Some sources - including *Jane’s Defense Weekly* - suggest the system has at least rudimentary inertial guidance, with advanced guidance systems (IISS suggests steering vanes and controlled thrust termination) that give it greater accuracy than the Shahab systems, but its CEP is unknown. Its range is subject to wide estimates (although all observers place it above 1800 km, and most above 2000 km). As a solid-fuel missile, Iran has the option to allow several to remain ready to fly at all times. Given the absence of unclassified estimates for the number of missiles, the number of TELs, the existence of missile silos (although some are known to exist), or improvements in the warhead that would make the weapon tactically relevant, it is difficult to assess what impact this missile will have on future competition in the Gulf.

Hildreth describes the system as follows:⁴⁸

The Sejjil is a solid-fueled ground-mobile ballistic missile that Iran says has a range about 2,000 km according to official U.S. sources. Both Postol and Elleman state a 2,200 km range. Some in Israel and elsewhere believe the missile might have a range up to 2,500 km.

The Ashura was announced by Iran in November 2007. This announcement was accompanied either by an unsuccessful test of the solid propellant motors or the Ashura missile itself depending on whether an Israeli or Russian account, respectively, was accurate.

Subsequently renamed the Sejjil, it was flight tested successfully in November 2008, reportedly at about 800 km. Additional tests of the Sejjil or a modified and apparently more capable version of it (Sejjil 2) took place in May, September and December 2009. From the progress shown in the Sejjil solid-fuel rocket program, Elleman concludes that “Iran is at a minimum in the process of mastering the technology.”...Many consider the Sejjil 2 a nuclear capable ballistic missile as its payload capacity could accommodate a first generation nuclear warhead. Some have suggested that the MRBM silos near Tabriz and Khorramabad might be intended for the Sejjil 2. Many believe the missile is the same regardless of the naming designation (i.e., Sejjil, Sejjil 2, or Ashura).

Some US and Israel experts believe at least some Sejjil-2s are in the field. The IISS does not, however, treat the system as fully operational. It reported in May 2012 that,

“Iran is also developing a new medium-range, solid-propellant missile, the *Sajjil-2*, potentially capable of delivering a 750kg warhead to a range of about 2,200km. Iran is the only country to have developed a missile of this reach without first having developed nuclear weapons. The solid-fuelled system offers many

strategic advantages, including being less vulnerable to pre-emption thanks to its shorter launch-preparation time. The *Sajjil-2*, which was successfully flight-tested for the first time in November 2008, is still two to three years of flight testing away from becoming an operational system that can be deployed to military units. Iran has yet to demonstrate that the missile's individual stages perform consistently and reliably under a variety of operational conditions. If deemed necessary, this new missile could conceivably be used for combat in late 2010 or early 2011. However, the history of solid-propellant missile programs elsewhere suggests an initial deployment of the *Sajjil-2* in 2012 or later is more likely."⁴⁹

Missile Threat describes the *Sejjil-2* as follows:

Development of the Sejjil missile likely began in the late 1990s, but the program can hardly be understood apart from other Iranian missile programs whose development began much earlier. Most importantly, Iran began development on the Zelzal missiles in 1994 or 1995. The production of the Zelzal missiles required Iran to develop the domestic ability to produce composite solid propellant in fairly large quantities. The technology and equipment used in Zelzal fuel production has almost definitely been used for the Sejjil missile project. It is believed that China aided Iran in the improvement of their solid-propellant production ability for the Zelzal missiles; it seems likely that China has also aided Iran in the production of fuel for the Sejjil missile.

At the same time that Iran was developing composite solid-propellant fuel, they were working with the North Korean No Dong 1 missile design to produce the Shahab 3. The Shahab 3 design was used by Iranian engineers to produce a number of domestic missile technologies - a major advance from earlier Shahab designs, which relied almost entirely on Russian and North Korean technology. The Shahab 3 variants have provided a number of advantages over the original North Korean design and proved that Iranian engineers can domestically design and produce improved warheads and SLVs. The Sejjil missile, internally quite different from the Shahab 3 missile (solid propellants require very different motors and internal design), probably borrows from a number of Shahab 3 technologies. At the very least, it is believed that the RV/nose cone design that first appeared in Shahab 3 variants has been used on the Sejjil missile.

Though the missile has a similar size, weight, payload, and range to the Shahab 3 variants, the fact that it is fuelled by solid propellants is a huge improvement over the Shahab design. Solid propellants allow for a near-immediate launch time, leaving the missile much less vulnerable during launch. Because solid-propellant missiles do not have to be fuelled immediately prior to launch, they are also much more easily transported. On the other hand, solid propellant missiles have particular performance characteristics that make them more difficult to guide and control. How Iranian engineers have overcome these hurdles is unknown, but it seems likely that they have modified Shahab guidance systems and/or received considerable foreign assistance.

The Sejjil missile has a length of 17.6 m, a diameter of 1.25 m, and an overall launch weight of 23,600 kg. It carries a payload of 500 to 1,000 kg. Presumably the missile will carry HE warheads until Iran gains nuclear warheads. The missile's maximum range is about 2,000 km, though these figures are based upon a missile fuselage with the weight and performance characteristics of aeronautical-grade steel. Supposing that Iran had the technology to produce missiles built of maraging steel, titanium, or composite material, the missile would potentially be lighter and have an extended range upwards of 2,400 km.

The first test launch occurred in 2008 and the missile reportedly flew 800km. A second launch was conducted in May 2009 to test improved guidance and navigation systems. Four other flight tests have occurred since 2009, with the sixth test flying approximately 1,900 km into the Indian ocean...

The Sejjil missile appears to be a unique Iranian design. Though some speculation has tied the missile to the Chinese DF-11 and DF-15, the size and specifications of the missile suggest that the Iranian missile is unique. Unlike earlier Iranian systems, the missile also does not appear to be a copy of a previously released North Korean missile. Of course, it is highly likely that the missile project has made significant gains through foreign assistance. Because the design is new, Iran will probably have to subject it to a great deal of testing before putting the missile into regular operation. Assuming that the Sejjil project moves at about the same speed as foreign missile development projects, Iran will probably not declare the missile operational until at least 2012...

The Sejil missile system may be operational, but regardless, Iran continues to make improvements. There may be multiple versions of the Sejil system. In 2009, Iran referred to the test launch as the Sejil 2. An unconfirmed report stated that a Sejil 3 may be in development. The Sejil 3 would reportedly have three stages, a maximum range of 4,000 km, and a launch weight of 38,000 kg...⁵⁰

There is also a controversy over the extent to which Iran may have carried out Shahab 3 and Sejil tests capable of carrying a nuclear warhead. Once again, Hildreth provides an excellent summary of the issues involved,⁵¹

In comments to the British parliament in June 2011, British Foreign Minister William Hague said Iran had conducted three secret tests of ballistic missiles capable of carrying nuclear weapons in contravention of UN Security Council Resolution 1929...An Iranian spokesman denied the British allegations, saying that none of the missiles tested by Iran has a nuclear capability....Britain apparently reported these tests to the UN, but had not previously made them public.

Although it received little media attention at the time, a report by a Panel of Experts at the UN became public the month before Hague's speech in London. According to AP the UN report said Iran launched a liquid-fueled Shahab-3 missile with a range of about 800 kilometers, and one or two solid-fueled Sejil 1 missiles with a range of about 2,000 kilometers. AP further said the UK believed these missile tests showed that Iran's leaders wanted to avoid scrutiny over "the real extent of their weapons programs."

This unpublished May 2011 report...was not circulated because it had not been approved by the UN Security Council, apparently for political reasons—China and Russia opposed its release according to UN sources. Nonetheless, the news it shed on previously undisclosed Iranian MRBM tests was highly significant. Specifically, the report mentioned the launch of the Sejil/Ashura in October 2010 and a Sejil and Shahab-3 test in February 2011.

...By early July 2011, Iran conceded the two February tests. Reuters reported that Iran state television admitted test-firing two long-range missiles from the "Semnan province into the mouth of the Indian Ocean" about 1,900 kilometers away sometime between January 21 and February 19, 2011. BG Hajjzadeh, head of the IRGC's Aerospace Division, said U.S. spy planes were operating in the area where the missiles hit, but it was "interesting that they [the United States] did not report it."

...Jane's said these medium-range missile tests were likely the Sejil-2 or the Shahab-3. The fact that there was neither public announcement by Iran at the time of these launches, nor any public condemnation from the United States or from any other nation represented a notable departure from the past. Three key questions are thus raised. First, what might account for this change in Iranian policy that normally publicizes or televises missile tests? There are several conceivable explanations:

- One or more of the tests might have failed and Iran did not want that known. This could explain what happened with the first launch, but evidence is that the February flights were successful, or
- Iran may have tested to a new, untried range for which it did not want international attention. Only after media reports and the leaked UN draft report did Iran concede the longer range tests into the Indian Ocean; or
- Iran may have decided for whatever reason that it no longer wanted to publicly demonstrate its MRBM capabilities, perhaps over concern regarding UNSCR 1929. But in "Great Prophet" 7 Iran said it had flown a 2,000 kilometer missile, which should be noted was not independently verified. And Iran had declared two other Sejil launches and a Shahab-3 test in 2009, after UNSCR 1929 passed earlier that year. Also, just because Iran did not publicly announce or show these tests does not mean they cannot be verified by others. A second key question is why neither the United States nor any other nation at the time chose to criticize Iran for those tests, which to many seemingly violates UNSCR 1929. Possible reasons might include:
- The United States might have wanted to forge a consensus behind closed doors for additional sanctions and worried that public attention to the tests might make it harder to bring in Russian or Chinese support, or both. U.S. Permanent Representative to the UN Susan Rice complained about Iran's noncompliance with UNSCR 1929 in June 2011 and referred to the draft Panel of Experts as containing "troubling findings, including significant evidence about several reported violations"

of UN sanctions related to Iran, but implied some Member States were holding up public release...Some have noted that the Final Report released in June 2012 did not mention the three tests from the unpublished earlier Final Report in May 2011. This was for no other reason than the missile launches occurred in a different mandated reporting period.

- Due to the sensitive, ongoing talks with Russia over the U.S. European Phased Adaptive Approach (EPAA), there may have been some reticence within parts of the U.S. Government to “shove this ” into the Russian face. Keeping an announcement of these Iranian tests out of the public debate may have been seen as having a greater policy priority in order to facilitate an agreement with Moscow.

As is the case in so many other aspects of the data on Iran’s forces, unclassified data are limited and contradictory both regarding the missile and its operational status. Some experts do believe, however, that if the Sejil-2 has not yet been deployed in missile brigades like the Shahab-1 and Shahab-2, there are operational missiles that could be married with warheads and used in case of a conflict.

Iran’s development of the Sejil-2 also reflects a broader trend among ballistic weapons states to gradually emphasize solid-fueled missiles over their liquid-fueled counterparts. Although liquid missiles are generally easier to develop and manufacture at smaller scales, their high maintenance cost and vulnerability to first-strike attacks limits their usefulness. While liquid-fueled systems are still useful for space flight, and despite the tendency for solid fuels to exhibit higher variance between missiles, all major nuclear powers rely on solid-fueled rockets to deliver their weapons.

Solid fuel system development goes require improved technology in both casting the fuel and building the engine, and refinements in each are necessary to develop efficient and long-range weapons. Even so, it seems probable that the Sejil-2 is mostly or wholly produced indigenously. Iran has spent considerable time and capital developing its solid fuel program, starting with domestic production of unguided artillery rockets and gradually building up. Unlike its liquid fuel rockets and fuel production, Iran potentially has developed a sufficient store of local knowledge and construction expertise to develop and manufacture this weapon. While many of its systems are still undeveloped by Western standards (particularly regarding guidance and thrust production), if Iran were able to build the entire missile domestically, upgrading may be easier than for its liquid-fueled missiles.⁵²

BM-25

Some estimates may include systems Iran has never actually deployed. In 2010, there were allegations that Iran has received the BM-25/SS-N-26/R-27 missile from North Korea. The SS-N-26 was a liquid-fueled Soviet SLBM with an advanced engine and guidance system. These reports were partly substantiated by the appearance of R-27 steering rockets on the side of the Safir SLV.⁵³

Despite this, there is little evidence that Iran actually possesses a working copy of the BM-25. These weapons transfers are alleged to have taken place in 2005; since then, Iran has not demonstrated a working model of any ballistic missile similar to the BM-25. When launching its Safir, it used an underpowered engine that forced it to launch a small satellite to a very low orbit; using a BM-25 engine would have increased the payload capacity and orbital height. While it seems likely Iran does have access to some BM-25 technology, their regular tests and development of other missiles, particularly using underpowered engines, suggests that Iran does not have a working version of this weapon.⁵⁴

Hildreth seems to provide the most authoritative picture of the controversies over this system:⁵⁵

at some point The issue of whether Iran received at some point some number of Soviet-era R-27 SLBMs (submarine launched ballistic missiles) or components remains unsettled, controversial and persistent. Early on, the German press named this missile the BM-25 when they referred to the Iranian version, and others have referred to this as the Musadan when used in the context of North Korean involvement. The pedigree of this system is far from trivial and its reported design or redesign remains obscure. No official public U.S. assessment or word of this was found.

This issue, therefore, has been largely been a debate among technical experts and observers who track Iranian missile programs. Whether Iran acquired these missiles or their rocket motors in whole or part, or received other technical assistance regarding these missiles or their component parts is important. If accurate, acquiring this capability or technical knowledge might enable Iran to build more powerful and longer range ballistic missiles.

Some experts lend credence to assessments that Iran may have some number of these missiles or their components. Uzi Rubin stated that “Iran has acquired eighteen BM25 land-mobile missiles with launchers from North Korea, which can strike targets in Europe. In the past, the BM-25 has been produced in two models: one with a range of 2,500 km and the second with a range of 3,500 km.”...Similarly, according to an unpublished May 2011 UN Panel of Experts Report, two Member States shared the assessment that “Iran received a shipment of 19 BM-25 missiles from the DPRK in semi-knock down and complete knock down kits....Schmucker and Schiller acknowledge that the BM-25 is “seen as an operational part of the North Korean and Iranian missile arsenals, though it was never actually launched,” but that its display in a 2007 DPRK military parade turned out to be a different, very short-range missile.

The Washington Post reported in 2010, citing U.S. cables, that Iran had obtained 19 of the BM-25 or Musadan missiles from North Korea. The document reportedly summarized a meeting of U.S. and Russian technical experts and officials, where the Russians claim the BM-25 might not even exist and U.S. officials acknowledge never seeing the missile in Iran. It turns out that the U.S. delegation reportedly relied heavily on a 2005 article from a conservative leaning German tabloid called Bild Zeitung quoting German intelligence sources that Iran had purchased 18 (not 19) BM-25 kits made up of missile components for the BM-25 from North Korea. One technical expert was quoted in the Post article as saying “the U.S. side does not firmly say we have evidence that the BM-25 is in Iran.”

This missile has not been seen publicly in Iran and has not been tested. Some were reportedly shown in North Korea, but subsequently discounted as mock-ups. Some analysts have reported the BM-25 might be capable of reaching 3,500 km. It is reputedly based on a Soviet-era submarine launched ballistic missile known as the R-27 in Russia and the SS-N-6 in the West. Experts such as Michael Elleman believe that although it is “highly improbable that complete or disassembled R-27 missiles were exported by Russia, it is possible that individual components of the missile may have been smuggled out of the country...”

Other missile experts such as Ted Postol of MIT argue that the evidence suggests that an unknown quantity of Soviet-era naval ballistic missile parts were shipped to North Korea without the approval or knowledge of the central government during the collapse of the 1990s. Russia never acknowledged this transfer, Postol and Elleman said, because it would tarnish Russia’s reputation as a country that claims to have never sold technology that could be used in an intercontinental ballistic missile...

Stacked Threats and Basing on Mobile Launchers and in Silos

As is the case with its shorter range systems, Iran reduces the vulnerability of its missile systems, and potentially increases their effectiveness, by using arrays of “stacked threats” by deploying several different types of missiles in a given attack area. This complicates missile defense since Iran try to saturate a given capability with lower-range missiles and then fire longer-range systems, makes it harder to use strike fighters to suppress the missile threat to a given area, and raises the possibility that Iran could lead a given defender to exhaust its holdings of missile interceptors by firing its lower quality systems first.

Iran has both mobile launchers and missile silos. Iran announced its silos publically by showing video on Press TV in late June 2011. It did so as part of an exercise called “Great Prophet 6” and claimed they would allow it to launch missiles more quickly and reliably. These silos seem to have been in near Tabriz and Khorramabad in northwest Iran, but this is uncertain and other silos may well exist.

The same video showed mobile launchers for the Shahab-3, and press reports indicated that the silos had C⁴I links linked to a missile control center - presumably commanded by the IRGC Aerospace Force. *The New York Times* quoted the commander of the Guards’ Aerospace Force, Amir Ali Hajizadeh, as stating that the silos were a crucial asset in Iran’s standoff with the West, and as saying that as a result, “we are certain that we can confront unequal enemies and defend the Islamic Republic of Iran.”

The New York Times reported that another Guards officer had said on state television that, “only few countries in the world possess the technology to construct underground missile silos. The technology required for that is no less complicated than building the missile itself.” It reported that Iran claimed its designs were original and not copied from North Korea.⁵⁶

Iran’s Fars news service stated separately that,⁵⁷

The silos are a part of the swift reaction unit of the [IRGC] missile brigade; missiles are stored vertically, ready to be launched against pre-determined targets,” Fars News Agency quoted the IRGC spokesman in charge of the drills, General Asghar Qelich-Khani, as saying on Monday.

Qelich-Khani said the country has been using domestically-built missile silos for fifteen years and added that the newer generation silos are operational from a launch control center located far from the launch pads.

The main advantage of missile silos is the reduced launch time as the weapons need not be moved or aligned prior to launch.

On Sunday, Commander of the Aerospace Division of the IRGC Brigadier General Amir Ali Hajizadeh short-, medium- and long-range missiles, namely Khalij Fars (Persian Gulf), Sejjil (Baked Clay), Fateh (Conqueror), Qiam (Rising), Shahab-1 and Shahab-2 missiles would be fired during the war games.

Hajizadeh stressed that Great Prophet 6 maneuver has completely defensive objectives and will be staged with the message of “peace and friendship.”

IRGC’s naval, air and ground forces staged the Great Prophet 5 military drill in the Persian Gulf in April 2010.

Hildreth describes these silo developments in ways that again highlight the difficulties in separating Iranian claims and hints from any clear picture of reality.⁵⁸

During the June 2011 “Great Prophet” military exercises, Iranian military leaders publicly revealed for the first time the existence of a secret network of what they characterized as ‘underground missile silos’. These structures are distinctly different than those that have been built by the United States, Russia and China. The Shahab-3 is housed in a chamber that has a vertical tunnel that the missile flies through. Both the chamber and the tunnel are large relative to the missile diameter. This creates a very large volume that the rocket exhaust gases can expand into, greatly reducing the challenges associated with flying out of the types of ballistic missile silos built by the United States, Russia and China.

Iran’s IRGC Aerospace Forces Commander BG Amir Ali Hajizadeh told state media that the Guard had the capability to “attack all American facilities in the region by these [Shahab 3] missiles.”...In a televised segment another military official said that Iran had been building this network for the past 15 years. ..In June 2012, the UN said these missile silos, “which have been reported for a number of years, have not been confirmed to be operational....”

...It was not until 2008, however, that more specific claims about silo construction, hardened sites, locations, and imagery, began to surface in public....Two different blogs, gemint.com and arms controlwonk.com, wrote about the same time in early 2008 of a possible silo missile base near Tabriz

If the Iranian military official was quoted correctly, it would mean that work would have started on these silos around 1996. In fact, perhaps the first public account of Iranian interest in such came in 1993 when then Iranian Defense Minister Foruzandeh led an economic delegation to the DPRK and may have discussed the possibility of joint production of the Nodong missile and construction of underground missile shelters at 18 sites across Iran.

Construction may have been underway by 1998 when Israeli Prime Minister Netanyahu said Iran is “building an enormous infrastructure [including] hardened missiles silos,” which can house Iranian ballistic missiles and protect them against U.S. or Israeli preemptive strikes.

...The next time there was any apparent mention of Iranian missile silos came in 2006. Former head of Israel’s missile defense agency and missile engineer Uzi Rubin wrote that “there are indications they [Iranians] are now constructing fixed silo-like hardened sites to make their missiles even more survivable.”...Rubin mentioned this in the context of Iran’s MRBMs.

...Based on these previous assessments and using imagery obtained through the Library of Congress, this report locates what appear to be those missile silos in northwest Iran near Tabriz. ...Imagery obtained through the Library of Congress dated around 2000 and examining additional imagery dated about once every year or two at this location shows what appears to be gradual construction of the second silo site referenced by O’Connor. This second silo pair may have been completed by 2011 from looking at that imagery ...

Since then, only a few other experts have mentioned these silos until the Iranian videos and interviews in June 2011. To date, there does not appear to have been any official U.S. public assessment or acknowledgment of these silos. It is unclear what the absence of any such assessment might mean.

To the extent such silos are operational, they offer the potential advantage of allowing Iran to emplace substantially larger missiles as it develops them. While its current MRBMs are fully road-mobile - both the Sejil and the Shahab-3 and its variants can be launched from movable transporter-erector-launchers - later missiles may be in the range of 40-80 tons (from around 20 for the Sejil) and hence will not be able to use current TELs. Mobile launchers are generally considered to be more secure than missiles in silos, so constructing them now only makes sense if Iran seeks to streamline construction techniques for later use.

While silos might be a vulnerability in a conflict with the US in the near future, more advanced designs could serve as the home of any future Iranian ICBM force if Iran had sufficient numbers to make a first strike uncertain. They also present added risks from any missile system if Iran chooses to act on the basis of launch on warning or launch under attack.

Some recent reports indicate that Iran has approximately 4-6 active missiles for every TEL (this ratio does not hold for Sejjils), with Iran expected to build more launchers as it produces additional missiles to avoid bottlenecks in its firing rate. In a conflict in which Iran seeks to use its SRBMs, MRBMs, and IRBMs, it will likely rely exclusively on mobile TELs to avoid US and GCC airstrikes and maintain its missile deterrent.

Iranian Statements About its Medium and Longer-Range Missile Programs

Iran makes ambitious statements about such missile programs, although some are clearly propaganda. While Iran continues to deny it is seeking nuclear weapons it stresses its long-range missile threat and has made missile test firings a major part of its televised military exercises:

- There are many uncertainties in Patriot Missile battle field operational capabilities...There are many tactics for overcoming them, and they certainly cannot be a safe defensive shield for anyone, but may a psychological comfort for some (probably referring to Turkey), who rely upon these systems in a non-operational circumstance...(Israel's) Iron Dome also demonstrated the gap between theoretical and operational realities." - Hossein Salami, IRGC Deputy Commander, on Iran's ability to defeat Patriot missile defenses, February 15, 2013. <http://www.irandailybrief.com/2013/02/15/iran-knows-how-to-penetrate-patriot-missile/>
- "Iran has now reached to a point of progress that can target 2,000 enemy bases within a range of 2,000km...We don't need missiles with over 2000km but we have the technology to build them...Israel is our longest-range target." - General Morteza Qorbani, senior advisor to the General Staff of the Iranian Armed Forces, January 7, 2013. <http://english.farsnews.com/newstext.php?nn=9107133861>
- "We did not send any weapons into Gaza, but declare with pride and dignity that we did provide the technology to produce Fajr-5 missiles, and now they have built a large number of missiles that are in their possession. We never hesitate to transfer knowledge and technology to all oppressed Muslims." - Major General Mohammad Ali Jafari, Commander of the Islamic Revolution Guards Corps, November, 21, 2012. <http://www.irandailybrief.com/2012/11/28/revolutionary-guards-commander-iran-did-not-send-weapons-into-gaza-but-provided-the-technology-for-the-production-of-fajr-5-rockets-to-the-palestinian-authority/>
- "We can simultaneously fire numerous and countless missiles from different spots at one or several targets, which indicates our capability to perform convergent and parallel operations." - Brigadier General Hossein Salami, Lieutenant Commander of the Islamic Revolution Guards Corps, September 7, 2012. <http://english.farsnews.com/newstext.php?nn=9106242598>
- "The (Russian-made S-200) system has been optimized for improved detection and electronic warfare... Two new types of missiles will be mounted on the system." Brigadier General Farzad Esmayeeli, Commander of Khatam ol-Anbia Air Defense Base, September 7, 2012. <http://www.irandailybrief.com/2012/09/06/iran-has-optimized-the-capabilities-of-the-russian-made-s-200-air-defense-systems/>
- "We are through with developing the threat-detection capability of the system and its sensitive parts have been manufactured in Iran...We have no problem for supplying the missiles needed for this system...With this powerful system in our hand, we would not think of S-300 anymore...Bavar 373 system is an important and completely indigenous achievement that can be a powerful rival for S-300." - Brigadier General Farzad Esmayeeli, Commander of Khatam ol-Anbia Air Defense Base, September 3, 2012. <http://english.farsnews.com/newstext.php?nn=9106061552>
- The fourth generation of the Fateh 110 missile, with a range of more than 300 kilometers, was successfully tested by the Aerospace Organization of the Defense Ministry...[the missile can target] enemy deployment areas, command centers, missile sites, ammunition depots, radar and other targets with 100% precision." - General Ahmad Vahidi, Iranian Defense Minister, August 7, 2012. <http://www.irandailybrief.com/2012/08/07/dm-new-generation-of-fateh-110-can-destroy-enemy-concentration-points-command-centers-missile-sites-ammunition-depots/>
- "In our strategic planning, we have set out a radius we call the preventive/deterrent radius that covers all the strategic interests of the enemy in the region, and we will therefore be able to control the arena of conflict at any level. The IRGC navy's cruise missiles have the highest capabilities in terms of accuracy, range, and radar evasion, and these are missiles that can be fired at different ranges and from different launchers with great precision." - Hussein Salami, Acting Commander of the IRGC, June 25, 2012. <http://www.irandailybrief.com/2012/06/25/interview-with-hussein-salami-in-honor-of-irgc-day/>
- "Our missiles have tactically offensive and strategically deterrent and defensive features... Our fingers are still kept on the trigger, but the number of these triggers has increased." - Brigadier General Hossein Salami, Lieutenant Commander of the IRGC, June 28, 2011. <http://english.farsnews.com/newstext.php?nn=9004074141>
- "We feel to be threatened by no county but the US and the Zionist regime and the ranges of our missile have been designed based on the distances between us and the US bases in the region and the Zionist

regime.” - Brigadier General Amir Ali Hajizadeh, commander of the IRGC’s Aerospace Division, June 28, 2011.
<http://english.farsnews.com/newstext.php?nn=9004074047>

- “The mass production of the Qiyam missile, the first without stabilizer fins, shows the Islamic Republic of Iran’s self-sufficiency in producing various types of missiles.” - Iranian Defense Minister Ahmad Vahidi, May 22, 2011.
<http://www.presstv.ir/detail/181167.html>
- “As the enemy’s threats will likely come from the sea, air, and by missiles, the Revolutionary Guard has been equipped to neutralize the enemy’s advanced technology.” - Mohammed Ali Jafari, commander of the IRGC on a new anti-ship ballistic missile that Iran has allegedly developed, February 7, 2011.
<http://www.google.com/hostednews/afp/article/ALeqM5hfIrLpGsCvEg1YS5ANA8bTP939NA?docId=CN.G.30a945d880fb0c467a82e584423dac3f.281>
- “Iran is mass producing a smart ballistic missile for sea targets with a speed three times more than the speed of sound.” - Major General Mohammed Ali Jafari, commander of the IRGC, February 7, 2011.
<http://www.google.com/hostednews/afp/article/ALeqM5hfIrLpGsCvEg1YS5ANA8bTP939NA?docId=CN.G.30a945d880fb0c467a82e584423dac3f.281>
- “The operational capabilities of the missile unit of the IRGC Aerospace Force will be remarkably enhanced.” - Iranian Minister of Defense Ahmad Vahidi regarding the new indigenously produced Fateh-110 ballistic missile, September 21, 2010.
<http://www.dsrc.ir/En/news/view.aspx?nid=4636>
- “Those who are hostile to the Islamic Republic of Iran definitely have the right to be concerned about the drills, but we didn’t hear any feeling of concern from the side of the regional countries since our moves and actions have always been in pursuit of defensive goals...We are entitled to the right to growingly strengthen ourselves to protect the Islamic Iran and we naturally increase our power on a daily basis until we acquire full (power of) deterrence.” - General Amir Ali Hajizadeh, commander of the IRGC’s Aerospace Division in reference to Iran’s most recent missile tests, July 9, 2011.
<http://english.farsnews.com/newstext.php?nn=9004183678>

Such statements show that Iran views its ballistic missiles as a critical component of its national defense, and stresses that an effective ballistic missile program provides the country with increased strategic and asymmetric capabilities. Iranian officials regularly refer to their conventionally armed missile forces as an effective deterrent to attack, and the Iranian leadership is not shy about its country’s advancements concerning ballistic missile technology. High-ranking officials in Iran’s political and military establishments regularly boast of their country’s progress in this field.

During the Great Prophet 6 war games in late June 2011, the commander of the IRGC’s Aerospace Division, Brigadier General Amir Ali Hajizadeh, stated that,

“We feel to be threatened by no county [sic] but the US and the Zionist regime and the ranges of our missile [sic] have been designed based on the distances between us and the US bases in the region and the Zionist regime.”⁵⁹

Later, on July 9, 2011, General Hajizadeh stated the following about the war games:

“Those who are hostile to the Islamic Republic of Iran definitely have the right to be concerned about the drills, but we didn’t hear any feeling of concern from the side of regional countries since our moves and actions have always been in pursuit of defensive goals.

We are entitled to the right to growingly strengthen ourselves to protect the Islamic Iran and we naturally increase our power on a daily basis until we acquire full (power of) deterrence.”⁶⁰

On June 28, 2011, Lieutenant Commander of the IRGC, Brigadier General Hossein Salami, also referred to the deterrent that Iran perceives in its missile forces:

“Our missiles have tactically offensive and strategically deterrent and defensive features...Our fingers are still kept on the trigger, but the number of these triggers has increased.”⁶¹

Ballistic missiles have been prominently displayed at parades and public functions, with video footage of drills given prominent showing on public TV. The Iranian government has made a concerted effort to link the missile effort with the state, turning the space/missile program into a national issue. This effort has the effect of not only rallying the public around further research and development efforts in ballistics, but also demonstrating to the West that putting the lid back on the program will be nearly impossible due to domestic concerns.

Remarks made by such a high-ranking figure and public demonstrations are revealing. They are a direct indication of the Iranian regime’s continued willingness to improve its ballistic missile arsenal as a component of its asymmetric warfare capabilities and the deterrent it generates against the US and regional US allies. Given Iran’s foreign policy objectives, conventional shortcomings, and ever-expanding missile program, it is clear that Iran uses its missile program to try to improve its strategic standing and assert itself in the region.

Iran’s Possible Search for an ICBM

There have been reports that Iran is developing an ICBM with ranges greater than 5000 kilometers (3,400 miles). Iran has clearly been developing and testing rocket motor technology and multi-stage boosters since 2008 that *could* serve this purpose. Iran launched its first satellite, the Omid (Hope), in February 2009, and its second in June 2011. These seem to have used a Safir solid-fuel rocket booster with limited payload capability.⁶² Iran had another launch fail in October 2011, but did launch another small satellite in February 2012.

The NTI also reports that Iran announced in February 2010 that it had, “created a new satellite launch vehicle (SLV), the Simorgh” in February 2010. The NTI report indicates that this was a larger, “‘a 27-meter-long, multi-stage, liquid-fuel missile with a thrust of 143 metric tons.’ The Simorgh is designed to carry a 60kg (132lb) satellite into low earth orbit (LEO) and could be enhanced to carry a 700kg satellite.”⁶³

Iran successfully launched a second satellite, dubbed Rassad (Observation), into orbit in June 2011. Its mission was to take images of the Earth and transmit them along with telemetry information to ground stations. It launched a Navid-e Elm-o Sanat (Harbinger of Science and Industry) satellite into orbit in February 2012. The records made by the telecom, measurement and scientific satellite could be used in a wide range of fields.⁶⁴

Iran’s current satellite launch vehicle, the Safir, likely lacks the thrust or structural integrity to carry any type of warhead. The Simorgh, assuming that it is derived from the North Korean Unha,⁶⁵ would similarly face difficulties carrying a military payload. While it would probably only take a few years to fully weaponize such a system, the testing necessary to guarantee its structural integrity and accuracy would provide the US with sufficient warning to react.

Iran has, however, continued to make progress in its space program. Iran launched its second satellite, dubbed the Rassad (Observation), into orbit on June 2011. Its mission was to take images of the Earth and transmit them along with telemetry information to ground stations.

Iran then launched its Navid-e Elm-o Sanat (Harbinger of Science and Industry) satellite into orbit in February 2012. It was a “telecom, measurement and scientific satellite.”⁶⁶

Hamid Fazeli, the Director of the Iran Space Agency (ISA) announced on February 2, 2013 that Iran would launch indigenous satellites into space.⁶⁷ Fazeli said that Iran had launched a Kavoshgar Pishgam (Pioneer Discoverer) satellite carrying a monkey on January 28th, that the Nahid, Qaem and Fajr satellites would be launched into orbit within the next few days and that Iran planned to launch a satellite called the Sharifsat by the end of the current Iranian calendar year (March 20, 2013). He also said that a Toloo' satellite would be launched into orbit in the near future. Iran announced on January 30th that it would send a Zafar satellite into space using a new and larger booster within the next eight months.

These “space” efforts could allow Iran to develop an ICBM capability as early as 2015-2020, and some estimates indicate that Iran could do so much earlier. In February 2012, Israel’s Finance Minister, Yuval Steinitz, stated that Iran could develop an ICBM that could reach the East Coast of the US within the next two to three years,⁴⁸In February 2012, Israel’s Finance Minister, Yuval Steinitz, stated that Iran could develop an ICBM that could reach the East Coast of the US within the next two to three years,⁶⁸

“They (the Iranians) are working now and investing a lot of billions of dollars in order to develop intercontinental ballistic missiles...And we estimate that in two to three years they will have the first intercontinental ballistic missiles that can reach the East Coast of America. So their aim is to put a direct nuclear ballistic threat...to Europe and to the United States of America.”

Given what is known about Iran’s ballistic missile technology, these claims probably represent a worst case for any date before 2015. US intelligence sources have not yet announced that Iran has a full-scale ICBM program at present. The Secretary of Defense stated in his April 2012 report to Congress that,⁶⁹

“Since 2008, Iran has launched multistage space launch vehicles that could serve as a test bed for developing long-range ballistic missile technologies.

...During the last two decades, Iran has placed significant emphasis on developing and fielding ballistic missiles to counter perceived threats from Israel and Coalition forces in the Middle East and to project power in the region. With sufficient foreign assistance, Iran may be technically able of flight-testing and intercontinental ballistic missile by 2015.”

Without such an effort, it seems unlikely that Iran will reach reached the level of guidance or re-entry technology necessary to effectively strike at the East Coast of the US or anywhere else of similar range with an ICBM in less than 4-10 years.⁷⁰ The longer time frame seems more likely and Iran would then need a nuclear or extremely effective biological warhead to do serious damage.

Hildreth summarizes what seems to be the current view of US experts as follows:⁷¹

In 1999, the U.S. intelligence community assessed that at some point the United States would probably face ICBM threats from Iran...This remains the official U.S. position. More specifically, the 1999 assessment warned that “Iran could test an ICBM in the last half of the next decade using Russian technology and assistance” (emphasis in the original). A similar report was issued in 2001....Such a test did not occur in this time frame, but in 2010 the DIA assessed that, by 2015: “Iran’s Ballistic Missile and Space Launch Programs with sufficient foreign assistance, Iran could develop and test an intercontinental ballistic missile (ICBM) capable of reaching the United States. In late 2008 and early 2009, Iran launched the Safir, a multi-stage space launch vehicle (SLV), demonstrating progress in some technologies relevant to ICBMs. Iran displayed its next generation SLV, the Simorgh, in February 2010. The Simorgh is much larger than the Safir and shows progress in booster design that could be applicable to an ICBM design.”

The 2012 annual report on Iran's military power to Congress (April 2012) restated that "Iran has launched multistage space launch vehicles that could serve as a test bed for developing long-range ballistic missile technologies."

These assessments are often interpreted as stating that Iran will have nuclear-tipped ICBMs capable of striking the United States by 2015, but the unclassified intelligence statements continue to place various caveats on potential capability to test at some date. These assessments focus only on the ability to test an ICBM and do not make any judgments about the ability of Iran to successfully deliver a nuclear warhead at ICBM range.

These intelligence statements serve as the official U.S. basis for assessing the Iranian ICBM threat to the United States and to its friends and allies. These assessments drive U.S. military efforts designed to respond to such threats, such as the U.S. BMD program in general and the U.S. missile defense system in Europe specifically, as well as U.S. diplomatic and other efforts such as sanctions to dissuade or slow down Iranian long-range ballistic missile programs...However, they do not offer a probability assessment for such technological assistance being available.

These assessments do not mean that currently universal agreement exists within the U.S. intelligence community on the issue of an Iranian ICBM. According to these same unclassified statements, some within the intelligence community argued that an Iranian ICBM test was likely before 2010 (which did not happen), and very likely before 2015. Other U.S. officials believed, however, that there is "less than an even chance" for such a test before 2015. Furthermore, U.S. assessments are also conditional in that an Iranian ICBM capability would have to rely on access to foreign technology, from, for example, North Korea or Russia.

...Finally, some argue that an Iranian ICBM could be developed out of the Iranian space program under which a space-launch vehicle might be converted into an ICBM program. In the 1990s, some argued that Iran could have developed and tested such a space launch vehicle by 2010. Iran successfully demonstrated a space launch capability in 2009 with the launch of a low-earth orbit satellite, but the IC has not assessed that Iran has conducted an ICBM test or acquired an ICBM capability.

The IISS and other expert sources agreed with this assessment as of November 2013, and development and testing of an effective ICBM system is highly visible process.⁷² Static burn tests for solid fuel motors are nearly impossible to conceal, and satellite-based detectors would likely be able to determine that Iran is experimenting with far more powerful engines. Additional flight tests would be necessary to determine whether the entire missile flies correctly and can carry a warhead. All these trials would allow the US to monitor progress in Iran's missile development, potentially triggering preventive strikes or allowing it to improve missile defenses before a crisis.

Furthermore, development and testing of such a system is an onerous and highly visible process. Static burn tests for solid fuel motors are nearly impossible to conceal, and satellite-based detectors would likely be able to determine that Iran is experimenting with far more powerful engines. Additional flight tests would be necessary to determine whether the entire missile flies correctly and can carry a warhead. All these trials would allow the US to monitor progress in Iran's missile development, potentially triggering preventive strikes or allowing it to improve missile defenses before a crisis.

Cruise Missiles

Iran's unmanned shorter-range cruise missile systems have been described in Part I (Chapter II) of this series. Iran is, however, developing longer-range cruise missiles with a land attack capability. According to various reports, it has had access to as many as three advanced cruise missiles that could pose a significant threat to US forces in the region, with one capable of carrying nuclear payloads.

These three systems include the Kh-55 or AS-15A, the SS-N-22 Sunburn, and the SS-N-26, all three were developed by the Soviet Union in the 1980s, the latter two to combat Aegis-equipped ships; if they have been properly maintained and are used correctly, in the confined waters of the Gulf, they represent a threat to US ships.⁷³

Twelve Kh-55 missiles were likely transferred to Iran by Ukraine in 2001.⁷⁴ Although the weapon was designed to carry a nuclear warhead, as a conventional weapon it could carry 410 kg of explosive, enough to do substantial damage to a naval vessel. With a maximum speed of Mach .8, a range of 2500 km, and inertial navigation and terrain matching guidance giving it a CEP of 25 m, it is slower but more accurate than any of Iran's ballistic missiles.

The Kh-55 was designed as air-launched cruise missiles, and while Iran may have adapted them for ground launch, so far there have been no public demonstrations of these missiles. The system was designed as a ground-attack system, and is unlikely to be effective against moving vessels unless Iran has upgraded its seeker system. Given Iran's difficulty fabricating parts for its ballistic missile program, and the need to develop suitable power plants and guidance packages, Iran is unlikely to have reverse-engineered this or any other cruise missile, and there are no indications that Iran has test-fired a Kh-55 or any cruise missile with similar characteristics in recent drills.

If Iran could eventually make use of these systems or reverse engineer them, they could represent a serious threat. Their range would allow Iran to target Israel, the entire Gulf, and Southeastern Europe from bases well within Iran. While the missile was originally armed with nuclear weapons, it is unlikely that Iran would be able to develop a 410 kg nuclear device in the near future (see below), and the Kh-55's main danger comes from precision and long range. Although far more accurate than any ballistic missile currently in Iran's inventory, its relatively small payload (410 kg vs. 1000 kg for most SRBMs) and vulnerability to anti-missile weapons limits its effectiveness in hitting hardened and defended targets.

There are unconfirmed reports that Iran received eight SS-N-22 Sunburns from Russia early in the 1990s.⁷⁵ The Sunburn is larger and heavier than the Kh-55, with a maximum speed of Mach 2.5 at high altitudes and 2.1 at low altitudes. It carries a 300-320 kg warhead and has a maximum range of 160 km. Its guidance package uses inertial navigation and data links for launch and mid-course flight, with the final approach controlled by the missile's radar. This weapon was designed to be a carrier-killer for Soviet bombers, and for its time would likely have been highly effective against US anti-missile defenses. It is unknown if Iran has managed to improve on these weapons or has only been able to refurbish its current stock, and with the exception of a 2006 image of a Sunburn-like missile being fired from an Iranian frigate, there are no public data on their current status.

The SS-N-26 was designed to be a lighter, cheaper version of the SS-N-22. First publicly displayed in 1993, it is unknown if Iran has received any shipments of this missile. It has a longer range than the Sunburn but carries a lighter payload - 300 km vs. 160 km and 250 kg vs. 300-320 kg. It can be launched from submarines, surface ships, aircraft, and land batteries. If Iran actually has any, they are likely stationed on mobile launchers around the Strait of Hormuz. With the exception of a passing reference in *Missile Threat*, however, there is no indication that Iran has access to these weapons and intelligence experts do not feel they are a current threat.

In addition to these cruise missiles, Iran also has several hundred C-801, C-802, and SSC-3 missiles. These weapons have shorter ranges (50 km, 120 km, and 80 km), slower speeds (Mach

.85, .85, and .9), and generally smaller warheads (165 kg, 165 kg, and 513 kg). All three carry some form of inertial guidance or autopilot combined with radar for the attack phase. All are based on designs that date from the 1960s or 1970s, although the Chinese production runs that Iran likely had access to from the 1980s and 1990s.

Iran also potentially has access to the Chinese HY-4 (NATO designation C-7 Sadsack), although reports in this regard are unconfirmed. The HY-4 has a range of 135 km, a maximum speed of Mach .8, and a 513 kg warhead. While more dangerous than the C-801, C-802, or SSC-3, none pose the same level of risk to military vessels that the SS-N-22 and SS-N-26 do.

Iran does claim to have upgraded its speedboats and patrol craft to launch more advanced cruise missiles.⁷⁶ Observers of recent naval exercises have not publicly verified such claims. The mounting of the C-700 and C-800 series of weapons on small vessels is confirmed, however, and presents a real threat. It is also one where US and allied navies and air forces must attack the moment such a missile launch becomes likely in order to minimize the threat of a successful strike on a US or allied ship.

Iran also has claimed it was going to deploy a new long-range land attack missile. The *New Straits Times* reported on April 1, 2013 (<http://www.nst.com.my/latest/iran-to-unveil-new-cruise-missile-1.141722>) that,

Iranian Deputy Defense Minister Mehdi Farahi announced that a new domestically manufactured cruise missile with a range of 2,000 kilometers will be unveiled in the near future, Iran's Mehr News Agency (MNA) reported. Farahi also said that the cruise missile, named the Meshkat (Lantern), can be launched from land-based and sea-based missile systems, adding that the missile can also be fired by fighter jets.

In addition, he said that Iran has built or is building 14 types of cruise missiles, including Zafar, Nasr, Qader, and Ghadir missiles. Elsewhere in his remarks, Farahi said that in the field of missile technology, the Defense Ministry has focused its efforts on increasing the precision, radar-evading capability, and operational range of domestically manufactured ballistic missiles.

On the United States plan to build missile defense shields in the region, he said, "They are making some efforts and some claims, most of which are false, exaggerated, and have no basis in fact." He also said, "We hope that no incident will take place, but if a conflict occurs, they will see that their claims are ineffective."

This would be a far more ambitious cruise missile strike system that Iran has announced to date. The Zafar missile is a short-range anti-ship cruise missile designed for mounting on speed boats and small craft. The Noor seems to be a larger anti-ship cruise missile with a range of 130 to 1270 kilometers.

The Qader or Ghadar has variously been reported as an upgrade to the Shahab 3, as an unpowered electro-optically guided 2,000 pound glide-bomb, as a cruise missile with a range of up to 200 kilometers that can be used against ships and land targets, and as identical to the Meshkat - illustrating the problems in charactering Iran's forces using unclassified sources.

A land attack capable attack version of the Qader missile called does seem to be the same system that the US Director of National intelligence identified as a new land attack capability in April 2013. However, a similarly named Ghadir has been reported as a smaller anti-ship cruise missile that can also be used against land targets, and the same name is used for midget submarines.

Iran may not have been able to activate its KH-55s as operational systems, or reverse engineer them, but it does seem to be developing the capability to produce and deploy long range cruise missiles. The key point is that Iran has not shown it has been able to activate its KH-55s or

reverse engineer them, but does seem to have developed enough long-range cruise missile technology and production capability to deploy such systems in the future.

It is clear, however, that that Iran is continuing to develop new cruise missiles, although most of its public focus is still on naval systems. Tasnim news agency reported that Rear Admiral Habibollah Sayyari, the Commander of the Iranian Navy, stated in late November 2013 that Iran planned to new cruise missiles during military exercises in January, 2014. He stated the Vilayat-92 exercises would be Iran's largest yet, and would be held in northern part of the Indian Ocean and neutral waters, Tasnim news agency reported, "The newest cruise missiles will be tested during these exercises, aside from that, we will also test new weapons." He also talked about new unmanned aerial vehicles (UAV) and said that Iran would demonstrate a new phased array radar named "Asr."⁷⁷

These statements came days after Iran had reached its nuclear agreement with the P5+1, but were tied to National Navy Day in Iran which occurs on November 28th, and celebrates Operation Morvarid of 1980, an Iranian Navy victory in the Iran-Iraq war. Sayyari also said that new military vessels and aircraft were planned to enter service, that the Navy would step up manufacture of the Sahand destroyer and that a 28th fleet of warships, comprised of Alborz and Bandar Abbas warships, along with the Younes kilo-class submarine, had been sent on a 70-day mission to in the Indian Ocean and would go to the Gulf of Aden and the Red Sea, and would dock in a number of ports in India, Sri Lanka, and Oman.⁷⁸

Assessing Warfighting Capabilities of Iran's Current and Future Medium and Longer-Range Missile Force

For all of the reasons discussed earlier, the warfighting impact of Iran's medium and long-range missile capabilities should not be exaggerated. Nevertheless, Iran already has operational missiles that are mobile and in silos with ranges of 1,500 to 2,500 km, and can clearly strike at targets throughout the Middle East, Turkey, and southeast Europe.⁷⁹ Moreover, both Israeli and US experts feel Iran is improving the accuracy of its missiles, is arming them with submunitions that can achieve better lethality with conventional and chemical munitions, and is developing at least limited countermeasures to missile defenses.

An April 2012 report to Congress by the US Secretary of Defense stated that,⁸⁰

...Regular Iranian ballistic missile training occurs throughout the country. Iran continues to develop ballistic missiles that can range regional adversaries, Israel, and Eastern Europe - including an extend range version of the Shahab 3 and a 2,000-kilometer range medium range ballistic missile, the Ashura. Beyond steady growth in missile and rocket inventories, Iran has boosted the lethality and effectiveness of existing systems by improving accuracy and developing new submunition payloads.

This progress raises a number of key uncertainties about Iran's current and future force issue that anyone assessing the warfighting capabilities of Iran's missile programs must consider:

The operational readiness and capability of both Iran's operators and missiles remain uncertain. Almost all launches seem to be "white suit" launches prepared by technical expert with long warning and time to both check out and ready the system. There is no way to know what real world combat preparation time and readiness really is. Iran stated that its July 2012 Great Prophet VII exercise was more realistic, but there is as yet no way to verify this claim.

Many systems are destroyed in flight during the test. This deprives Iran as well as outside observers of the ability to know what ordinary operators and forces can do. It is unclear whether these premature detonations are accidental, ordered by Iran to avoid providing information to observers, or necessary to prevent the missile from landing in Iran.

Declassified sources mention efforts to reduce vulnerability to missile defenses but give no details.

Iran seems to be seeking some form of GPS guidance and terminal homing capability, but it is far from clear what progress it has made - if any. A truly precision-guided missile would be far more lethal with even a conventional warhead.

The possible use of volleys to compensate for accuracy and reliability exists, but it is unclear if any test data really demonstrate whether Iran has a serious capability at more than short ranges. Volleys are likely to be limited by the number of TELs, which is currently believed to be around twenty - although that number may have risen sharply in the last two years as Iran expanded other aspects of its missile program.

There are no meaningful unclassified reports on the details of Iran's warning systems, command, control, computer, intelligence, surveillance, and reconnaissance systems (C4IS&R), command structures, or operational doctrine.

There are no useful data on Iranian target doctrine, targeting capability, and damage assessment capability.

Iran does have long-range Russian cruise missiles it can reverse engineer, could convert combat aircraft in high payload unmanned combat aerial vehicles (UCAVs), and used medium-range UCAVs during the Israeli-Hezbollah War in 2006. It is unclear, however, whether Iran is moving forward in long-range, high payload cruise missiles and UCAVs. Constructing engines and guidance systems for these, while not as challenging as for ballistic missiles, is still likely to slow down Iranian efforts to develop additional long-range delivery systems.

While it is an outlier, much depends on the warhead and if Iran goes nuclear, on how quickly it can achieve reliable fission weapons, move on to boosted weapons, and then to thermonuclear weapons.

While data are lacking in many of these areas, the following analysis addresses several of the key challenges affecting Iran's warfighting capability.

The Accuracy and Reliability Challenge

Figure 2 has already indicated that Iran may be sharply exaggerating the accuracy of its missiles. Although Iran boasts the large arsenal of conventionally-armed missiles of varying ranges and payloads shown in **Figure 5 through Figure 10**, their seeming lack of terminal guidance and advanced warheads sharply reduces their military effectiveness. Without the accuracy necessary for conventionally armed missiles to be effective against point or high value targets, they can be used as tools of terror and intimidation and to strike at targets throughout the region with little, if any, warning.

It is unclear that Iran has the warfighting ability in the short run to translate its current medium and long-range missile forces into anything more than a limited "terror" weapon. While Iran is improving its guidance technology, its short- and medium-range missiles remain blanket weapons systems that can hit a broad area but not a key point target - and then only if they are properly targeted and fired, and function reliably.

As **Figure 11** shows, the destruction of even a light target with Shahab-1 would likely require over 100 missiles, far too many for any practical military role. This number is smaller for a substantial target such as an airfield or radar center, but such military targets - which generally have built-in redundancies - would require substantial numbers of missiles to disable.

Iran's longer-range systems have had too little consistent testing to produce accurate engineering estimates of their reliable circular errors of probability (CEPs) under deployed and operational

conditions. As such, they are assumed to have CEPs similar to Shahab-1 and -2 and their military value is believed to be minor, as Iran lacks the numbers of Sejjil-2 and Ghadir-1 to launch sustained volleys.

It is important to understand the difference between *theoretical* CEP and accuracy based on a statistically large-enough sample to establish a reliable *operational* estimate. CEP is defined as the level of accuracy that *should* occur if the system is perfectly aimed, launches under ideal circumstances, and every aspect of the design functions as exactly as it should. It then estimates the radius of the circle that half the rockets of missiles will land within as determined by the technology of the guidance platform. It is not a practical measurement in the sense it does not normally include any input from statistically relevant tests and evaluations that establishes the real-world reliability of the system.

In practice, Iran has not conducted sufficient realistic tests of its systems to provide enough data to calculate accuracy and reliability, particularly under field conditions. This is compounded by the problem that missiles rarely achieve stated CEP in practice. As a result, barring the success of Iran's modernization and accuracy upgrades, many of Iran's medium-range systems will be lucky to hit within a one kilometer distance of their target even if they function perfectly.

Iran is well aware of this dilemma regarding accuracy. Its primary limitation is that missile guidance technology is technically complex and requires advanced raw materials and considerable expertise to develop and operate. To date, Iran has used spin stabilization and steering vanes at the exhaust point of its missiles; the former at best achieves error of roughly 1.5% distance traveled, while the latter reduces missile range. Iran has not developed either the inertial guidance or GPS systems necessary to accurately track its missiles (although the Khalij Fars may have some inertial tracking), and so far has had limited experience with steering fins, gimballed thrust, or vernier engines to adjust rockets in flight.⁸¹ It is likely that Iran's ballistic weapons will grow more accurate over time as it develops a pool of experience in steering systems, but Iran has made no public demonstrations in this regard.

As **Figure 12** shows trying to destroy hardened targets using missiles with a CEP over 200 (note that most reports for Iranian missiles place their best-case CEP at 450 m) requires over a hundred missiles to achieve even a 50% chance of destruction; even to destroy a soft target with 50% confidence would require at least 11 missiles. Doubling the CEP - to 400 m, or the maximum efficiency Iran is expected to reach - would still require over 40 ideally-performing missiles for even a single soft, point target.

These technical difficulties compel Iran to develop either a larger or more precise missile force to compensate for its systems' weaknesses. Iran is likely to concentrate its R&D on three aspects of its missile program - improving accuracy, increasing production, and developing warheads that are more effective. The first and last will make each individual missile more effective, allowing Iran to reduce the number of missiles needed; increasing production improves accuracy and reliability by swamping defensive systems and increasing the odds of a single hit.

Iran has made progress in all three. With the triconic warhead replacing the old conical nosecone, Iran has improved the maximum payload and stability of its warheads. Based on data from a laptop obtained by US intelligence in 2004, Iran also has developed an altitude device for the Ghadir-1 that would let it detonate at 600 m. Assuming this upgrade is successful, the safety, arming, and fusing system would allow the triconical warheads to operate for both cluster warheads and unconventional munitions.⁸²

While developing a new warhead section is a challenging engineering task, it is far simpler than the establishment of domestic facilities for producing rocket engines, guidance and control systems, high-quality fuel, and low-weight, high-caliber missiles. Iran has striven to develop a domestic capacity, as these Iranian speeches highlight:

- “Our missiles can be launched from boats with speeds of over 30 knots, and these missiles include Zafar, Nasr, Nour and Qader...The tactical use (and goals) of these missiles can vary in accordance with the type of threat.” - General Mehdi Farah, Deputy Defense Minister and Head of Iran’s Aerospace Organization, October 19, 2012. <http://www.irandailybrief.com/2012/10/19/deputy-defense-minister-iranian-speedboats-capable-of-launching-cruise-missiles/>
- “Our cruise missiles can completely respond to any kind of threat...Nasr, Qader, Nour, Zafar and Fateh anti-ship cruise missiles can hit every enemy target...[Iran] feels no shortage in missile fields.” - Brigadier General Ahmad Vahidi, Iranian Defense Minister, October 6, 2012. <http://english.farsnews.com/newstext.php?nn=9107110952>
- “The Islamic Iran’s progress in different fields of aerospace and missile industries is endless and Iran is self-sufficient today in producing missiles in different sizes and needs no one. The youths of this land are able to manufacture missiles and are manufacturing them.” - Vice President for Parliamentary Affairs Seyed Mohammad Reza Mir-Tajaddini, October 10, 2012. <http://english.farsnews.com/newstext.php?nn=9007160864>
- “Different kinds of cruise missiles that are currently in our possession are for marine targets, and Nasr, Qader, Nour, and Zafar missiles as well as Fateh ballistic missile are able to repel any threat...Iran has no shortage in the missile field... - Brigadier General Ahmad Vahidi, October 6, 2012. <http://www.presstv.ir/detail/2012/10/06/265261/iran-missiles-will-answer-threats/>
- He said that Iran has reached self-sufficiency in the missile industry and added we can target every base of the enemy in the region from any spot with the desired precision and degree of power.⁸³
- “We intend to reach the point where our aerial defense ability will be so efficient from the operational perspective that it will destroy and disrupt all the enemy’s military plans. Regarding anti-missile defense shields such as the Iron Dome, it must be understood that these systems can give limited coverage, to a certain height and range, and therefore all these plans are just psychological warfare. They know full well that they are very vulnerable from the technical and operational perspective, and they cannot remain protected from a multi-missile attack by Iran’s accurate, destructive missiles.” - Mohammad Eslami, Deputy Defense Minister for Industry and Research, August 27, 2012. <http://www.irandailybrief.com/2012/08/27/iran-to-expand-range-of-cruise-missiles-distancing-enemy-miles-from-maritime-borders/>

Tehran has also been experimenting with new engines, suggesting that it has either learned how to vastly improve its old engines or started to develop new motors. Each rocket test renders the engine inoperable, which has been a major impediment to upgrading and testing Iran’s old, restricted stock of Kh-55 cruise missiles and, potentially, Shahab-3 and Ghadir-1 MRBMs.

The explosion at the Bid Kaneh missile test site on November 12, 2011 was believed by ISIS to be during the testing of a new engine,⁸⁴ with the presence of Major General Hassan Moghaddam (head of the “self-sufficiency section” of the IRGC missile center) suggesting that the event was significant for the development of Iran’s missile program. While the explosion has been blamed on both careless maintenance by untrained technicians and sabotage, the presence of such a high-ranking official so close to a missile suggests that engine test would have been strategically significant.

The other evidence that Iran has developed at least a limited ability to construct its own engines comes from recent tests and exercises carried out by the IRGC. During the Great Prophet 3 drill,

in July 2008, Iran reportedly fired nine ballistic missiles.⁸⁵ By Great Prophet 7, carried out in July 2012, Iran was reportedly able to fire “dozens” of missiles.⁸⁶ Although the uptick in tensions at the time may have led Iran to expend additional missiles, this also suggests that Iran either has a sufficient number of ballistic weapons stockpiled that it can afford to fire several dozen, or else is capable of rebuilding its stocks through domestic manufacture.

In between these two exercises, according to the 2010 DOD report on Iran’s military,⁸⁷ Iran had amassed an arsenal of 1000 missiles with ranges between 90 and 1200 miles; there are no sources that estimate how much the missile force has grown since then. IISS also suggests that Iran has, using the expertise gained in its artillery rocket program developed far greater knowledge about solid fuels than liquid fuels.⁸⁸ This suggests that while Iran’s stocks of Shahab-1, -2, and -3 may remain dependent on imports, longer-range systems such as the Sejil-2 may be fully locally-sourced and hence present in greater numbers as tensions in the Gulf escalate.

There is as yet no solid evidence as to whether Iran has mastered the casting of missile fuels. This technical challenge is critical to the establishment of an indigenous missile program, and the expertise entailed normally requires both training by outside experts and considerable personal experience.

While many sources suggest that Iran is receiving help on its missile program from North Korea (with some possible assistance from Chinese and/or Russian scientists⁸⁹), other experts question how dependent Iran is on North Korea versus North Korea (and Syria) acquiring technology from Iran. They feel North Korean rocket scientists do not have experience mixing fuels that are more effective than those currently in use by Iran.

Some feel that if Iran is to develop better fuels, it will have to obtain convince another ballistic missile state to violate the Missile Technology Control Regime (MCTR) and provide it with techniques, steal them via industrial espionage, or gradually develop the expertise locally. Iranian efforts to smuggle in aluminum powder suggests that while it may have mastered the production process for some solid rocket fuels, it is not yet self-sufficient in producing the precursor ingredients domestically.⁹⁰

Iranian improvements in accuracy are less evident than increases in engine knowledge and warhead capacity. The existence of steering vanes on the Sejil-2, along with reports of tungsten powder smuggled from China, implies Iran may have learned how to craft an inefficient but useful guidance system for an IRBM.⁹¹ The steering fins on the Khalij Fars may provide a higher degree of accuracy, albeit for a slower and shorter-range system - if the video is accurate, they permit a relatively slow ballistic missile to hit within a few dozen meters of its target.

In addition to the accuracy of the weapons, the tactical relevance of ballistic missiles is compromised without an effective over-the-horizon targeting capability. While no such capacity is needed for engaging fixed points - infrastructure, established military bases, cities - it is fundamental for engaging mobile forces, naval vessels, and troop concentrations. If Iran wants to turn its ballistic program into a viable military threat, it will have to develop sensor platforms and integrate those into its ballistic command and control.[]

Regarding Iran’s ability to overcome these hurdles, the 2012 Great Prophet 7 also saw the introduction of a new ballistic missile, the Qiyam. While little is known about the technical specifications of the weapon, two details stand out. First is its improved warhead, which is mounted on a body that appears very similar to a Shahab-2. Like the new reentry vehicle for the

Ghadir-1, it is triconic, implying that Iran has found a way to improve the payload for its older missiles. Second, the absence of steering fins suggests that Iran has improved its internal guidance systems to a more efficient (non-steering fin or steering vane) technology. While there are no public testing data on how this upgrade impacts accuracy, it has the potential to reduce CEP and create a missile that could potentially, after additional refinements, pose a military threat.⁹² These improvements suggest that Iran has begun to develop the domestic capacity to improve its existing missile stocks, expertise that may be used to reverse-engineer and locally produce missiles already in its inventory.

Here, it is important to note that Iran has been conducting the Great Prophet series of exercises since March-April 2006 and that its claims of success in these exercises have become progressively greater. This is illustrated by summaries of Great Prophet 4 to Great Prophet 7 developed by Steven Hildreth,⁹³

Great Prophet 4 (September 2009): Iran conducted military and missile exercises from September 27 - 28, 2009 in which it reportedly launched the Shahab-3 MRBM and the new solid-fueled Sejil-2 MRBM...An Iranian military official, Abdullah Araqi, was quoted as saying “Iranian missiles are able to target any place that threatens Iran.”...Another source said the “optimized Shahab-3” missile has a range of 1,300 – 2,000 kilometers and that the Sejil was launched for the first time in military maneuvers from the central province of Semnan where Iran’s space program is located.

The IRGC’s Air Force Commander said the main aim of the exercise was to evaluate the “technical developments recently achieved in surface-to-surface missiles ... including simultaneous ... and successive” missile launches....Also reported were launches specifically of Shahab-1 and 2 SRBMs, and Fateh, Tondar, Zelzal, and various other tactical ballistic missiles...Iran claimed to have also tested a “multiple missile launcher for the first time.”

Great Prophet 5 (April 2010): Iran conducted war games on April 22 – 25, 2010, reportedly firing five tactical sea-to-sea and shore-to-sea missiles at a single target simultaneously from different locations...The Deputy Head of Iran’s Armed Forces Headquarters, BG Massoud Jazayeri, said Iran “is designing defense operations to strengthen deterrent power of its forces and give a crushing response to any aggression.” But it does not appear that any short or medium-range ballistic missiles were launched in this exercise.

Great Prophet 6 (June 2011): Iran conducted military exercises June 27-July 6, 2011 and reportedly launched 14 ballistic missiles, including Shahab-1 and Shahab-2 SRBMs and Zelzal and Fateh-110 tactical ballistic missiles. At least one Qiam SRBM, or an upgraded Shahab-3 or Ghadr (or Kadr), or a Sejil MRBM...was reportedly launched, depending on which source is cited. Reports said some missiles were aimed at targets at sea and perhaps as many as nine of the missiles were fired simultaneously...The Department of Defense subsequently confirmed that this exercise included a multiple missile salvo of some unspecified number.

Iran also unveiled the existence of a network of underground missile silos for the first time, which

IRGC spokesman Asghar Qelich-Khani said were “part of the swift reaction unit of [Iran’s] missile brigade; missiles are stored vertically.”...*The New York Times* added that Iranian officials showed an underground launching pad or silo for what they called the Shahab-3 MRBM. The televised reports also showed a large metal roof opening atop the silo to allow the firing of the missile...Iran claimed the silos were built indigenously, but Israel was reported as saying the silos were built with DPRK assistance.

One account of a tour of the silo complex also showed reported footage of a missile launch from a silo...which at least one analyst said looked like the launch of a DPRK missile from its silo. Although Iran kept the location of the silos a secret, others, such as *Jane’s Defence Weekly*, said Iran’s hidden silos were near Tabriz and Khorramabad. IRGC deputy commander BG Hossein Salami further added, “our missiles have aggressive, tactical, strategically deterrent and defensive features, of course we will not initiate any operation but our responses will be purely aggressive.”

...The Washington Post reported a Shahab-3 was fired at targets at sea and added that Iranian television quoted Iranian military officials saying that Iran “began building a network of such silos across the nation 15 years ago.”

Great Prophet 7 (July 2012): Iran held military exercises and missile launches July 1-3, 2012. Iran reported that it fired from different locations tens of Shahab-1 and Shahab-2 SRBMs, Shahab-3 MRBMs and Fateh, Qiam, Persian Gulf,...and Zelzal tactical ballistic missiles simultaneously at a mock air base in Iran’s Lut desert in southeastern Iran.

IRGC Aerospace Force Commander BG Amir Ali Hajizadeh said “these maneuvers send a message to the adventurous nations that the IRGC is standing up to bullies alongside the determined and unified Iranian nation, and will decisively respond to any trouble they cause.” Iran’s FARS news agency further said these exercises “underline Tehran’s threat to strike U.S. military bases in the neighboring countries—in Afghanistan, Bahrain, Kuwait and Saudi Arabia—if it comes under attack by Israel or the United States.”

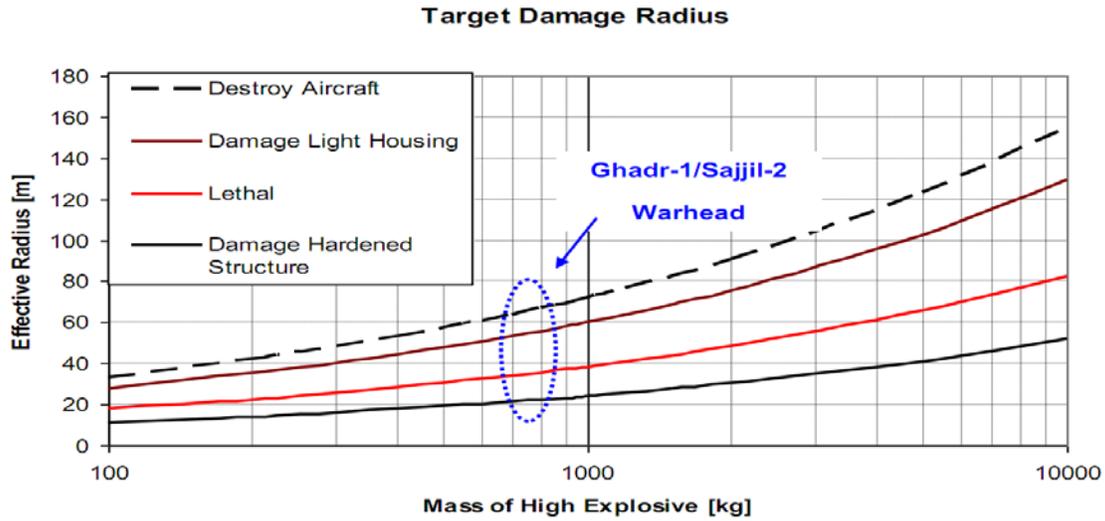
The Associated Press (AP) reported from Iranian sources that the missile tests demonstrated improved accuracy where 90% of the missiles hit their targets. Additionally, AP reported that Iran said it fired a considerable number of missiles against a single target (mock air base) making it “impossible for anti-missile systems to intercept and destroy them.” Iran warned that 35 U.S. military bases in the Middle East are within Iran’s missile range and would “be destroyed within seconds after any attack on Iran.”...Another source said Iran claimed it had launched a missile capable of reaching targets 2,000 km away, but only fired to a range of 1,300 km. and repeated many of the things said here of July 2012 test launches. There was no reported official U.S. response as to the accuracy of the claims made by Iran about their Great Prophet 7 exercises.

Iran held Great Prophet 8 in February 2013 in Eastern Iran and it involved a mix of land, Air, and asymmetric warfare activity including activity in the cities of Kerman and Sirjan, but there were no new announcements of major missile activity.

There is no unclassified way to validate the claims Iran makes during its exercises, and US and other experts indicate there is evidence that they have sometimes exaggerated claims relating to accuracy and reliability in conducting successful multiple launches, and physical faked imagery on their level of accuracy in striking area targets like air bases.⁹⁴ At the same time, any current exaggerations and delays in Iranian efforts to produce and test new missiles does not mean that the Iranian ballistics program cannot achieve high levels of accuracy and reliability or evolve to the point where missiles have highly accurate terminal guidance..

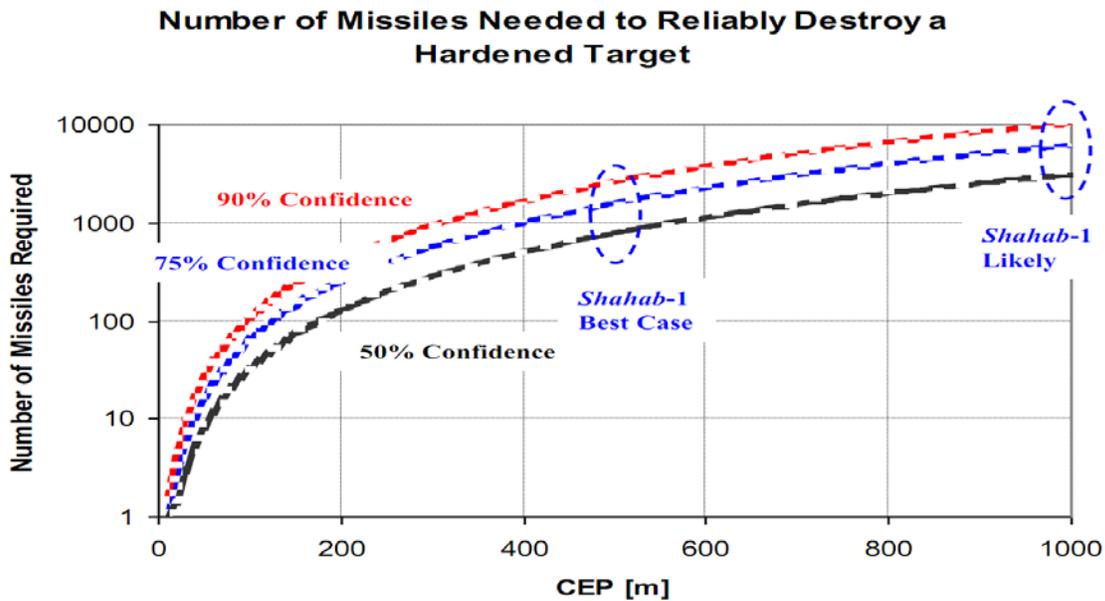
According to various experts, new missile systems routinely take 4-6 years; while Iran’s jump from the Zelzal to the Sejjil has taken twice as long, this effort has helped Iran reduce its industrial deficit, and it now has a much higher level of ballistic know-how than it did during the 1990s. While failures are costly, in terms of time, money, and, occasionally, people, they have also helped Iran build a far better platform for continuing its missile research. While strongly hindered by sanctions and the general low level of industrial technology in the Iranian economy, Iran likely has enough indigenous experience to continue developing and improving its ballistic missiles, even in the face of international pressure and efforts to prevent it from importing missile technology.

Figure 11: Estimate of Sejji Lethality Against Soft Targets



Source: Michael Elleman, "Iran's Ballistic Missile Capabilities: Assessing the Threat to Civilian Infrastructure." April 24, 2012. <http://www.fleminggulf.com/cms/uploads/conference/downloads/IISS.pdf>

Figure 12: Estimate of Shahab-1 Lethality Against a Hardened Target



Source: Michael Elleman, "Iran's Ballistic Missile Capabilities: Assessing the Threat to Civilian Infrastructure." April 24, 2012. <http://www.fleminggulf.com/cms/uploads/conference/downloads/IISS.pdf>

The Range-Payload Challenge

Many of the data on Iran's missiles use computer models to guess the range of Iran's missiles by assuming a nominal payload on 750 to 1,000 kilograms. These models normally have at least an uncertainty of +/- 30%, even assuming such a normal payload. In the real world, the actual payload determines missile performance, which may be much heavier or lighter than the nominal payload. Missiles that use conventional or CBR warheads, or early nuclear designs, may well have much higher payloads than the nominal 750 or 1,000-kilogram warhead. They may also require less stable warhead shapes and increase reentry and stability problems, further reducing the accuracy of the system.

This is one reason any Iranian long-range ballistic missile program is likely to incorporate significant testing before Iran attempts to use it. Different warheads have slightly different centers of mass, which, while not noticeable during short-range testing, can have a dramatic effect on a missile over several thousand kilometers of flight. Even with advanced in-flight steering systems, the warheads must be tested for stability, forcing Iran to use either advanced warheads or very close analogues if it wishes to install CBRN weapons on its missiles.

Iran also is confronted with the difficulty of building missiles out of more advanced materials than it currently has available. Lighter, stronger components such as maraging or flow-formed steel, titanium, or composite materials would reduce missile weight and extend range, but at this time Iran does not have the technical know-how to produce these components. Doing so would also allow it to reduce structural integrity concerns, removing one constraint on warhead weight.

Iran's recent missile test over the Indian Ocean was likely a trial for a system with an improved range-payload. Although it is unknown whether the missile was solid- or liquid-fueled or derived from a Shahab-3 or Sejil-2 - the test shows that Iran believes it can no longer gain sufficient range-payload data from land-overflight tests within Iran itself. Due to insufficient open source information, it is unknown what data Western and Iranian military planners gathered from this test.

The Warhead Lethality Challenge

A high explosive warhead on a long-range missile presents design problems that limit its lethality compared to bombs, air launched missiles, and cruise missiles. Unless it is almost perfectly fused and designed - or uses cluster munitions that are explosively disseminated at exactly the right altitude and are designed and fused so they are actually lethal against the target type being struck - the damage tends to be limited by the fact that due to warhead design and high reentry speeds the explosion of a unitary warhead is deflected upwards as the warhead hits the earth - vectoring much of its explosive effective where it will do far less damage..

As a result, the damage is significantly less than that caused by a bomb or artillery shell of the same general size. Iran may have cluster munitions on some of its systems, but the presence, character, and effectiveness of such warheads is uncertain from unclassified data and it is not clear that Iran could have conducted enough suitable tests of its longer range systems for even it to have reliable data.

Unless these submunitions are armed with chemical, radiological, or biological agents, they present the problem that each additional submunition imposes extra non-explosive weight on the missile, reducing its effective payload. Further, on an inaccurate missile, the submunitions are still likely to miss the target area; while they increase the chance that one will strike something

of value, they are unlikely on their own to cause significant damage. The submunitions that Iran can deploy are also of limited value; while some advanced types can seek out individual tanks and penetrate their thin armor at the top, Iran is more likely to use grenades with an altimeter, meaning they can only injure light structures and individuals.

The lethality of conventional cluster munitions could be substantially higher where shorter-range missiles or rocket could be fired in volley and line of sight observations are possible, but it is one thing to use cluster munitions with a precision-guided air launched bomb or missile, or unguided cluster munitions against exposed infantry, and quite another to fire them almost at random. Until-and if - Iran acquires medium to long-range missiles with precise terminal guidance and/or truly effective warheads using some form of weapon of mass destruction, the lethality of its missiles will be sharply limited.

These conditions do not apply if a missile warhead has reliable and accurate terminal homing of the kind the US deployed on the Pershing II, the level of accuracy of US cruise missiles, or have truly reliable and effective cluster weapons. Even then, however, the probable lethality will at best be that of a single bomb of the same size, and it is far from clear that the terminal guidance of a ballistic missile will really achieve the same accuracy as a cruise missile or precision guided bomb. The problems imposed by range, far greater levels of acceleration, and reentry buffeting are simply too great.

The CBR Warhead Challenge

These conditions also do not apply if a missile is armed with a nuclear warhead or a truly effective chemical or biological weapon. Once again, however, even nuclear weapons need to be part of a warhead with a reliable height of burst to reach maximum, predictable effectiveness. The conditions are far more challenging for chemical and biological weapons (CBW). The closing velocities of missile warheads are so great that getting the correct height for a broad, effective dissemination of chemical agents, particularly in varying local conditions, is a major engineering challenge. This is equally true of biological agents, some of which are also extremely sensitive to sunlight. CBW warheads are much easier to design in the computer than to make work in the field, particularly given the error-prone fusing and proximity equipment Iran likely has access to. Any sort of CBRN weapon will need live testing to ensure its accuracy and efficacy, and there is no evidence to date that Iran has done such tests.

Designing chemical and radiological warheads that can achieve anything like the potential lethality of the agents they carry under operational conditions is extremely difficult. Under many real world conditions, they would have more of an area denial, psychological, or panic impact than actual lethality and chemical weapons and all but the most advanced radiological weapons have lethalties several orders of magnitude less lethal than nuclear weapons and the most lethal biological weapons.

During the Iraqi SCUD strikes against Israel in 1991, even the threat of chemical weapons was sufficient to badly impair civilian life for a few weeks. The psychological and political impact of these weapons, particularly on populations that have no exposure to military operations, is hard to estimate but is likely to be severe. Even a prepared military may take some casualties from CBR attacks, and are forced to use bulky and time-consuming equipment to avoid fatal contamination. These problems are particularly acute for biological weapons, which only need a few successful initial contaminations to cause mass casualties.

Biological warheads also present critical problems for missile warhead design, and again, the theoretical lethality of the agent is no indication of operational lethality. Moreover, short of extensive testing against live humans under realistic urban or combat conditions, real world lethality is extremely difficult to predict. Animal testing can help with some biological agents, but many can only be used against humans, and past testing warns that selective use of agents against animals under simulated operational conditions cannot be scaled up or reliability predict lethality.

Nevertheless, chemical, biological, or radiological (CBR) warheads would provide a much more effective deterrent to attack and provide Tehran with the ability to strike at major population centers. Given such payloads, even a small number of missiles armed with CBRN warheads that bypassed US and Arab Gulf defenses and countermeasures could potentially cause serious to massive casualties - although much would still depend on the ability to design truly effective chemical and radiological submunitions, solving the problem of dispersing effective biological weapons, or having truly reliable nuclear warheads.

Under worst-case conditions, such weapons could still do considerable damage to the militaries, economies, and critical infrastructure of regional countries. These capabilities, in combination with the deterrent and the psychological impact they would produce, would have a profound impact on the strategic balance between Iran and the US and its Arab Gulf allies.

External Dimensions of Iran's Missile Program

Starting from a low industrial base and with no prior experience in ballistic missile production, Iran was forced to rely on other states' support during the early years of its missile program. Iran obtained most of its ballistic equipment and expertise from North Korea; there are unconfirmed reports that China and Russia assisted as well. As Iran's missile program has matured to the point that Tehran can build its own missiles, Iran has begun exporting its short-range systems, enabling its proxies throughout the region to leverage Iranian systems.⁹⁵

Most public sources identify the Shahab-1, Shahab-2, and Shahab-3 as imported SCUD-B, SCUD-C, and Nodong North Korean missiles. North Korea exported these weapons as fully developed systems, allowing Iran to rapidly develop a SCUD missile force in the late 1980s and Shahab-3 missiles in the mid-1990s. Pyongyang also permitted Iranian engineers to visit North Korean production facilities, training them in the basics of missile design and production.

However, North Korea also suffered from a low technological base for missile production. As Dr. Elleman reports,⁹⁶ it is likely that North Korea's liquid fueled missile program still depends on Russian-manufactured engines and critical components. It is likely that North Korea's relative inexperience and lack of sophisticated systems, and consequent inability to teach Iranian scientists, helped retard the growth of the Iranian ballistic missile program.

Unconfirmed reports⁹⁷ suggest that under these circumstances Iran accessed China expertise in overcoming major technical roadblocks. Although Iran likely preferred to resolve problems on its own and build indigenous know-how, it probably turned to China for help in addressing some intractable problems, probably relating to solid-fuel and engine production. It is also possible that the reports of a Chinese presence at missile tests were either false or simply reflected Beijing's interest in Tehran's missile development, rather than a sustained commitment to building Iran's missile program. Examples of Russia's involvement are even more fragmented, with the strongest evidence unconfirmed reports of Russian individuals working with Iranian

ballistics engineers. Iran is also clearly using Russian technology, but given the proliferation of Russian ballistic systems in the aftermath of the Cold War, this does not point to direct support by the Russian government.

The only nation whose support at the state level for Iran's ballistic program has been confirmed is North Korea.⁹⁸ The DPRK has provided complete missiles, metrics on missile testing, training, and possibly joint research and development, enabling Tehran to quickly build-up its missile stock and study a more advanced missile program at close range. This expertise likely enabled Iran to begin refurbishing and repairing missiles domestically by the 1990, gradually advancing to assembling the missiles domestically with imported parts.⁹⁹

This aid was partially limited by the poor quality of support from Pyongyang. While Iran used North Korean engines to power its first and second generation of liquid-fueled missiles, early tests often encountered significant problems in achieving hoped-for reliability. It is unknown whether North Korea has improved the quality of its exports (in effect, having used Iranian and Pakistani missile launches as extended tests for its own ballistic program) or whether Iran has learned how to check and repair faulty components that it imports.

Open source information suggests that Iran has begun proliferating its weapons to allies and proxies throughout the region. Iran was possibly a transshipment point for North Korean exports to Syria, and likely provided support for Syria's establishment of its own assembly, maintenance, and repair facilities for its SCUDs. Iran also exported Fateh-110 missiles to Syria, possibly supplying entire production facilities to allow Syria to develop its own domestic missile capacity.¹⁰⁰

Iran has also provided material support for Hezbollah and other proxy groups around the Middle East. It appears likely that Iran provided Zelzal rockets to Hezbollah during the early 2000s, in addition to shorter range rockets and military material.¹⁰¹ Israel claimed that during the 2006 it destroyed the majority of these imported missiles in bunkers, preventing Hezbollah from firing them during the conflict. Unconfirmed reports suggest that Hezbollah has or had as many as 220 Zelzal missiles, although the number operable today - between years of wear and tear and Israeli raids - is unknown.

Iranian exports to the heart of the Middle East are believed to travel two routes. Some weapons are air-shipped over Iraq to Syria and Hezbollah, a route that has only been available since the fall of Saddam. Most proliferation, however, travels by water, allowing foreign intelligence agencies the opportunity to track and occasionally interdict these shipments.¹⁰² Despite this, Iran has continued to supply Hezbollah and Syria with missile systems, as this integration of ballistic technology and proxy war forms an integral component in Iran's extension of its strategic reach in the Middle East.

Currently, Iran's ballistic program appears to be making a transition from net importer to net exporter of ballistic technology. While it still may be importing some components from North Korea - likely engines - Iran either has already made or has attempted to make the switch to self-sufficiency. For solid fuel, Iran appears to be self-sufficient for its smaller missiles (Zelzal and Fateh-110), and maybe self-sufficient for the larger Sejil-2 as well. Open sources indicate that it still may be working with China in advancing solid-fuel technology, but it is already sufficiently advanced to help Syria assemble and perhaps produce its own first-generation solid-fuel rockets.

The Missile Defense Challenge

Missile defense poses a growing challenge to both the US and its allies, and to Iran – particularly as Iran uses short and medium rockets and missiles to extend the strike range of its land, air, and sea forces, and to compensate for the weaknesses in its air forces. The US and its allies must deal with the current threat posed by Iranian artillery rockets and missiles, and the future threats of increasing accuracy, terminal guidance, increased reliability and targeting capability, and layers of different type of fire units in sufficient numbers for volleys to overcome defenses and make up for limits on accuracy and lethality.

The Wikipedia coverage of the Shahab 3 already indicates that Iran has taken serious steps to reduce the vulnerability of its missiles to missile defenses – although much of the following analysis of the Shahab is speculative and based on uncertain data,¹⁰³

...the Shahab-3B differs from the basic production variant. It has improvements to its guidance system and warhead, a few small changes on the missile body, and a new re-entry vehicle whose terminal guidance system and rocket-nozzle steering method are completely different from the Shahab-3A's spin-stabilized re-entry vehicle.

The new re-entry vehicle uses a triconic aeroshell geometry (or 'baby bottle' design) that improves the overall lift to drag ratio for the re-entry vehicle. This allows greater range maneuverability that can result in better precision. The triconic design also reduces the overall size of the warhead from an estimated 1 metric ton (2,200 lb.) to 700 kg (1,500 lb.).

The rocket-nozzle control system allows the missile to change its trajectory several times during re-entry and even terminal phase, effectively preventing interceptor guidance via trajectory prediction by early warning radar - a method nearly all long range ABM systems use. As a high-speed ballistic missile and pre-mission fueling capability, the Shahab-3 has an extremely short launch/impact time ratio. This means that the INS/gyroscope guidance would also remain relatively accurate until impact (important, given the fact that the gyroscopes tend to lose accuracy with longer flights). The CEP is estimated to be at 30–50 meters (98–160 ft.) or less.[9] However, the accuracy of the missile is largely speculative and cannot be confidently predicted for wartime situations.[10]

These improvements would greatly increase the Shahab-3B's survivability against ABM systems such as Israel's Arrow 2 missile as well as being used for precision attacks against high value targets such as command, control and communications centers

Iran, in turn, must deal with the fact that the US, the Southern Gulf States, and other US allies are steadily improving their missile defenses. The US has long agreed to provide the Gulf States and Israel with data that warns them of missile launches and the missile's target. Most Gulf States have greatly improved versions of the Patriot missile defense system that can defend against Iran's Shahab-1 and Shahab-2s, and have some capability against high-speed closures from larger missiles like the Sejil-2 and Shahab-3.

Moreover, Qatar and the UAE have purchased the THAAD wide area theater missile defense system and the US is deploying advanced missile defense ships to the Gulf and the Eastern Mediterranean

Missiles defenses are a key option for both the US and its allies, and for Iran. At present, the US, Israel, Turkey, and the Arab Gulf states have the advantage for containment, deterrence, and defense Much depends, however, on whether Russia or China will sell Iran more advanced missile defense systems.

US, Israeli, and Arab Gulf Systems

As has already been noted, the US has made it clear that it will rely on a combination missile defense and deterrence whether or not Iran does deploy nuclear-armed aircraft and missiles. The U.S. has continued to work with its allies to create missile defense forces in the Gulf, has

supported Israel's missile defense programs, and has laid the ground for missile defense in Europe.

US Missile Defense Forces and Developments

The full performance capabilities of all US missile defense systems are classified, but it is clear that a modified SM-3 destroyed a US satellite at an altitude of 130 nautical miles (240 kilometers), and some sources put its maximum range at 114-230 miles.¹⁰⁴ The US has begun to deploy advanced missile defense destroyers in the Gulf and will upgrade to the Standard SM-6 beginning in 2015. The new US strategy announced in January 2012 calls for four advanced guided missile defense destroyers - with wide area ballistic missile defense coverage - to be based in Rota, Spain that can be used to defend Europe and Israel.

Other key missile defense assets in the region include US Navy Aegis anti-ballistic missile cruisers stationed in the Gulf, and advanced versions of the MIM-104 Patriot surface-to-air missile system that Bahrain, Egypt, Israel, Jordan, Kuwait, and Saudi Arabia have acquired from the US.

The US Missile Defense Agency (MDA) describes US shipborne missile defense capabilities with the SM-3 missile as follows:¹⁰⁵

Aegis Ballistic Missile Defense (BMD) is the sea-based component of the Missile Defense Agency's Ballistic Missile Defense System (BMDS). Aegis BMD builds upon the Aegis Weapon System, Standard Missile, Navy and joint forces' Command, Control and Communication systems. The Commander, Operational Test and Evaluation Force, formally found Aegis BMD to be operationally effective and suitable. The Navy embraces BMD as a core mission. In recognition of its scalability, Aegis BMD/SM-3 system is a keystone in the Phased Adaptive Approach (PAA) for missile defense in Europe.

Regional Defense – Aegis BMD Engagement Capability

- Defeats short- to intermediate-range, unitary and separating, midcourse-phase, ballistic missile threats with the Standard Missile-3 (SM-3), as well as short-range ballistic missiles in the terminal phase with the SM-2.
- Flight tests are conducted by Fleet warships. Each test increases the operational realism and complexity of targets and scenarios and is witnessed by Navy and Defense Department testing evaluators.

Homeland Defense – Aegis BMD Long Range Surveillance and Track

- Aegis BMD ships on Ballistic Missile Defense patrol, detect and track ballistic missiles of all ranges – including Intercontinental Ballistic Missiles and report track data to the missile defense system. This capability shares tracking data to cue other missile defense sensors and provides fire control data to Ground-based Midcourse Defense interceptors located at Fort Greely, Alaska and Vandenberg Air Force Base, Calif. and other elements of the BMDS including land-based firing units (Terminal High Altitude Area Defense, Patriot) and other Navy BMD ships.

Deployment

- As of November 2012, there are 26 Aegis BMD combatants (5 cruisers [CGs] and 21 destroyers [DDGs]) in the U.S. Navy. Of the 26 ships, 16 are assigned to the Pacific Fleet and 10 to the Atlantic Fleet. In response to the increasing demand for Aegis BMD capability from the Combatant Commanders, the MDA and Navy are working together to increase the number of Aegis BMD capable ships. Such efforts consist of upgrading Aegis DDGs to the BMD capability, incorporating Aegis BMD into the Aegis Modernization Program and new construction of Aegis BMD DDGs.

International Efforts

- Aegis BMD is the first missile defense capability produced by the MDA that has been purchased by a military ally. Japan's four KONGO Class Destroyers have been upgraded with BMD operational capabilities.
- SM-3 Cooperative Development Program is the joint U.S.-Japan development of a 21-inch diameter variant of the SM-3 missile, designated SM-3 Block IIA, to defeat longer range ballistic missiles. Deployment begins in 2018.

Future Capabilities

- Engagement of longer range ballistic missiles.
- Improving existing early intercept capability.
- Enhanced terminal capability against short and medium range ballistic missiles.
- Aegis Ashore.
- Increased number of ships and missiles.
- More maritime ally involvement

Given time, the US can also rush additional surface-to-air missile defense units into the Gulf or other friendly regional states, and the US Army will be able to deploy THAAD or SM-6 wide area missile defenses once it acquires and integrates such systems into its forces.¹⁰⁶

The Gulf states, in turn, are expanding and improving their surface-to-air missile forces and acquiring at least limited anti-missile defense capabilities. Most have – or will acquire – the PAC 3 version of the Patriot system, which has a greatly improved anti-missile defense capability as well as greatly upgraded air defense capabilities.¹⁰⁷

The PAC 3 is designed only for the missile defense role and is far more maneuverable than the previous Patriot missile series, including the PAC 2 GEM – which has greatly improved missile defense capability relative to earlier Patriots and can also be used for air defense. The PAC 3 has a more advanced hit-to-kill warhead, and has a much greater range and an advanced Ka-Band seeker that can detect and home in on the missile warhead. It is relatively smaller and 16 can be loaded on a launcher versus only four PAC 2. Unclassified estimates give the PAC-3 a maximum ballistic missile intercept range of 15 kilometers and the improved PAC-3 MSE a range of 22 kilometers.

The US Missile Defense Agency (MDA) states that the PAC 3:¹⁰⁸

- Provides simultaneous air and missile defense capabilities as the Lower Tier element in defense of U.S. deployed forces and allies.
- Works with THAAD to provide an integrated, overlapping defense against missile threats in the terminal phase of flight. Jointly, these systems engage the threat by forming a multi-tier theater defense against adversary missile threats using peer-to-peer engagement coordination, early warning track data, and battle management situational awareness.
- Contributes to the entire system's situational awareness by transmitting precision cueing data to other theater elements while simultaneously protecting system assets against short-range ballistic missiles, large-caliber rockets, and air-breathing threats.
- ...provides detection, track, and engagement of short-range ballistic missiles and cruise missiles. These engagements are further enhanced by networked remote sensors that supply early warning data to increase the probability of success.
- ...has added Upper-Tier Debris Mitigation capability to mitigate the excessive radar load and potential missile waste caused by debris from upper-tier intercepts.

The UAE has already announced plans to buy the new US THAAD wide area missile defense system, including a \$1.96 billion buy of 9 THAAD launchers and 48 missiles, plus additional equipment valued at \$1.135 billion. Qatar has requested the sale of two THAAD units with 12 launchers, 150 missiles, plus parts, training, and logistic support at a potential cost of \$6.5 billion. Possible arms transfer plans are being briefed to other Gulf states.¹⁰⁹

THAAD has a range greater than 200 kilometers and a speed of over Mach 8.24 or 2.8 km/s. It began deployment in the US Army in 2012. It is an advanced missile defense system capable of shooting down a ballistic missile both inside and just outside the atmosphere., and is designed to defend against asymmetric ballistic missile threats. It uses hit-to-kill technology whereby kinetic energy destroys the incoming warhead, and its high altitude intercept reduce the effects of enemy weapons of mass destruction before they reach the ground. The system has for major components:¹¹⁰

- **Launcher:** Truck mounted, highly mobile, able to be stored; interceptors can be fired and rapidly reloaded. **Interceptors:** Eight per launcher.
- **Radar:** Army Navy/Transportable Radar Surveillance (AN/TPY-2) – Largest air-transportable X-band Radar in the world searches, tracks, and discriminates objects and provides updated tracking data to the interceptor.
- **Fire Control:** Communication and data-management backbone; links THAAD components together; links THAAD to external Command and Control nodes and to the entire BMDS; plans and executes intercept solutions.

According to its manufacturer, THAAD,¹¹¹ “can accept cues from Aegis, satellites, and other external sensors to further extend the battle space and defended area coverage, and operates in concert with the lower-tier Patriot/PAC-3 system to provide increased levels of effectiveness.”

Once again, however, Iran cannot compete with the GCC states in this aspect of military capability, much less the combined capabilities of GCC and US forces. Most GCC states also have a wide range of relatively advanced short-range vehicle mounted and manportable surface-to-air missile systems or SHORADs.

As noted earlier the main problem with GCC forces is the lack of true integration and interoperability. This is particularly critical in case of air and missile defenses, where the short flight times over the Gulf, concentration of key targets in the Gulf or near the coast, risk of Iran penetrating through the “edges” of national air defense systems, and problems in deconflicting air and surface-based defense systems all combine to create a clear need for a truly integrated air and missile defense system. The failure to create such a system is the fault of the leaders of the GCC states, and not their military, but it does significantly degrade the real-world capability of this aspect of Gulf forces.

The GCC States and Turkey

As **Figure 13** shows, the US has continued to push for missile defense forces in the Gulf, to support Israel’s missile defense programs, and lay the ground for missile defense in Europe.

The Southern Gulf States have upgraded most of their Patriot systems to the PAC 3 version that has far better missile defense capabilities. The UAE and Qatar are seeking to purchase wide area BMD systems like THAAD, and the GCC is studying the creation of a broader wide area BMD system.

Qatar and the UAE recently requested permission from the United States to buy the THAAD system. Qatar has asked to purchase two fire units, 12 launchers, 150 interceptors, and associated radar units, spare parts, and training. The UAE requested 48 interceptors, nine launchers, and associated spare parts and training. The requested systems were worth over \$7.6 billion, with the bills totaling \$6.5 billion for Qatar and \$1.135 billion for the UAE.¹¹²

In September, 2011 the US and Turkey reached an agreement whereby a missile defense radar site will be constructed only 435 miles from the Turkey-Iran border.¹¹³ While Iran's missiles have not been stated as the exclusive target of the system, it will greatly enable the US' ability to detect and intercept an Iranian missile launch.

This radar station is an element of the US' larger European Phased Adaptive Approach to missile defense, which is comprised of four phases:¹¹⁴

Phase one: the construction of the aforementioned radar system in Turkey as well as the stationing of three Aegis anti-ballistic missile cruisers in the eastern Mediterranean.

Phase two: the deployment of a ballistic missile defense interceptor site at Deveselu Air Base in Romania scheduled for 2015.

Phase three: the installation of a land-based interceptor site in Poland and the deployment of a more advanced Standard Missile-3 (SM-3) interceptor scheduled for 2018.

Phase four: the deployment of more advanced SM-3 interceptors in 2020 to enhance the ability to counter MRBMs and potential future ICBMs missile threats to the US from the Middle East through the deployment of more advanced SM-3 interceptors.

Israel

As for Israel, it first deployed its Arrow missile defense system in 2000, and has integrated them with its Patriot defense systems. It has deployed two Arrow batteries. Their complement of missiles and fire units is not clear, but each fire unit holds six Arrow missiles, and Israel may be deploying a third battery.

Israel has upgraded its system to use the Arrow 2, Mod 4, with US financial and technical assistance. It tested the system in intercepts at altitudes as high as 40 and 60 kilometers, at speeds of up to Mach 9, and at ranges of 90-135 kilometers. The Arrow 2 is designed for intercepts above the stratosphere, in order to ensure that the effects of hitting nuclear, chemical, and biological weapons do not affect the Israeli populations. It uses a blast-fragmentation warhead, rather than hit-to-kill. Israel is developing an arrow 2, Mod 5 to integrate lower altitude missile defense into a layered missile defense using its new Arrow 3.

Israel plans to deploy the Arrow 3 system in 2014 to provide a full exoatmospheric interception capability. The full details of the system are not available, but it is designed to intercept far outside Israeli territory and eliminate the risk of a nuclear, chemical, and biological weapon affecting the territory where the warhead is intercepted and destroyed.

These Israeli defenses inevitably affect the Gulf since they limit Iran's ability to pose a real world threat to Israel along with Israel's nuclear-armed missile forces. Israel is also developing two other systems, however, which may provide a model for upgrading mid-term Gulf missile defenses.

The Israel Iron Dome or Iron Cap system is a mobile system that – like the Arrow – is partially US-funded under the United States–Israel Missile Defense Cooperation and Support Act (H.R. 5327). It is designed to defend against mortars, short-range artillery rockets and missiles firing

from ranges of 4 to 70 kilometers, as well as VSHORAD Missiles System (up to 10 kilometers, and discriminate against those that would hit key populated or infrastructure targets. The system has four major components: Mobile detection and tracking radar - multi-mission radar (MMR); battle management and control unit, sensors, and mobile missile firing unit (MFU) with 20 “TAMIR” interceptors

Its manufacturer, Rafael, is seeking to grow the system to defend against firings up to 250 km and allow it to simultaneous intercept rockets and missiles come from different directions. Iron dome is also capable of anti-aircraft operations against targets flying up to 10,000 meters. It was used extensively against rockets being fired from the Gaza in 2012, and Israel claimed it achieved something like 90% success against the rockets that would have hit population centers out of some 400 fired during this period.¹¹⁵

The second system is David’s Sling or Magic Wand – a system in joint development by Raytheon and Rafael. It is a possible replacement for the IHawks in the IDF, and is an anti-ballistic and anti-cruise missile system with a range of 40 to 300 kilometers. It will use a larger, two-stage missile “Stunner” missile with both radar and electro-optical nose-cone sensors. It is in the final development stage and is due to be deployed in 2013 or 2014.¹¹⁶

While it is unlikely that Arab Gulf states will ever buy Israeli systems, they might buy similar systems made in the US. More importantly, Israel’s shorter range systems illustrate what may be the shape of things to come in the Gulf as Iran makes more long-rang artillery rockets and missiles that can fire across the Gulf or directly into neighboring states like Iraq and Kuwait.

The US and Gulf states may also adapt the missile and rocket suppression tactics that the Israel air force first developed to use against Hezbollah rockets during the war between Israel and the Hezbollah in 2006.¹¹⁷ Israel developed a mix of sensors and on-call strike fighter equipped with precision guided missiles that were often able to take out rocket launchers after their first firing. These tactics have grown steadily more sophisticated since that time, and Israel has shown that missile defense can be combined with anti-missile offense in ways the US and Arab Gulf air forces are well equipped to adopt.

Iran

Iran now has no missile defense capabilities, and Russia and China are Iran’s only potential sources of direct sales of missile defense systems. Iran has shown in the past it is well aware that it would take major deliveries of a new integrated air defense system based around the S-300 or S-400 surface-to-air missiles to begin addressing Iran’s strategic vulnerabilities to an aerial campaign. So far, however, neither Russia nor China has proved willing to sell the Russian version or Chinese modified version of such systems.

Russia halted the sale of modern S-300PMU1 (SA-20 Gargoyle) long range SAMs in 2010, and has since refused since then to reopen the deal. Although a future shift in Russian policy – or Chinese sale of its version – represents a potential risk, this leaves a critical gap in Iran’s conventional capabilities that reinforces its weakness in airpower.

Iran has claimed it is compensating by upgrading its S-200 missile series and by building its own equivalent of S-300/S-400 called the Bavar 373, but its claims to date seem to be sharply exaggerated:¹¹⁸

- “With the changes being made to this system by our experts, the S-200 will be able to deal with threats at medium altitudes in addition to (threats) at high altitudes.” Brigadier General Farzad Esmaeili, commander

of the Khatam-ol-Anbiya Air Defense Base, announced in late September s announced that Iran is upgrading the S-200 long-range surface-to-air missile system.

He also said that after the upgrade of the missile system, it will be renamed because the system will undergo systemic and structural modifications and will be used as a medium-to-high altitude missile system. He stated this would eliminate the need to use medium-altitude missile systems, such as the Ra'ad (Thunder) air defense system, in the areas where the upgraded S-200 will be deployed.

Esmaili also said on September 7, 2012 Iran was building a missile system more advanced than the Russian S-300 missile system, and that missile system, named the Bavar 373 (Belief 373), would replace the need for the S-300 missile system. Tehran Times, September 28, 2012.

<http://tehrantimes.com/politics/101865-iran-upgrading-s-200-air-defense-system>.

- The IRGC displayed its new, domestically designed Ra'ad air medium ranged air to surface missile system during the annual military parade on Friday, which it said was designed to hit US aircraft, and which it said can be equipped with 'Taer' (Bird) missiles, which can trace and hit targets 50km in distance and 75,000 feet in altitude. "The system has been built in a bid to confront US aircraft and can hit targets 50km in distance and 75,000 feet in altitude," Commander of the IRGC Aerospace Force Brigadier General Amir Ali Hajizadeh. September 21, 2012.

Open source intelligence suggests that Iran has only deployed limited upgrades of its Soviet-era SA-5/S-200 medium to high altitude long-range surface-to-air missiles. (The PO Almaz S-200 Angara/Vega/Dubna (Russian Ангара\Вера\Дубна), is called the SA-5 or Gammon by NATO.) Upgraded versions of the SA-5/S-200 s have been tested since 2008, but there are few unclassified data to support ambitious and probably grossly exaggerated Iranian claims for either the upgrades to the SA-5/S-200 or building its own versions of the S-300/S-400.¹¹⁹ While the upgraded system may be more effective than the old SA-5/S-200, it is unlikely to pose a significant threat to American or Israeli aircraft as a long-range air-denial weapon.

As for the developmental Bavar-373 (Belief-373) system, Brigadier General Farzad Esmaili, a commander of the Iranian army's air defense force said to reporters in Tehran on the National Day of Air Defense on September 3, 2012. He stated that the said the system was "30 per cent complete" and that Iran could execute the project without foreign assistance.

"We are through with developing the threat-detection capability of the system, and its sensitive parts have been manufactured in Iran...we have no problem with supplying the missiles needed for this system."

Esmaili went on to say that he hoped the system would be finished by the end of the Iranian year, which would be March 2013, or by March 2014, and would be a "*powerful rival*" for the Russian surface-to-air system. Iran would deploy up to three different types of missiles, with "*higher capabilities than the S-300 in detecting, identifying and destroying targets.*"

Other Iranian officers and officials have made similar claims:

- "We are through with developing the threat-detection capability of the system and its sensitive parts have been manufactured in Iran. We have no problem for supplying the missiles needed for this system.

With this powerful system in our hand, we would not think of S-300 anymore.

Bavar 373 system is an important and completely indigenous achievement that can be a powerful rival for S-300." – Brigadier General Farzad Esmayeeli, Commander of Khatam ol-Anbia Air Defense Base, September 3, 2012.

- "Manufacturing Bavar (Belief) 373 Missile System is in progress and all production needs have been supplied domestically.

This project will soon enter its final stage (of production) and it will be much more advanced than the S-300 missile system.

The flaws and defects of the (Russian) S-300 system have been removed in the indigenous version of the system and its conceptual designing has finished.” – Brigadier General Farzad Esmayeeli, Commander of Khatam ol-Anbia Air Defense Base, September 22, 2011.

- “It is now several years that our defense industries researchers and experts have been designing a system whose capabilities are way beyond the S-300 missile system.

The system has been designed based on our own operational needs.” – Colonel Mohammad Hossein Shamkhali, Deputy Commander of Khatam ol-Anbia Air Defense Base for Research and Self-Sufficiency Jihad, September 22, 2011.

- Defense minister Ahmad Vahidi told Iranian media at Sept. 22, 2010 that they will develop a similar domestic system by themselves: “We have planned to build a long-range air defense missile system similar to S-300. By God’s grace and by the Iranian engineers’ efforts, we will reach self-sufficiency in this regard.”
- “If they do not deliver S-300 defensive system to us, we have replacements and we can supply our operational requirements through innovative techniques and different designs.” – General Hassan Mansourian, Deputy Commander of Khatam ol-Anbia Air Defense Base for Coordination, July 6, 2010.¹²⁰

To put such statements in context, Iran has made many claims for systems it later did not deploy, only deployed in token numbers, or deployed in forms that lacked anything like the capability claimed – such as a radarless version of a supposed SA-6 clone. It is far from clear Iran has the production base required to build a robust air defense network. Moreover, anecdotal unclassified reporting indicates that Iran lacks effective test and evaluation methods and has politicized its technology to the point it sometimes believes its own rhetoric. Exaggerated claims are a sin common to all weapons developers and military powers, but there are signs that Iran sins more than most.

Impact on Deterrence and Warfighting

Missiles pose their greatest threat as nuclear-armed, long-range systems, but it is clear that Iran’s rocket and missile forces blur the distinction between ground and air forces, that the same is true of its sea and air-launched systems, and that Iran’s longer-range systems blur any distinction between missile and air power in both the offensive and defensive roles. The short-range implications of these issues are covered in *Volume One: The Conventional and Asymmetric Dimensions*, but there is no clear separation between the impact of rocket and missile systems based solely on range, anymore that there is a clear separation of missile, land, air, and seapower. Like efforts to distinguish between “asymmetric” and “conventional” warfare, they are potentially useful in structuring an analysis but they have steadily less real world meaning in terms of both deterrence and warfare.

It is also clear that missile defense technology is becoming a key aspect of rocket, ballistic missile, and cruise missile warfare. Just as giving conventional missiles terminal guidance or even accuracy for small volleys to be used in precision strikes can be fundamental game changers, missile defense can radically alter the impact of rockets and missiles on containment, deterrence and warfighting at every level of combat. It also creates a highly uncertain duel in terms of future warfighting since the real world exchange outcomes between missiles and missile defense systems are unproven in major combat, involve systems with limited real world testing, and involve weapons and technology that is constantly evolving.

All of the rocket and missile defenses just discussed also present the problem that they are vulnerable to some degree to countermeasures ranging from tactics as simple as oversaturation of

the defensive system to highly sophisticated penetration technology. A few practical examples illustrate this further dimension of missile warfare.

If, as some Israeli and US experts report, Iran is using relatively simple technologies to make the path of its warheads less predictable to missile defenses, this may have some effectiveness in both reducing the area coverage of missile defenses and their effectiveness even if the warhead is closer to the missile launcher. At the same time, such developments can increase the risk that the warhead will miss its target or tumble in ways that can affect its reliability.

Iran also, however, is allegedly developing missiles with a limited radar cross-section, reducing the reaction time available to anti-missile systems. Like other Iranian claims about improvements in its weapons systems, such an assertion may lack merit and should be treated cautiously. Given Iran's difficulties in producing indigenous rockets and the significant trouble it has had constructing missiles with a range over 2000 km, reliable integration of effective countermeasures is still likely some years away.

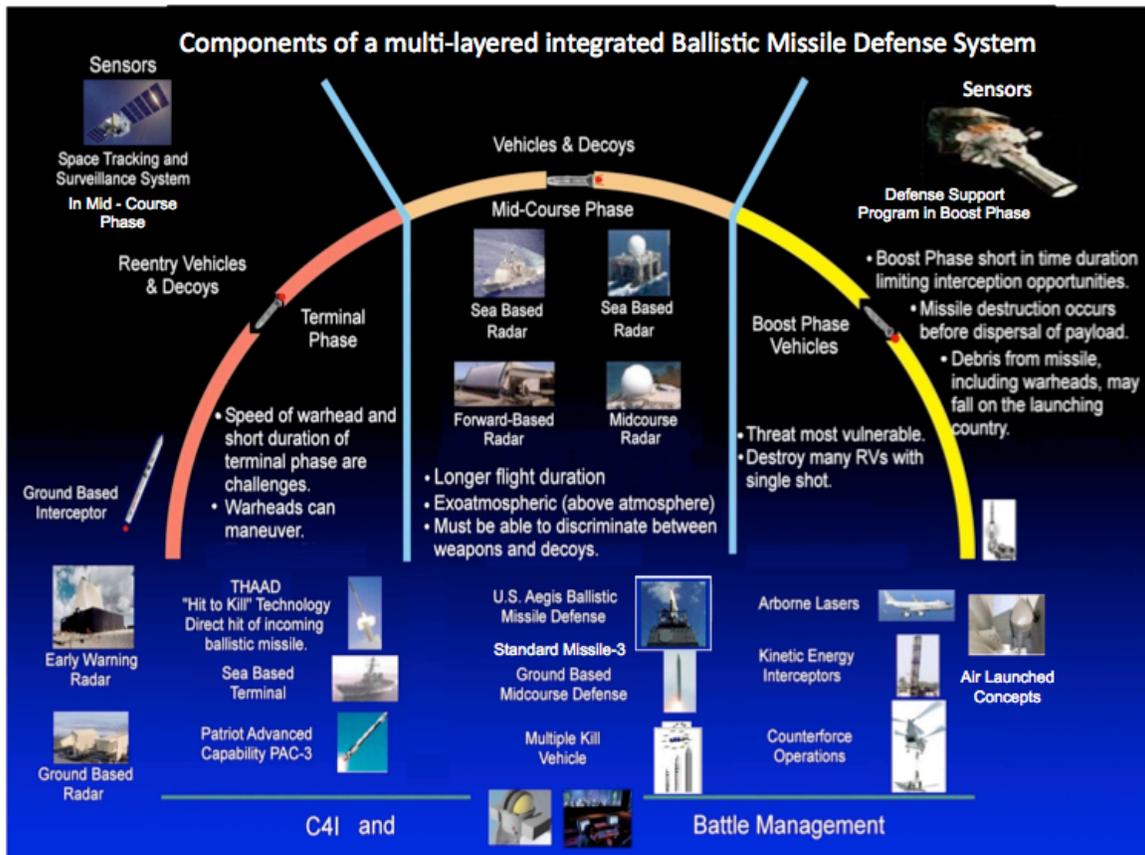
Test, evaluation, simulation, and limited exchanges in actual combat are all useful in building understanding of what is happening. There still, however, is no clear way to estimate real world defense capabilities since there have been no operational cases of sufficient scale to show the relative effectiveness of the improvement in missile defenses versus Iran's missiles and the real-world success of Iran's efforts to improve its missile countermeasures to missile defenses is both classified and untested against Gulf and US missile defenses. While the US has had the opportunity to test its missile defenses against SCUD missiles similar to Iran's Shahab-1 and Shahab-2 weapons, Iran's modifications to these and its use of newer models renders the statistical relevance of these models insignificant.

No system is likely to be "leak proof," or free from vulnerability to saturation or the exhaustion of its stocks of anti-missile missiles - and any exchange would now be one between missiles and anti-missile which both have unproven and unpredictable performance - but Iran's missile threat grows steadily less credible as these missile defenses improve. Moreover, it is one thing to be threatened by the risk that one nuclear-armed missile gets through to a key target area, and quite another to face the risk a few far less lethal missiles get through.

Conventional or even CB-armed missiles become steadily less credible as "terror" or psychological weapons as missile defenses improve. The only risk is that current Iranian doctrine likely calls for overwhelming volleys of weapons to overcome their individual inaccuracy, which would further complicate matters for missile defense. Sheer numbers could overwhelm a nascent anti-missile system, and the leakers, even if highly inaccurate, could still have a propaganda or psychological impact. If worst case estimates are right that Iran estimated possess nearly 1000 missiles that could be fired across the Gulf in 2010 (including shorter range Fateh-110s and Zelzals), defending states would require a massive investment in anti-missile missiles to reduce the number of successful attacks to an acceptable level.

Furthermore, if Iran were to arm its missiles with more effective warheads with accurate and reliable terminal guidance - or develop long-range cruise missiles with such capability - this would significantly change such war fighting calculations. Key export, power, desalination, and military targets could then become targets or hostages. Similarly, even the credible threat - much less use of - CBRN warheads might dramatically upset the regional balance. Such capabilities would provide Iran with a much more solid deterrent, and a greater capability to exercise a bolder and more aggressive regional foreign policy.

Figure 13: Gulf Integrated Missile Defenses



Source: Dr. Abdullah Toukan.

Missiles and Political and Psychological Warfighting

Missile forces also have political dimensions that help Iran fight “wars of intimidation” even in peacetime. At a minimum, Iran’s growing missile forces increase its deterrent and defensive ability to deter attack on Iran and compensate for its weaknesses in airpower. More broadly, Iran can use its missiles politically and strategically, and not simply to damage targets. Selective firings and “volleys” of conventionally armed, unguided long-range missiles and rockets can be used as political symbols or terror weapons. Iran might use its missiles to strike Israel after an Israeli preventive strike, or to strike at Israel in some other contingency where it felt the political symbolism inside Iran and the Arab and Islamic worlds were worth the cost.

Copying Saddam’s strategy from 1991, it could hope to break US-Arab cooperation if Israel retaliates, limiting America’s ability to hinder its regional ambitions. It might take the same approach in an asymmetric war with the US and Arab Gulf States, or after a US preventive strike on Iran. Even a few missile strikes might be seen as a demonstration of Iran’s willingness to escalate even further, or growing future ability to strike with far more effectiveness. Moreover, even token strikes can be used for internal political propaganda purposes.

As was demonstrated during the “war of the cities” during the Iran-Iraq war, by the use of the Scud missile during the Afghan War, and by the Iraqi Scud attacks on Israel and Saudi Arabia during the Gulf War in 1991, weapons of this kind can have a powerful propaganda impact - at least initially. There were reports during the Iran-Iraq War of civilians and officials fleeing Tehran. Iraqis, Israelis, Saudis, and Coalition forces also routinely took shelter during missile attacks, and the Israeli press report many cases of individuals that effectively panicked in 1991 - although perhaps more from fear that missiles might have chemical weapons than out of a fear of missiles or conventional warheads per se.

The initial psychological impact of Iran’s ability to launch a sudden, massive missile barrage on regional population centers and military installations should not be underestimated. Neither should the possibility of a lucky hit producing enough casualties or highly visible damage to have a lasting psychological impact - what might grimly be called the “World Trade Center effect.” Iran’s ability to launch a large volume of missiles over a period of days with little warning before the first round of launches gives Iran leverage and makes such missiles a weapon of intimidation. Even if - and perhaps especially if - they are never used, Iran’s missiles also have the capability to intimidate and leverage Iran’s neighbors, and to force the US and its regional allies to devote resources to missile defense.

These psychological effects, however, wore off relatively quickly. There were not enough missile firings to sustain a high degree of popular fear, and people were soon reported to be going to their roofs at night to “watch the show.” There is simply too much empty area in a given urban complex or large military base for largely random strikes to either produce critical damage or kill enough people to shock or intimidate the population. Limited by the number of TELs and static launching sites, Iran may be unable to continue a bombardment campaign for an extended period of time in the face of Arab or US airstrikes.

The weapons may also have a psychological impact within Iran. Current Iranian retaliatory posture appears to rely heavily on proxy attacks around the world, along with potential military action in the Strait of Hormuz. Hezbollah rocket strikes and bombings at Western targets are unlikely to provide a psychological boost to the Iranian population, as the objective is to hit Israeli and American targets with (semi-) plausible deniability. While Iran has threatened to

target oil shipments, doing so is likely to provoke joint Arab-US escalation, and may not be Iran's primary retaliatory option.

In the face of limited, attrition-like conflict between Iran and the US and GCC, ballistic strikes provide Iran with the chance to show its public that it is prosecuting the war and inflicting casualties on the other side. Framed as retaliation for a combination of sabotage, assassination, sanctions, and potentially overt strikes, ballistic missiles demonstrate to the Iranian population that its government is capable of repaying the suffering it has undergone.

Political aims are likely to be at the heart of Iranian ballistic strategy. Copying Saddam's strategy from 1991, Iran could hope that strikes on Israel lead to Israeli retaliation, leading to political pressure on Arab states to reduce ties to the US. Strikes on Arab states would bring the costs of war home to populations that are ill prepared for conflict, raising the penalties for Gulf publics that have rarely had to face the personal risks stemming from regional instability. For a regional state that is seeking to drive out non-regional powers from the Gulf, successful missile strikes may provide an effective opportunity to demonstrate both the costs of cooperating with the US and its relative powerlessness.

The Impact of Retaliatory Threats and Retaliation

Regardless of how or why Iran uses its missile and other delivery system, Iran cannot operate in an environment where there will be no response. Israel has a wide range of retaliatory and escalatory options, including nuclear-armed ballistic and sea-launched cruise missiles. Saudi Arabia already has long-range, conventionally armed Chinese missiles that can strike area targets in Iran, and the UAE has some SCUD-B missiles (likely equivalent to Shahab-1s). There are questions about the status, reliability, readiness, and accuracy of the Saudi and Emirati missiles, but these same questions apply to Iran's forces. This raises the specter of any missile "war of the cities" of the kind observed between Iran and Iraq.

Iran also faces the risk of retaliation by the best air forces of the Gulf as states like Saudi Arabia and the UAE acquire steadily better strike fighters with sophisticated stand-off, air-to-surface weapons. While their precision munitions are less likely to terrify civilian populations, they provide an effective infrastructure targeting capability that Iran, under international arms sanctions, can do little to reduce. Iran is becoming more vulnerable to Southern Gulf air forces as they acquire missile defenses and become less vulnerable to Iranian missiles.

Any Iranian use of long-range missiles against another Gulf state presents a broader escalatory problem for Iran. Even one such missile firing would effectively escalate to a level where the US would have no clear limits on its use of air and cruise missile power to strike at strategic targets in Iran. Iran's major cities are as vulnerable in terms of power, water, and fuel supplies as the cities of the southern Gulf, and Iran's refineries and certain key links in its ports and transport systems are highly vulnerable as well. Iran cannot possibly win a contest in escalation with its current conventional forces and conventionally armed missiles, and such a contest could spiral into an asymmetric or unconventional war that is costly and destructive for all sides.

Moreover, the first time Iran uses even a conventionally armed missile, it may create conditions that lead to some form of US guarantees and "extended deterrence." The US has stated that it will not accept an Iran with nuclear weapons, but even if it does, this scarcely offers Iran security or freedom from preemption and retaliation. Should Iranian nuclear efforts prompt Riyadh to

develop its own nuclear program, as was mentioned previously, this would only increase the risks of escalation if Iran uses its ballistic missiles.

These risks will also increase if Iran does deploy missiles with weapons of mass destruction even if it does not use them. The US Director of National Intelligence, James R. Clapper, touched on this case in his Worldwide Threat Assessment for 2012 statement:¹²¹

We judge Iran would likely choose missile delivery as its preferred method of delivering a nuclear weapon. Iran already has the largest inventory of ballistic missiles in the Middle East, and it is expanding the scale, reach, and sophistication of its ballistic missile forces, many of which are inherently capable of carrying a nuclear payload.

We judge Iran's nuclear decision-making is guided by a cost-benefit approach, which offers the international community opportunities to influence Tehran. Iranian leaders undoubtedly consider Iran's security, prestige, and influence, as well as the international political and security environment, when making decisions about its nuclear program.

Iran's growing inventory of ballistic missiles and its acquisition and indigenous production of anti-ship cruise missiles (ASCM) provide capabilities to enhance its power projection. Tehran views its conventionally armed missiles as an integral part of its strategy to deter—and if necessary retaliate against—forces in the region, including US forces. Its ballistic missiles are inherently capable of delivering WMD, and, if so armed, would fit into this strategy.

Clapper was also reported to have said during his testimony that Iran might get a nuclear device in as short as a year under worst case conditions and arm a missile in as little as two more years.

As has already been mentioned and is discussed in more detail later in this analysis, Iran cannot win either any arms race in which the US takes part, or any process of escalation that involves the US and Israel. Iran's actions have almost certainly already provoked Israel into developing the capability to target thermonuclear warheads on every major Iranian city, creating an "existential" threat to Iran long before Iran will pose one to Israel. Saudi Arabia and the GCC states may well have the option of turning to Pakistan for nuclear-armed missiles, and senior Saudi officials have said Saudi Arabia has examined nuclear options. The US has also officially offered its regional friends and allies "extended deterrence" of the kind it once provided to Europe during the Cold War - essentially confronting Iran with an open-ended threat of US retaliation.

Even if Iran does go nuclear as part of this aspect of its competition with the US and its Gulf neighbors, it is far from clear that it will not suffer more than any nations it attacks. No one can downplay the psychological and political impact of even the threat of nuclear strikes, the deterrent impact it might have in limiting a response to Iran's use of asymmetric warfare, or the risk of some "accident" or miscalculation. The worst moments in history rarely occurred because of accurate calculations by rational bargainers.

Impact on Policy

Given this analysis, it is clear that Iran's ballistic missile programs serve several strategic goals.

- One is a population and infrastructure-centric approach based on large numbers of SRBMs that can strike across the Gulf or into Iraq and Kuwait and provide a coercive edge in a dispute with Iran's Arab neighbors.
- These systems act as a substitute for advanced strike aircraft and may well exist in numbers that could saturate or exhaust missile defenses.

- They can be used to attack area and population targets and while they would have limited lethality, they could have a major political and psychological impact.
- They are systems that Iran can use to arm movements like Hezbollah and attack or threaten a state like Israel indirectly.
- Iran's longer-range, conventionally-armed MRBM and IRBM forces can be used to intimidate Iran's neighbors and other states at much longer ranges, and
- Conventionally-armed MRBM and IRBM forces can also conduct conventional attacks on area targets like population centers and infrastructure. They only exist in limited numbers and they too have limited lethality. They still, however, have value as weapons of political intimidation.
- Longer-range anti-ship cruise and ballistic missiles already supplement Iran's conventional and other asymmetric forces, while posing a different form of "stacked threat" to the flow of world oil exports at the strategic level.

These threats will remain limited until Iran acquires nuclear warheads and/or more lethal conventional warheads with terminal guidance. The prospect of salvos of conventionally missiles already provides a serious threat. Even relatively large salvos of such weapons would be unlikely to have a major lethal impact even on large area targets, and even if they proved capable of saturating or penetrating missile defenses. However, would largely have the effective of increasing the political or terror impact of strikes that

The practical question for US and allied policy is what level of missile threat can be tolerating and is safe to deter and contain. There seems to be a current consensus that a nuclear-armed forces cannot be tolerated and would lead to preventive strikes. Nuclear-armed missile forces that can do massive damage to any area target and provide a far more effective deterrent against US, Israeli, and European interference in Iran's sphere of influence within the Gulf - and shield against attacks on Iran's asymmetric forces.

An Iran armed with missiles with nuclear warheads and massive capability for asymmetric warfare would not need to match other states in advanced conventional arms, and would be seen as a dominant regional power unless Arab states also acquired nuclear weapons or a convincing commitment to extended deterrence from the US.

US declared policy is that no Iranian nuclear weapons capability would be tolerated. It is one thing, however, to threaten and another to act. As is discussed later in this analysis, it is unlikely that an Israeli strike could have lasting impact and a truly successful US strike would be a major attack, one requiring restrikes, and one that would probably require the support of the Arab Gulf states for the US to sustain its impact over time.

What is less clear is whether Iran's acquiring long-range missiles with terminal homing would or would not be tolerated. While the current accuracy of its missiles so far does not permit it to threaten grievous damage to key targets, the US and its allies need to pay as much attention to future improvements in guidance systems and conventional payloads as Iran's efforts to deploy nuclear warheads.

Iran may not have missiles with sophisticated and reliance terminal homing capability or point target destruction capability for some years, but the current focus on Iran's nuclear programs may understate the future limits to containment and deterrence. It may also understate the priority the US and its allies should give to deploying the most advanced missile defenses and agreeing on some form of US extended deterrence.

Given the vulnerability of key Gulf water, petroleum, and infrastructure facilities, there is the prospect that such forces could become “weapons of mass effectiveness even against better missile defenses if fired in large salvos. Quantity imposes its own quality in warfare, and Iran’s ballistic missile stocks are larger than the strategic anti-missile holdings of the GCC.¹²² While the Gulf States are improving their missile defenses, given the need to have multiple interceptors for each attacking missile, Iran is likely to maintain an edge.

This also means that the US and its allies should base their defense and deterrence on dealing with the combined prospect of an Iranian nuclear warhead and precision conventional strike capability. They need to consider both in deciding what forms of preventive strike, counterstrike, or preventive attacks are needed. The risk Iran will acquire a precision conventional strike capability indicates that if the US does carry out a preventive strike on Iran’s nuclear facilities, it should destroy as many of Iran’s missiles and missile RDT&E and production facilities as possible. It also raises questions about whether such preventive attacks should be carried out against any Iranian deployed or still longer-range systems - particularly ones with ICBM-like ranges - even if Iran does not appear to be creating nuclear warheads.

As for containment, deterrence and retaliation, Iran has much to fear from both the US and its Arab neighbors. Iran appears unlikely to develop any ability to launch a meaningful strike against the US in the near future. While its missile program has made significant strides, it still faces substantial challenges in building a force that could reach the United States. A true intercontinental ballistic missile would almost certainly require improved engines, more efficient multi-staging technique, advanced guidance systems, and larger and lighter construction components, all which would require development and testing. Until such a threat materializes, Iran will lack the ability to deter the US from supporting the Arab Gulf states, Israel, and its other neighbors.

This could make the US offer of extended deterrence an important asset to its Arab allies. It also help keep the threat of US stealth and cruise missile attacks on Iran credible - attacks that could disable its power grid, communications, and key infrastructure, government and military facilities. Weapons of mass effectiveness work in two directions and the US now has such weapons and Iran does not.

Much will depend, however, hinge on the willingness of Arab Gulf states to actively defend themselves, cooperate with the US in some form of preventive strikes and retaliation prove necessary, and on their ability to destroy incoming missiles. While the MTCR restricts what ballistic weapons the US can supply to Gulf States, there are no limits on anti-missile cooperation. Neither are there any restrictions on supporting Gulf efforts to build up strike aircraft and ground attack munitions.

While strike aircraft lack the speed, firepower, and limited opportunities for air defense, their precision and cheapness could allow Gulf States to go air strike for missile with Iran, targeting Iranian infrastructure in return for Iranian ballistic strikes. Moreover, the threat of Gulf air strikes on Iran may not match the impact of some formal US guarantee of extended deterrence or giving the GCC states their own missiles, but it could provide enough additional security to reduce the risk of a steadily deepening arms race, provide a cheaper and more controlled escalation potential, and limit the advantages Iran accrues from its ballistic program in the region.

Nuclear Competition: Estimating and Reacting to the Iranian Nuclear Threat

Important as Iran's asymmetric and missiles threats are, Iran's nuclear programs present the most controversial and uncertain aspect of its military efforts and competition with the US and its neighbors. Iran's nuclear activities also indicate that it is involved in developing nuclear weapons: Iran does continue to increase its enrichment capacity, its research and development efforts suit other efforts to develop nuclear weapons technology, Iran refuses to provide key data on its programs that it is obligated to provide to the IAEA by the NPT, and it does not allow IAEA inspectors to inspect some key facilities.

Iran's efforts to develop its nuclear capabilities track closely with a nuclear weapons program, but there are no "smoking guns" that absolutely prove it is seeking nuclear weapons, and no Iranian statements that provide a clear indication of how Iran might deploy them and use for political or military purposes.

The most that can be said is that the weight of evidence strongly indicates Iran is actively developing nuclear weapons and has clear reasons to do so. While Iran continues to deny that it is seeking nuclear weapons every new IAEA and media report documents further indicators that Iran is actively developing the capability to manufacture and deploy nuclear weapons if it chooses to do so. Moreover, Iran's history of vulnerability to outside meddling and invasion, its nationalism, and its ambitions for regional power and influence are all obvious motives, as is the recent history of British and Russian occupation during World War II.

The Shah was detected importing weapons-related technology and equipment before his fall from power, and while Khomeini originally seemed to oppose such a program, Iraq's use of missiles and chemical weapons against Iran's civilian targets during the Iran-Iraq War gave Iran a new incentive to acquire unconventional weapons. The US military role in the Gulf, and the steady buildup of the conventional forces of Iran's Arab neighbors have since created a new set of incentives as has Iran's tensions with a nuclear-armed Israel.

Military necessity provides another strong set of motives. The previous analyses of the strengths and weakness of Iran's asymmetric and conventional military forces, and of its missile forces, also highlights the fact that Iran's conventional weakness makes it acutely vulnerable to US or Gulf conventional escalation if Iran uses its forces for asymmetric warfare. It also highlights the limits in its conventionally armed missiles. This creates a strong military incentive for Iran to develop and deploy nuclear-armed missiles as an "equalizer."

Iran's Statements about Its Nuclear Program

Iran denies it is seeking nuclear weapons, and there is no clear way to use open source material to determine Iranian intentions, the truth of any given Iranian statements, determine how Iran would use a nuclear break out capability, know whether Iran would go on to deploy nuclear weapons, or determine how Iran would exploit such nuclear capabilities politically and militarily.

Iran has, however, made statements regarding the nature of its nuclear program and its role in competition with the US and other countries that provide at least limited insights into Iranian attitudes:

- It is not acceptable to Iran to respect the NPT and the (International Atomic Energy) Agency's rules, while the US and the West ignore the NPT, including its Article 6 (which underlines decreasing the number of

nuclear weapons) and Article 4 (which stresses every country's inalienable right to use the civilian nuclear technology), therefore, there is no reason for Iran to remain a member of the NPT and the Islamic Consultative Assembly (the Parliament) can give this issue a second thought." - Alaeddin Boroujerdi, Chairman of the parliament's National Security and Foreign Policy Commission, April 8, 2013. <http://english.farsnews.com/newstext.php?nn=9107158720>

- "Iran has on many occasions announced that it has (the use of) a peaceful nuclear technology on its agenda and will have the necessary cooperation with the IAEA within the framework of the NPT (Non-Proliferation Treaty). But the westerners are apparently after taking advantage of this humble stance, do not do the things which could make Iran revise this path of interaction." - Ali Larijani, Speaker of the Parliament, March 10, 2013. <http://english.farsnews.com/newstext.php?nn=9107151630>
- "The final production line of these centrifuges has finished...The early generation of these centrifuges which have low efficiency will be put away soon. We unveiled the first cascade of the new generation centrifuges in February 2012 and after that our studies completed in that pilot (cascade)...We should install a large number of such systems to reach (the level of) industrial production...Installation of the new centrifuges started in Natanz around a month ago, we will be able to complete the laboratory of the new generation centrifuges." - Fereidoon Abbasi, Head of the Atomic Energy Organization of Iran, March 3, 2013. <http://english.farsnews.com/newstext.php?nn=9107149574>
- The negotiating team should defend the Iranian nation's rights within the framework of the Non-Proliferation Treaty (NPT) and the IAEA rules and base any agreement on these rights and national interests...As representatives of the great Iranian nation, we propose that the US and its western allies accept the Islamic Republic of Iran's today nuclear realities and change their policy of confrontation to interaction and learn that Iran's nuclear train, which is moving on the rails of peaceful goals, will never stop." – Statement of Iranian MPs in Regard to the P5+1 Negotiations, February, 24. 2013
- "If Iran intended to produce nuclear weapons, the US by no means could prevent the Iranian nation's bid...The Islamic Republic of Iran doesn't intend to produce nuclear weapons and this is not related to the US concerns, rather it is based on the belief which assumes (production and use of) nuclear weapons as a crime against humanity and while it lays emphasis on its non-production, it also urges elimination of the existing nuclear weapons in the world." - Supreme Leader Ayatollah Ali Khamenei, February 6, 2013. <http://english.farsnews.com/newstext.php?nn=9107144928>
- "They should respect our concerns, including our right within the framework of the Non-Proliferation Treaty (NPT) for taking peaceful advantage of the nuclear energy, inclusive of having access to the full process of enrichment and fuel provision for our facilities, which is inclusive of uranium enrichment." - Ali Akbar Salehi, Iranian Foreign Minister, February 5, 2013. <http://english.farsnews.com/newstext.php?nn=9107141954>
- "The two sides (Iran and world powers) have reached a conclusion that they must exit the current stalemate." - Ali Akbar Salehi, Foreign Minister, December 17, 2012. <http://www.reuters.com/article/2012/12/17/us-iran-nuclear-idUSBRE8BG0DK20121217>
- "The Islamic Republic of Iran doesn't possess atomic bombs and is never after this weapon as it believes that this weapon has not efficiency (any more)...Atomic bomb has never been able to solve the economic and social problems of the European states like France and Britain while these countries incur huge costs for their storage and maintenance..." - President Mahmoud Ahmadinejad, December 10, 2012. <http://english.farsnews.com/newstext.php?nn=9107125736>
- "Despite sanctions, we will most likely see a substantial increase in the number of centrifuge machines this year. We will continue enrichment with intensity..." - Fereidoun Abbasi, Head of the Iranian Atomic Energy Organization, November 28, 2012. http://www.washingtonpost.com/world/middle_east/iran-nuclear-chief-enrichment-to-move-ahead-with-intensity/2012/11/28/98834224-3965-11e2-9258-ac7c78d5c680_story.html
- "We presented false information sometimes in order to protect our nuclear position and our achievements, as there is no other choice but to mislead foreign intelligence...sometimes we present a weakness that we

do not in fact really have, and sometimes we appear to have power without having it.” - Fereydoon Abbasi, head of the Atomic Energy Organization of Iran, talking about Iran issuing false information on its nuclear program, September 16, 2012. <http://www.nytimes.com/2012/09/21/world/middleeast/iran-atomic-official-says-it-gave-false-nuclear-information-to-fool-spies.html?ref=internationalatomicenergyagency>

- “According to the international rules, use of the civilian nuclear technology is the right of all the world countries. Everyone should be entitled to make use of this safe energy for various vital purposes for their country and nation and should not depend on others for putting this right into effect...A few western countries which possess nuclear weapons themselves and have embarked on this illegal action (possession of the nuclear weapons), intend to keep monopolizing the ability to produce nuclear fuel” - Supreme Leader Ayatollah Ali Khamenei, August 30, 2012. <http://english.farsnews.com/newstext.php?nn=9106060650>
- “We insist on our right to enrich uranium for the peaceful use of nuclear energy. There is no proof that we are pursuing nuclear research for military purposes. We have to differentiate between two things here: First, we have our obligations under the non-proliferation treaty, which we are fulfilling... second, there are demands that go beyond this, and that we are not obliged to meet, such as those relating to a military complex like Parchin... If our right to enrichment is recognized, we are prepared to offer an exchange. We would voluntarily limit the extent of our enrichment program, but in return we would need a guaranteed supply of the relevant fuels from abroad.” Ali Akbar Salehi, Foreign Minister, August 8, 2012. <http://www.spiegel.de/international/world/iranian-foreign-minister-salehi-on-syria-and-nuclear-weapons-a-860015.html>
- “(A) constructive and positive attitude towards the Islamic Republic of Iran’s new initiatives in this round of talks could open positive perspective for our negotiation. Therefore...I propose to resume our talks in order to take fundamental steps for sustainable cooperation in the earliest possibility in a mutually agreed venue and time.” - Iranian chief negotiator Saeed Jalili, February 16, 2012. <http://www.reuters.com/article/2012/02/16/us-iran-idUSTRE81E0RF20120216>
- “The era of bullying nations has past. The arrogant powers cannot monopolize nuclear technology. They tried to prevent us by issuing sanctions and resolutions but failed. Our nuclear path will continue.” - President Mahmoud Ahmadinejad, February 15, 2012. <http://www.reuters.com/article/2012/02/15/us-iran-idUSTRE81E0RF20120215>
- “The U.N.’s chief nuclear inspector arrived in Iran on Sunday on a mission to clear up “outstanding substantive issues” on Tehran’s atomic program, and called for dialogue with the Islamic state. We have always had a broad and close cooperation with the agency and we have always maintained transparency as one of our principles working with the agency.” - Iranian Foreign Minister Ali Akbar Salehi, January 29, 2012. <http://www.alarabiya.net/articles/2012/01/29/191187.html>.
- “Iranian nation cannot be defeated... Not only should we be able to use all our capacities and potentials in nuclear technology, we should also export nuclear know-how.” - Iranian President Mahmoud Ahmadinejad, April 9, 2011. . <http://edition.presstv.ir/detail/173889.html>
- “Iran plans to build four to five new reactors with a capacity of 10 to 20 megawatts in different provinces within the next few years to produce radio-medicine and perform research...Fuel production or uranium enrichment to a purity level of 20 percent will not be halted. Iran will produce fuel for the Tehran Research Reactor in due course...To provide the fuel for these reactors, we need to continue with the 20-percent enrichment of uranium.” - Fereydoon Abbasi, head of the Atomic Energy Organization of Iran, April 12, 2011. <http://edition.presstv.ir/detail/fa/174371.html>
- “We will transfer the 20 percent enrichment from Natanz to the [Qum] site this year, under the supervision of the (International Atomic Energy) Agency. We will also triple the (production) capacity. The 20 percent enrichment will not be stopped at Natanz until the production level is three times higher than its current rate.” - Fereydoon Abbasi, head of the Atomic Energy Organization of Iran, June 8, 2011. http://www.armscontrol.org/act/2011_%2007-08/%20Iran_to_Boost_Enriched_Uranium_Output.

- “The day after the first Iranian nuclear test for us Iranians will be an ordinary day, but in the eyes of many of us, it will have a new shine, from the power and dignity of the nation.” - Excerpt from a text entitled “The Day After the First Iranian Nuclear Test - a Normal Day,” which was posted on the IRGC-run Gerdab website, June 9, 2011. <http://www.guardian.co.uk/world/julian-borger-global-security-blog/2011/jun/08/iran-blogging>
- “No offer from world leaders could stop Iran from enriching uranium.” - Iranian President Mahmoud Ahmadinejad, June 7, 2011.
- “When we say we do not want to make bomb it means we do not want to. If we want to make a bomb we are not afraid of anyone and we are not afraid to announce it, no one can do a damn thing.” - Iranian President Mahmoud Ahmadinejad, June 23, 2011. <http://www.google.com/hostednews/afp/article/ALeqM5hH8mB4iW9MJ6ElbozG5o8-QLZDqA?docId=CNG.34a096065d43eb06d18ea86500b8f1a9.01>

Once again, it must be stressed that no recent Iranian statement describes a nuclear weapons program. Iranian officials usually insist that their country’s nuclear program is for solely peaceful purposes, namely research and the production of nuclear power and medical isotopes. It is clear, though, that Iran perceives its nuclear program as a source of national pride.

Iranian officials do, however, regularly make defiant statements about increasing the production of uranium enriched to 20%, and indirect statements about producing a nuclear weapon. For example, Iranian President Mahmoud Ahmadinejad stated the following at a June 23, 2011 inauguration of a sewage treatment plant in southern Tehran:

“When we say we do not want to make bomb it means we do not want to. If we want to make a bomb we are not afraid of anyone and we are not afraid to announce it, no one can do a damn thing.”¹²³

US Official Views of Iran’s Competition in Nuclear and Missile Efforts

The US, most European countries, most Arab states, Israel and many other countries and experts have a very different view. They have long seen Iran as on the path to acquiring nuclear weapons and as actively seeking nuclear-armed missile forces. At the same time, there are serious differences between experts and national views are particularly important in assessing Iran’s nuclear weapons program. In spite of the steady disclosure of more information on Iran’s nuclear efforts – such as the IAEA report issued in November of 2011 – data are lacking on many aspects of Iran’s current nuclear and missile efforts, and experts are forced to speculate.

The military annexes to the November 2011 IAEA report indicated that Iran has made major progress in assembling all the technology and developing the manufacturing skills and equipment necessary to design a fission warhead. The annexes indicated that Iran is closer to building a warhead small enough to mount on a missile and test it through simulated explosive testing than has previously been publically reported. IAEA reporting since that time has provided more indicators that Iran is close to being able to test a Uranium fission device once it obtains weapons grade Uranium, and key US experts indicate that Iran may have acquired more weapons design and passive test data than the IAEA has yet announced.

There are still experts, however, who question whether Iran is seeking nuclear weapons, or whether it desires a stronger bargaining chip for dealing with the West or wants the prestige and regional influence stemming from a nuclear program. There is no consensus over how soon it will be able to get the weapons-grade fissile material it needs or then advance to the point where it can able deploy nuclear bombs and missile warheads.

There are significant uncertainties over how many nuclear facilities Iran really has and how far it has gotten in producing more advanced centrifuges like the IR-2 and IR-4. Some experts estimate that even the IR-2 could be far more reliable and have some six times the output of the IR-1, making it far easier to disperse and conceal. The IR-4 would presumably be even more efficient, allowing Iran to conceal enrichment activity in smaller spaces and disperse such activity at much lower cost. Other uncertainties exist over its reactor project in Arak and whether it will seek more power reactors in ways that might affect its future weapons production capabilities. “Guesstimates” are notoriously unreliable – particularly in their worst-case form.

As yet, there are only limited unclassified data that allow open sources to assess the size and nature of any Iranian plans to deploy a nuclear-armed force; determine what role various types of aircraft and missiles might play; determine how such a force will be based; and assess what kinds of command, control, computer, communications, and intelligence (C⁴I) systems Iran might deploy.

It is clear that Iran has modified the warhead of its Shahab-3 variants in ways that would make it easier to mount a nuclear weapon, and that Iran is constantly testing variants of its existing missiles and claiming it is producing new types, as well as using alleged satellite launches as a vehicle for research and development into ballistic missile technology. It is shifting from liquid-fueled missiles to solid-fuel types, enabling it to build rockets with greater ranges and an improved capacity to launch on warning in the face of a surprise attack, and it keeps changing warhead configurations.

Moreover, the annual unclassified reports to Congress by the US Director of National Intelligence do offer a relatively apolitical official overview of US perceptions and estimates - views that now seem to track closely with the views of many European and Gulf officials and experts.

The unclassified report produced by the Office of the Director of National Intelligence in February 2012 provides a useful picture of how the US intelligence community judges Iran’s capabilities:¹²⁴

Nuclear

During the reporting period, Iran continued to expand its nuclear infrastructure and continued uranium enrichment and activities related to its heavy water research reactor, despite multiple United Nations Security Council Resolutions since late 2006 and most recently in June 2010 calling for the suspension of those activities. Although Iran made progress in expanding its nuclear infrastructure during 2011, some obstacles slowed progress during this period.

- In 2011, Iran continued to make progress enriching uranium at the underground cascade halls at Natanz with first-generation centrifuges, and in testing and operating advanced centrifuges at the Natanz pilot plant. As of early November, Iran had produced about 4,900 kilograms of low-enriched uranium hexafluoride (LEUF6) gas product at Natanz, compared to about 3,200 kilograms by November 2010 and 1,800 kilograms of LEUF6 in November 2009. Iran’s holdings as of November 2011 include about 4,150 kg of 3.5 percent LEUF6 and about 80 kg of 20-percent enriched UF5. Between August 2010 and November 2011, Iran decreased the number of installed centrifuges from about 8,900 to about 8,000, but the number reported to be operating is around 6,200, up from about 3,800 in August 2010.
- Iran has installed centrifuges at the underground Fordow Fuel Enrichment Plant near Qom and initiated production of near-20 percent enriched uranium there. Iran has declared it plans to use Fordow for both production of enriched material as well as centrifuge research and development.

- Iran in 2011 continued construction of the IR-40 Heavy Water Research Reactor and it claims it will attempt to commence operations there by the end of 2013.
- Iran in 2011 commenced low-level reactor operations at the Bushehr Nuclear Power Plant but has not yet operated it at full power.
- Iran's Uranium Conversion Facility (UCF) at Esfahan shut down for maintenance in August 2009 and Iran had postponed UF6 production as of early November 2011. International Atomic Energy Agency Director General reports to the Board of Governors indicate Iran has almost exhausted its imported stockpile of yellowcake.

Ballistic Missiles

Iran has continued to develop its ballistic missile program, which it views as its primary deterrent. Iran is fielding increased numbers of short- and medium-range ballistic missiles (SRBMs, MRBMs) and we judge Tehran will continue to work on producing more capable MRBMs and developing space launch vehicles, which incorporate technology directly applicable to longer-range missile systems. Iran's ballistic missile inventory is one of the largest in the Middle East.

- Iran as of 2011 continues to develop an anti-ship variant of its Fateh-110 SRBM called the Kalij Fars, which would represent an additional Iranian threat to military and commercial vessels in the Persian Gulf and Gulf of Oman.
- An Aerospace Division commander in the Islamic Revolutionary Guard Corps in early 2011 announced Iran had launched two long-range ballistic missiles into the Indian Ocean. However, the official did not provide further detail on the types of missiles.
- In late May 2011, Iran's defense minister claimed that the new Qiyam-1 SRBM cuts down on launch preparation timelines and reduces detection to anti-missile systems, according to press reports.
- Iran in late June and early July launched a series of missiles and rockets as part of its Noble Prophet VI military exercise, including Shahab-1/2 SRBMs, a Shahab-3 MRBM, and Zelzal rockets. Iran also publicized its underground ballistic missile launch silos that it claims are less vulnerable to attack. As early as 2005, Iran stated its intentions to send its own satellites into orbit. As of January 2008, Tehran reportedly had allocated \$250 million to build and purchase satellites. Iran announced it would launch four more satellites by 2010 to improve land and mobile telephone communications.
- Iran in mid-June 2011 launched the Rasad satellite on board a Safir space launch vehicle (SL V), which was the same type SLV used to launch the Omid satellite in February 2009, according to press reports.
- In October 2011 Iran announced it would launch the Fajr satellite into space by 2012, along with other announcements related to advances in their space program.
- In mid-August 2008, Iran first launched the Safir, carrying the Omid satellite. Iran claimed the launch a success; however US officials believed the vehicle did not successfully complete its mission.
- In February 2010, Iran displayed a much larger space launch vehicle dubbed the Simorgh, as well as its first stage clustered engines. Iran claims the Simorgh can launch a 100kg satellite into a 500km orbit, according to press reports. Iran continued to move toward self-sufficiency in the production of ballistic missiles, but almost certainly remains dependent on foreign suppliers for some key missile components. Entities in China and Russia along with North Korea are among likely suppliers. Iran has also marketed at least one ballistic missile system for export.

Chemical and Biological

We assess that Iran maintains the capability to produce chemical warfare (CW) agents and conducts research that may have offensive applications. Tehran continues to seek dual-use technologies that could advance its capability to produce CW agents. We judge that Iran is capable of weaponizing CW agents in a variety of delivery systems.

Iran probably has the capability to produce some biological warfare (BW) agents for offensive purposes, if it made the decision to do so. We assess that Iran has previously conducted offensive BW agent research

and development. Iran continues to expand its biotechnology infrastructure and seek dual-use technologies that could be used for BW.

Clapper's testimony to the Congress on January 31, 2012 provides a further update of the official US position and suggested for the first time that Iran might strike at targets in the US:¹²⁵

We assess Iran is keeping open the option to develop nuclear weapons, in part by developing various nuclear capabilities that better position it to produce such weapons, should it choose to do so. We do not know, however, if Iran will eventually decide to build nuclear weapons.

Iran nevertheless is expanding its uranium enrichment capabilities, which can be used for either civil or weapons purposes. As reported by the International Atomic Energy Agency, to date, Iran in late October 2011 had about 4,150 kg of 3.5 percent LEUF6 and about 80 kg of 20-percent enriched UF6 produced at Natanz. Iran confirmed on 9 January that it has started enriching uranium for the first time at its second enrichment plant, near Qom.

Iran's technical advancement, particularly in uranium enrichment, strengthens our assessment that Iran has the scientific, technical, and industrial capacity to eventually produce nuclear weapons, making the central issue its political will to do so. These advancements contribute to our judgment that Iran is technically capable of producing enough highly enriched uranium for a weapon, if it so chooses.

We judge Iran would likely choose missile delivery as its preferred method of delivering a nuclear weapon. Iran already has the largest inventory of ballistic missiles in the Middle East, and it is expanding the scale, reach, and sophistication of its ballistic missile forces, many of which are inherently capable of carrying a nuclear payload.

We judge Iran's nuclear decision making is guided by a cost-benefit approach, which offers the international community opportunities to influence Tehran. Iranian leaders undoubtedly consider Iran's security, prestige, and influence, as well as the international political and security environment, when making decisions about its nuclear program.

Iran's growing inventory of ballistic missiles and its acquisition and indigenous production of anti-ship cruise missiles (ASCM) provide capabilities to enhance its power projection. Tehran views its conventionally armed missiles as an integral part of its strategy to deter—and if necessary retaliate against—forces in the region, including US forces. Its ballistic missiles are inherently capable of delivering WMD, and, if so armed, would fit into this strategy.

...The 2011 plot to assassinate the Saudi Ambassador to the United States shows that some Iranian officials—probably including Supreme Leader Ali Khamenei—have changed their calculus and are now more willing to conduct an attack in the United States in response to real or perceived US actions that threaten the regime. We are also concerned about Iranian plotting against US or allied interests overseas.

Iran's willingness to sponsor future attacks in the United States or against our interests abroad probably will be shaped by Tehran's evaluation of the costs it bears for the plot against the Ambassador as well as Iranian leaders' perceptions of US threats against the regime.

So did Clapper's testimony in his annual *Statement for the Record Worldwide Threat Assessment of the US Intelligence Community* to the Senate Select Committee on Intelligence on March 13, 2013 (p. 7)

Iran already has the largest inventory of ballistic missiles in the Middle East, and it is expanding the scale, reach, and sophistication of its ballistic missile arsenal. Iran's growing ballistic missile inventory and its domestic production of anti-ship cruise missiles (ASCM) and development of its first long-range land attack cruise missile provide capabilities to enhance its power projection. Tehran views its conventionally armed missiles as an integral part of its strategy to deter—and if necessary retaliate against—forces in the region, including US forces.

Iran is developing nuclear capabilities to enhance its security, prestige, and regional influence and give it the ability to develop nuclear weapons, should a decision be made to do so. We do not know if Iran will eventually decide to build nuclear weapons.

Tehran has developed technical expertise in a number of areas—including uranium enrichment, nuclear reactors, and ballistic missiles—from which it could draw if it decided to build missile-deliverable nuclear weapons. These technical advancements strengthen our assessment that Iran has the scientific, technical, and industrial capacity to eventually produce nuclear weapons. This makes the central issue its political will to do so.

Of particular note, Iran has made progress during the past year that better positions it to produce weapons-grade uranium (WGU) using its declared facilities and uranium stockpiles, should it choose to do so. Despite this progress, we assess Iran could not divert safeguarded material and produce a weapon-worth of WGU before this activity is discovered.

We judge Iran’s nuclear decision-making is guided by a cost-benefit approach, which offers the international community opportunities to influence Tehran. Iranian leaders undoubtedly consider Iran’s security, prestige and influence, as well as the international political and security environment, when making decisions about its nuclear program. In this context, we judge that Iran is trying to balance conflicting objectives. It wants to advance its nuclear and missile capabilities and avoid severe repercussions—such as a military strike or regime threatening sanctions.

We judge Iran would likely choose a ballistic missile as its preferred method of delivering a nuclear weapon, if one is ever fielded. Iran’s ballistic missiles are capable of delivering WMD. In addition, Iran has demonstrated an ability to launch small satellites, and we grow increasingly concerned that these technical steps—along with a regime hostile toward the United States and our allies—provide Tehran with the means and motivation to develop larger space-launch vehicles and longer-range missiles, including an intercontinental ballistic missile (ICBM).

The Analyses of the International Atomic Energy Agency (IAEA)

The US may be one of the few countries that makes detailed public intelligence estimates of Iran’s efforts, but great more information has surfaced over the last two decades in the reports of the International Atomic Energy agency (IAEA). This reporting reveals case after case where Iran did not comply with the terms of the Nuclear Non-Proliferation Treaty (NNPT). In each case, Iranian failure to comply seems to contradict Iran’s claims that it is not seeking a weapon, or at least attempting to reach a “breakout” capacity, where Iran is technologically able to produce a weapon and has - or can rapidly produce - the highly enriched weapons grade material needed.

This IAEA reporting, and the evidence involved, is complex. Some key parts are summarized in the Appendix to this report, but fully understanding it requires a careful reading of the full history of the IAEA reports contained on its web page at http://www.iaea.org/newscenter/focus/iaeairan/iaea_reports.shtml - reports that only cover the period since 2003. Much of this material is highly technical and interpreting requires the reader to study outside explanations by groups like the Institute for Science and International Security (ISIS), which is available at sis-online.org/countries/category/iran/. Once again, it is only possible to see how often Iran has concealed, lied, delayed or obfuscated by fully examining the historical record, which in ISIS’s case goes back to 1992.

This latter date is significant because more than two decades ago, press reports and IAEA studies report that a series of secret telexes dating to 1992 emerged in February 2012 that revealed Iranian attempts to procure 220 pounds of highly caustic fluorine gas - a material used in uranium enrichment - in addition to mass spectrometers and other materials used in nuclear programs. These items were purportedly ordered by the Iran’s Sharif University for use in research. These telexes reveal, however, that these materials were intended for a secret research program under the control of the Iranian military.¹²⁶

These telexes - and Iran's attempt at masking the true destination of these materials and equipment - indicate that Iran has been operating a clandestine nuclear program for 20 years. Furthermore, they establish that Iran has engaged in a pattern of deception regarding its nuclear activity since the early 1990s.

US intelligence publically reported in an NIE it issued on Iran in 2007 that Iran did have a formal nuclear weapons program from the early 1990s onwards. The report stated that this program involved a series of projects overseen by "senior Iranian figures" who were directly involved "working level correspondence" consistent with a coordinated program. An Arms Control Association summary of the key findings showed these programs included:¹²⁷

- **Fissile Material Production:** As documented in previous reports, Iran ran an undeclared effort to produce uranium-tetrafluoride (also known as Green Salt), a precursor for the uranium used in the enrichment process. The affiliation between this project and other projects directly related to warhead development suggests that Iran's nuclear weapons program included both fissile material production and warhead development. Although the report does not detail a uranium enrichment effort as part of the AMAD Plan, the secret nature of the Natanz enrichment plant prior to 2002 suggests that it was originally intended to produce the highly enriched uranium (HEU) for weapons.
- **High Explosives Testing:** Iran's experiments involving exploding bridgewire (EBW) detonators and the simultaneous firing of explosives around a hemispherical shape points to work on nuclear warhead design. The agency says that the type of high explosives testing matches an existing nuclear weapon design. Iran admits to carrying out such work, but claims it is for conventional military purposes and disputes some of the technical details.
- **Warhead Design Verification:** Iran carried out experiments using high explosives to test the validity of its warhead design and engaged in preparatory work to carry out a full-scale underground nuclear test explosion.
- **Shahab-3 Re-entry Vehicle:** Documentation reviewed by the IAEA has suggested that, as late as 2003, Iran sought to develop a nuclear warhead small enough to fit on the Shahab-3 missile. Confronted with some of the studies, Iran admitted to the IAEA that such work would constitute nuclear weapons development, but Tehran denies carrying out the research.

The 2007 NIE also reported that Iran seemed to have formally ended this program - at least for cover purposes - in 2003. However, this was the year the US invasion of Iraq both highlighted the strengths of US military power and put US forces on both Iran's western and eastern borders. Moreover, the 2007 NIE also noted that Iran could go on with its efforts using a range of individual programs and research activities.

A new NIE issued in 2012 made this point far clearer by focusing on the record of Iranian actions documented by the IAEA and other sources rather than the declared statements of Iranian officials.¹²⁸

There are still serious differences within the US intelligence community - and between US, Israeli, and other intelligence experts - over whether Iran actually disbanded its program in 2003. Some believe Iran has since resumed a different covert program or never really disbanded its program in 2003 - simply changing the cover structure concealing the program and some key personnel.

The difficulty in making such assessments is illustrated by the fact that the IAEA reporting described in the following parts of this analysis has shown Iran can carry out every part of a nuclear weapons development program except final integration as a series of parallel technology and manufacturing development efforts.

Iran can also create a whole new set of layers to hide a covert program, and it can carry on creating new technologies like improved centrifuges and reactor development which it later can use to set up new enrichment sites in much smaller deep mountain shelters or surface buildings in the nuclear equivalent of a shell game. Virtually every such activity can be explained away if discovered, or denied with varying levels of credibility. Many can also have legitimate dual uses in civil programs, research, or actually be for civil uses.

There is no magic point where a nation reaches the “breakout” level and there are many intermediary stages where Iran can quietly ready its nuclear program for a nuclear test. Going on to enrich material to the level where a weapon can be assembled leaves great ambiguity as to Iran’s intentions and what it may conceal, as well as presents major problems in terms of outside assessments of how far Iran has actually progressed.

Similarly, assembling - or claiming to assemble - a device does not require fissile explosive testing to produce very useful results. As Pakistan demonstrated during its own weapons development efforts, Iran can leave its ability to design a functioning weapon through modeling and simulation a matter of speculation. Non-critical testing of a weapons design or subcritical testing of a fractional explosion is an issue. A nuclear underground test does not reveal the level of progress in weapons design. Testing of simulated warheads may not be detected by inspectors or intelligence agencies and is further hidden due to its lack of reliance on telemetry.

In short, Iran may well have created a complex network of deception, denial, fears, and false claims throughout the process of developing and deploying a nuclear weapon. Moreover, as IAEA reports have now shown over the last decade, Iran can comply with most - or all - of the terms of the NPT and IAEA inspection and still move forward at a slower, more parallel pace.

The Data in the IAEA Report of November 8, 2011 - Understanding Iran’s Activities in Layman’s Terms

These points are illustrated in practical terms in the IAEA’s report on Iran’s programs of November 8, 2011. All of the previous IAEA reporting had focused largely on Iran’s non-compliance in technical terms. This report provided the first detailed military annex the IAEA had ever issued on the military Iran’s programs. The annex was also written in relatively plain English and provided important new indicators that Iran was weaponizing its nuclear programs.

The IAEA found that Iran had engaged in substantial R&D activities to create technology that is critical to developing a functional nuclear weapons program. These activities include the research into and experimentation with detonator technology, multipoint initiators, neutron initiators, exploding-bridgewire detonator (EBW), and other technology that has little, if any, use outside of military applications.

The IAEA found that Iran had engaged in “experimentation which would be useful were Iran to carry out a test of a nuclear explosive device.” While it is impossible to know Iran’s true intentions regarding its nuclear program, these indicators taken with Iran’s refusal to engage the IAEA or the international community substantively on these matters indicate a probable military dimension to the country’s program.

And, the IAEA found Iran had taken steps to integrate a spherical payload into the existing payload chamber on the re-entry vehicle of the Shahab-3 missile, as well as developed fusing, arming, and firing systems that would give re-entry vehicles an airburst capability, or explode on impact with the Earth’s surface.

The November 8, 2011 report provided the IAEA's analysis of the likely payload of an Iranian ballistic missile given the developments in the country's nuclear and ballistic missile programs. While the diagram indicates that an Iranian missile could carry a range of payloads, a nuclear payload is most likely. Although by no means certain, these indicators reflect that Iran likely intends to arm its missiles with nuclear warheads, or achieve the capability to do so.

These points are summarized in **Figure 14**:

Figure 14: Key Points in the Military Annex to the IAEA November 8, 2011 Report on Iran's Nuclear Program

- Describes Iran's lack of cooperation with the IAEA regarding heavy water at the Iran Nuclear Research Reactor (IR-40) at Arak. Although the Agency was allowed access to the site on October 17, 2011, it has not been permitted access since then. According to Iran, operation of the IR-40 reactor is due to commence by the end of 2013. Although the Agency has not been permitted access to the Heavy Water Production Plant (HWPP) since August 17, 2011, satellite imagery has indicated that the HWPP appears to be in operation. Lastly, to date Iran has not allowed the Agency access to the heavy water stored at the Uranium Conversion Facility (UCF) to take samples.
- Provides a description of the IAEA's knowledge of the Uranium Conversion Facility (UCF) as of October 18, 2011. It reflects that Iran is continuing enrichment and heavy water production at the site in contravention of international demands and regulations. It indicates that as of October 18, 2011, the Agency observed the ongoing installation of the process equipment for the conversion of UF₆ (uranium hexafluoride) enriched to 20% into U₃O₈ (triuranium octoxide).
- Provides an introduction and summary of the possible military dimensions of Iran's nuclear program. Importantly, it indicates that Iran has not engaged the IAEA substantively regarding the military dimensions of its program since August 2008, and it stresses the following:
 - Efforts, some successful, to procure nuclear related and dual-use equipment and materials by military-related individuals and entities.
 - Efforts to develop undeclared pathways for the production of nuclear material.
 - The acquisition of nuclear weapons development information and the documentation from a clandestine nuclear supply network.
 - Work on the development of indigenous nuclear weapon design, including the testing of components.

This section of the report states that the Agency has "serious concerns regarding possible military dimensions to Iran's nuclear program."

- Provides a historical overview of the possible military dimensions of Iran's nuclear program. It reveals that the IAEA discovered that Iran's program has roots going back nearly 40 years, and that it has had ongoing undeclared R&D program for nuclear testing, experimentation, uranium conversion, enrichment, fabrication, and irradiation activities, including the separation of plutonium. Moreover, it reports that Iran admitted to engaging in undeclared activities at clandestine locations, and procured nuclear material via a clandestine supply network.
- Reflects what the IAEA believes to be the structure of Iran's nuclear production, which is thought to involve the participation of a number of research centers, government bodies, universities, and committees, all of which operate under the Ministry of Defense Armed Forces Logistics (MODAFL). Moreover, it indicates that the program's nuclear activity was consolidated under the AMAD Plan in the late 1990s and early 2000s, although it was halted in 2003.
- Provides the IAEA's knowledge of Iran's nuclear procurement activities relevant to nuclear weapons production, many of which were allegedly undertaken by private front companies. For instance, Kimia

Maadan, a private Iranian company, was a company for chemical engineering operations under the AMAD Plan, while also being used to help with procurement for the Atomic Energy Organization of Iran (AEOI).

Among the equipment procured relevant to nuclear weapons production include high-speed electronic switches and spark gaps (useful for triggering and firing detonators); high-speed cameras (useful in experimental diagnostics); neutron sources (useful for calibrating neutron measuring equipment); radiation detection and measuring equipment (useful in a nuclear material production environment); and training courses on topics relevant to nuclear explosives development (such as neutron cross section calculations and shock wave interactions/hydrodynamics).

- Describes the IAEA's knowledge of Iran's attempts to acquire nuclear material relevant to nuclear weapons production. It also emphasizes that Iran only declared a number of facilities once the IAEA was made aware of their existence by sources other than Iran. Taken with Iran's additional past efforts to conceal nuclear activity, this reality creates more concern about the possible existence of further undeclared nuclear facilities, material, and activities in Iran.
- Provides the IAEA's analysis of Iran's alleged ongoing efforts to acquire nuclear components for use in an explosive device. It reiterates that Iran received documents that describe the processes for the conversion of uranium compounds into uranium metal and the production of hemispherical enriched uranium metallic components, which are integral in the production of a rudimentary fission device.

Additionally, the Agency indicates that during a 2007 interview with a member of Iran's clandestine supply network, it was told that Iran had been provided with nuclear explosive design information. Lastly, this portion of the report stresses that the Agency is concerned that Iran may have obtained more advanced design information than the information identified in 2004.

- Discusses the IAEA's knowledge of Iran's R&D into and acquisition of "safe, fast-acting detonators, and equipment suitable for firing the detonators," an integral component to constructing an implosion type nuclear device. It indicates that the Agency discovered that Iran had developed fast-functioning detonators known as "exploding bridgewire detonators" (EBWs) during the period 2002-2003 as safe alternatives to previous detonator technology it had developed.

Moreover, in 2008, Iran told the Agency that before the period 2002-2004, it had already achieved EBW technology. It also provided the Agency with a short, undated document in Persian, which was understood to be the specifications for a detonator development program, and a document from a foreign source that showed the example of a civilian application in which detonators fired simultaneously. Iran, however, has not explained its own need or application for such detonators.

- Describes development of a multipoint initiation system, which is used to reshape the detonation wave into a converging smooth implosion to ensure uniform compression of the core fissile material to supercritical density. As such, it is a vital component of a fission weapon. According to the Agency, Iran has had access to information on the design concept of a multipoint initiation system that can be used to initiate a high explosive charge over its surface effectively and simultaneously. This information was reportedly supplied to the IAEA by a Member State.
- Discusses Iran's efforts to evaluate the theoretical design of an implosion device using computer simulations, as well as high explosive tests referred to as "hydrodynamic experiments" in which fissile and nuclear components may be replaced with surrogate materials.

According to information provided, Iran has manufactured simulated nuclear explosive components using high density materials such as tungsten. Such experiments have also been linked to experiments involving the use of high-speed diagnostic equipment, including flash X-ray, to monitor the symmetry of the compressive shock of the simulated core of an explosive device. Such experiments would have little, if any, civilian application, and represent a serious source of concern regarding the potential weaponization of Iran's nuclear program.

- Provides an overview of the IAEA's knowledge of Iran's studies that focus on modeling of spheres, components, and neutronic behavior indicating investigation into a nuclear warhead. Moreover, the

Agency has acquired information that indicates Iran has conducted studies and done calculations relating to the state of criticality of a solid sphere of uranium being compressed by high explosives. Such efforts provide an additional indication of the potential weaponization of Iran's nuclear program.

- Discusses Iran's research and development into neutron initiators, which, "if placed in the center of a nuclear core of an implosion type nuclear device and compressed, could produce a burst of neutrons suitable for initiating a fission chain reaction." Iran has yet to explain its objectives and capabilities in this field.
- Discusses what the IAEA perceives as Iran's efforts to "have planned and undertaken preparatory experimentation which would be useful were Iran to carry out a test of a nuclear explosive device." It also indicates that these efforts directly reflect those undertaken by declared nuclear-weapon states. These indicators could perhaps point to a potential Iranian nuclear weapons test in the future.
- Reflects what the IAEA perceives as a structured Iranian program to carry out "engineering studies to examine how to integrate a new spherical payload into the existing payload chamber which would be mounted in the re-entry vehicle of the Shahab 3 missile." Such explorations into warhead development provide a key indicator that Iran's program is military in nature.
- Describes Iran's efforts at developing "a prototype firing system that would enable the payload [a nuclear warhead on a Shahab 3 missile] to explode both in the air above a target, or upon impact of the re-entry vehicle with the ground." It presents further indication that Iran is at least considering the possibility of installing nuclear warheads on its existing arsenal of Shahab 3 missiles.
- Provides an overview of the different bodies and projects that constitute the Iranian nuclear program (according to the IAEA).
- Provides an analysis of the likely payload of an Iranian missile, given the above indicators. It shows that Iran's R&D into its ballistic missile and nuclear programs reflect a probable effort to develop both nuclear warheads and an effective delivery vehicle thereof.
- The IAEA report also provides insight into the foreign sources that supplied Iran with nuclear equipment and technical know-how. One of these sources was referred to as a "clandestine nuclear supply network," purported to be the now-disbanded A.Q. Khan network.

According to the report, Iran admittedly had contact with the network in the late 1980s and early 1990s. The document also asserts that this network supplied Iran with technical know-how regarding the production of neutron initiators and spherical hemispherical enriched uranium metallic component, neither of which have any real civilian application.

According to the IAEA, Iran admitted to having received a 15-page document that provided detailed instructions for the construction of components critical to building a nuclear device. This document, known as the "uranium metal document" was also provided to Libya, and is known to have been part of a larger package of information that includes elements of a nuclear explosive design.¹²⁹

Given the circumstances surrounding Iran's acquisition of the document as well as the well-known role the A.Q. Khan network played in jump-starting nuclear weapons programs in Pakistan, Libya, and North Korea, it remains doubtful that Iran's program is purely peaceful.

The IAEA's report of November 8, 2011 also stated that there were,

"...strong indications that the development by Iran of the high explosives initiation system, and its development of the high speed diagnostic configuration used to monitor related experiments, were assisted by the work of a foreign expert who was not only knowledgeable in these technologies, but who, a Member State has informed the Agency, worked for much of his career with this technology in the nuclear weapon program of the country of his origin."¹³⁰

The ISIS later identified this individual as former Soviet weapons engineer Vyacheslav Danilenko. According to the IAEA, Danilenko worked in Iran from 1996 to 2002, returning to Russia in 2002.¹³¹ Moreover, given the small size and sophistication of a multipoint initiation

system the IAEA observed in Iran in 2004, it was likely to have been developed using Danilenko's expertise as a springboard.¹³² Iran's strides in detonator technology are, in all likelihood, the result of Danilenko's technical expertise.

What the IAEA November 8, 2011, Report Said in Detail

No summary can fully substitute for reading what the IAEA said in its own words as taken directly from IAEA, *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*.¹³³

Heavy Water Production

Contrary to the relevant resolutions of the Board of Governors and the Security Council, Iran has not suspended work on all heavy water related projects, including the construction of the heavy water moderated research reactor, the Iran Nuclear Research Reactor (IR-40 Reactor), which is subject to Agency safeguards.

On 17 October 2011, the Agency carried out a DIV at the IR-40 Reactor at Arak and observed that construction of the facility was ongoing and the coolant heat exchangers had been installed. According to Iran, the operation of the IR-40 Reactor is planned to commence by the end of 2013.

Since its visit to the Heavy Water Production Plant (HWPP) on 17 August 2011, the Agency, in a letter to Iran dated 20 October 2011, requested further access to HWPP. The Agency has yet to receive a reply to that letter, and is again relying on satellite imagery to monitor the status of HWPP. Based on recent images, the HWPP appears to be in operation. To date, Iran has not provided the Agency access to the heavy water stored at the Uranium Conversion Facility (UCF) in order to take samples.

Uranium Conversion Facility

Although it is obliged to suspend all enrichment related activities and heavy water related projects, Iran is conducting a number of activities at UCF and the Fuel Manufacturing Plant (FMP) at Esfahan that, as described below, are in contravention of those obligations, although both facilities are under Agency safeguards.

...On 18 October 2011, the Agency carried out a DIV at UCF during which the Agency observed the ongoing installation of the process equipment for the conversion of UF₆ enriched up to 20% U-235 into U₃O₈. During the DIV, Iran informed the Agency that the initial tests of this conversion line, originally scheduled to start on 6 September 2011, had been postponed and would not involve the use of nuclear material.

As previously reported, Iran informed the Agency in July 2011 that it would start R&D activities at UCF for the conversion of UF₆ enriched up to 5% U-235 into UO₂. During the aforementioned DIV, Iran informed the Agency that 6.8 kg of DU in the form of UF₆ had been processed and that Iran had produced 113 g of uranium in the form of UO₂ that met its specifications.

According to Iran, this UO₂ has been sent to FMP to produce test pellets. Iran has also started using UF₆ enriched to 3.34% U-235 to produce UO₂. During the DIV, Iran further informed the Agency that this UO₂ would also be sent to FMP to produce fuel pellets, which would then be sent to TRR for "performance test studies".

In a letter dated 4 October 2011, Iran informed the Agency of the postponement of the production of natural UF₆, involving the use of uranium ore concentrate (UOC) produced at the Bandar Abbas Uranium Production Plant, originally scheduled to restart on 23 October 2011.

In a letter dated 11 October 2011, Iran informed the Agency that, from 11 November 2011, it intended to use UOC produced at the Bandar Abbas Uranium Production Plant for the production of natural uranium in the form of UO₂. During the DIV on 18 October 2011, the Agency took a sample of this UOC.

During the same DIV, Iran informed the Agency that, since 23 July 2011, it had fed into the process 958.7 kg of uranium in the form of UOC31 and produced about 185.6 kg of natural uranium in the form of UO₂, and further indicated that some of the product had been fed back into the process.

In a letter dated 8 October 2011, Iran informed the Agency that it had transferred about 1 kg of this UO₂ to the R&D section of FMP in order to "conduct research activities and pellet fabrication."

Possible Military Dimensions

Previous reports by the Director General have identified outstanding issues related to possible military dimensions to Iran's nuclear program and actions required of Iran to resolve these. Since 2002, the Agency has become increasingly concerned about the possible existence in Iran of undisclosed nuclear related activities involving military related organizations, including activities related to the development of a nuclear payload for a missile, about which the Agency has regularly received new information.

In resolution 1929 (2010), the Security Council reaffirmed Iran's obligations to take the steps required by the Board of Governors in its resolutions GOV/2006/14 and GOV/2009/82, and to cooperate fully with the Agency on all outstanding issues, particularly those which give rise to concerns about the possible military dimensions to Iran's nuclear program, including by providing access without delay to all sites, equipment, persons and documents requested by the Agency. Since August 2008, Iran has not engaged with the Agency in any substantive way on this matter.

...The information that serves as the basis for the Agency's analysis and concerns, as identified in the Annex, is assessed by the Agency to be, overall, credible. The information comes from a wide variety of independent sources, including from a number of Member States, from the Agency's own efforts and from information provided by Iran itself. It is consistent in terms of technical content, individuals and organizations involved, and time frames.

The information indicates that Iran has carried out the following activities that are relevant to the development of a nuclear explosive device:

- Efforts, some successful, to procure nuclear related and dual use equipment and materials by military related individuals and entities (Annex, Sections C.1 and C.2);
- Efforts to develop undeclared pathways for the production of nuclear material (Annex, Section C.3);
- The acquisition of nuclear weapons development information and documentation from a clandestine nuclear supply network (Annex, Section C.4); and
- Work on the development of an indigenous design of a nuclear weapon including the testing of components (Annex, Sections C.5-C.12).

Summary of Concerns: While the Agency continues to verify the non-diversion of declared nuclear material at the nuclear facilities and LOFs declared by Iran under its Safeguards Agreement, as Iran is not providing the necessary cooperation, including by not implementing its Additional Protocol, the Agency is unable to provide credible assurance about the absence of undeclared nuclear material and activities in Iran, and therefore to conclude that all nuclear material in Iran is in peaceful activities.

The Agency has serious concerns regarding possible military dimensions to Iran's nuclear program. After assessing carefully and critically the extensive information available to it, the Agency finds the information to be, overall, credible. The information indicates that Iran has carried out activities relevant to the development of a nuclear explosive device. The information also indicates that prior to the end of 2003, these activities took place under a structured program, and that some activities may still be ongoing.

Given the concerns identified above, Iran is requested to engage substantively with the Agency without delay for the purpose of providing clarifications regarding possible military dimensions to Iran's nuclear program as identified in the Annex to this report.

The Agency is working with Iran with a view to resolving the discrepancy identified during the recent PIV at JHL...

Historical Overview of the Possible Military Dimensions of Iran's Nuclear Program

Since late 2002, the Director General has reported to the Board of Governors on the Agency's concerns about the nature of Iran's nuclear program.

Such concerns coincided with the appearance in open sources of information that indicated that Iran was building a large underground nuclear related facility at Natanz and a heavy water production plant at Arak.

Between 2003 and 2004, the Agency confirmed a number of significant failures on the part of Iran to meet its obligations under its Safeguards Agreement with respect to the reporting of nuclear material, the processing and use of undeclared nuclear material and the failure to declare facilities where the nuclear material had been received, stored and processed.

Specifically, it was discovered that, as early as the late 1970s and early 1980s, and continuing into the 1990s and 2000s, Iran had used undeclared nuclear material for testing and experimentation in several uranium conversion, enrichment, fabrication and irradiation activities, including the separation of plutonium, at undeclared locations and facilities.

In October 2003, Iran informed the Director General that it had adopted a policy of full disclosure and had decided to provide the Agency with a full picture of its nuclear activities. Following that announcement, Iran granted the Agency access to locations the Agency requested to visit, provided information and clarifications in relation to the origin of imported equipment and components and made individuals available for interviews.

It also continued to implement the modified Code 3.1 of the Subsidiary Arrangements General Part, to which it agreed in February 2003, which provides for the submission of design information on new nuclear facilities as soon as the decision to construct or to authorize construction of such a facility is taken. In November 2003, Iran announced its intention to sign an Additional Protocol to its Safeguards Agreement (which it did in December 2003 following Board approval of the text), and that, prior to its entry into force, Iran would act in accordance with the provisions of that Protocol.

Between 2003 and early 2006, Iran submitted inventory change reports, provided design information with respect to facilities where the undeclared activities had taken place and made nuclear material available for Agency verification. Iran also acknowledged that it had utilized entities with links to the Ministry of Defense in some of its previously undeclared activities.

Iran acknowledged that it had had contacts with intermediaries of a clandestine nuclear supply network in 1987 and the early 1990s, and that, in 1987, it had received a handwritten one page document offering assistance with the development of uranium centrifuge enrichment technology, in which reference was also made to a reconversion unit with casting equipment.

Iran further acknowledged that it had received a package of information related to centrifuge enrichment technology that also included a 15 page document (hereafter referred to as the “uranium metal document”) which Iran said it did not ask for and which describes, inter alia, processes for the conversion of uranium fluoride compounds into uranium metal and the production of hemispherical enriched uranium metallic components.

The Agency continued to seek clarification of issues with respect to the scope and nature of Iran’s nuclear program, particularly in light of Iran’s admissions concerning its contacts with the clandestine nuclear supply network, information provided by participants in that network and information which had been provided to the Agency by a Member State.

This last information, collectively referred to as the “alleged studies documentation”, which was made known to the Agency in 2005, indicated that Iran had been engaged in activities involving studies on a so-called green salt project, high explosives testing and the re-engineering of a missile re-entry vehicle to accommodate a new payload. All of this information, taken together, gave rise to concerns about possible military dimensions to Iran’s nuclear program.

In August 2007, Iran and the Agency agreed on “Understandings of the Islamic Republic of Iran and the IAEA on the Modalities of Resolution of the Outstanding Issues” (generally referred to as the “work plan”) (INFCIRC/711).

By February 2008, the four items identified in the work plan as “past outstanding issues”, and the two items identified as “other outstanding issues”, had been determined by the Agency to be either closed, completed or no longer outstanding. The remaining issues which needed to be clarified by Iran related to the alleged studies, together with other matters which had arisen in the course of resolving the six other issues and which needed to be addressed in connection with the alleged studies, specifically: the circumstances of Iran’s acquisition of the uranium metal document, procurement and research and development (R&D) activities of military related institutes and companies that could be nuclear related; and the production of nuclear equipment and components by companies belonging to defense industries.

Between February and May 2008, pursuant to the work plan, the Agency shared with Iran information (including documentation) on the alleged studies, and sought clarifications from Iran. In May 2008, Iran submitted to the Agency a 117 page assessment of that information. While Iran confirmed the veracity of some of the information that the Agency had shared with it (such as acknowledgement of names of people, places and organizations), Iran's assessment was focused on deficiencies in form and format, and dismissed the allegations as having been based on "forged" documents and "fabricated" data.

The Agency continued to receive additional information from Member States and acquired new information as a result of its own efforts. The Agency tried without success to engage Iran in discussions about the information, and finally wrote to Iran in October 2010 to inform it about this additional information.

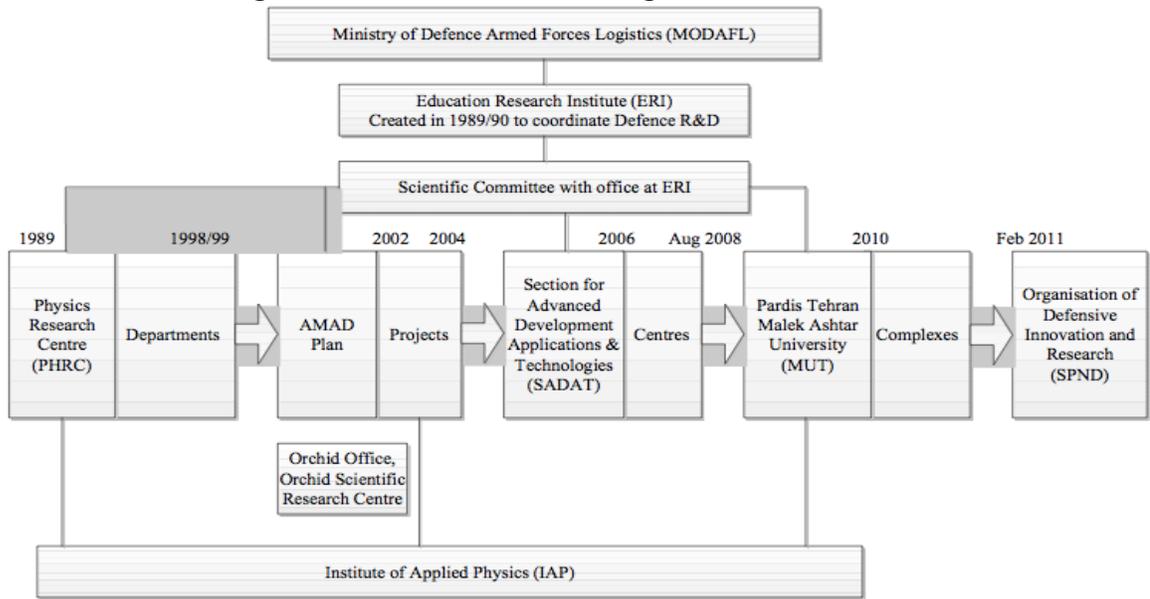
Between 2007 and 2010, Iran continued to conceal nuclear activities, by not informing the Agency in a timely manner of the decision to construct or to authorize construction of a new nuclear power plant at Darkhovin and a third enrichment facility near Qom (the Fordow Fuel Enrichment Plant). The Agency is still awaiting substantive responses from Iran to Agency requests for further information about its announcements, in 2009 and 2010 respectively, that it had decided to construct ten additional enrichment facilities (the locations for five of which had already been identified) and that it possessed laser enrichment technology...

Program Management Structure

The Agency has been provided with information by Member States that indicates that the activities referred to in Sections C.2 to C.12 were, at least for some significant period of time, managed through a program structure, assisted by advisory bodies, and that, owing to the importance of these efforts, senior Iranian figures featured within this command structure. From analysis of this information and information provided by Iran, and through its own endeavors, the Agency has been able to construct what it believes to be a good understanding of activities undertaken by Iran prior to the end of 2003.

*The Agency's ability to construct an equally good understanding of activities in Iran after the end of 2003 is reduced, due to the more limited information available to the Agency. For ease of reference, the figure below depicts, in summary form, what the Agency understands of the program structure, and administrative changes in that structure over the years. Attachment 1 to this Annex provides further details, derived from that information, about the organizational arrangements and projects within that program structure. (See **Figure 15 below.**)*

Figure 15: Iranian Nuclear Program Structure



Departments, Projects, and Centers Relating to Iran’s Nuclear Program

PHRC Departments	AMAD Plan Projects	SADAT Centers
Department 01: Nuclear Physics	Project 110: Payload Design	Center for Readiness & New Defense Technologies
Department 02: Centrifuge Enrichment	Project 111: Payload Integration	Center for R&D (1) of Explosion and Shock Technology
Department 03: Laser Enrichment	Project 3: Manufacture of Components 3.12: Explosives and EBW Detonator 3.14: Uranium Metallurgy	Center for Industrial Research & Construction
Department 04: Uranium Conversion	Project 4: Uranium Enrichment	Center for R&T (2) of Advanced Materials - Chemistry
Department 05: Geology	Project 5: Uranium Mining, Concentration, and Conversion 5.13: Green Salt Project 5.15: Gchine Mine Project	Center for R&T of New Aerospace Technology
Department 06: Health Physics	Projects 8, 9, and 10	Center for Laser and Phototonics Applications
Department 07: Workshop	Project Health and Safety	
Department 08: Heavy Water	Project 19: Involvement of IAP	
Department 09: Analytical Laboratory	Project/Group 117: Procurement and Supply	
Department 10: Computing		
Department 20: Analysis		

- (1) R&D = Research & Development
- (2) R&T = Research and Technology

Source: IAEA, *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, November 8, 2011.

http://isis-online.org/uploads/isis-reports/documents/IAEA_Iran_8Nov2011.pdf

The Agency received information from Member States which indicates that, sometime after the commencement by Iran in the late 1980s of covert procurement activities, organizational structures and administrative arrangements for an undeclared nuclear program were established and managed through the Physics Research Centre (PHRC), and were overseen, through a Scientific Committee, by the Defense Industries Education Research Institute (ERI), established to coordinate defense R&D for the Ministry of Defense Armed Forces Logistics (MODAFL). Iran has confirmed that the PHRC was established in 1989 at Lavisian-Shian, in Tehran.

Iran has stated that the PHRC was created with the purpose of “preparedness to combat and neutralization of casualties due to nuclear attacks and accidents (nuclear defense) and also support and provide scientific advice and services to the Ministry of Defense”. Iran has stated further that those activities were stopped in 1998. In late 2003/early 2004, Iran completely cleared the site.

According to information provided by Member States, by the late 1990s or early 2000s, the PHRC activities were consolidated under the “AMAD Plan”. Mohsen Fakhrizadeh (Mahabadi) was the Executive Officer of the AMAD Plan, the executive affairs of which were performed by the “Orchid Office”. Most of the activities carried out under the AMAD Plan appear to have been conducted during 2002 and 2003.

The majority of the details of the work said to have been conducted under the AMAD Plan come from the alleged studies documentation which, as indicated in paragraph 6 above, refer to studies conducted in three technical areas: the green salt project; high explosives (including the development of exploding bridgewire detonators); and re-engineering of the payload chamber of the Shahab 3 missile re-entry vehicle.

According to the Agency’s assessment of the information contained in that documentation, the green salt project (identified as Project 5.13) was part of a larger project (identified as Project 5) to provide a source of uranium suitable for use in an undisclosed enrichment program.

The product of this program would be converted into metal for use in the new warhead that was the subject of the missile re-entry vehicle studies (identified as Project 111). As of May 2008, the Agency was not in a position to demonstrate to Iran the connection between Project 5 and Project 111. However, subsequently, the Agency was shown documents which established a connection between Project 5 and Project 111, and hence a link between nuclear material and a new payload development program.

Information the Agency has received from Member States indicates that, owing to growing concerns about the international security situation in Iraq and neighboring countries at that time, work on the AMAD Plan was stopped rather abruptly pursuant to a “halt order” instruction issued in late 2003 by senior Iranian officials. According to that information, however, staff remained in place to record and document the achievements of their respective projects. Subsequently, equipment and work places were either cleaned or disposed of so that there would be little to identify the sensitive nature of the work that had been undertaken.

The Agency has other information from Member States which indicates that some activities previously carried out under the AMAD Plan were resumed later, and that Mr. Fakhrizadeh retained the principal organizational role, first under a new organization known as the Section for Advanced Development Applications and Technologies (SADAT), which continued to report to MODAFL, and later, in mid-2008, as the head of the Malek Ashtar University of Technology (MUT) in Tehran. The Agency has been advised by a Member State that, in February 2011, Mr. Fakhrizadeh moved his seat of operations from MUT to an adjacent location known as the Modjeh Site, and that he now leads the Organization of Defensive Innovation and Research. The Agency is concerned because some of the activities undertaken after 2003 would be highly relevant to a nuclear weapon program.

Procurement Activities

Under the AMAD Plan, Iran’s efforts to procure goods and services allegedly involved a number of ostensibly private companies that were able to provide cover for the real purpose of the procurements.

The Agency has been informed by several Member States that, for instance, Kimia Maadan was a cover company for chemical engineering operations under the AMAD Plan while also being used to help with procurement for the Atomic Energy Organization of Iran (AEOI).

In addition, throughout the entire timeline, instances of procurement and attempted procurement by individuals associated with the AMAD Plan of equipment, materials and services which, although having other civilian

applications, would be useful in the development of a nuclear explosive device, have either been uncovered by the Agency itself or been made known to it.

Among such equipment, materials and services are: high speed electronic switches and spark gaps (useful for triggering and firing detonators); high speed cameras (useful in experimental diagnostics); neutron sources (useful for calibrating neutron measuring equipment); radiation detection and measuring equipment (useful in a nuclear material production environment); and training courses on topics relevant to nuclear explosives development (such as neutron cross section calculations and shock wave interactions/hydrodynamics).

Nuclear Material Acquisition

In 2008, the Director General informed the Board that: it had no information at that time — apart from the uranium metal document — on the actual design or manufacture by Iran of nuclear material components of a nuclear weapon or of certain other key components, such as initiators, or on related nuclear physics studies, and that it had not detected the actual use of nuclear material in connection with the alleged studies.

However, as indicated in paragraph 22 above, information contained in the alleged studies documentation suggests that Iran was working on a project to secure a source of uranium suitable for use in an undisclosed enrichment program, the product of which would be converted into metal for use in the new warhead which was the subject of the missile re-entry vehicle studies.

Additional information provided by Member States indicates that, although uranium was not used, kilogram quantities of natural uranium metal were available to the AMAD Plan.

Information made available to the Agency by a Member State, which the Agency has been able to examine directly, indicates that Iran made progress with experimentation aimed at the recovery of uranium from fluoride compounds (using lead oxide as a surrogate material to avoid the possibility of uncontrolled contamination occurring in the workplace).

In addition, although now declared and currently under safeguards, a number of facilities dedicated to uranium enrichment (the Fuel Enrichment Plant and Pilot Fuel Enrichment Plant at Natanz and the Fordow Fuel Enrichment Plant near Qom) were covertly built by Iran and only declared once the Agency was made aware of their existence by sources other than Iran.

This, taken together with the past efforts by Iran to conceal activities involving nuclear material, create more concern about the possible existence of undeclared nuclear facilities and material in Iran.

Nuclear Components for an Explosive Device

For use in a nuclear device, HEU retrieved from the enrichment process is first converted to metal. The metal is then cast and machined into suitable components for a nuclear core.

As indicated in paragraph 5 above, Iran has acknowledged that, along with the handwritten one page document offering assistance with the development of uranium centrifuge enrichment technology, in which reference is also made to a reconversion unit with casting equipment.

Iran also received the uranium metal document that describes, inter alia, processes for the conversion of uranium compounds into uranium metal and the production of hemispherical enriched uranium metallic components.

The uranium metal document is known to have been available to the clandestine nuclear supply network that provided Iran with assistance in developing its centrifuge enrichment capability, and is also known to be part of a larger package of information which includes elements of a nuclear explosive design.

A similar package of information, which surfaced in 2003, was provided by the same network to Libya. The information in the Libyan package, which was first reviewed by Agency experts in January 2004, included details on the design and construction of, and the manufacture of components for, a nuclear explosive device.

In addition, a Member State provided the Agency experts with access to a collection of electronic files from seized computers belonging to key members of the network at different locations. That collection included documents seen in Libya, along with more recent versions of those documents, including an up-dated electronic version of the uranium metal document.

In an interview in 2007 with a member of the clandestine nuclear supply network, the Agency was told that Iran had been provided with nuclear explosive design information. From information provided to the Agency during that interview, the Agency is concerned that Iran may have obtained more advanced design information than the information identified in 2004 as having been provided to Libya by the nuclear supply network.

Additionally, a Member State provided information indicating that, during the AMAD Plan, preparatory work, not involving nuclear material, for the fabrication of natural and high enriched uranium metal components for a nuclear explosive device was carried out.

As the conversion of HEU compounds into metal and the fabrication of HEU metal components suitable in size and quality are steps in the development of an HEU nuclear explosive device, clarification by Iran is needed in connection with the above.

Detonator Development

The development of safe, fast-acting detonators, and equipment suitable for firing the detonators, is an integral part of a program to develop an implosion type nuclear device. Included among the alleged studies documentation are a number of documents relating to the development by Iran, during the period 2002-2003, of fast functioning detonators, known as “exploding bridgewire detonators” or “EBWs” as safe alternatives to the type of detonator described for use in the nuclear device design referred to in paragraph 33 above.

In 2008, Iran told the Agency that it had developed EBWs for civil and conventional military applications and had achieved a simultaneity of about one microsecond when firing two to three detonators together, and provided the Agency with a copy of a paper relating to EBW development work presented by two Iranian researchers at a conference held in Iran in 2005.

A similar paper was published by the two researchers at an international conference later in 2005. Both papers indicate that suitable high voltage firing equipment had been acquired or developed by Iran. Also in 2008, Iran told the Agency that, before the period 2002-2004, it had already achieved EBW technology.

Iran also provided the Agency with a short undated document in Farsi, understood to be the specifications for a detonator development program, and a document from a foreign source showing an example of a civilian application in which detonators are fired simultaneously. However, Iran has not explained to the Agency its own need or application for such detonators.

The Agency recognizes that there exist non-nuclear applications, albeit few, for detonators like EBWs, and of equipment suitable for firing multiple detonators with a high level of simultaneity.

Notwithstanding, given their possible application in a nuclear explosive device, and the fact that there are limited civilian and conventional military applications for such technology, Iran’s development of such detonators and equipment is a matter of concern, particularly in connection with the possible use of the multipoint initiation system referred to below.

Initiation of High Explosives and Associated Experiments

Detonators provide point source initiation of explosives, generating a naturally diverging detonation wave. In an implosion type nuclear explosive device, an additional component, known as a multipoint initiation system, can be used to reshape the detonation wave into a converging smooth implosion to ensure uniform compression of the core fissile material to supercritical density.

The Agency has shared with Iran information provided by a Member State that indicates that Iran has had access to information on the design concept of a multipoint initiation system that can be used to initiate effectively and simultaneously a high explosive charge over its surface. The Agency has been able to confirm independently that such a design concept exists and the country of origin of that design concept. Furthermore, the Agency has been informed by nuclear-weapon States that the specific multipoint initiation concept is used in some known nuclear explosive devices. In its 117 page submission to the Agency in May 2008, Iran stated that the subject was not understandable to Iran and that Iran had not conducted any activities of the type referred to in the document.

Information provided to the Agency by the same Member State referred to in the previous paragraph describes the multipoint initiation concept referred to above as being used by Iran in at least one large scale experiment in 2003 to initiate a high explosive charge in the form of a hemispherical shell. According to that information,

during that experiment, the internal hemispherical curved surface of the high explosive charge was monitored using a large number of optical fiber cables, and the light output of the explosive upon detonation was recorded with a high speed streak camera. It should be noted that the dimensions of the initiation system and the explosives used with it were consistent with the dimensions for the new payload which, according to the alleged studies documentation, were given to the engineers who were studying how to integrate the new payload into the chamber of the Shahab 3 missile re-entry vehicle (Project 111) (see Section C.11 below). Further information provided to the Agency by the same Member State indicates that the large scale high explosive experiments were conducted by Iran in the region of Marivan.

The Agency has strong indications that the development by Iran of the high explosives initiation system, and its development of the high speed diagnostic configuration used to monitor related experiments, were assisted by the work of a foreign expert who was not only knowledgeable in these technologies, but who, a Member State has informed the Agency, worked for much of his career with this technology in the nuclear weapon program of the country of his origin. The Agency has reviewed publications by this foreign expert and has met with him. The Agency has been able to verify through three separate routes, including the expert himself, that this person was in Iran from about 1996 to about 2002, ostensibly to assist Iran in the development of a facility and techniques for making ultra-dispersed diamonds (“UDDs” or “nanodiamonds”), where he also lectured on explosion physics and its applications.

Furthermore, the Agency has received information from two Member States that, after 2003, Iran engaged in experimental research involving a scaled down version of the hemispherical initiation system and high explosive charge referred to in paragraph 43 above, albeit in connection with non-nuclear applications. This work, together with other studies made known to the Agency in which the same initiation system is used in cylindrical geometry, could also be relevant to improving and optimizing the multipoint initiation design concept relevant to nuclear applications.

The Agency’s concern about the activities described in this Section derives from the fact that a multipoint initiation system, such as that described above, can be used in a nuclear explosive device. However, Iran has not been willing to engage in discussion of this topic with the Agency.

Hydrodynamic Experiments

One necessary step in a nuclear weapon development program is determining whether a theoretical design of an implosion device, the behavior of which can be studied through computer simulations, will work in practice. To that end, high explosive tests referred to as “hydrodynamic experiments” are conducted in which fissile and nuclear components may be replaced with surrogate materials.

Information which the Agency has been provided by Member States, some of which the Agency has been able to examine directly, indicates that Iran has manufactured simulated nuclear explosive components using high density materials such as tungsten. These components were said to have incorporated small central cavities suitable for the insertion of capsules such as those described in Section C.9 below.

The end use of such components remains unclear, although they can be linked to other information received by the Agency concerning experiments involving the use of high speed diagnostic equipment, including flash X ray, to monitor the symmetry of the compressive shock of the simulated core of a nuclear device.

Other information which the Agency has been provided by Member States indicates that Iran constructed a large explosives containment vessel in which to conduct hydrodynamic experiments. The explosives vessel, or chamber, is said to have been put in place at Parchin in 2000. A building was constructed at that time around a large cylindrical object at a location at the Parchin military complex.

A large earth berm was subsequently constructed between the building containing the cylinder and a neighboring building, indicating the probable use of high explosives in the chamber. The Agency has obtained commercial satellite images that are consistent with this information.

From independent evidence, including a publication by the foreign expert referred to in paragraph 44 above, the Agency has been able to confirm the date of construction of the cylinder and some of its design features (such as its dimensions), and that it was designed to contain the detonation of up to 70 kilograms of high explosives, which would be suitable for carrying out the type of experiments described in paragraph 43 above.

As a result of information the Agency obtained from a Member State in the early 2000s alleging that Iran was conducting high explosive testing, possibly in association with nuclear materials, at the Parchin military complex, the Agency was permitted by Iran to visit the site twice in 2005.

From satellite imagery available at that time, the Agency identified a number of areas of interest, none of which, however, included the location now believed to contain the building which houses the explosives chamber mentioned above; consequently, the Agency's visits did not uncover anything of relevance.

Hydrodynamic experiments such as those described above, which involve high explosives in conjunction with nuclear material or nuclear material surrogates, are strong indicators of possible weapon development.

In addition, the use of surrogate material, and/or confinement provided by a chamber of the type indicated above, could be used to prevent contamination of the site with nuclear material. It remains for Iran to explain the rationale behind these activities.

Modeling and Calculations

Information provided to the Agency by two Member States relating to modeling studies alleged to have been conducted in 2008 and 2009 by Iran is of particular concern to the Agency. According to that information, the studies involved the modeling of spherical geometries, consisting of components of the core of an HEU nuclear device subjected to shock compression, for their neutronic behavior at high density, and a determination of the subsequent nuclear explosive yield.

The information also identifies models said to have been used in those studies and the results of these calculations, which the Agency has seen. The application of such studies to anything other than a nuclear explosive is unclear to the Agency. It is therefore essential that Iran engage with the Agency and provide an explanation.

The Agency obtained information in 2005 from a Member State indicating that, in 1997, representatives from Iran had met with officials from an institute in a nuclear-weapon State to request training courses in the fields of neutron cross section calculations using computer codes employing Monte Carlo methodology, and shock wave interactions with metals.

In a letter dated 14 May 2008, Iran advised the Agency that there was nothing to support this information. The Agency has also been provided with information by a Member State indicating that, in 2005, arrangements were made in Iran for setting up projects within SADAT centers (see Section C.1 and Attachment 1), inter alia, to establish a databank for "equation of state" information and a hydrodynamics calculation center.

The Agency has also been provided with information from a different Member State that, in 2005, a senior official in SADAT solicited assistance from Shahid Behesti University in connection with complex calculations relating to the state of criticality of a solid sphere of uranium being compressed by high explosives.

Research by the Agency into scientific literature published over the past decade has revealed that Iranian workers, in particular groups of researchers at Shahid Behesti University and Amir Kabir University, have published papers relating to the generation, measurement and modeling of neutron transport.

The Agency has also found, through open source research, other Iranian publications which relate to the application of detonation shock dynamics to the modeling of detonation in high explosives, and the use of hydrodynamic codes in the modeling of jet formation with shaped (hollow) charges. Such studies are commonly used in reactor physics or conventional ordnance research, but also have applications in the development of nuclear explosives.

Neutron Initiator

The Agency has information from a Member State that Iran has undertaken work to manufacture small capsules suitable for use as containers of a component containing nuclear material. The Agency was also informed by a different Member State that Iran may also have experimented with such components in order to assess their performance in generating neutrons.

Such components, if placed in the center of a nuclear core of an implosion type nuclear device and compressed, could produce a burst of neutrons suitable for initiating a fission chain reaction.

The location where the experiments were conducted was said to have been cleaned of contamination after the experiments had taken place. The design of the capsule, and the material associated with it, are consistent with the device design information which the clandestine nuclear supply network allegedly provided to Iran.

The Agency also has information from a Member State that work in this technical area may have continued in Iran after 2004, and that Iran embarked on a four year program, from around 2006 onwards, on the further validation of the design of this neutron source, including through the use of a non- nuclear material to avoid contamination.

Given the importance of neutron generation and transport, and their effect on geometries containing fissile materials in the context of an implosion device, Iran needs to explain to the Agency its objectives and capabilities in this field.

Conducting a Nuclear Test

The Agency has information provided by a Member State that Iran may have planned and undertaken preparatory experimentation which would be useful were Iran to carry out a test of a nuclear explosive device.

In particular, the Agency has information that Iran has conducted a number of practical tests to see whether its EBW firing equipment would function satisfactorily over long distances between a firing point and a test device located down a deep shaft.

Additionally, among the alleged studies documentation provided by that Member State, is a document, in Farsi, which relates directly to the logistics and safety arrangements that would be necessary for conducting a nuclear test.

The Agency has been informed by a different Member State that these arrangements directly reflect those which have been used in nuclear tests conducted by nuclear-weapon States.

Integration into a Missile Delivery Vehicle

The alleged studies documentation contains extensive information regarding work which is alleged to have been conducted by Iran during the period 2002 to 2003 under what was known as Project 111. From that information, *the project appears to have consisted of a structured and comprehensive program of engineering studies to examine how to integrate a new spherical payload into the existing payload chamber which would be mounted in the re-entry vehicle of the Shahab 3 missile.*

According to that documentation, using a number of commercially available computer codes, Iran conducted *computer modeling studies of at least 14 progressive design iterations of the payload chamber and its contents to examine how they would stand up to the various stresses that would be encountered on being launched and travelling on a ballistic trajectory to a target.*

It should be noted that the masses and dimensions of components identified in information provided to the Agency by Member States that Iran is alleged to have been developing (see paragraphs 43 and 48 above) correspond to those assessed to have been used in Project 111 engineering studies on the new payload chamber.

During these studies, prototype components were allegedly manufactured at workshops known to exist in Iran but which Iran refused the Agency permission to visit. The six engineering groups said to have worked under Project 111 produced many technical reports, which comprise a substantial part of the alleged studies documentation.

The Agency has studied these reports extensively and finds that they are both internally consistent and consistent with other supporting information related to Project 111.

The alleged studies documentation also shows that, as part of the activities undertaken within Project 111, consideration was being given to subjecting the prototype payload and its chamber to engineering stress tests to see how well they would stand up in practice to simulated launch and flight stresses (so-called “environmental testing”).

This work would have complemented the engineering modeling simulation studies referred to in paragraph 60 above. According to the information reflected in the alleged studies documentation, within Project 111, some, albeit limited, preparations were also being undertaken to enable the assembly of manufactured components.

Iran has denied conducting the engineering studies, claiming that the documentation which the Agency has is in electronic format and so could have been manipulated, and that it would have been easy to fabricate. However, the quantity of the documentation, and the scope and contents of the work covered in the documentation, are sufficiently comprehensive and complex that, in the Agency's view, it is not likely to have been the result of forgery or fabrication.

While the activities described as those of Project 111 may be relevant to the development of a non-nuclear payload, they are highly relevant to a nuclear weapon program.

Fusing, Arming, and Firing System

The alleged studies documentation indicates that, as part of the studies carried out by the engineering groups under Project 111 to integrate the new payload into the re-entry vehicle of the Shahab 3 missile, additional work was conducted on the development of a prototype firing system that would enable the payload to explode both in the air above a target, or upon impact of the re-entry vehicle with the ground. Iran was shown this information, which, in its 117 page submission ...it dismissed as being "an animation game".

Decision makers, military planners, and intelligence experts cannot ignore these possibilities. In fact, the same senior U.S. intelligence officers who were quoted earlier in regard to the risk in Iran's nuclear programs have repeatedly warned in public that Iran has chemical and suspected biological weapon programs. There are however, no Israeli or US official statements that go beyond this level of detail to provide a meaningful picture of how either country really perceives such threats.

Missiles, Nuclear Weapons, and Their Impact on Containment, Deterrence, Missiles, Preventive Strikes and Warfighting

It should be all too clear that any assessment of the net impact of Iran deploying nuclear weapons has to be problematic. The uncertainties in knowing when Iran could set off a nuclear device are compounded by trying to estimate when it could produce a fully functioning device or successfully miniaturize such a weapon into a functional warhead for placement onto a long-range missile.

The fact remains, however, that Israel has long been a nuclear power and Israel took the decision at the time of the Iran-Iraq War to extend its missile forces to cover targets in both countries, and has long had the capability to target Iran with nuclear weapons. An Iranian-Israeli nuclear arms race is already underway and it is necessary to consider both how Iran might attempt to catch up and how an Iranian nuclear force might affect the military balance in the rest of the region.

Iran's Use of Nuclear Weapons Once It Possesses Them

Much will depend on how Iran exploits its nuclear programs and if it acquires and deploys such weapons. Iran has already reached the point where it is so close to a nuclear weapons break-out capability that the US, its allies in the region, and the world must take this into account.

The Threshold State and "Wars of Intimidation"

Iran is already using its nuclear and missile programs to conduct what might be called "wars of intimidation," and it can exploit each further step that it takes to acquire the capability to deploy nuclear weapons. Every new step in technology, missile development, enrichment, and the dispersal and sheltering of Iran's capabilities reinforces this leverage, even if Iran never formally revives a nuclear weapons program. The question now is whether Iran will persist to the point where it is undeniably a threshold state, go on to test a device, or actually deploy.

Releasing enough additional data to show that Iran has actually reached enough weapons grade material to build a device or weapons would be another major step that would increase Iran's leverage and the risk of a US, Gulf Arab, or Israeli military response. An actual Iranian test would remove all ambiguity about Iran's intentions and capability. Activity indicating Iran was about to deploy nuclear warheads and bombs would be another major signal. The actual deployment of a nuclear-armed missile force, and tacit or overt threats to use weapons, would be the penultimate steps before use.

Each such step will give Iran more potential leverage, but also provoke a stronger response in kind from the US and Iran's neighbors, and accelerate the on-going nuclear arms race with Israel. Each new step will produce new US, Arab, European, and Turkish diplomatic reactions and probably sanctions - as well as new reactions from other states. Each step will increase

tension throughout the region, the risks of unplanned escalation, and the risk of US or Israeli preventive attacks.

The Transition Stage: Launch on Warning? Launch Under Attack?

Iran can set the pace it wants in regards to deploying nuclear weapons. Iran has a number of tactics it may use, they can act quickly and rush forwards, or back off for a period of years, or limit its activity to dispersed efforts that move it forward without being a nuclear weapons program per se, or carry out a slow and systematic program while using its past tactics of denial and negotiation.

Iran's leaders have generally been more cautious in actually taking risks than some of their rhetoric would signal. Iran's leaders must realize that it is one thing to threaten and intimidate and seek political leverage, and quite another to move towards an exchange that could involve the vastly superior nuclear and conventional US forces, push neighbors into creating their own nuclear retaliatory forces, or lead to nuclear or conventional strikes on Iran by Israel. If Iran does create nuclear forces, they will only benefit Iran if they are never actually used.

It is also possible, that Iran's actions in regards to nuclear weapons are the most risk prone during the time between when Iran has a few nuclear weapons and when Iran creates an assured second strike capability. Once Iran has improved its nuclear forces to a level of secured second strike capability, it will be able to deter conventional and nuclear attack due to its ability to retaliate.

Given the fact that Iran's strike aircraft and bombers have aged considerably - and are nearly obsolescent in comparison with their US, Israeli, and Gulf equivalents - Iran would probably select ballistic or cruise missiles for nuclear weapons delivery.

Iran's longer-range missiles are mobile and some are in silos - although it is not clear why Iran deploys in this manner since they are targetable and can be destroyed with earth penetrators or low yield nuclear weapons. Many such systems would, still be partly targetable by US IS&R and satellite systems, and Iran would have to fear that they could provoke a preemptive strike. However, long before Iran had anything approaching a survivable second strike capability, it could seek to deter any such attacks by creating a force designed to be used through launch on warning (LOW) or launch under attack (LUA) after Iran received the first strike.

This is a high-risk posture compared to riding out an enemy first strike, analyzing the result, and then acting. LOW or LUA, however, are postures that almost all emerging nuclear powers have had to consider or take at some point before a secured second strike capability is built.

It is also possible that Iran would consider delivering a nuclear weapon covertly if it felt it faced an almost inevitable attack from the outside, using any one of its regional proxies or its Al Quds Force. However, if such a transfer is detected by foreign intelligence agencies, or the device is used, there is large chance that Iran will be blamed nonetheless. Iranian proxies might smuggle in a nuclear device or detonate it in the water off the coast of a city like Haifa or Tel Aviv, or in a key city or petroleum export facility in the Southern Gulf. But realistically, there is only one country that would provide nuclear weapons to Hamas or Hezbollah and therefore would be easily traceable.

Iranian Efforts to Use a Survivable or “Mature” Nuclear Force

A mature Iranian force might not be more secure for either side. If Iran does successfully create a dispersed or protected force large enough to pose a major threat even in a retaliatory strike or “ride out” mode, creating such a “mature” force might provoke the US, Iran’s Arab neighbors, and Israel to target Iran’s major population centers in the event of a nuclear exchange.

Iran could, however, still seek to exploit its nuclear leverage, and the extent to which the US and its neighbors would make concessions to reduce the resulting nuclear tensions. Such a game of “nuclear chicken” could range from prudent cautious Iranian demands to heightened levels of tension and miscalculation. The Cold War consisted largely of a cautious version of the game, with the exception of the Cuban missile crisis. North Korea, India, and Pakistan have been cautious players. There are no guarantees, however, that caution wins the day. The Napoleonic Wars, the Crimean War, WWI, and WWII all illustrate the extent to which caution can fail and sometimes do so suddenly and in totally unpredictable ways.

Iran might also seek to leverage such nuclear forces to keep the US and Southern Gulf States from using their conventional superiority in an asymmetric conflict in the Gulf. In addition to putting US forces and installations in the Gulf at risk, Iran could use the risk of nuclear escalation to prevent a conventional attack if Iranian asymmetric forces threaten or attack the Southern Gulf States, move into Iraq, support a proxy war by force like Hezbollah against Israel, or attack Gulf shipping and oil export capabilities.

A mature Iranian nuclear force might even lead Iran to attempt to use a limited or demonstrative strike to reinforce the threat while being so limited in nature so as not to garner massive nuclear retaliation. The practical problem for Iran would be that every potential mix of opponents could counter escalate in proportion - but again history scarcely consists of actions based solely on restraint and the wise calculations in a crisis.

It also seems likely that the mere existence of a significant Iranian nuclear arsenal would also provide Iran with some ability to deter and neutralize the US and Gulf state action against Iran or its goals to at least some degree. Iran would be enabled to pursue a more aggressive foreign policy, and tacitly use its nuclear capability to exert leverage over other regional actors and competitors.

US Responses to Iran’s Nuclear and Missile Efforts

The US response to Iran’s existing and potential actions has scarcely been passive. As is described in the next chapter, the US continues to use sanctions and diplomacy as its primary *current* means of limiting Iran’s nuclear efforts, and other diplomatic and negotiating initiatives. US officials have consistently stated that military options are still under consideration, but the US has joined its P5+1 (US, France, UK, China, Russia, and Germany) allies at the negotiating table with Iran each year since 2008, and most recently summer 2012, but no further talks have been scheduled.

The results of the negotiations have been mixed. On one hand, they reduced tensions between the P5+1 and Iran for a period of time. On the other hand, little was accomplished at, and no meaningful agreement was ever reached. The United States still publically continues to view diplomacy and sanctions as the most effective way to reach an understanding with Iran and end this aspect of competition. However, the need to keep many key aspects of US threat perceptions

classified means that there is no clear way to determine how top level US decision makers view the broader trade-offs between negotiation, preventive and preemptive military options, and deterrence/containment.

What is clear is that the US is treating Iran's missile and nuclear programs as a key aspect of US and Iranian military competition, and one where current US perceptions will almost certainly change if Iran clearly moves to the point of a nuclear break out capability, tests a device, and begins to deploy some mix of nuclear armed forces.

Direct Negotiations Before 2013

The full course of US negotiating and sanctions efforts is described in a separate volume in this series. In brief, the US first participated in direct talks with the Islamic Republic over its nuclear program in a 2008 negotiation between Iran and the P5+1 (the five permanent members of the UN Security Council -- United States, Russia, China, United Kingdom, and France -- plus Germany) in Geneva. Those talks stalled due to the perceived inability of the Iranians to adequately confront the nuclear issue.¹³⁴

Following other unsuccessful attempts, direct negotiations were re-launched in January 2011 between the P5+1 and Iran, which also ended without agreement as the Iranian delegation was determined to push for preconditions, stressing its desire for relief from international sanctions and its resolve to continue enrichment.¹³⁵

In the spring of 2012, Catherine Ashton announced on behalf of the P5+1 countries that direct negotiations would continue as the Iranian government committed itself to discussing its nuclear program.¹³⁶ The first meeting in this new round of negotiations was held in Istanbul on April 15, with a commitment to hold a second meeting on May 23 in Baghdad.

While many of the specific details of the exact content of the Istanbul meeting were not disclosed, some of the steps taken by each side suggest that some progress was made. Both sides characterized the meeting as "positive" and "constructive with both sides reportedly refraining from rhetoric that had marked early conferences. Although it was initially reported that the US would pursue a somewhat rigid positional negotiating strategy in these talks, indications later surfaced after the meeting that the US was possibly beginning to alter its negotiating stance on Iran's uranium enrichment.

Just days before the meeting in Istanbul, sources in the US and European diplomatic communities suggested that the US would take the position that Iran must close and dismantle the facility at Fordow, stop generating near-weaponizable uranium fuel, and cease exporting such uranium fuel.¹³⁷ However, 12 days after the meeting, officials within the Obama Administration suggested that the US might be willing to allow Iran to enrich uranium at levels below what would be needed to create a weapon, with the caveat that Iran gives inspectors' unfettered access to their nuclear program.¹³⁸

Some experts felt there have since been indications that Iran's approach to the negotiations was more genuine than in past sessions. One indication was that while Iran had made it a point in the past to steer negotiations away from the nuclear issue, the Iranian delegate gave his assurances that the issue will be central to these new negotiations.¹¹⁵

They feel that while factions within the Iranian government had hindered negotiations in the past, there was a direct line of authority from Iran's delegate at the talks, Saeed Jalili, to

Ayatollah Khamenei, the Supreme Leader of the Islamic Republic. Some feel his brought “unprecedented legitimacy” to the negotiations. Others, however, were concerned that the Ayatollah had taken a firmer stance.

Another P5+1 meeting with Iran took place from June 18 to 19 in Moscow. During that meeting the two sides did not change their public positions: Iran expressed a willingness to halt 20% enrichment and increase their cooperation with the IAEA in return for sanction relief on the central bank and the oil industry, international recognition that it has a right to enrich uranium, and the resolving of several non-nuclear issues.¹¹⁶

The P5+1 continued to express their demand for a “stop, shut, and ship” agreement, where Iran halts 20% enrichment, closes the Qom enrichment complex, and ships the remaining 20% enriched Uranium out of the country in return for commercial airline parts, cooperation on medical isotope production, fuel for the Tehran Research Reactor, and sanctions relief over time.¹¹⁷

Catherine Ashton met with Saeed Jalili on September 18, 2012, in Istanbul to discuss the future of negotiations but no new meetings were announced. It was clear at the time that there might be options that Iran and the 5+1 could agree upon if they accepted the realities of Iran’s programs at the time of the agreement and not its past limits. During the 2009 negotiations in Geneva, President Ahmadinejad backed a deal with the P5+1 on a fuel-swap arrangement - a deal which was vetoed by Ayatollah Khamenei.¹¹⁸ Moreover, according to US government sources, in the wake of the Istanbul meeting the Iranian government has framed the talks in a positive light for their constituents, suggesting that, “the Iranian government is preparing the public for a deal with the West that could be portrayed as a win for Iran.”¹¹⁹

On October 20, there was a report in the *New York Times* that stated Iran and the United States had agreed to one-on-one nuclear talks despite Iranian insistence that negotiations wait until the end of the election in November.¹²⁰ But a day later, both Iran and the United States denied that such an agreement had been reached. However, as the election is over in the United States, whether Iran will look to restart negotiations is unknown but there are both supportive and unsupportive voices for negotiations since the election.

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On November 7, 2012 the Iranian Intelligence Ministry posted a report on their website that highlights negotiations and the effects of war on Iran and the region. It notes that diplomacy is the preferred way to avert war,

...it is clear that the outbreak of war and resort to force, is so serious and horrendous that the smallest neglect of it, is an unforgivable sin. For the same reason, for the prevention of war different options exist. One of those is the adoption of diplomatic and political policies and utilizing the potential of international forums, which is a necessary course and of course is less costly.¹²¹

Other statements echoed similar sentiments, Javad Larijani, Secretary General of the Iranian High Council for Human Rights stated, “If the interests of the regime require it, we will negotiate even with the United States and even in the depths of hell.”¹²²

Former President Ali Akbar Hashemi Rafsanjani, who widely regarded as a reformer or pragmatic conservative told a gathering of reformists, “In the present situation, all those who really care for our country, from all parties and with different points of view, must focus on accepting mistakes and changing behaviors and policies.”¹²³

The IAEA continued to meet with Iran during this time. A meeting, on December 15, 2012, was reported as a “good meeting” and there were news reports that Iran and the IAEA may come together on an agreement that resolves some of the issues between the international nuclear energy organization and the Republic of Iran.¹²⁶ It is not known if the deal includes IAEA visitation to the Parchin military facility, other specifics, or if the deal will even happen. Previous optimistic predictions in January 2011 and May 2012 did not come to fruition.¹²⁷ A final agreement could be signed as soon as January.

But Iran also indicated that it will not stop higher grade enrichment (to 20%) ahead of any new talks that may occur. Fereydoun Abbasi-Davani, head of the Atomic Energy Organization of Iran was quoted as saying, “The Islamic Republic of Iran will not suspend 20 percent uranium enrichment because of the demands of others...The Islamic Republic of Iran will produce 20 percent enriched uranium to meet its needs and for however long it is required.”¹²⁸

It was not until sanctions truly began to bite, that Iran could see a broad military build up across the Gulf, and after the election of a more moderate Iranian President -- Hassan Rouhani – on 14 June 2013, that Iran began to move towards a meaningful agreement. visibly change its behavior. to the point that Israel would seriously consider a preemptive strike. The P5+1-talks with Iran continued to stall until Iran indicated in December 2012 that it was willing to enter into new talks with the western group of nations. The P5+1 agreed to a new package, similar to the one offered during negotiations in the summer of 2012. and it became clear that both sides might be working towards determining a timetable for talks to begin sometime in January 2013.¹³⁹

When talks finally did get underway in Almaty, Kazakhstan in early April 2013, it the two sides were still far apart from each other. At the meeting, the P5+1 put a new proposal on the table that required Iran to suspend enrichment at Fordow, limit the amount of 20% enriched uranium to less than required to build a nuclear weapon, and allow greater access for IAEA inspectors.¹⁴⁰ In return the P5+1 offered limited sanctions relief, mostly pertaining to Iran's gold transactions and petrochemical trade. Iran did little more than offer a rehash of its previous proposals and a demand for almost total relief from sanctions, including banking sanctions, along with recognition of its right to enrich.¹⁴¹

Two days of negotiations ended in nothing more than both sides praising their Kazak hosts and vague promises to meet again. The chief negotiator Catherine Ashton said, “Over two days of talks we had long and intensive discussions on the issues” An unnamed US official said, “It is fair to say that both sides came away with a better understanding of the other’s thinking.”¹⁴² In reality, nothing had happened except Iran had won more time in which to move forward in its nuclear efforts.

The IAEA reported to the UN Security Council in May 2013 that Iran had taken no steps to comply with its requests for added inspections and data on areas of suspected weapons activity and that Iran had taken new steps towards the possible acquisition of nuclear weapons while actively concealing its past activities at Parchin. No visible further progress took place through June 2013 – a time when all of the candidates for the Iranian presidency had endorsed pursuing Iran’s nuclear programs and supported Iran’s Supreme Leader in doing so.

Yet progress was being made. The full nature of the negotiations that finally managed to lead to an interim agreement in November 2013 remain unclear, as do the changing relationships within the Iranian power structure and the Supreme Leader’s positions that made such changes possible. The fact remains, however, that the terms of the interim agreement did make a massive change in

Iran's previous positions, and that these changes came as part of a broader shift to more moderate positions by the Rouhani government.

The November 2013 Interim Agreement

Media reports on the negotiations that led to an interim agreement in November 2013 indicate that it came after months of secret efforts and was still a cliff hanger as both sides reached a last minute set of compromises over issues like the permissible level of Iranian enrichment activity and the status of the heavy water reactor at Arak.

When the new agreement came, however, it potentially limited Iran's activities in virtually every critical area of weapons development. A White House factsheet summarized the key provisions of the new agreement as follows:¹⁴³

A Six Month Interim Agreement Will Roll Back the Most Critical Parts of the Threat

The initial, six month step includes significant limits on Iran's nuclear program and begins to address our most urgent concerns including Iran's enrichment capabilities; its existing stockpiles of enriched uranium; the number and capabilities of its centrifuges; and its ability to produce weapons-grade plutonium using the Arak reactor.

The concessions Iran has committed to make as part of this first step will also provide us with increased transparency and intrusive monitoring of its nuclear program. In the past, the concern has been expressed that Iran will use negotiations to buy time to advance their program. Taken together, these first step measures will help prevent Iran from using the cover of negotiations to continue advancing its nuclear program as we seek to negotiate a long-term, comprehensive solution that addresses all of the international community's concerns.

In return, as part of this initial step, the P5+1 will provide limited, temporary, targeted, and reversible relief to Iran. This relief is structured so that the overwhelming majority of the sanctions regime, including the key oil, banking, and financial sanctions architecture, remains in place. The P5+1 will continue to enforce these sanctions vigorously. If Iran fails to meet its commitments, we will revoke the limited relief and impose additional sanctions on Iran.

The interim agreement is the prelude to a lasting general agreement that would require Iran to fully comply with all the terms and concerns of the IAEA

The P5+1 and Iran also discussed the general parameters of a comprehensive solution that would constrain Iran's nuclear program over the long term, provide verifiable assurances to the international community that Iran's nuclear activities will be exclusively peaceful, and ensure that any attempt by Iran to pursue a nuclear weapon would be promptly detected.

The set of understandings also includes an acknowledgment by Iran that it must address all United Nations Security Council resolutions – which Iran has long claimed are illegal – as well as past and present issues with Iran's nuclear program that have been identified by the International Atomic Energy Agency (IAEA).

This would include resolution of questions concerning the possible military dimension of Iran's nuclear program, including Iran's activities at Parchin.

As part of a comprehensive solution, Iran must also come into full compliance with its obligations under the Non-Proliferation Treaty (NPT) and its obligations to the IAEA. With respect to the comprehensive solution, nothing is agreed until everything is agreed. Put simply, this first step expires in six months, and does not represent an acceptable end state to the United States or our P5+1 partners.

The agreement would halt the progress of Iran's program and roll back key elements in every meaningful area of Uranium enrichment

Iran committed to halt enrichment above 5%:

- Halt all enrichment above 5% and dismantle the technical connections required to enrich above 5%.

Iran committed to neutralize its stockpile of near-20% uranium:

- Dilute below 5% or convert to a form not suitable for further enrichment its entire stockpile of near-20% enriched uranium before the end of the initial phase.

Iran committed to halt progress on its enrichment capacity:

- Not install additional centrifuges of any type.
- Not install or use any next-generation centrifuges to enrich uranium.
- Leave inoperable roughly half of installed centrifuges at Natanz and three-quarters of installed centrifuges at Fordow, so they cannot be used to enrich uranium.
- Limit its centrifuge production to those needed to replace damaged machines, so Iran cannot use the six months to stockpile centrifuges.
- Not construct additional enrichment facilities.

Iran committed to halt progress on the growth of its 3.5% stockpile:

- Not increase its stockpile of 3.5% low enriched uranium, so that the amount is not greater at the end of the six months than it is at the beginning, and any newly enriched 3.5% enriched uranium is converted into oxide.

Iran committed to making no further advances of its activities at Arak and to halt progress on its plutonium track:

- *Not commission the Arak reactor.*
- Not fuel the Arak reactor.
- Halt the production of fuel for the Arak reactor.
- No additional testing of fuel for the Arak reactor.
- Not install any additional reactor components at Arak.

- Not transfer fuel and heavy water to the reactor site.
- Not construct a facility capable of reprocessing. Without reprocessing, Iran cannot separate plutonium from spent fuel.

Iran committed to Unprecedented transparency and intrusive monitoring of Iran's nuclear program:

- Provide daily access by IAEA inspectors at Natanz and Fordow. This daily access will permit inspectors to review surveillance camera footage to ensure comprehensive monitoring. This access will provide even greater transparency into enrichment at these sites and shorten detection time for any non-compliance.
- Provide IAEA access to centrifuge assembly facilities.
- Provide IAEA access to centrifuge rotor component production and storage facilities.
- Provide IAEA access to uranium mines and mills.
- Provide long-sought design information for the Arak reactor. This will provide critical insight into the reactor that has not previously been available.
- Provide more frequent inspector access to the Arak reactor.

- Provide certain key data and information called for in the Additional Protocol to Iran's IAEA Safeguards Agreement and Modified Code 3.1.

Iran committed to an effective IAEA Verification Mechanism

The IAEA will be called upon to perform many of these verification steps, consistent with their ongoing inspection role in Iran. In addition, the P5+1 and Iran have committed to establishing a Joint Commission to work with the IAEA to monitor implementation and address issues that may arise. The Joint Commission will also work with the IAEA to facilitate resolution of past and present concerns with respect to Iran's nuclear program, including the possible military dimension of Iran's nuclear program and Iran's activities at Parchin.

Iran will get Limited, Temporary, Reversible Relief that will act as a Major Incentive to move Forward to Reach a Lasting General Agreement

In return for these steps, the P5+1 is to provide limited, temporary, targeted, and reversible relief while maintaining the vast bulk of our sanctions, including the oil, finance, and banking sanctions architecture. If Iran fails to meet its commitments, we will revoke the relief. Specifically the P5+1 has committed to:

- Not impose new nuclear-related sanctions for six months, if Iran abides by its commitments under this deal, to the extent permissible within their political systems.
- Suspend certain sanctions on gold and precious metals, Iran's auto sector, and Iran's petrochemical exports, potentially providing Iran approximately \$1.5 billion in revenue.
- License safety-related repairs and inspections inside Iran for certain Iranian airlines.
- Allow purchases of Iranian oil to remain at their currently significantly reduced levels – levels that are 60% less than two years ago. \$4.2 billion from these sales will be allowed to be transferred in installments if, and as, Iran fulfills its commitments.
- Allow \$400 million in governmental tuition assistance to be transferred from restricted Iranian funds directly to recognized educational institutions in third countries to defray the tuition costs of Iranian students.

The US and Other Members of the P5+1 Will Facilitate Humanitarian Transactions

Facilitate humanitarian transactions that are already allowed by U.S. law. Humanitarian transactions have been explicitly exempted from sanctions by Congress so this channel will not provide Iran access to any new source of funds. Humanitarian transactions are those related to Iran's purchase of food, agricultural commodities, medicine, medical devices; we would also facilitate transactions for medical expenses incurred abroad. We will establish this channel for the benefit of the Iranian people.

Limited Relief While Maintaining Economic Pressure on Iran and Preserving Sanctions Architecture

In total, the approximately \$7 billion in relief is a fraction of the costs that Iran will continue to incur during this first phase under the sanctions that will remain in place. The vast majority of Iran's approximately \$100 billion in foreign exchange holdings are inaccessible or restricted by sanctions.

In the next six months, Iran's crude oil sales cannot increase. Oil sanctions alone will result in approximately \$30 billion in lost revenues to Iran – or roughly \$5 billion per month – compared to what Iran earned in a six month period in 2011, before these sanctions took effect. While Iran will be allowed access to \$4.2 billion of its oil sales, nearly \$15 billion of its revenues during this period will go into restricted overseas accounts. In summary, we expect the balance of Iran's money in restricted accounts overseas will actually increase, not decrease, under the terms of this deal.

- During the first phase, we will continue to vigorously enforce our sanctions against Iran, including by taking action against those who seek to evade or circumvent our sanctions.

- *Sanctions affecting crude oil sales will continue to impose pressure on Iran's government.* Working with our international partners, we have cut Iran's oil sales from 2.5 million barrels per day (bpd) in early 2012 to 1 million bpd today, denying Iran the ability to sell almost 1.5 million bpd. That's a loss of more than \$80 billion since the beginning of 2012 that Iran will never be able to recoup. Under this first step, the EU crude oil ban will remain in effect and Iran will be held to approximately 1 million bpd in sales, resulting in continuing lost sales worth an additional \$4 billion per month, every month, going forward.
- Sanctions affecting petroleum product exports to Iran, which result in billions of dollars of lost revenue, will remain in effect.
- The vast majority of Iran's approximately \$100 billion in foreign exchange holdings remain inaccessible or restricted by our sanctions.

Other significant parts of the US and UN sanctions regime remain intact, including:

- Sanctions against the Central Bank of Iran and approximately two dozen other major Iranian banks and financial actors;
- Secondary sanctions, pursuant to the Comprehensive Iran Sanctions, Accountability, and Divestment Act (CISADA) as amended and other laws, on banks that do business with U.S.-designated individuals and entities;
- Sanctions on those who provide a broad range of other financial services to Iran, such as many types of insurance; and,
- Restricted access to the U.S. financial system.
- All sanctions on over 600 individuals and entities targeted for supporting Iran's nuclear or ballistic missile program remain in effect.
- Sanctions on several sectors of Iran's economy, including shipping and shipbuilding, remain in effect.
- Sanctions on long-term investment in and provision of technical services to Iran's energy sector remain in effect. Sanctions on Iran's military program remain in effect.
- Broad U.S. restrictions on trade with Iran remain in effect, depriving Iran of access to virtually all dealings with the world's biggest economy.
- All UN Security Council sanctions remain in effect.
- All of our targeted sanctions related to Iran's state sponsorship of terrorism, its destabilizing role in the Syrian conflict, and its abysmal human rights record, among other concerns, remain in effect.

Restricting Iran's Breakout Capability Does Involve Serious Challenges Even if the Agreement is Successful

For all the reasons made clear earlier this analysis, no feasible agreement could have been a perfect agreement. The interim agreement had serious limits and was a beginning, not a guarantee for the future. It did not halt all Iranian enrichment or deprive Iran of an advanced technology base that it had brought it to the edge of nuclear break out. It did not deprive Iran of the option of arming its missiles with terminal guidance and greatly improving the lethality of their conventional warheads.

If the agreement is to be success, it seems clear that the US should only ease key sanctions after it reach a lasting agreement with Iran, and in proportion to Iran's compliance. Its limits mean the US must continue its military presence in the Gulf, that the US must continue to aid friendly Gulf and other Arab states in building up their military forces and missile defense capabilities, and the US must continue to ensure the security of Israel.

At the same time, full and lasting Iranian compliance with the kind of terms set forth in the interim agreement would address the security issues that really matter. Far too much of the current debate over Iran's nuclear programs focuses on trying to keep Iran from getting one nuclear weapon, rather than on the need to create a more stable military balance in the Gulf, preventing Iran from creating a serious nuclear force, and halting the nuclear arms race in the region. It is desirable to keep Iran's capabilities at a minimum, but it is also necessary to be realistic.

No One Could Have Rolled Back the Reality that Iran Was Already Near the Break Out Point and can continue Some Weapons Related Activity

The negotiator has to face the reality that Iran was already at the point where it had all of the technology to produce some kind of nuclear device. It had all of the basic components for a fissile device, and has almost certainly acquired all of the necessary technology. It had shown that it can enrich Uranium to weapons grade, and seems to have the technology in its Arak reactor to produce weapons grade Plutonium weapons as well. In short, Iran has come as close to the point of nuclear "break out" as a nation can without actually producing weapons grade material or actually showing it can create a fissile event.

Even given their access to intelligence, the negotiations also had to reach an agreement under conditions where they had is no way of knowing how much weapons design data Iran has acquired from Pakistani or other sources, or whether it had carried out tests of nuclear designs using non-fissile materials at facilities like Parchin.

They had to accept the fact that any agreement Iran would accept to negotiate the disposal of Iran's highly enriched material and full IAEA inspection of known and suspect facilities could still not be sure of halting progress in an Iran's efforts to acquire nuclear weapons technology. A IISS analysis of IAEA Iran Safeguards Report issued in early November 2013, weeks before that the November 2013 interim agreement, showed that Iran continued to make steady, if sometimes slow progress in areas that could give it a nuclear weapons capability. ISIS reports that the IAEA found that,¹⁴⁴

- Iran continued to produce near 20 and 3.5 percent low enriched uranium (LEU) at the same rate as the last reporting period. Its centrifuge capability at the Natanz and Fordow enrichment facilities remained essentially the same as the last reporting period.
- The number of installed IR-1 centrifuges at the Natanz Fuel Enrichment Plant (FEP) had increased by only 4 machines; the number of enriching centrifuges decreased by two cascades.
- No new IR-2m machines had been installed and no enrichment was taking place in IR-2m cascades in the FEP.
- No new centrifuges were enriching at the Fordow Fuel Enrichment Plant, and no increase in the number of installed centrifuges at the plant.
- Iran continues to convert its 19.75 percent uranium hexafluoride into uranium oxide, but it had increased its stockpile of near 20 percent low enriched uranium hexafluoride by 10 kg to 196 kg total. Combined, the PFEP at Natanz and the FFEP had produced 410 kg of 19.75 percent uranium. The total average monthly production of 19.75 percent LEU hexafluoride during the most recent period remained consistent at an average of 15 kilograms per month of 19.75 percent LEU hexafluoride. If Iran begins enriching in the additional deployed cascades, this rate could dramatically increase.
- Critical components of the IR 40 Reactor at Arak remained uninstalled.

- No new fuel assemblies were completed for the IR-40 reactor; the number of fuel assemblies remained consistent at 10; but Iran was in the process of completing an eleventh assembly. A full core would hold 150 fuel assemblies
- Iran had taken some positive steps in concluding initial cooperation agreement with IAEA; much more was required to satisfy IAEA's concerns about past or possibly ongoing nuclear weapons work.
- Iran did not agree to provide updated, detailed design information on the Arak Heavy Water Reactor

Iran was still having problems at many levels, but the full details of the IAEA report and the ISIS assessment show that unless a lasting Iran-P5+1 agreement brought a lasting halt to the higher levels of Iran's Uranium enrichment activity, and halted activation of the reactor at Arak or brings it under tight control, Iran would still have the ability to produce weapons grade material. Moreover, If Iran could continue to develop improved centrifuges, it will acquire both far greater ability to conceal a nuclear enrichment and the ability to produce significant stockpiles more quickly even if it does not deploy them.

ISIS concluded in a detailed analysis of Iran's breakout capability completed in September 2013 that,¹⁴⁵

Iran has steadily expanded its number of IR-1 centrifuges installed at both its Fordow and Natanz gas centrifuge plants...Additionally, it has started installing its more advanced centrifuge model, the IR-2m centrifuge, at the Natanz Fuel Enrichment Plant (FEP). These substantial changes merit updating our previous breakout estimates of the time Iran would need to produce one significant quantity (SQ) of weapon-grade uranium (WGU), taken as 25 kilograms of WGU, using its existing safeguarded nuclear facilities and low enriched uranium (LEU) stocks as of August 2013.

... Iran maintains a number of options should it choose to breakout of the Nuclear Nonproliferation Treaty (NPT). This report evaluates those options in various realistic combinations to examine Iran's current ability to produce WGU. We also look for the first time in this report at breakout times in the case of Iran having a covert centrifuge plant of advanced centrifuges.

Since the last iteration of these calculations in October 2012, Iran has not enriched uranium beyond 20 percent; however, it has growing stockpiles of LEU enriched up to both 3.5 percent and near 20 percent. The size of its LEU stocks exceeds any realistic assessment of Iran's need for reactor fuel in the short and near-term. Combined with its dramatically increased centrifuge capability, these stockpiles bolster Iran's latent capability to manufacture a nuclear weapon.

Given the growth in Iran's centrifuge capabilities over the last two years, Iran may aim to create the capability to produce sufficient WGU for a nuclear weapon faster than IAEA inspectors could detect the production of one or two SQs. ISIS defines the date when Iran achieves such a breakout capability as a "critical capability". In other reports, ISIS has estimated that Iran could achieve critical capability in mid-2014...

As in the October 2012 iteration, the estimates in this report do not include the additional time that Iran would need to convert WGU into weapons components and manufacture a nuclear weapon. This extra time could be substantial, particularly if Iran wanted to build a reliable warhead for a ballistic missile. However, these preparations would most likely be conducted at secret sites and would be difficult to detect. If Iran successfully produced enough WGU for a nuclear weapon, the ensuing weaponization process might not be detectable until Iran tested its nuclear device underground or otherwise revealed its acquisition of nuclear weapons. Therefore, the most practical strategy to prevent Iran from obtaining nuclear weapons is to prevent it from accumulating sufficient nuclear explosive material, particularly in secret or without adequate warning. This strategy depends on knowing how quickly Iran could make WGU.

In the process, ISIS examined four different scenarios in which Iran could overly and covertly move towards nuclear weapons. It is important to stress that experts differed sharply over such studies and the ISIS estimates were worst cases of how soon Iran could manufacture enough

fissile material for a nuclear device and that ignored the, “additional time that Iran would need to convert WGU into weapons components and manufacture a nuclear weapon.” As such, Iran would probably have needed years to actually test, build, and deploy reliable, functioning nuclear weapons – but the times that emerge from the ISIS calculation are still a clear warning of how urgent some form of agreement preventive strikes, or new forms of deterrence and containment had become:¹⁴⁶

Scenario 1: Breakout with only enriching centrifuges at Natanz and Fordow

- Four step: Without use of LEU inventory: 9.0-9.6 months. With use of LEU inventory 2.3-3.2 months
- Three step: 1.3-2.3 months
- Two step: n.a.

Scenario 2: Breakout with all installed centrifuges at Natanz and Fordow

- Four step: Without use of LEU inventory 5.4-6.8 months. With use of LEU inventory: 1.7-2.3 months
- Three step: With use of both 3.5% and near 20%: 1.0-1.6 months. With use of 3.5% LEU and no 20% LEU: 1.9-2.2 months.
- Two step (not enough near 20 percent as of August but close) If 205kg near 20% LEU hexafluoride: 1.0 –1.2 months. If 250 kg near 20% LEU hexafluoride: 0.7–0.8 months

Scenario 3: Covert Facility of IR-2m Centrifuges Optimized for WGU Production with Separative power of 3-5 SWU/yr

- From 0.7% to 90%: 2.55-4.25 months.
- From 3.5% to 90%: 0.73-1.22 months,
- From 19.75% to 90%: 0.15-0.25 months

Scenario 4: Covert Facility of IR-2m Centrifuges Using More Realistic, Multi-Step Cascade Setup and Separative Power of 3-5 SWU/yr

- Four step: Without use of LEU inventory: 6.4-11.3 months. With use of LEU inventory: 1.6-2.6 months,
- Three step: With use of both 3.5% and near 20%: 1.3-2.3 months. With use of 3.5% LEU and no 20% LEU: 2.2-4.5 months
- Two step, With 250 kg near 20% LEU hexafluoride: 0.7-1.4 months. With 205 kg near 20% LEU hexafluoride: 1.1-2.3 months.

Given Iran’s capabilities at the time the November interim agreement was reached, it is unclear that any agreement (or any preventive strikes) could halt some other important aspects of Iran’s nuclear weapons design efforts. Iran cannot be sure any such post agreement activities will remain covert, but it can have reasonable confidence that some would. Creating a surface facility at Parchin was an unnecessary embarrassment. Iran can disperse design and test facilities, and carry out as much of the nuclear bomb and warhead modeling and testing as it needs with little risk of detection. It can launch simulated nuclear warheads in its missile tests and nuclear bombs in simulated air exercises – testing the technology based on the results of physical recovery or highly encrypted telemetry.

As a fall back, Iran could also avoid the design complications of an implosion weapon and go for a gun device. The result would be much heavier, but easily transportable by ship, and present the threat of some kind of rouge attack: A ship sailing into Haifa or a port in the Gulf. This kind of asymmetric threat may lack the credibility of serious nuclear forces, but would be impossible to dismiss.

However, The Real Iranian Threat is a Nuclear Armed Force and the Interim and Full Agreement Would Prevent This

At the same time, proper verification and enforcement of the interim agreement and any full agreement with similar terms does seem likely to be capable of prevent the most important threat posed by Iran's efforts. This threat is not an Iranian break out capability or even a token weapon whose use would only be credible in a crisis so serve that its impact would be marginal at most. It is an Iranian effort that would develop enough effective weapons to arm its long-range missiles and air force and make it a serious nuclear power.

Breakout capabilities and token nuclear stockpiles could give Iran some degree of added deterrence and ability to lever or intimidate other states. The actual use of such limited capabilities, however, escalates a conflict to total war in an environment where the US and the world cannot tolerate such a threat to the flow of world oil exports, and any rogue attack against a mature nuclear power like Israel would be suicidal. As Henry Kissinger once said, the threat of committing suicide is not an adequate deterrent to being murdered. A potential or token Iranian nuclear force is the real world equivalent.

These limits on Iran would change drastically the moment Iran can deploy significant nuclear forces and they are mobile or sheltered enough to limit the risk of a successful preventive first strike. A serious Iranian force that can launch significant numbers of nuclear warheads on warning or the moment Iran is under attack, that the US and Israel cannot credibly deter or destroy, and that will have enough surviving elements to make any form of preemption extremely dangerous is a far more credible threat.

The creation of such a nuclear-armed missile force would also correct Iran's greatest military weaknesses. Iran's air force is now largely obsolete, as its surface-based air defense system. Its long-range missiles and rockets lack the accuracy and lethality to destroy key point targets and are largely area weapons that may intimate but have little strategic effect. As long as Iran remains so vulnerable to US, Gulf, and Israeli air attack; its growing asymmetric forces have limited real-world value. The US, GCC states, and Israel can escalate with precision strikes in ways that make any Iranian use of asymmetric warfare a high risk effort than may well cost Iran far more than it is worth.

These are key reasons why Iran's nuclear efforts should not be seen as irrational, as matters of prestige, or some form of military eccentricity. They make perfect sense from the viewpoint of a nation that both sees itself as under siege from the US and many of its neighbors and wants to greatly increase its influence in the region. Iran's nuclear efforts make good sense when seen in terms of its overall military posture.

There is no way, however, that Iran could conceal such a major weapons production and deployment program under the terms of the interim agreement. The agreement came at time Iran still faced serious problems in creating such a force. For all the talk of how quickly Iran could acquire enough fissile material for one or a few nuclear devices, it is years away from developing a reliable mix of fissile nuclear warheads and bombs. Iran would also assume massive risks if it tried to deploy actual bombs and warheads without a series of detectable nuclear tests. It would have to risk arming its missiles and aircraft with implosion weapons of unpredictable safety and yield, and North Korean, Indian, and Pakistani tests have shown just how uncertain the results can be even in carrying out static tests of such devices.

It also seems very doubtful that any Iranian covert program would not bring it close to becoming a meaning nuclear threat if it complied with the terms listed earlier. Moreover, unless Iran reneged completely, any major Iranian activity would be detected far more quickly and reliably, would clearly violate an international agreement recognized by the UN and major powers, and would act as de facto justification for preventive strikes, far more serious sanctions, and/or US guarantees of extended deterrence.

The Risks of an Open-Ended Regional Nuclear Arms Race

There also are good reasons why Iran should give up such nuclear efforts in spite of the military gains it might achieve. Iran faces the reality that it cannot develop the nuclear forces it needs without provoking a response. It cannot credibly hope to hide the creation of serious nuclear forces in the way it can hope to conceal improvements in enrichment and most aspects of weapons design. It probably would need detectable nuclear tests to be sure such a force would work and would have serious problems in concealing a major weapons production effort. It cannot hope to conceal the actual deployment of nuclear bombs and missile warheads in the field in any serious numbers.

The end result would not be the creation of Iranian nuclear forces in some kind of strategic vacuum. Israel already can probably target most of Iran's population with missiles armed with thermonuclear warheads, and would find it far easier to carry out decisive preventive strikes if Iran's actions justified the use of nuclear weapons.

Saudi Arabia may be able to acquire nuclear weapons from Pakistan, and arm its Chinese supplied missile forces. The US, Israel, and the GCC state also have far better access to advanced missile defenses, as well as the ability to support any retaliatory or preventive strikes with air power, and the US has offered its regional allies "extended deterrence" – an offer that would leave Iran with the constant threat of US military action.

The Prospects for Controlling the Nuclear Dimension of Iran's Military Efforts

The end result is that it is may prove easier to counter the Iranian nuclear threat that really matters than it is to create a perfect agreement to limit its progress towards some form of breakout capability. Iran can probably refine its nuclear technology and present some form of break out capability regardless of such an agreement. Under worst-case conditions, it might just be possible to create a few gun-type weapons or high-risk fusion devices.

However, Iran cannot develop a credible nuclear force under the terms of the interim agreement or any full agreement with the same constraints. As long as Iran faces the agreed inspection and controls on enrichment, it cannot act in ways that will prevent Israel from at least having mutual assured destruction capability and the US from deploying an effective form of extended deterrence. Iran cannot be sure that Saudi Arabia cannot match or exceed its rate of nuclear deployment. In broad terms, Iran can only "win" the kind of nuclear arms race it needs if other states do not react, and it cannot hope to violate any meaningful nuclear agreement with the P5+1 in trying to create such a force in ways that will not provide ample warning.

The US and other members of the P5+1 should still do what they can to limit Iran's capability to improve its break out capability and prevent it from getting even one nuclear device. This does not, however, mean reaching a perfect agreement that goes beyond the detailed terms of the

interim agreement that have been outlined earlier, and it seems unlikely that any perfect agreement is now feasible at any practical political and technical level.

At the same time, the main focus of the US and the P5+1 should be on reaching a full agreement that clearly denies Iran any ability to covertly create an effective nuclear force backed by the clear understanding that this will risk preventive war and that the best case for Iran would be US extended deterrence, a growing Israeli nuclear threat, and the strong possibility of Saudi nuclear forces – backed by far more effective missile and air defenses.

This not only may be easier to achieve than totally halting all Iranian enrichment activity or other variants on creating “perfect” limits on breakout capability, but success will have far more military importance and do far more to limit a real nuclear arms race in the Middle East. It also will mean creating the conditions that will show Iran that it has a secure route to development, that can ease the other aspects of the arms race in the Middle East, roll back the tension between Iranian and Arab, and eases the pressures that have led to a nascent religious war between Sunni and Shi’ite and fueled violent Islamist extremism. It might even at some point in the future offer some real hope of a weapons of mass destruction free zone in the Middle East.

Enforcement, Security Assistance, and “Extended Deterrence”

At the same time, it is clear that the US and other members of the P5+1 will need to insist on full compliance and verification, and make it clear that they will reintroduce past sanctions and enforce even stronger ones if Iran does not comply. Iranian compliance will not only depend on the degree to which the US can establish better relations with Iran and end sanctions, but the continuing credibility of US efforts to prepare for preventive strikes, offer Arab and other regional states missile defenses, and make it clear to Iran that no Iranian nuclear effort can succeed in dominating the region.

The US should make it clear that it will continue to offered regional allies “extended regional deterrence.” Secretary of State Hillary Clinton described the U.S. position as follows in June 2009,

“We want Iran to calculate what I think is a fair assessment that if the United States extends a defense umbrella over the region, if we do even more to support the military capacity of those in the Gulf, it’s unlikely that Iran will be any stronger or safer because they won’t be able to intimidate and dominate as they apparently believe they can once they have a nuclear weapon.”¹⁴⁷

The U.S. went further in its April 2010 Nuclear Posture Review.¹⁴⁸ The review discussed arms control options, and efforts to eventually end U.S. reliance on nuclear weapons, but also stated that,

Security architectures in key regions will retain a nuclear dimension as long as nuclear threats to U.S. allies and partners remain. U.S. nuclear weapons have played an essential role in extending deterrence to U.S. allies and partners against nuclear attacks or nuclear-backed coercion by states in their region that possess or are seeking nuclear weapons. A credible U.S. “nuclear umbrella” has been provided by a combination of means - the strategic forces of the U.S. Triad, non-strategic nuclear weapons deployed forward in key regions, and U.S.-based nuclear weapons that could be deployed forward quickly to meet regional contingencies.

In Asia and the Middle East - where there are no multilateral alliance structures analogous to NATO - the United States has mainly extended deterrence through bilateral alliances and security relationships and through its forward military presence and security guarantees. When the Cold War ended, the United States withdrew its forward-deployed nuclear weapons from the Pacific region, including removing nuclear weapons from naval surface vessels and general-purpose submarines. Since then, it has relied on its central strategic forces and the capacity to re-deploy non-strategic nuclear systems in East Asia, if needed, in times

of crisis.

The Administration is pursuing strategic dialogues with its allies and partners in East Asia and the Middle East to determine how best to cooperatively strengthen regional security architectures to enhance peace and security, and reassure them that U.S. extended deterrence is credible and effective.

The US position has been less clear since 2010. The offer still seems to be on the table, but no regional state has acted upon it, and the US seems to be deliberately lowering its profile -either because it might interference with negotiations by the 5+1 or because it has less support within the Obama Administration.

Uncertain Theater Nuclear Options

One key issue is what “extended deterrence” really needs to consist of in today’s world. The US is still a major nuclear power, but it has accepted growing limits on its nuclear forces. According to the NTI, nuclear-armed US missile forces now include:¹⁴⁹

...500 warheads on 450 Minuteman nuclear-tipped intercontinental at bases in Montana, North Dakota, and Wyoming. The bomber force deploys approximately 300 and consists of 76 nuclear-capable B-52 bombers that can deliver air-launched cruise missiles (ALCM), advanced cruise missiles (ACM), or gravity bombs, and 18 nuclear-capable B-2 bombers that carry gravity bombs. The Navy’s 14 operational Ohio-class nuclear-powered ballistic missile submarines (SSBN) carry approximately 1,152 Trident submarine-launched ballistic missiles (SLBM). In the 2010 Nuclear Posture Review, the United States decided to retire the Navy’s nuclear-tipped Tomahawk sea-launched cruise missiles (TLAM-N).

Following the Intermediate-Range Nuclear Forces Treaty (INF), the United States eliminated its entire stockpile of intermediate-range ballistic missiles (IRBM) and medium-range ballistic missiles (MRBM). Pursuant to the restrictions of the INF, the United States does not possess ballistic or cruise missiles with ranges between 500 and 5,500 kilometers.

During the Cold War, it consisted of the linkage between forward deployed tactical and theater nuclear weapons that were forward deployed in Europe, held by the US, and could be delivered by atomic demolition emplacement teams, for use in artillery systems, for delivery on US and allied quick reaction alert (QRA) strike aircraft, and mixes of rockets and missiles that later came to include the Lance, Pershing II, and Ground Launched Cruise Missile.

These latter systems have all been withdrawn and the status of US non-strategic nuclear systems is now ambiguous and tied more to arms reduction efforts with Russia than deterrence or war fighting. A report by Amy Woolf of the US Congressional Research Service describes their current stats as follows,¹⁵⁰

In 1991, the United States and Soviet Union both withdrew from deployment most and eliminated from their arsenals many of their nonstrategic nuclear weapons. The United States now has approximately 760 nonstrategic nuclear weapons, with around 200 deployed with aircraft in Europe and the remaining stored in the United States. Estimates vary, but experts believe Russia still has between 1,000 and 6,000 warheads for nonstrategic nuclear weapons in its arsenal. The Bush Administration quietly redeployed and removed some of the nuclear weapons deployed in Europe. Russia, however seems to have increased its reliance on nuclear weapons in its national security concept. Some analysts argue that Russia has backed away from its commitments from 1991 and may develop and deploy new types of nonstrategic nuclear weapons.

Recent discussions about the U.S. nuclear weapons policy have placed a renewed emphasis on the role of U.S. nonstrategic nuclear weapons in extended deterrence and assurance. Extended deterrence refers to the U.S. threat to use nuclear weapons in response to attacks, from Russia or other adversaries, against allies in NATO and some allies in Asia. Assurance refers to the U.S. promise, made to those same allies, to come to their defense and assistance if they are threatened or attacked. The weapons deployed in Europe are a visible reminder of that commitment; the sea-based nonstrategic nuclear weapons in storage that could be deployed in the Pacific in a crisis served a similar purpose for U.S. allies in Asia. Recent debates, however,

have focused on the question of whether a credible U.S. extended deterrent requires that the United States maintain weapons deployed in Europe, and the ability to deploy them in the Pacific, or whether other U.S. military capabilities, including strategic nuclear weapons and conventional forces, may be sufficient....

In the 2010 Nuclear Posture Review, the Obama Administration stated that the United States “will continue to assure our allies and partners of our commitment to their security and to demonstrate this commitment not only through words, but also through deeds.” The NPR indicated that a wide range of U.S. military capabilities would support this goal, but also indicated that U.S. commitments would “retain a nuclear dimension as long as nuclear threats to U.S. allies and partners remain.” The Administration did not, however, specify that the nuclear dimension would be met with nonstrategic nuclear weapons; the full range of U.S. capabilities would likely be available to support and defend U.S. allies. In addition, the Administration announced that the United States would retire the nuclear-armed sea-launched cruise missiles that had helped provide assurances to U.S. allies in Asia. In essence, the Administration concluded that the United States could reassure U.S. allies in Asia, and deter threats to their security, without deploying sea-based cruise missiles to the region in a crisis.

Moreover, the possible use of nuclear weapons, and extended nuclear deterrence, were a part of a broader concept that the Administration referred to as “regional security architectures.” The NPR indicated that regional security architectures were a key part of “the U.S. strategy for strengthening regional deterrence while reducing the role and numbers of nuclear weapons.” As a result, these architectures would “include effective missile defense, counter-WMD capabilities, conventional power-projection capabilities, and integrated command and control—all underwritten by strong political commitments.” In other words, although the United States would continue to extend deterrence to its allies and seek to assure them of the U.S. commitment to their security, it would draw on a political commitments and a range of military capabilities to achieve these goals.

...In the past, U.S. discussions about nonstrategic nuclear weapons have also addressed questions about the role they might play in deterring or responding to regional contingencies that involved threats from nations that may not be armed with their own nuclear weapons. For example, former Secretary of Defense Perry stated that, “maintaining U.S. nuclear commitments with NATO, and *retaining the ability to deploy nuclear capabilities to meet various regional contingencies*, continues to be an important means for deterring aggression, protecting and promoting U.S. interests, reassuring allies and friends, and preventing proliferation (emphasis added).”

... Specifically, both during the Cold War and after the demise of the Soviet Union, the United States maintained the option to use nuclear weapons in response to attacks with conventional, chemical, or biological weapons. For example, in 1999, Assistant Secretary of Defense Edward Warner testified that “the U.S. capability to deliver an overwhelming, rapid, and devastating military response with the full range of military capabilities will remain the cornerstone of our strategy for deterring rogue nation ballistic missile and WMD proliferation threats. The very existence of U.S. strategic and theater nuclear forces, backed by highly capable conventional forces, should certainly give pause to any rogue leader contemplating the use of WMD against the United States...”

The George W. Bush Administration also emphasized the possible use of nuclear weapons in regional contingencies in its 2001 Nuclear Posture Review. The Bush Administration appeared to shift towards a somewhat more explicit approach when acknowledging that the United States might use nuclear weapons in response to attacks by nations armed with chemical, biological, and conventional weapons, stating that the United States would develop and deploy those nuclear capabilities that it would need to defeat the capabilities of *any* potential adversary whether or not it possessed nuclear weapons. This does not, by itself, indicate that the United States would plan to use nonstrategic nuclear weapons. However, many analysts concluded from these and other comments by Bush Administration officials that the United States was planning for the tactical, first use of nuclear weapons. The Bush Administration never confirmed this view, and, instead, indicated that it would not use nuclear weapons in anything other than the most grave circumstances.

The Obama Administration, on the other hand, seemed to foreclose the option of using nuclear weapons in some regional contingencies. Specifically, it stated, in the 2010 NPR, that, “the United States will not use or threaten to use nuclear weapons against non-nuclear weapons states that are party to the Nuclear Non-Proliferation Treaty (NPT) and in compliance with their nuclear nonproliferation obligations.” Specifically,

if such a nation were to attack the United States with conventional, chemical, or biological weapons, the United States would respond with overwhelming conventional force, but it would not threaten to use nuclear weapons if the attacking nation was in compliance with its nuclear nonproliferation obligations and it did not have nuclear weapons of its own...At the same time, though, the NPR stated that any state that used chemical or biological weapons “against the United States or its allies and partners would face the prospect of a devastating conventional military response—and that any individuals responsible for the attack, whether national leaders or military commanders, would be held fully accountable.”...

...Through the late 1990s and early in George W. Bush Administration, the United States maintained approximately 1,100 nonstrategic nuclear weapons in its active stockpile. Unclassified reports indicate that, of this number, around 500 were air-delivered bombs deployed at bases in Europe. The remainder, including some additional air-delivered bombs and around 320 nuclear-armed sea-launched cruise missiles, were held in storage areas in the United States...

After the Clinton Administration’s 1994 Nuclear Posture Review, the United States eliminated its ability to return nuclear weapons to U.S. surface ships (it had retained this ability after removing the weapons under the 1991 PNI). It retained, however, its ability to restore cruise missiles to attack submarines, and it did not recommend any changes in the number of air-delivered weapons deployed in Europe. During this time, the United States also consolidated its weapons storage sites for nonstrategic nuclear weapons. It reportedly reduced the number of these facilities “by, over 75%” between 1988 and 1994. It eliminated two of its four storage sites for sea-launched cruise missiles, retaining only one facility on each coast of the United States. It also reduced the number of bases in Europe that store nuclear weapons from over 125 bases in the mid-1980s to 10 bases, in seven countries, by 2000...

The Bush Administration did not recommend any changes for U.S. nonstrategic nuclear weapons after completing its Nuclear Posture Review in 2001. Reports indicate that it decided to retain the capability to restore cruise missiles to attack submarines because of their ability to deploy, in secret, anywhere on the globe in time of crisis. The NPR also did not recommend any changes to the deployment of nonstrategic nuclear weapons in Europe, leaving decisions about their status to the members of the NATO alliance.

Nevertheless, according to unclassified reports, the United States did reduce the number of nuclear weapons deployed in Europe and the number of facilities that house those weapons during the George W. Bush Administration. Some reports indicate that the weapons were withdrawn from Greece and Ramstein Air Base in Germany between 2001 and 2005. In addition reports indicate that the United States also withdrew its nuclear weapons from the RAF Lakenheath air base in the United Kingdom in 2006.5...According to a recent unclassified report, the United States now deploys 160-200 bombs at six bases in Belgium, Germany, Italy, the Netherlands, and Turkey. Some of these weapons are stored at U.S. bases and would be delivered by U.S. aircraft. Others are stored at bases operated by the “host nation” and would be delivered by that nation’s aircraft if NATO decided to employ nuclear weapons.

The Obama Administration has not announced any further reductions to U.S. nuclear weapons in Europe and has indicated that the United States would “consult with our allies regarding the future basing of nuclear weapons in Europe.” In the months prior to the completion of NATO’s new Strategic Concept, some politicians in some European nations did propose that the United States withdraw these weapons. For example, Guido Westerwelle, Germany’s foreign minister, stated that he supported the withdrawal of U.S. nuclear weapons from Germany. Some reports indicate that Belgium and the Netherlands also supported this goal. ... As was noted above, NATO did not call for the removal of these weapons in its new Strategic Concept, but did indicate that it would be open to reducing them as a result of arms control negotiations with Russia.

Moreover, in the 2010 NPR, the Obama Administration indicated that it would take the steps necessary to maintain the capability to deploy U.S. nuclear weapons in Europe. It indicated that the U.S. Air Force would retain the capability to deliver both nuclear and conventional weapons as it replaced aging F-16 aircraft with the new F-35 Joint Strike Fighter. The NPR also indicated that the United States would conduct a “full scope” life extension program for the B61 bomb, the weapon that is currently deployed in Europe, “to ensure its functionality with the F-35.” This life extension program will consolidate four versions of the B61 bomb, including the B61-3 and B61-4 that are currently deployed in Europe, into one version, the B61-12. Reports indicate that this new version will reuse the nuclear components of the older

bombs, but will include enhanced safety and security features and a new “tail kit” that will increase the accuracy of the weapon....

On the other hand, the NPR indicated that the U.S. Navy would retire its nuclear-armed, sea-launched cruise missiles (TLAM-N). It indicated that “this system serves a redundant purpose in the U.S. nuclear stockpile” because it is one of several weapons the United States could deploy forward. The NPR also noted that, “U.S. ICBMs and SLBMs are capable of striking any potential adversary.” As a result, because “the deterrence and assurance roles of TLAM-N can be adequately substituted by these other means,” the United States could continue to extend deterrence and provide assurance to its allies in Asia without maintaining the capability to redeploy TLAM-N missiles....

The documents submitted with the US proposed FY2014 budget do not describe any aspect of US theater nuclear weapons or extended deterrence, but do state that:¹⁵¹

The Department will maintain a strong nuclear deterrence posture in the face of all potential threats, including developments in North Korea and risks from Iran. We are also committed to providing effective missile defense and maintaining a safe, secure, and effective nuclear arsenal. Despite budget pressures, DoD has ensured robust funding for these mission areas, making investments and taking actions to ensure the U.S. remains ahead of threat developments, including:

- Refocusing technologically advanced systems unlikely to be fielded quickly towards tech development activities to reduce risk and cost but that will field later (SM-3 IIB)
- Cancelling expensive surveillance systems and reinvesting in achievable, near-term upgrades to ground based radars (PTSS)
- Adding to national hedge against ballistic missile attack from rogue states (GBIs)
- Partnering with the National Nuclear Security Agency (NNSA) to assess the true requirements of the nuclear stockpile and associated infrastructure.

Providing nuclear guarantees to the Arab Gulf states, other regional allies, and Turkey would require a major refocus of US policy toward threat nuclear weapons they were to be forward deployed, although they could be sea-based and submarine launched, and eliminate any Iranian capability to target them and the political problems in deploying them on allied soil. US strategic systems also have the accuracy to be used against Iranian military area targets and as countervalue retaliation to any Iranian nuclear strike on an allied population center.

The US could be ambiguous in stating that it would meet any Iranian nuclear strike in kind without specifying how it would retaliate. It is unclear whether US allies would find this commitment to be adequate, but many might well prefer it to forward deployment, and even large states like Saudi Arabia might prefer such a broad guarantee to buying their own nuclear-armed missile forces from a state like Pakistan. As is the case with every aspect of deterrence involving nuclear weapons, however, they would push Iran to find countermeasures that could range from broadening the scope of initial use of nuclear weapons to threats it would use nuclear weapons against key petroleum export facilities or escalate to strike Southern Gulf cities and capitals.

While all sides involved would have every reason for restraint in making threats, in first use, and in escalation, it is a grim, reality that every acquisition of nuclear weapons leads to actual war plans to use them. This risk of miscalculation is always real, and any form of nuclear extended deterrence does – to some degree – increase the risk of nuclear war at least the margins of probability.

Conventional Options and “Weapons of Mass Effectiveness”

At the same time, there are other forms of “extended deterrence,” and there is no clear distinction between “containment,” the regular aspects of deterrence and forward deployed US forces, and “extended deterrence.” The fact the US forward deploys air, sea, and some elements of land power to some extent makes the US a tangible hostage to any massive form of Iranian escalation – linking it to retaliation against Iran or any other regional power using missiles, nuclear weapons, or major conventional forces against an ally. Even if the US says nothing more about extended deterrence. Iran can never safely calculate that an Iranian use of such weapons would not produce a nuclear response – and as is described in later sections, Iran has a highly vulnerable overall economic, ethnic, ruling elite, and military structure.

US stealth and precision strike air power, and conventional armed US cruise missiles, can destroy Iran’s critical infrastructure with conventional precision weapons – the equivalent of “weapons of mass destruction.” It can destroy Iran’s power grid, water systems, key communications node, refineries, POL export resources, and key aspects of its road and rail system. US missile defense systems, operating in concern with Southern Gulf and other allied missile and air defenses, can not only reduce the impact of a major Iranian attack, but confront it with fact it can never predict the outcome of any limited use of a nuclear strike system – which may simply result in the loss of the strike system and what initially will be a very limited number of Iranian nuclear weapons.

The US is, however, examining new ways to use its strategic missiles and new conventional strike systems in Prompt Global Strike missions (PGS). These systems could become conventional weapons of mass effectiveness and play a major role in deterrence, defense, and countering the use of nuclear weapons by the DPRK or China.

A report by Amy Woolf of the US Congressional Research Service notes that,¹⁵²

Many analysts believe that the United States should use long-range ballistic missiles armed with conventional warheads for the PGS mission. These weapons would not substitute for nuclear weapons in the U.S. war plan but would, instead, provide a “niche” capability, with a small number of weapons directed against select, critical targets, which might expand the range of U.S. conventional options. Some analysts, however, have raised concerns about the possibility that U.S. adversaries might misinterpret the launch of a missile with conventional warheads and conclude that the missiles carry nuclear weapons. DOD is considering a number of systems that might provide the United States with long-range strike capabilities.

The Air Force and Navy have both considered deploying conventional warheads on their long-range ballistic missiles. The Navy sought to deploy conventional warheads on a small number of Trident II submarine-launched ballistic missiles. In FY2008, Congress rejected the requested funding for this program, but the Navy has continued to consider the possibility of deploying intermediate-range technologies for the prompt strike mission. The Air Force and DARPA are developing a hypersonic glide delivery vehicle that could deploy on a modified Peacekeeper land-based ballistic missile—a system known as the Conventional Strike Missile (CSM). In FY2008, Congress created a single, combined fund for the conventional prompt global strike (CPGS) mission. This fund is supporting research and development into the Air Force CSM and two possible hypersonic glide vehicles. Congress appropriated \$174.8 million for CPGS capability development in FY2012; DOD has requested \$110.4 million in FY2013.

Unclassified studies do not specifically mention the role of these missiles in deterring and defending against Iran, but some of the target types that described in US Department of Defense documents could clearly affect Iran:¹⁵³

The United States might also be faced with circumstances during an ongoing conflict when it would need to destroy targets that could appear quickly and remain vulnerable for short periods of time. These might

include leadership cells that could move during a conflict or mobile military systems that the adversary had chosen to keep hidden prior to their use. These types of targets might only be vulnerable to weapons that the United States could launch promptly and direct to their targets quickly. Analysts have noted that PGS might provide the means to attack such targets if the United States did not have the necessary weapons located near the conflict.

The Defense Science Board outlined several of these potential scenarios in a March 2009 report prepared by the Task Force on Time Critical Conventional Strike from Strategic Standoff. This report “formulated five representative scenarios” that might require a “very rapid strike response to a developing situation.”...These scenarios included several cases:

- A near-peer competitor had used its emerging counter-space capability to destroy a U.S. satellite.
- The United States wanted to destroy a package of special nuclear materials that a terrorist organization had shipped to a neutral country.
- A small package of weapons of mass destruction was located temporarily in a rural area of a neutral country.
- The leadership of a terrorist organization had gathered in a known location in a neutral country.
- A rogue state armed with a nuclear weapon was threatening to use that weapon against a U.S. ally.

The US Navy and Air Force both have suggested global strike programs, but the Air Force currently seems to have the most chance of sustained funding, and its programs illustrate the capabilities of the possible delivery systems:¹⁵⁴

... [M]odified Minuteman II missiles might each be able to carry a single warhead that weighed between 500 and 1,000 pounds; a modified Peacekeeper could possibly carry between 6,000 and 8,000 pounds of payload, which would allow for multiple warheads or reentry vehicles.⁵¹ According to some estimates, these missiles could even destroy some targets without an explosive warhead, using the, “sheer force of impact of a reentry vehicle moving at 14,000 feet per second...”

According to the DSB study, Peacekeeper missiles could also carry a single reentry body that had been modified to improve accuracy by allowing for the maneuverability of the warhead, like the E2 warhead described above.

In addition, as was noted above, the United States could use a hypersonic glide vehicle, like the CAV under consideration in the Falcon Study, as the reentry body on a long-range ballistic missile. According to the Falcon Study, the CAV would be an unpowered, maneuverable hypersonic glide vehicle capable of carrying approximately 1,000 pounds in munitions or other payload...This vehicle is a cone-shaped winged body that, after launch aboard a booster derived from a ballistic missile, would fly within the atmosphere at hypersonic speeds and maneuver to its target. ...DOD has funded this program through the defense-wide Conventional Prompt Global Strike (CPGS) program since FY2008.

The US is also examining the option of deploying shorter-range systems called the Forward-Based Global Strike (FBGS),¹⁵⁵

Analysts have...explored the option of deploying long-range land-based ballistic missiles at bases outside the continental United States. For example, they might be deployed in Guam, Diego Garcia, or Alaska. This system would use a two-stage rocket motor, with a payload of up to 1,000 pounds, a flight time to target of less than 25 minutes, and an accuracy of less than 5 meters. It could employ many of the same reentry vehicle and warhead options as the CTM and CSM systems. Because it would rely on existing rocket technologies, it might be available for deployment by 2012, in roughly the same time frame as the CSM system. However, because it would be launched from outside the continental United States, its trajectory would not resemble that of a land-based ICBM. Hence, some analysts argue that it would solve many of the questions about misunderstandings and misperceptions that plague the CTM and CSM systems.

At the same time, the USAF is seeking to develop a new manned strategic bombers for conventional munitions delivery as one of the procurement priorities in its FY2014 budget

request, although some outside experts feel this may be a financial place holder for funding a future unmanned combat aerial vehicle (UCAV) or shifting future funds to make up for the cost-escalation in the F-35.

US Preventive Strike Options

The US also needs to preserve its preventive strike options. US senior officials and officers have long made it clear that the US has developed serious military contingency plans to carry out preventive strikes on Iran, and has steadily improved its intelligence and targeting coverage. President Obama pledged that the US would not allow Iran to obtain nuclear weapons as part of his Presidential campaign in October 2012, and Governor Romney took an even stronger position during the same debate.

The need to keep many key aspects of US plans and intelligence classified means that no public details are available, and there is no clear way to determine exactly how top level US decision makers view the trade-offs between negotiation, preventive and preemptive military options, and deterrence/containment.

Moreover, current US perceptions will almost certainly change as its competition with Iran progresses: Key steps will include the point when Iran clearly moves to the point of a nuclear break out capability, tests a device, and then begins to deploy some mix of nuclear armed forces. Given the timing of Iran's actions, a different set of key actors and possibly a different US Administration may also be in office before Iran has significant nuclear capabilities. Iran may define its goals in ways that raise or lower US perceptions of threat, and the P5+1, Gulf, and other regional states may change their perceptions as well.

The Diplomacy and Politics of Preventive Strikes

It is possible to provide some unclassified insights into the probable nature of US plans and perceptions of preventive and preemptive strike options. It is also clear that the US has strike assets that are far larger and more capable than those of Israel.

It is clear that the US has created serious military contingency plans for striking Iranian targets, has exercised and tested some elements of such strikes, and has improved its intelligence and targeting coverage. It is also clear from media sources that the US has focused on developing better ordnance to destroy underground and hardened targets, has developed regional missile defense options, is seeking to improve regional air defenses, and retains stealth capabilities and cruise missiles as important potential assets, whereas Israel has far more limited capabilities.

What is not clear is exactly how the US would approach such strikes, and how much acceptance or support it feels it needs, or can count on, from its allies in the Gulf and around the world. The US does have major *potential* advantages over Israel. It may be possible for the US to obtain the kind of overt or covert support from the Arab Gulf States, that Israel will not be able to obtain due to Arab-Israeli tensions. The US may be able to base and launch attacks from the Gulf area and from its carriers. It also has sufficient forces to strike with near simultaneous strikes at key Iranian nuclear, missile, air defense, and leadership targets.

Depending on its access to forward bases in or near the Gulf, the US can carry out a wide range of potential strikes ranging from limited, hitting just those targets associated with the nuclear project, to massive, hitting Iran's larger military force. The US could then take the time to assess battle damage, and carry out restrikes over a period of days, weeks, months, or years.

At the same time, it is important to stress that there is no practical way to determine how US senior policymakers and military leaders perceive US abilities to identify, target and destroy Iran's current nuclear and other strike capabilities. Neither is there a way to assess the degree to which they calculate a given pattern of strikes would provide security over time rather than provoke Iran into some massive new effort to acquire nuclear weapons due to a strike.

This would also give the US a very different kind of credibility in preventive operations from Israel. Israel may only be able to carry out one major wave of strikes - which would be far more limited than those the US can conduct - before Israel faced political constraints it cannot ignore, and must consider threats in terms of non-state actors with ties to Iran.

It is important to note, however, that US success would still depend heavily on partnership with key southern Gulf and other Arab states, the extent to which they felt threatened by Iran's nuclear and missile programs, and access to land facilities, airbases, and sustainment capabilities. Much depends on whether the US would be able to get regional support for a continuous presence and overwatch similar to that of operations Northern and Southern Watch that would allow it to continue to strike Iran - if Iran attempted to reconstitute its nuclear and missile programs. This would give the US an indefinite ability to restrike, suppress Iran, and attack other types of Iranian targets if a covert Iranian program was suspected and Iran did reveal its actions.

Any current judgment about Gulf perceptions has to be speculative. Neither the public statements of Gulf leaders, nor the material available from sources like Wikileaks, provide a clear indication of the links between U.S. and Gulf perceptions of the Iranian threat at the official level, or their willingness to act. Moreover, current Gulf perceptions are certain to change over time just as Israeli and U.S. perceptions will evolve as the Iranian threat alters and becomes more tangible. It is far from clear that today's threat perceptions provide a clear picture for the future.

Moreover, the US would face a number of other issues:

- It must deal with the legacy of the fact it invaded Iraq after totally mischaracterizing the Iraqi WMD threat. It would also have to deal with the negative political consequences of the military aftermath of any US preventive strike.
- Unless America's Arab, major Western European, and other allies saw that the US had exhausted diplomatic options, it could face serious diplomatic problems even with some of its closest friends.
- The US must seek to minimize the cost it will have to pay in terms of reactions from states that do not support its policies on sanctions or have a complicated regional relationship with Iran - which include major powers like Russia and China, and important regional allies like Turkey.
- The US must consider the impact strikes will have on the US role in Iraq, future operations in Afghanistan, and the war on terrorism.
- The US confronts a possible dilemma in which Israeli strikes create conditions where only the US could effectively finish the job, but where Arab states would either not feel threatened enough to support such a strike or would not support any follow on action to Israel.
- The US must balance the need for restraint in attacking Iran against whether limited US action would convince Iran that a nuclear weapon is needed and provoke Iran into a massive new covert nuclear weapons program. The US also needs to balance how a larger or smaller strike will affect how Iran might react and what forces it could use to retaliate against energy exporters in the Gulf, Israel, targets in Afghanistan, and other US interests in the region.
- Senior US intelligence officers have repeatedly warned in public that Iran has chemical and suspected biological weapon programs. Accordingly, options like missile defense, preemptive strikes, and extended regional deterrence must look beyond competition on a nuclear level.

Targeting and US Strike Options Against Iran

US officials have never described the US options for preventive and preemptive strikes in any detail, but it is clear that the US can draw upon a number of assets that Iran would find difficult to counter and which are listed in **Figure 16**.

Unlike Israel, and the Southern Gulf States, the US can project enough air and cruise missile power over all of Iran to strike at possible targets as well as confirmed targets. In fact, the Iran faces the problem in conducting the equivalent of a nuclear shell game that Iran ends is potentially provoking US strikes at all the possible shells.

The US could strike quickly at a critical Iranian military facilities of the kind shown in **Figure 17**, and include its major missile production facilities as well. Most are soft or semi-soft targets, and their destruction would be extremely costly to Iran. Even if many of Iran's nuclear facilities did survive US strikes, Iran would be faced with either complying with the EU3 and UN terms or taking much broader military losses - losses its aging and limited forces can ill afford.

It is important to note, however, that Iran's total target base does include a far wider range of targets than the major facilities that are listed on unclassified maps of its nuclear facilities and some Iranian facilities are very large clusters of buildings and growing. Iran also has a wide range of facilities that could be used for missile, biological, and chemical weapons production as well as deployed mobile and sheltered missile forces.

There is no way to know how broadly distributed even its nuclear facilities and potential nuclear targets are, but the NTI has put together lists of possible research facilities that at least illustrate how broad the target base could be, and how deep US (or Israeli) strikes would have to go into Iran.

An illustrative list of possible facilities is shown in **Figure 18**. Many are primarily civil facilities in populated areas, and many are almost certainly innocent of any military purpose. It would take exceptional intelligence to know what target points to hit and still minimize civilian casualties and collateral damage. Moreover, the list in **Figure 18** does not include any covert military facilities, deployed forces, and most of Iran's chemical weapons facilities and holdings.

More broadly, a comparison of **Figure 17** and **Figure 18** provide a rough indication of how difficult an all-out effort to suppress Iran's WMD programs might be. An effort to hit all of these targets would be many times more complex than targeting and strike plans needed to destroy just those facilities declared to the IAEA under the terms of the NPT.

It is important to understand, however, that US and Israeli intelligence can almost certainly eliminate many of uncertainties in an unclassified analysis. They can use a wide range of classified sources to narrow the target list of the suspect civilian facilities while adding covert and military targets.

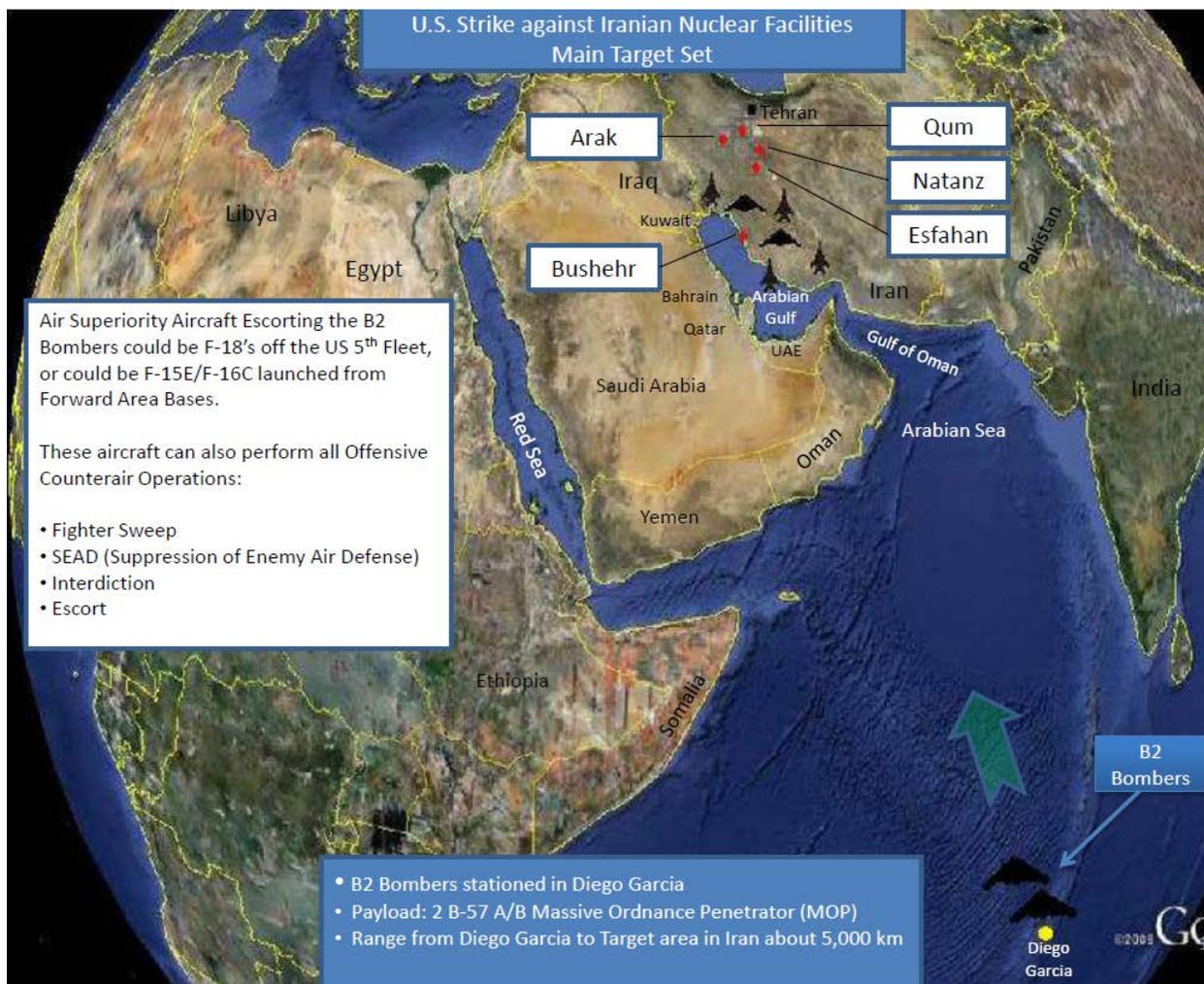
*Figure 16: Key Assets for a US Strike on Iran - Part I***B-2A Spirit Bomber**

Primary Function	Multi role heavy bomber
Engines:	Four GE F-118-GE-100 engines, each with a thrust of 17,300 pounds (7,847kg)
Speed, Cruise:	High Subsonic
Ceiling:	50,000 ft. (15,000 meters)
Weight Takeoff, (typical):	335,500 - 350,000 pounds (152,600 - 159,000kg)
Weight, Empty (typical):	125,000 - 160,000 pounds
Range:	6,000 nautical miles (9,600 km), unrefueled range for a Hi-Lo mission with nuclear free-fall bombs. 10,000 nautical miles with one aerial refueling.
Payload:	40,000 pounds (18,000kg)
Crew:	2 pilots
Current Armament:	Nuclear: 16 B61, 16 B83 Conventional: 80 MK82 (500lb), 16 MK84 (2000lb), 34-36 CBU-87, 34-36 CBU-89, 34-36 CBU-97 Precision: 216 GBU-39 SDB (250lb), 80 GBU-30 JDAM (500lb), 16 GBU-32 JDAM (2000lb), GBU-27, GBU-28, GBU-36, GBU-37, AGM-154 HSOW, 8-16 AGM-137 TSSAM, 2 MOP/DSHTW/Big BLU

*Figure 16: Key Assets for a US Strike on Iran - Part II***GBU-57 Massive Ordnance Penetrator (MOP)**

GBU-57A/B Massive Ordnance Penetrator (MOP)	Specifications
Weight, total:	13,600kg (slightly less than 30,000 pounds)
Weight, explosive:	2,700kg (6,000lb)
Length:	6m/20.5 feet
Diameter:	31.5 in
Penetration:	60 meters (200ft) through 5,000 psi reinforced concrete. 40 meters (125ft) through moderately hard rock. 8 meters (25ft) through 10,000 psi reinforced concrete.
Control:	Short-span wings and trellis-type tail
Contractors:	Boeing, Northrop Grumman
Platforms:	B-52, B2
Guidance	GPS aided Inertial Navigation System

Figure 17: Potential US Strike on Iran's Key Known Nuclear Facilities



Source: Dr. Abdullah Toukan.

Figure 18: NTI List of Suspect Nuclear, Missile, and Biological Facilities

Nuclear

Nuclear-Conversion

Jabr Ibn Hayan Multipurpose Laboratories (JHL)
Rudan Conversion Facility
Uranium Conversion Facility (UCF)

Nuclear-Education and Training

Amir Kabir University of Technology
Imam Hussein University (IHU)
Institute for Studies in Theoretical Physics and Mathematics (IPM)
Malek Ashtar University (MAU)
Sharif University of Technology (SUT)
University of Tehran (UT)

Nuclear-Enrichment

7th of Tir Industries
Defense Industries Organization (DIO)
Farayand Technique
Fordow Fuel Enrichment Plant
Fuel Enrichment Plant (FEP)
Kalaye Electric Company
Kaveh Cutting Tools Company/Abzar Boresh Kaveh Co
Lashkar Ab'ad
Natanz Enrichment Complex
Pars Trash
Pilot Fuel Enrichment Plant (PFEP)
Tehran Nuclear Research Center (TNRC)

Nuclear-Fuel Fabrication

Fuel Fabrication Laboratory (FFL)
Fuel Manufacturing Plant (FMP)
Zirconium Production Plant (ZPP)

Nuclear-Heavy Water Production

Heavy Water Production Plant (HWPP)

Nuclear-Mining and Milling

Ardakan Yellowcake Production Plant
Bandar Abbas Uranium Production Plant (BUP)
Saghand

Nuclear-Power Reactors

Darkhovin Nuclear Power Plant

Nuclear-Regulatory

Atomic Energy Organization of Iran (AEOI)

Nuclear-Reprocessing

Tehran Nuclear Research Center (TNRC)

Nuclear-Research Reactors

IR-40
Miniature Neutron Source Reactor (MNSR)

Tehran Research Reactor (TRR)

Nuclear-Research and Development

Bonab Atomic Energy Research Center
Graphite Sub-Critical Reactor (ENTC GSCR)
Heavy Water Zero Power Reactor (ENTC-HWZPR)
Isfahan (Esfahan) Nuclear Fuel Research and Production Center (NFRPC)
Isfahan (Esfahan) Nuclear Technology Center (INTC)
Karaj Agricultural and Medical Research Center
Light Water Sub-Critical Reactor (ENTC-LWSCR)
Plasma Physics Research Center
Tehran Nuclear Research Center (TNRC)
Yazd Radiation Processing Center (YRPC)

Nuclear-Waste Management

Anarak Waste Storage Facility
Isfahan (Esfahan) Nuclear Waste Storage Facility
Karaj Waste Storage Facility
Qom Waste Disposal Site

Nuclear-Weaponization

Institute of Applied Physics (IAP)
Kimia Maadan Company (KM)
Parchin Military Complex
Physics Research Center (PHRC)
Tehran Nuclear Research Center (TNRC)

Missile

Missile-Education and Training

Imam Hussein University (IHU)
Malek Ashtar University (MAU)
Sanam College

Missile-Missile Bases

Abu Musa Island
Bakhtaran Missile Base
Bandar Abbas
Imam Ali Missile Base
Kuhestak Missile Battery
Mashad Airbase
Semnan Space and Missile Center
Tabriz Missile Base

Missile-Production

Bank Sepah
Dorud
Fajr Industrial Group
Farhin
Gostaresh Scientific Research Center
Iran Aircraft Manufacturing Industries
Isfahan Missile Complex
Karaj Missile Development Complex
Lavizan Technical and Engineering Complex
Manzariyah

Parchin Chemical Industries
Parchin Military Complex
Qods Aeronautics Industries
Semnan Missile Complex
Shahid Bakeri Industrial Group
Shahid Hemmat Industrial Group
Shiraz Missile Plant
Sirjan Missile Plant
Ya Mahdi Industries Group

Missile-Regulatory

Aerospace Industries Organization (AIO)
Defense Industries Organization (DIO)
Ministry of Defense and Armed Forces Logistics (MODAFL)

Missile-Testing

Garmsar Missile Test Range
Shahrud Missile Test Site
Tabas

Biological

Biological-Dual-Use Infrastructure

Persian Type Culture Collection

Biological-Education and Training

Amir Kabir University of Technology
Sharif University of Technology Biochemical and Bioenvironmental Engineering Research Center
Tehran University Institute for Biochemistry and Biosphysics Research (IBB)

Biological-Production

Razi Institute for Serums and Vaccines
Vira Laboratory

Biological-Regulatory

Science and Technology Group
Special Industries Organization (SIO)

Biological-Research and Development

Biotechnology Institute of the Iranian Research Organization for Science and Technology
Institute for Pestilence and Plant Disease Research
Institute for Plant and Seed Modification Research
Iranian Research Organization for Science and Technology
National Research Center of Genetic Engineering and Biotechnology (NRCGEB)
Pasteur Institute
Research Center of the Construction Crusade (Jihad-e Sazandegi)

Chemical-Production

Damghan

Source: NTI (Nuclear Threat Initiative), "Iran: Facilities," <http://www.nti.org/country-profiles/iran/facilities/>, updated July 2012.

Key US Delivery Systems

Iran would find it difficult to defend against US forces. It would face a complex and unpredictable mix of attacks from cruise missiles, stealth aircraft, and stand-off precision weapons. It would also face a US opponent equipped with a mix of vastly superior air combat and IS&R assets necessary to strike and restrike Iranian targets in near real time.

Cruise Missiles

For example, the US could use a range of regular and special purpose cruise missiles, including submarines and ship launched Tomahawk BGM-109s. These cruise missiles have steadily improved in performance since the system was first deployed in the 1970s. It is unclear that all of these improvements have been declassified, but the Block III models that entered service in 1993 can fly farther and use GPS receivers to strike more precisely. The newer Block IVs that began to deploy in 2004 have been equipped with an improved turbofan engine. According to one source,¹⁵⁶

“The Block IV TLAMs have enhanced deep-strike capabilities and are equipped with a real-time targeting system for striking fleeting targets. A major improvement to the Tomahawk is network-centric warfare-capabilities, using data from multiple sensors (aircraft, UAVs, satellites, foot soldiers, tanks, ships) to find its target. It will also be able to send data from its sensors to these platforms. It will be a part of the networked force being implemented by the Pentagon.

“Tactical Tomahawk” takes advantage of a loitering feature in the missile’s flight path and allows commanders to redirect the missile to an alternative target, if required. It can be reprogrammed in-flight to attack predesignated targets with GPS coordinates stored in its memory or to any other GPS coordinates. Also, the missile can send data about its status back to the commander. It entered service with the US Navy in late 2004...In May 2009, Raytheon Missile Systems proposed an upgrade to the Tomahawk Block IV land-attack cruise missile that would allow it to destroy or disable large, hardened warships at 900-1,000 nautical miles (1,700 km) range...

The US Navy’s unclassified summary of the Block IV’s capability states that the missile has a maximum range of 900 nautical miles (1000 statute miles, 1600 km), and that,¹⁵⁷

Tomahawk carries a nuclear or conventional payload. The conventional, land-attack, unitary variant carries a 1,000-pound-class warhead (TLAM-C) while the submunitions dispenser variant carries 166 combined-effects bomblets (TLAM-D). The Block III version incorporates engine improvements, an insensitive extended range warhead, time-of-arrival control and navigation capability using an improved Digital Scene Matching Area Correlator (DSMAC) and Global Positioning System (GPS)...which can significantly reduce mission-planning time and increase navigation and terminal accuracy. Tomahawk Block IV (TLAM-E) is the latest improvement to the Tomahawk missile family. Block IV capability enhancements include: (a) increased flexibility utilizing two-way satellite communications to reprogram the missile in-flight to a new aim point or new preplanned mission, send a new mission to the missile en route to a new target, and missile health and status messages during the flight; (b) increased responsiveness with faster launch timelines, mission planning capability aboard the launch platform, loiter capability in the area of emerging targets, the ability to provide battle damage indication in the target area, and the capability to provide a single-frame image of the target or other areas of interest along the missile flight path; and (c) improved affordability with a production cost of a Block IV significantly lower than the cost of a new Block III and a 15-year Block IV recertification interval compared to the eight-year interval for Block III.

Raytheon notes that,¹⁵⁸

Today’s Tomahawk Block IV can circle for hours, shift course instantly on command and beam a picture of its target to controllers halfway around the world. Controllers can plan missions in an hour, which is a huge improvement over the 80 hours needed when the weapon first debuted in combat....Tomahawks can fly into heavily defended airspace and precisely strike high-value targets with minimal collateral damage...During the NATO-led effort against the regime of Libyan leader Moammar Gadhafi in 2011, the

Tomahawk played an instrumental role in the operation. One submarine fired more than 90 missiles at a variety of targets, and the USS Barry fired the 2,000th Tomahawk in combat.

The US has developed systems that allow Special Forces and other combat units to use small UAVs to target enemy facilities and provide precise target coordinates to loitering Tomahawks. It also is developing a more advanced cruise missile called the Cruise Missile XR, with new penetration aids and a range-payload roughly twice that of the Tomahawk Block ¹⁵⁹

The Tomahawks do have weight-limited conventional warheads, and even if Tactical Tomahawk Penetrator Variant version designed to hit hardened targets has quietly been put into production and the use of two shaped charge warheads to greatly increase penetration has proven successful, it would still have limited penetration capability. Nevertheless, the Tomahawks can deliver extremely precise strikes and do so with minimal collateral damage even in relatively crowded urban areas. These weapons could potentially destroy Iran's nuclear, missile, and other critical military production and research centers both outside and within cities with limited cumulative civilian casualties and collateral damage.

The ability to use sea-launched versions would also limit the need for land basing and the burden on US carriers, and preventive strikes could be begun with less warning than be deploying added carriers or large air movements into the Gulf region. There would also be less risk of losing US aircraft or exposing US ships to Iranian attack.

Air Strike Assets

The US might use a combination of cruise missiles and air strikes to create corridors through Iran's air defense systems or destroy and suppress the key elements of the entire land-based system. As the previous report on Iran's conventional forces has shown, Iran's only fully modern surface-to-air missile system is the Tor-M missile system, a Russian short-range surface-to-air system designed to shoot down ALCMs. Iran reportedly acquired 29 of these systems from Russia in 2007; each is equipped with eight missiles, the associated radar, fire control system, and command post.¹⁶⁰ The US could use a mix of regular strike aircraft, anti-radiation missiles, electronic warfare aircraft, cruise missiles, UAVs, and other systems to systematically suppress most of Iran's aging land-based surface-to-air defense systems as well as its air defense fighters, strike fighters, and bombers to destroy Iran's air force.

Once it did so, the US would have free reign to attack Iranian land targets with stand-off precision guided munitions that would reduce the risk of Iran's surviving short-range air defenses to US planes. These strikes could hit a full range of targets including critical missile and other military production sites crippling Iran's overall military capabilities, while destroying its nuclear facilities. Knocking out key corridors in Iran's land-based air defenses would also allow the US to restrike at will, preventing Iran from reconstituting its military capabilities.

As for the forces involved, the US would probably use stealth as well as non-stealth aircraft in its initial attacks, although it is just as possible that it might conduct a more limited mix of strikes only using cruise missiles and stealth aircraft. US stealth capacity will provide attacking forces a further level of advantage against Iran's limited air-defense capabilities. Both large-scale strikes as well as more limited strikes by cruise missiles will be able to use this advantage to strike at even well-protected targets.

Stealth Strike Capability

Each US B-2A Spirit stealth bomber can carry eight 4,500-pound enhanced BLU-28 satellite-guided bunker-busting bombs or their more modern precision-guided equivalents - potentially enough to take out one hardened Iranian site per sortie. Such bombers could operate from Al Udeid air base in Qatar, Diego Garcia in the Indian Ocean, RAF Fairford in Gloucestershire, United Kingdom, and Whiteman Air Force Base in Missouri.

At the same time, the B-2 could be used to deliver large numbers of precision-guided 250 and 500-pound bombs, or two GBU-57A/B Massive Ordnance Penetrators (MOP) against dispersed surface targets. Likewise, it could carry a mix of light and heavy precision-guided weapons. Submarines and surface ships could deliver cruise missiles for such strikes, and conventional aircraft and bombers could deliver standoff weapons against most Iranian facilities without the risk from Iranian air defense. The challenge would be to properly determine what targets and aim points were actually valuable in order to lower the risk to US forces and prevent civilian casualties, not to inflict high levels of damage.

At present, a large-scale US attack might include B-2A bombers carrying 2 GBU-57 MOP bombs, escorted by F/A-18s from the 5th Fleet stationed in the Gulf area, or F-15E's, F-16C's, or F-22's from forward operating bases. The specifications for the MOP are below:

The MOP is a GPS-guided weapon containing more than 5,300 pounds of conventional explosives inside a 20.5 ft. long bomb body of hardened steel. It is designed to penetrate dirt, rock and reinforced concrete to reach enemy bunker or tunnel installations. The B-2 will be capable of carrying two MOPs, one in each weapons bay.

The B-2 currently carries up to 40,000 pounds of conventional ordnance. For example, it can deliver 80 independently targeted 500-lb class bombs from its smart bomb rack assembly; or up to 16 2,000-lb class weapons from its rotary launcher.

As the US increases its stealth platforms, new weapons, especially UAVs will further improve this advantage. US stealth UCAVs are known to exist, but their capabilities are classified. While the F-22 is generally treated as an air superiority aircraft, it too is a sophisticated stealth strike aircraft that allow it to fly demanding high-speed, low altitude missions while carrying a payload of precision guided weapons in two internal bomb racks that can each hold a 1,000lb JDAM bomb or four to eight small diameter bombs.

Furthermore, as the F-35's production and deployments increase, the US will have a land-based, carrier-based, and VSTOL stealth attack aircraft that can carry two 2,000 pound precision guided munitions or eight small diameter bombs, increasing the US's ability to evade Iran's air-defense.¹⁶¹

While the success rate of any attack on Iran's nuclear facilities would depend on its duration and the number of strikes carried out, it seems highly likely that the US would have a very high success rate if its attacks were sustained for a several days. The US could also cripple Iran's economy at the same time by striking at major domestic gas production and distribution facilities, refineries, and electric power generations.

If Iran's air defenses were destroyed at the same time, the US could use any of its strike fighters and bombers - with or without stealth - to engage in restrikes over almost any period of time. If the US chose to strike at the necessary level of intensity, it could use then conventional weapons to cripple Iran's ability to function as a nation in a matter of days with attacks limited to several hundred aim points.

None of these scenarios, however, involve minor air wars. One analyst has privately estimated that strikes against some 400 targets would be necessary to totally dismantle Iran's nuclear, missile, and related facilities. According to other reports, the Department of Defense is considering both conventional strikes against Iran's other WMD and missile facilities, by creating an entry corridor by destroying part of Iran's air defense system. This could easily require 800-1,200 sorties and cruise missile strikes.

Killing Hardened and Deeply Buried Targets

The US would face some important uncertainties where much depends on Iran's level of hardening and the persistence with which the US would strike. The greatest physical challenges in the first phases of a U.S. campaign would be the risk that unknown facilities and targets would survive, and possibility that Iran's hardened and underground facilities at Natanz and Fordow, would survive.

It should be noted, however, missing some sites would be unimportant if the US could go back and strike sites that had not been detected or destroyed the first time, or destroy rebuilt entrances to deeply sheltered facilities. If anything, the constant risk and or reality of such restrikes would then become a way of showing Iran it had no alternative other than to negotiate.

Iran's hardest targets do present challenges. The US does have a wide range of hard target killers - but it is uncertain they could destroy an underground site as large and as well compartmented as Natanz or do more than destroy the entrance of a deep mountain site like Fordow. Some reports indicate that the DoD has concluded that its capabilities, mainly the ability to penetrate 200 feet underground, are not robust enough to counter all Iran's hardened facilities.¹⁶² This may explain why Boeing received a \$98 million contract in April 2012 to "procure enhanced threat response redesign for the Massive Ordnance Penetrator, a quick reaction capability program" in order to increase its penetration power.¹⁶³

The US systems that are publically known to be deployed include the BLU-109 Have Void "bunker busters," a "dumb bomb" with a maximum penetration capability of four to six feet of reinforced concrete. It can be fitted with the Joint Direct Attack Munition (JDAM) guidance kit that allows for a CEP of 13 meters.

The JDAM GBU-31 version has a nominal range of 15 kilometers with a CEP of 13 meters in the GPS-aided Inertial Navigation System (INS) modes of operation and 30 meters in the INS-only modes of operation.

More advanced systems that have been discussed in the unclassified literature include the BLU-116 Advanced Unitary Penetrator (AUP), the GBU-24 C/B (USAF), or the GBU-24 D/B (US Navy), which has about three times the penetration capability of the BLU-109. The US is investing in other weapons that are supposed to destroy targets that are buried under more than 20 meters of dirt and concrete.

It is not clear whether the United States has fully deployed the AGM-130C with an advanced earth penetrating/hard target kill system. The AGM-130 Surface Attack Guided Munition was developed to be integrated into the F-15E, so it could carry two such missiles. It is a retargetable, precision-guided standoff weapon using inertial navigation aided by GPS satellites and has a 15-40 NM range.

The US does, have a number of other new systems in the developmental stage and can probably deploy systems capable of roughly twice the depth of penetration with twice the effectiveness of the systems known from their attacks on Iraq in 1991.

The nature and characteristics of such systems are classified. The newest, most advanced weapons publically declared to be in US service are the 5,000-pound BLU-122 and the 30,000-pound Massive Ordnance Penetrator (MOP). The MOP weighs almost 30,000 pounds and carries 5,300 pounds of explosives. According to some estimates optimum penetrating distance for the MOP is up to 200 feet. Possible alternatives to these weapons are directed-energy and high-power microwave (HPM) weapons, none of which are currently beyond testing phase.

Despite the size and power of the MOP, reports surfaced in January of 2012 that it would not be capable of destroying some of Iran's nuclear facilities because of their depth and new fortifications.¹⁶⁴ According to government officials who briefed the *Wall Street Journal*, this is why the Pentagon is seeking to invest \$82 million to make the bomb more effective against hardened, deeply-buried structures such as Iran's nuclear sites.¹⁶⁵ In an interview with the *Wall Street Journal*, however, US Secretary of Defense acknowledged that the MOP could still do significant damage to Iran's sites in its current configuration, but not destroy them outright.¹⁶⁶

Some US officials seem to have gone further. One unnamed senior defense official is reported to stated that conventional weaponry would not be effective in destroying the Fordow site, and that a tactical nuclear weapon may be the only military option to destroy it.¹⁶⁷ If this statement is accurate, the likelihood that Iran's nuclear facilities would be completely destroyed in a conventional attack seems uncertain.

There is also something of "hardening race" between Iran and the US. Iran is reported to be drawing on North Korean expertise and to have created a separate corporation (Shahid Rajaei Company) for such tunneling and hardening efforts under the IRGC, with extensive activity already under way in Natanz and Isfahan, and possibly within the 3,000 centrifuge site inside the mountain complex at Fordow.

The facilities are said to make extensive use of blast-proof doors, extensive divider walls, hardened ceilings, 20-centimeter-thick concrete walls, and double concrete ceilings with earth filled between layers to defeat earth penetrates. Such passive defenses could have a major impact, but reports of such activity are often premature, exaggerated, or report far higher construction standards than are actually executed. Much depends on the accuracy of reports that Iran has undertaken a massive tunneling project with some 10,000 square meters of underground halls and tunnels branching off for hundreds of meters from each hall.

The US would not, however, have to "kill" or destroy such sites in an extended campaign. Unlike Israel, the US could deploy enough forces with hard-target and earth penetrating weapons over extended periods of time to do serious damage to any Iranian site even if it were buried and destroy its entrance and access facilities, as well as exposed support facilities and infrastructure.

If the US should adopt a strike-assess-restrike approach, it could use hard target killers like the GBU-28 and its precision guided equivalent to strike decisively at the more vulnerable hard or buried targets, closing the close the entrances and destroying the above ground service facilities for even the hardest targets. In a prolonged overwatch and restrike scenario, it could keep them shut or unusable indefinitely.

The Aftermath of A US Preventive Attack

The US will have to consider the broader impact of preventive strikes will have on the conflicts in Iraq, Afghanistan, and the war on terrorism; whether US actions will provoke Iran into a massive new covert effort; and how Iran might react by attacking energy exports in the Gulf, Israel, and other US interests in the region.

Iran can escalate in many different ways over very different periods of time, and Iran can do so even if the US is prepared to maintain a major air and sea overwatch and restrike capability and has the support of Arab Gulf States and other neighboring states in doing so.

Iran would still have a wide range of surviving asymmetric warfare capabilities that it could use to strike at its neighbors or US targets. It could conduct some kind of spasmodic effort to close the Gulf - either having already lost many key conventional assets or being willing to accept further losses. It could conduct a long war of attrition using its asymmetric assets against non-US and/or US targets over time at levels that did not justify a major US retaliatory attack but kept up constant visible pressure.

Iran will also have a wide range of other options. It could use its long-range missiles and rockets to make politically symbolic or “terror” attacks on targets in the Gulf. It could seek to work with Hezbollah and possibly, but not probably Hamas to attack Israel - attacking the US indirectly in the process.

Iran could attack a US ship or embassy outside the region, or conduct attacks similar to the 1983 Marine Corps Barracks Bombing or 1996 Khobar Towers Bombing. It could try to sabotage a major oil exporting facility in Saudi Arabia or the rest of the Gulf to strike at the US economy. It could try the use the UN and World Court to charge aggression and discredit the US. In addition, Iran could use the opportunity to try to gain additional influence or control in Iraq by force.

Once again, much would also depend on the extent to which the leaders of friendly Gulf States were actually willing to back the US in such a post-preventive strike campaign. Any such judgment about Gulf perceptions has to be speculative. Neither the public statements of Gulf leaders, nor the kind of material available from sources like Wikileaks, provide a clear indication of Gulf perceptions of the Iranian threat at the official level, or their willingness to act.

Moreover, current Gulf, Israeli, and US perceptions are certain to change over time as the Iranian threat alters and becomes more tangible. Perceptions in peacetime will be very different from perceptions once a conflict has begun - particularly if a US preventive strike is followed by some form of Iranian-initiated asymmetric attack or war in the Gulf.

Possible US War Plans: Attacking, Delaying, Waiting Out

These uncertainties make it useful to consider a wider range of scenarios and war plans and their impact if the negotiating process fails.. Much will depend on the exact nature of the intelligence available at a given time, how the US analyses the vulnerability of given targets and the effectiveness of specific munitions, the urgency the US feels in acting and its willingness to take risks in targeting and striking, allied support and international attitudes, and where Iran’s programs stand.

If the US does choose to respond militarily, however, it could turn the broad options in its escalation ladder into the more detailed military options reflected in **Figure 19** through **Figure 24**.

It should be stressed that these are only rough outlines of such US options. They are not based on any inside knowledge of actual US war plans, and calculations.

Figure 19 reflects a potential scenario in which the US used limited “demonstrative” or “deterrent” strikes to coerce Iran into abandoning its efforts to acquire nuclear weapons without launching a full strike on Iran’s nuclear facilities. It is unclear how Iran would respond to such action.

Figure 20 reflects a potential scenario in which the US used limited strikes to damage or destroy Iran’s largest and most important nuclear sites.

Figure 21 reflects a potential scenario in which the US engaged in major strikes on Iran’s CBRN and major missile targets.

Figure 22 reflects a potential scenario in which the US engaged in major attacks on Iran’s nuclear facilities, major missile assets, as well as “dual use” assets that contribute to Iran’s “technology base” such as universities.

Figure 23 reflects a potential scenario in which the US waited for Iran to provide proof of or a “smoking gun” that indicated nuclear proliferation to strike at the country’s facilities.

Figure 24 reflects a potential scenario in which the US would not attack Iran’s nuclear sites, but indicated nuclear targeting of Iran’s military and CBRN facilities and its cities. Other potential action could include deploying anti-ballistic missile and cruise missile defense and tacitly signaling a “green light” for Israeli nuclear retaliation or preemption, among others.

Figure 19: US Demonstrative, Coercive, or Deterrent Strikes

- Conduct a few cruise missile or stealth strikes simply as a demonstration or warning of the seriousness of US intentions if Iran does not comply with the terms of the EU3 or UN.
- Hit at least one high value target recognized by IAEA and EU3 to show credibility to Iran, minimize international criticism.
- Might strike at new sites and activities to show Iran cannot secretly proceed with, or expand its efforts, by ignoring the UN or EU3.
- Could be carrier-based; would not need territory of Gulf ally.
- International reaction would be a problem regardless of the level of US action.
- Might trigger Iranian counteraction in Iraq, Afghanistan, and with Hezbollah.

Figure 20: Limited US Attacks

- Limited strike would probably take 16-20 cruise missile and strike sorties. (Total sorties in Gulf and area would probably have to total 100 or more including escorts, enablers, and aerial refueling tankers).
- Might be able to combine B-2s and carrier-based aircraft and sea-launched cruise missiles. Might need land base(s) in Gulf for staging, refueling, and recovery.
- Goal would be to destroy or critically damage at least 2-3 of the most important facilities.
- Hit at high value targets recognized by IAEA and EU3 to show credibility to Iran, minimize international criticism.
- Might strike at new sites and activities to show Iran cannot secretly proceed with or expand its efforts by ignoring the UN or EU3.
- Might slow down Iranian effort if hard and underground targets were struck, but the impact over time would probably be more of a show of force or signaling of intent than crippling.
- Hitting hard and underground targets could require multiple strikes during mission, and follow-on restrikes to be effective.
- Battle damage assessment would be a significant problem, particularly for large buildings and underground facilities.
- Size and effectiveness would depend very heavily on the quality of US intelligence and suitability of given ordnance as well as the time the US sought to inflict a given effect.
- Iran's technology base would survive; the same would be true of much of equipment even in facilities hit with strikes. Little impact, if any, on pool of scientists and experts.
- Iranian response in terms of proliferation could vary sharply and unpredictably, the balance between deterring and delaying Iran will be weighed against Iran's mobilization and the level they are provoked into retaliatory action.
- Likely to produce cosmetic Iranian change in behavior at best. Would probably make Iran disperse program even more, and drive it to deep underground facilities. Might provoke Iran to implement a (more) active biological warfare program.
- Any oil embargo likely to be demonstrative show of force and a view of the consequences if Iran is attacked further.
- Could trigger Iranian counteraction in Iraq, Afghanistan, and with Hezbollah.
- International reaction could be a serious problem; US might well face same level of political problems as if it had launched a comprehensive strike on Iranian facilities.

Figure 21: Major US Attacks on Iranian CBRN and Major Missile Targets

- Would take at least 7-10 days to fully execute and validate.
- Goal would be at least 70-80% of most costly and major facilities critically damaged or destroyed.
- 200-600 cruise missiles and strike sorties; would have to be at least a matching number of escorts, enablers, and aerial refueling. Period of attacks could extend from 3 to 10 days.
- Hit all suspect facilities for nuclear, missile, BW, and related C4IBM.
- Knock out key surface-to-air missile sites and radars for future freedom of action.
- Would need to combine B-2s, carrier-based aircraft and sea-launched cruise missiles, and use of land base(s) in Gulf for staging, refueling, and recovery.
- Threaten to strike extensively at Iranian capabilities for asymmetric warfare and to threaten tanker traffic, facilities in the Gulf, and neighboring states.
- Hit at all high value targets recognized by IAEA and EU3 to show credibility to Iran, minimize international criticism, but also possible sites as well.
- Strike at all known new sites and activities to show Iran cannot secretly proceed with, or expand its efforts, unless hold back some targets as hostages to the future.
- Impact over time would probably be crippling, but Iran might still covertly assemble some nuclear device and could not halt Iranian biological weapons effort.
- Hitting hard and underground targets could easily require multiple strikes during mission, and follow-on restrikes to be effective.
- Battle damage would be a significant problem, particularly for large buildings and underground facilities.
- Size and effectiveness would depend very heavily on the quality of US intelligence and suitability of given ordnance, as well as the time the US sought to inflict a given effect.
- Much of Iran's technology base would still survive; the same would be true of many equipment items, even in facilities hit with strikes. Some impact, if any, on pool of scientists and experts.
- Iranian response in terms of proliferation could vary sharply and unpredictably, the balance between deterring and delaying Iran will be weighed against Iran's mobilization and the level they are provoked into retaliatory action.
- A truly serious strike may be enough of a deterrent to change Iranian behavior, particularly if coupled to the threat of follow on strikes in the future. However, it still could as easily produce only a cosmetic Iranian change in behavior at best. Iran might still disperse its program even more, and shift to multiple, small, deep underground facilities.
- Might well provoke Iran to implement (more) active biological warfare program.
- An oil embargo might be serious.
- The Iranian government could probably not prevent some elements in Iranian forces and intelligence from seeking to use Iraq, Afghanistan, support of terrorism, and Hezbollah to hit back at the US and its allies.
- International reaction would be a serious problem, but the US might well face same level of political problems as if it had launched a small strike on Iranian facilities.

Figure 22: Major US Attacks on Military and Civilian Targets

- 1,000-2,500 cruise missiles and air strike sorties.
- Hit all suspect facilities for nuclear, missile, BW, and C4IBM, and potentially “technology base” targets including universities, dual use facilities.
- Either strike extensively at Iranian capabilities for asymmetric warfare and to threaten tanker traffic, facilities in the Gulf, and neighboring states or threaten to do so if Iran should deploy for such action.
- Would require a major portion of total US global assets. Need to combine B-2s, other bombers, and carrier-based aircraft and sea-launched cruise missiles. Would need land base(s) in Gulf for staging, refueling, and recovery. Staging out of Diego Garcia would be highly desirable.
- Would probably take several weeks to two months to fully execute and validate.
- Goal would be to critically damage or destroy 70-80% or more of most costly and major CBRN, missile and other delivery systems, key conventional air and naval strike assets, and major military production facilities.
- Hit at all high value targets recognized by IAEA and EU3 to show credibility to Iran, minimize international criticism, but also possible sites as well.
- Strike at all known new sites and activities to show Iran cannot secretly proceed with, or expand its efforts, unless hold back some targets as hostages to the future.
- Hitting hard and underground targets could easily require multiple strikes during mission, and follow-on restrikes to be effective.
- Impact over time would probably be crippling, but Iran might still covertly assemble some nuclear device and could not halt Iranian biological weapons effort.
- Battle damage would be a significant problem, particularly for large buildings and underground facilities.
- Size and effectiveness would depend very heavily on the quality of US intelligence and suitability of given ordnance, as well as the time the US sought to inflict a given effect.
- Much of Iran’s technology base would still survive; the same would be true of many equipment items, even in facilities hit with strikes. Some impact, if any, on pool of scientists and experts.
- Iranian response in terms of proliferation could vary sharply and unpredictably, the balance between deterring and delaying Iran will be weighed against Iran’s mobilization and the level they are provoked into retaliatory action.
- Such a series of strikes might be enough of a deterrent to change Iranian behavior, particularly if coupled to the threat of follow on strikes in the future. It still, however, could as easily produce only a cosmetic Iranian change in behavior at best. Iran might still disperse its program even more, and shift to multiple, small, deep underground facilities.
- Might well provoke Iran to implement (more) active biological warfare program.
- An oil embargo might be serious.
- Iranian government could probably not prevent some elements in Iranian forces and intelligence from seeking to use Iraq, Afghanistan, support of terrorism, and Hezbollah to hit back at the US and its allies if it tried; it probably would not try.
- International reaction would be a serious problem, and far greater than strikes that could be clearly associated with Iran’s efforts to proliferate.

Figure 23: Delay and Then Strike

- The US could execute any of the above options, and wait until after Iran provided proof was proliferating. Such a “smoking gun” would create a much higher chance of allied support and international tolerance or consensus.
- Iran will have committed major resources, and created much higher value targets.
- The counter-risk is an unanticipated Iranian break out; some form of Iranian launch on warning (LOW), launch under attack (LUA), or survivable “ride out” capability.
- Iranian dispersal and sheltering may be much better.
- Iran might have biological weapons as a counter.
- Allied and regional reactions would be uncertain. Time tends to breed tolerance of proliferation.

Figure 24: Ride Out Iranian Proliferation

- Announce or quietly demonstrate US nuclear targeting of Iran’s military and CBRN facilities and cities.
- Tacitly signal US “green light” for Israeli nuclear retaliation or preemption.
- Deploy anti-ballistic and cruise missile defenses, and sell to Gulf and neighboring states.
- Signal US conventional option to cripple Iran by destroying its power generation, gas, and refinery facilities.
- Provide US guarantees of extended deterrence to Gulf States.
- Tacitly accept Saudi acquisition of nuclear weapons.
- Maintain preventive/preemptive option at constant combat readiness. Act without warning.
- Encourage Israel to openly declare its strike options as a deterrent.
- Announce doctrine that any Iranian use of biological weapons will lead to nuclear retaliation against Iran.

The Impact of Israeli-Iranian Nuclear Arms Race on US and Iranian Competition

There is another major wild card at play. The US and its other friends and allies cannot ignore the fact that Israel has military options, that key Israel political figures like Prime Minister Benjamin Netanyahu immediately opposed the interim agreement the P5+1 and Iran reached in November 2013, and that Israeli military action might reshape the game board in the competition between the US and Iran.

While Iran does not yet possess a nuclear weapon, it already possesses aircraft and missiles with the range to target Israel, and Israel has nuclear-armed missiles that can reach any target in Iran. This creates a de facto nuclear arms race in the Middle East, and creates an even stronger incentive for Israel to try to suppress Iran's nuclear program and missile capabilities than exists for the US and Arab Gulf States.

Israel's Fear of An "Existential Threat"

Despite Israel's advantage in nuclear forces and nuclear-armed missiles, many Israelis feel that one nuclear detonation on Israeli territory could prove to be an "existential" threat to Israel given its size, dependence on Tel Aviv and Haifa, and the impact of such a strike on Israel's political cohesion after such a strike. They feel that any Iranian nuclear delivery capability might produce enough casualties to threaten Israel's continued existence as a viable state.

Israeli officials and officers have also focused heavily on the threat posed by Iran's missile programs - which can already reach any target in Israel and present only a relatively minor threat to US interests and allies in Europe.

What is an "Existential" Threat? How Can it be Defined?

Senior Israeli officials and officers have never publically discussed exactly what an "existential" threat consists of. Moreover, any such discussion would necessarily have to be speculative. There is no magic number of casualties that determines the point at which a state cannot survive or so radically changes its character that its values shift beyond recognition. There is no way to know what level of attack would lead an unsupportable number of survivors to emigrate, make economic recovery too difficult, or critically weaken the ability to defend Israel against outside threats.

Would it take one weapon? Three? Thirty? Would the prospect of an attack undermine Israel's cohesion and raise emigration? Will Israelis unify or fracture in the event of an actual attack? Some Israeli leaders may not be prepared to learn the answers or take such risks. It is clear that most of Israel's leaders would prefer diplomatic solutions or to have the US take military action, but at least some perceive the threat as so serious in broad terms that they are prepared to strike preemptively to deny Iran the option - *if* they feel they have no choice, and *if* the Israeli Defense Forces (IDF) concludes such strikes will be effective and produce acceptable costs in terms of US and other international reactions.

The CIA estimates that Israel will have a population of some 7.6 million in mid-2012. Data on ethnicity is dated, but the CIA estimates this population is 76.4% Jewish (of which Israel-born 67.1%, Europe/America-born 22.6%, Africa-born 5.9%, Asia-born 4.2%), non-Jewish 23.6% (mostly Arab) (2004). It estimates religious divisions are Jewish 75.6%, Muslim 16.9%, Christian 2%, Druze 1.7%, other 3.8% (2008 census). Israeli data are more current, but involve

complex debates over ethnicity and defining resident. The population is mixed in many areas, but Jerusalem (780,000) is the only potential target which has both the religious significance and a large enough Muslim Arab population so as to deter Iranian nuclear targeting on an a largely Jewish population center.

Israel is 92% urbanized. While current estimates of its population in greater urban areas are uncertain for nuclear targeting purposes, the CIA estimates that a small number of Israel's major cities contain much of its population - the best educated part and most important in terms of Israel's economy and Jewish culture.¹⁶⁸ Nuclear strikes on only two Israeli cities - Tel Aviv-Yafo 3.219 million and Haifa 1.027 million - could pose a major threat to Israel's existence in anything like its current form.¹⁶⁹

The Effects of an Iranian Strike On Israel

The psychological and political dimensions of an Iranian attack would be as important as the physical and killing impact. Horrifying as a small nuclear attack with basic fission weapons with nominal yields of around 20 kilotons each would be, much of the population in a coastal city would survive an attack by one bomb, although the long-term death rate from radiation and fall out would later be significant. The question would then be how much of Israel's Jewish population would stay, how would Israel's Palestinians and Arab neighbors react, and how nations outside the region would treat Israel's suffering.

A larger nuclear armed Iranian missile force that was still restricted to basic fission weapons with nominal yields of around 20 kilotons each could strike at Israel's key coastal cities using a mix of air and ground bursts to both achieve maximum near-term killing capability and to contaminate the area. It could do so without producing physical damage to Jerusalem, although strikes on Tel Aviv might produce significant fall out on Jerusalem or Palestinian areas under some conditions. It is unlikely that Iranian strikes limited to basic fission weapons would produce enough prompt damage and casualties to Israel's Jewish populations to make recovery impossible - although it might kill a significant percentage and the political and psychological impact might well reach the point where a significant percentage of the remaining population would leave.

An Iranian force armed with boosted fission weapons of 100 kilotons each or more - or thermonuclear weapons in the 1 megaton or larger range - is probably 6-10 years in the future if Iran can then achieve such a force. It could deliver enough damage to destroy much of Israel's coastal cities and population.

The damage done to Israel's Palestinian population would depend heavily on the prevailing winds and the height of burst of the Iranian nuclear explosions. Fall out models are extremely difficult to calculate, and far less even than most nominal unclassified estimates indicate.

It is likely, however, that this level of Iranian strikes would have a major impact on the Palestinians, and affect neighboring Arab states to significant degree. It might well produce a much more significant degree of contamination in Jerusalem. It is much less likely, however, that it would produce mass prompt Palestinian and Arab casualties versus cause a significant increase in the longer-term death rate from cancer and radiation poisoning.

Israeli Nuclear-Armed Missiles: IRBMs and a Submarine-Launched Option?

Israel is believed to have placed its nuclear armed missiles on mobile launchers, and in sheltered facilities, but some experts believe Israel began research and development on additional nuclear

strike systems, - and ones that could give it a more advanced second-strike capability that would ensure it could credibly threaten retaliation against Iran under all circumstances. While the public centerpiece of Israel's nuclear deterrent is still reported to be its "Jericho II" IRBM, Israel is reported to be seeking to deploy nuclear-armed cruise missiles aboard its submarines.¹⁷⁰

According to Der Spiegel, Israel has used the diesel-electric *Dolphin*-class submarines built in Germany as guided-missile submarines, using the indigenously-produced Popeye cruise missile with Israeli nuclear warheads to provide a sea-based nuclear strike capability. Israel is believed to have four *Dolphin* submarines currently available, with two more scheduled to be delivered within the next two years.

According to such reports, Israel may be developing two such versions of the Popeye:

- Popeye Turbo ALCM - The air launched Popeye Turbo, which uses a jet engine, and liquid fuel is approximately 6.25 m (20.5 ft.) long, it is reported to have a range of more than 320 km (200 mi).¹⁷¹
- Popeye Turbo SLCM - A suspected stretched version of the Popeye Turbo developed primarily for use as a submarine launched cruise missile (SLCM) was widely reported in a US Navy observed 2002 test in the Indian Ocean to have hit a target at 1500 km, it can allegedly carry a 200 kg nuclear warhead. It is suspected that the stretched Popeye Turbo is the primary strategic second strike nuclear deterrent weapon which can be fired from the 650mm secondary torpedo tubes of the Israeli *Dolphin* class submarines. It is believed that the SLCM version of the Popeye was developed by Israel after the US Clinton administration refused an Israeli request in 2000 to purchase Tomahawk long range SLCM's because of international MTCR proliferation rules...While the standard Popeye is 533mm the *Dolphin* class submarines have four 650mm torpedo tubes in addition to the six standard 533mm tubes allowing for the possibility that a SLCM Popeye derivative may be a larger diameter.¹⁷²

Such reports would only make sense if the use of the name Popeye was a cover for a totally different cruise missile based on totally different designs and guidance technology similar to the US Tomahawk. The original Popeye is not a cruise missile. Pop Eye is a modification of the US *Have Nap* design that (a) is not a cruise missile, (b) is small, (c) has guidance systems suited for more limited ranges, and (d) has a relatively small warhead. There are two variants, neither of which is a suitable technical base for such developments

- **Popeye** (also known as *Have Nap*) - Israeli-built solid rocket powered standoff missile. It has a range of some 78 kilometers or 48 miles. According to the Federation of American Scientists, it is 4.82 m (15 ft. 10 in) long and weighs 1,360 kg (3,000 lb.) with a 340 kg (750 lb.) blast fragmentation or 360 kg (800 lb.) I-800 penetrating warhead, inertial and imaging infrared or TV guidance.¹⁷³
- **Popeye II** or *Popeye Lite* (also known as *Have Lite*). This is a reduced size (shortened to 424 cm/167 in) and weight version (weight is now 1125 kg/2500 lb.) of the Popeye to give light aircraft such as the F-16I *Sufa* a precision standoff strike capability. It has an even shorter range.¹⁷⁴

Other reports have mentioned conversion of the Harpoon to use a nuclear warhead and be used in a sea-to-land mode. The regular Harpoon an anti-ship missile system that has been further developed into a land-strike weapon, the Standoff Land Attack Missile (SLAM). The UGM-84 variant has a solid-fuel rocket booster and is encapsulated in a container that allows submerged launch through a torpedo tube

- The regular Harpoon uses technology suited only to anti-ship roles: active radar homing suited to track and hit ships and a low-level, sea-skimming cruise trajectory not suited for land attack modes. It has a relatively small 488 pounds (221 kg) warhead and a range open sources describe as, "in excess of 67 nautical miles (124 km) depending on launch platform." It is very difficult to modify for land attack purposes because its terminal guidance package is so small and the missile is normally dependent on a combination of command guidance with an inertial navigation system (INS) fly from its launch point until the target is close enough to be detected and tracked by the limited range homing system in the missile warhead. As Wikipedia notes,

“The missile therefore requires guidance updates via a datalink from the launching platform up until this point, in case the target is maneuvering, otherwise the missile may get to the projected interception point and find that the target is not there. Sometimes the launching platform (especially if it is an aircraft) may be in danger while continuing to guide the missile in this way until it ‘goes active’; In this case it may turn around and leave it to luck that the target ends up in the projected “acquisition basket” when the missile goes active. It is possible for a system other than the launching platform to provide guidance to the missile before it switches its radar on; this may be other, similar fighter aircraft or perhaps an AWACS.

- The “growth versions of the Harpoon might well be more suitable for Israeli reverse engineering but it is unclear what level of technology transfer has occurred.” Again using open source like Wikipedia, the growth versions include: “Harpoon Block 1D: This version featured a larger fuel tank and re-attack capability, but was not produced in large numbers because its intended mission (warfare with the Warsaw Pact countries of Eastern Europe) was considered to be unlikely following the events of 1991-92. Range is 278 km. Block 1D missiles were designated RGM/AGM-84F. SLAM ATA (Block 1G): This version, under development, gives the SLAM a re-attack capability, as well as an image comparison capability similar to the Tomahawk cruise missile; that is, the weapon can compare the target scene in front of it with an image stored in its on-board computer during terminal phase target acquisition and lock on.[2] Block 1G missiles AGM/RGM/UGM-84G, and the SLAM-ER missiles are designated AGM-84H. Harpoon Block 1J: A proposal for a further upgrade, AGM/RGM/UGM-84J Harpoon (or Harpoon 2000), for use against both ship and land targets. Harpoon Block II offers an expanded engagement envelope, enhanced resistance to electronic countermeasures and improved targeting. Specifically, the Harpoon was initially designed as an open-ocean weapon...The key improvements of the Harpoon Block II are obtained by incorporating the inertial measurement unit from the Joint Direct Attack Munition program, and the software, computer, Global Positioning System (GPS)/inertial navigation system and GPS antenna/receiver from the SLAM Expanded Response (SLAM-ER), an upgrade to the SLAM.

Israel may be working on a long-range cruise missile, but any Israeli ALCM submarine-launched cruise missile would be a totally different system with no real technical ties to the Pop Eye. It might well have ties to some version of the Harpoon or SLAM, but most probably would be an Israeli engineered version of a SLCM using some mix of the technologies available for SLAM and Tomahawk.

The ranges for a submarine-launched missile would need to be around 1,000-1,200 miles (1,600+ kilometers) to Natanz from the Israeli coast. This is just about the maximum range of the Tomahawk (Block II TLAM-A - 1,350 nmi (1,550 mi; 2,500 km) Block III TLAM-C, Block IV TLAM-E - 900 nmi (1,000 mi; 1,700 km) Block III TLAM-D - 700 nmi (810 mi; 1,300 km). No low-flying system relying on a data link and INS could be remotely *accurate and reliable* at these ranges, which is why the US system uses TERCOM (terminal guidance, GPS, and satellite-derived digital ground mapping.)

There are reports that US officials have confirmed witnessing Israeli missile tests, with some reports claiming an effective range up to 1500 km (sufficient to reach major urban centers in Iran).¹⁷⁵ Given Iran’s lack of modern anti-air systems and limited radar coverage, it is unlikely Iran would be able to successfully engage any cruise missile attack by Israel.

In short, Israel does seem to be working on such cruise missiles and to have tested them. It may have them for its submarines. If so, it has almost certainly borrowed the technology from US cruise missiles, and not the Pop Eye. It is also far from clear that it as yet has systems reliable enough to arm with a nuclear warhead or would deploy them to attack Iran.

Israeli is also getting at least Dolphins - four delivered and a fifth coming in 2013. They are highly capable submarines and can perform the mission. They can carry up to 16 surface-to-surface missiles or torpedoes, and the Dolphin submarine has ten bow torpedo tubes. Four of the tubes have a 650mm diameter that can be used for both swimmers and larger missiles. The submarine is reported to have speed of 20kt dived and a snorkel speed of 11 knots. Its range is up to 8,000 miles at a surface speed of 8 knots, and over 400 miles

at its most economic submerged speed of 8 knots. The hull is rated for a diving depth of 350m. Its endurance is rated at 30 days.¹⁷⁶

Israel is allegedly keeping at least one submarine at sea at all times; furthermore, it has started increasing overall training for its *Dolphins* and increasing the security requirements for their crew, presumably with the aim of creating a larger pool of reliable personnel.^{177 178} If Israel does continuously keep at least one nuclear-armed *Dolphin* at sea, then Israel must have some form of regular communication - and presumably a fail-deadly system as well - to control the launch of these weapons. Due to the classified nature of Israel's entire nuclear program, however, such information is not in the public domain.

Israel would, however, face the fact that its submarines would either have to be based in the Gulf of Aqaba, have to transit the Suez Canal, or sail around the Cape to reach water near Iran. The relatively small number of Israeli subs and lack of crewmen (currently only one crew per sub, unlike the US practice of staffing each *Ohio* SSBN with two crews) may also currently limit Israel's ability to continuously have one *Dolphin* near Iran at all times. More importantly, it would need some form of covert submarine tender to be deployed in the Indian Ocean for any prolonged mission and additional support ships if it were to try to move covertly around the Horn rather than try to transit the Suez Canal or deploy covertly through the Red Sea from the Gulf of Aqaba.

Israel's Ability to Use Missile Defense, "Extended Deterrence," and Destroy Iran's Population Using Nuclear Weapons

Senior Israeli leaders and military officers have long made it clear that they see an Israeli preventive strike as a possible alternative to Israeli reliance on the threat of retaliation in the form of an existential counterstrike on Iran, reliance on some degree of US "extended deterrence," and reliance on defenses like anti-missile systems and passive civil defense.

There are no unclassified sources to aid in understanding the degree to which Israeli leaders and defense planners feel a combination of Israel's undeclared nuclear forces, missile and air defenses, and US missile defense support, and a currently undefined US extended regional deterrent could safely contain an Iranian threat and deter nuclear and missile attacks.

However, there are a variety of media and think tank reports that have inferred that Israel has already extended the range-payload of its missile forces to be able to conduct nuclear strikes with thermonuclear weapons on any target in Iran. Iran also has key target points like Tehran, and Israel could conduct its own existential strikes on Iran by destroying some 5-7 major Iranian cities.

Unfortunately, there is no practical way to discuss Israeli or Iranian perceptions of what already is a covert nuclear and missile arms race tied to missile defenses, air capabilities, and possible submarine and sea launch forces. Comparing perceptions of an undeclared force relative to one that does not yet exist presents obvious problems, and it is one that has a major impact on both US competition with Iran and how the Arab Gulf States and other neighboring states assess the balance of present and future risks.

As Herman Khan noted, "thinking about the unthinkable" is anything but pleasant, but it is important to note that "existential" is a relative term shaped by the character and success of a specific attack. It is also important to remember that Israel's missile defenses might significantly

limit the damage Iran's forces could inflict - particularly when their numbers remained small, warhead yields were limited, and they had few or no penetration aids.

It is equally important to remember that Iran has long been vulnerable to Israel, Iran has no meaningful missile defenses, and Israel has a mature nuclear-armed missile force. It has some 70-300+ nuclear weapons, and experts now put the probable number at the 300+ level. They also feel that Israel has a range of advanced boosted and thermonuclear weapons.

Israel would not face the problem Iran would of trying to limit damage to Jerusalem, Palestinian areas, and nearby Arab states from prompt damage and fall out. Israel could use ground bursts designed to maximize population kills from both prompt thermal, blast, and radiation effects and from fall out - using satellite weather mapping and the understanding most fallout would move west to east through Iran with minimal risk of serious contamination of other areas. Alternatively, Israel could target multiple thermonuclear warheads, timed or spread to avoid fratricide, and use air burst to achieve the desired mix of prompt thermal, blast, and radiation effects with minimal or no significant long-range fall out.

“Reverse Existentialism:” The Effects of an Israeli Strike on Iran

The CIA estimates that Iran will have a population of some 78.8 million in mid-2012, and that it is well over 70% urbanized. While accurate current estimates of its urban population are uncertain, the CIA estimates that a small number of Iran's major cities contained much of its population - that includes the most education population and most important in terms of its economy and culture.

A mix of several air and ground bursts in an Israeli thermonuclear or high fission yield attack on five key cities - Tehran (capital) 7.19 million; Mashhad 2.592 million; Esfahan 1.704 million; Karaj 1.531 million; Tabriz 1.459 million - would probably destroy Iran as a nation in anything like its current form.¹⁷⁹ The greater metropolitan area of Tehran alone is home to some 8-9 million people. Furthermore, 45% of large Iranian industrial firms are located in Tehran, as is 50% of all Iranian industry. As such, an Israeli nuclear strike on Tehran would have disastrous consequences for the Iranian state and Israel could target every major Iranian city.

It seems likely that Israel can already deliver an “existential” nuclear strike on Iran, and will have far more capability to damage Iran than Iran is likely to have against Israel for the next decade. Moreover, Israel has steadily improving missile defenses, and the US may offer extended deterrence to Israel and/or various Arab states. This potentially could mean US retaliation for any Iranian nuclear attack on Israel or an Arab ally of the US.

Most of Iran's major cities are also far enough inland so that Israel could strike them with large numbers of ground and air bursts while doing only limited damage to neighboring states - all of which except Turkey and Pakistan are not key political actors. Israel could use airbursts on Iran's cities near its borders and minimize the risk of major amounts of fall out crossing borders and still inflict catastrophic damage on these cities.

Moreover, Israel could selectively target Iran's Persian population to pose an existential threat using fewer weapons. While such estimates are dated and uncertain, the CIA estimates that Iran's population has the following ethnic distribution: Persian (official) 53%, Azeri Turkic and Turkic dialects 18%, Kurdish 10%, Gilaki and Mazandarani 7%, Luri 6%, Balochi 2%, Arabic 2%, other 2% (2008 est.). Nuclear targeting could also include key religious cities like Qom and all of

Iran's major shrine cities and those with key theological seminars - effectively destroying the structure of the Shi'ite clergy and possibly much of the support for Iranian Shi'ite practices.

It should be noted, however, that as the attack levels rise - and to some degree even during limited attacks - a significant number of the missiles launched would not hit near their target. It is doubtful that either Israel or Iran would take the design risk of trying to create fail-safe arming mechanisms in their nuclear warheads that would keep such missiles from producing nuclear strikes. Given the probable attack vectors, some Arab population centers might be struck by accident and the fall out effects from any such strikes could produce significant longer-term casualties.

The Unknowns in Assessing Israel's Preventive Attack Options

Other key uncertainties are involved. There is no practical way to determine exactly how Israel's senior policymakers and military leaders perceive Israel's ability to identify, target, and destroy Iran's current nuclear and other strike capabilities. Nor is there a practical way to assess the degree to which this would give Israel security over time vs. strikes provoking Iran to move ahead with some massive new effort to acquire nuclear weapons. There is no way to determine the degree to which their public statements represent real war plans and threats versus efforts to push the US and the P5+1 group into taking a harder line with Iran, pushing the country to halt its efforts, or push the US towards a focus on military options.

These uncertainties include Israeli perceptions of the extent to which an Israeli strike on Iran would force the US to deal with the military aftermath. They include Israeli assessments of the cost Israel would have to pay in terms of reactions from the US and other states, and they include Israeli perceptions of how much damage Iran might be able to inflict using Hezbollah, Hamas, and other proxies and asymmetric means. It is clear from Israeli media and think tanks that Israelis recognize these issues, but it is not clear how Israel's leaders and military planners perceive them.

The US has also made it clear in recent years that it is not giving Israel any kind of "green light" for conducting attacks on Iran. Both Secretary Clinton and Secretary Gates gave Israel this message, and Secretary Panetta has repeated it since he replaced Secretary Gates. Key US military leaders like Admiral Mike Mullen and General David Petraeus made it clear in public statements in 2010 and 2011 that they opposed any near-term Israeli strike on Iran. Both saw such options as deeply destabilizing at a time when the US is still engaged in Iraq and Afghanistan in addition to dealing with a broader struggle against Islamic extremism.¹⁸⁰

General Martine Dempsey, the new Chairman of the Joint Chiefs, made similar points in an interview in the *National Journal* after a visit to Israel in January 2012,¹⁸¹

"We have to acknowledge that they (the Israeli)...see that threat differently than we do. It's existential to them...My intervention with them was not to try to persuade them to my thinking or allow them to persuade me to theirs, but rather to acknowledge the complexity and commit to seeking creative solutions, not simple solutions...We are determined to prevent them (Iran) from acquiring that weapon, but that doesn't mean dropping bombs necessarily," he said. "I personally believe that we should be in the business of deterring as the first priority. I do think the path we're on—the economic sanctions and the diplomatic pressure—does seem to me to be having an effect...I just think that it's premature to be deciding that the economic and diplomatic approach is inadequate...A conflict with Iran would be really destabilizing, and I'm not just talking from the security perspective. It would be economically destabilizing.

The Ongoing Policy Debate within Israel Regarding a Preemptive Strike on Iran

There have been reports for years that Israel is planning a preventive or preemptive strike on Iran, including leaks of official reports. Material released by Wikileaks indicates, for example, that as of 2005,¹⁸²

Senior defense officials ruled out an Israeli military attack on Iran's nuclear sites as early as five and a half years ago, telegrams sent from the U.S. embassy in Tel Aviv in 2005 and 2006 indicate. The cables, which were revealed over the weekend, are among hundreds of thousands shared exclusively with Haaretz by the Wikileaks website. In the first telegram, sent on December 2, 2005, American diplomats said their conversations with Israeli officials indicate that there is no chance of a military attack being carried out on Iran. A more detailed telegram was sent in January 2006, summing up a meeting between U.S. Congressman Gary Ackerman (a Democrat for New York) and Dr. Ariel Levite, then deputy chief of Israel's Atomic Energy Commission. "Levite said that most Israeli officials do not believe a military solution is possible," the telegram ran. "They believe Iran has learned from Israel's attack on Iraq's Osirak reactor, and has dispersed the components of its nuclear program throughout Iran, with some elements in places that Israel does not know about."

The Israeli Public Debate on Attacking Iran

In recent years, Israeli and international media reports have routinely speculated as to when Prime Minister Netanyahu might order a preemptive attack on Iran's nuclear program, but no projection has yet been proven correct. This is partly due to the complicated nature of Israeli decision-making regarding Iran which is influenced by factors such as the state of public debate in Israel, the opinions of former government officials, parties in or out of the government in the Knesset, the effects of a strike, and Iranian reactions stemming from a strike.

Israeli leaders, officers, and experts seem to take two broadly defined sides based on different threat perceptions, timelines, and preferred methods of dealing with the Iranian nuclear program. One side, that includes the government of Prime Minister Netanyahu, seems to be on the more aggressive side that argues for increased pressure on Iran through sanctions and the declaration of a "red line" for delineating possible military action.

The other side can be roughly characterized as those Israelis against a pre-emptive strike and who believe that Iran either poses less of a danger to Israel or whose nuclear program is not yet advanced enough to threaten Israel in the near future. However, Israeli officials and officers - like those in the US - have a long history of revising Israeli threat perceptions and changing such estimates.

As *Haaretz* noted on January 6, 2011,¹⁸³

"The Israeli intelligence community's assessments of Iran's nuclear capability have changed during [Mossad Director Meir] Dagan's tenure," the story noted. "In 2003, Israeli intelligence officials thought Iran would have its first bomb by 2007. In 2007, they thought it would be 2009, and a year later they put it at 2011. Now the date has moved to 2015. These adjustments were not the result of mistaken evaluations, but due to the difficulties Iran has encountered in advancing its program, largely because of the Mossad's efforts...Dagan's term centered around two main issues: the Iranian nuclear program, and the assassinations of Hezbollah and Hamas leaders and Iranian scientists, most if not all of which have been attributed to the Mossad."

Some Israeli officials currently in the government have taken on a more hawkish view of the Iranian nuclear program and their options for a preemptive strike. Statements emanating from

key individuals within the Israeli government since the fall of 2011 have indicated that Israel might be more active in considering a strike.

At the same time, members of the Israeli government have continued to press for additional multilateral sanction as well as declared “red lines” from the United States and its allies in order to increase the pressure on Iran to end its nuclear program and supposed nuclear weapons program. Several Israeli decision-makers were in favor of the spring and summer talks in 2012 between the P5+1 and Iran, as long as those talks met the aims of Israel, mainly a complete halt to uranium enrichment and the closure of Iran’s enrichment facilities.

However, since those talks have foundered, some Israeli officials have publically opposed negotiations. In August, Israel Deputy Foreign Minister Danny Ayalon called on the P5+1 nations to “declare today that the talks have failed” and that “it will be clear that all options are on the table.”¹⁸⁴ The increasing Iranian threat has also led several Israel leaders to take a harder stance. Key policymakers like Benjamin Netanyahu, Ehud Barak, and Shimon Peres, have sharply increased the frequency with which they discussed the possibility or likelihood of a preemptive attack on Iran’s nuclear facilities in late 2011, as Iran moved towards higher levels of enrichment and tensions increased.

- “I made clear that once Iran crosses that enrichment threshold, the chances of us effectively stopping Iran’s nuclear weapons program would be reduced dramatically...Iran is two and a half months closer to crossing this line and there is no doubt that this will be a major challenge that will have to be addressed next year.” - Israeli Prime Minister Benjamin Netanyahu. December 10, 2012. <http://www.reuters.com/article/2012/12/10/us-israel-iran-idUSBRE8B90V120121210>
- “Of course, we would love to see some heavenly intervention that will stop them, to wake up some morning and learn that they’ve given up on their nuclear intentions. You cannot build a strategy based on these wishes or prayers. Sanctions are working and they are more hurting than anything I remember from the past vis-a-vis Iran, but I don’t believe these kinds of sanctions will bring the ayatollahs to a moment of truth where they sit around a table, look into each other’s eyes and decide that the game is over.” - Israeli Defense Minister Ehud Barak. November 29, 2012. <http://www.wired.com/dangerroom/2012/11/barak/>
- “Five minutes after, contrary to what the skeptics say, I think a feeling of relief would spread across the region...Iran is not popular in the Arab world, far from it, and some governments in the region, as well as their citizens, have understood that a nuclear armed Iran would be dangerous for them, not just for Israel.” - Israeli Prime Minister Benjamin Netanyahu. October 30, 2012. <http://www.reuters.com/article/2012/10/30/us-israel-iran-idUSBRE89T19120121030>
- “My approach is that if we can have others take care of it, or if we can get to a point where no one has to, that’s fine; but if we have no choice and we find ourselves with our backs against the wall, then we will do what we have to do in order to defend ourselves.” -Prime Minister Benjamin Netanyahu. November 11, 2012. <http://www.nytimes.com/2012/11/06/world/middleeast/netanyahu-uses-tough-tone-on-possible-iran-strike.html?ref=iran>
- “Those in the international community who refuse to put red lines before Iran don’t have a moral right to place a red light before Israel...So far, we can say with certainty that diplomacy and sanctions haven’t worked. The sanctions have hurt the Iranian economy, but they haven’t stopped the Iranian nuclear program...The fact is that every day that passes, Iran gets closer and closer to nuclear bombs.” -Prime Minister Benjamin Netanyahu. September 11, 2012. <http://www.nytimes.com/2012/09/12/world/middleeast/united-states-and-israel-engage-in-public-spat-over-iran-policy.html?pagewanted=all>
- “Today, as opposed to the past, the world has no doubt that the Iranian military nuclear program is steadily approaching maturity and is about to enter the zone of immunity, after which the Iranian regime will be

able to complete the program without effective interruption and at a time it finds convenient.

The dividing line may not pass not where the Iranians decide to break out of the non-proliferation treaty and move toward a nuclear device or weapon, but at the place where the dispersal, protection, and survivability efforts will cross a point that would make a physical strike impractical.

The assessment of many experts around the world, not only here, is that the result of avoiding action will inevitably be a nuclear Iran, and that dealing with a nuclear Iran will be more complicated, more dangerous, and more costly in blood and money than stopping it.” - Israeli Minister of Defense, Ehud Barak. February 2, 2012. http://www.washingtonpost.com/world/middle_east/barak-says-time-running-out-for-action-against-irans-nuclear-program/2012/02/02/gIQAZFm5kQ_story.html

- “The possibility of a military strike on Iran is more likely to be realized than the diplomatic option. I do not think there has already been a decision on the matter, but it appears that Iran is getting closer to obtaining nuclear weapons.” - Israeli President, Shimon Peres
- “A situation could be created in the Middle East in which Israel must defend its vital interests in an independent fashion, without necessarily having to reply on other forces, regional or otherwise.” - Israeli Minister of Defense, Ehud Barak. November 2, 2011. <http://www.defensenews.com/article/20111102/DEFSECT01/111020310/Israel-Tests-Rocket-Amid-Talk-Strike-Iran>
- “This is not a matter of days or weeks. It is also not a matter of years. The result has to be that the threat of a nuclear weapon in Iran’s hands is removed.... If you don’t make the decision, and you don’t succeed in preventing it, who will you explain that [to]? To historians? To the generations that were here before us? To the generations that won’t come after us? It is forbidden to let the Iranians get nuclear arms. And I intend not to allow that to happen.” - Prime Minister Benjamin Netanyahu, March 9, 2012. <http://www.jpost.com/IranianThreat/News/Article.aspx?id=261079>
- “So if these are the facts - if these are the facts - and they are - where should a red line be drawn? A red line should be drawn right here before - before - Iran completes the second stage of nuclear enrichment necessary to make a bomb, before Iran gets to a point where it’s a few months away - or a few weeks away - from amassing enough enriched uranium to make a nuclear weapon. Now, each day that point is getting closer. And that’s why I speak today with such a sense of urgency, and that’s why everyone should have a sense of urgency. Now, there are some who claim that even if Iran completes the enrichment process, even if it crosses that red line that I just drew, our intelligence agencies will know when and where Iran will make the fuse, assemble the bomb and prepare the warhead.” - Prime Minister Benjamin Netanyahu, September 27, 2012. <http://www.reuters.com/article/2012/09/27/us-un-assembly-israel-text-idUSBRE88Q1RR20120927>
- “The Iranians are deliberately trying to create a level of redundancy and protection for their program, what we call the ‘zone of immunity’. Once they enter the zone of immunity, fate will be out of our hands... The state of Israel was founded precisely so that our fate would remain in our own hands.” - Israeli Defense Minister Ehud Barak, December 18, 2012. <http://www.reuters.com/article/2012/12/18/us-iran-nuclear-israel-idUSBRE8BH0BC20121218>

It is hard to put such statements in context. As has been touched upon earlier, Israel has every reason to make threats and develop options as a means of reinforcing US and other efforts to find a solution through sanctions and diplomacy. Israel’s fractious politics almost ensure there is no unified message emanating from the Israeli leadership or other officials regarding an Israeli preemptive attack, and it is clear that those involved in the debate are divided.

In September 2012, media reports described a divided security cabinet with in the then current Israeli government, with four members in favor of a strike and three or four opposed out of a group of 14 ministers.¹⁸⁵ This security cabinet had the primary responsibility for any decision to attack Iran and that according to Nathaniel Kern and Matthew Reed, there are debates as to the

views of the members of this decision-making body.¹⁸⁶ Kern and Reed say that Netanyahu's so called "inner cabinet" - an eight person informal body used by Netanyahu called the Octet - is divided on the issue of Israeli strikes. Other reports have talked of a growing rift between Prime Minister Netanyahu and his Defense Minister Ehud Barak.¹⁸⁷

Other reporting from the academic journal *Survival* described an internal debate within the Israeli government as to the merits of an attack on Iran. These reports says planning for such an attack on Iran had been conducted for nearly two decades, and that every relevant portion of the national security establishment had been deeply involved.¹⁸⁸

As of 2012, the main level of Iran policy planning was said to be taking place in the currently divided Octet, which is one in a long line of temporary policy planning cabinets that is used to discuss highly important issues and to build broader cabinet support for preferred policies. This report also reports that the Octet is divided and has reported that it is widely believed that Prime Minister Netanyahu has appointed a ninth member of the group, who is more favorable towards an attack, creating a Nonet.¹⁸⁹

Israeli intelligence officers did take independent stands. On January 25, 2011, Israel's head of military intelligence, Brigadier General Aviv Kochavi, testified to the Knesset Foreign Affairs and Defense Committee that,

"The question is not when Iran will acquire the bomb, but how long until the leader decides to begin enriching (uranium) at 90 percent...Once such a decision is made, it would take 'a year or two' to produce a nuclear warhead" he said, adding that Iran would then need more time to develop an effective missile delivery system for it.¹⁹⁰

Kochavi is reported to have said that it was unlikely that Iran, which then had enriched uranium to 20 percent, would start enriching it to the 90 percent level needed for a bomb because it would be in open breach of the nuclear Non-Proliferation Treaty, exposing it to harsher sanctions or even a US or Israeli military strike. He said Iran was reluctant to do this at a time when the country was going through a period of "instability and "religious tension," "At the moment, it's not in Iran's interest to move their program ahead" he told the committee.¹⁹¹ These comments have come amid reports that Israel was involved in a plot to sabotage Iran's nuclear program through a destructive computer worm called Stuxnet, and might have been involved in the assassination of Iranian nuclear experts.

In a speech at Tel Aviv University, Meir Dagan, the former head of the Mossad, made the following statement regarding a potential attack on Iran's nuclear facilities,

"The war won't be against Iran, but will be a regional war. I recommend that the prime minister not decide to attack...I will express my opinion anyway. I am not prepared for it to be on my conscience that there will be a repeat of what happened in 1973."¹⁹²

According to Israeli media reports, Dagan reportedly stated that such a strike was "the stupidest thing I have ever heard" in a public conference.¹⁹³ Such statements made by the former director of the Mossad cannot be taken lightly.

Dagan also spoke out against an attack in September 2011:

"An Israeli bombing would lead to a regional war and solve the internal problems of the Islamic Republic of Iran. It would galvanize Iranian society behind the leadership and create unity around the nuclear issue. And it would justify Iran in rebuilding its nuclear project and saying, 'Look, see, we were attacked by the Zionist enemy and we clearly need to have it.'"¹⁹⁴

In early November of 2011, former Israeli Minister of Defense, Benjamin Ben-Eliezer, said he feared a “horror scenario” in which Netanyahu and Barak decide to attack Iran. He warned of a “rash act” and said he hoped “common sense will prevail.”¹⁹⁵ Once again, statements made by Benjamin Ben-Eliezer, who, like Meir Dagan, held a top post in the Israeli defense community, must be taken seriously. While nebulous and ill-defined, they show that there is an unmistakable opposition to an Israeli strike on Iran within the Israeli defense community.

Speaking to the potential repercussions of such an attack, Israel’s Interior Minister, Eli Yishai, stated in an October 31, 2011 speech to Shas activists in northern Israel that,

“This is a complicated time and it’s better not to talk about how complicated it is. This possible action is keeping me awake at night. Imagine we’re [attacked] from the north, south and center. They have short-range and long-range missiles - we believe they have about 100,000 rockets and missiles.”¹⁹⁶

It is too at this writing soon to be sure of Israel public opinion on the interim agreement. The initial reaction was negative but it takes time for opinion to react to events and develop some lasting consensus. What is clear is the a survey by the Jewish Virtual Library of various polls from 2011 onwards found contradictory results and that much depended on the political attitudes of those doing the polls.

Surveys during 2012 found 21% to 45% of Israelis supported a unilateral attack on Iran’s nuclear facilities, and 40% to 66% opposed it. Surveys in 2013, were more negative: Polls in October and November 2013 found that 46% to 66% of Israelis supported a unilateral attack on Iran’s nuclear facilities, and 22% to 38% opposed it. The results for surveys of whether a nuclear-armed Iran constituted an existential threat to Israel found that surveys during 2012 found 74-77% of Israelis said yes and 21-22% said no. a survey in April 2013 found that 75% said yes and 21% said no. There is no clear way, however, to determine how valid and objective such pools really were.¹⁹⁷

Evolving Israeli Views of the Timing of an Attack

There has been no Israeli consensus as to when Iran would acquire meaningful nuclear capabilities. In December, 2011, Tamir Pardo, the Director of the Mossad, addressed an audience of 100 Israeli ambassadors and told them that he did not believe that a nuclear Iran was an existential threat to Israel.

“What is the significance of the term existential threat? Does Iran pose a threat to Israel? Absolutely. But if one said a nuclear bomb in Iranian hands was an existential threat, that would mean that we would have to close up shop and go home. That’s not the situation. The term existential threat is used too freely.”¹⁹⁸

Meir Dagan, the former chief of Mossad, testified to the Knesset Foreign Affairs and Defense Committee on January 6, 2011 that he did not believe that Iran would have a nuclear weapons capability before “2015 approximately.”¹⁹⁹ The Israeli newspaper *Haaretz* reported the next day that Dagan had had said Iran was a long way from being able to produce nuclear weapons, following a series of failures that had set its program back by several years.²⁰⁰

Other Israeli officials - including Prime Minister Netanyahu - contradicted Dagan. Moreover, other Israeli intelligence officers since have been more nuanced. According to *Haaretz* reports on January 25, 2011, Israel’s head of military intelligence, Brigadier General Aviv Kochavi, testified to the same Foreign Affairs and Defense Committee that,

“The question is not when Iran will acquire the bomb, but how long until the leader decides to begin enriching (uranium) at 90 percent...Once such a decision is made, it would take “a year or two” to produce

a nuclear warhead,” he said, adding that Iran would then need more time to develop an effective missile delivery system for it.²⁰¹

In April 2012, Lieutenant-General Benny Gantz, Chief of Staff of the Israeli Defense Forces, stated, “I think the Iranian leadership is comprised of very rational people.”

His statement also seemed to indicate that he believed that Iran had not yet committed itself to developing a nuclear weapon:

“Iran is moving step-by-step towards a point where it will be able to decide if it wants to make a nuclear bomb. It has not decided yet whether to go that extra mile.”²⁰²

That same month, Yuval Diskin - the former director of the Shin Bet, Israel’s internal security organization - spoke out against what he believes is the aggressive leadership of Prime Minister Netanyahu and Defense Minister Barak on the Iran issue, and their alleged deception in pursuing policies that may not ensure Israeli security. Diskin stated:

“I have no faith in the current leadership, which must lead us in an event on the scale of war with Iran or a regional war...I don’t believe in a leadership that makes decisions based on messianic feelings...They are misleading the public on the Iran issue. They tell the public that if Israel acts, Iran won’t have a nuclear bomb. This is misleading. Actually, many experts say that an Israeli attack would accelerate the Iranian nuclear race.”²⁰³

Shortly after Diskin’s statement, former Prime Minister Ehud Olmert expressed concern about an immediate strike against Iran. He stated, “There is enough time to try different avenues of pressure to change the balance of power with Iran without the need for a direct military confrontation with Iran and now is not the right time.”²⁰⁴

Other senior Israeli officials had said that the US was the only power that would be fully capable of, and should, carrying out such an attack. Moreover, some Israeli (as well as some outside) experts disagree over whether the extent of Iran’s threat to Israel is more than rhetoric, or if Iran would risk attacking a nuclear-armed Israel. Some feel that Iran finds Israel to be a convenient stalking horse and way of justifying a massive military and missile build-up that is primarily intended to give Iran leverage over the Gulf, other Arab states, and Iran’s neighbors and limit US military freedom of action.

This debate still continues, although it was sharply downplayed during a meeting between Prime Minister Netanyahu and President Obama in early 2013. Senior Israeli officials provided an unusual amount detail about their views on the timing of an attack in interviews for an article in the New York Times in January 2012.²⁰⁵ In an interview, Ehud Barak made it explicitly clear that Israel saw an unacceptable threat in the form of an Iranian nuclear weapon, but that the US and Israel sometimes had different perspectives,

“I accept that Iran has other reasons for developing nuclear bombs, apart from its desire to destroy Israel, but we cannot ignore the risk,” he told me earlier this month. “An Iranian bomb would ensure the survival of the current regime, which otherwise would not make it to its 40th anniversary in light of the admiration that the young generation in Iran has displayed for the West. With a bomb, it would be very hard to budge the administration.” Barak went on: “The moment Iran goes nuclear, other countries in the region will feel compelled to do the same. The Saudi Arabians have told the Americans as much, and one can think of both Turkey and Egypt in this context, not to mention the danger that weapons-grade materials will leak out to terror groups.

“From our point of view,” Barak said, “a nuclear state offers an entirely different kind of protection to its proxies. Imagine if we enter another military confrontation with Hezbollah, which has over 50,000 rockets that threaten the whole area of Israel, including several thousand that can reach Tel Av A nuclear Iran announces that an attack on Hezbollah is tantamount to an attack on Iran. We would not necessarily give up

on it, but it would definitely restrict our range of operations...And if a nuclear Iran covets and occupies some gulf state, who will liberate it? The bottom line is that we must deal with the problem now.

“...Our discourse with the United States is based on listening and mutual respect, together with an understanding that it is our primary ally. The U.S. is what helps us to preserve the military advantage of Israel, more than ever before. This administration contributes to the security of Israel in an extraordinary way and does a lot to prevent a nuclear Iran. We’re not in confrontation with America. We’re not in agreement on every detail, we can have differences — and not unimportant ones — but we should not talk as if we are speaking about a hostile entity.”

E Israeli officials who have taken a more cautious view of the urgency and pace of the Iranian threat and the need for preventive strikes have backed other types of attempts to halt Iran’s efforts. Meir Dagan, then head of the Mossad, began to implement a “five-front strategy” to halt Iran using a combination of political pressure, covert measures, counter proliferation, sanctions and regime change no later than 2007. He sent a cable to his US counterparts in 2007 that was later leaked to the media, and that stated, “the United States, Israel and like-minded countries must push on all five fronts in a simultaneous joint effort...Some are bearing fruit now. Others...will bear fruit in due time, especially if they are given more attention.”

Uncertain Agreement or Disagreement with the US

Other Israeli officials have described past tensions with the United States over the urgency and danger of a nuclear-capable Iran. Israel’s Deputy Prime Minister, Moshe Ya’lon was quoted as saying,²⁰⁶

We have had some arguments with the U.S. administration over the past two years, but on the Iranian issue we have managed to close the gaps to a certain extent. The president’s statements at his last meeting with the prime minister — that ‘we are committed to prevent’ and ‘all the options are on the table’ — are highly important. They began with the sanctions too late, but they have moved from a policy of engagement to a much more active (sanctions) policy against Iran. All of these are positive developments.... (However) The main arguments are ahead of us. This is clear.

Israeli officials have since had to deal with growing warnings from the President, the Secretary of Defense, and the Chairman of the Joint Chiefs that the US opposes an Israeli preventive strike. This led to a new series of conflicting statements by Israeli senior political figures, officials and officers, and made preventive strikes a key issue in Prime Minister Netanyahu’s visit to Washington in March 2012.

On the one hand it led to uncertain press reports of detailed Israeli strike plans, claims Iran was developing ICBMs to attack the US, and that Israel would not notify the US if it did launch a preventive strike. On the other hand, it led a senior statesman like Israel’s President Shimon Peres to state that an Israeli strike might be necessary and that,²⁰⁷

We need a total and clear commitment that the catastrophe of Iran will not create an impossible situation.. If you can achieve it by economic and political measures, yes, that’s the best way to start. But in order that the Iranians will take it seriously, you have to say, ‘Gentlemen, we’ll try the way which may be the best, but all the other options are on the table...You have to be decisive...You have to make a choice.’”

It is never clear whether Israeli officials are giving real warnings or attempting to put pressure on the US. In an interview with *The Daily Telegraph*, Defense Minister Barak said that the Iranian decision to use between a third and a half of its stockpile of 20% enriched Uranium in its conversion facilities, “allows contemplating delaying the moment of truth by 8 to 10 months.”²⁰⁸ He said this reduction and the subsequent conversion of 20% enriched material into fuel rods has postponed an immediate crisis.

As for why Iran has pulled back from the edge, Barak stated,

“There could be at least three explanations. One is the public discourse about a possible Israeli or American operation deterred them from trying to come closer. It could probably be a diplomatic gambit that they have launched in order to avoid this issue culminating before the American election, just to gain some time. It could be a way of telling the IAEA [International Atomic Energy Agency] ‘oh we comply with our commitments’.”

Barak also discussed the possibility that if Iran does produce a nuclear weapon, it will pressure Saudi Arabia and possibly Egypt to produce nuclear weapons. An Iranian nuclear weapon will, “make any non-proliferation regime impossible. Saudi Arabia will turn nuclear within weeks - according to them. Turkey will turn nuclear in several years. The new Egypt will have to follow.”²⁰⁹

Finally, Defense Minister Barak insisted that Israel would make a decision to strike the Iranian nuclear program irrespective of other allies,

“When it comes to the very core of our security interests and, in a way, the future of Israel, we cannot delegate the responsibility for making decisions even into the hands of our most trusted and trustworthy ally...It doesn’t mean that we would be sorry if the Iranians come to the conclusion on their own. The opposite is true. But, if no one acts, we will have to contemplate action.

...Basically, it’s about the question of when they come into this zone of immunity, where no Israeli surgical attack, probably somewhat later not even an American surgical attack, can delay them significantly. That’s the issue that bothers us.”²¹⁰

These Israeli statements are hard to put in context, do not necessarily represent real world Israeli plans or the private views of those who make them, and the steady release of more conflicting statements has done little to clarify the situation. Like the US, Israeli experts and officials have never provided public statements revealing their estimates of what Iran’s ultimate force goals are, how many weapons it will have of what yield, and the progress it will have made in delivery systems. This means there is no unclassified basis for understanding the degree to which Israeli leaders and defense planners feel a combination of Israel’s undeclared nuclear forces, missile and air defenses, and US missile defense support, and a currently undefined US extended regional deterrent could safely contain an Iranian threat and deter nuclear and missile attacks.

What is clear is that the debate changed the moment any serious possibility of a successful agreement between the P5+1 and Iran emerged in 2013, and that Prime Minister Netanyahu announced his opposition to the agreement even before all of its terms were made public. US efforts to persuade him to accept an agreement that gave Iran any ability to retain its enrichment capability failed, and Netanyahu called the agreement a ‘Historic Mistake.’²¹¹

Netanyahu stated in a press interview that,

"What was concluded in Geneva last night is not a historic agreement, it's a historic mistake. It's not made the world a safer place. Like the agreement with North Korea in 2005, this agreement has made the world a much more dangerous place...For years the international community has demanded that Iran cease all uranium enrichment. Now, for the first time, the international community has formally consented that Iran continue its enrichment of uranium."

Netanyahu stated that to his cabinet that Israel had “the right and obligation” to defend itself and would not permit Iran to develop the capability to build atomic weapons. “The Iranian regime is committed to Israel’s destruction, and Israel has the right to defend itself, by itself...Israel won’t let Iran develop military nuclear capability.” He also stated over Israeli radio on November 24, 2013 that, “What was achieved last night in Geneva is not historic; it is a historic mistake.

Today, the world has become a much more dangerous place...Israel is not bound by this agreement.”

Israeli Foreign Minister Avigdor Liberman stated that, “This deal will create a new arms race that includes the entire Middle East.” Israel Finance Minister Yair Lapid stated that he was concerned that, “the world is no longer listening to Israel.” Israeli Economy Minister Naftali Bennett stated that the deal would increase the chances of Israel preventive strikes, “A bad deal definitely increases the need for action,” Bennett said on Channel Two television. “If the deal gives Iran the ability to achieve a bomb within six weeks, we won’t be able to sit idly by.”²¹²

As might be expected from the previous analysis, other Israelis – including both military and arms control experts – soon emphasized the more positive aspects of the agreement. It was also possible that at least some of the Netanyahu rhetoric was designed to push the Obama Administration, the US Congress, and other states into fully enforcing the terms of the agreement and focusing on the nuclear issue rather than options for improved relations. It was equally clear, however, that President Obama and other Administration officials had failed to persuade the Netanyahu government that they should publically accept the agreement, and all of the previous divisions between the US and Israel remained all too real.

Israeli Public Opinion

Figures 25 through **Figure 28** reflect Israeli public opinion regarding an Israeli strike on Iran’s nuclear facilities, as well as the potential aftermath thereof. These data show that there is no unified public opinion regarding such a strike, and that there is a wide range of disparate views among Jewish and non-Jewish Israelis alike.

Figure 25: Israeli Public Opinion Regarding a Strike on Iran's Nuclear Facilities 1- February 2012 - Part One

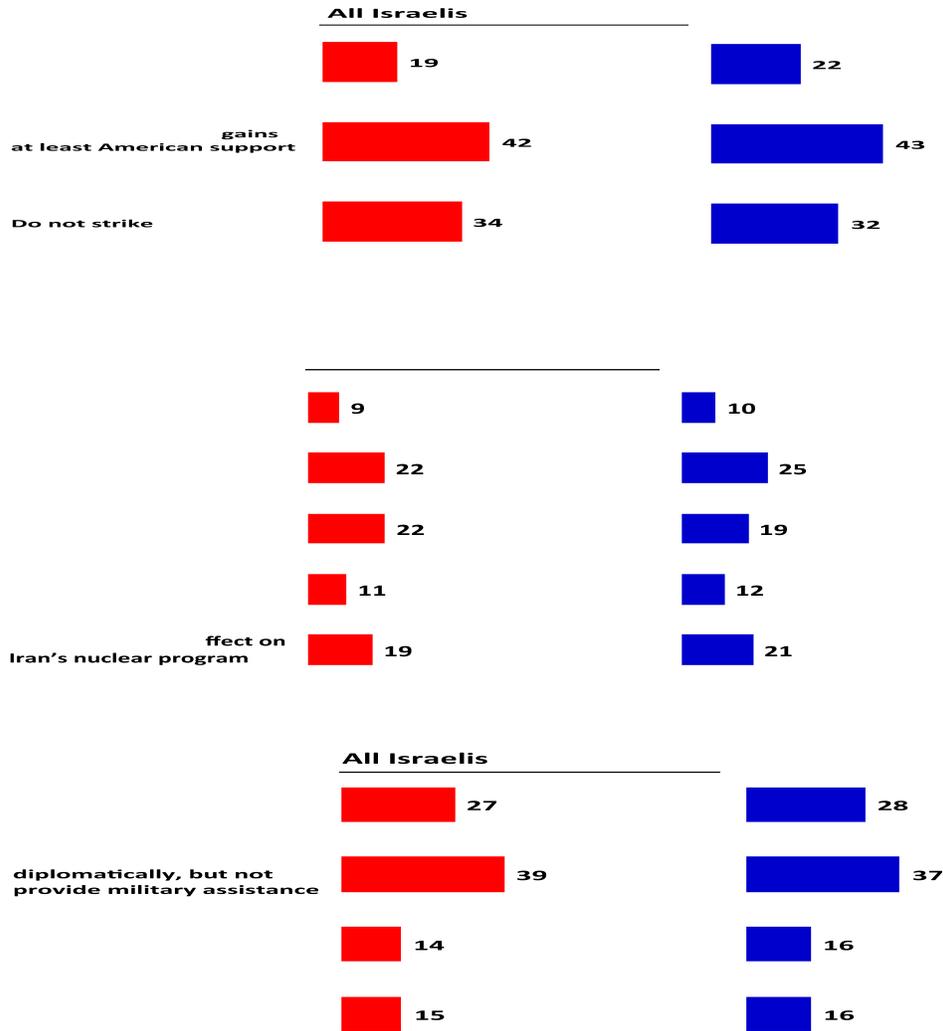
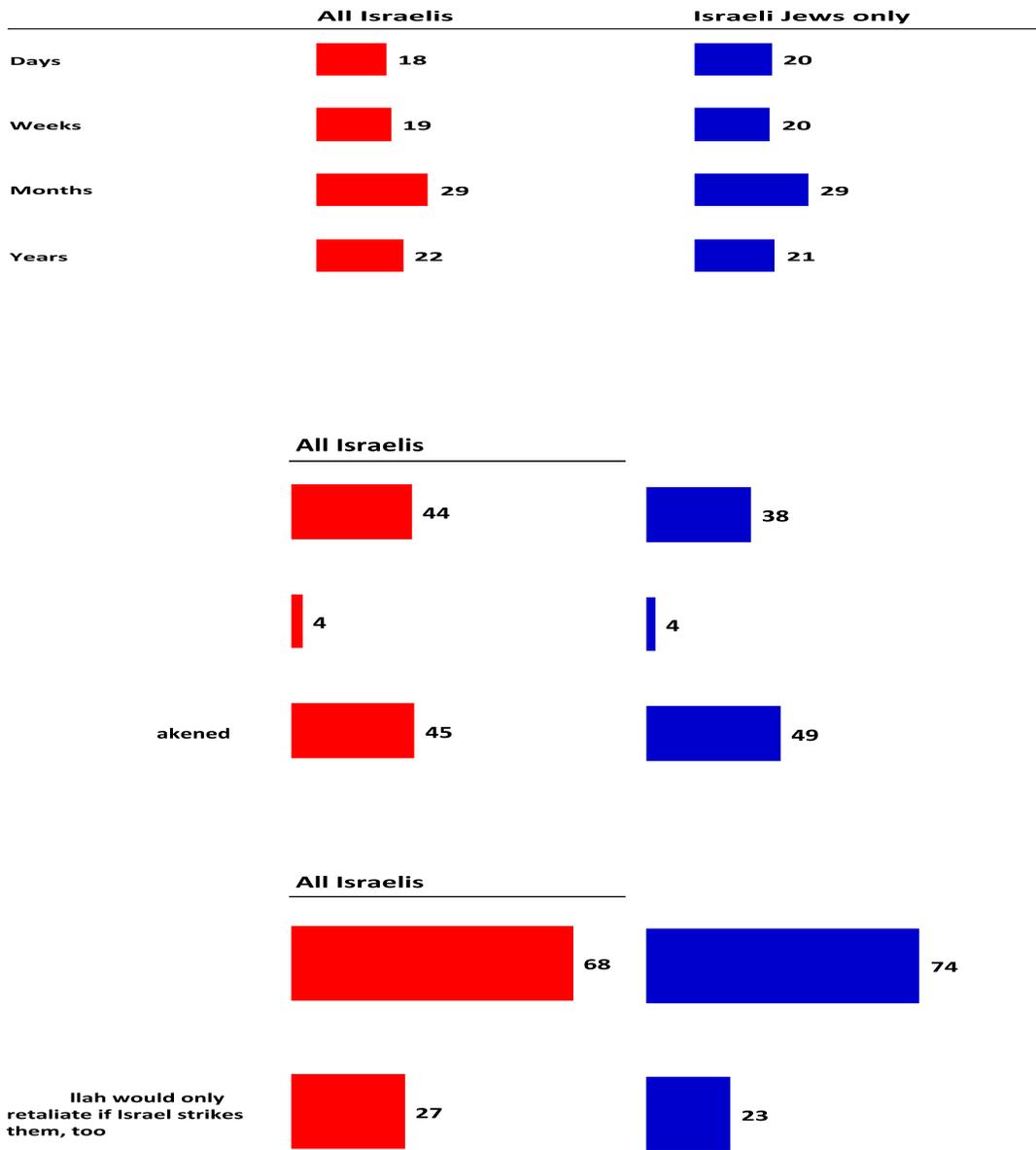


Figure 25: Israeli Public Opinion Regarding a Strike on Iran’s Nuclear Facilities 1- February 2012 - Part Two



Source: Shibley Telhami, “February 2012 Israeli Public Opinion Survey,” Sadat Chair at the University of Maryland/Dahaf Institute, Israel, February 2012. [http://Sadat.umd.edu/TelhamiIsraelPollFebruary2012\[1\].pdf](http://Sadat.umd.edu/TelhamiIsraelPollFebruary2012[1].pdf)

Figure 26: Israeli Public Opinion Regarding a Strike on Iran's Nuclear Facilities Over Time - June

19. Suppose all diplomatic and economic efforts fail to convince Iran to halt its nuclear weapons program. If that happens, would you support or oppose Israeli military action aimed at destroying the Iranian nuclear facilities?

Answers	2012 Survey	2009 Survey
1. Oppose	23%	15%
2. Support action under certain conditions	31%	-
3. Support	35%	66%
4. Don't know and other answers	11%	19%
Total	100% (N=540)	100% (N=610)

Source: "Israeli Public Views on the U.S., 2012," Begin-Sadat Center for Strategic Studies, June 2012.
<http://www.biu.ac.il/SOC/besa/docs/PollUS-IL0612En.pdf>

Figure 27: Israeli Public Opinion Regarding a Strike on Iran's Nuclear Facilities and Cooperation with the United States- July

4. Do you support or not support an Israeli attack on Iran without the cooperation of the United States?

	General Public	Jews	Arabs
1. Strongly support		10.9	
2. Moderately support		16.2	
3. Moderately oppose		32.0	
4. Strongly oppose		28.7	
5. I don't know\ Refuse to answer		12.2	

5. In your opinion, what are the chances that Israel will soon launch an attack on Iran's nuclear facilities even without the cooperation of the United States?

	General Public	Jews	Arabs
1. Very high chances		4.9	
2. Moderately high chances		28.2	
3. Moderately low chances		41.9	
4. Very low chances		13.7	
5. I don't know\ Refuse to answer		11.3	

6. What, in your assessment, are the chances that an attack of this nature, without U.S. cooperation, will succeed in stopping Iran's nuclearization for a significant time?

	General Public	Jews	Arabs
1. Very low chances		19.6	
2. Moderately low chances		34.7	
3. Moderately high chances		26.5	
4. Very high chances		9.0	
5. I don't know\ refuse to answer		10.1	

7. And if the attack on Iran's nuclear facilities is carried out in cooperation with the United States, how do you then assess the chances that such an attack will succeed in stopping Iran's nuclearization for a significant time?

	General Public	Jews	Arabs
1. Very low chances		4.6	
2. Moderately low chances		14.8	
3. Moderately high chances		47.4	
4. Very high chances		28.3	
5. I don't know\ refuse to answer		4.9	

Source: "The Peace Index, July 2012." The Israel Democracy Institute, Tel Aviv University.
[http://www.peaceindex.org/files/The%20Peace%20Index%20Data%20-%20July%202012\(2\).pdf](http://www.peaceindex.org/files/The%20Peace%20Index%20Data%20-%20July%202012(2).pdf)

Figure 28: Joint Israeli-Palestinian Opinion Poll- September**V10) Should Israel or should it not try to stop Iran's nuclear bomb development by military means?**

	Israeli Jews	All Israelis
1) Yes, but only with US	58.5%	52.4%
2) Yes, even Israel alone	15.1%	18.4%
3) No	21.2%	24.2%
4) DK/NA	5.2%	5.1%

V12) In your opinion, will Israel bomb Iran's nuclear facilities on its own, without the US, in the coming months?

	Israeli Jews	All Israelis
1) Certainly it will	4.6%	5.1%
2) Think that it will	16.6%	18.2%
3) Think that it will not	45.2%	42.5%
4) Certainly not	25.7%	27.2%
5) DK/NA	7.9%	7.0%

V13) (Q67) If Israel will to carry out a military strike against Iran, do you think such a strike would lead to a big war in the region with Iran and its proxies in the region (Hamas and Hizbollah)?

If Israel carried out a military strike against Iran, do you think such a strike would lead to a big war in the region between Israel, Iran, and other parties?

	Israeli Jews	All Israelis	Palestinians
1) Certainly will lead to a big war	37.5%	39.5%	35.5%
2) Will lead to a big war	40.3%	37.1%	46.3%
3) Will not lead to a big war	15.2%	16.1%	14.1%
4) Certainly will not lead to a big war	3.1%	3.7%	1.8%
5) DK/NA	3.9%	3.6%	2.3%

Source: Harry S. Truman Research Institute and Hebrew University of Jerusalem, "Joint Israeli Palestinian Poll, September 2012," September, 2012. <http://truman.huji.ac.il/upload/Portfolio1.pdf>

Potential Israeli Options for Striking Iran's Nuclear Program

Israeli officials have not discussed the details of their country's options for striking against Iran's nuclear program. It is possible, however, to discuss Israel's potential capabilities and various scenarios.

A Limited Strike Scenario

Israel faces serious limits on the level of strikes it could conduct, and the size of the Iranian target base it could cover. As a result, it seems likely that Israel would have to focus on Iran's largest and most critical facilities, although Israel's targets might include suspect or secret sites that are omitted from unclassified lists. The key unclassified facilities Israeli might give high priority to in a preventive strike include:

- **Natanz Centrifuge Facility:** Reportedly hardened by steel reinforced concrete and buried by roughly 30 feet of earth.
- **Fordow Fuel Enrichment Plant:** Built into the side of a small mountain and covered by roughly 300 feet of earth.
- **Bushehr City and Reactor Area:** Bushehr reactor vulnerable, and also within close proximity to populated areas.
- **Arak:** Heavy water production plant, essential to the IR-40 Heavy Water Reactor.
- **Esfahan:** Uranium conversion plant.

Only two of these sites - Fordow and Natanz - are really hardened. Only one reactor - Bushehr - might produce serious radiological effects if attacked. Arak's two complexes, the heavy water production plant and the IR-40 heavy water reactor do not both need to be hit, destroying or heavily damaging either will make the other one useless. Illustrative Israeli options for attacking this set of targets include the scenarios set forth in the following escalation ladder:

- Single set of strikes against limited number (approximately 4 to 8) of main forward facilities. "Close" entrance of Natanz and Fordow. Do not strike Bushehr reactor.
- Single set of strikes against limited number (approximately 4 to 8) of main forward facilities. Attempt major damage to Natanz and Fordow. Do strike Bushehr reactor.
- Single or multiple strikes against broad range of known and suspect facilities including centrifuge production and research reactor; hit all main sites. Possibly strike Bushehr reactor.
- Tailor strikes to stimulate maximum Iranian hostile attack: "Trigger force" to push US and Gulf States to respond.
- Restrike after Iran attempts to recover; escalation to other key infrastructure or military target to deter further Iranian efforts.
- Preventive/preemptive nuclear strike on Iranian force after test or deployment; threat to attack Iranian population centers if Iran responds.

There is no way to know how much Israel could accomplish if it attacked this more limited set of targets. It is possible, however, that even a relatively limited Israeli strike could set Iran's program back by a year or more by focusing on such key facilities. The main problems it would face include:

- Overflight of Arab territory,

- Distances Israeli aircraft would have to fly in order to penetrate Iranian airspace,
- Need to destroy or evade Iranian air-defenses,
- Refueling and supporting enabling aircraft in hostile air space,
- Range-payload problems in penetrating deeply into Iran, and subsequent damage to hardened targets such as Fordow or Natanz, and,
- Risk of losing aircraft to fuel problems if they had to make combat maneuvers.

Nuclear versus Conventional Israeli Strike Options

Illustrative examples of Israeli capabilities to conduct such strikes include the courses of action described in **Figure 29** to **Figure 31**.

Figure 29 shows what a low yield Israeli nuclear strike on Iran's nuclear facilities would look like. Israel would use either ballistic missiles or nuclear-armed strike aircraft to carry out such a mission.

Figure 30 and **Figure 31** present a picture of what an Israeli conventional strike using air power would look like. Israeli aircraft could take any one of three routes (northern, central, or southern), all of which would involve traversing unfriendly airspace to reach targets in Iran. The central route would involve flying 1,500-1,700 kilometers through Jordan and Iraq, the southern route would involve flying 1,900-2,100 kilometers through Saudi Arabia, and the northern route would involve flying 2,600-2,800 kilometers in a loop through Turkey.

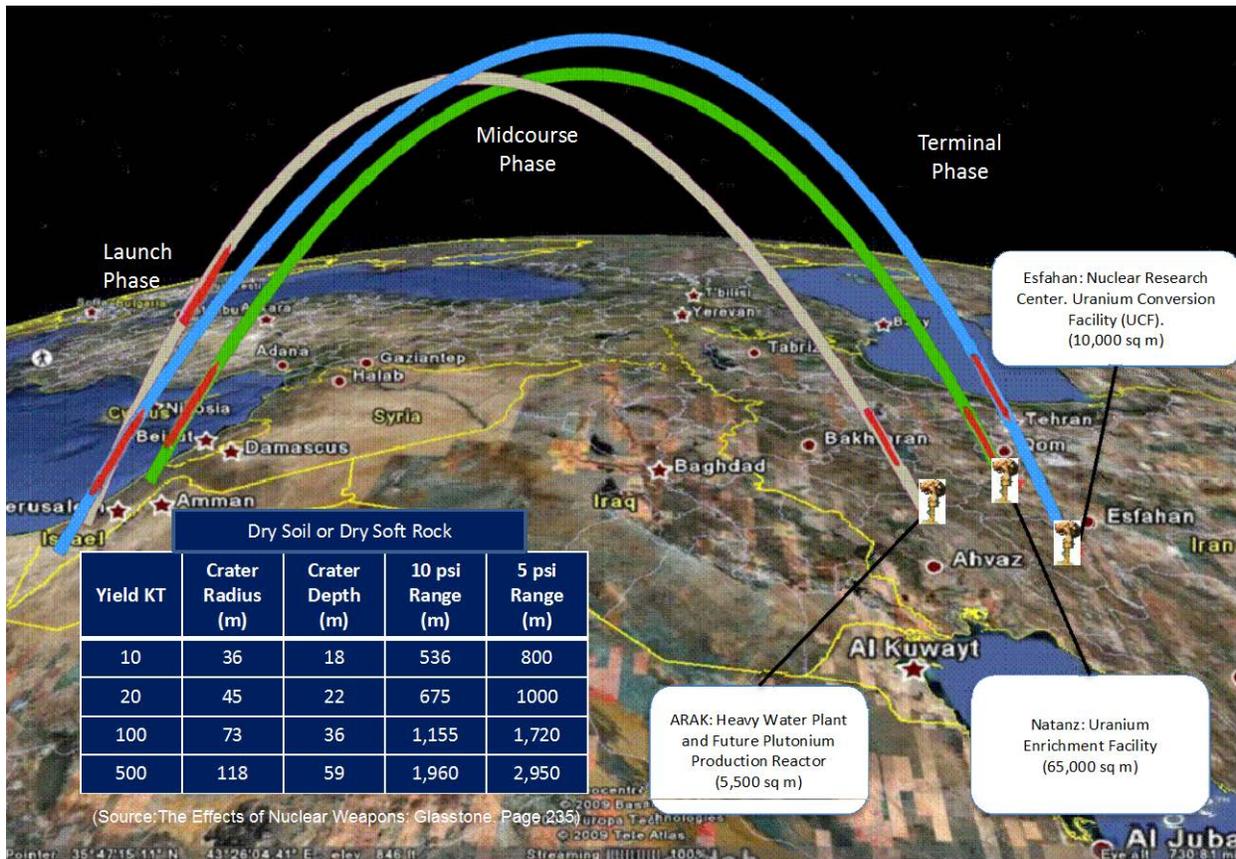
It seems likely that any current Israeli preventive strike would be conventional. Iran does not yet have nuclear weapons and any Israeli first use of nuclear weapons of the kind shown in **Figure 30** would be drastic. It may lead to an almost universal international condemnation of Israel, turn Arab states that are amenable to an Israeli strike against Israel, present major problems in terms of US-Israeli relations, lead to condemnation in the UN, and possibly even lead to sanctions and war crimes trials.

Moreover, it is unclear that Israel could count on the level of reliability and accuracy in its missiles forces necessary to use low yield weapons in single strikes against hardened targets like Natanz and Fordow, and Israel might have to use ground bursts against other targets to get suitable levels of damage. The use of a strike aircraft to deliver a low yield nuclear weapon would reduce these risks, but not the massive political risks in initiating a nuclear war against a state that did not yet have nuclear weapons.

An Israeli conventional strike on Iran's nuclear facilities of the kind shown in **Figure 30** and **Figure 31** seems more likely, but it would have an uncertain probability of lasting success for several reasons. Given the unfriendly airspace Israeli strike aircraft would have to traverse to reach Iran's facilities as well as Israel's geographic distance from Iran, the likelihood of Israel being able to carry out repeated strikes is low. Israeli strike aircraft would only have one opportunity to strike at Iran's nuclear facilities. Moreover, Iran's nuclear facilities are dispersed and fortified, and a single Israeli strike would probably only temporarily impede Iran's nuclear progress.

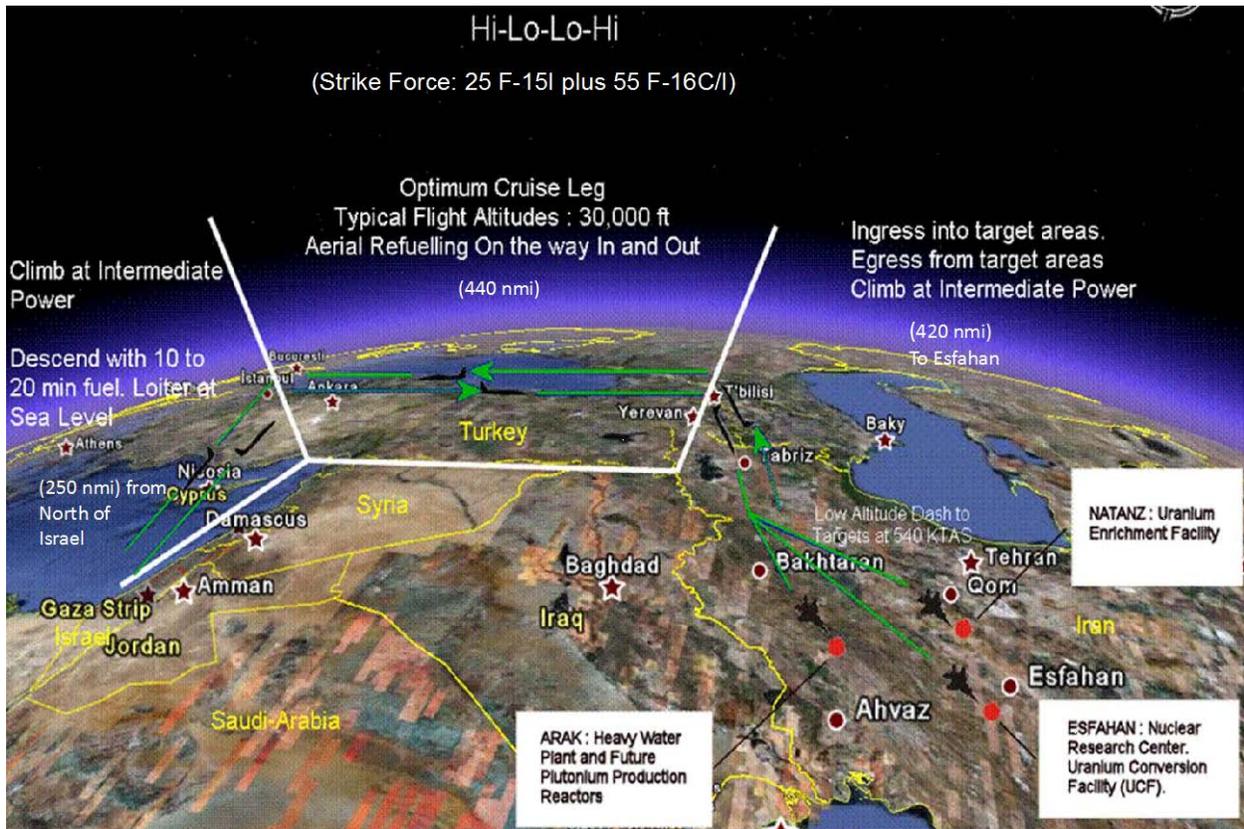
Even if Israel had the attack capabilities needed for the destruction of all elements of the Iranian nuclear program, it is doubtful whether Israel has the kind of intelligence needed to be certain that all the necessary elements of the program were traced and destroyed fully. Israel has good photographic coverage of Iran with the Ofeq series of reconnaissance satellites, but being so distant from Iran, one can assume that other kinds of intelligence coverage are rather partial and weak.

Figure 29: Low-Yield Israeli Nuclear Strike on Iran's Nuclear Facilities



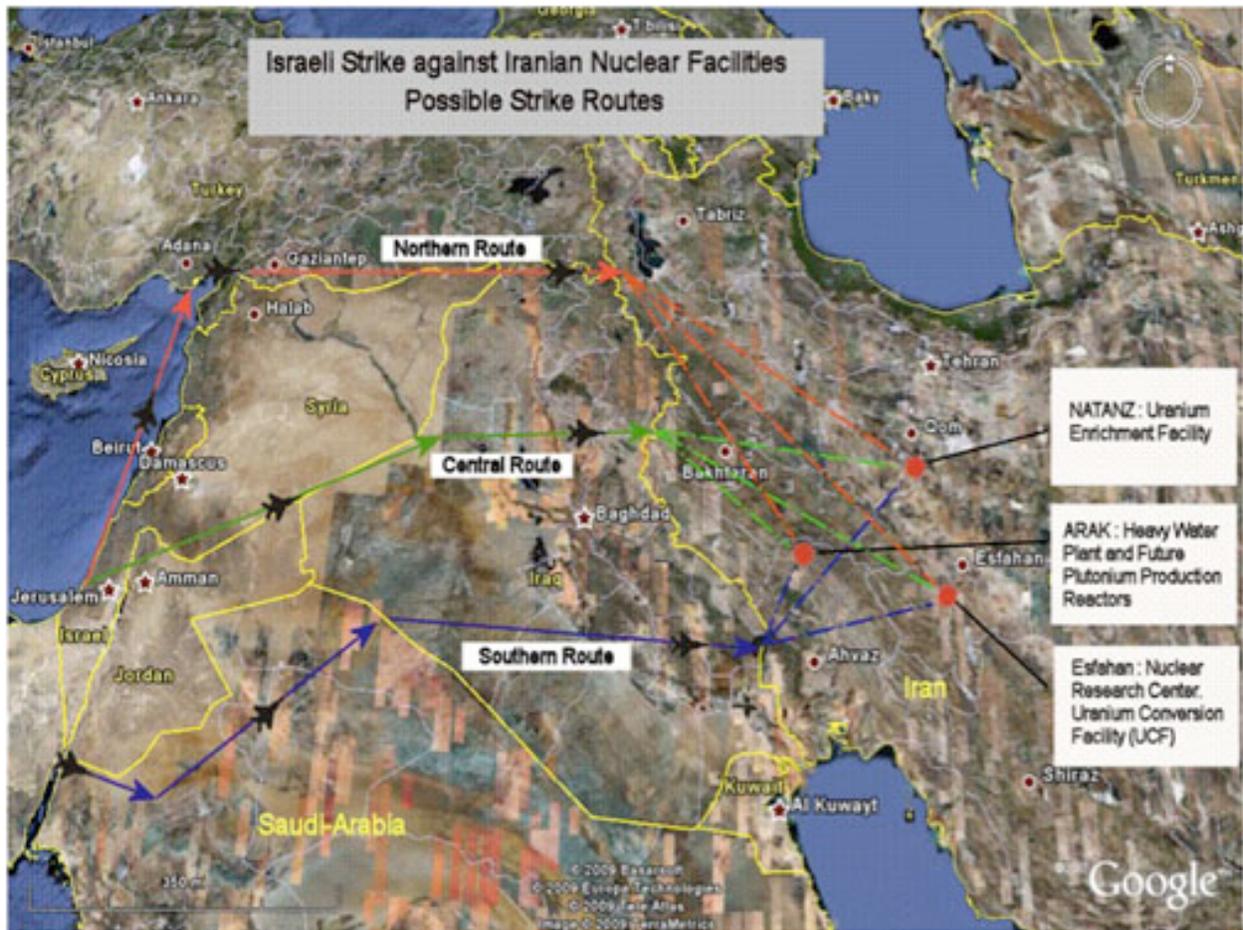
Source: Dr. Abdullah Toukan.

Figure 30: Israeli Conventional Strike on Iran's Nuclear Facilities



Source: Dr. Abdullah Toukan.

Figure 31: Possible Israeli Strike Route



Source: Dr. Abdullah Toukan.

An Illustrative Israeli Air Strike

Israel would have to make difficult calculations of how many combat aircraft it could actually support in operations over Iranian air space, knowing that two of the most hardened targets which would require the highest payload to attack are Fordow and Natanz, which are relatively deep in Iran. It would have to choose between a maximum force with maximum effectiveness, and a smaller force that would be easier to refuel and support. It would have to decide whether it would use only strike aircraft, or add fighter escorts, and how many fighters it would use that carried anti-radiation missiles and electronic jammers and warfare equipment versus ground attack payloads.

Air defense and strike fighters are not passenger or cargo aircraft. They are small aircraft with limited range and payload. Every mile flown outside the direct flight path to targets in Iran would burn critical fuel. A Jordan that tolerated Israeli flights and denied any knowledge of such an attack would ease - but scarcely eliminate - Israel's problems and present a serious risk of political complications for Jordan.

Flying through a Syria in political chaos might be easier, but the least vulnerable routes through Syria are to the north and might require the Israeli aircraft to fly out over the Mediterranean and penetrate through northern Syria, adding to the range. Flying through Saudi Arabia would risk encountering a modern fighter force and it is unclear that the Saudi government would ever give even tacit permission. Iraq has no surface-to-air missiles or a meaningful air force, but over flights of Iraq would present political problems for the US.

Possible Israeli Routes of Attack

There are three main flight paths Israel might use to strike at targets in Iran:²¹³

- The Northern Route: North over the Mediterranean to refuel from staged tankers, fly East over Turkey into Iran
- The Central Route: East through Jordan or Northern Saudi Arabia and Iraq, with refueling over the empty desert in Iraq
- The Southern Route: Southeast through Saudi Arabia with refueling over Saudi Arabia or in the Persian Gulf

The Northern Route has the advantage of keeping the refueling tankers out of harm's way since they are flying over international waters. However, by refueling so close to Israel, the IAF will only be able to take on a limited amount of fuel and would be operating at the far end of their F16s and F15s combat radius.²¹⁴ This route also necessitates Israel to violate Turkish airspace and creates uncertainty as to what the Turks will do in this event as relations between the two countries have been rocky since the 2010/2011 Gaza Flotilla Raid that killed nine activists.

The Central Route has the advantage of being the most direct but like the Northern Route, involves diplomatic cooperation with Jordan, and depending on the flight path, Saudi Arabia. Refueling would be staged over Iraq's Anbar Province, and would pose little to no danger due to Iraq's limited air defense capabilities. By staging refueling over Iraq, it increases the IAF's combat radius.

The Southern Route crosses the least defended airspace but is also the longest route. This route poses the same type of diplomatic challenges as the first two routes, requiring Saudi acquiescence to limit the danger to Israeli planes. Refueling over the Persian Gulf would also be

a challenge and the tankers would require a larger number of escorts due to their proximity to Iranian air bases.

On the approach to Iran, Israeli planes would most likely fly at their cruising altitude to reduce fuel consumption. But over Iranian airspace, Israeli planes would most likely fly low to avoid or minimize radar detection. Additional fuel would be used if Israeli planes had to conduct SEAD missions or engage in a major electronic warfare effort to protect fighters. Any major maneuver to avoid Iranian fighters, or an Iranian surface-to-air missile would consume far more fuel than a simple penetration and attack profile, and create serious risks in terms of need for refueling or loss of the aircraft.

Penetrating Iran's Air Defense System

Analysts differ in their assessment of how well Israel could penetrate Iran's air defense systems. Iran's air-to-surface missile capability has been assessed as poorly netted, having significant gaps and problems in their radar and sensor coverage and modernization and a number of its systems are vulnerable to electronic warfare. The bulk of Iranian SAMs are comprised of 1960's and 1970s platforms bolstered with a mix of indigenous upgrades of Soviet/Russian systems and accompanied by a small number of modern Russian Tor-M1 and SA-22 systems. Iran's air defense network is also a source of contention, with some analysts describing a modern coordinated network, but others describing a lackluster defense system that can easily be negated with electronic countermeasures and anti-radiation missiles.

Iran's warplanes are a generation behind Israel's and limited in mission capacity, the International Institute of Strategic Studies says that at any given time, 40%-60% of Iran's warplanes are limited or have no mission capacity. The bulk of Iran's aircraft are aging US and Soviet/Russian aircraft that are poorly supplied with spare parts, limiting the number of planes available to fly as well as increasing downtime.

According to various experts, Iran is attempting to improve the Air Force's capabilities and competences by modifying various Shah-era US F-4s, C-130s, F-14s, and P-5, however, they still have limited sortie generation capabilities and spare parts for aircraft is a continual issue.

Potential Israeli Strike Forces and Assets

Israel could mount a relatively large attack force relative to the number of major Iranian targets if it chose to do so. In a conventional strike, Israel could launch and refuel two to three full squadrons of 36 to 54 combat aircraft for a single set of strikes with refueling. It could use either its best F-15s (28 F-15C/Ds, 25 F-15I Ra'ams) or part of its 126 F-16 C/Ds and 23 F-16I Sufas. It has at least three specially configured squadrons with conformal fuel tanks specially designed for extended range use. It could add fighter escorts, but refueling and increased warning and detection would be major problems.

Israel's primary strike aircraft would probably be the F-15I, although again this is guesswork. Global Security describes the F15I as follows:

The key aspects are that Boeing's (formerly McDonnell Douglas) F-15E Strike Eagle entered service with the IDF/Heyl Ha'Avir (Israeli Air Force) in January of 1998 and was designated the F-15I Ra'am (Thunder). The F-15E Strike Eagle is the ground attack variant of the F-15 air superiority fighter, capable of attacking targets day or night, and in all weather conditions.

The two-seat F-15I, known as the Thunder in Israel, incorporates new and unique weapons, avionics, electronic warfare, and communications capabilities that make it one of the most advanced F-15s. Israel

finalized its decision to purchase 25 F-15Is in November 1995. The F-15I, like the US Air Force's F-15E Strike Eagle, is a dual-role fighter that combines long-range interdiction with the Eagle's air superiority capabilities. All aircraft are to be configured with either the F100-PW-229 or F110-GE-129 engines by direct commercial sale; Night Vision Goggle compatible cockpits; an Elbit display and sight helmet (DASH) system; conformal fuel tanks; and the capability to employ the AIM-120, AIM-7, AIM-9, and a wide variety of air-to-surface munitions.

Though externally the Ra'am looks similar to its USAF counterpart, there are some differences, mainly in the electronic countermeasures gear and the exhaust nozzles. The Ra'am has a counterbalance on the port vertical stabilizer instead of the AN/ALQ-128 EWWS (Electronic Warfare Warning System) antenna found on USAF Strike Eagles. The Ra'am uses two AN/ALQ-135B band 3 antennas, one mounted vertically (starboard side) and one horizontally (port side). These are located on the end of the tail booms. They are distinguished by their chiseled ends, unlike the original AN/ALQ-135 antenna, which is round and located on the port tail boom of USAF Eagles.

The Ra'am utilizes extra chaff/flare dispensers mounted in the bottom side of the tail booms. Unlike USAF Eagles, the Ra'am still use engine actuator covers (turkey feathers) on their afterburner cans. The US Air Force removed them because of cost and nozzle maintenance, though curiously, USAF F-16s still have their actuator covers installed. Israeli Strike Eagles and some USAF Eagles based in Europe use CFT air scoops. These scoops provide extra cooling to the engines.

The 25 F-15Is operational since 1999 [and the 100 F-16Is] were procured first and foremost to deal with the Iranian threat. In August 2003 the Israeli Air Force demonstrated the strategic capability to strike far-off targets such as Iran [which is 1,300 kilometers away], by flying three F-15 jets to Poland 1,600 nautical miles away.

The Limits to Israeli Capabilities: Hard Target Kills

Israeli strike aircraft would probably need to carry close to their maximum payloads to achieve the necessary level of damage against some Iranian surface targets suspected of WMD activity as well, although many structures could be destroyed with 1-3 weapons. (This would include the main Bushehr reactor enclosure, but its real-world potential value to an Iranian nuclear program is limited compared to more dispersed and/or hardened targets). At least limited refueling would be required, and back-up refueling and recovery would be an issue.

According to open source reporting, Israel has a number of munitions in its arsenal able to penetrate hardened and buried targets. These include the BLU-109, the GBU-27, the GBU-28 Hard Target Penetrator, and GBU-39 Small Diameter Bomb. In addition, Israel has developed domestic weapons, the PB 500 A1 and the MPR-500.

Israel's fighters would face more serious range problems in carrying the higher payloads necessary to destroy hardened targets. One key weapon that might be used against hard targets and underground sites like Natanz would be the GBU-28 - although the US may have quietly given Israel more sophisticated systems or Israel may have developed its own hard target killers - including a nuclear armed variant.

In September 2011, reports surfaced that the Obama administration had transferred an unknown number of 5,000 lb. GBU-28 Hard Target Penetrator bunker busters to Israel. Israel reportedly requested the weapons as early as 2005.²¹⁵ Although it is uncertain to what level exactly these bombs could enable Israel to launch an effective strike on Iran's nuclear facilities or damage its program in a meaningful way, they do provide Israel with an increased comparative capability to do so.

The F-15I can carry the GBU-28. It is a 5,000-pound laser-guided bomb with a 4,400-pound earth-penetrating warhead that can be upgraded by the IAF to use electro-optical or GPS

targeting. It is a vintage weapon dating back to the early 1990s, and the IAF is reported to have bought at least 100. It has been steadily upgraded since 1991 and the USAF ordered an improved version in 1996. It can glide some 3-7 miles depending on the height of delivery. It is 153” long x 14.5” in diameter.

Israel was eligible to purchase the GBU-28 Hard Target Penetrator in 2005, but did not take delivery of the weapons until 2009.²¹⁶ Experts speculated whether the purchase was a power projection move or whether Israel was planning to use these bombs against Iranian nuclear sites. These speculations were further exacerbated when the Israeli Chief of Staff, Lt. General Dan Halutz, was asked how far Israel would go to stop Iran’s nuclear program, he said “2,000 kilometers.” It is important to note, however, that these bombs are systems designed to kill hardened surface targets and not deeply buried underground facilities. They could damage entrances to such facilities but not the underground areas.

Moreover, it should be stressed that Israel has the technology base to develop its own weapons or modifications and to reverse engineer US and European systems as seen in the Israeli PB 500 A1 and MPR-500. It is not possible to estimate the limits to the lethality and range-payload of Israeli strike capabilities simply by examining known transfers of US systems.

Some estimates for destroying the hardened targets of Fordow and Natanz describe repeated strikes, one on top of each other, in order to burrow deep enough to destroy the facility below. For Natanz, a study done in 2007 described the need for 2 BLU-28’s sequenced properly to first remove the layers of concrete and dirt and second, to actually destroy the facility.

...the BLU-113 would be the most likely weapon to use. One BLU-113 might be sufficient to penetrate the protective earth and concrete over the Natanz facility, but two properly sequenced almost certainly would. The probability of two LGBs aimed at the same point hitting essentially one on top of the other is likely to be about 0.45. Sequencing of the BLU-113s would be necessary for only the upper end of the estimated hardness of the Natanz centrifuge halls. For example, if the facility is protected by 23 meters of concrete and earth, sequencing would be needed only if roughly 2 meters or more of the 23-meter total are concrete. For the lower estimate of 8 meters of concrete and earth cover, one BLU-113 could easily penetrate.

The delivery of six pairs of BLU-113s on each hall, for a total of twelve pairs or twenty-four weapons, would give fairly high confidence of achieving this level of damage. With each pair having a 0.45 probability of success, six pairs would give a total probability of about 0.31 of achieving at least three successful penetrations in both halls and a 0.71 probability of at least two penetrations in each hall.⁴³In addition to the weapons that actually penetrated the centrifuge halls, all but one or two of the other BLU-113s would be expected to detonate over each hall, possibly collapsing the entire structure.²¹⁷

The Fordow facility, protected by roughly 200 feet of earth and a thick layer of concrete, will be difficult to destroy and might force Israel to divert most of its F-15I’s as a report below details:

...I calculated the probability of the Israeli Air Force successfully targeting the Fordow facility. I assume 25 F-15I aircraft, each carrying one 5,000-pound bunker buster and two 2,000-pound bunker busters, would expend all 75 of those bombs on a single aim point at Fordow. If angle-of-arrival control is good, the Air Force could have between a 35 percent and 90 percent chance of at least 36 of those weapons arriving on the same aim point (this calculation is very sensitive to assumptions about individual weapons). If the spoil problem compounds the depth by only 30 percent or less (in other words, pulverized and collapsing rock adds the equivalent of no more than 27 meters of solid rock) this would likely be sufficient to have at least one weapon penetrate the facility. It thus seems plausible that Fordow can be targeted successfully, if my assumptions are correct.

...Additionally, as all of the F-15Is would be dedicated to Fordow, this option would require F-16Is carrying the smaller 2,000-pound bunker buster to be used against the Natanz facility, which would make that strike more difficult.²¹⁸

In light of the difficulties of getting at and destroying the Fordow facility, Israel would most likely use its forces to attack and destroy the entrances or other piping or conduits exposed above ground. This would destroy the access points leading to the facility, render it useless until it could be repaired, and would free up other forces to attack a larger amount of targets.

On December 10th, 2012, the Department of Defense notified Congress informing them of a possible foreign military sale of 6,900 JDAM tail kits and associated equipment, parts, training, and logistical support for roughly \$647 million. These tail kits will provide Israel additional smart weapon and precise targeting abilities for its Air Force. More importantly however, is included in the sale; the transfer of 1,725 BLU-109 bunker busters that while effective weapons may not be suitable for destroying deeply buried targets.²¹⁹ The US will also not be providing any new capabilities to Israel's Air Force. The full list of weapons and systems include:²²⁰

- 3,450 JDAM Anti-Jam KMU-556 kits (GBU-31) for the Mk-84
- 1,725 JDAM KMU-557 kits (GBU-31) for the BLU-109
- 1,725 JDAM KMU-572 kits (GBU-38) for the Mk-82
- 3,450 Mk-84 2,000 lb. General Purpose Bombs
- 1,725 Mk-82 500 lb. General Purpose Bombs
- 1,725 BLU-109
- 3,450 GBU-39 Small Diameter Bombs
- 11,500 FMU-139 fuses
- 11,500 FMU-143 fuses
- 11,500 FMU-152 fuses

However, this sale is not final and like most sales will take some months to finalize and more months to ship the weapons to Israel.

Choosing Target Numbers

Unless Israel has near total, real-time transparency into Iran's programs, it could probably only hit a limited number of nuclear facilities - and would probably not strike Iran's additional missile, biological, or chemical facilities unless it was certain these posed so active a threat that they could not be avoided. This means, however, that while an Israeli strike on Iran's best-known nuclear targets might appear to be successful, a strike might actually be a failure in halting key elements of Iran's program due to dispersion or to the failure to hit previously unknown facilities.

It also raises the critical issue that an attack might effectively legitimize an Iranian nuclear weapons program in the eyes of Iranians and many outside Iran. The end result of strikes could be a hardened Iranian regime with a workable excuse to withdraw from the NPT and halt inspection, dedicated to the reconstitution of a nuclear program that uses far more Iranian resources than the previous program, and that has made the decision to pursue a nuclear weapon.

As noted earlier, Israel would have to make hard choices as to how many known and suspect targets could be attacked with what level of lasting damage, civilian casualties, and collateral damage. Multiple strikes on the dispersed buildings and entries in a number of facilities would be necessary to ensure adequate damage without re-strikes - which may not be feasible for Israel given the limits to its sortie generation capability over even Iranian soft targets. As for hardened

and underground targets, the IAF's mix of standoff precision-guided missiles - such as Harpoon or Popeye - or smart bombs, would not have the required lethality with conventional warheads, and Israel's use of even small nuclear warheads would cause obvious problems.

The "shell game" or "lottery targeting" problems Israel would face in choosing which and how many targets to attack are illustrated by looking at the potential target list in **Figure 18**

Israel may or may not feel it has an accurate targeting list of all key Iranian facilities. It is very unlikely, however, that Israel feels that this list is perfect, or that the Israeli list of known and suspect targets is far too long for Israel to strike at all targets. It is also unlikely that Israel would strike at targets with munitions that could involve significant innocent civilian casualties and collateral damage.

Moreover, Israeli planners almost certainly must feel that Iran is now hiding and dispersing some of its highly enriched material, as well as key elements of its nuclear program in order to reconstitute it after a strike. Furthermore, at least some suspect facilities are in northeast Iran, greatly complicating the range-payload and survivable strike problems Israel would face, and radically altering the kind of strike profiles shown in **Figure 30** and **Figure 31**.

Refueling and Supporting Enablers

Another key problem would be refueling Israeli fighters - particularly if they had to engage in even preparatory air-to-air combat or surface-to-air missile evasion - and creating a survivable mix of tankers and any mix of enabling electronic warfare, intelligence, and air control aircraft. Israel's 5 KC-130H and 5 B-707 tankers are slow and vulnerable and would need escorts - and its ordinary B-707 AE&W, ELINT and electronic warfare aircraft are also slow, although the new G-550 Shaved ELINT aircraft is relatively fast and the IAF has a long-range UAV capability that could support its aircraft before, during, and after such missions.

The Israeli Air Force had previously bought commercial Boeing 707's and then converted them into refueling tankers reportedly due to budgetary constraints and the US Air Force's delay in choosing its future tanker.²²¹ In July, the President Obama signed the "United States-Israel Enhanced Security Cooperation Act of 2012" into law, this allows Israel to purchase KC-135 refueling tankers from the United States. However, it could be some time before contracts are negotiated, deliveries take place, and crews are trained, making Israel's current refueling force the one they will most likely use for strikes against Iranian nuclear facilities.

The bigger Israeli manned "slow fliers" would have serious problems penetrating and surviving in Iranian air space. The radars in the countries involved would probably detect all IAF and US missions relatively quickly, and very low altitude or nap-of-the-earth penetration profiles would lead to serious range-payload problems. The countries overflown would then be confronted with the need to either react or have limited credibility in claiming surprise. An over flight of Iraq - which currently has no meaningful air force and no surface-to-air missiles - might be seen in the region as having been given a US "green light," although the problems the US has had in creating a meaningful strategic framework agreement with Iraq have reduced the implied level of US responsibility for protecting Iraqi airspace.

Israel has, however, specially configured some of its F-15s and F-16s with targeting, EW, SAM-suppression aids, and ELINT for this kind of mission. The full details of such capabilities are unknown. Israel would also have to stage such aircraft at some point over Arab territory as well as use fighters to escort and protect them.

Assembling a mix of tankers and enablers to wait over Arab territory or the Gulf while Israeli fighters struck targets in Iran would increase the problem of detection and expose forces over Arab countries. Assembling a scattered force of tankers and enablers would present command and control problems and leave the individual elements more vulnerable. Staging them over the Mediterranean off the Syrian coast might be a partial solution, but would increase the risk that fighters might run out of fuel before completing their missions.

An Israeli Strike as a One Time Option

Israel would find strikes to be a major political and military problem. Israel might get away with going through Jordan and then through Saudi Arabia or Iraq once, given the fears these countries have of Iran's nuclear efforts. However, any repeated effort would be too politically dangerous for Arab governments to easily tolerate.

Israel would probably face problems in getting accurate restrike and battle damage data for missions against several of the targets involved using its intelligence satellites and UAVs. A lack of totally reliable battle damage assessment and time-urgent retargeting capabilities for precision strikes with a target mix as complex as Iran's could be another major problem.

Much would depend on just how advanced Israel's long-range UAV capabilities really are and whether Israel could get access to US intelligence and IS&R capabilities for both its initial targeting and restrikes. Confirming the actual nature of damage, carrying out restrikes, and sending a clear signal that Israel can repeat its strikes if Iran rebuilds or creates new facilities would be a problem.

The Diplomatic Aftermath Problem

As senior US officers and officials have repeatedly warned, the aftermath of such an attack would be a major problem. Iran might withdraw from the NPT and refuse all future IAEA inspection. It might claim any Jordanian, Turkish, and/or Saudi tolerance of such an IAF strike was a hostile act. It might claim the US gave "green light" in any case in an effort to mobilize hostile Arab and Muslim (and possibly world) reactions. At a minimum, the attack would trigger years of Iranian efforts in the UN and other forums to charge Israel with aggression.

Israel would have to face the impact of US official opposition to such an attack, particularly since it might create major operational problems for the US. In late February 2012, reports surfaced that Israeli Prime Minister Benjamin Netanyahu and Israeli Defense Minister Ehud Barak had informed US officials that Israel would not provide the US with advance notice prior to an Israeli strike on Iran's nuclear facilities.²²² In such a case, the US would have minimal time to prepare for and counter a range of probable Iranian responses, including those mentioned below. It is unknowable whether such an action would drag the US into a larger conflict with Iran, although such a scenario remains a distinct possibility as the US would have to respond to potential Iranian counter attacks on Gulf commercial traffic, US forces in the region, and the US's Gulf Arab allies.

Israel would also have to face the Arab, Turkish, European, Russian, and Chinese reaction to what Arabs and Turks may see as an attack on an Islamic - albeit dangerous - state.

The actual reaction of outside states would also be determined to some extent by Israel's success and losses, and the outside world would probably see partial Israeli success as a serious failure. This would be particularly true if the Israeli attack caused the US major political problems or

pushed it into having to follow up the Israeli attack to bring some level of stability to a failed or too limited Israeli effort - the “trigger force” problem.

The Military Aftermath Problem

If Israel used conventional air and missile power to strike at Iran’s nuclear program, Iran would again be able to respond in a variety of different ways. Many of these options have already been discussed in Chapter III, and there is no way to be sure what approach Iran would take. In broad terms, its choices include:

- Accuse the US of “green lighting” the Israeli strike, and being the real cause of the attacks.
- Refuse to allow IAEA inspectors to monitor Iran’s nuclear sites or conduct inspections.
- Try to use the UN and/or International Criminal Court to prosecute Israel for aggression and war crimes.
- Withdraw from the NPT and increase its long-term resolve to develop a nuclear deterrent program.
- Create an all-out nuclear weapons program with its surviving equipment and technology base, using Israel’s strike and aggression as an excuse to openly pursue a nuclear program.
- Shift to genetically engineered biological weapons if such a program does not already exist.
- Immediately retaliate against Israel with ballistic missiles. Retaliation would consist of multiple launches of Shahab-3s, including the possibility of launching CBR (Chemical, Biological, Radiological) warheads against Tel Aviv, Israeli military and civilian centers, and Israeli suspected nuclear weapons sites. Launch political attacks on Arab regimes friendly to the US on the grounds that they did nothing to prevent an attack on Israel’s greatest enemy.
- Use allied or proxy groups such as Hezbollah or Hamas to attack Israel proper with suicide bombings, covert CBR attacks, and rocket attacks from southern Lebanon.
- Launch asymmetric attacks against American interests and allies in the Arabian Gulf.
- Target US and Western shipping in the Gulf, and possibly attempt to interrupt the flow of oil through the Strait of Hormuz.
- Attack US forces, ships, or facilities in the Gulf or anywhere in the world as a way of showing that Iran could attack the “great Satan” and Israel’s closest ally.
- Strike at Israeli or Jewish targets anywhere in the world using Iranian agents or anti-Israeli-proxies. Transfer high-technology small air-to-surface and guided anti-armor weapons to Hamas, Hezbollah, or other anti-Israeli extremist groups. Provide them with more lethal rockets, UAVs, and chemical weapons.
- Seek to use its leverage with Iraq, Syria, and Hezbollah to create an actual “Shi’ite crescent” to create a more intense range of threats to Israel.
- Try to use the transfer of funds and arms, the MOIS/VEVAK, and other covert means to influence the new regimes coming out of unrest in the Arab world to be far more aggressively anti-Israel.

The fighting in Gaza during November 13-21 illustrates the potential effectiveness of such options. Iran did not have to commit any forces, was never under threat from Israel, and did little more than provide some short-range rockets and rocket components. The end result, however, was a major Israel air campaign, massive Israeli expenditures on anti-rocket defense, and expensive Israeli preparations for a ground campaign. It was also a battle of perceptions where Israel suffered serious perceptual problems because its attacks produced collateral damage and civilian casualties that strengthen anti-Israeli opinion in Europe, the rest of the Arab and Muslim world, and many other countries.

The basic statistics of the conflict are shown in **Figure 32** and illustrate how Iran's use of other states and non-state actors could be used to respond to Israel:²²³

Figure 32: Fighting in Gaza during November 13-21

- **Impact of 8 days of conflict,**
 - **1,506** targets in Gaza were hit during the Israeli operation.
 - **933** rockets from Gaza hit Israel since November 14th (875 in open areas, 58 in urban areas).
 - **421** rockets fired from Gaza were intercepted by the Iron Dome system (84% is the rate of successful interceptions. Below 7% is Hamas' accuracy with regards to hitting populated areas within Israel). The highest cost Iron Dome round, however, costs roughly \$100,000 per intercept.
 - **Over 140** Palestinians were killed (source: Hamas Health Ministry in Gaza), with many more injured.
 - **5** Israelis, including one soldier, have been killed. **240** injured.
 - **24** hours after the ceasefire is the timeframe stated in the agreement for dealing with the issue of opening Gaza's border crossing and allowing the movement of people and goods into and out of the strip.
 - **0** is the number of past ceasefires that have held together since Hamas took over control of the Gaza Strip in 2007.
- **IDF Targeting**
 - Over the course of Operation Pillar of Defense, the IDF targeted over 1,500 terror sites including 19 senior command centers, operational control centers and Hamas' senior-rank headquarters, 30 senior operatives, damaging Hamas' command and control, hundreds of underground rocket launchers, 140 smuggling tunnels, 66 terror tunnels, dozens of Hamas operation rooms and bases, 26 weapon manufacturing and storage facilities and dozens of long-range rocket launchers and launch sites.
- **Senior Hamas Operatives Targeted:**
 - Ahmed Jabari, head of Hamas' military wing - targeted on November 14
 - Hab's Hassan Us Msamch, senior operative in Hamas' police - targeted on November 15
 - Ahmed Abu Jalal, Commander of the military wing in Al-Muazi - targeted on November 16
 - Khaled Shaer, senior operative in the anti-tank operations - targeted on November 16
 - Osama Kadi, senior operative in the smuggling operations in the southern Gaza Strip - targeted on November 17
 - Muhammad Kalb, senior operative in the aerial defense operations - targeted on November 17
 - Ramz Harb, Islamic Jihad senior operative in propaganda in Gaza city - targeted on November 19
- **Number of Rocket Launches Toward Israel During the Operation by Day:**
 - November 14: 75 rockets
 - November 15: 316 rockets
 - November 16: 228 rockets
 - November 17: 237 rockets
 - November 18: 156 rockets
 - November 19: 143 rockets
 - November 20: 221 rockets

- November 21 (Until 21:00): 130 rockets
- **Total Rockets Launched Towards Israel:**
 - Total number of rockets launched from the Gaza Strip: 1,506 rockets
 - Number of rockets hit open areas: 875 rockets
 - Number of rockets hit urban areas: 58 rockets
 - “Iron Dome” interceptions: 421 rockets
 - Failed launching attempts: 152 rockets
- **Israeli Casualties:**
 - Fatalities: 5
 - Injuries: 240

It is important to note that Hamas and the PIJ did not initiate the conflict before of Iran, and it is unclear how many of the 10,000 to 12,000 rockets estimated to be held by Hamas and other factions in Gaza came from Iran or had Iranian components versus supplies from countries like Libya and home-made rockets. It is clear, however, that the new round of fighting did involve Iranian-made Fajr 5 75-kilometer range rockets that could reach Tel Aviv and Israel for the first time, as well as new 45-kilometer range Grad 122mm rockets that could reach far deeper into Israel than in the past.²²⁴

Some of these arms came via Iranian arms shipments through the Sudan that seem to have been coordinated by the Al Quds force.²²⁵ It is also clear - as was the case in Iraq and Lebanon - that Iran supplied at least some man-portable surface-to-air missiles, and anti-tank guided missiles to Hamas. Furthermore, Iran made no secret of its support for the Palestinian operation. Ali Larijani, the speaker of the Iranian Majlis, stated on November 22, 2012, that,

“We proudly state that we have supported the Palestinian people and Hamas. We proudly declare that we will be with the Palestinian people in the most difficult situations. We are proud that we have provided military and financial support to the Palestinians. Arab countries who sit and hold summits must know that the Palestinians do not need lectures and summits... Arab countries should provide military aid to the Palestinians.”²²⁶

As is described in detail in Part I of this analysis of Iran and the Gulf balance, Hezbollah followed up with new threats against Israel, and reports surface that Iran had already begun to rearm the PIJ and Hamas. Israel is countering by strengthening Iron dome, rushing a system called David’s Sling into operation to handle longer range rocket attacks, and upgrading its Arrow TBDM system to a Mark 3 version. Nevertheless, the Hezbollah attacks in 2006 and the Hamas attacks in 2012 show how Iran can use limited, low cost efforts like the Al Quds force and small arms transfers to actors like Hamas, the PPIJ, and Hezbollah to attack Israel, and they are only one of Iran’s options.²²⁷

The Cyber Aftermath Problem

During Israel’s most recent conflict in Gaza, the country experienced cyber-attacks on a level not seen and which may represents new dimension in Israel’s conflict with Iran. It seems now that Iran has become more adept at cyber warfare and last July, researchers may have discovered Iran’s counterattack to the Flame and Stuxnet attacks over the past few years. However, while the cyber-attacks against Israeli companies and Government sites have been only marginally

effective at either taking sites down or exposing personal information, this may be an increasingly important aspect of competition between Iran and Israel.

Israeli Military Options Do Exist

Israel may manipulate the threat of unilateral action to pressure Iran, the US, and the other members of the 5+1, but this does not mean that it has not developed a real military option, and would not be willing to use it in spite of the risks Iran poses and “red lights” from the US. Press leaks in November 2012 made it clear that Israel was actively preparing for a strike on Iran’s nuclear facilities in 2010. In early November of 2011, Israeli aircraft participated in a large exercise with Italy over Sardinia, over 2,300 km from Israel.²²⁸ The exercise involved fighter jets, aerial refueling, and airborne warning and control aircraft. Furthermore, Israeli pilots were able to fly against adversaries flying unfamiliar aircraft such as the Eurofighter.

While a simulation of an attack on Iran was not the stated purpose of the exercises, an IAF Lieutenant Colonel identified only as “Yiftah” stated that such exercises are important because flying over unfamiliar territory “prepares people for battle over unfamiliar ground.”²²⁹ Moreover, he stated that, “we train for long-range flights and prepare ourselves for every type of terrain.”²³⁰

A pilot of the Knights of the North squadron, identified only as “Major B.” stated that, “we’re practicing in an unknown place. The size of our flight field is larger than the entire State of Israel, allowing us to practice things we can’t back home.”²³¹ While somewhat vague and unspecific, such statements are indicative of the emphasis the training placed on mounting a long-distance operation over large, unfamiliar terrain and airspace.

Although preparation for a strike on Iran was not the stated objective of the exercise, it could be considered a test-run for the kind of operation Israel would mount to strike at Iran. Given the similar distances of both objectives and the dispersed nature of Iran’s nuclear program, Israel would have to engage in the same kind of operational planning to carry out such a strike as it did in its exercises with the Italian Air Force.

As for timing, there is no way to know if the latest round of speculation that Israel might actually be preparing for a strike will be any more valid than previous rounds of such speculation. Israel clearly finds it politically useful to constantly keep Iran aware it might be struck, and to use the threat of preventive strikes to push the US and other states into taking a strong stand on sanctions and negotiations. It seems unlikely, however, that Israel would launch a preemptive or preventive nuclear strike on Iran’s nuclear facilities until it is more certain that Iran is actually developing or seeking to deploy nuclear weapons.

Israel does face the risk that Iran’s target base will become larger, harder to locate, and harder to destroy with time. There are no magic “red lines” however, and Israel must be sensitive to US opposition, reactions of other states, and the willingness of other states to follow up Israeli action. Israel must also be as sensitive as the US to the fact that every military action has geopolitical and security consequences that go far beyond the immediate military impact.

In most cases, the law of unintended consequences dominates the real-world course of events over time. The risks to Israel, the US, US regional allies, and commercial shipping through the Strait of Hormuz from such strikes can be both easily exaggerated as well as dangerously underestimated. For all of the reasons cited earlier in this analysis, however, Israel’s potential success and the political and military aftermath of any Israeli strikes would at best be uncertain and further destabilize a deeply unstable region.

Whether or not Israel actually has the capabilities to carry out such strikes is uncertain. In a documentary on Israeli channel 2, Prime Minister Netanyahu reportedly attempted to order the Israeli military to prepare for a strike on Iran but was blocked by concerns by the IDF general Staff over whether the military could conduct such strikes and if Netanyahu had the authority to give such an order.²³² Reportedly, Netanyahu attempted to order then Chief of Staff Gabi Ashkenazi to prepare the military for an imminent strike. But both Ashkenazi and then Mossad Chief Dagan opposed the strike, saying that such an order needed the approval of the full cabinet and that the military did not have the capability. Ehud Barak was quoted as saying “Eventually, at the moment of truth, the answer that was given was that, in fact, the ability did not exist.”²³³

US Policy toward US and Israeli Preventive Strikes and High Level Israeli Reactions

President Obama laid out US policy towards Iran’s nuclear efforts and preventive strikes in considerably more detail, and with considerable frankness, in an interview in the *Atlantic* in March 2012. Key excerpts from the President Obama’s statements made it clear that the US prefers diplomatic options and has not given Israel any kind of support - or “green light” - in a preventive attack on Iran:

...In addition to the profound threat that it poses to Israel, one of our strongest allies in the world; in addition to the outrageous language that has been directed toward Israel by the leaders of the Iranian government - if Iran gets a nuclear weapon, this would run completely contrary to my policies of nonproliferation. The risks of an Iranian nuclear weapon falling into the hands of terrorist organizations are profound. It is almost certain that other players in the region would feel it necessary to get their own nuclear weapons. So now you have the prospect of a nuclear arms race in the most volatile region in the world, one that is rife with unstable governments and sectarian tensions. And it would also provide Iran the additional capability to sponsor and protect its proxies in carrying out terrorist attacks because they are less fearful of retaliation.

...I think it’s important to recognize, though, that the prime minister (of Israel) is also head of a modern state that is mindful of the profound costs of any military action, and in our consultations with the Israeli government, I think they take those costs, and potential unintended consequences, very seriously.

...as Israel’s closest friend and ally, and as one that has devoted the last three years to making sure that Israel has additional security capabilities, and has worked to manage a series of difficult problems and questions over the past three years, I do point out to them that we have a sanctions architecture that is far more effective than anybody anticipated, that we have a world that is about as united as you get behind the sanctions; that our assessment, which is shared by the Israelis, is that Iran does not yet have a nuclear weapon and is not yet in a position to obtain a nuclear weapon without us having a pretty long lead time in which we will know that they are making that attempt.

In that context, our argument is going to be that it is important for us to see if we can solve this thing permanently, as opposed to temporarily. And the only way, historically, that a country has ultimately decided not to get nuclear weapons without constant military intervention has been when they themselves take [nuclear weapons] off the table.

...I think the prime minister - and certainly the defense minister - would acknowledge that we’ve never had closer military and intelligence cooperation. When you look at what I’ve done with respect to security for Israel, from joint training and joint exercises that outstrip anything that’s been done in the past, to helping finance and construct the Iron Dome program to make sure that Israeli families are less vulnerable to missile strikes, to ensuring that Israel maintains its qualitative military edge...

...If Iran gets a nuclear weapon, I won’t name the countries, but there are probably four or five countries in the Middle East who say, “We are going to start a program and we will have nuclear weapons.” And at that point, the prospect for miscalculation in a region that has that many tensions and fissures is profound. You essentially then duplicate the challenges of India and Pakistan fivefold or tenfold.

...The potential for escalation in those circumstances is profoundly dangerous, and in addition to just the potential human costs of a nuclear escalation like that in the Middle East, just imagine what would happen in terms of the world economy. The possibilities of the sort of energy disruptions that we've never seen before occurring, and the world economy basically coming to a halt, would be pretty profound. So when I say this is in the U.S. interest, I'm not saying this is something we'd like to solve. I'm saying this is something we have to solve.

...there's no doubt that Iran is much weaker now than it was a year ago, two years ago, three years ago. The Arab Spring, as bumpy as it has been, represents a strategic defeat for Iran because what people in the region have seen is that all the impulses towards freedom and self-determination and free speech and freedom of assembly have been constantly violated by Iran. [The Iranian leadership is] no friend of that movement toward human rights and political freedom. But more directly, it is now engulfing Syria, and Syria is basically their only true ally in the region.

And it is our estimation that [President Bashar al-Assad's] days are numbered. It's a matter not of if, but when... If that happens, that will be a profound loss for Iran."

President Obama and Prime Minister Netanyahu

President Obama's speech had a special impact because it was timed to coincide with the coming visit of the Israeli Prime Minister. Israeli Prime Minister Benjamin Netanyahu responded as follows,

"I very much appreciated the fact that President Obama reiterated his position that Iran must not be allowed to develop nuclear weapons and that all options are on the table. I also appreciated the fact that he made clear that when it comes to a nuclear armed Iran, containment is simply not an option, and equally in my judgment, perhaps most important of all, I appreciated the fact that he said that Israel must be able to defend itself, by itself, against any threat. I appreciate all his statements and I look forward to discussing them further with President Obama tomorrow."²³⁴

On March 2, 2012, Prime Minister Netanyahu followed up his initial response by making explicit demands regarding Iran's uranium stockpile, and warned the international community against further talks and negotiations with Iran:

"Right now, Iran is feeling the pressure from the economic sanctions, and it could try to evade that pressure by entering talks... I think the international community should not fall into this trap. I think the demands on Iran should be clear: Dismantle the underground nuclear facility in Qom, stop enrichment inside Iran and get all the enriched material out of Iran. And when I say all the material, I mean all the material."²³⁵

Prime Minister Netanyahu's statements make it clear that the Israeli leadership seeks not only a halt to nuclear activity, but also the surrender of Iran's enriched uranium and nuclear material.

President Obama then reiterated his policy on Iran's nuclear program in a March 4, 2012 speech to the annual conference of AIPAC:

"A nuclear-armed Iran is completely counter to Israel's security interests. But it is also counter to the national security interests of the United States. Indeed, the entire world has an interest in preventing Iran from acquiring a nuclear weapon. A nuclear-armed Iran would thoroughly undermine the non-proliferation regime that we have done so much to build. There are risks that an Iranian nuclear weapon could fall into the hands of a terrorist organization. It is almost certain that others in the region would feel compelled to get their own nuclear weapon, triggering an arms race in one of the most volatile regions in the world. It would embolden a regime that has brutalized its own people, and it would embolden Iran's proxies, who have carried out terrorist attacks from the Levant to southwest Asia.

...And so from my very first months in office, we put forward a very clear choice to the Iranian regime: a path that would allow them to rejoin the community of nations if they meet their international obligations, or a path that leads to an escalating series of consequences if they don't. In fact, our policy of engagement - quickly rebuffed by the Iranian regime - allowed us to rally the international community as never before, to

expose Iran's intransigence, and to apply pressure that goes far beyond anything that the United States could do on our own.

Because of our efforts, Iran is under greater pressure than ever before. Some of you will recall, people predicted that Russia and China wouldn't join us to move toward pressure. They did. And in 2010 the U.N. Security Council overwhelmingly supported a comprehensive sanctions effort. Few thought that sanctions could have an immediate bite on the Iranian regime. They have, slowing the Iranian nuclear program and virtually grinding the Iranian economy to a halt in 2011. Many questioned whether we could hold our coalition together as we moved against Iran's Central Bank and oil exports. But our friends in Europe and Asia and elsewhere are joining us. And in 2012, the Iranian government faces the prospect of even more crippling sanctions.

...Of course, so long as Iran fails to meet its obligations, this problem remains unresolved. The effective implementation of our policy is not enough - we must accomplish our objective. And in that effort, I firmly believe that an opportunity still remains for diplomacy - backed by pressure - to succeed.

The United States and Israel both assess that Iran does not yet have a nuclear weapon, and we are exceedingly vigilant in monitoring their program. Now, the international community has a responsibility to use the time and space that exists. Sanctions are continuing to increase, and this July - thanks to our diplomatic coordination - a European ban on Iranian oil imports will take hold.

...both Israel and the United States have an interest in seeing this challenge resolved diplomatically. After all, the only way to truly solve this problem is for the Iranian government to make a decision to forsake nuclear weapons.

...Moreover, as President and Commander-in-Chief, I have a deeply held preference for peace over war. I have sent men and women into harm's way. I've seen the consequences of those decisions in the eyes of those I meet who've come back gravely wounded, and the absence of those who don't make it home. Long after I leave this office, I will remember those moments as the most searing of my presidency. And for this reason, as part of my solemn obligation to the American people, I will only use force when the time and circumstances demand it.

...We all prefer to resolve this issue diplomatically. Having said that, Iran's leaders should have no doubt about the resolve of the United States - just as they should not doubt Israel's sovereign right to make its own decisions about what is required to meet its security needs.

I have said that when it comes to preventing Iran from obtaining a nuclear weapon, I will take no options off the table, and I mean what I say. That includes all elements of American power: A political effort aimed at isolating Iran; a diplomatic effort to sustain our coalition and ensure that the Iranian program is monitored; an economic effort that imposes crippling sanctions; and, yes, a military effort to be prepared for any contingency.

Iran's leaders should understand that I do not have a policy of containment; I have a policy to prevent Iran from obtaining a nuclear weapon. And as I have made clear time and again during the course of my presidency, I will not hesitate to use force when it is necessary to defend the United States and its interests.

Moving forward, I would ask that we all remember the weightiness of these issues; the stakes involved for Israel, for America, and for the world. Already, there is too much loose talk of war. Over the last few weeks, such talk has only benefited the Iranian government, by driving up the price of oil, which they depend on to fund their nuclear program. For the sake of Israel's security, America's security, and the peace and security of the world, now is not the time for bluster. Now is the time to let our increased pressure sink in, and to sustain the broad international coalition we have built. Now is the time to heed the timeless advice from Teddy Roosevelt: Speak softly; carry a big stick. And as we do, rest assured that the Iranian government will know our resolve, and that our coordination with Israel will continue.

US Secretary of Defense Leon Panetta echoed President Obama's statements on March 7, 2012 in an interview with the *National Journal*. Secretary Panetta stated, "Let me be clear - we do not have a policy of containment. We have a policy of preventing Iran from acquiring nuclear weapons."

Secretary Panetta also stated that US military planners are “absolutely” planning for a potential preventive strike on Iran’s nuclear facilities. In an interview with *Meet the Press* on September 16, Netanyahu discussed Iran’s nuclear program and his relationship with President Obama:

“Well, the way I would say it, David, is they are in the red zone. You know, they are in the last 20 yards. And you can’t let them cross that goal line. You can’t let them score a touchdown, because that would have unbelievable consequences, grievous consequences, for the peace and security of us all- of the world really.

...The world tells Israel, wait. There’s still time. And I say, wait for what? Wait until when? Those in the international community who refuse to put red lines before Iran don’t have a moral right to place a red light before Israel.

...Now first of all, President Obama and the U.S. administration have repeatedly said that Israel has the right to act by itself against any threat to defend itself. And I think that that remains our position. And for me, the issue is- as the prime minister of a country that is threatened with annihilation by a regime that is racing a brutal regime in Tehran that is racing to develop nuclear bombs for that and, obviously, we- we cannot delegate the job of stopping Iran if all else fails to someone else.

That was the main point that I was saying there. It was directed at the general international community. A lot of leaders calling me telling me don’t do it, it’s not necessary. You know, the danger of acting is much greater than not acting. And I always say the danger of not acting in time is much greater because Iran with nuclear weapons would mean that the kind of fanaticism that you see storming your embassies would have a nuclear weapon. Don’t let these fanatics have nuclear weapons.

...President Obama has said that he’s determined to prevent Iran from getting nuclear weapons and I appreciate that and I respect that. I think implicit in that is that if you’re determined to prevent Iran from getting nuclear weapons, it means you’ll act before they get nuclear weapons. I just think that it’s important to communicate to Iran that there is a line that they won’t cross. I think a red line in this case works to reduce the chances of the need for military action because once the Iranians understand that there’s no- there’s a line that they can’t cross, they are not likely to cross it, you know, when President Kennedy set a red line in the Cuban missile crisis, he was criticized.

But it turned out it didn’t bring war, it actually pushed war back and probably purchased decades of peace with the Soviet Union. Conversely, when there was no American red line set before the Gulf War, Saddam Hussein invaded Kuwait, and maybe that war could have been avoided. And I can tell you David that Iran has been placed with some clear red lines on a few matters and they have avoided crossing them. So I think that as they get closer and closer and closer to the achievement of weapons grade material, and they are very close, they are six months away from being about ninety percent of having the enriched uranium for an atom bomb, I think that you have to place that red line before them now before it’s- it’s too late. That was the point that I was making.”²³⁶

A week later in his speech to the UN General Assembly, President Obama reiterated his position on Iran:

“In Iran, we see where the path of a violent and unaccountable ideology leads. The Iranian people have a remarkable and ancient history, and many Iranians wish to enjoy peace and prosperity alongside their neighbors. But just as it restricts the rights of its own people, the Iranian government props up a dictator in Damascus and supports terrorist groups abroad. Time and again, it has failed to take the opportunity to demonstrate that its nuclear program is peaceful, and to meet its obligations to the United Nations.

Let me be clear: America wants to resolve this issue through diplomacy, and we believe that there is still time and space to do so. But that time is not unlimited. We respect the right of nations to access peaceful nuclear power, but one of the purposes of the United Nations is to see that we harness that power for peace. Make no mistake: a nuclear-armed Iran is not a challenge that can be contained. It would threaten the elimination of Israel, the security of Gulf nations, and the stability of the global economy. It risks triggering a nuclear-arms race in the region, and the unraveling of the non-proliferation treaty. That is why a coalition of countries is holding the Iranian government accountable. And that is why the United States will do what we must to prevent Iran from obtaining a nuclear weapon.”²³⁷

These exchanges caused predictable tension between President Obama and Prime Minister Netanyahu that continued through the 2012 US election. They seemed to ease during a visit by President Obama to Israel in early 2013, but partly because Prime Minister Netanyahu was in a had been given stronger US assurances of its commitment to preventing Iran from getting a nuclear weapon and Iran's nuclear progress seemed somewhat slower.

During President Obama's Israel trip in March 2013, he continued to say that a nuclear-armed Iran was unacceptable, time is not on Iran's side, and diplomacy is the best option for solving the current impasse. However, Obama also continued to state that all options were on the table in attempting to solve the issue.²³⁸

When I consider Israel's security, I also think about a people who have a living memory of the Holocaust, faced with the prospect of a nuclear-armed Iranian government that has called for Israel's destruction. It's no wonder Israelis view this as an existential threat. But this is not simply a challenge for Israel – it is a danger for the entire world, including the United States. It would raise the risk of nuclear terrorism, undermine the non-proliferation regime, spark an arms race in a volatile region, and embolden a government that has shown no respect for the rights of its own people or the responsibilities of nations.

That is why America has built a coalition to increase the cost to Iran of failing to meet their obligations. The Iranian government is now under more pressure than ever before, and that pressure is increasing. It is isolated. Its economy is in a dire condition. Its leadership is divided. And its position – in the region, and the world – has only grown weaker.

All of us have an interest in resolving this issue peacefully. Strong and principled diplomacy is the best way to ensure that the Iranian government forsakes nuclear weapons. Moreover, peace is far more preferable to war, and the inevitable costs – and unintended consequences – that would come with it. Because of the cooperation between our governments, we know that there remains time to pursue a diplomatic resolution. That is what America will do – with clear eyes – working with a world that is united, and with the sense of urgency that is required.

But Iran must know this time is not unlimited. And I have made the position of the United States of America clear: Iran must not get a nuclear weapon. This is not a danger that can be contained. As President, I have said to the world that all options are on the table for achieving our objectives. America will do what we must to prevent a nuclear-armed Iran.

In a joint press conference, Prime Minister Netanyahu responded by warning that sanctions and diplomacy had not worked:²³⁹

Mr. President, you have made it clear that you are determined to prevent Iran from developing nuclear weapons. I appreciate your forthright position on this point. I also appreciate that you have noted, that you have acted to thwart this threat, both through determined diplomacy and strong sanctions that are getting stronger yet. Notwithstanding our joint efforts and your great success in mobilizing the international community, diplomacy and sanctions so far have not stopped Iran's nuclear program. And as you know, my view is that in order to stop Iran's nuclear programs peacefully, diplomacy and sanctions must be augmented by a clear and credible threat of military action.

In this regard, Mr. President, I want to thank you once again for always making clear that Israel must be able to defend itself by itself against any threats. I deeply appreciate those words because they speak to the great transformation that has occurred in the life of the Jewish people with the rebirth of the Jewish state. The Jewish people only two generations ago were once a powerless people, defenseless against those who sought our destruction. Today we have both the right and the capability to defend ourselves. As you said earlier today, the essence of the State of Israel, the essence of the rebirth of the Jewish state, is the fulfillment of the age-old dream of the Jewish people: to be masters of our fate in our own state, and I think that was a wonderful line that I will cherish, because it really gets down to the essence of what this state is about.

That is why I know that you appreciate that Israel never cede the right to defend ourselves to others, even to the greatest of our friends, and Israel has no better friend than the United States of America.

President Obama asserted that diplomacy was the preferred option, but also kept all the options on the table.²⁴⁰

We agree that a nuclear armed Iran would be a threat to the region a threat to the world and potentially an existential threat to Israel. We agree on our goal. We do not have a policy of containment when it comes to a nuclear Iran. Our policy is to prevent Iran from acquiring a nuclear weapon. We prefer to resolve this diplomatically and there is still time to do so.

Iran's leaders must understand however that they have to meet their international obligations. And meanwhile the international community will continue to increase the pressure on the Iranian government. The United States will continue to consult closely with Israel on next steps, and I will repeat: all options are on the table; we will do what is necessary from prevent Iran from getting the world's worst weapons. Meeting none of these challenges will be easy. It will demand the same courage and resolve of those as those who have preceded us.

All of these issues have become even more critical now that the US and other members of the P5+1 have reached an interim agreement with Iran. Prime Minister Netanyahu and other hardline Israeli officials made it clear that they opposed any agreement that left Iran with enrichment capability and any potential capability to manufacture weapons grade material in the months before the November 2013 agreement.

There is no way to predict how they will play out as the Interim Agreement goes into force and the P5+1 and Iran seek a lasting agreement. If Iran does fully comply and move forward, Israel fear may ease and the position of the Israeli government may change. If Iran does not comply or the efforts to reach a lasting agreement falter, Israel may serious consider preventive strikes. At a minimum, Israel will put constant pressure in the US and other states to fully enforce the agreement, to react decisively to any violations or failures, and quietly refine both its conventional options for preventive strikes and its nuclear capabilities to strike Iran either preemptively or in retaliation to any Iranian use of nuclear weapons.

Ironically, key Arab states have made it clear that they share the same concerns and worries about US resolve, and some senior Saudis have talked about acquiring their own nuclear weapons. Some senior Arab officials fear that the US may turn away from the Arab Gulf to reach an agreement with Iran, and the Arab press and public commentators have been even more outspoken in expressing such concerns.

No one in the region seems ready to accept the SALT slogan of "trust but verify." At best, their approach is "verify then trust." Many seem to adopt the slogan of "don't trust and preempt."

Implications for US Policy

US and allied competition with Iran over Iran's nuclear and missile programs affect the entire region and the world. Given the importance of the Gulf in global energy security, Iran's goals of becoming a regional power, and socio-political instability in the Middle East, military competition between the US and Iran will either force some form of fully successful negotiation or continue to intensify.

In spite of the Interim agreement, Iran has already managed to trigger a nuclear arms race without even having a nuclear weapon. Israel long ago extended the range of its nuclear-armed land-based missiles, probably now targets Iran with thermonuclear weapons, and is examining options for sea launched cruise missiles. The region faces a future that could go from possibly

100+ Israeli nuclear weapons and a potential Iranian weapon to a broad regional arms race accelerating year-by-year for the indefinite future.

There is also a matching race in missile and air defenses defense where the US, its Gulf allies, and Israel so far have an advantage over Iran. The US is deploying advanced missile defense ships with wide area theater missile and air defense capabilities. The Arab Gulf States are buying the PAC-3 and THAAD. Israel has the Arrow and PAC 3, and is working with the US to develop a far more advanced Arrow 3.

The US is also selling modern attack aircraft with stand off precision strike capabilities that offer regional states a counterweight to Iran's conventionally armed missiles, and has the ability to deploy major air strike assets of its own – including stealth bombers and strike fighters. It can deploy carrier-based aircraft and a wide range of precision cruise missiles. The Arab Gulf states also have the option of creating integrated missile defenses with US aid and access to US missile warning and tracking systems.

Iran is countering with efforts to develop penetration aids and countermeasures for its missiles, but so far has been unable to buy or indigenously develop any form of modern surface-to-air missile or missile defenses. Iran's efforts to develop or purchase anti-missile assets is also likely to further stoke fears in Tel Aviv, particularly if Israel believes that its retaliatory power is being eroded and may no longer function as a credible deterrent.

The key issue, however, is Iran's progress in acquiring and deploying nuclear weapons and the success of the agreements reached in November 2013..Unless the current negotiating effort is fully successful and the behavior of the Iranian regime decisively changes, the US and its allies will have hard choices to make.

There is time to determine whether Iran is serious about reaching a meaningful nuclear agreement. Arms control experts would like Iran to lack any nuclear alternatives. From a real world military viewpoint, however, Iran cannot suddenly rush forward into deploying a meaningful nuclear force or deter preventive strikes with a potential nuclear warfighting capability. The technical challenges involved in creating any form of nuclear weapon are serious, as are safety and reliability. A large gun device is not an effective nuclear weapon, and the ability to create an explosive fissile event does not mean that a national has a reliable implosion weapon or the ability to create an effective nuclear force.

Deploying a reliable weapon could take several years after an initial fissile event - depending on how much technology Iran has developed to date and obtain through sources like North Korea - which seems to have obtained Chinese design data - and other sources like Abdul Qadeer Khan. Some US experts believe Iran has much of the data for a workable fission warhead design.

This gives the US and its allies the time they need time to focus on creating a lasting a negotiated solution to Iran's nuclear efforts, and the US has pressed Israel to wait to see if such negotiations can be successful. Nevertheless, Israel's opposition to the interim agreement leaves the risk that Israel might launch preventive strikes against Iran's nuclear programs at some point in the next few years. Moreover, success depends heavily on the willingness of the US and EU to restore and enforce sanctions the moment Iran fails to implement an agreement and the US must continue to show Iran and the world it will keep helping the Arab Gulf states develop effective deterrent and warfighting capabilities, the US will make good on its offer of extended deterrence and missile defense, and that the US will continue to be ready to exercise a "military option" if

Iran does not negotiate an agreement to abide by the terms of the Nuclear Non-Proliferation Treaty.

The fact remains, however, that Iran's *red lines* have shifted to the point where Iran is now at the nuclear breakout and IRBM stage of development, and where Iran can choose to try to move towards the following new red lines: fissile grade enrichment, "cold" or passive nuclear weapons testing, creation of new dispersed or sheltered facilities with more advanced centrifuges, testing an actual nuclear device, and arming its missiles with an untested nuclear warhead – a risk that sounds extreme until one remembers the reliability and accuracy of US nuclear-armed systems like Jupiter and the M-4/MGM-18 Lacrosse.

There is no reliable way to predict the timing and probability of such Iranian actions. There is no unclassified way to know how much design and test data Iran has received from the outside, and how well it can hide its efforts and leap frog to some form of weapons deployment. Moreover, Iran's actions are only likely to become real world "red lines" in terms of any action by the US and other outside powers when Iran actually crosses them *and* Iran's actions have been detected.

There also is no way to know exactly how the US would react when and if Iran clearly violated the terms of the interim agreement or rejected a full and lasting agreement, and how much international support the US would get in taking decisive action. Gulf leaders, talk privately about providing such support but many are remarkably silent when the subject of supporting and basing US preventive strikes is raised in any open forum that even hints at public commitment. At the same time, key Saudi figures not only talk about the need to take preventive action, but a credible Saudi voice like Prince Turki has stated that Saudi Arabia is examining its own nuclear options.

Moreover, there is no way to know how Israel will react. At this point, its nuclear efforts are so tightly concealed that there is no public debate over its nuclear weapons holding, missile forces, and possible addition of sea or air-launched systems. The US has made it clear that it does not want Israeli preventive strikes, but has never publically said it would ride out any Israel effort and let Israel take the consequences. Israel may or may not be able to hit at all of Iran's current major publically known nuclear enrichment facilities. The hardening of Natanz and Fordow raise questions for a force of fighter-bombers using conventional earth penetrators

As a result, the key uncertainties affecting international action in dealing with the Iranian missile and nuclear threat now focus on both progress in negotiations, whether the US and its allies would react decisively with new sanctions if the negotiations fail or Iran does not comply, on whether the US will conduct preventive strikes or rely on containment, and the level of Arab and other regional support it would receive if it does choose military options. The US has said that an Iranian nuclear force is "unacceptable." Like the word "no," however, "unacceptable" is far more difficult to define in practice than in the dictionary.

Preventive strikes will clearly have unpredictable and potentially negative consequences. Strikes by either the US or Israel can trigger a far more intensive Iranian nuclear effort, withdrawal from the NNPT with claim the act is "defensive," and a wide range of low level military acts in the Gulf or effort to use proxies and surrogates in Lebanon, Iraq, and the Gaza. Sustaining even a major US strike requires sustain support from the Arab Gulf states for restrikes, as well as willingness to counter Iranian asymmetric and even missile strikes.

At the same time, the US cannot afford to underreact. If some argue that Iran should learn from

Libya, the US should definitely learn from North Korea. Brazil, South Africa and Argentina are not the models for dealing with Iran. Once Iran has become an active military power, it is likely to move forward toward more and more nuclear weapons, boosted and thermonuclear weapons designs, and combinations of launch on warning, launch under attack and then dispersed and shelter forces. Pressure from Israel, Saudi (and possibly Turkish) nuclear and missile forces will add to the resulting arms race.

This means that if negotiations fail, the US has to consider the tradeoff between all of the risks and costs of preventive strikes and the costs and risks of nuclear exchanges or the use of extended deterrence if the US does not act. Arms control negotiations, sanctions, clearly defined redlines and public analysis of the cost to Iran of a nuclear exchange are all interim steps that might eliminate the need for preventive strikes, *but some red lines are deadlines and make it time to act.*

If Iran ever does cross the most critical “red lines” -- clear evidence of weapons production, an actual test of a fissile device, and/or preparing to arm its aircraft and missiles with nuclear warheads -- the key US military choices become preventive strikes and follow-on containment, or containment without preventive strikes.

Other possible “red lines” like weapons grade enrichment, “cold” or passive nuclear weapons testing, and creation of new dispersed or sheltered facilities with more advanced centrifuges would also present massive problems in terms of US credibility given the US false alarms in Iraq. The US cannot afford to underreact, but it also cannot afford to be seen as over-reacting and neither can its allies.

Hopefully, Iran does realize that preventive strikes are real world options for the US. Senior US military figures have made it clear that the US is steadily refining and improving its military strike options and has kept them very real. The US can hit at the full mix of suspect sites – including research and centrifuge production, take out much of Iran’s defenses and missile capabilities, and has access to Gulf bases. The US can also restrike from the Gulf region if Iran tries to recreate its facilities.

These also are all US capabilities Israel probably lacks -- although several factors may have eased its may have eased its penetration and refueling problems, including Israel’s quasi-rapprochement with Turkey, Syria’s civil war, and Iraq’s problems in getting advanced fighters and weapons from the US. It is also important to note that US rhetoric about refusing to rely on “containment” is more rhetoric than reality since the US would have to rely on containment after preventive strikes and has no credible options to invade Iran or force Iranian regime change on its own.

If the US does not choose to carry out such preventive strikes, it should at least strengthen containment by deploying some tangible form of the “extended deterrence” that Secretary Clinton has already offered the US allies in the region.

- The most “quiet” or discrete extended deterrence option would be nuclear armed, submarine or surface launched cruise missiles backed with the deployment of conventionally armed cruise or ballistic missiles with terminal guidance systems capable of point attacks on Iran’s most valuable civil and military assets.
- The most decisive extended deterrence options would be the equivalent of the combination of Pershing II and GLCMs that were land based, had US operating crews both deep inside the Arab Gulf and other regional states and in or near key major cities, and had both nuclear and precision conventional warheads. Iran would be faced with the inability to strike at key Arab population centers without striking at US forces

and still see mobile US nuclear armed forces in reserve. It also could not use conventional warheads without facing a more accurate and reliable US strike force in return.

Finally, it is important for the US and its allies – *as well as Iran* -- to consider the “unthinkable” in terms of what a nuclear war in the region might become if Iran continues to threaten Israel, actually deploys nuclear weapons, and any form of nuclear exchange takes place. . Even today, it is possible to think of some Iranian covert nuclear attack on Israel or a Gulf state using a gun device hidden in a ship – or less credibly – given to a proxy like the Hezbollah.

The end result of any Iranian nuclear attack on Israel would probably be nuclear missile strikes involving ground bursts on Iranian cities – a far greater “existential threat” to Iran than the kind of attack Iran will be able to launch against Israel during the first years of its nuclear forces. Israel would have no reason to limit the scale of its retaliation, and outside states would have no strategic reason to urge such restraint.

Horrible as a nuclear exchange of any kind could be in humanitarian terms, the grim logic of strategic realism does not place any restraints on Israeli retaliatory attacks on Iran. The outside world may need Iranian oil – although that is now questionable given developments in shale oil and gas and other sources of energy and liquid fuels. No one needs Iranians and no one needs an Iranian regime with any chance of recovering nuclear capability.

Appendix: Laying Out the Technical Evidence Regarding the Patterns and Uncertainties in Iran's Efforts

The chain of evidence that describes Iran's nuclear programs is long and complex, and deciding how to weigh the gaps and conflicting claims depends heavily on examining the record in detail over an extended period of time. **Figures A1** through **Figure A47** address these issues and uncertainties by providing a range of data and views of developments in the Iranian nuclear and missile programs, Iran's lack of cooperation with the IAEA, and indicate the possible weaponization of Iran's nuclear program.

These **Figures** deliberately provide a high level of detail to help distinguish between sources and the individual aspects of Iran's programs. They show the relevant patterns in Iranian activity and what is known about how quickly Iran's programs could develop a break out capability or begin to produce actual weapons:

Figure A1 shows the amount of fissile material needed to build a basic fission weapon.

Figure A2 indicates that Iran told the IAEA during an August 9, 2011 visit to the Arak IR-40 reactor that the reactor is planned start operations in 2013. On August 17, 2011, the IAEA visited the Arak Heavy Water Production Plant for the first time since 2005. Iran informed the IAEA that the plant was operational, and had produced a total of 60 tons of heavy water to that date. Iran continues to deny the IAEA access to the heavy water it has produced.

Figure A3 provides the main points stressed in the IAEA report of February 24, 2012. It shows that Iran has achieved a near three-fold increase in production of 19.75 percent LEU at Natanz and Fordow, has increased the number of centrifuges enriching at Natanz by nearly 50%, and has installed 8,000 additional IR-1 centrifuge casings at Natanz and Fordow.

Figure A4 describes Iran's recent installation of 6,177 empty IR-1 centrifuge casings at the Natanz FEP.

Figure A5 provides information regarding the deployment of advanced centrifuge designs at the Pilot Fuel Enrichment Plant (PFEP) at Natanz as well as information concerning uranium enriched to 19.75% as of February 2012.

Figure A6 provides information concerning the status and progress of Iran's fuel enrichment facility at Fordow. The Fordow site now has four cascades of 174 IR-1 centrifuges each operating in two, tandem sets producing 19.75% LEU. Between December 14, 2011, when the first set started producing LEU, until February 17, 2012, these sets of cascades produced approximately 13.8 kg of 19.75% enriched uranium at a rate of 6.46 kg 19.75% LEU hexafluoride per month. With the stockpile of 19.75% uranium produced at the Pilot Fuel Enrichment Plant at Natanz, Iran now has approximately 110 kg of 19.75% uranium. Its monthly production has increased to about 11 kilograms per month of 19.75% LEU hexafluoride, somewhat less than a three-fold increase. However, this level of production far exceeds Iran's need for enriched uranium for the Tehran Research Reactor.

Figure A7 provides the ISIS' overview and analysis of developments at Natanz and Fordow as of February 2012. Between the two enrichment sites, Iran has produced 109.2 kilograms of 19.75% LEU hexafluoride. Of that total, Iran has sent an unknown amount of 19.75% LEU to the Uranium Conversion Facility at Esfahan. Typically, transport containers would contain about 25 kilograms of such LEU. As of February 19, 2012, Iran had converted about 8 kilograms into U3O8 for use in Tehran Research Reactor fuel, which it is making at the nearby Fuel Manufacturing Plant. So, about 101.2 kilograms of 19.75% LEU remains in the form of hexafluoride as of that date. Iran has produced a total of 5,451 kilograms of 3.5% LEU hexafluoride. About 985 kilograms has been used to make the 19.75% LEU hexafluoride.

Figure A8 provides the ISIS' projection of Iran's potential future capabilities to make weapon-grade uranium.

Figure A9 provides ISIS' estimates regarding the different probabilities of Iranian paths to nuclear explosive materials. Each probability reflects the likelihood that Iran would pursue each method, based on a judgment of its technical capabilities to do so and a range of factors that deter its pursuit of this method.

Figure A10 provides details on Iran's efforts to increase the production of 19.75% enriched uranium. Stockpiling uranium enriched to 19.75% would enhance Iran's ability to achieve a fast nuclear breakout capability.

Figure A12 provides an ISIS analysis of the suspected "sanitation" of the Parchin complex, which is purported to have been used to design nuclear detonators and carry out other weapons-related research. The fact that the IAEA has not been granted access to the site is of note, as an inspection of the complex could provide definitive evidence that Iran is carrying out R&D into nuclear weapons development.

Figure A13 reflects Iran's total enriched uranium stockpile by the level to which it is enriched, quantities at each site, as well as the gross and net total estimations of Iran's enriched uranium as of November 16th 2012.

Figure A14 reflects the cumulative production of 3.5% low-enriched uranium (LEU) at Iran's principal enrichment site, Natanz. As of November 16th, 2012, more than 7,000 kg of LEU has been produced. As of February 2008, less than 200 kg had been produced.

Figure A15 shows trends in the number of centrifuges operating at Natanz. While the number has increased dramatically since February 2007, the number of centrifuges in operation since August 2009 has fluctuated, possibly due to the Stuxnet virus. In November 2012, however, the IAEA reported that Iran is operating almost all of its available centrifuges, and is enriching uranium at the site at an accelerated rate.

Figure A16 shows trends in the number of cascades enriching uranium, the amount of LEU produced monthly, and the amount of UF₆ produced monthly. Note that there has been a general increase in each, with intermittent drops in production starting in June 2008. It is likely that equipment restrictions due to sanctions and the effects of the Stuxnet virus are to blame for the sporadic drops in production.

Figure A17 indicates Iran's monthly rate of production of LEU at the Natanz Fuel Enrichment Plant (FEP). It indicates a steady increase in monthly LEU production at the FEP since June 2007. Notably, it also reflects a dramatic increase in Iran's monthly production of LEU as of March 2012.

Figure A18 reflects Iran's progress and describes LEU production at the Natanz FEP as of August 2012. Iran's total 3.5 percent LEU production at the FEP through August 30, 2012 is reported to be 7,611 kg, including 735 kg estimated by Iran to have been produced since August 7, 2012. This total amount of 3.5 percent low enriched uranium hexafluoride, if further enriched to weapon grade, is enough to make between six and seven nuclear weapons. The average production of 3.5 percent LEU at the FEP was 237 kg per month of LEU hexafluoride, a slight decrease from the last reporting period, when Iran produced on average 242 kg per month. The difference, according to ISIS reflects an estimated reduction in the Separative Work Unit (swu) per centrifuge year figure, from an estimated .9 kg U per swu per centrifuge year to an estimated 0.76 kg U per swu per centrifuge year, as the number of centrifuges enriching material has remained the same throughout this reporting period.

Figure A19 describes the continuing installation of advanced centrifuges at the PFEP at Natanz. Over the last reporting period it appears that all 164 IR-2m centrifuges in cascade 5 were functional and 14 IR-2m centrifuges were installed in cascade 3 where during the last reporting period there were none installed. It is not clear if the centrifuges in cascade 5 were enriching material. In a potential breakthrough, Iran continued installing IR-4 centrifuges in cascade 4, increasing their number as of November 16, 2012 to 144 IR-4 centrifuges out of 164 planned. 32 new IR-4 centrifuges were also installed in cascade 2, whereas during the last reporting period it was empty. As of August, 2012 it had only installed 123 of 164 IR-4 centrifuges. Iran has been intermittently feeding up to 104 of these IR-4 centrifuges with uranium hexafluoride.

Figure A20 describes the status of Iran's 19.75% LEU production as of November 2012. In total, Iran has fed 1,177 kg of 3.5% LEU to produce 137 kg of 19.75% uranium since the beginning of operations in February 2010.

Figure A21 provides the status of uranium enrichment at the Fordow Fuel Enrichment Plant (FFEP) as of November 2012. Iran has increased the number of installed centrifuges from 2,140 to 2,784 IR-1 rotor

assemblies installed. However, of the 12 installed cascades, only 4 are equipped with pipes, electronics, and other critical materials, have been vacuum tested, and are ready to enrich material. The Fordow site has four cascades of 174 IR-1 centrifuges each operating in two, tandem sets totaling 696 enriching centrifuges, producing 19.75 percent LEU, the same number as the August and May IAEA report.

Figure A22 describes the Uranium Oxide production at the Fuel Plate Fabrication plant in Esfahan. Iran shipped 96.3 kg of 19.75% LEU to Esfahan during the last reporting period and has fed 71.25 kg was fed into the process, resulting in 31.1 kg of U_3O_8 . There remains about 13.6 kg of LEU in the form of hexafluoride at the plant.

Figure A23 provides an overview of the IAEA's primary concerns and observations of Iran's uranium enrichment as of November 2012. Between Iran's two primary enrichment sites, Iran has produced 232.8 kilograms of 19.75 percent LEU hexafluoride. Of that total, Iran has downblended 1.6 kilograms of 19.75 percent LEU hexafluoride into LEU enriched to less than five percent. Iran has also sent 82.7 kg of uranium hexafluoride enriched up to 20 percent uranium-235 to the Uranium Conversion Facility at Esfahan to make into fuel for the Tehran Research Reactor. Iran has produced 38 kg of uranium enriched up to 20 percent in the form of U_3O_8 . Some has been manufactured into TRR fuel assemblies and a portion sent to the TRR. It appears that up to 13.6 kg of 19.75 percent LEU may still be in the form of uranium hexafluoride. The exact amount sent to this plant, however, is not clearly specified in the IAEA report. In summary, about 134.9 kilograms of 19.75 percent LEU hexafluoride remains as of November 16.

Figure A24 provides information regarding differences over resolving the possible military dimensions of Iran's nuclear program, as well as Iran's refusal to grant the IAEA access to the Parchin complex, which the IAEA suspects to have been used in modeling and designing explosive detonators for nuclear weapons. It also describes the changes that have the IAEA has viewed at the Parchin complex.

Figure A25 describes Iran's progress in its development of the IR-40 heavy water moderated research reactor at Arak. The IAEA reports that construction of the IR-40 heavy water moderated research reactor at Arak is still ongoing. The August IAEA report details "cooling and moderator circuit piping was being installed." The manufacture of fuel pellets for the IR-40 reactor using natural UO_2 is ongoing. It also continues to manufacture dummy assemblies for the IR-40 reactor. Iran told the Agency that startup of the reactor is delayed until 2014. Whether Iran can operate the reactor by this date is unclear. However, once this reactor operates, it can make weapon-grade plutonium, if Iran decided to do so.

Figure A26 shows the location of Iran's major/principle nuclear facilities that are concentrated in the west-central part of the country.

Figure A27 shows the Bipartisan Research Center's timeline of Iran's monthly enrichment rate as well as Iran's IAEA-confirmed 19.75% LEU stockpile. It reveals that the Stuxnet worm did not have any kind of significant effect on the country's ability to enrich uranium, and that the country's enrichment rate has gone up nearly 5x in comparison to the pre-Stuxnet rate.

Figure A28 provides the Bipartisan Policy Center's graph of Iran's LEU stockpile and enrichment rate. It reveals that Stuxnet may have had a deleterious effect on the number of operational centrifuges Iran operated, but that Iran's rate of enrichment has nevertheless increased, as has the number of operational centrifuges since the last major Stuxnet attack in May of 2010. Moreover, it shows that Iran's LEU stockpile surpassed the 1,850 kg needed for one nuclear explosive device in August 2010.

Figure A29 reflects the growth of Iran's 3.5% enriched uranium stockpile. It indicates that Iran could perhaps produce enough 3.5% enriched LEU to produce two fission devices by May 2012 at a minimum.

Figure A30 shows the Bipartisan Policy Center's projections for the growth of Iran's stockpile of 19.75% enriched uranium. At its current average rate of enrichment, Iran could produce enough 19.75% enriched uranium to produce one fission weapon. Iran's enrichment rate, however, is increasing, and it is likely that it could produce this quantity sooner. At 300% of the 2011 rate, Iran could produce enough 19.75% uranium to build a fission device by December 2012.

Figure A31 indicates that Iran might be able to produce 20 kg of 90% HEU at Natanz using a two-step batch recycling method to enrich its stockpiles of 3.5% and 19.75% uranium in as little as 28 days.

Figure A32 indicates that Iran might be able to produce 20 kg of 90% HEU at Natanz using a three-step batch recycling method to enrich its stockpiles of 3.5% and 19.75% uranium in approximately 103 days.

Figure A33 shows the total amount of enriched material, centrifuges installed and enriching, and enrichment rate at Natanz and Fordow as of November 16, 2012. The report shows that there is a total of 3,881 kg of 3.5% enriched Uranium, 91.2 kg of 20% enriched Uranium between the two sites.

Figure A34 shows the time and amount of 20% enriched Uranium it will take to produce 20kg of HEU using a one-cycle processing mechanism is 8 days with 155 kg 20%.

Figure A35 provides a detailed account of Iran's lack of cooperation with the IAEA in matters pertaining to weapons production and the militarization of its nuclear program as of February 25, 2011. These areas include production of LEU up to 20% U-235 at Natanz; construction of the Fordow Fuel Enrichment Plant; heavy water production; locations, equipment, persons, or documentation related to the possible military dimensions of Iran's program; high explosives manufacturing and testing, exploding bridgewire detonator studies, particularly involving applications necessitating simultaneity, and missile re-entry vehicle redesign activities for a new payload assessed as being nuclear in nature; IR-40 reactors.

Figure A36 describes continuing work on heavy water-related projects as of May 24, 2011, contrary to the resolutions of the IAEA Board of Governors and the UN Security Council. Moreover, Iran had not allowed access to these facilities as of May 24, 2011.

Figure 47 provides details regarding enrichment activities at the Fuel Enrichment Plant (FEP) and Pilot Fuel Enrichment Plant (PFEP) as of May 24, 2011. Both the FEP and PFEP are located at the Natanz enrichment facility.

Figure A38 describes IAEA concerns as of June 2011. Yukiya Amano, the head of the IAEA, makes it clear that certain undisclosed nuclear-related activities in Iran seem to indicate military dimensions to the program. He also indicates that Iran has repeatedly rebuffed IAEA requests to inspect its facilities.

Figure A39 describes the IAEA's ongoing concerns with the Parchin facility, the lack of information regarding the site, as well as satellite images of the site after IAEA requests to inspect the site. The figure also states the IAEA's concerns with the lack of negotiations over a structured approach that would allow the international agency to inspect the facility.

Figure A40 details the increased output of 5% and 20% enriched Uranium and the total amount of material enriched since the declared facilities began operation.

Figure A41 reports in Natanz as of November 2012, Iran had fully installed 61 cascades in production hall A, 54 of which were being fed. Preparatory installation work had been completed for 28 cascades and was ongoing for 54 more. At Fordow, Iran has installed 644 centrifuges in Unit 1 but none were being fed. In Unit 2 all 8 cascades were installed but only 4 were being fed UF₆.

Figure A42 shows that 82.7 kg of 20% LEU had been fed into the FFPF in Esfahan to produce 38 kg of U₃O₈ plates for the Tehran Research Reactor.

Figure A43 shows ISIS's estimate for an Iranian breakout ability to produce a Significant Quantity of HEU for a weapon using a four step process at Natanz to be 9.5 months to 17 months depending on the cascade configuration.

Figure A44 details ISIS's estimate for an Iranian breakout capacity at Natanz using a three step process. ISIS estimates it may take Iran 2.5 months to 4.1 months to produce one Significant Quantity.

Figure A45 shows ISIS's estimated ability for Iran to produce multiple Significant Quantities using a three step process at Natanz.

Figure A46 details ISIS's estimate for Iran's future potential breakout capacity if the installation of centrifuges at the Fordow facility were complete. Iran would need anywhere between 5.5 months to 38 months to enrich one Significant Quantity depending on the process used.

Figure A47 details ISIS's estimates for Iran's future breakout potential using a two-step process at Natanz if Iran had the requisite amount of 20% enriched Uranium depending on the cascade configuration.

Figure A48 shows ISIS's estimate for the future potential of Fordow's breakout capacity given the Iranian's use a two step process. 200kg to 220kg of 20% enriched Uranium would be needed to allow Iran to produce one Significant Quantity between 2 and 2.2 months.

Figure A49 is ISIS's estimate of Iran's future breakout capacity if Fordow and Natanz were used together. They show Iran would need between .8 and 1.4 months to produce one Significant Quantity. The data in these Figures are constantly evolving, however, and they contain many detailed uncertainties, such as how many nuclear facilities Iran really has and how far it has gotten in producing more advanced centrifuges like the IR-2 and IR-4. Many experts estimate, for example, that the IR-2 could be much more reliable and have some six times the output of the IR-1, making it far easier to disperse and conceal. However, as of November, the installation and use of the IR-2 centrifuges has been intermittent and best and the IR-4 centrifuges do not seem to be improving since the last reporting period.

While the length and complexity of the data in these figures takes time to interpret and understand them, it is worth the effort. It is all too easy to generalize about the evidence if one has never examined it. If one does, there still is no "smoking gun," but the cumulative impact is remarkably close to having one.

Figure A1: Amount of Fissile Material Need to Build a Basic Fission (Non-Boosted) Weapon

Highly Enriched Uranium

HEU (90% U-235)

Simple gun-type weapon	90-110 lbs./40-50 kg
Simple implosion weapon	33lbs/15 kg
Sophisticated implosion weapon	20-26lbs/9-12kg

Weapons Grade Plutonium

Simple implosion weapon	14lbs/6 kg
Sophisticated implosion weapon	4.5-9lbs/2-4 kg

Source: Extract from the unclassified estimates in Union of Concerned Scientists, "Preventing Nuclear Terrorism Fact Sheet," April 2004, and work by Abdullah Toukan.

Figure A2: Heavy Water Production

Iran told the IAEA during an August 9 visit to the Arak IR-40 Reactor that the start of the operation of the reactor is planned for the end of 2013. During the visit, the IAEA observed the reactor's construction was ongoing. Moderator heat exchangers had been installed and coolant heat exchangers had been delivered to the site.

On August 17, the IAEA visited the Arak Heavy Water Production Plant (HWPP) for the first time since 2005. Iran told the IAEA that the plant was operational and it had produced a total of 60 tons of heavy water to date. Iran continues to refuse the IAEA access to the heavy water stored at the Uranium Conversion Facility (UCF) for sampling.

Source: David Albright, Paul Brannan, Andrea Stricker, and Christina Walrond *IAEA Iran Safeguards Report, September 2, 2011*, ISIS, September 2, 2011, http://www.isis-online.org/uploads/isis-reports/documents/IAEA_Iran_Report_ISIS_analysis_2Sept2011.pdf

Figure A3: ISIS Analysis of IAEA February, 2012 Report - Main Points

- Iran achieves a near three-fold increase in production of 19.75 percent LEU at Natanz and Fordow.
- Iran installs approximately 8,000 additional IR-1 centrifuge casings at Natanz and Fordow.
- Iran increases the number of centrifuges enriching at Natanz by nearly 50%.
- The testing of advanced centrifuge production-scale cascades at the Natanz pilot testing is going far more slowly than expected.
- IR-1 centrifuge performance remains below par.

Source: David Albright, Paul Brannan, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, February 24, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_Report_24Feb2012.pdf

Figure A4: ISIS Analysis of IAEA February, 2012 Report LEU Production and Centrifuge Levels at the Natanz Fuel Enrichment Plant (FEP)

- **Iran's total LEU production at the FEP through February 4, 2012 is reported to be 5,451 kg of low enriched uranium hexafluoride, including 580 kg estimated by Iran to have been produced since October 17, 2011. This total amount of low enriched uranium if further enriched to weapon grade is enough to make over four nuclear weapons.** The FEP is Iran's primary enrichment facility, where the majority of its IR-1 centrifuges are installed. Activity at the Pilot Fuel Enrichment Plant, where Iran is enriching uranium up to the 20 percent level, is discussed below.
- **The average production of LEU at the FEP was 170 kg per month of LEU hexafluoride, a rate that has increased significantly from the last reporting period, where Iran produced 145 kg per month. However, Iran also used significantly more centrifuges to produce a marginal additional amount of product.**
- As of February 19, 2012, Iran had 54 centrifuge cascades installed with 9,156 IR-1 centrifuges and was enriching in 52 cascades containing a total of 8,808 IR-1 centrifuges. The IAEA noted that "not all of the centrifuges in the cascades being fed with uranium hexafluoride may have been working." At the end of the last reporting period, Iran was enriching in 15 fewer cascades and 2,600 fewer centrifuges. To achieve this increase in enriching centrifuges, Iran has re-connected about 1,000 IR-1 centrifuges, which had originally been installed and under vacuum in 2009.
- In a new development, Iran placed an additional 6,177 empty IR-1 centrifuge casings at the FEP. It is unknown if Iran has enough raw materials to actually install this number of centrifuge rotor assemblies into the outer casings and make the centrifuges operational.
- Uranium hexafluoride feed rates are not given for this reporting period.
- **The number of centrifuges enriching at the FEP has increased by about 50 percent, but centrifuge performance remains below par...** On an annualized basis, this is about 4,732 kg swu per year. The number of centrifuges declared as enriching was 6,208 at the beginning of the reporting period and rose to 8,808 at the end of the reporting period, corresponding with a swu/centrifuge-year of 0.76 and 0.53 respectively. For most of 2010, this value was about 0.9 kg U swu per year per centrifuge. These numbers imply that not all of Iran's centrifuges in cascades fed with uranium are actually enriching, and that these centrifuges are enriching less efficiently. **Despite the overall increase in LEU production during this reporting period, Iran's IR-1 centrifuges are performing no better.**

Source: David Albright, Paul Brannan, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, February 24, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_Report_24Feb2012.pdf

IAEA Safeguards Report of February 24, 2012. http://isis-online.org/uploads/isis-reports/documents/IAEA_Iran_Report_24February2012.pdf

Figure A5: ISIS Analysis of IAEA February, 2012 Report Deployment of Advanced Centrifuges at Pilot Fuel Enrichment Plant (PFEP) Delayed, 19.75 Percent Enrichment Continues

Advanced Centrifuges: Iran appears to be encountering problems in its testing of production-scale cascades of advanced centrifuge at the Pilot Fuel Enrichment Plant. Over the last reporting period, it maintained one 164-machine cascade of IR-2m centrifuges in cascade 5. All 164 IR-2m machines were under vacuum and only being intermittently fed with uranium hexafluoride, an unexpected development. Iran continued work on its installation of IR-4 centrifuges in cascade 4, but, as of February 21, 2012 it had only installed 58 of 164 centrifuges in its planned IR-4 cascade, a decrease of 8 centrifuges from the end of the last reporting period. No uranium hexafluoride was introduced into the IR-4 centrifuges. According to IAEA information, Iran moves the IR-4 centrifuges in and out of the PFEP in a noticeable manner. This may imply significant problems with the IR-4 centrifuge design.

Iran also declared to the IAEA its plans to install three new types of centrifuges, called the IR-5, IR-6, and IR-6s as single machines at the PFEP. The designs specifications for the centrifuges are not disclosed in this report. Iran continues to feed natural uranium hexafluoride into single machines as well as ten and twenty machine cascades of IR-1, IR-2m, and IR-4 centrifuges.

19.75 percent LEU production: Iran has designated two cascades at the smaller, above-ground pilot fuel enrichment plant for the production of LEU enriched to nearly 20 percent uranium-235 for the Tehran Research Reactor (TRR). One of these cascades enriches from 3.5 percent LEU to almost 20 percent LEU, while the second one takes the tails from the first one and outputs about 10 percent LEU and a tails of natural uranium. The ten percent material is fed into the first cascade in addition to 3.5 percent LEU. This process allows Iran to more efficiently use its 3.5 percent LEU stock.

Between September 14, 2011 and February 11, 2012, 164.9 kg of 3.5 percent low enriched uranium in the form of uranium hexafluoride was introduced into the two, interconnected cascades, a slight decrease from the last reporting period. Iran withdrew a total of 21.7 kg of nearly 20 percent LEU hexafluoride. **During the reporting period, Iran produced 19.75 percent enriched uranium at a rate of 4.5 kg/month, about a 20 percent increase from the last reporting period but equal to the rate reported by the IAEA in May 2011. In total, Iran has fed 885.7 kg of 3.5% LEU to produce 95.4 kg 19.75% uranium since the beginning of operations in February 2010.**

Source: David Albright, Paul Brannan, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, February 24, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_Rerport_24Feb2012.pdf

IAEA Safeguards Report of February 24, 2012. http://isis-online.org/uploads/isis-reports/documents/IAEA_Iran_Report_24February2012.pdf

Figure A6: ISIS Analysis of IAEA February, 2012 Report - Fordow Fuel Enrichment Plant

The Fordow site now has four cascades of 174 IR-1 centrifuges each operating in two, tandem sets producing 19.75 percent LEU. Between December 14, 2011, when the first set started producing LEU until February 17, 2012, these sets of cascades produced approximately 13.8 kg of 19.75 percent enriched uranium at a rate of 6.46 kg 19.75 percent LEU hexafluoride per month. With the stockpile of 19.75 percent uranium produced at the Pilot Fuel Enrichment Plant at Natanz, Iran now has approximately 110 kg of 19.75 percent uranium. Its monthly production has increased to about 11 kilograms per month of 19,75 percent LEU hexafluoride, somewhat less than a three-fold increase. However, this level of production far exceeds Iran's need for enriched uranium for the Tehran Research Reactor.

In a new development, Iran installed 2,088 empty IR-1 centrifuge outer casings as well as all the associated feed and withdrawal piping at the Fordow facility. It is unclear whether and when Iran will install the rotor assemblies necessary to create operational IR-1 centrifuges. Fully outfitting the Fordow facility with centrifuges ready to enrich would have been a significant development. As in the case of the newly installed casings at the FEP, it is unknown if Iran has enough raw materials to actually install this number of centrifuge rotor assemblies into the outer casings at the Fordow site. However, given the international sensitivity about the deeply buried Fordow site, by installing the outer casings for over 2,000 machines and the associated piping, Iran is in effect sending a warning to the international community that it intends to fully outfit the Fordow site. If it cannot do so with advanced centrifuges, it appears to be willing to do so with IR-1 centrifuges. Only time will tell if Iran can actually install the critical centrifuge rotors and operate the machines.

Iran also submitted to the IAEA a new Design Information Questionnaire (DIQ), revising yet again the stated purpose of the Fordow enrichment facility. Iran originally stated that Fordow would be used to make 3.5 percent enriched uranium, and later said that Fordow would also be used for R&D purposes. Then Iran submitted a new DIQ declaring that Fordow would be used to make 19.75 percent enriched as well. In the latest DIQ, Fordow will be used for only 19.75 and 3.5 percent enriched uranium production but Iran left open how many of the centrifuges will be dedicated to making 19.75 percent LEU. That Iran has changed the stated purpose of the Fordow facility so many times over such a short period of time raises significant questions regarding the original purpose of the facility. Iran's decision to build a relatively small enrichment facility without informing the IAEA suggested that Fordow was intended to be used to quickly and securely make highly enriched uranium for nuclear weapons.

In summary, Iran is being ambiguous over the number of its centrifuges at Fordow that will make 19.75 percent LEU. It is signaling that it intends to fully outfit the plant with centrifuges, despite having no credible civilian need for the LEU that these machines would produce.

Source: ISIS Report. *ISIS Analysis of IAEA Iran Safeguards Report*. David Albright, Paul Brannan, Christina Walrond. February 24, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_Report_24Feb2012.pdf

IAEA Safeguards Report of February 24, 2012. http://isis-online.org/uploads/isis-reports/documents/IAEA_Iran_Report_24February2012.pdf

Figure A7: ISIS Analysis of IAEA February, 2012 Report - Taking Stock of Fordow and Natanz

Between the two enrichment sites, Iran has produced 109.2 kilograms of 19.75 percent LEU hexafluoride. Of that total, Iran has sent an unknown amount of 19.75 percent LEU to the Uranium Conversion Facility at Esfahan. Typically, transport containers would contain about 25 kilograms of such LEU. As of February 19, 2012, Iran had converted about 8 kilograms into U3O8 for use in Tehran Research Reactor fuel, which it is making at the nearby Fuel Manufacturing Plant. So, about 101.2 kilograms of 19.75 percent LEU remains in the form of hexafluoride as of that date.

Iran has produced a total of 5,451 kilograms of 3.5 percent LEU hexafluoride. About 985 kilograms has been used to make the 19.75 percent LEU hexafluoride.

Iran has achieved varying rates of separative work in the IR-1 centrifuge in its enrichment plants. Although it continues to install and enrich in additional centrifuges at the FEP, the swu/centrifuge-year at this plant has varied wildly and declined overall. The separative work achieved at both the PFEP and FFEP indicates that Iran has been using tandem cascades to enrich to 19.75 percent comparably effectively. However, it is unknown whether Iran could maintain this level of output if it deployed these centrifuges on a broader scale.

Source: David Albright, Paul Brannan, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, February 24, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_Rerport_24Feb2012.pdf

IAEA Safeguards Report of February 24, 2012. http://isis-online.org/uploads/isis-reports/documents/IAEA_Iran_Report_24February2012.pdf

Figure A8: ISIS Timeline of Potential Future Capabilities to Make Weapon-Grade Uranium: Modest Growth Projection

	2012	2013	2014	2015
Natanz FEP (3.5% and 19.75% LEU)	6,000-9,000 enriching	IR-1s 6,000-12,000 enriching	IR-1s 4,000-15,000 centrifuges enriching	4,000-15,000 centrifuges enriching
Fordow (19.75% LEU; 3.5% LEU; HEU?)	2-4 IR-1 cascades (with 696-1044 centrifuges); another 1,000 centrifuges (advanced centrifuges?)	IR-1 tandem 2,000 centrifuges; (or 500-1,000 advanced centrifuges)	IR-1 tandem 2,000 centrifuges	IR-1 or 1,000-2,000 advanced centrifuges
Third enrichment site	Under construction	500-1,000 centrifuges	1,000 centrifuges	1,000-2,000 centrifuges
Covert, parallel site (3,000 centrifuges maximum)	Under construction?	Under construction?	Under construction?	1,000 centrifuges?
Covert uranium supply and conversion facility	Under construction?	Under construction?	Operational?	Operational?
Covert laser separation facility	Under development?	Under development?	Under construction?	Operational?

Source: David Albright, Paul Brannan, Andrea Stricker, Christina Walrond, and Houston Wood, "Preventing Iran from Getting Nuclear Weapons: Constraining its Future Nuclear Options," March 5, 2012. http://www.isis-online.org/uploads/isis-reports/documents/USIP_Template_5March2012-1.pdf

Figure A9: Probabilities of Iranian Paths to Nuclear Explosive Materials

(Each probability reflects the likelihood that Iran would pursue each method, based on a judgment of its technical capabilities to do so and a range of factors that deter its pursuit of this method)

Method	Probability		
	2012	2013	2014-2015
Dash at declared centrifuge sites to highly enriched uranium (HEU) using safeguarded LEU			
Natanz:	Low	Low	Low
Fordow:	Low	Low-medium	Low-medium
Dash at undeclared, covert centrifuge site using the safeguarded LEU stockpile	Low	Low-medium	Medium
HEU production under safeguards at declared centrifuge plants	Low	Low	Medium
Parallel covert centrifuge program	Low	Low	Medium
Secret production of HEU at declared safeguarded sites	Low	Low	Low
Arak reactor and secret, undeclared reprocessing plant (reactor to be operational in 2014)	-	-	Low
Laser enrichment to produce HEU	Low	Low	Low
Illicitly acquire fissile material overseas for use in nuclear weapons	Low	Low	Low
II. NPT withdrawal			
Legal withdrawal from NPT and then weapons production	Low	Low	Low-medium

Source: David Albright, Paul Brannan, Andrea Stricker, Christina Walrond, and Houston Wood, "Preventing Iran from Getting Nuclear Weapons: Constraining its Future Nuclear Options," March 5, 2012. http://www.isis-online.org/uploads/isis-reports/documents/USIP_Template_5March2012-1.pdf

Figure A10: 20% Enrichment and Weapons Production

May 31 IAEA safeguards report on Iran is the first to contain any data on the production of 19.75 percent enriched uranium in IR-1 centrifuges at the Natanz Pilot Fuel Enrichment Plant (PFEP).

The Natanz PFEP is configured to hold six 164-centrifuge cascades in total. Iran uses one of these cascade bays to test several more advanced types of centrifuges configured in 10, 20 and single unit cascades for R&D purposes. When Iran started making 19.75 percent enriched uranium, the PFEP held only one 164-centrifuge cascade, called cascade 1. It has now reinstalled a second cascade, called cascade 6, also designated for production of LEU enriched up to 20 percent. As of late May, cascade 6 had been prepared for enrichment but was not enriching pending the application of more sophisticated safeguards arrangements.

Between 18 and 29 September 2010, the Agency conducted a PIV at PFEP and verified that, as of 18 September 2010, 352 kg of low enriched UF₆ had been fed into the cascade(s) since 9 February 2010, and that a total of 25.1 kg of UF₆ enriched up to 20% U-235 had been produced. Iran declared that the enrichment level of the UF₆ product was 19.89%. The Agency is continuing with its assessment of the P

Iran has estimated that, between 19 September 2010 and 19 November 2010, a total of 62.5 kg of UF₆ enriched at FEP was fed into the two interconnected cascades and that approximately 7.8 kg of UF₆ enriched up to 20% U-235 was produced. This would result in a total of approximately 33 kg of UF₆ enriched up to 20% U-235 having been produced since the process began in February 2010.

How quickly Iran might produce 19.75 percent enriched uranium will depend on whether it uses only one cascade or decides to use more cascades at the PFEP. Although Iran has said that it will expand the enrichment effort beyond a single cascade, it has not revealed the enrichment level of the product of the second cascade.

...if Iran installs more cascades at the PFEP, it can speed up its production of 19.75 percent LEU. Nonetheless, one or two cascades would require several years to have enough 19.75 percent LEU to then further enrich and have sufficient weapon-grade uranium for a nuclear weapon. If Iran deploys five cascades it would produce this material in 0.5-1.7 years.

Iran has not stated how much 19.75 percent LEU it plans to produce or, for that matter, how many cascades it will ultimately devote to the production of this material. .

...As long as Iran maintains its centrifuge capability, it can incrementally strengthen its nuclear weapons capabilities under the guise of “peaceful” declarations, and shorten the time needed to make enough weapon-grade uranium for a nuclear weapon.

Source: David Albright, Paul Brannan, and Andrea Stricker, *Moving 20 Percent Enrichment to Fordow: Slow Motion Breakout Continues?*, June 8, 2011, <http://isis-online.org/isis-reports/detail/moving-20-percent-enrichment-to-fordow-slow-motion-breakout-continues/8>

Figure A11: ISIS on Parchin

Iran's ongoing activities at the Parchin site continue to raise concerns about efforts to destroy evidence of possible nuclear weapons-related work. Since the last image ISIS provided on June 7, 2012 several activities have taken place.

Debris from one of the previously demolished buildings located just north of the explosives testing building appears to have been removed from the site. The layout of the site has been heavily altered by earth displacement, and there is no remaining trace of one of the previously demolished buildings or the roads within the complex perimeter.

An object that was previously placed near the alleged explosive chamber building and was suspected to be the origin of the water flow in the June 7 satellite imagery has now been moved to a nearby building just south of the testing chamber structure. Once again, traces of water flow are visible. This suggests the object may be a water tank and is being moved around the site, possibly to clean the buildings.

The area around the northernmost building on the site that was previously unchanged now shows evidence of new earth movement since the June 7 image. A clearly visible geometrical layout to the right of the building is no longer recognizable suggesting earth displacement or heavy machinery activity.

Since the first signs of a possible clean up at Parchin emerged in the April 9, 2012 satellite imagery, the site containing the suspect activity has undergone very noticeable changes with two buildings demolished, excavation of earth including most of the surrounding vegetation and roads covered or removed, dismantlement of the security perimeter around the site, and evidence of water usage potentially for cleaning the insides of buildings.

As ISIS has previously noted, water could be used as part of a process to attempt to wash out radiological evidence from hydrodynamic testing which used natural uranium metal as a surrogate material for highly enriched uranium. The process could involve grinding down the surfaces inside the building, collecting the dust and then washing the area thoroughly. This could be followed with use of new building materials and paint. Washing alone runs the risk of contaminating the wider area outside. Removal of the surrounding, contaminated earth suggests recognition of the need to remove the layer of soil that was contaminated by water runoff.

Some have raised the possibility that, if the explosive chamber had been used to test a neutron initiator, this type of test would leave behind a radioactive signature in the steel. According to *Suddeutsche Zeitung* (article in German language), the chamber could have been used to test a uranium deuteride initiator at the center of a sphere of tungsten used as a surrogate material, all of which would have been compressed by high explosives. If successful, the resulting fusion of deuterium would have produced a small spurt of neutrons. In this case, a tiny fraction of these neutrons would have activated elements in the steel chamber. This has led to the question whether the induced radiation could now be detected by the IAEA.

However, in such a neutron initiator test, the number of neutrons is very small and many of the activated materials would have had relatively short half-lives. Although long lived radionuclides should have been produced in such a test, they would exist in very small quantities. Claims that such radioactive materials would be easily detectable today appear doubtful. Moreover, the detection of minute amounts of long-lived radionuclides in the steel chamber may not provide definitive proof of an initiator test. Iran could claim that the steel was already contaminated when it purchased it. In addition, Iran could have removed the chamber altogether, preventing any risk of such detection, even if it were possible to accomplish.

Source: David Albright and Robert Avagyan, *Activity at Parchin Explosive Testing Site Continues: Time Is Running Out for a Sound IAEA Inspection.*, ISIS, July 2, 2012. http://isis-online.org/uploads/isis-reports/documents/Parchin_test_site_imagery_2July2012.pdf

Figure A12: ISIS Analysis of IAEA November, 2012 Report - Cumulative Totals of Natural and Enriched Uranium Feed and 3.5 and 19.75 Percent Product in Iran

LOCATION	0.711 percent feed	3.5 percent LEU product	3.5 percent LEU feed	19.75 percent LEU product
FEP	87,220 kg	7,611 kg	N/A	N/A
PFEP	N/A	N/A	1,177 kg	137.3 kg
FFEP	N/A	N/A	693 kg **	95.5 kg
GROSS TOTAL	87,220 kg	7,611 kg	1,870 kg	232.8 kg
NET TOTAL	87,220 kg	5,688 kg*	1,870 kg	134.9 kg***

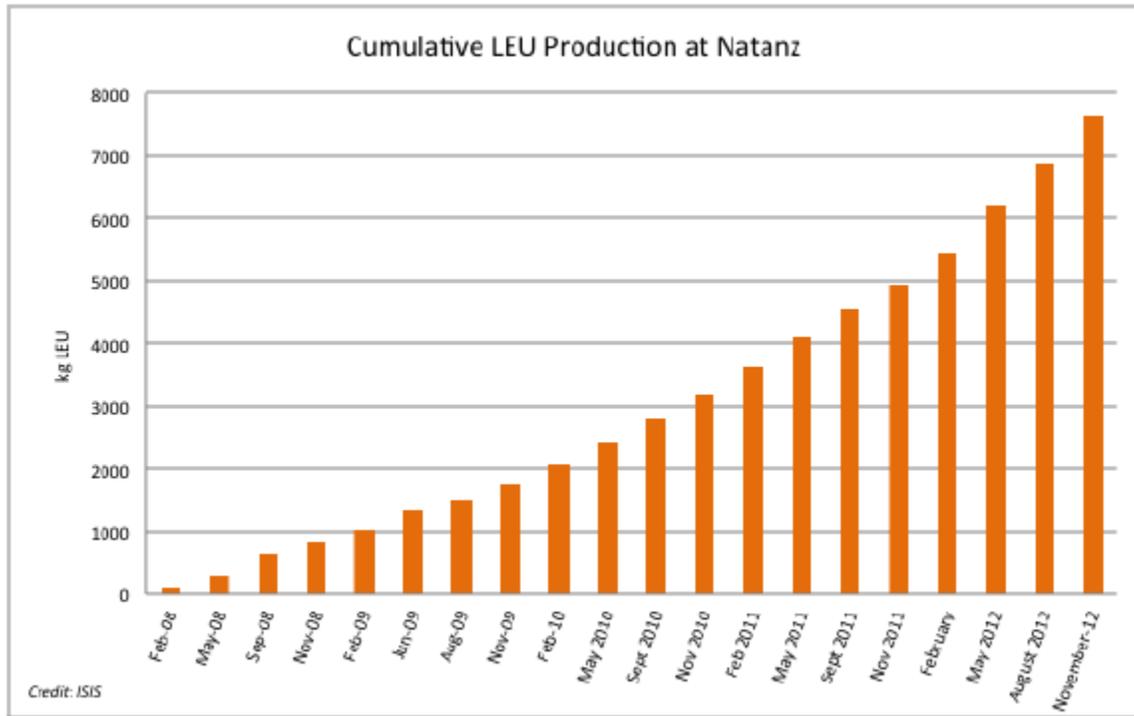
*Number is less 3.5 percent enriched uranium hexafluoride used as feedstock at the PFEP and FFEP as well as 53 kg 3.5 percent LEU hexafluoride converted to uranium oxide.

**This number is the smaller of the two numbers given by the IAEA and is the one that appears in the Fordow section. It tracks more closely with previous reporting periods

***Number is less 96.3 kg of 19.75 percent LEU hexafluoride sent to the Fuel Plate Fabrication Plant near Esfahan and 1.6 kg 19.75 percent LEU hexafluoride downblended. As of November 10, 13.6 kg of this material at Esfahan remained in the form of uranium hexafluoride but is slated for conversion to oxide, which is the reason for not including it in the table.

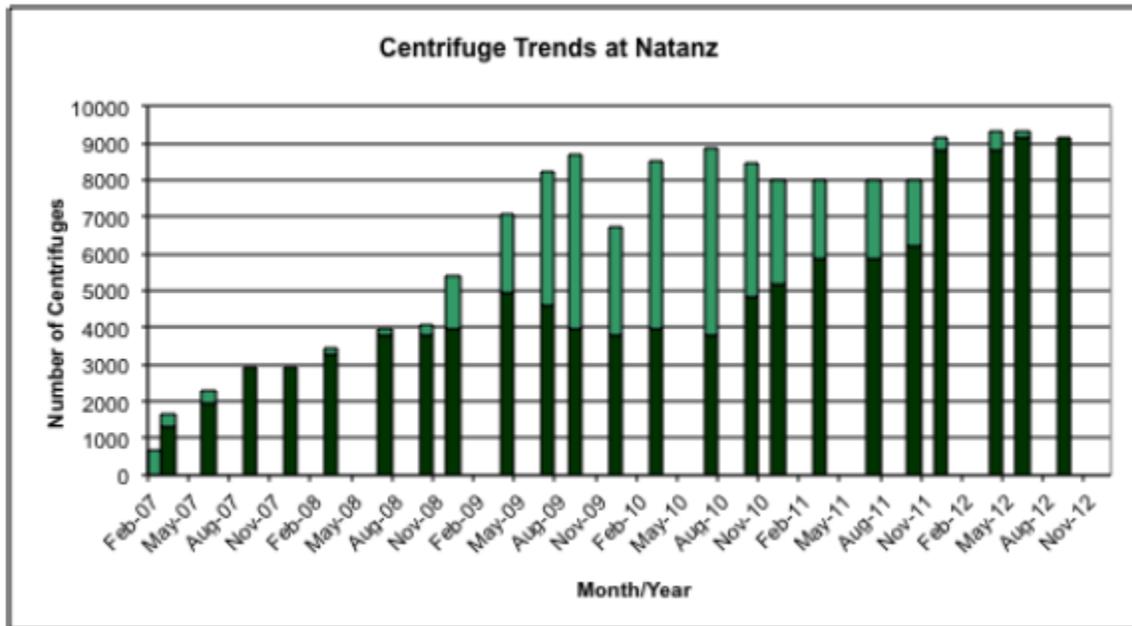
Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

Figure A13: ISIS Analysis of IAEA November, 2012 Report - Cumulative LEU Production at Natanz



Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

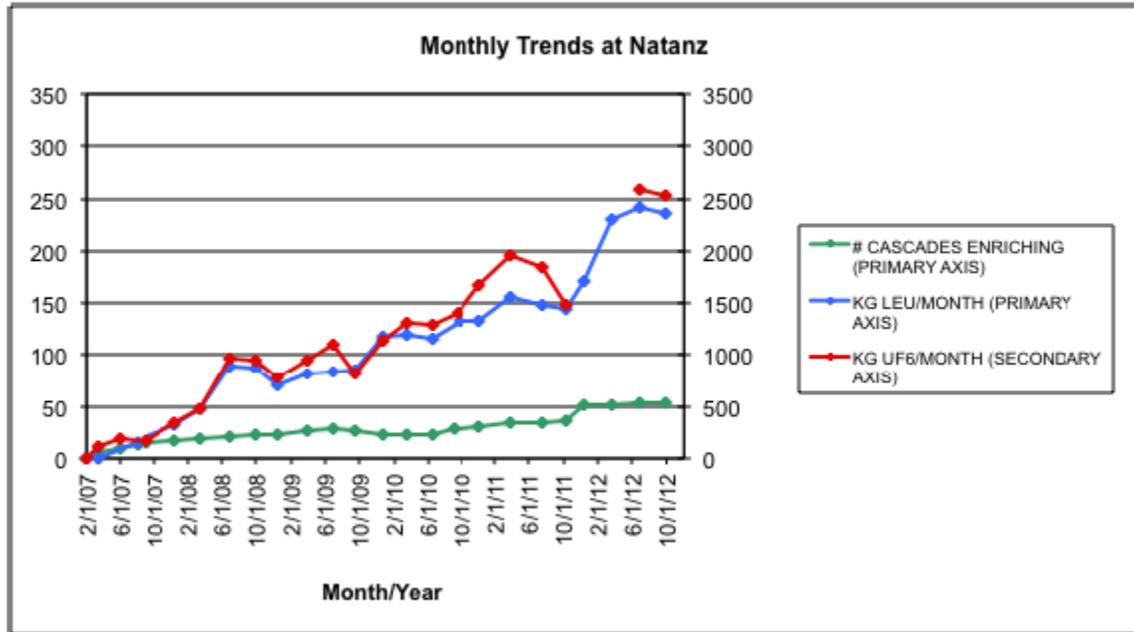
Figure A14: ISIS Analysis of IAEA November, 2012 Report - Centrifuge Trends at Natanz



The dark green bar represents the number of centrifuges enriching, while the light green bar represents the number of centrifuges installed but not enriching. The sum of the two represents the total number of centrifuges installed at the FEP.

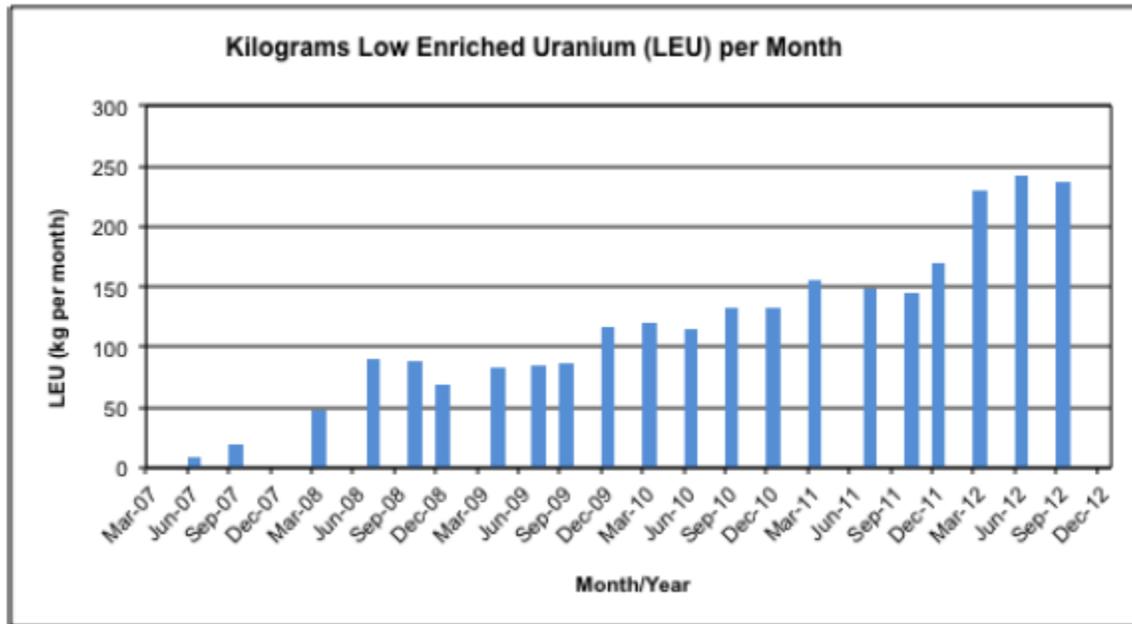
Source: David Albright, Andrea Stricker, and Christina Walrond *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

Figure A15: ISIS Analysis of IAEA November, 2012 Report -Estimate of Monthly Trends at Natanz



Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

Figure A16: ISIS Analysis of IAEA November, 2012 Report - Kilograms of Low Enriched Uranium (LEU) per Month



Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

Figure A17: ISIS Analysis of IAEA November, 2012 Report - LEU Production and Centrifuge Levels at Natanz Fuel Enrichment Plant (FEP)

Iran's total 3.5 percent low enriched uranium (LEU) production at the FEP through November 9, 2012 is reported to be 7,611 kilograms (kg), including 735 kg estimated by Iran to have been produced since August 7, 2012. This total amount of 3.5 percent low enriched uranium hexafluoride, if further enriched to weapon grade, is enough to make, in theory, six or seven nuclear weapons. The FEP is Iran's primary enrichment facility, where the majority of its IR-1 centrifuges are installed. Activity at the Pilot Fuel Enrichment Plant (PFEP), where Iran is enriching uranium up to the 20 percent level, is discussed below.

The average production of 3.5 percent LEU at the FEP was approximately 237 kg per month of LEU hexafluoride, a rate that has stayed about the same as the last reporting period, when Iran produced on average 242 kg per month.

...Iran fed 7,839 kg of natural uranium hexafluoride into the cascades at the FEP. This appears to be consistent with the previous reporting period, although the IAEA has reported feed numbers sporadically and precise estimates of the feed rate at the FEP are very difficult to ascertain from the available data.

Iran's centrifuge performance at the FEP can be evaluated in terms of separative work units (swu). ISIS derives this value from the declared LEU production. In the most recent reporting period, the LEU value is used with an assumption that the material is 3.5 percent enriched and the waste has a tails assay of 0.4 percent. The IAEA did not provide updated numbers in this report, but these older numbers are used. Using standard idealized enrichment calculations, 735 kg of LEU translates to 1,807 kg of swu, or 19 kg swu/day. On an annualized basis, this is about 6,943 kg swu per year. These numbers are consistent with the previous reporting period.

The number of centrifuges declared as enriching was 9,156 at both the beginning and the end of the reporting period, corresponding with an average swu/centrifuge-year of 0.76, nearly the same as the last reporting period. However, for most of 2010, this value was about 0.9 kg U swu per year per centrifuge...This consistently lower enrichment output likely indicates that Iran is continuing to have trouble with the IR-1 centrifuges installed at the FEP.

Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

Figure A18: ISIS Analysis of IAEA November, 2012 Report - Deployment of Advanced Centrifuges Moving Ahead

As of the latest IAEA report, Iran has been testing advanced centrifuges in production scale cascades at the Pilot Fuel Enrichment Plant (PFEP) at Natanz. Since the last reporting period, Iran has slightly increased the number of advanced centrifuges at the PFEP. As of August 18, 2012, 162 out of 164 IR-2m centrifuges were installed and apparently enriching in cascade 5. As of November 6, cascade 5 contained its full complement of 164 IR-2m centrifuges, and cascade 3 had 14 IR-2m centrifuges, where in the previous reporting period this cascade was empty.

Iran has also increased the number of IR-4 centrifuges in the pilot plant. As of August 18, 2012, it had 123 IR-4 centrifuges in cascade 4 and 10 IR-4 centrifuges in cascade 2. Both were being fed intermittently. As of November 6, cascade 4 had 144 IR-4 centrifuges and cascade 2 had 32 IR-4 centrifuges. Iran continues to feed these cascades intermittently.

Iran has yet to install three new types of centrifuges (IR-5, IR-6, and IR-6s) although it has indicated it intends to do. On November 6, 2012, inspectors observed the presence of two empty casings for IR-6 centrifuges at the PFEP. According to Iran, complete IR-6 centrifuges had been delivered to the pilot plant, but the rotors had subsequently been removed for testing somewhere other than the PFEP.

The IAEA report does not provide any indication of how well the advanced centrifuges are operating. The IR-4 involves a carbon fiber bellows, which is not a common way to make a bellows, and many governments expect that Iran has encountered difficulties in developing this centrifuge. However, Iran should have less trouble with the IR-2m centrifuge, which uses a maraging steel bellows, like the IR-1 centrifuge, albeit considerably more difficult to make. Iran has an incentive to succeed with the advanced centrifuges, because their enrichment capacity could be four times that of the IR-1.

A troubling possibility is that Iran could deploy the IR-2m in a third, possibly secret, enrichment facility. Iran claims it does not have to inform the IAEA about a new nuclear facility until it is nearly complete, and Iran has been ambiguous about whether it is building one. However, the IAEA rejects Iran's attempt to exempt itself from the requirement to report a new nuclear facility when construction is approved and views Iran as not in conformity with its comprehensive safeguards agreement. Iran was discovered secretly building the Fordow enrichment plant in early 2009; many increasingly worry that Iran is in the process of building another secret gas centrifuge plant. It is unlikely that it would be operational but a question is whether the IR-2m may be the centrifuge of choice for such a facility.

Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

***Figure A19: ISIS Analysis of IAEA November, 2012 Report - 19.75% LEU
Production***

Iran has designated two, tandem cascades at the smaller, above-ground Pilot Fuel Enrichment Plant for the production of LEU enriched to nearly 20 percent uranium-235, ostensibly for the Tehran Research Reactor (TRR). One of these cascades enriches from 3.5 percent LEU to almost 20 percent LEU, while the second one takes the tails from the first and outputs roughly 10 percent LEU and a tails of natural uranium. The ten percent material is fed into the first cascade in addition to 3.5 percent LEU. This process allows Iran to more efficiently use its 3.5 percent LEU stock.

Between August 22, 2012 and November 11, 2012, 92.2 kg of 3.5 percent low enriched uranium in the form of uranium hexafluoride was introduced into the two, interconnected cascades. Iran withdrew from the tandem cascades a total of 13.2 kg of nearly 20 percent LEU hexafluoride during this reporting period. Iran appears to be operating this set of cascades fairly consistently, and has achieved the same level of performance over the past year. **Thus, Iran is producing 19.75 percent enriched uranium at a rate of 5 kg per month in this tandem set. In total, Iran has fed 1,1771 kg of 3.5% LEU to produce 137 kg of 19.75% uranium since the beginning of operations in February 2010.**

Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

Figure A20: ISIS Analysis of IAEA November, 2012 Report -Fordow Fuel Enrichment Plant (FFEP) Cascade Halls Filled, But Additional Centrifuges Not Enriching

The Fordow site has two enrichment halls, Units 1 and 2, which are currently each designed to hold 8 cascades of 174 IR-1 centrifuges. Iran is continuing to operate the four cascades of 174 IR-1 centrifuges each in two, tandem sets to produce 19.75 percent LEU in a total of 696 enriching centrifuges, the same number of centrifuges enriching as was reported in both the August and May 2012 safeguards reports. **Thus, Iran has not increased the number of centrifuge cascades producing 20 percent LEU at either Fordow or Natanz.**

At the beginning of this reporting period, Units 1 and 2 had a total of 2,140 IR-1 centrifuges installed. During this reporting period, Iran continued to place IR-1 rotor assemblies into outer casings. As of the November 16, 2012 report, it had fully installed all the rotor assemblies in this facility, bringing the total to 2,784 IR-1 rotor assemblies installed. **However, of the 12 cascades installed at the Fordow facility but not enriching, only four cascades are fully outfitted with pipes, electronics, and other critical materials. These four have been subjected to vacuum testing and are ready for feeding with uranium hexafluoride. The eight additional cascades have centrifuges with rotors and casings, but lack critical equipment that would allow Iran to enrich uranium in these last eight cascades.**

Iran has not started to enrich in any of these newly installed centrifuges; in fact, Iran has not increased the number of centrifuges enriching in two reporting periods. Based on Iran's patterns of installation, it may be that it plans to orient all of the cascades at the Fordow facility as tandem cascades.

Between August 13, 2012 and November 10, 2012, the two sets of tandem cascades produced approximately 30.2 kg of 19.75 percent enriched uranium at a combined average rate of 10.25 kg of 19.75 percent LEU hexafluoride per month. This tracks closely with Iran's rate of production during the last reporting period, where it produced 29.8 kg of 19.75 percent enriched uranium at a rate of 10.04 kg per month.

The Fordow plant appears to have received higher priority than the Natanz FEP in terms of the installation of the IR-1 centrifuges. Moreover, Iran seems to have deliberately focused on placing centrifuges in this facility rather than bringing centrifuges into enrichment operations.

...Although we can only speculate on Iran's motivations, it may be signaling that it is choosing to limit its production rate of 19.75 percent LEU because it fears a more negative reaction from the international community, understanding that increasing that rate could stimulate greater sanctions and even military strikes. It may also be doing its own signaling, in essence using the Fordow facility as a bunker for IR-1 centrifuges, a facility Israel states it cannot destroy. Thus, if Israel attacks, Iran may calculate that the centrifuges at Fordow would survive, even if all centrifuge capabilities on the surface, including at Natanz, were destroyed. After the strike, Iran could use the centrifuges at Fordow or elsewhere in a reconstituted program, perhaps without any IAEA inspectors and with the intention to make weapon-grade uranium.

Iran may choose to pipe these cascades into tandem sets and produce near 20 percent LEU, and it bears watching whether it can operate these cascades as well as it operates its current sets of tandem cascades. Iran seems to have achieved a greater level of efficiency by using a tandem cascade orientation, with the tandem cascades achieving about 0.9 swu/centrifuge-year. The individual cascades in the Natanz FEP only achieve about 0.76 swu/centrifuge-year. However, it is possible that Iran simply has trouble operating its IR-1 on a wide scale; the Natanz facility enriches to 3.5 percent in about 9,000 centrifuges, while Iran has only dedicated approximately 1,000 centrifuges between the FFEP and the PFEP to enrichment to 19.75 percent.

Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

Figure A21: ISIS Analysis of IAEA November, 2012 - Uranium Oxide Production

Iran reported in the August 2012 report that it began feeding its 19.75 percent uranium hexafluoride into the Fuel Plate Fabrication Plant at Esfahan. A total of 96.3 kg of 19.75 percent LEU hexafluoride was sent to the conversion plant by this date. Of this amount, 25.05 kg was in the form of uranium hexafluoride in a cylinder connected to the plant. The other 71.25 kg had been fed into the process lines, resulting in 31.1 of good U3O8 product. The remainder, or 40.15 kg, was held up in the process or in the waste flow.

According to this most recent report, between the start of conversion activities on December 17, 2011 and September 26, 2012, 82.7 kg of the near 20 percent enriched uranium hexafluoride had been fed into the conversion process and 38 kg of uranium had been produced in the form of U3O8 powder and fuel items. Iran stated that between September 27, 2012 and November 10, 2012, it did not convert any more of the near 20% LEU hexafluoride contained in the cylinder attached to the process line. **Thus, about 13.6 kg of near 20 percent LEU remains in the form of hexafluoride at the plant.**

The relatively small amount of good, near 20 percent U3O8 raises questions about whether the Fuel Plate Fabrication Plant is performing well. It is known that Iran has recycled some of material that has not met required specifications.

The report does not make clear if Iran has sent additional near 20 percent LEU hexafluoride to the Esfahan conversion site after August 2012. However, if it did, the near 20 percent LEU remains in the form of hexafluoride.

Source: David Albright, Andrea Stricker, Christina Walrond *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

Figure A22: ISIS Analysis of IAEA November, 2012 Report - Taking Stock

Iran has produced a total of 7,611 kilograms of 3.5 percent LEU hexafluoride. About 1,870 kilograms have been used to make the 19.75 percent LEU hexafluoride.

Combined, the PFEP at Natanz and the FFEP have produced 232.8 kg of 19.75 percent uranium. [Figure 22] represents the cumulative production of 19.75 percent enriched uranium in Iran. The total average monthly production of 19.75 percent LEU hexafluoride during the most recent period tracks closely with the average in the last reporting period, 15.1 versus 14.4 kilograms per month of 19.75 percent LEU hexafluoride, respectively. If Iran begins enriching in the additional deployed cascades, this rate could triple.

Iran has produced a total of 7,611 kilograms of 3.5 percent LEU hexafluoride. About 1,870 kilograms have been used to make the 19.75 percent LEU hexafluoride.

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Even the current rate of production of 20% LEU far exceeds Iran's need for enriched uranium for the Tehran Research Reactor.

Of the 232.8 kg of near 20 percent LEU, according to the IAEA's May 2012 report, Iran had down blended 1.6 kilograms of 19.75 percent LEU hexafluoride into LEU enriched to less than five percent. Between December 17, 2011 and November 10, 2012 the IAEA reported that Iran fed into the process line at the Fuel Plate Fabrication Plant at Esfahan 82.7 kilograms of uranium hexafluoride enriched up to 20 percent uranium-235, and it produced 38 kilograms of uranium enriched up to 20 percent in the form of U3O8 powder. A small amount has been manufactured into TRR fuel assemblies or elements, a portion of which were sent to the TRR. Since the beginning of operations, the IAEA has stated that 96.3 kilograms of 19.75 percent LEU has been sent or fed to the uranium conversion facilities. **In summary, about 134.9 kilograms of 19.75 percent LEU hexafluoride remained as of November 10, 2012 at the enrichment plants. Another 13.6 kg of 19.75 percent LEU hexafluoride was at the Fuel Plate Fabrication Plant and slated for conversion to oxide.**

Iran has achieved varying rates of separative work in the IR-1 centrifuge at its enrichment plants. Although it continues to install and enrich in additional centrifuges at the FEP, the enrichment output measured in swu/centrifuge-year at this plant has varied and declined overall. The separative work achieved at both the PFEP and FFEP indicates that Iran has been using tandem cascades to enrich to 19.75 percent comparably and effectively. During this reporting period, the FFEP achieved 0.97 swu/centrifuge-year up marginally from 0.95 swu/centrifuge-year during the last reporting period, and the PFEP cascades achieved 0.99 swu/centrifuge-year, comparable to their performance during the last reporting period.

Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report.*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

Figure A23: ISIS Analysis of IAEA November, 2012 Report - No Results on Resolving Possible Military Dimensions

The IAEA reports that “since the November 2011 Board, **the Agency, through several rounds of formal talks and numerous informal contacts with Iran, has made intensive efforts to seek to resolve all of the outstanding issues related to Iran’s nuclear programme, especially with respect to possible military dimensions, but without concrete results.**” The Agency describes this safeguards report as providing a “comprehensive report on substantive implementation” of IAEA Board of Governors resolutions calling on Iran to address military related dimensions.

The IAEA describes in detail its long running effort to establish a process with Iran or otherwise make progress on resolving questions and concerns about the military dimensions of its nuclear program. Specific steps listed by the IAEA include: seeking agreement on a “structured approach” to clarify outstanding issues; requesting an initial declaration about evidence of the military related activities outlined in an annex in the IAEA’s November 2011 safeguards report; identifying as part of a structured approach thirteen topics which need to be addressed; providing Iran with on-going clarifications about the IAEA’s concerns, including its concerns about the Parchin site suspected of housing high explosive tests related to nuclear weapons development and the unnamed foreign expert alleged to have assisted Iran at Parchin...and finally, requesting access to the Parchin site for inspection.

The IAEA concludes that as a result of this lack of progress, “The Director General is, therefore, unable to report any progress on clarifying the issues relating to possible military dimensions to Iran’s nuclear programme.” It adds, “Given the nature and extent of credible information available, the Agency continues to consider it essential for Iran to engage with the Agency without further delay on the substance of [its] concerns.” The IAEA reports that it will meet with officials in Tehran on December 13, 2012 in yet another attempt to establish a structured approach to resolve these outstanding issues, the result of a suggestion in a letter from the IAEA to Iran in late October.

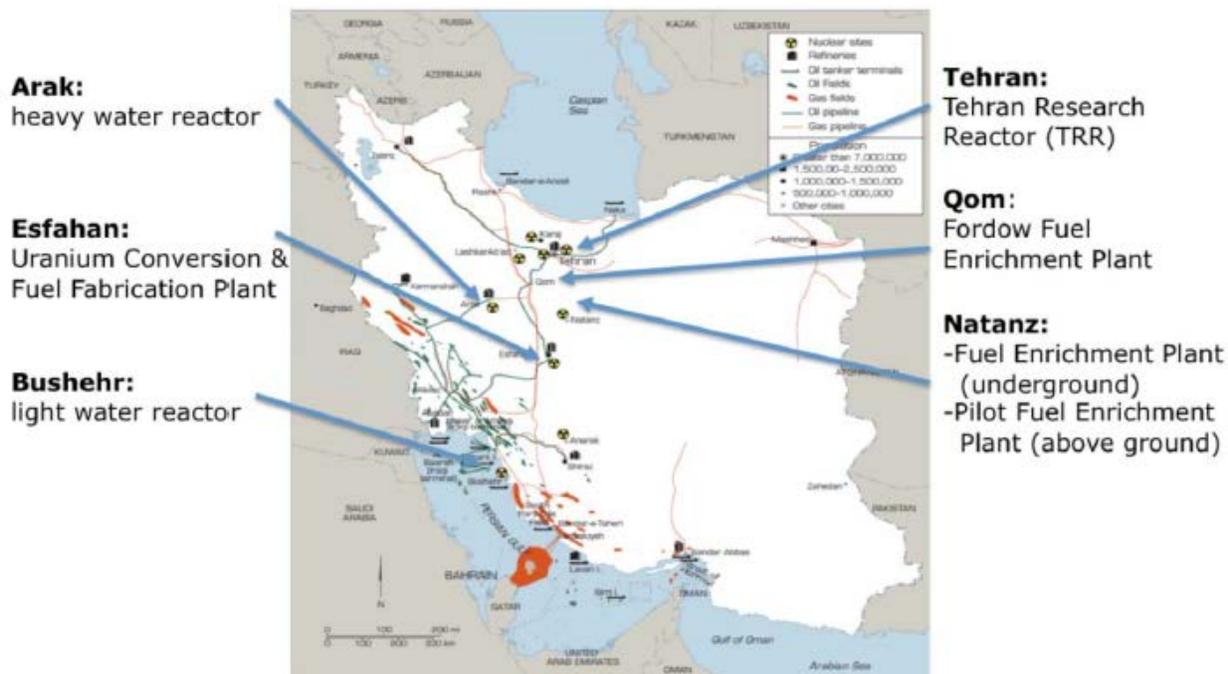
Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

***Figure A24: ISIS Analysis of IAEA August, 2012 Report - IR-40 Work
Continues but Start Date Delayed Until 2014***

The IAEA reports that construction on the IR-40 heavy water moderated research reactor at Arak continued, in particular that the installation of cooling and moderator circuit piping continues. However, Iran told the IAEA that the operation of the IR-40 Reactor was now expected to commence in the first quarter of 2014, not late 2013 as previously stated.

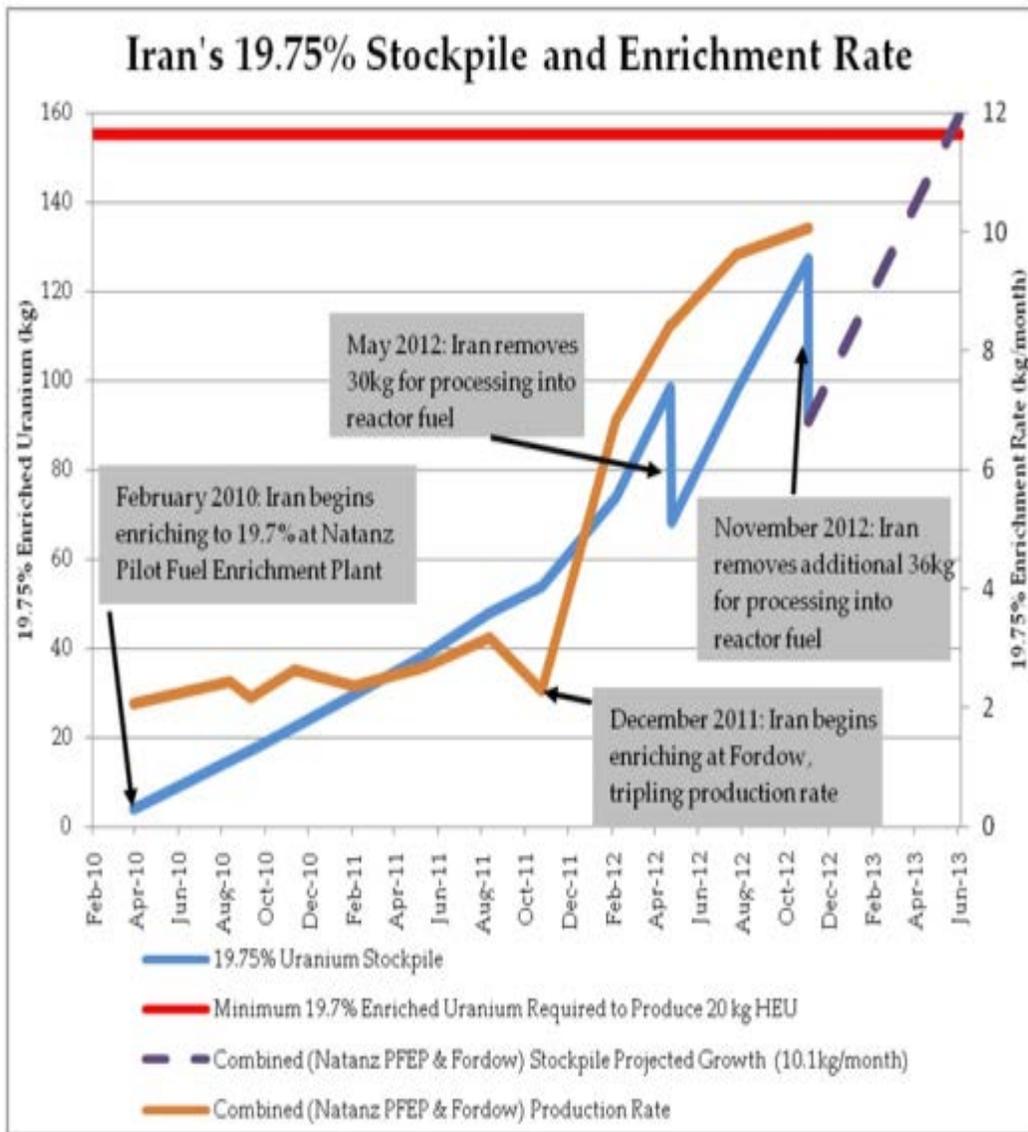
Source: David Albright, Andrea Stricker, and Christina Walrond, *ISIS Analysis of IAEA Iran Safeguards Report*, ISIS, November 16, 2012. http://isis-online.org/uploads/isis-reports/documents/ISIS_Analysis_IAEA_safeguards_Report_November_16_2012-final.pdf

Figure A25: Iran's Main Nuclear Facilities



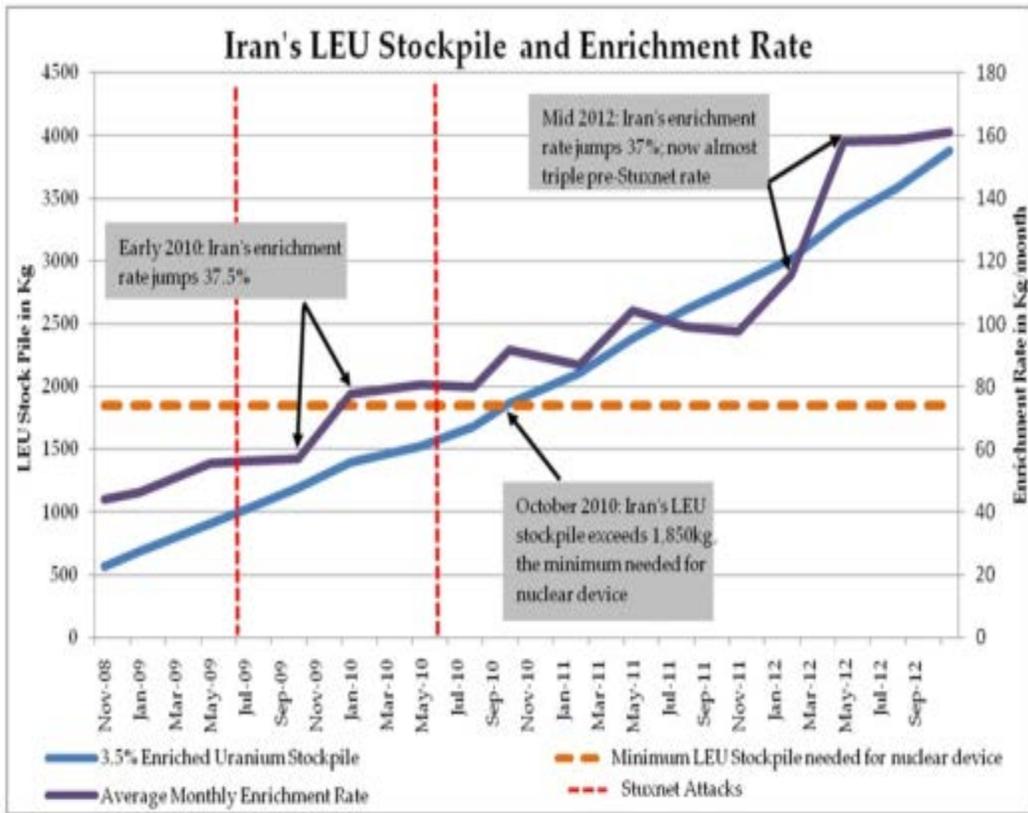
Source: Bipartisan Policy Center, "Iran's Nuclear Program: Status and Breakout Timing," September 12, 2011. <http://www.bipartisanpolicy.org/sites/default/files/Iran%20Nuclear%20Program.pdf>

Figure A26: Iran's 19.75% LEU Stockpile and Enrichment Rate



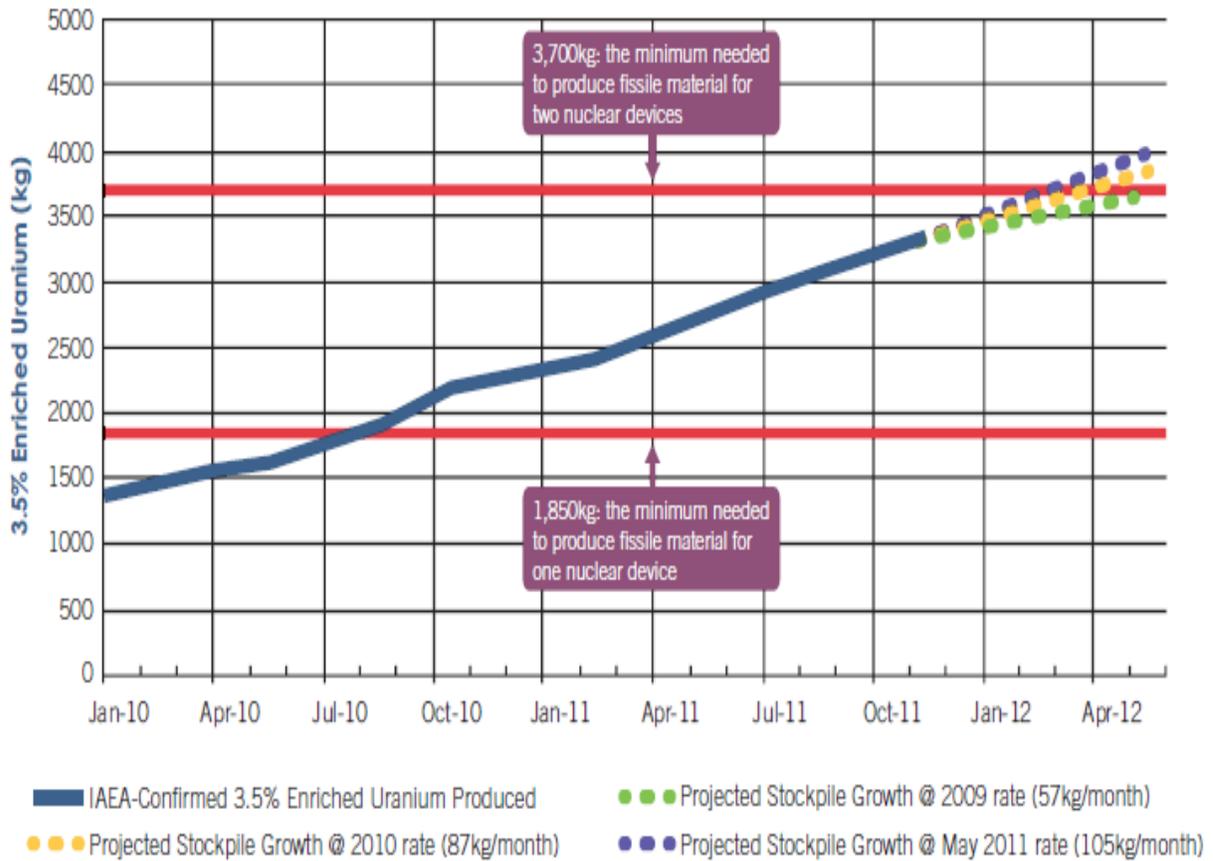
Source: Blaise Misztal, "Update on Iran's Nuclear Program, August 2012," Bipartisan Policy Center, November 19, 2012. <http://bipartisanpolicy.org/blog/2012/11/update-iran%E2%80%99s-nuclear-program>

Figure A27: LEU Stockpile and Enrichment Rate for 3.5% LEU



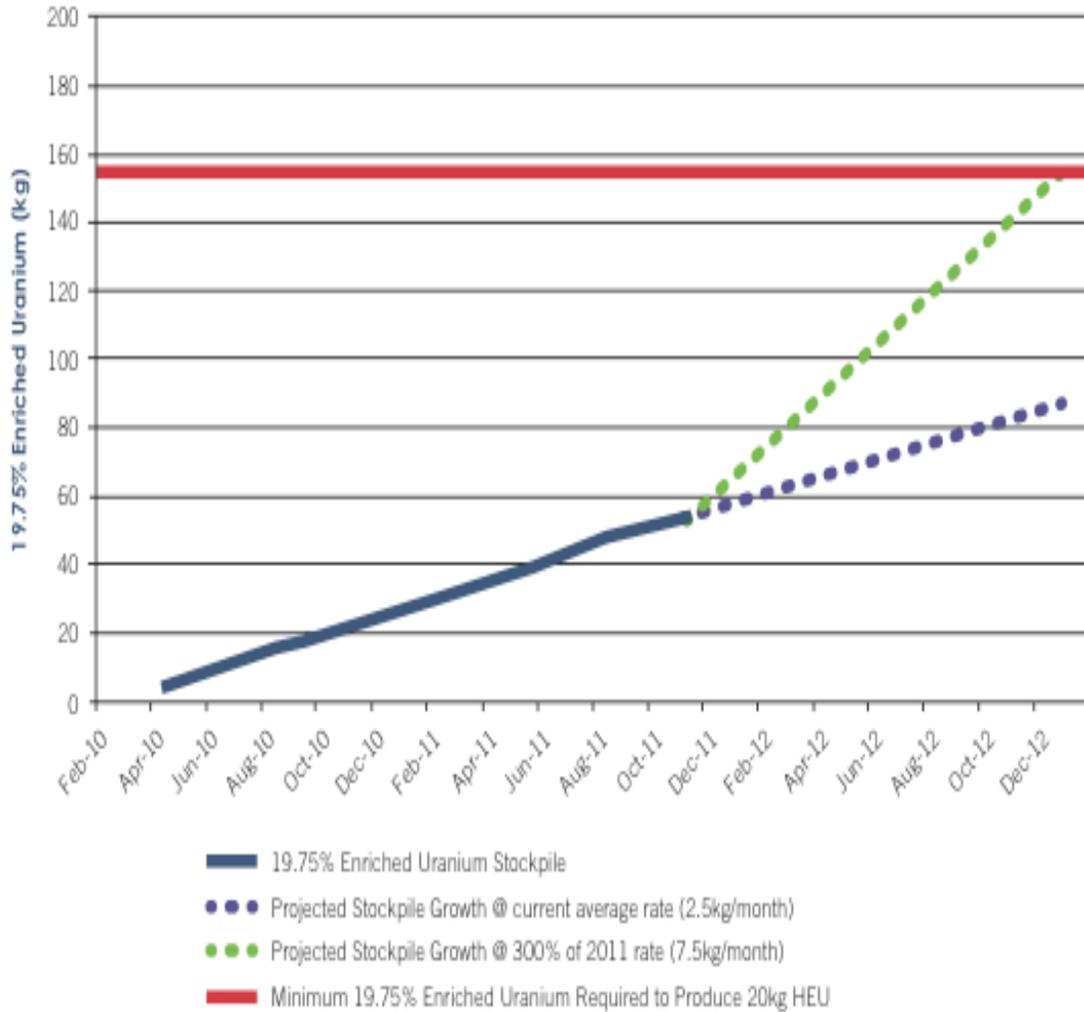
Source: Blaise Misztal, "Update on Iran's Nuclear Program, August 2012," Bipartisan Policy Center, November 19, 2012. <http://bipartisanpolicy.org/blog/2012/11/update-iran%E2%80%99s-nuclear-program>

Figure A28: Growth of Iran’s 3.5% Enriched Uranium Stockpile



Source: Bipartisan Policy Center, “Meeting the Challenge: Stopping the Clock,” February 2012.
<http://www.bipartisanpolicy.org/sites/default/files/BPC%20Iran%20Report.pdf>

Figure A29: Projected Growth of Iran’s 19.75% Enriched Uranium



Source: Bipartisan Policy Center, “Meeting the Challenge: Stopping the Clock,” February 2012.
<http://www.bipartisanpolicy.org/sites/default/files/BPC%20Iran%20Report.pdf>

Figure A30: Time to Produce 20 kg of HEU at Natanz Using a Two-Step Batch Recycling Process (assuming 7,027 SWU/year)

TIME TO PRODUCE 20 KG HEU AT NATANZ USING TWO-STEP BATCH RECYCLING (assuming 7,027 SWU/ year)					
CYCLE	FEEDSTOCK ENRICHMENT	FEEDSTOCK QUANTITY	PRODUCT ENRICHMENT	PRODUCT QUANTITY	TIME
FIRST	3.5%	734 kg	19.7%	62 kg	16 days
SECOND	19.7%	153.2 kg (62 kg from 1 st cycle + 91.2 kg from stockpile)	90%	20 kg	8 days
TOTAL					28 days

Source: Blaise Misztal, "Update on Iran's Nuclear Program, August 2012," Bipartisan Policy Center, November 19, 2012. <http://bipartisanpolicy.org/blog/2012/11/update-iran%E2%80%99s-nuclear-program>

Figure A31: Time to Produce 20 kg of HEU at Natanz Using a Three-Step Batch Recycling Process

TIME TO PRODUCE 20 KG HEU AT NATANZ USING THREE-STEP BATCH RECYCLING					
CYCLE	FEEDSTOCK ENRICHMENT	FEEDSTOCK QUANTITY	PRODUCT ENRICHMENT	PRODUCT QUANTITY	TIME
FIRST	3.5%	3,739 kg	19.7%	316 kg	79 days
SECOND	19.7%	407 kg (316 kg from 1 st cycle + 91.2 kg from stockpile)	55.4%	71.4 kg	13 days
THIRD	55.4%	71.4 kg	86.3%	21 kg	4 days
TOTAL					103 days

Source: Blaise Misztal, "Update on Iran's Nuclear Program, August 2012," Bipartisan Policy Center, November 19, 2012. <http://bipartisanpolicy.org/blog/2012/11/update-iran%E2%80%99s-nuclear-program>

Figure A32: Total Enriched Material, Centrifuges, and Enrichment Rate at Natanz and Fordow

NOVEMBER 16, 2012 IAEA REPORT OVERVIEW					
	NATANZ FUEL ENRICHMENT PLANT	NATANZ PILOT FUEL ENRICHMENT PLANT			FORDOW FUEL ENRICHMENT PLANT
		IR-1	IR-2M	IR-4	
CENTRIFUGES ENRICHING	9,156	328	176	176	696
TOTAL CENTRIFUGES INSTALLED	10,414	328	176	176	2,784
PRODUCT ENRICHMENT	3.5%	19.7%	N/A	N/A	19.7%
PRODUCED SINCE LAST REPORT	503kg	8.9kg	N/A	N/A	20.4kg
TOTAL PRODUCED	5,145kg	92.8kg	N/A	N/A	64.5kg
ENRICHMENT RATE	161kg/month	3.3kg/month	N/A	N/A	6.8kg/month
HIGHEST ENRICHMENT RATE	161kg/month (current)	3.3kg/month (current)	N/A	N/A	6.8kg/month (current)
TOTAL 3.5% STOCKPILE		3,881kg			
TOTAL 20% STOCKPILE		91.2 kg			

Source: Blaise Misztal, "Update on Iran's Nuclear Program, August 2012," Bipartisan Policy Center, November 19, 2012. <http://bipartisanpolicy.org/blog/2012/11/update-iran%E2%80%99s-nuclear-program>

Figure A33: Time to Produce 20kg of HEU at Natanz From 20% Enriched Uranium

TIME TO PRODUCE 20 KG HEU AT NATANZ FROM 20% ENRICHED URANIUM (assuming 7,027 SWU/ year)					
CYCLE	FEEDSTOCK ENRICHMENT	FEEDSTOCK QUANTITY	PRODUCT ENRICHMENT	PRODUCT QUANTITY	TIME
FIRST	19.7%	155 kg	90%	20 kg	8 days

Source: Blaise Misztal, "Update on Iran's Nuclear Program, August 2012," Bipartisan Policy Center, November 19, 2012. <http://bipartisanpolicy.org/blog/2012/11/update-iran%E2%80%99s-nuclear-program>

Figure A34: Lack of Iranian Cooperation with the IAEA as of February 25, 2011

Areas where Iran is not meeting its obligations, as indicated in this report and previous reports of the Director General Iran has not suspended its enrichment related activities as follows:

- Production of UF₆ at UCF as feed material for enrichment
- Manufacturing centrifuge components, and assembling and testing centrifuges
- Conducting enrichment related research and development
- Conducting operations, installation work and the production of LEU up to 3.5% U-235 at the Fuel Enrichment Plant (FEP)
- Conducting operations, installation work and the production of LEU up to 20% U-235 at the Pilot Fuel Enrichment Plant (PFEP)
- Conducting construction work at the Fordow Fuel Enrichment Plant (FFEP)

Iran is not providing supporting information regarding the chronology of the design and construction, as well as the original purpose, of FFEP Iran has not suspended work on heavy water related projects as follows:

- Continuing the construction of the IR-40 Reactor
- Production of heavy water at the Heavy Water Production Plant (HWPP)
- Preparing for conversion activities for the production of natural UO₂ for IR-40 Reactor fuel
- Manufactured a fuel assembly, fuel rods and fuel pellets for the IR-40 Reactor

Iran has not permitted the Agency to verify suspension of its heavy water related projects by:

- Not permitting the Agency to take samples of the heavy water stored at UCF
- Not providing access to HWPP

Iran is not cooperating with the Agency regarding the outstanding issues that give rise to concern about possible military dimensions to Iran's nuclear program:

- Iran is not providing access to relevant locations, equipment, persons or documentation related to possible military dimensions to Iran's nuclear program; nor has Iran responded to the many questions the Agency has raised with Iran regarding procurement of nuclear related items
- Iran is not engaging with the Agency in substance on issues concerning the allegation that Iran is developing a nuclear payload for its missile program. These issues refer to activities in Iran dealing with, inter alia:
 - neutron generation and associated diagnostics
 - uranium conversion and metallurgy
 - high explosives manufacturing and testing
 - exploding bridgewire detonator studies, particularly involving application necessitating high simultaneity
 - multipoint explosive initiation and hemispherical detonation studies involving highly instrumented experiments
 - high voltage firing equipment and instrumentation for explosives testing over long distances and possibly underground
 - missile re-entry vehicle redesign activities for a new payload assessed as being nuclear in nature

Iran is not providing the requisite design information in accordance with the modified

Code 3.1 in connection with:

- The IR-40 Reactor
- The announced new enrichment facilities
- The announced new reactor similar to TRR

Source: IAEA, *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, February 25, 2011
<http://www.iaea.org/Publications/Documents/Board/2011/gov2011-7.pdf>

Figure A35: IAEA on Plutonium/ Heavy Water Facilities as of May 24, 2011

Contrary to the relevant resolutions of the Board of Governors and the Security Council, Iran has not suspended work on all heavy water related projects, including the construction of the heavy water moderated research reactor, the IR-40 Reactor, which is under Agency safeguards.

As indicated in the Director General's previous reports, in light of the request by the Security Council to report to it on whether Iran has established full and sustained suspension of, inter alia, all heavy water related projects,³⁰ the Agency has requested that Iran make the necessary arrangements to provide the Agency, at the earliest possible date, with access to: the Heavy Water Production Plant (HWPP); the heavy water stored at the Uranium Conversion Facility (UCF) in order to take samples; and any other location in Iran where projects related to heavy water are being carried out. Iran has objected to the Agency's requests on the basis that they go beyond the Safeguards Agreement and because Iran has already stated that it has not suspended its heavy water related projects. The Security Council has decided that Iran shall provide such access and cooperation as the Agency requests to be able to verify the suspension of its heavy water related projects. To date, Iran has not provided the requested access.

While Iran has made statements to the effect that it has not suspended work on all its heavy water related projects, without full access to the heavy water at UCF, to HWPP, and any other heavy water related projects there may be in Iran, the Agency is unable to verify such statements and therefore to report fully on this matter.

On 10 May 2011, the Agency carried out a DIV at the IR-40 Reactor at Arak and observed that construction of the facility was ongoing and that the moderator heat exchangers had been delivered to the site. According to Iran, the operation of the IR-40 Reactor is planned to commence by the end of 2013.

Source: IAEA, *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, May 24, 2011.
<http://www.iaea.org/Publications/Documents/Board/2011/gov2011-29.pdf>

Figure A36: IAEA on Natanz, May 24, 2011

Fuel Enrichment Plant (FEP): There are two cascade halls at FEP: Production Hall A and Production

Hall B. According to the design information submitted by Iran, eight units are planned for Production Hall A, with 18 cascades in each unit. No detailed design information has yet been provided for Production Hall B.

On 14 May 2011, 53 cascades were installed in three of the eight units in Production Hall A, 35 of which were being fed with UF₆. Initially, each installed cascade comprised 164 centrifuges. Iran has modified 12 of the cascades to contain 174 centrifuges each. To date, all the centrifuges installed are IR-1 machines. As of 14 May 2011, installation work in the remaining five units was ongoing, but no centrifuges had been installed. There had been no installation work in Production Hall B.

Following a physical inventory verification (PIV) at FEP, the Agency confirmed that, as of 17 October 2010, 34 737 kg of natural UF₆ had been fed into the cascades since the start of operations in February 2007, and a total of 3135 kg of low enriched UF₆ had been produced.

Iran has estimated that, between 18 October 2010 and 13 May 2011, it produced an additional 970 kg of low enriched UF₆, which would result in a total production of 4105 kg of low enriched UF₆ since

February 2007. The nuclear material at FEP (including the feed, product and tails), as well as all installed cascades and the feed and withdrawal stations, are subject to Agency containment and surveillance. In a letter dated 4 April 2011, Iran informed the Agency that a metal seal in the feed and withdrawal area of FEP had been accidentally broken by the operator. The consequences for safeguards of this seal breakage will be evaluated by the Agency upon completion of the next P

Pilot Fuel Enrichment Plant (PFEP): PFEP is a research and development (R&D) facility and a pilot, low enriched uranium (LEU) production facility, which was first brought into operation in October 2003. It has a cascade hall that can accommodate six cascades, and is divided between an area designated for the production of LEU enriched up to 20% U-235 and an area designated for R&D.

In the production area, Iran first began feeding low enriched UF₆ into Cascade 1 on 9 February 2010, for the stated purpose of producing UF₆ enriched up to 20% U-235 for use in the manufacture of fuel for the Tehran Research Reactor (TRR). Since 13 July 2010, Iran has been feeding low enriched UF₆ into two interconnected cascades (Cascades 1 and 6), each of which consists of 164 centrifuges.

Iran has estimated that, between 19 September 2010 and 21 May 2011, a total of 222.1 kg of UF₆ enriched at FEP was fed into the two interconnected cascades and that approximately 31.6 kg of UF₆ enriched up to 20% U-235 was produced. This would result in a total of approximately 56.7 kg of UF₆ enriched up to 20% U-235 having been produced since the process began in February 2010.

In the R&D area, between 12 February 2011 and 21 May 2011, a total of approximately 331 kg of natural UF₆ was fed into centrifuges, but no LEU was withdrawn as the product and the tails of this R&D activity are recombined at the end of the process

Source: IAEA, *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, May 24, 2011.

Figure A37: IAEA Concerns as of June 2011

The head of the IAEA, Yukiya Amano, disclosed on June 3, 2011 that the IAEA had received “further information related to possible past or current undisclosed nuclear-related activities that seem to point to the existence of possible military dimensions to Iran’s nuclear program...The activities in Iran related to the possible military dimension seem to have been continued until quite recently.”

Amano said he had written last month to the head of Iran’s Atomic Energy Organization, Fereydoun Abbasi-Davani, “reiterating the agency’s concerns about the existence of possible military dimensions.” He had asked for Iran to “provide prompt access” to locations, equipment, documentation and officials to help resolve the agency’s queries, and had sent a new letter to Abbasi-Davani on June 3 “in which I reiterated the agency’s requests to Iran.”

In his May 26 letter to Amano, Abbasi-Davani reiterated Iran’s position that the allegations were fabricated, and said U.N. sanctions resolutions against the country were “illegal and unacceptable.”

Amano stated that, Iran was “not providing the necessary cooperation to enable the agency to provide credible assurance about the absence of undeclared nuclear material and activities in Iran... I urge Iran to take steps toward the full implementation of all relevant obligations in order to establish international confidence in the exclusively peaceful nature of its nuclear program.”

On June 8, 2011 Reuters reported that Iran had announced major new underground enrichment activity to start at Fordow, a mountain bunker near the clerical city of Qom. This facility was secret until September 2009, when Western intelligence revealed its existence and it and said it was evidence of covert nuclear work.

“This year, under the supervision of the (International Atomic Energy) Agency, we will transfer 20 percent enrichment from the Natanz site to the Fordow site and we will increase the production capacity by three times,” (Iranian state broadcaster IRIB, quoting Fereydoun Abbasi-Davani, head of Iran’s atomic energy agency, in briefing after a cabinet meeting.)

EU issued a statement at IAEA meeting stating: “We note with particular concern the announcement made only today by Iran that it will increase its capacity to enrich (uranium) to 20 percent, thereby further exacerbating its defiance of the United Nations Security Council.” It also calls on IAEA chief Yukiya Amano to submit “at the earliest possible date a comprehensive analysis of the possible military dimensions of Iran’s nuclear program” to the IAEA governing board.

Source: IAEA, “June Board of Governors Meeting Convened.” June 6, 2011
<http://www.iaea.org/newscenter/news/2011/bog060611.html>

Figure A38: November, 2012 - IAEA Concerns with the Parchin Facility

As previously reported, in resolution GOV/2011/69, the Board, inter alia, stressed that it was essential for Iran and the Agency to intensify their dialogue aimed at the urgent resolution of all outstanding substantive issues for the purpose of providing clarifications regarding those issues, including access to all relevant information, documentation, sites, material and personnel in Iran. In that resolution, the Board also called on Iran to engage seriously and without preconditions in talks aimed at restoring international confidence in the exclusively peaceful nature of Iran's nuclear programme. In light of this, from January 2012 onwards, Agency and Iranian officials held several rounds of talks in Vienna and Tehran, including during a visit by the Director General to Tehran in May 2012. However, no concrete results were achieved.⁷ In particular, there was no agreement on a structured approach to resolving outstanding issues related to possible military dimensions to Iran's nuclear programme and no agreement by Iran to the Agency's request for access to the Parchin site.

...As indicated in Section B above, since the November 2011 Board, the Agency, through several rounds of formal talks and numerous informal contacts with Iran, has made intensive efforts to seek to resolve all of the outstanding issues related to Iran's nuclear programme, especially with respect to possible military dimensions, but without concrete results. Specifically, the Agency has:

- Sought agreement with Iran on a structured approach to the clarification of all outstanding issues (referred to in paragraph 4 above), focusing on the issues outlined in the Annex to GOV/2011/65. Agreement has yet to be reached;
- Requested that Iran provide the Agency with an initial declaration in connection with the issues identified in Section C of the Annex to GOV/2011/65. Iran's subsequent declaration dismissed the Agency's concerns in relation to these issues, largely on the grounds that Iran considered them to be based on unfounded allegations;
- Identified, as part of the structured approach, thirteen topics, consistent with those identified in the Annex to GOV/2011/65, which need to be addressed;
- Provided Iran with clarification of the nature of the Agency's concerns, and the information available to it, about Parchin and the foreign expert,⁴³ and presented Iran with initial questions in this regard, to which Iran has not responded; and
- Requested on several occasions, from January 2012 onwards, access to the Parchin site. Contrary to Board resolution GOV/2012/50, Iran has still not provided the Agency with access to the site.

As stated in the Annex to the Director General's November 2011 report, information provided to the Agency by Member States indicates that Iran constructed a large explosives containment vessel in which to conduct hydrodynamic experiments; such experiments would be strong indicators of possible nuclear weapon development. The information also indicates that the containment vessel was installed at the Parchin site in 2000. As previously reported, the location at the Parchin site of the vessel was only identified in March 2011, and the Agency notified Iran of that location in January 2012. Iran has stated that "the allegation of nuclear activities in Parchin site is baseless".

As previously reported, satellite imagery available to the Agency for the period from February 2005 to January 2012 shows virtually no activity at or near the building housing the containment vessel. Since the Agency's first request for access to this location, however, satellite imagery shows that extensive activities and resultant changes have taken place at this location. Among the most significant developments observed by the Agency at this location since February 2012 are:

- Frequent presence of, and activities involving, equipment, trucks and personnel;
- Run off of large amounts of liquid from the containment building over a prolonged period;
- Removal of external pipework from the containment vessel building;
- Razing and removal of five other buildings or structures and the site perimeter fence;
- Reconfiguration of electrical and water supply infrastructure;
- Shrouding of the containment vessel building and another building; and

- Initial scraping and removal of considerable quantities of earth at the location and its surrounding area, covering over 25 hectares, followed by further removal of earth to a greater depth at the location and the depositing of new earth in its place.

In light of the extensive activities that have been, and continue to be, undertaken by Iran at the aforementioned location on the Parchin site, when the Agency gains access to the location, its ability to conduct effective verification will have been seriously undermined. While the Agency continues to assess that it is necessary to have access to this location without further delay, it is essential that Iran also provide without further delay substantive answers to the Agency's detailed questions regarding the Parchin site and the foreign expert, as requested by the Agency in February 2012.

Source: IAEA, *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, November 16, 2012.

Figure A39: November, 2012 - IAEA Reports Increased Output of 20% Enriched Uranium

Since Iran began enriching uranium at its declared facilities, it has produced at those facilities approximately:

- 7611 kg (+735 kg since the Director General's previous report) of UF₆ enriched up to 5% U-235, of which: 5303 kg is presently in storage; 1226 kg has been fed into the Pilot Fuel Enrichment Plant (PFEP) and 1029 kg has been fed into the Fordow Fuel Enrichment Plant (FFEP) for enrichment up to 20% U-235; and 53 kg has been fed into the Uranium Conversion Facility (UCF) for conversion to UO₂; and
- 232.8 kg (+43.4 kg since the Director General's previous report) of UF₆ enriched up to 20% U-235, of which: 134.9 kg is presently in storage; 1.6 kg has been downblended; and 96.3 kg has been fed into the Fuel Plate Fabrication Plant (FPFP) for conversion to U₃O₈.¹⁵

Source: IAEA, *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, November 16, 2012.

Figure A40: November 2012 - IAEA Reports the Number of Cascades at Natanz and Fordow has Increased

Natanz

As of 10 November 2012, Iran had fully installed 61 cascades in Production Hall A, 54 of which were declared by Iran as being fed with natural UF₆. Iran had also partially installed one other cascade. Preparatory installation work had been completed for another 28 cascades, and was ongoing in relation to 54 others. All of the centrifuges installed in Production Hall A are IR-1 machines.

Fordow

The facility, which was first brought into operation in 2011, contains 16 cascades, equally divided between Unit 1 and Unit 2, with a total of 2784 centrifuges. To date, all of the centrifuges installed are IR-1 machines. Iran has yet to inform the Agency which of the cascades are to be used for enrichment up to 5% U-235 and/or for enrichment up to 20% U-235.

Since the Director General's previous report, Iran has installed 644 centrifuges at FFEP, thereby completing the installation of centrifuges in all eight cascades in Unit 1, none of which it was feeding with UF₆. Iran had installed all eight cascades in Unit 2, four of which (configured in two sets of two interconnected cascades) it was feeding with UF₆ enriched up to 5% U-235 and four of which, having been subjected to vacuum testing, were ready for feeding with UF₆.

Source: IAEA, *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, November 16, 2012.

Figure A41: November, 2012 - IAEA Reports Fuel Fabrication and Uranium Conversion

According to the latest information available to the Agency:

- Iran has produced at UCF: 550 tons of natural UF₆, 99 tons of which has been sent to FEP; and
- Iran has transferred to TRR the following fuel items produced at FMP and FFPF: ten containing uranium enriched up to 20% U-235, four containing uranium enriched to 3.34% U-235 and five containing natural uranium.

...The Agency has verified that, as of 5 November 2012, Iran had produced 24 kg of uranium in the form of UO₂ during R&D activities involving the conversion of UF₆ enriched up to 3.34% U-235. Iran subsequently transferred 13.6 kg of uranium in the form of UO₂ to FMP. As of 6 November 2012, Iran had resumed these R&D activities, but had not produced additional uranium in the form of UO₂ from the conversion of UF₆ enriched to 3.34% U-235. As of the same date, Iran, through the conversion of uranium ore concentrate, had produced about 6231 kg of natural uranium in the form of UO₂, of which the Agency has verified that Iran transferred 3100 kg to FMP.

...On 7 November 2012, the Agency carried out a DIV and an inspection at FMP and confirmed that the manufacture of pellets for the IR-40 Reactor using natural UO₂ was ongoing. Iran informed the Agency that it had completed the manufacture of dummy fuel assemblies for the IR-40 Reactor. As of 7 November 2012, Iran had not commenced the manufacture of fuel assemblies containing nuclear material. On the same date, the Agency also verified two prototype fuel rods made of UO₂ enriched to 3.34% U-235 prior to their transfer to TRR.

...The Agency carried out a PIV at FFPF on 29 September 2012 and verified that, between the start of conversion activities on 17 December 2011 and 26 September 2012, 82.7 kg of UF₆ enriched up to 20% U-235 had been fed into the conversion process and 38 kg of uranium had been produced in the form of U₃O₈ powder and fuel items. Iran has declared that, between 27 September 2012 and 10 November 2012, it did not convert any more of the UF₆ enriched up to 20% U-235 contained in the cylinder attached to the process. On 11 November 2012, the Agency verified a new fuel assembly prior to its transfer to TRR and verified the presence of 46 fuel plates. On 12 November 2012, the Agency and Iran agreed to an updated safeguards approach for FFPF.

Source: IAEA, *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, November 16, 2012.

Figure A42: Four Step Process at Natanz

Table 1 summarizes predictions for a four-step breakout at the Natanz FEP. Eight simulations are reported, of which five considered slight variations on the single cascades currently installed at the FEP, and three considered the case in which new tandem cascades would be formed at the FEP.

These simulations did not incorporate Iran's existing LEU supplies. Instead, they started with natural uranium hexafluoride and could be repeated continuously.

ISIS estimates that, using a four-step process at the Natanz FEP, Iran would require at least 14.5-17 months to produce one SQ with its single cascades.

If Iran were to reconfigure some cascades into the tandem format, ISIS estimates that at least 9.5-13 months would be required for one SQ.

Scenario		Setup Time (months)	Enriching Time (months)	Total Time (months)
Single Cascades	1	0.5	14	14.5
	2	0.5	16.5	17
	3	0.5	13.5	14
	4	0.5	14.5	15
	5	0.5	14	14.5
New Tandem Cascades	6	1	9	10
	7	1	12	13
	8	1	8.5	9.5

Source: William C. Witt, Christina Walrond, David Albright, and Houston Wood, *Iran's Evolving Breakout Capacity*, ISIS, October 8, 2012.

http://www.isisnucleariran.org/assets/pdf/Irans_Evolving_Breakout_Potential_8October2012.pdf

Figure A43: Three Step Process at Natanz

With the three-step process, Iran would utilize its stored LEU to produce one (or a few) SQ(s) more quickly. Its 3.5 percent and 19.75 percent stocks would be used as feed for the second and third steps in the Khan process, eliminating the need for the first step (natural uranium to 3.5 percent). Predicted breakout times for this approach are summarized in Table 2.

The estimates are made assuming the stockpile sizes reported in the August 2012 IAEA Iran safeguards report. One set of predictions is made with the near 20 percent LEU hexafluoride stock taken as 91.4 kg, and a second set is made which includes the extra 25 kg of the same material stored at the uranium conversion facility.

The second set of calculations shows how the breakout times generally decrease as the stockpile sizes increase. Again, eight simulations are reported, some based on the single cascades currently installed at the FEP, and the rest assuming that new tandem cascades would be formed at the FEP. Iran could not follow this strategy indefinitely because its LEU stockpiles are limited.

ISIS estimates that, using a three-step process at the Natanz FEP, Iran would require at least 2.5-4.1 months to produce one SQ with its single cascades if it only used the LEU hexafluoride stored at enrichment facilities, and at least 2.3-2.5 months if it also used the LEU hexafluoride currently scheduled for conversion to oxide form.

If Iran were to reconfigure some cascades into the tandem format, ISIS estimates that at least 2.3-2.7 months would be required for one SQ if the extra LEU hexafluoride is excluded, and at least 2.0-2.3 months if the extra LEU hexafluoride is included.

Scenario	Setup Time (months)	Enriching Time (months)	Total Time (months)	Enriching Time Extra 25 kg 20% UF6 (months)	Total Time Extra 25 kg 20% UF6 (months)	
Single Cascades	1	0.5	2.0	2.5	2.0	2.5
	2	0.5	3.6	4.1	1.9	2.4
	3	0.5	2.0	2.5	2.0	2.5
	4	0.5	2.5	3.0	2.0	2.5
	5	0.5	2.0	2.5	1.8	2.3
New Tandem Cascades	6	1	1.3	2.3	1.1	2.1
	7	1	1.7	2.7	1.0	2.0
	8	1	1.3	2.3	1.3	2.3

Source: William C. Witt, Christina Walrond, David Albright, and Houston Wood, *Iran's Evolving Breakout Capacity*, ISIS, October 8, 2012.

http://www.isisnucleariran.org/assets/pdf/Irans_Evolving_Breakout_Potential_8October2012.pdf

Figure A44: Multiple Significant Quantities Using the Three Step Process at Natanz

At this time, Iran could dash to one SQ most quickly with the three-step process at the Natanz FEP. However, it could only produce a few SQs in this manner before depleting its LEU stockpiles. [

The chart below shows that Iran could produce at most two SQs this way with its single cascades, and at most four SQs if it formed new tandem cascades.

Notice that in order to conserve enough feed to produce multiple SQs, Iran would have to run its cascades more conservatively and would have to wait longer for the first SQ.

In the case of single cascades, Iran might attempt a tails recovery strategy after a three-step breakout, re-enriching the waste from its cascades to obtain a few additional SQs.

Not surprisingly, tandem cascades, which include some measure of tails recycling in their design, would allow Iran to more effectively convert its LEU into WGU.

Scenario		Time for One SQ (months)	Time for 1 st /2 nd SQs (months)	Time for 1 st /2 nd /3 rd SQs (months)	Time for 1 st /2 nd /3 rd /4 th SQs (months)
Single Cascades	1	2.5	4.4/8.3	x	x
	2	4.1	x	x	x
	3	2.5	2.6/4.6	x	x
	4	3.0	3.1/5.7	x	x
	5	2.5	3.0/5.5	x	x
New Tandem Cascades	6	2.3	2.7/4.3	2.7/4.5/6.2	3.0/5.0/6.9/8.9
	7	2.7	4.0/6.9	3.9/6.9/9.8	4.0/6.9/9.9/12.8
	8	2.3	2.5/3.9	2.6/4.1/5.7	3.1/5.2/7.3/9.4

Source: William C. Witt, Christina Walrond, David Albright, and Houston Wood, *Iran's Evolving Breakout Capacity*, ISIS, October 8, 2012.

http://www.isisnucleariran.org/assets/pdf/Irans_Evolving_Breakout_Potential_8October2012.pdf

Figure A45: Four and Three Step Processes at Fordow - Future Potential

Iran appears to be prioritizing the Fordow facility for new IR-1 installation.

The facility is built to hold 2,784 centrifuges. It is reasonable to expect that the Fordow facility could be operating at full capacity sometime in the first half of 2013, given that Iran has already installed three-fourths of the necessary centrifuges.

Estimates for a four- and three-step breakout at Fordow that reflect the expected increases in capacity are given in Table 4.

The three-step prediction is made based on Iran's August 2012 stockpile sizes. Most likely, these stockpiles will change over the next few months. With greater 3.5 percent and near 20 percent supplies, Iran could break out more quickly and produce more SQs.

ISIS estimates that, at the Fordow facility in 2013, assuming its August 2012 LEU stockpiles, Iran would require at least 38 months to produce one SQ with a four-step process and at least 5.5 months to produce one SQ with a three-step process and its LEU supplies.

Full Capacity	Setup Time (months)	Enriching Time (months)	Total Time (months)
Four-Step Process	0.5	37.5	38
Three-Step Process	0.5	5.0	5.5

Source: William C. Witt, Christina Walrond, David Albright, and Houston Wood, *Iran's Evolving Breakout Capacity*, ISIS, October 8, 2012.

http://www.isisnucleariran.org/assets/pdf/Irans_Evolving_Breakout_Potential_8October2012.pdf

Figure A46: Two Step Process at Natanz - Future Potential

If Iran produces enough near 20 percent LEU, it could break out in two steps rather than three, devoting all cascades to further enriching that material. In these scenarios, Iran does not replenish its 3.5 percent or 19.75 percent LEU.

Iran does not currently possess enough and is not expected to have such large quantities of near 20 percent LEU until at least late 2012 or more likely sometime in 2013.

The Table lists the amount of near 20 percent feed as well as the estimated time required to produce one SQ using this method at Natanz. The estimated feed requirement varies considerably, with much more 20 percent material needed in the simulations involving single cascades.

The tails recycling feature of the tandem cascades helps them conserve feed. In both cases, the estimated setup time is generally longer than the estimated enriching time.

ISIS estimates that, using a two-step process at the Natanz FEP, Iran would require at least 0.9-1.2 months and 320-380 kg of near 20 percent LEU hexafluoride to produce one SQ with single cascades.

If Iran were to form new tandem cascades, ISIS estimates that it could produce one SQ in a slightly longer 1.4 to 1.7 months, but would require only 180-230 kg of near 20 percent feed.

Scenario		Required 20% Stockpile (kg UF6)	Setup Time (months)	Enriching Time (months)	Total Time (months)
Single Cascades	1	320	0.5	0.4	0.9
	2	380	0.5	0.4	0.9
	3	320	0.5	0.7	1.2
New Tandem Cascades	4	180	1	0.7	1.7
	5	200	1	0.5	1.5
	6	200	1	0.5	1.5
	7	230	1	0.4	1.4

Source: William C. Witt, Christina Walrond, David Albright, and Houston Wood, *Iran's Evolving Breakout Capacity*, ISIS, October 8, 2012.

http://www.isisnucleariran.org/assets/pdf/Irans_Evolving_Breakout_Potential_8October2012.pdf

Figure A47: Two Step Process at Fordow - Future Potential

The same two-step strategy could be employed at the Fordow facility. Again, Iran does not currently possess a large enough 20 percent stockpile for this process, but will likely have enough 20 percent material in late 2012 or sometime in 2013.

The Table gives the estimated time and near 20 percent LEU hexafluoride feed requirements for a two-step breakout at Fordow, assuming it operates at full capacity and that its cascades are arranged in tandem pairs.

ISIS estimates that, using a two-step process at the Fordow facility in 2013, Iran would require at least 2.0-2.2 months and 200-220 kg of near 20 percent LEU hexafluoride feed to produce one SQ.

20% Stockpile (kg UF6)	Setup Time (months)	Enriching Time (months)	Total Time (months)
200	0.5	1.7	2.2
220	0.5	1.5	2.0

Source: William C. Witt, Christina Walrond, David Albright, and Houston Wood, *Iran's Evolving Breakout Capacity*, ISIS, October 8, 2012.

http://www.isisnucleariran.org/assets/pdf/Irans_Evolving_Breakout_Potential_8October2012.pdf

Figure A48: Two Step Process at Natanz and Fordow Together - Future Potential

Assuming the Fordow facility operates at full capacity, Iran could combine it with the Natanz FEP for the fastest two-step breakout.

Furthermore, by combining the single cascades at Natanz with the tandem cascades at Fordow, Iran could achieve a rapid breakout with only a moderate amount of near 20 percent LEU. Table 8 gives estimated breakout times generated using this strategy.

ISIS estimates that, using a combined two-step process at the Natanz FEP and at the Fordow facility in 2013, Iran would require at least 0.8-1.0 months and 240-270 kg of near 20 percent LEU hexafluoride to produce one SQ with its single cascades at Natanz.

If Iran were to form new tandem cascades at Natanz, ISIS estimates that Iran could produce one SQ in a slightly longer period of time, 1.3-1.4 months, but would require only 190-200 kg of near 20 percent LEU feed.

Scenario		Required 20% Stockpile (kg UF6)	Setup Time (months)	Enriching Time (months)	Total Time (months)
Single cascades at Natanz; Tandem cascades at Fordow	1	250	0.5	0.4	0.9
	2	270	0.5	0.3	0.8
	3	240	0.5	0.5	1.0
	4	270	0.5	0.3	0.8
	5	270	0.5	0.4	0.9
Tandem cascades at both Natanz and Fordow	6	200	1	0.3	1.3
	7	190	1	0.4	1.4
	8	190	1	0.4	1.4

Source: William C. Witt, Christina Walrond, David Albright, and Houston Wood, *Iran's Evolving Breakout Capacity*, ISIS, October 8, 2012.

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Warfighter in their defining moments. The PAC-3 Missile is a high velocity interceptor that defeats incoming targets by direct, body-to-body impact. PAC-3 Missiles, when deployed in a Patriot battery, will significantly increase the Patriot system's firepower, since 16 PAC-3s load-out on a Patriot launcher, compared with four of the legacy Patriot PAC-2 missiles. ... The PAC-3 Missile Segment upgrade consists of the PAC-3 Missile, a highly agile hit-to-kill interceptor, the PAC-3 Missile canisters (in four packs), a fire solution computer and an Enhanced Launcher Electronics System (ELES). These elements are integrated into the Patriot system, a high to medium altitude, long-range air defense missile system providing air defense of ground combat forces and high-value assets. The PAC-3 Missile uses a solid propellant rocket motor, aerodynamic controls, attitude control motors (ACMs) and inertial guidance to navigate. The missile flies to an intercept point specified prior to launch by its ground-based fire solution computer, which is embedded in the engagement control station. Target trajectory data can be updated during missile flyout by means of a radio frequency uplink/downlink. Shortly before arrival at the intercept point, the PAC-3 Missile's on board Ka band seeker acquires the target, selects the optimal aim point and terminal guidance is initiated. The ACMs, which are small, short duration solid propellant rocket motors located in the missile forebody, fire explosively to refine the missile's course to assure body-to-body impact."

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