MASSACHUSETTS INSTITUTE OF TECHNOLOGY

REVIEW PANEL ON SPECIAL LABORATORIES

FINAL REPORT

OCTOBER, 1969

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I. Introduction

This Report is the second and final Report of the Review Panel for Special Laboratories. It contains sections which differ from one another in that they were prepared at different times and by rather different processes.

The First Report of the Panel was submitted on May 31, 1969. It was based on very intensive efforts by the Panel working as a group from April 26 to May 31, 1969 and contains the Panel's principal policy recommendations. It appears as Section II of this Report.

Because of the importance of the policy issues it faced, the Panel did not devote its energies to the development of descriptive material for its First Report. This material, including histories of each of the two laboratories, is included in Section V of this Report. Listings of the projects at the laboratories which are both complete and unclassified are under preparation by the administration and will be made available when complete. The Panel urges that the assembly of these listings proceed with all deliberate speed.

Since May 31 the Panel has not worked as one group but in subgroups and as individuals. In an environment as rapidly changing as the one surrounding the members of the Review Panel it is not surprising perhaps that individual positions have changed or become clarified since May 31. Evidence of some of these changes appear in Section IV which contains personal statements of Panel members. Some of these statements are related to the work of the Panel and some are directed to issues and concerns not included in our charge but which individuals saw more clearly as a result of their work with the Panel and upon which they felt an obligation to comment.

This Report also contains one policy recommendation in addition to those which appear in the First Report.

II. First Report of the Review Panel on Special Laboratories, May 31, 1969[1]

1. Members of the Review Panel

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Robert L. Bishop
Dean, School of Humanities and Social Science

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Peter Elias
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Peter R. Gray
Alumnus, Class of 1961

David G. Hoag, Director of Apollo Group
Instrumentation Laboratory

Jonathan P. Kabat
Graduate Student, Biology

George N. Katsiaficas
Student, Management

Irwin L. Lebow
Group Leader, Lincoln Laboratory

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[1] The members of the Panel are in substantial agreement with this report except as otherwise indicated in the additional statements attached hereto.*

* In a letter dated September 17, 1969, Jonathan P. Kabat indicated he wished to make an additional comment on this statement. It appears in Section IV of this Report.

Members of the Review Panel (continued)

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2. Preamble

Among the several laboratories in which the research activities of M.I.T. are centered, two are distinguished by their size and the nature of their programs as "special laboratories."

Instrumentation Laboratory, since its formation more than 25 years ago by a faculty group led by Professor C. Stark Draper in the Department of Aeronautics and Astronautics, has been at the forefront of guidance, navigation, and control technology. Its current effort, supported by many separate contracts, is about equally divided between NASA and Department of Defense programs. It has been responsible for the guidance systems for the Apollo and for several generations of ballistic missiles.

Lincoln Laboratory was created 18 years ago in response to urgent appeals to M.I.T. by the Department of Defense to do research and development directed at continental air defense. The laboratory is almost totally supported by the DOD with major programs in space communications, re-entry technology, radar technology, solid state research, and other areas of applied electronics. It has made major contributions to the technology of such early warning systems as SAGE, DEW and BMEWS and has built several experimental communications satellites.

The annual budget in Fiscal 1968 for both laboratories was about $120 million; the total M.I.T. budget was $214 million.

On April 25, 1969, M.I.T. President Howard W. Johnson formed the Review Panel on Special Laboratories to examine the relationships between M.I.T. and these two laboratories. The Panel consisted of twenty-two members including faculty, administration, alumni, trustees, students, laboratory staff and one member not affiliated with M.I.T. The Panel was asked specifically:

1. "to conduct a full assessment of the laboratories' relationship to M.I.T.";
2. "to evaluate the implications that the laboratories have for the Institute in its prime responsibility for education and research and in its responsibility for service to the nation"; and
3. "to review" the following:
    a. "the appropriateness for Institute sponsorship of the current programs at the laboratories";
    b. "the decision-making process by which new programs are accepted";
    c. "the relationship of the laboratories to on-campus research and education"; and
    d. "in general, the long-standing policies and procedures with respect to public service obligations."

From the beginning of its deliberations, the Panel recognized both the great responsibility it had been assigned and the complexity of the issues it had been asked to consider. Most of these issues are not new, though some have become more pressing as the size of the laboratories rapidly expanded beyond that anticipated by those involved in their original organization. These issues were considered carefully at the time the laboratories were established and not everyone, even at that time, was convinced that M.I.T. was embarking on a wise course of action. Since then these questions have been raised periodically and decisions made which have led to the situation which exists today.

The Panel quickly became aware that the evolution of these laboratories over many years has yielded a spectrum of expectations and obligations which involve individuals and organizations both inside and outside the M.I.T. community. It is also aware that these expectations and obligations cannot and should not be revised unilaterally or in such haste as to preclude a most careful consideration of each proposed change. The final decision as to the course to be taken should give due consideration to the views and interests of the parties involved.

The Panel is aware, however, that certain policy decisions need to be made by M.I.T. to reduce the uncertainty which has arisen on all sides as a result of the questions which the Panel was asked to consider. In this report the Panel recommends for the President's consideration some specific decisions and a framework for future action.

In its deliberations, the Panel encouraged the maximum degree of input from all relevant sources that could be managed in the time available. We took extensive oral and written testimony from interested parties in the M.I.T. community, visited the laboratories, asked a number of individuals to meet with the Panel to present their views and respond to our questions, sought out interested and knowledgeable persons outside the community--especially in government--and, of course, conducted our own discussions. All of the sessions were open and transcripts are available in the M.I.T. Student Center Library.

3. Introduction

A. M.I.T.

In working toward its final conclusions the Panel came to agreement on a set of fundamental premises about M.I.T. These premises served as the basis of the Panel's analysis of the particular questions it addressed, and they are therefore a necessary preamble to its conclusions and recommendations.

1. M.I.T. is a community of individuals dedicated to learning, the free exchange of ideas, and critical analysis.

2. M.I.T. interacts with society through ideas, artifacts and people by means of its teaching, research and public programs.

3. M.I.T. should preserve a creative environment for the generation of new ideas and methods that can enlarge our body of knowledge and

insight, for these are an important means by which it serves society. Essential to this creative environment is a commitment to the concept of academic freedom and free exchange of ideas, jealously protected from inhibiting restrictions.

4. M.I.T. must recognize that it operates within certain constraints:

a. Intellectual, human, physical, and financial resources are always limited. Undertaking new programs will thus have effects on existing commitments and vice versa.

b. Research today often requires large team efforts or expensive equipment. Frequently, therefore, large financial support and close involvement with industry and government are required.

c. Activity in education and research at M.I.T. must be consonant with underlying principles of humaneness and public benefit. The impact on society and on the university community of specific projects must be recognized.

B. Technology and society

Science and technology are powerful forces that have brought inestimable benefits to society, but today two major problems stand out which we face in the nation at large and at M.I.T.

1. The effects of technology on society are difficult to predict and control; they are poorly understood and often have unexpectedly harmful

aspects. In the past few years some of the detrimental effects have become painfully apparent, and the resulting needs of society urgently require new approaches and means to deal with them. As a corollary, there is an imperative need for meaningful evaluation of the effects of technology on society.

2. We find today a heavy emphasis on defense-related research and development in the country at large, an emphasis which detracts from similar efforts aimed at other urgent needs of society. Although the emphasis on defense work came about as a response to perceived national needs, it has hampered the nation's ability to cope with the problems of the contemporary world. As far as M.I.T. is concerned, the nation's emphasis on defense produces a bias toward specific areas of research at the Institute, and makes it more difficult to move in other directions. M.I.T. has a role to play in attempting to redress this balance, not only within itself but also at the national level.

C. The Special Laboratories

The two special laboratories have quite different histories, even though they pose many similar issues for the Institute. Instrumentation Laboratory is a direct descendant of the work on gunfire control begun during World War II by Professor Draper; in fact, the Laboratory has been continuously guided by the genius of Professor Draper, its first and current Director. It is an advanced technology laboratory devoted primarily to vehicle guidance and control, largely for space and military applications; its current triumph is the magnificent performance of the Apollo guidance system. The laboratory's competence in guidance technology stands out nationally and internationally to such an extent that it can best be described as unique.

Lincoln Laboratory, on the other hand, was created in 1951 in response to what was perceived to be a pressing national requirement in the air defense field. It is a broadly based electronics research laboratory, working in basic and applied research, as well as on specific military projects. Among many other accomplishments, it has made possible unique achievements by M.I.T. faculty and students in the field of radio astronomy. Lincoln Laboratory, more diversified in its interests, though more closely tied to defense missions than Instrumentation Laboratory, is generally considered to be one of the best electronics laboratories in the world. In some portions of the field, it too appears to be essentially unique.

Both laboratories were founded, it should be noted, during a period in which there was little debate about the appropriateness of a university responding to a military need. The missions of the laboratories have evolved and changed over the years.

The histories of the laboratories, the ways in which they have evolved and their changing relationship to the campus are all relevant matters. But a most important fact is that both laboratories have been superbly successful in meeting their defined missions. Moreover, both represent a high degree of excellence in their fields. The fact that these laboratories have been spawned and directed by M.I.T. and that they have both performed high priority national missions and performed them well we believe is a source of justifiable pride to the Institute.

To say, however, that the laboratories are of top technical quality and that they have been performing their missions well does not necessarily imply that there should be no changes in the future. It is that question--what changes should there be in the future--that has dominated the Panel's deliberations.

4. Conclusions and recommendations

We arrived at our conclusions and recommendations after considering the following aspects: present and potential education and research interactions between the laboratories and the campus; the proper roles for M.I.T. in relation to military research and development; the effect of the laboratories' emphasis on defense subjects upon the overall balance of M.I.T.'s activities; the implications for M.I.T. of the sheer size of the laboratories; the appropriateness of specific projects underway and proposed; possible new mechanisms for project review; and possible future goals for the laboratories. This list does not exhaust the issues that were considered at some length, but it gives a fair impression of the scope of the inquiry.

A. Long-term objectives and implications for the special laboratories

The Panel's views on the possibilities for the long-range evolution of the laboratories are predicated on the following objectives for the Institute as a whole:

1. M.I.T.'s non-academic public service (those services to society that go beyond teaching and scholarly research) should be diversified by including a considerably larger non-military component devoted to the major problems of society.

2. M.I.T. should not overcommit its human and material resources in fulfilling its non-academic public service role in order to avoid degrading its primary function of education and research.

3. M.I.T. should evolve diverse institutional mechanisms so that its future response to the needs of society can be flexible,

original and significant.

4. M.I.T.'s efforts in non-academic public service should always include intimate involvement of faculty and students, both in the selection of projects and as participants in their implementation.

In a world in which applications of technology have increasing importance, it seems clear that M.I.T. will want a variety of opportunities to interact with practical problems, sometimes involving large-scale projects, in its education, research and public service roles. The existing special laboratories have provided a major source of such opportunities, primarily in research and development areas supported by DOD and NASA. While this has presented exciting opportunities for a limited number of students and faculty, the scope of the available programs is narrow compared to the diversity of campus interests. For responding to future challenges, M.I.T. should have the same flexibility which it illustrated in the past by starting the special laboratories. Equivalent challenges may arise in such fields as biomedical engineering, transportation, and many others. New opportunities will be needed to make possible more broadly based participation, particularly in non-defense areas.

In the long term we expect that there will be an increasing public awareness of the powerful contributions that universities can make to the solution of pressing social problems which face the country, and we hope that the necessary funds will be provided by government agencies. The nation's universities should consider it their responsibility to help bring this about.

The present programs at the laboratories (particularly at Lincoln Laboratory) are limited in range of sponsorship, to a large extent military in orientation, and large in total scale. This presents a serious problem of imbalance for M.I.T., which has been discussed earlier. Given the limitations on M.I.T.'s central administration and fiscal resources, the Panel does not feel that M.I.T. can correct the imbalance and respond to future challenges simply by adding new large laboratories to its direct administrative structure. Such simple addition would also increase concern as to the relative roles of teaching and research at M.I.T. We feel, therefore, that a continuation in the long term of the present mix and scale of the programs of the special laboratories would not fulfill M.I.T.'s ultimate objective.

Alternative strategies must therefore be considered for the future involvement of M.I.T. in mission-oriented work. Some suggestions follow:

1. Major conversion of activities in the existing laboratories to non-military areas could be attempted. There is considerable enthusiasm among laboratory staff for applying their technological talents to new kinds of problems. If such a diversification is sufficiently successful, it may fulfill the need for broader capabilities and it may supply to a much larger group of students and faculty the same kind of opportunities which the laboratories already provide to a smaller group. In this process, changes in administrative structure of the laboratories may be appropriate. Moving

into new areas requires a careful match of talents, leadership and financial support, which M.I.T. as a whole should help to provide. There are, however, substantial difficulties in accomplishing these objectives. A conversion of this scale without substantial growth implies a significant reduction in defense work. This might be undesirable from the standpoints of both the Department of Defense and the laboratory staff engaged in defense projects.

2. Another alternative would be the creation of new laboratories or of affiliations with other organizations in order to be able to deal on an appropriate scale with problems outside the scope of the present special laboratories. This would be accomplished by an evolutionary reduction in the scale of the laboratories, by their increased independence from M.I.T., or by their ultimate separation. An intermediate possibility is that different segments of the laboratories evolve into different relationships with M.I.T., some parts becoming independent institutions, some parts becoming much closer to the campus, some maintaining their current relationship, with different degrees of conversion from defense to non-military work. M.I.T.'s total commitment to defense work would then be reduced relative to its commitment to other areas.

For the long term, it is important that all options be fully considered in the light of developing circumstances, and that decisions have due regard for the important considerations of size and balance.

B. Recommendations

In view of the above long-term objectives we have a number of recommendations directed primarily toward the next few years, based on the judgment of the Panel that in the present circumstances the laboratories will remain part of M.I.T.

1. The laboratories and M.I.T. should energetically explore new projects to provide a more balanced research program. Since the special laboratories are currently committed in a major way to important defense-related problems, it is obvious that they cannot precipitously modify their mix. Rapid changes cannot be expected, but we feel that a real sense of urgency is required in the redeployment of our energies.

It is important to note that the objective of this recommendation is not the ultimate elimination of all defense work in the special labora- tried it tories. The country's scientific and technological base rests in large part in the universities and this base should be available to support advances in defense-related fields. It is therefore clear that the two special laboratories should continue research on defense problems.

2. The educational interaction between the special laboratories and the campus should be expanded. The Panel encourages the special laboratories and the departments to explore methods of expanding the number and variety of educational programs in which the laboratories can participate. The laboratories can benefit from the infusion of new ideas from faculty and students, while faculty and students can in turn benefit from the staff and facilities made available in the laboratories and from the opportunity to work on important scientific and engineering problems.

Some specific possibilities which have occured to the Panel are:

a. "Project laboratory" work at Lincoln Laboratory.

b. Cooperative work-study programs between academic departments and the special laboratories.

c. More direct communication from the laboratories to students and faculty on program descriptions, and thesis and part-time employment opportunities.

The Panel further encourages the exploration of new techniques for integrating the research staff of the laboratories into the functioning of the M.I.T. community.

3. <u>There should be intensive efforts to reduce classification and clearance barriers in the special laboratories</u>. The Panel recognizes that classified work may have to be continued at the laboratories, but recommends reducing the present amount of classified research to a minimum, both by selection of projects and by pressing for declassification wherever possible. In particular, classification of project descriptions must be severely limited or removed entirely, since this practice prevents the M.I.T. community as a whole from knowing even the nature of some of M.I.T.'s activities.

Changes are also required in the physical arrangements to make it easy for uncleared students and faculty to participate in the unclassified parts of the laboratories' program. These steps are essential to achieve the desired increase in campus interaction and must be pursued, even at the cost of administrative inconvenience.

4. <u>A Standing Committee on the special laboratories should be established</u>. The existing processes by which the two laboratories undertake new projects differ, but both include a weighing of the sponsors' needs, the importance of the program, the laboratory's capabilities and the appropriateness of the program for M.I.T. Final responsibility in this review is exercised by the M.I.T. administration which acts on behalf of the M.I.T. community. We propose the establishment of a Standing Committee as a means of providing the President with the considered advice of students, faculty, and laboratory staff. At the same time, this Standing Committee could provide a useful means for informing and involving the community in the laboratories' programs.

The Panel's recommendations for the selection and operation of this committee, and a further assessment of its role appear in Section 5 of this report. Some guidelines for the consideration of the Standing Committee appear in an Appendix.

We recognize that some time may elapse before the proposed Standing Committee becomes operational. In the meantime the present moratorium on new classified research projects at the special laboratories should be discontinued with the receipt of this report. Decisions with respect to new projects (classified and unclassified) may be necessary;

if so, ad hoc procedures may provide a useful substitute for the Committee.

A second function of the Standing Committee--that of reviewing existing programs--has performed in part by this Panel. Our findings are discussed in the next section.

C. Discussion of present projects

Though the Panel believes that a university role in defense research is appropriate, we also believe, as noted in our basic premises, that the university community is properly concerned with the nature of specific projects carried on within its confines. Accordingly, the projects at the special laboratories ought to be examined on the basis of a variety of criteria that include representation of community attitudes toward the appropriateness of certain kinds of work for a university-affiliated laboratory, as well as more obvious questions of educational benefit, intellectual interest, uniqueness of program for M.I.T., importance of problem, and so forth.

There remain complex issues as to which of the tasks facing society are appropriate for the university, as a humane institution. These questions are most acute in the military domain, but are not restricted to it. We attempted to write guidelines in this area, searching for usable criteria for choice. We considered possible criteria such as: Is the military application offensive or defensive? Will the work contribute primarily to existing military hostilities? Is it tied directly to a capability for destroying human life? Is it justified on strategic grounds, or is it an unnecessary escalation of the arms race? Do the potential civilian applications outweigh the military? Are some sponsors acceptable and others not?

As soon as these questions are asked about specific projects, it becomes obvious that collective judgments on military and strategic policy would be necessary. The Panel believes such judgments are inappropriate for any official group at the Institute to make. This is not to say members of the Panel may not speak out as individuals on these matters.

In addition, we believe there is an important difference between undertaking research and development and making a decision to build and deploy specific systems. Research and development may easily be justified on many grounds--to avoid technological surprise, to evaluate opponents' claims, to understand system vulnerabilities, and to be prepared for deployment if necessary even when immediate deployment itself may be very unwise.

Although each Panel member may give different weights to each of the factors discussed, the Panel agrees that M.I.T. should avoid projects involving the actual development of a prototype weapons system, except in times of grave national emergency.

Beyond that general guideline, we must leave the decisions on military projects to the informed judgments on a case-by-case basis of the M.I.T. administration and the advisory committee and process which is recommended later.

To indicate the kind of considerations we have in mind, the Panel examined a number of existing projects at the special laboratories. This discussion of these projects should not be taken as a criticism either of those who first undertook them, or of those working on them. Times and values change, and the issues surrounding a specific project may appear very different when the project is well along from the way they did before research and development was begun. Also, there are substantial differences between making a decision to cancel a project and making a decision not to start a project in the first place. Our evaluations are made in this vein.

The projects we examined included some that the Panel deems appropriate, such as PRESS (a ballistic missile reentry physics program at Lincoln Laboratory), Space Communications, Apollo guidance and the Deep Submergence Rescue Vehicle. Three controversial projects were also examined in detail: the Poseidon project at Instrumentation Laboratory, the MTI radar at Lincoln Laboratory, and the VTOL flight control project at Instrumentation Laboratory.

The Poseidon missile guidance program involves development to the production prototype stage of a multiple warhead guidance system for missiles. These missiles are to be carried on existing submarines which would be modified to carry Poseidon rather than Polaris missiles.

In the Panel's deliberations with reference to this project, the following factors were discussed: the national importance of the program;

the uniqueness of the M.I.T. capability and contribution; the extent to which this program has moved out of research toward the production and deployment phase of its development; the technical and scientific interest of the research and development in this project phase; the potential effect of Poseidon development and testing on arms negotiations; the relation of Poseidon development to the arms race; and the adequacy of the national review of the implications of this program.

The Panel agrees that it is inappropriate for it to make collective judgments about military and strategic national policies. However, judgments on the other considerations, in particular closeness to the production and deployment phase, suitability for an educational institution and intellectual content, led to the conclusion by the Panel that the Poseidon program at this stage of its development in inappropriate for M.I.T. sponsorship.

In view of this conclusion the Panel recommends that the M.I.T. administration review the Institute's future commitments to this program. It recognizes, however, that M.I.T. must be prepared to honor its existing contractual obligations.

The experimental MTI radar developed at Lincoln Laboratory from 1966 to 1968 can detect people in motion through foliage. One of these experimental radars was demonstrated in Southeast Asia with the direct though short-time participation of M.I.T. employees in the field. The radar has been subsequently turned over to the Army for further tests and improvement and has been in use. The Panel questions the appropriateness of M.I.T. carrying out the development to field test of an operating system in an area of hostilities. The Panel recommends that on another occasion the transfer of the relevant technology to a more suitable agency for prototype development and field test would be a preferable course of action.

Lincoln Laboratory is engaged currently in a derivative program emphasizing basic investigations of signal processing and antenna techniques as applied to radar. The development of this basic technology is an appropriate area for Lincoln Laboratory research.

The VTOL flight control project is not a weapons system. It is a control system which deals with the peculiar instability problems of hovering vehicles--helicopters and other VTOL aircraft, especially at takeoff and landing. It is an advanced development project, far from the production prototype stage. If it does reach actual application, it could make VTOL's safer for interurban use and army helicopters easier to fly. This project is an example of non-weapons-directed technology of interest for both civil and military applications. We consider it appropriate for M.I.T. sponsorship.

5. Composition and role of the Standing Committee

The importance of the work undertaken at the special laboratories, the responsibility of M.I.T. for the quality and effects of the work of the laboratories, the growing interest and capability of the M.I.T. community as a whole to participate in decision-making with regard to the laboratories, and the interest in coupling the laboratories more closely to the campus and modifying their direction--all dictate more direct involvement by the community in the guidance of the laboratories. Accordingly, we recommend the establishment of an advisory committee to the President that will meet regularly to review the program of the laboratories, review particular projects and recommend steps for advancing the evolutionary process we recommend in this report.

We recommend that the committee consist of ten members: four faculty, two students, two administration, and one staff member from each of the laboratories. The method of selection of the committee members should be determined by the President in consultation with each of the constituent groups.

The committee will have as one of its purposes the expression of community attitudes toward the appropriateness of specific activities for the university. The method and responsibility of determining and representing those attitudes will be critical in the performance of the committee.

We would also suggest that this committee can and should when desirable turn to external sources of analysis and advice when facing important decisions for M.I.T., such as, for example, whether to start another large laboratory.

The committee would function in part by comparing new proposals against guidelines. As already noted, such guidelines are hard to write in other than general terms, so that interpretation and judgment on the part of the committee and the M.I.T. administration will always be necessary.

Although there was some feeling on the Panel that the suggested committee should have the authority to veto projects brought before it for review, it was recognized that a strong recommendation by the committee would be hard to resist in any case. The Panel's position rests heavily on the traditional problem of giving authority without continuing responsibility. To give formal authority to such a committee would be likely to affect adversely the ability of administrators to operate effectively, and would make it much more difficult to recruit competent individuals to administrative positions. In addition, on a practical level, it is hard to see how any such part-time committee could devote the time necessary to develop the responsibility to go along with the authority.

In any case, a university must in the end be run on the basis of mutual trust and confidence between the administration and the faculty, students and staff. That sense of confidence is of much greater importance in the functioning of the university than are the formal arrangements that on paper assign authority and responsibility. M.I.T. has that sense of confidence now; it must not be lost.

6. Appendices

A. Guidelines for the Study Committee

(i) Prologue*

We recognize that not only are the guidelines general in nature; parts of the report itself are non-specific. Several members of the Panel from quite divergent starting points have said that their opinions have shifted as they saw more clearly the complexity of the problem. The role of a university, the level of national security in the military field, the level of national security internally as the result of our desperate internal needs, the level of public opinion, the high need to maintain academic freedom, the high value of respecting the newly developed responsibilities of students, the changing level of international tensions and of course the Vietnam war -- all of these trace the pattern of complexity.

Those to a large degree have been guidelines to the guidelines.

However, the general patina of the guidelines does not mean the Panel has found satisfaction in a status quo position for the laboratories. Several of us, for the first time, have been brought face to face with the laboratories. All of us want a new line of thinking -- a new process that will be innovative -- that will create new frontiers. Some may want the new programs at the expense of existing programs -- some as additions to the existing programs -- all want them.

* The prologue was prepared by Gregory Smith at the request of the Panel.

We want to state that any program's success depends on the wisdom, the judgment, the sense of responsibility, the sensitivity and the courage of those entrusted with the implementation.

A review by any group lacking any of these qualities will either accept a status quo,or worse, degrade the status quo to a level below the hopes of the Panel.

A review by a group having all of these qualities will see the guidelines as general in nature in order to give creative intellects a chance to thrive, and at the same time test specific proposals against the background that there is a tragic imbalance between money spent in this country (and specifically at M.I.T.) on military programs as compared to the money spent seeking solutions to internal problems -- and that indeed the guidelines can be guides to goals.

Finally we concede that a review group lacking the sense of a university's heritage and this Panel's clearly expressed desires could even after reading the guidelines justify support for the status quo. That is the hazard of generalities. However a review group of creative and responsible people, that accepts the fact that this Panel did spend time in more than a cursory study and does not want a status quo will see the guidelines to develop new and creative programs in new fields.

This new direction will go further in filling M.I.T.'s commitment to public service.

Every policy, be it that of a family, church, government of university, depends on the judgment of those selected to carry it out. So, to say the selection of the group to carry out the policy indicated by the guidelines is the controlling value is to state a fact common to all policy implementations.

(ii) Recommendations

The following guidelines are proposed to assist the committee in its deliberations. We recognize that they are quite general in nature. Their generality arises from our desire to provide flexibility in dealing with a very complex and dynamic situation and to encourage imaginative thought and decision in situations we cannot fully predict. Whatever the character of these declarations their use and value will depend wholly upon the wisdom, judgment, sense of responsibility, sensitivity and courage of those who seek to apply them.

The guidelines are intended as factors to be considered by the decision makers. They are not directives. The decision in each case must be made in the established process for decision making, after balancing all of the listed factors and any others that may seem pertinent to intelligent decision on a case-by-case basis as to what is appropriate for M.I.T.

1. M.I.T's most appropriate contribution to large-scale programs is in scientific, social and technological innovation. This is in contrast to contributions which are largely operational or routine in character. Continuing programs should be examined for declining intellectual challenge.

2. In considering projects justified on grounds of national need, it is important that M.I.T. understand the overall objectives the project is designed to meet, as well as its possible implications. An important consideration is the extent to which M.I.T. has special qualifications to carry out the project.

3. M.I.T. must consider the impact of a new program or project on all aspects of its operation. Possible benefits include an increase in educational opportunities, access by faculty and students to new facilities and techniques, and the development of new competence. Possible costs include those arising from classification, the creation of, or increase in, imbalance in M.I.T.'s scope of activities and opportunities, and the effect upon M.I.T.'s limited resources.

4. M.I.T.'s evaluation of a project must address the questions of appropriateness that arise from the dedication of the university to humane objectives, and must consider the attitudes of the M.I.T. community with respect to the relevant issues in each case.

B. Additional Statements of Members of the Panel

(i) Personal Addendum to the Panel Report by Noam A Chomsky[1]

Although I concur in a general way with the short-term recommendations of the Panel, I have various reservations with regard to the general framework of assumptions within which these conclusions were reached. I will try to make clear these differences, in the hope that the work of the Panel will be only the first stage in a continuing review of the problems of technology and society in general and of the way in which the Institute should conceive its "public service" function.

Any act undertaken by M.I.T. in its public service function is a political act, and must be considered with great care. Those who develop science and technology have in their hands a powerful instrument of destruction, and a set of tools and techniques for overcoming at least some of the problems of contemporary society. They cannot ultimately control the social use of knowledge, but they also cannot remain blind to the question of how their contributions are likely to be put to use, under given social conditions. It is possible, of course, to adopt uncritically the concept of "national interest" and "public service" that is defined by those in a position to allocate funds and determine public policy. To do so is, in effect, to make a particular political judgment, namely, to support the existing structure of power and privilege and the particular ideological framework that is associated with it. This decision may or

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1. Since the First Report of the Panel was published, Professor Chomsky, in a letter dated September 10, 1969, has asked that his statement be modified as described in Section IV of this report.

may not be correct. It must be recognized clearly, however, that it is a political decision, and must not be disguised by the pretense that it is no political decision at all, but simply the nonideological, value-free pursuit of knowledge for its own sake. In an institution largely devoted to science and technology, we do not enjoy the luxury of refusing to take a stand on the essentially political question of how science and technology will be put to use, and we have a responsibility to take our stand with consideration and care. Those who find this burden intolerable are simply complaining of the difficulties of a civilized life. To exercise this responsibility, scientists must continually make political and historical judgments. This is true of the work of an individual. It is far more important when the university makes an institutional commitment to the support or organization of research. Such commitments must involve careful and dispassionate deliberation on the part of the university community as a whole, for two reasons: first, so that the decision itself will be a thoughtful and considered one, and second, so that the members of the university community will rise to the level of citizens in the true sense, that is, men who are conscious of their responsibilities and prepared to exercise them. This is true of every person in a democratic society, but is particularly important in the case of scientists and engineers, because the social consequences of their acts are potentially so great.

The point is not academic. In the specific cases of weapons research and development, it is clear that there are, in our society, powerful and convergent forces that are impelling us onwards to an endless and potentially suicidal arms race. Furthermore, quite apart from the shameful waste of resources, the technology that is developed is in fact put to use for the specific ends of those who set national policy. To mention just two cases discussed in the report of the Panel, the MTI project was initiated by the DOD for the purpose of counterinsurgency and has been used in Vietnam to further American war aims; and the VTOL project, if successful, will undoubtedly be used for repressing domestic insurgency in countries subject to our influence or control. Indeed it is fair to suppose that this will be the primary result of the project. There are in our society few countervailing forces that may inhibit or reverse the arms race or the use of technology for repression of popular movements. One such force, potentially at least, is the organized community of scientists. They may refuse to act as a countervailing force -- a civilizing force, in my opinion. They may choose, instead, to add their independent contribution to waste, destruction, and repression. They may do this after having decided, consciously and explicitly, that this is the part they wish to play, or they may make this political decision thoughtlessly through passive acquiescence in policies determined elsewhere. They are not free, however, simply to avoid the problem.

The commitment to weapons research can be justified only in terms of specific views concerning modern history and the international role of the United States. We must not merely drift into tacit acceptance of this framework of assumptions. Rather, it must be a matter of intensive and continuing inquiry. In my personal opinion, a serious inquiry will show these conceptions to be indefensible, and will lead to the conclusion that military work should be drastically scaled down, not only in the university but in government laboratories and industry as well. However this may be, what is clear and beyond doubt is that any decision taken in this regard will express controversial political and historical judgments. There is no way to avoid this dilemma.

The major contribution that a university can make to a free society is by preserving its independence as an institution committed to the free exchange of ideas, to critical analysis, to experimentation, to exploration of a wide range of ideas and values, to the study of the consequences of social action or scientific progress and the evaluation of these consequences in terms of values that are themselves subject to careful scrutiny. The university betrays its public trust -- in Senator Fulbright's apt phrase -- if it merely adopts and limits itself to policy determined elsewhere, on whatever grounds. Academic freedom is violated, not ensured, when the university merely bends to the will of outside forces and, in effect, ratifies the existing distribution of power in the society by simply meeting the demands that are articulated by the institutions that are in a position both to articulate their needs and to support the work that answers to them. This point cannot be emphasized too strongly. The idea that a university preserves its neutrality and remains "value free" when it simply responds to requests that originate from without is an absurdity.

In the light of these general remarks, I would like to turn to the question of the special laboratories and the Panel Report. Although individuals may indeed be quite free when they work in the laboratories, there is, nevertheless, an essentially political criterion for association with them. This subpart of the university community is restricted to participants who share a particular political ideology, and in this way, the laboratories contribute to a dangerous and unwelcome politicization of the university. The constraint is a necessary consequence of the requirement that one can be associated with the special laboratories only if his work can be funded by particular government agencies, primarily the DOD, and the fact that one can work comfortably in the laboratory only if he is willing to undergo clearance procedures. Obviously, it is going to be difficult to avoid this kind of politicization, but we should, I believe, recognize its drastic character and express our principled opposition to it, our determination to struggle incessantly against it. The concept of a political criterion for association is intolerable for a university.

I do not think that the Panel Report deals adequately with the general problems raised above. It asserts, correctly, that the university should preserve "a commitment to the concept of academic freedom and free exchange of ideas, jealously protected from inhibiting restriction." It does not, however, stress the inevitable conclusion that the special laboratories are presently organized in such a way as to violate this commitment. The statement that work on "important defense-related problems" is quite appropriate for the university expresses a political judgment that I do not personally share, but that, in any event, was taken without sufficient consideration of the political and historical issues that are relevant to this judgment. The statement that a "significant reduction in defense work... might be undesirable from the standpoints of both the Department of Defense and the laboratory staff engaged in defense projects" might be read as implying that such a reduction would be unwarranted and improper. I wish to dissociate myself from any such conclusion. Such a reduction would, I believe, be highly desirable; it would increase the probability that civilization will survive, and would contribute to freedom by diminishing our capacities for aggression, as in Vietnam. The willingness to tolerate "classification of project descriptions," even if "severely limited," also seems to me unacceptable, since as the report states, "this practice prevents the M.I.T. community as a whole from knowing even the nature of some of M.I.T.'s activities," and since it is a fair assumption that such work is directed towards military end that would, indeed, be intolerable to at least part of the Institute community were these ends known.

Still more seriously in error, in my opinion, is the statement with regard to "collective judgments on military and strategic policy," namely, that "such judgments are inappropriate for any official group at the Institute to make," including, by implication, the group empowered to review projects to which the Institute commits its resources. I think that the statement is false; that is, such judgments are entirely appropriate, indeed, inescapable. In fact, the statement is inconsistent with the thesis expressed in the Panel Report that war-related research (some, of a sort that will remain unknown to the Institute community) is desirable and appropriate. Acceptance of such research implies support for particular judgments on military and strategic policy, for reasons already noted. Hence this statement is false in itself and inconsistent with the body of the report.

I agree with the conclusion of the Panel that we should not sever the connection with the special laboratories, but should, rather, attempt to assist them in directing their efforts to "socially useful technology," and away from war-related research. At the same time, I feel that we should try to establish certain guidelines for the work that the laboratories undertake, recognizing that these guidelines cannot be very precise and that they will change through time and with circumstances. In my opinion, the special laboratories should not be involved in any work that contributes to offensive military action. They should not be involved in any form of counterinsurgency operations, whether in the hard or soft sciences. They should not contribute to unilateral escalation of the arms race. They should not be involved in the actual development of weapons systems. They should be restricted to research on systems of a purely defensive and deterrent character. Such guidelines as these must take into account not only the intrinsic character of the technology that is being studied and developed but also the political context in which the technology will be put to use. The decision as to whether a technical capability, or even a specific weapon, is offensive or defensive in nature is a historical as well as a technical decision, and must be clearly recognized as such. These are delicate and uncertain judgments, but they cannot be avoided. They must be made seriously, and as explicitly as possible. As I understand these recommendations, they would, under present circumstances, rule out not only CBW but also development of MIRV, and steps toward deployment of ABM and similar systems. We should positively encourage the kind of research that leads toward arms control and de-escalation of the arms race. We should immediately abandon all work relating to counterinsurgency, including social science research that is likely to be used, primarily, for repression of popular movements and interference in the internal affairs of other nations, and perhaps for domestic repression as well. Evaluation of such projects, in these terms, seems to me an obligation for a responsible community of scientists. This, incidentally, is a recommendation that relates to the Institute as a whole, not merely the special laboratories. I think we should propose an immediate moratorium on MIRV and should urge that arms control negotiations be undertaken forthwith, on a large scale, and with great seriousness.

We must, furthermore, establish a procedure by which guidelines for research are administered. The ultimate responsibility for work that receives institutional support lies in the hands of the faculty, the staff, and the student body. The matter of research of an institutional character should be handled in the way that academic affairs are handled. A new department or program can be initiated only with faculty authorization. This is as it should be, and the same principle should be extended to research that exceeds a certain scale. An individual should be free to do what he wants (though even here there are limits -- no principles that I can imagine are absolute.) But a research project that exceeds a certain size should be subject to review in terms of the loose guidelines that we set, guidelines that should themselves be subject to review. This review should be carried out by a student-faculty-staff committee which is elected by the faculty, the staff, and the student body, and is directly responsive to them. The committee should report back to the bodies that it represents, and should see its function as dual: first, ensuring that the work that is carried out with Institute authorization and support meets the loose guidelines that have been established; second, educating the Institute community by bringing relevant information to it and encouraging discussion and debate of the underlying issues, which -- I repeat -- are far too important to be left to the casual procedures that may have seemed adequate in the past. I think that the faculty should have the dominant role in this committee. I would expect that it would rarely exercise its authority, since the usual informal measures of mutual adaptation should, for the most part, suffice. But it should have a very visible "presence" and should, as a matter of course, review all contracts that exceed a certain size -- perhaps about $50,000 a year might be a reasonable minimum. The committee should also seek to engage itself in the educational role just mentioned with diligence and care.

In this respect, too, I find my views somewhat at variance with those of the Panel, which recommended that such a committee should have only an advisory capacity, residual authority resting with the administration. Let me make clear that my dissatisfaction with this plan does not result from any lack of confidence in the administration. On the contrary, to be quite frank, I would not be much surprised to discover that decisions taken by the administration would often be more in accord with my personal hopes and wishes than those taken by such a committee. But I think that it is improper procedure for this authority to rest in the hands of any group other than the Institute community as a whole -- the faculty, the students, and the staff -- for reasons already mentioned: the general requirements of democratic procedure, and the beneficial effect, on the Institute community as a whole, of the demand that it face these problems, both technical and political-historical, in a serious way. I do not find the reasoning of the Panel convincing in this regard.

The strongest argument that I have heard for maintaining Lincoln Laboratories in roughly its present form is that it provides objective and independent evaluation of weapons systems. I remain skeptical about this. Although I do not doubt the integrity or competence of the laboratory staff, nevertheless the fact remains that they represent a limited range of opinion. Furthermore, evaluation cannot be dissociated from political-historical judgments, and I do not feel that these are adequately represented, for reasons already mentioned. What is more, I find it hard to believe that the evaluation is not constrained by the total financial dependence of the laboratory on the DOD. A much more constructive and useful evaluation could be given if the labs were free from the constraint of security clearance and reliance on the executive branch, specifically, the DOD. The suggestion was made, in testimony before the Panel, that the lab ratory should be responsible to Congress and funded independently of the DOD. Perhaps Congress might be receptive to such a suggestion. It would be quite important for Congress, and the public at large, to have its own independent source of technical information, and its independent facilities for research and evaluation. Furthermore, the university can provide a truly objective and broad-ranging service in the evaluation of weapons systems -- and, more generally, national goals and the political context in which weapons systems are developed -- if it is free from the constraints now imposed. This seems to me an important matter. These are goals that cannot be realized immediately. But I think that a firm statement of principle and intent, on our part, coupled with specific measures to realize this intent, might have a useful effect on public opinion and on Congress.

We must emphasize that the role of the university in evaluation is not limited to providing technical information and advice. For example, in the case of the ABM or the MIRV systems, the university should not only provide information as to whether it will work, what its effects will be on arms control negotiations, and so on, but should also attempt to provide the best possible analysis of the political and historical context in which these programs are proposed. It has been charged, for example, that the ABM is motivated more by the needs of the electronics industry and aerospace for a continuing public subsidy -- in part to counteract the technologically regressive impact of the Vietnam war on government spending -- than by any military or strategic objectives (objectives which, in any event, I do not think acceptable). Whether or not this is correct, it is clearly a relevant question to be raised in evaluating these systems. A primary task for the university is the study of decision-making in American society and the international role of the United States. Obviously, we cannot expect much agreement about this. But we should not contribute to the illusion that the government merely expresses the national will, independently formulated, and that it simply uses the best technical advice to achieve objectives determined by an informed citizenry. This is a caricature, and a dangerous one. We must emphasize that political and historical judgments are critical even in what appear to be technical matters, that there are no experts qualified to deal with these general issues, and that public policy is a reflection, to a very significant extent, of economic power that is entirely removed from the democratic process. The university must not become a party to a perversion of democratic ideals or to the perpetuation of social myths. Its function, in a free society, is to act in independence of powerful social institutions, and the ideology they seek to impose, to the fullest degree that it can. Again, this is an ideal that may not be fully realizable, but we must be constantly struggling to achieve it.

I would like finally to express my personal appreciation to the students in SACC for their serious and conscientious efforts over the past few months, efforts which led directly to the formation of the Panel and the review of policy it has conducted. The Institute as a whole owes them a debt of gratitude.

(ii) Personal Addendum to the Panel Report by Marvin A. Sirbu, Jr. and Edwin R. Gilliland

We concur with the Panel Report in most aspects including the recommendations and the continuation of the special laboratories as part of the Institute at the present time, but we differ from that report by concluding now that the Institute should divest itself of all or part of these laboratories during the next few years.

Some of the Problems

A major difficulty with most large mission-oriented laboratories involves more than simply the current contracts. There is a fundamental problem which should be addressed, namely: How do you set up an organization to solve a particular task in such a way that it does not remain behind after the problem has been solved? The style of operations which should be evolved is one in which it would be easier to phase out efforts in one area and initiate efforts in another in response to the changing frontiers of technology and changing Institute priorities. The sheer size of the present laboratories gives them an inertia which makes it very difficult to have this kind of flexibility.

Moreover, the rapid growth of these laboratories and of on-campus research during the past twenty years has resulted in the Institute's having a responsibility for research and development expenditures that are now five to ten times the nonresearch academic budget. M.I.T.'s main function is fast becoming a research and development institute rather than an educational institution. This imbalance between research and education is changing the character of the Institute.

Anticipating that the new "Lewis Commission" will reaffirm that the long-range primary objective of the Institute should be education rather than public service, there is a serious imbalance in our efforts. If the new "Lewis Commission" and the Institute should decide that M.I.T. should become a research and development institute and graduate study center, then these large mission-oriented laboratories would be more appropriate.

Difficulties of Redirecting Laboratories

Both the Instrumentation and the Lincoln Laboratories have important roles to play within their present framework and style.

For the Instrumentation Laboratory there is and will continue to be a demand for creative applications of sophisticated guidance and control systems for NASA, for undersea navigation, and perhaps for commercial air traffic. This laboratory now constitutes a highly competent, perhaps unique group capable of working on these problems.

The Lincoln Laboratory has made major contributions to radar, computers and communication satellites. Its value to the nation is substantial.

The argument has been advanced that M.I.T. can, by adding some new projects at the two laboratories and eliminating a few others, achieve the necessary balance and expansion in scope. We do not believe this is the case. Achieving the kind of change in scope and competence necessary to fulfill our conception of the range of activities in which M.I.T. should be involved would amount to keeping an administrative shell and a name, while changing almost everything else. This would have the effect of destroying the laboratories as facilities capable of performing the missions for which they are now suited.

Advantages of Divestment

To pursue the Institute's educational functions effectively, the faculty and students will need to engage in mission-oriented research on a variety of problems for a variety of sponsors employing a variety of disciplines. We believe that divestment or contraction of the existing laboratories and the creation of new mission-oriented projects will be the most effective way to meet the new technological challenges and to rebalance the emphasis between public service and education. It will be easier to achieve this new style of operation with new laboratories than through changes in the existing facilities.

We believe that the new organizations will provide a better opportunity for student-faculty participation and allow them to have a larger part in influencing the program undertaken.

Smaller laboratories of limited duration will enable the Institute to perform its public service with less long-range commitments.

Need for Prompt Action

The changes we propose for these laboratories will involve many problems, some of which will be difficult to solve. Careful studies and wise decisions need to be made on the future security of the people involved, the conservation of the national assets, the financial implication for M.I.T. and the laboratories, and the interest of the laboratory personnel and of the sponsors. These problems will become more difficult to solve effectively the longer they are deferred.

Developing the best plan for these changes will probably involve a period of several years, and it is essential that such planning begin soon. No future time will be as advantageous as the present for making definite decision on the proper relationship between the Institute and the laboratories. Such planning should be done in a positive way that will maintain the morale of the special laboratories during the transition period.

(iii) Statement by Gregory Smith which Panel Members as Individuals Endorsed

THE USA AND THE USSR

The center of our charge directed a study of the relationship of M.I.T. to its special laboratories. This relationship is, perforce, fluid, and changes with the tides of current events and national policy. Particularly will it change and has changed with the state of affairs between nations. This fact brought to the minds of some members that a statement regarding our relations to the USSR lies at least on the periphery of the charge; to others that it lies within the charge. So while we may differ on the relevance of the intimacy, we feel we have, as individuals, the privilege to make the following statement.

We hope with deep sincerity that discussions with the Soviet Union will be entered upon with the determination to make them fruitful in easing tensions between the two great powers and make real progress in a program to ease the arms race.

The achievement of such a goal will go far in helping to develop activities at our special laboratories directed to national needs of non-military nature, and would make the allocation of funds for such programs a probability.

Significant success will hasten the implementation of the recommendations and plans of this Panel.

(iv) Review Panel on Special Laboratories

Report*

by

Jonathan P. Kabat

Co-signers:

Noam Chomsky

Jerome Lerman

* In a letter dated September 17, 1969, Jonathan P. Kabat indicated he wished to make an additional comment on this statement. It appears in Section IV of this report.

A Personal Addendum to the Panel Report

I. Introduction

There is, both inside and outside the university, a growing recognition that our society is changing very rapidly under the impetus of scientific and especially technological advances. Along with obvious benefits, technology has created ecological, social and political problems of great consequence, problems that cannot be ignored by the general public or the scientific community itself. Among these is the emergence in the past 20 years of a Gargantuan war industry whose function is to help develop and to manufacture a weapons technology to serve our national policies of nuclear deterrence and limited warfare. This technological development has been closely associated with the great university centers of technological innovation, including the Instrumentation and Lincoln Laboratories at M.I.T., and finds its sustenance in the Department of Defense, which has grown since World War II to be the largest corporate structure in the world. [In the words of one American economist, the second largest planned economy in the world (Kenneth Boulding)]. The disproportionate power wielded by the Department of Defense is not due to the zeal of the military so much as to our civilian decision makers who have felt that their concept of world order can be secured only if America retains overwhelming military superiority. At the same time, this power has enabled the Department of Defense to sponsor large amounts of nonmilitary research at universities, much of which is of fundamental scientific interest, and for which other sources of support, governmental or otherwise, are lacking or scarce. However, the serious social consequences of these vast military expenditures can no longer be ignored, and have begun to receive the attention they deserve as have the policies, both foreign and domestic, which generated this distortion. There is, increasingly, a feeling that our national priorities must be reexamined and a more suitable set of national goals defined for the future. We call the transition from military to a peaceful national posture conversion.

These concerns do not seem overly academic after twenty years of nuclear terror and in a country that, in the name of freedom, has virtually annihilated a weak and distant peasant society, in order to preserve it from itself and to impose upon it the social order that we deem appropriate.

Our own society must begin to come to grips with the deep-seated inequities that it harbors and which are demanding immediate redress. Riots in our cities, widespread poverty and malnutrition, grossly deficient school systems, poor and inequitable medical care, urban decay, inadequate public transportation, air and water pollution may not seem per se to be areas of concern for the university. But in the most affluent society on earth, they are poor testimony to our national values and priorities, especially since we seem to have endless resources for the construction of ever-more sophisticated weapons and for a war effort that has brought indescribable destruction to a nation that is among the poorest on earth.

There has been widespread concern at M.I.T. that we have, with the best of intentions, been contributing to this imbalance by a lack of sufficient attention to the ultimate uses to which technology, which we help shape and develop, is put, and the ensuing effects upon the society. This applies even to our educational process. The majority of M.I.T.'s engineering students go into the aerospace and defense industries because that is where the money and the challenging problems are to be found. In this way they contribute to the maintenance and further growth of militarism. Moreover, through its two special laboratories, M.I.T. creates and develops new military-oriented systems of vast proportions and of great political impact on the nation.

Some of the military projects that have been assailed by faculty and students at M.I.T. as dangerous in general and detrimental to the spirit of the university are:

1. MIRV
2. SABRE
3. VTOL
4. MTI

The nature of the objections varies with the project, but the overriding concern is that large scale facilities and manpower in the university community are engaged in military projects, the ultimate purpose of which is to increase overwhelmingly America's strategic nuclear superiority and its tactical counterinsurgency capabilities.

Two questions immediately arrise which demand assessment:

i. Are such endeavors consonant with an institution of higher learning?

ii. Are we serving the best interests of the society by continuing an unregulated and, therefore, given present national priorities, military-oriented technological development?

At the same time, we must try to define what we consider to be the role of a university which is also an institute of technology and engineering, and how mission-oriented research, in general, or as examplified by the special laboratories, should be accommodated in this framework.

II. <u>M.I.T.</u> - <u>A University? or More</u>?

The university should be a community of individuals committed to free inquiry, to critical analysis, to experimentation and exploration of a wide range of ideas and values. The fundamental preoccupation of this community is with learning; not only students, but everybody is engaged in furthering man's knowledge and understanding of himself and his universe. This is a humanistic pursuit of the highest order. The major contribution that a university can make to a free society is to preserve its independence to pursue such learning objectively and free from ideological constraints. Independence allows it to pass on from one generation in the society to another what is known while imposing minimal constraints on the students so that they can use that knowledge to generate new ideas and new values. Any limitations or imbalances in university pursuits must be minimal to counter the channelling or indoctrinating tendency inherent in institutions in general.

Unique to a university that is also a technological institute is the generation of artifacts as products of research and engineering development. These artifacts accompany the flow of ideas and people from the university into the society and have a surprising amplifying effect on the nature of that society which is poorly understood. Thus science and the technology to which it leads have changed western culture since the industrial revolution in a complex, exponential way and continue to affect profoundly both society and history. Those who develop science and technology have a vehicle that can serve as a powerful weapon of destruction and as a major instrument for overcoming the problems of contemporary society. It is highly ironic that the quality of self-awareness, which is unique to man in the evolutionary order, has generated such a powerful ability to change man's environment, but seemingly little consciousness of the consequences of his actions. The evolutionary and historical interaction has led to this critical moment for man as a species where the probability is very high that he will not be able to control his own power, and will destroy himself in a non-evolutionary way, either by nuclear holocaust, or some other irreversible contamination of the planet. We at M.I.T. <u>must</u> be aware of this fact, and <u>must</u> be conscious of our responsibilities in regard to the use of science and technology. As stated in Professor Chomsky's dissenting letter, to exercise this responsibility we must unavoidably and continually make political and historical judgments. This is true for the work of an individual. It is far more important when the univerisity makes an institutional commitment to the support or organization of research. Such commitments should involve careful and dispassionate deliberation on the part of the university community as a whole. This is a form of "politicization" of the university community that should be actively encouraged.

It is indisputable that to perform the sophisticated activities of science and technology in this age requires large financial support. This support in universities has been very great from the national government for the past 25 years - from NSF, NIH, AEC, NASA and DOD primarily. There are two basic forms of support: grants for pure or applied research and contracts for mission-oriented programs. The former, being the domain of one professor and an entourage of students is usually on a considerably smaller scale than the latter.

The accomplishment of specific missions usually requires well integrated team efforts on a large scale. These will be discussed further on in the section on the special laboratories, but a word is appropriate here about the place of such efforts in a university.

In an age when large scale technological feats are probably essential to the maintenance and development of modern society, the large mission-oriented laboratory serves a unique function, not readily reproduced by ad hoc teams of people with special and diverse interests. Its utility, however, is measured not only in its size, which must be above a certain threshold for efficient accomplishment of the mission, but in its flexibility, its ability to respond to whole ranges of missions requiring modern technological expertise. Another important feature should be its contribution to the educational role of the university as a resource of talented people, information, and as a proving ground for future scientists and engineers. In order to function, however, its missions must be important enough to merit support. Thus far, only military systems and space exploration have been considered important enough for the society to fund. A reallocation of national priorities will be necessary to re-orient the missions of such laboratories to more socially useful programs. We should not exclude from consideration the urgency of the conversion, nor the possible inclueence M.I.T. as a whole can have on the government to bring about such a change.

It is often claimed that by doing defense work at such facilities the university can exert civilian guidance and influence on the national uses of technological power. Many people at the Lincoln Laboratory feel that a crucial function they perform is to supply objective data on performance of strategic weapons, offensive and defensive, to various government agencies. They claim to serve in this way as a brake to uncontrolled utilization of military-oriented technology. The merits and limitations of this assertion are discussed by Professor Chomsky. Accepting a narrowly defined concept of "national interest" and "public service" through the missions of the special laboratories is in itself a serious political decision and should be recognized as such.

III. The Special Laboratories

The special laboratories of M.I.T. differ considerably from defense laboratories associated with other universities in that their origin and early growth were the responsibility of individual faculty members at M.I.T. in response to particular requests from the government--in the Instrumentation Laboratory case, the need for accurate naval gunfire control in World War II; and in the case of Lincoln Laboratory, for what was assessed as a need for a continental air defense system in 1951. As has been pointed out amply to this Panel, there has been periodic distress on the part of the administration of the Institute concerning the size to which these laboratories have grown over the past 20 years (total budget of $124 million) and the effect of their particular missions on the character of M.I.T. However, as of 1968-69, no full-scale inquiry and assessment had been effected. It appears that M.I.T. benefits financially from the special laboratories in the following way: the special laboratories use many M.I.T. facilities; under existing government regulations, they are charged for the use of these facilities, e.g., libraries, infirmary, accounting office. Were the laboratories to be severed from M.I.T., many of these common functions would not become appreciably less expensive to operate. To maintain M.I.T. on- campus facilities at their pre-divestment levels, the Institute would have to assume the laboratories' share of the operating expenses. Thus, M.I.T. benefits from the special laboratories in the reduction of overhead expenses by an estimated $7 million annually.

At present, the M.I.T. administration oversees the laboratory operations through the office of a Vice President for Special Laboratories, and an informal group consisting of the President, the Vice President, the Provost and the Chairman of the Corporation. They nominally see and approve all major contracts at both laboratories and exercise the prerogatives of Institute propriety and interest.

In practice, however, the labs operate independently. In the case of Instrumentation, its Director assumes the full burden for seeking support for limited-term projects and is presently receiving major NASA, USAF, and Navy support. Its property is owned by M.I.T. and lies adjacent to the main campus. It is officially part of the Aeronautics and Astronautics Department in the School of Engineering.

Lincoln has one main contractor, the U. S. Air Force, and is actually an Air Force owned Federal Contract Research Center laboratory. However, it was built and continues to be run by M.I.T. Its main projects are in space communications and radar and computer systems engineering.

Since the two laboratories differ considerably in structure and orientation, they shall be described separately in this section and will then be alluded to specifically in following sections.

A. The Instrumentation Lab: is a unique enterprise, conceived and developed from its inception by the genius of one man, Stark Draper, around problems in guidance and inertial navigation instrumentation for control of bodies in any environment. It has approximately 2,000 people working on a multitude of missions (total of 41 projects) with a variety of sponsors; most of the work comes under one of two main headings: ballistic missile guidance funded by DOD and space craft guidance navigation and control funded by NASA. The laboratory is internationally known in its field for unparalleled excellence and quality. The following is a list of major projects, their description, source of funding, and estimated funding for Fiscal 1969 and 1970 (all figures are in millions of dollars):

Apollo and other NASA programs

--design and development and responsibility for totality of navigation and guidance system for manned lunar landing program.

	1969	1970
NASA	21.1	13.4

Poseidon

--design, prototype development and follow on modification (in conjunction with industrial producers) of submarine launched ballistic missile guidance system with MIRV warheads (8-10 per missile). Contract has four more years to run.

		1969	1970
Companies: Raytheon, G.E., AVCO--reentry vehicle	Navy	8.3	7.8

Deep Submergence System

--design and prototype development of navigation system for deep submergence rescue vehicle.

	1969	1970
Navy	7.1	7.0

Sabre (Self-aligning Boost and Re-entry System)

--design and development of an advanced inertial guidance system for long-range ballistic missiles which allows inertial guidance of individual warheads during reentry and course alterations for evasive action and improved target accuracy. Hardened against nuclear effects (such as ABM).

	1969	1970
U. S. Air Force	3.2	2.4

Inertial Components

--engineering development and generation of manufacturing information for third-generation gyro units and accelerometers (not directly application-oriented).

	1969	1970
NASA	5.4	4.4

Polaris

--design and fabrication of inertial guidance system for submarine-launched ballistic missiles (some with 3 not independently targeted warheads).

	1969	1970
Navy	1.6	1.0

Adv. CG&N (command, guidance, navigation)

--study and preliminary design of advanced techniques for guidance and control of manned deep space vehicles.

	1969	1970
NASA	1.9	0.2

Army VTOL

--development of guidance and stability control system for all-weather helicopters and VTOLs. Part of Army Project TAGS (Tactical Aircraft Guidance Systems).

	1969	1970
Army	1.0	0.3

New Programs:

Orbiting Astronomical Observatory (OAO)

--development of a system for precision attitude control of an OAO.

	1969	1970
NASA	1.9	0.3

Structure Mounted Inertial Reference Unit (SIRBU)

--develop an inertial reference unit for use in the Apollo Applications Program.

	1969	1970
NASA	1.8	0.5

There are numerous other projects which are supported at a much lower level (most are less than $200,000 annually). Among these are:

a. object recognition study--sensory, decision and control systems for for use in search for extraterrestrial life NASA

b. SEAL--inertial locating equipment applied to survey and maintenance of airway navigation system FAA

c. computer aided design--development of on-line logical simulation as an aid to logical circuit design drawings, signal lists and simulators NASA

d. flight test instrumentation--investigation of the feasibility of using the Apollo G&N system for flight test instrumentation--industrial

e. Ocean telescope--development of an array of thermistors and pressure transducers to measure spectral and synoptic characteristics of ocean internal waves in main thermocline Navy

f. Project CARS--a large interdepartmental effort to provide taxi-like service at a cost commensurate with current public transportation. The project, directed by M.I.T. Civil Engineering Department, is funded by the DOT ($855,000) and Ford ($60,000)

g. air pollution study--development of a computer-controlled electron microscope to assist in air pollution tests Public Health Service

h. Biomedical Instrumentation--instrumentation to monitor internal body temperature in rats M.I.T. Department of Nutrition and Food Science

Present relationship of Instrumentation Lab to M.I.T.

The lab lies adjacent to the main campus in 14 different locations. As part of the Aeronautics and Astronautics Department, it functions as a teaching lab as well as in a mission capacity. It has 16 faculty members from the Department of Aeronautics and Astronautics, and approximately 400 students associated with it as staff members, research assistants, thesis candidates, student employees. The breakdown of students from various departments who were involved with the Instrumentation Laboratory in 1969 through courses or in above-mentioned capacities is as follows:

Aero and Astro	105 (half the graduate students in the department)
Electrical Engineering	159
Mechanical Engineering	33
Physics	16
Math	30
Management	23
Other	32

200 full-time summer students (summer 1968)

In 1967, 24 master's theses and 10 doctoral theses were produced by students using lab facilities and staff supervision.

The Aeronautics and Astronautics Department teaches 25 courses associated with Instrumentation Laboratory subject matter, staff, faculty, and lab facilities, out of a total of 80 courses offered by the department. The faculty feel that the laboratory facilities are essential for the high technical quality and excellent practical experience their students acquire.

Significant barriers, however, exist between Instrumentation Laboratory and the main campus. The laboratories are secured, classified areas with no admittance except to authorized and security-cleared personnel. Thus, contact between the main body of M.I.T. faculty and students and the laboratory staff remains minimal, although the people in the laboratory see themselves very emphatically as part of the M.I.T. community, through the students they train, M.I.T. paychecks and community benefits.

The administrative authority essentially resides in Dr. Draper, who takes personal responsibility for seeking funds to support the major laboratory programs. There are numerous, semi-autonomous project leaders (assistant directors). In the case of the NASA programs, there is an informal steering committee of senior staff members to help oversee the projects and keep them running efficiently. Almost all the missions involve highly sophisticated team efforts with interconnecting expertise channels for specific problem solving. Thus the Components R & D group will be called upon by various systems groups for help in subsystems problems dealing with gyros, miniature components, electro-magnetic engineering. There are also Technical Support Groups dealing with computing devices, analysis, digital development, mechanical design, special testing, reliability and Support Labs in dimensional stability, casting and solidification, line of sight detection devices, bearing research, gyro fluids, lubrication in a vacuum, and brazing of beryllium, as well as basic administrative and shop services. Thus there are immediate pools of expertise available on which to draw as a project develops. This structure exemplifies the principle of critical size alluded to earlier, which refers a threshhold size and complexity required for a mission-oriented technological laboratory to function with maximum creativity and efficiency. All of the engineers we have consulted consider this feature essential to a good mission-oriented laboratory.

Ideas for new projects originate from all points in this framework, and if they seem appropriate or are argued for strongly enough, Dr. Draper attempts to seek funding from interested agencies. Aside from NASA, invariably the only interested source with sufficient money is the military. Even doing pilot projects to test new ideas is constrained by a lack of funds. Contrary to the Lincoln Laboratory, there are no general research funds available for exploring new areas and developing new programs. Current projects must be the source of manpower and funds for preparing proposals and new projects. (This may be a difficult time-consuming operation.) Some use of manpower and funds to generate new proposals is tolerated by the sponsor if it falls within the scope of the current project. Thus, it is difficult to produce technical proposals for work that differs substantially for the kind already being done.

For the most part, the M.I.T. administration allows the laboratory to operate with full autonomy. They do not dictate specific directions or guidelines for the kinds of programs undertaken, nor do they make an effort to help secure funding for projects.

There is no apparent burden on the administrative structure of M.I.T. in running this lab (or Lincoln), though some faculty members have felt that the large lab budgets ($124 million for 1969) adversely affect their chances for getting government research support for on-campus research. Some departments apparently feel at a competitive disadvantage in attracting students. These phenomena have not been documented sufficiently to permit judgment.

B. Lincoln Laboratory, unlike the Instrumentation Laboratory, is physically removed from the campus (18 miles) and is owned by the U.S. Air Force as a Federal Contract Research Center operated for the Air Force by M.I.T. It is known for its outstanding work in the fields of radar, computer technology, and communications, and is probably comparable to Bell Labs in the excellence of its staff and the quality of its work. The following is a list of general areas of effort at the lab.

1. Space Communications	AF staff 111	$11 million
2. Navy Communications	Navy staff 26	$1.7 million
3. Radar Measurement	Army, ARPA staff 133	$32.5 million
4. Reentry Systems	AF staff 66	$6.0 million
5. Optics -- adjunct to Radar Measurements R & D of laser radar technology at Millstone Hill basic studies in laser technology	ARPA (Strategic technology) AF staff 57	$5.9 million

6. General Research a. solid state b. data systems c. radio physics	AF -- exploratory research in selected field relevant to its other programs staff 158	$11.7 million
7. Radar Research MTI	AF 15 staff	$1.5 million
8. Graphics -- developing computer languages and hardware which permit easy graphical interaction of man with a computer	ARPA staff 13	$1.0 million
9. National Library of Medicine	HEW staff 2	$70 thousand

Development of an on-line information storage and retrieval system (LISTAR) to gain rapid and convenient access to the huge data files of the National Library of Medicine.

10. Vela Uniform	ARPA staff 11	$1.8 million

Seismic methods for detection and location of underground nuclear explosions and discrimination of explosions from earthquakes of comparable magnitude.

11. Ambulatory Health Care -- initiated last year by the staff. Cooperative program between the laboratory, Harvard Medical School, and the Beth Israel Hospital.

FY 1969	Commonwealth Fund staff 2	$70 thousand
FY 1970	HEW staff 6	$500 thousand

This laboratory has a much better defined administrative structure and far greater financial security than has Instrumentation Lab. There are nine divisions and 43 working groups comprised of 1,800 people, of whom 600 are considered professional staff. Administrative decisions are made by a steering committee of 20, including the director of the labs. There is a joint advisory committee of three military people (two generals and the head of ARPA*) which annually reviews work at the laboratories.

Although the laboratory is highly oriented towards defense technology in the realms of space communications and ABM radar, it has a large operation in progress in "general research" which is of fundamental scientific interest. It is here that most faculty contact and collaboration with the staff occurs, namely in the fields of solid state physics, data systems, and radioastronomy. However, faculty interaction with the labs has tended to restrict itself to a small group of people who have had long-standing ties with the laboratory. Consequently, few students benefit from the facilities at Lincoln although those that do become involved claim that it has had overwhelmingly positive effects on their education. During 1967-68, 33 students used Lincoln Lab facilities for doctoral level theses. Thirty-one faculty served as consultants with pay at Lincoln, 39 M.I.T. faculty and students participated in cooperative programs at Lincoln without pay; there are 23 from Lincoln Lab staff now on the M.I.T. faculty. Lincoln Lab has a large percentage of M.I.T. graduates on its staff, 169 out of 600.

Laboratory Organization

The same basic laboratory structure has remained since its inception. Overall leadership is centered on a Director who reports to the M.I.T.

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*Advanced Research Projects Agency (Pentagon) administration. Under the Director's Office are several divisions (currently there are nine divisions) and in each division there are several groups. Most of these divisions and groups have changed completely over the years. The principal governing body is the Steering Committee, composed of the Director and his associates, the Division Director and his associates, the Division heads and associate heads, and some members of the M.I.T. administration.

The divisions are organized on the basis of technological areas, e.g. radar, communications, etc. Hence, major programs involving several areas may cut across division lines. The Space Communications program used as our example in the previous section is centered in division 6, communications with a strong component in division 7, mechanical engineering.

The heart of the technical program is in the lowest organization entity, the group, with anywhere from 10-40 staff members. Major programs involving many people have started with a technical idea from a single staff member. For example, the large West Ford program began with the idea conceived by two people in the Barnstable study. The speech compression program started with some novel ideas by one person.

Work on both of these ideas was originally funded under the Air Force sponsored General Research program. Later, when more fully developed, they were funded under the specific Air Force programs, West Ford and Space Communications, respectively.

The decision making process at Lincoln is complex. Under programs with flexibility such as the laboratory's Air Force sponsored programs, an idea is approved for initial development very informally by the Group Leader. As it requires more people and expenditures, higher level management becomes involved. A major development involving new programs or sponsors includes the M.I.T. administration. Approval is usually obtained after informal discussion involving the staff members, group leaders, division heads, etc. Faculty members are included in this process in much the same way, i.e. a faculty consultant or visiting scientist starts by convincing his group leader that his idea is meritorious and deserves support under an existing program.

IV. The Problem

The problem is indeed a national one, not particular to M.I.T. This being said, however, it still remains that in its present state there exist serious anomalies and distortions of M.I.T.'s commitment which diminish its autonomy and effectiveness as an institution of higher learning. Particularly distressing, with regard to the special laboratories, is the application of sophisticated scientific and technological knowledge to the development of weapons of counterinsurgency and mass destruction. We feel that such work should not be done at all. Furthermore, such an effort is highly inimical to the character of a university which, as we have stated, seeks to establish reason and understanding as the fundamental principles fo human activity and interaction. It is important to note that the missions of the two laboratories are primarily described as defense-oriented. This blanket term, however, is misleading, in that it may be taken as presupposing that the work is essential to our national security and well-being. This appears to us a very questionable assumption. In the nuclear age we have lost our ability to defend our nation against attack and major obliteration. Defense has been replaced by the "principle of nuclear deterrence," based on the assumption that an adversary will use reason and not risk obliteration of his own society by attacking ours if we can assure him that we have the capacity to return the attack. This concept has led to the nuclear arms race and to the uneasy "balance of terror" under which we have lived since 1949.[+]

[+] We point out that the Russians lived for four years without a nuclear capability while "responsible" circles in the government talked about using the bomb against them while we had the chance. If we shift perspective for a moment and consider that America is the only country to have dropped a nuclear device on a population, and we did it twice, that we bombed for two years at the Chinese border, that we are now bombing South Vietnam at a level of 130,000 tons a month, that we have used military might in the Dominican Republic, Guatemala, Cuba, Vietnam in attempts to impose our solutions on the domestic struggles of other nations, there is little reason to regard the U.S. as well-intentioned and benevolent.

Without going into past or future dynamics of this race, we point out that although the fine structure of the phenomenon seems perfectly rational and analyzable, the over-all human and national behavior it describes is totally irrational and, because of the enormity of the risk, patently insane. It is tragic that our university contributes to this madness, which leads it inexorably to exacerbate the situation by a factor of greater than ten through the development of MIRV and future weapons.[++] And it is especially tragic that the rationale is always the same -- namely, we are making a vital contribution to the defense of the country. The university has become wedded to the national myth. Moreover, once started, the momentum of the commitment is overwhelming. We have already pointed out in the introduction the power of the Defense Department and its associated industrial conglomerates. M.I.T. has been, in fact, an intricate and key member of this military-industrial-university menage a trois,

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[++] Among the new weapons the Military-Industrial-University complex has lined up for the coming decade are:
(1) SABRE - improved accuracy of the warhead by guidance
(2) WS - 120A - follow on to the Minuteman for improving the accuracy of the missile
(3) ULMS - Underseas Launched Missile System
(4) ARV - Advanced Reentry Vehicle - Each warhead on the multiple warhead missile will have a separate propulsion system and a separate guidance system. This will make a small warhead like the one on current Poseidon or Minuteman a first strike weapon.
(5) Terminal Advanced Guidance System (currently under study by Ling-Temco-Vogt Corporation) based on programming the guidance system with radar signature of the target and a radar system site target.

supplying technical expertise, but more important, imagination and innovation to further the efficiency and destructive capability of our military forces, for the no-longer attainable goal of a military-insured national security. Moreover, we contribute to this enterprise generously, and without financial reward, while the aerospace and defense industries, who press hard for more and more defense spending in the name of "national defense" are making astronomical profits from what amounts to a public subsidy, producing hardware that is obsolete before it is deployed, thus necessitating further production of new items. This is perhaps the greatest collective exercise in waste that a society has ever pursued, not just in terms of dollars, but in human effort.

There are some indications that at this time, in the wake of a war pursued under that same mythology of national defense and creating carnage and destruction on an immense scale, with a sophisticated technology that is out of rational control, our society is beginning to awaken and observe its own behavior with dismay and doubt.

Many of the problems we face seem paradoxical. Our strong feelings for our country and for its well-being are legitimate and deserving of implementation. But, if a military defense of the country is not feasible, how can we assure against disaster? The best way is to promote the possibilities of reason and understanding which underlie the principles embodied in the university and are, paradoxically, implicit in the idea of nuclear deterrence. We must redefine our national priorities and allocations so that human needs are met in our society and throughout the world, so that we can be satisfied with the quality and meaning of our lives. And we must redefine our foreign policy to make peace and security a reality.

In this regard, we recommend that the negotiations that are to start this summer with the Russians be given topmost national priority. To this end, we feel that further development or testing of MIRV at this time would be extremely ill-advised, and should be terminated. The MIRV program serves as a paradigm of how the development of technology takes on a specific political character and leads, predictably, to certain social and political consequences, whatever the motivation of participants may be. It would be quite irresponsible to blind ourselves to this phenomenon, which is of overwhelming importance in today's world. A public statement of a moratorium should be made by the President of the United States as a sign of good will. There is much evidence that the Soviet Union is significantly behind the U.S. in MIRV development.* If we seriously desire to avoid another upward spiral of the level of destructive power, this step could lead to a strengthening of our national security through negotiations without putting us in any further jeopardy.

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*Aviation Week and Space Technology, August 5, 1968, April 28, 1969

Among the problems that M.I.T. must confront in assessing the role of the special laboratories is the question of what posture a university can legitimately assume with regard to issues which have extensive political ramifications. As we pointed out in section II, through the development of technology, M.I.T. has an unavoidable and political impact on the society; moreover, it makes political judgments in accepting and, often, initiating contracts for missions like MIRV, the army TAGS project, the MTI radar, and the laser weapons work. Such work identifies the institution with the goals and ultimate intent of the missions and is thus a politicizing force of considerable magnitude.

Moreover, the shroud of classification and security make it quite impossible to determine the character of certain projects, and can legitimately be taken as prima facie evidence that the justification of social utility is unreal. We cite the dilemma exemplified by the VTOL-helicopter project. Its director argues that the project is of fundamental importance in terms of civilian air transportation; in principle this is undeniable and there is, no doubt, a highly beneficial potential. But we have already stated the conviction that the uses of a technology should be of concern to the scientists and engineers who develop it. It is not always appropriate to develop a gadget or functioning system merely on grounds of its intrinsic engineering interest. At a time when our government uses intensive counterinsurgency warfare against social movements in undeveloped countries, and when the army is clamoring for better helicopters and VTOL's with greater stability and all-weather capability, and when the VTOL project is funded by the army as an essential part of its Tactical Aircraft Guidance System and remains classified in detail, one must assume that the social benefits and the means for their implementation are far removed from the actual use to which the system will be put when developed. The present priorities of our society strongly indicate a lack of financial resources for widespread civilian deployment of such a transportation system for the benefit of any significant fraction of our population.

In the case of MTI (moving target indicator) radar, the technology of the Lincoln Laboratory was specifically focused on the problem of how to penetrate foliage to detect a slowly moving object as small as a crouched man, for use in Vietnam. A prototype system was built in response to a call from the Director of Defense Research and Engineering in the Pentagon, and is now in use to protect a special forces camp. It is argued that such a device is used to save lives, not as a weapon. The propriety of such endeavors, which involved M.I.T. personnel going to Vietnam to oversee installation, is highly questionable. No doubt MTI may save American lives, but it also detects Vietnamese in their own country for the purpose of killing them. The equipment is said to have applications for broader surveillance.

The Panel has recently learned that part of the laser work being done at the Lincoln Laboratories is so secret that we may not be apprised, even in broad terms, of its intended purposes, nor of the destructive capabilities of such devices. Under these conditions, one can only assume that this work is weapon-oriented; moreover, we must state categorically that work of such a secret nature is totally foreign to the spirit of free inquiry and has no place in a university regardless of any redeeming features it might possess.

The Apollo Project is an example of a large mission-oriented project at the Instrumentation Laboratory which does not suffer the same criticisms as weapons research and development, even though much of the technology is identical to that for Polaris, and the mission includes overseeing industrial production and actual field use. Closeness to production per se is not an important criterion for judging the suitability of projects for a university. In fact, one cannot expect that large mission-oriented projects divorce themselves from prototype production. The majority of the Panel use this criterion to skirt the issue of the propriety of building weapons systems. Thus, by their standards, Apollo is as objectionable as Poseidon. In fact, it provides an enlightening comparison to Polaris and Poseidon. The Apollo program has trained students, been a source of theses and intellectual excitement, and, furthermore, is almost totally unclassified, although it is done in a classified area.

V. Approaches and Recommendations: Conversion

Granting that M.I.T. reflects and contributes to the military orientation of our society, with all of the serious consequences that follow from this, we are faced with great barriers in the way of significant change and viable alternatives. In many ways, it would be most expedient for M.I.T. to divest itself from the special laboratories, with their undesirable classification barriers and weapon development; if this were done, M.I.T. would undoubtedly make arrangements for the labs to continue to function as viable independent corporate organizations. This avenue is being pursued by other universities who now find their defense laboratories an embarrassment. But if the problem is basically a national one, such action will contribute little if anything to facing the ills of our society. Legal separation of the laboratories avoids the fundamental problem, namely that technology transfer will still take place, through which we will continue to provide M.I.T. technology and expertise to those and other industrial laboratories for the same ultimate uses as we do now. Thus the waste of human and financial resources will continue, the misuses of technology will continue, as will the escalating level of violence and terror in the world.

It is not sufficient to feel discomfort with the inertia, of present priorities and values. We must devote our efforts as individuals, and collectively as a community, to establishing viable alternatives if we hope to bring about change. It is the seeking of viable alternatives which is the nexus of Conversion. We are obliged to start from the situation as it exists even if this implies obvious short range handicaps. For instance, one could argue that the special laboratories are overdeveloped, ossified, and too defense-oriented to change; that the solutions of social problems are too difficult and obscure; that no large scale new direction for those facilities is evident, nor is it obvious that technology can play a major role. One can offer the equally powerful argument that it is better to start fresh and build a new organization for a new purpose than to try to convert an old one from one function to another. All these observations have some measure of truth. However, the principle of Conversion is not so much a change from one function to another, as from one framework of total experience (life style, life purpose) to another. This is obviously a long-term, in itself seemingly unrealistic, goal. Once the problem is defined and set in its perspective, however, approaches and intermediate stages can be delineated.

The most obvious impediment is that the problem has not received serious and practical study. To this end, we propose that M.I.T. take immediate steps to set up an interdisciplinary Department of Conversion

Science. This department should appoint people from the special laboratories, community people not associated with the university, students, faculty and prominent non-resident national figures (such as Senator McGovern) to explore possibilities in new technologies, new social and economic orders, policy analysis, strategy studies. This department should work in close conjunction with people in the special laboratories to establish long range strategies and partial testing of methods of conversion. Many people in the laboratories have already devoted themselves to seeking non-defense areas to explore (as exemplified by many of the ancillary projects which are not well-funded) and are much further advanced than most people on campus in their efficient teamwork and practical experience with problems of social utility. Closer contact with nascent groups on campus, like the Urban Systems Laboratory and interdepartmental projects like the CARS project will help to define practical alternatives to defense work. We expect the M.I.T. community as a whole and the administration in particular to commit itself to making such an undertaking practicable by organizing fundraising and educating campaigns to bring in non-defense money. These efforts should be directed at the alumni, the Boston community, the industrial world, the Foundations, and the Congress. In forming closer ties with the laboratories the Institute should make clear that it is committed to them as an integral part of the community. The new interactions between students, faculty and laboratory staff alone should provide ample generation of new opportunities and new ideas to justify doing so.

Such a process is obviously a long term commitment, and cannot be accomplished overnight, however desirable. We, therefore, expect that the laboratories will continue for some time with much of the defense research in which they are currently engaged.

However, there are specific projects which we feel are highly dangerous for the well-being of the nation and inimical to the spirit and the responsibilities of a university and should be discontinued immediately. These are:

(1) all Poseidon Projects

(2) SABRE

(3) MTI radar

We suggest that the personnel now working on these projects begin work on seeking non-defense projects, or work on other programs in the labs. In any event, as a contingency measure, and given the urgency and importance of the problem of conversion, M.I.T. should undertake to salary all people involved at their present levels of income (with provisions for standard increases) until satisfactory long term arrangements can be made.

Concerning the army-VTOL project, we feel that given the probabilities for its ultimate major use in counterinsurgency operations, support for the project should be obtained with the help of the M.I.T. administration from a civilian agency like FAA. Whether this proves practical or not, we feel that M.I.T. and the project director should issue a public statement of intent that this navigation and control system should not be used for the suppression of popular social movements at home or abroad.

The laser program at Lincoln Laboratory should be declassified to the extent that the M.I.T. community can accurately ascertain its nature, at which point a judgment by the Standing committee proposed in the majority report can be made as to its appropriateness.

There is no intention in this report to assign blame or responsibility for the status quo. We have all contributed by our inaction and silence to allowing the society to espouse the values it displays. Some of those who do defense work and weapons work do so because they feel it is important for the country; others because the technology is more interesting than elsewhere, or because it pays better, or because the working conditions are congenial. What is clear is that when some students and faculty questioned the propriety of the work on the grounds of its ultimate uses, its contribution to war and the arms race, the people in the laboratories immediately feared for their jobs and their families, and rightfully so. Their reaction reflects their realistic awareness that money for new projects will not be forthcoming unless radical changes take place in American culture and society.

Their options are totally restricted by the society. What is necessary is for M.I.T. as a whole to commit itself to trying to make new options available, to persuading its alumni, the general public, the Congress, industries, and first of all itself that new and strikingly different approaches are necessary.

The CARS project is a good example of the kind of alternatives possible for future activity. It is an interdisciplinary enterprise involving 70 people at M.I.T. from six different departments: Civil Engineering, Electrical Engineering, Aeronautical Engineering, Architecture and City Planning, Political Science, Management. In addition, there are contributions from four major laboratories: the Civil Engineering Systems Laboratory; overall project coordination residing in the Urban Systems Laboratory. Current work is under two contracts; one from the Department of Transportation ($855,000. for 18 months - 5% cost sharing from M.I.T.) and one from the Ford Motor Company ($60,000. plus two people who have M.I.T. appointments as research affiliates). The idea originated with two students and came out of a course called Special Studies in Engineering. All the people involved feel very excited by the interdisciplinary nature of the project and the social relevance of the mission. For a complete description of the project, consult the Hearings of the Review Panel on Special Laboratories, 9 AM, May 15, 1969, testimony of Professor Daniel Ross, director of Civil Engineering Systems Laboratory.

Another example of an alternative to defense work is the Ambulatory Health Care program at the Lincoln Laboratory.

Conversion is on the horizon as a national necessity as well as a solution for M.I.T. The economic implications for this country of Conversion are enormous because so much of our economy is synchronized to the outpouring of defense expenditures on war materials and nuclear weapons. The inevitable end to the war in Vietnam will bring drastic reduction in the consumption of military field hardware; major cuts in defense spending will affect the aerospace and defense industries, whose life blood depends on wasteful and useless production of no social value. A change of production to the social sector to meet public demands will meet considerable opposition from lobbies of non-convertible industries and interest groups because of the money that will be diverted. Moreover, any changes must be carefully monitored by the public interest so that they define the direction of production rather than become molded by the industrial interests.

VI. Conclusion and Summary

We hope that M.I.T. will seek closer ties with the special laboratories as an initial step towards conversion and the creation of a true university community. We hope that M.I.T., collectively and as individuals, recognizes the great responsibilities that accompany the great power it wields through science and technology and that it will act as a countervailing force in the society for human ideals.

We are, therefore, opposed to any spinoff or other separation of components of the laboratories which would continue to do weapons development. We feel that this work is in itself inimical to the best interests of the country.

We are for total conversion of the laboratories to socially productive uses.

We are for discontinuing work on Poseidon, SABRE, and MTI since they are weapons systems which contribute to nuclear arms escalation and to counterinsurgency devices.

We propose a Department of Conversion Science to study and implement the conversion of the laboratories and the society from wasteful to socially useful production.

III. Additional Recommendation

1. Ad hoc review of the relationship between M.I.T. and the special laboratories

In concluding its deliberations the Panel adds to the specific recommendations in its First Report the recommendation that the entire matter of the relationship between the Institute and its two special laboratories be reviewed on a regular basis. This recommendation is made first, because the Panel feels that considerable insight and understanding has been gained by all parties as a result of the review and second, because the dynamics of both the M.I.T. campus and the two laboratories assure that many of the premises on which the Panel's current conclusions rest will change. It is suggested that such a review be initiated no later than five years hence by an ad hoc group distinct from the Standing Committee and appointed by the President. If the Standing Committee so recommends, such an ad hoc review could be initiated at an earlier date.

IV. Personal Statements by Panel members

1. Noam A. Chomsky - Comment on Personal Addendum in May 31 Report

I would like to add the following introductory paragraph to my personal addendum:

As the report of the Review Panel states at the outset, "the members of the Panel are in substantial agreement with this report except as otherwise indicated in the additional statements attached hereto." In this appended statement, I would like to indicate in what respects, and for what reasons I find myself in disagreement with this report. The nature of these disagreements is such that I cannot sign the report as it stands.

September 10, 1969

2. Jonathan P. Kabat - Additional Statement

The opening statement (in the May 31 report) that "the members of the Panel are in substantial agreement with this report" is factually incorrect as it regards me. My differences with the report are basic and are evident from the recommendations and conclusions in my May 31 Report (which I would like to be titled Minority Report) and in the more explicit criticisms in Noam Chomsky's statement.

September 17, 1969

3. George Katsiaficas - A Personal Statement

In submitting this minority statement, I wish to express my dissatisfaction with the Panel's initial report and to briefly outline alternative recommendations for change.

The Initial Report

By themselves, the recommendations and conclusions of the Panel can be viewed as an acceptable response to the problems surrounding military research at M.I.T. Although the recommendations do not nearly go far enough, I do not object to these proposals for change as much as to the spirit in which they were promulgated and received: the Panel's initial report served as a justification of the status quo to many of those concerned with the cancerous growth of the special laboratories. In some cases, past events and their present manifestations at M.I.T. should have been condemned rather than condoned.

My objection with the recommendations stems from the realization that radical change in the nature of the projects at the special laboratories is necessary for the laboratories to remain an integral part of the university. The panel, however, called for only moderate change. Unless rapid change occurs in the near future, the operation of the university is certain to be interrupted.

Military Research

The est ablishment of national priorities in the United States has placed militaristic concerns above all others. In light of the ecological and social problems existing today, a redefinition of national goals is necessary so that our society can cope with the exigencies confronting us.

At M.I.T., we have been overly concerned with applying science to the needs of the military. The immediate effect of the allocation of our resources in this area has been to preclude activity in other areas of concern. While this neglect is clearly unacceptable, other effects of our myopia are equally disastrous. By working almost solely for the military, for example, M.I.T. has trained its students in military technology and thereby induced them to continue in DOD work after graduation. In addition, by accepting military contracts, M.I.T. inculcates in its students a positive attitude concerning war research. Instead of focusing on militaristic concerns, M.I.T. should be preparing its students to confront a far broader spectrum of problems.

Conclusions

Because of the great influence exerted by M.I.T. on the technological advances of our society, I hope that the university will recognize greater responsibility in meeting the ecological and social problems now confronting us.

I therefore call for total conversion of the special laboratories to socially productive uses.

I strongly recommend the immediate curtailment of projects solely dealing with armament systems and counterinsurgency mechanisms.

While this document is brief, it accurately illustrates my feelings. I have carefully reviewed John Kabat's minority statement in the first report of the Panel and concur with that addendum in its entirety.

September 1969

4. Eugene B. Skolnikoff - Policy Research and Teaching at M.I.T.

In its discussions and deliberations, the Panel often found itself returning to the general question of the appropriate functions and responsibilities of M.I.T. in a world in which science and technology play such a central role in rapid social change. The recommendations that the capabilities of the special laboratories should be increasingly devoted to attacking the nonmilitary problems of our society reflected the view that M.I.T. does have an important responsibility to society that goes beyond its primary social responsibility of academic teaching and research.

M.I.T.'s record through its first century demonstrates that the Institute has always kept this broader responsibility to society high on its agenda. In the last several years, the Institute has also recognized that the task of fulfilling this broader responsibility has become more difficult and more intellectually demanding. The major difficulty is that the social problems that are besetting our society, many emerging as a direct result of scientific and technological advance, do not conform neatly to the traditional disciplinary organization of a university. Natural and social scientists and engineers are increasingly aware of the broad social, political and economic effects of their work, or are increasingly aware of current issues to which they must be able to contribute, but normally find it difficult to become seriously involved in those problems within their own disciplinary framework. At the same time, the rewards, the financial support, and the intellectual interests of the disciplines provide powerful incentives that discourage individuals from venturing out from their disciplinary homes, especially if the problems involve work across the boundary of the social and natural sciences.

In several important areas the Institute has developed multi-disciplinary research and teaching programs, in particular in urban affairs, transportation, and bio-medical technology. But many members of the Panel, along with many others at M.I.T., believe that we must consciously expand these kinds of efforts; that the potential contributions of the Institute, of its students, faculty and staff, including the special laboratories, have only begun to be explored.

One proposal relevant to these objectives has been under active discussion at M.I.T. and is near fruition. This is a proposal to create a new institutional mechanism, tentatively titled a Center for Policy Studies, that is intended to provide a focus for organizing, helping, and guiding new research, analysis and teaching efforts in problem-oriented areas. The functions envisaged for such a center would be to:

1. Provide administrative and financial support to Institute faculty, students and staff to enable concentrated work for a period of time on problems outside the normal disciplinary focus;

2. Sponsor seminars, conferences or summer studies in the subjects of interest;

3. Provide a source of initiative to explore specific areas of public interest that M.I.T. should or could be concerned about;

4. Provide a means for inviting individuals from outside M.I.T. to join with the M.I.T. faculty on specific studies included in the Center's program;

5. Develop new interdepartmental courses in cooperation with the existing departments that could reflect or complement the research sponsored by the Center;

6. Serve as an Institute focus for the development of systems analysis techniques and methodology, and join with interested departments in offering courses in the area;

7. Provide a source of initiative to bring students into participation in Center projects, devising special programs and procedures to facilitate such participation when necessary;

8. Serve an educational function in public policy issues, especially those growing out of science and technology, through lectures, seminars and the like.

The substantive areas of interest for such a Center, or for any other mechanism or project of this kind, can clearly cover a wide range. The Center in its experimental phase is starting with two areas of great interest and importance: environmental alteration and arms control. Others seem also to be of sufficient importance to warrant early exploration: technology assessment, allocation of resources for science and technology, and international implications of technology.

These latter subjects all carry with them a strong element of concern about the side effects of future developments in technology, and, more particularly, the degree and form of control over technological developments presently exercised within current decision-making processes of government and society. Many elements in the society--both within the government and outside--have come to share these concerns. Universities in general must play an important role in developing the facts, the analyses, the methodologies, the alternatives, the public understanding, and, ultimately, the individuals who can change, challenge, and improve our decision-making processes with respect to technological developments and their effects. The technically-oriented university with strong social as well as natural science competence ought to be in the forefront of that effort.

None of these teaching or research innovations and experiments will be easy to accomplish, and some will carry inherent threats to the discipline-oriented teaching and research of the university which must also be preserved. To lose the disciplinary base on which the problem-oriented work is built would not serve society or the university. It is a diffcult line that must be developed and followed but an essential one.

September 16, 1969

5. Gregory Smith and Victor F. Weisskopf - Public Policy, Public Opinion and the University

The Panel appointed by President Johnson and chaired by Dean Pounds was given a specific charge. The substantive part of the charge said, "The function of the Panel will be to evaluate the benefit and the implications that the laboratories have for the Institute in its prime responsibility for education and research and in its responsibility of service to the nation."

"I would ask the Panel to review the appropriateness for Institute sponsorship of the current programs at the laboratories, the decision-making process by which new programs are accepted, the relationship of the laboratories to on-campus research and education, and in general, the long-standing policies and procedures with respect to public service obligations." It was directed to file a preliminary report by May 31 to be followed by a final report on October 1.

In the report filed on May 31 recommendations were made affecting the relationships of the two special laboratories with M.I.T. The report perforce spoke almost entirely to the core of thinking that created the recommendations. On June 7 the Panel met and decided to expand certain portions of the report and incorporate them in the final report. This section has to do with the interactions of Public Opinion, Public Policy and the University in the National Scene. This interaction is of paramount importance in establishing the relationships of the special laboratories to M.I.T. Indeed it is of such importance that the question can properly be raised as to the ability to greatly change the activities of the special laboratories without a change in the overall interaction.

Harvard University has recently carried out an extensive survey of its Medical School in respect to its relations to its own area (Roxbury) and other activities of the school in the national problem of minorities. One subcommittee studying the responsibility of the school in the event of civil disorder and resulting injuries wrote in its opening paragraph:

"The mandate of the task force is to explore recommendations for emergency treatment in the urban areas during civil disorder... However we feel compelled to urge upon the faculty giving broader commitment to these problems, one that clearly extends beyond the traditional limits of medical endeavor, for the sorting and treating of broken bodies is but a minuscule fraction of the total disaster."

This statement, tragic in its implications, has relevance to the section here. For we can with equal validity say that M.I.T. not only has the commitment to invent and develop the scientific and technical tools for solving national problems, both military and social, the commitment extends beyond the traditional limits of technical endeavors toward a responsibility for a study of national problems and for formulating proposals to deal with them. These studies and these proposals should have an influence on public policy. It is one of the important public services of a university, in particular of a university of the kind M.I.T. represents, to search for the nature and for the solutions to the pressing problems of the times. It is also one of its services to find ways and means to contribute to the formulation of a constructive public policy; at the same time jealously protecting its traditional role as a free, unfettered university.

The problems which the country faces today are connected with the gross imbalance in the way the government spends its money.

Let us give the figures for a few areas:

D.O.D.	80 Billion
H.E.W.	10 Billion
Agriculture	4 Billion

These figures express the present one-sided approach to the threats to our national security. Most of our resources go to meet an external military threat. Whereas the grave and steadily mounting threats to our national security stemming from the internal problems are met on an insufficient scale. This is the place where the universities should exert their best influence for a remedy. For it is not only the money that is missing but the ideas.

It is easy to counter military threats by more and more sophisticated hardware. It needs much more study and ideas to find better ways towards a more stable world abroad which may make the arms race superfluous and towards a more stable situation within this country which provides for all our citizens the care and opportunities they deserve.

The Panel was unanimous that greatly increased amounts must be spent on our tragic internal problems.

The question arises, "What can a university do about it?"

The university is the highest reservoir of intellectual activity. It has for centuries been the beacon light of civlization guiding man's mind through education to seek solutions to his problems or to enrichment of his leisure hours. And the disciplines of science and technology have been the leaders in the direction of man's activities.

Science and technology have thus contributed to the positive values of life. But they have also contributed to the negative values.

Many ecological dangers facing us have resulted from technology, air pollution, stream pollution, species extinction, ecological imbalance, over-population through the lengthening of life span, all have been influenced by the products of technology.

Solutions to many of these problems will come from technology properly applied. Technology has the responsibility to attack them.

For centuries the university has been to many, to use the cliche, "The Ivory Tower." By that we mean it has not involved itself in "mission work" to a large degree, but rather has been the storehouse and dispenser of knowledge.

It has delivered learning to the students in the form of classical education but has not as an instrument involved itself in specific problems of society.

Government, on the other hand, exists largely to find solutions to problems. They are indeed its "RAISON D'ETRE."

The universities have educated. The governments have acted. This complete division is no longer appropriate. Civilization has become so complex and its problems are so enormous that the universities must be willing to a considerable extent to take on missions. There is simply not time to give out basic research data and hope it will be intelligently applied. The university must assume a portion of the leadership in directing itself to specific problems.

In 1939 the total amount of money invested by the Federal Government at M.I.T. was $25,000;--in 1969 it was $150,000,000.

The Radiation Lab at M.I.T. was perhaps the largest single activity in bringing victory over Nazism.

The Radiation Lab was an example of the term "Mission Oriented." That is, its activity was directed to a specific end.

A Mission Lab is a far cry from the classical pattern of a laboratory that carries on basic research; the findings of which have many applications.

When the war ended, the Radiation Lab was disassembled and the Institute then looked at its research programs.

It was clear that basic research in the universities required Federal subsidies. The avalanche of technology released by the war had stimulated the technology mind beyond any lengths of earlier years. And it was necessary to obtain Federal funds to push the program forward. In the early post-war years, the programs were not wholly mission-oriented. For example, RLE by 1947 was an exciting center of research in electronics and was not by any means wholly mission-oriented.

It is only necessary to recall briefly that in the early fifties national policy called for enormously strengthening our defenses.

In 1951 when the decision to establish the Lincoln Lab was made Dr Killian wrote to the Secretary of the Air Force. Let us quote from a report by Dr. Killian requesting in a letter to the Secretary of the Air Force an outside technical evaluation of the project, he added: "While the principal objective of my letter is to request a technical evaluation, I think it important to restate M.I.T.'s position in the matter. It is an educational institution, and a development project of this size would not normally be a project for which it should appropriately serve as contractor. M.I.T. is justified in serving as contractor only if there is a clear consensus that it is in the public interest for it to do so. In requesting a thorough-going, technical appraisal of Project Lincoln, the Institute would also welcome objective and outside judgment as to whether M.I.T. continues to be the best agency to serve as contractor.

"If the conclusion is reached that some agency other than M.I.T. should be the contractor for the project, we stand ready to withdraw. Since the project involves real hazards for the Institute, particularly financial hazards; and since it is not the kind of project that the Institute as an educational institution normally would wish to undertake, we feel it important that there be no question in regard to our serving as contractor.

"The answer was prompt. 'I want to reassure you unequivocally,' Secretary Thomas Finletter wrote, 'that there is absolutely no doubt anywhere in the Air Force that M.I.T. must, if willing to do so, continue as contractor for Project Lincoln.'

"Thus, in 1953 the present conformation of the Institute had been established; it has changed since then in size, but little in its general form."

It should be noted that in the early fifties there were no voices protesting the rebuilding of military might. Indeed there were far more misgivings on the part of the M.I.T. administration regarding the development of the mission labs than there was from public opinion regarding the huge defense budgets.

Fundamental questions then arise:

What is the role of the university?

Should it take on any problems as requested by the government concerning which it has competence?

Should it choose only those problems it wishes to attack?

Should it suggest that it be given funds to attack certain problems?

Should it refuse to take on certain problems for policy reasons?

Should it attempt to influence and redirect public policy?

Should it express itself in the public arena on public policy?

All of these questions are of the greatest importance--not only to the country but to the stature of a university. To what extent can a university involve itself in public policy and maintain its stature as a free, open reservoir of intellectual depth?

There must be a closer collaboration between universities and public life. If a university takes on the study of problems of society on a larger scale it must have the means and the instruments to do it. The special laboratories could be instruments for this purpose.

So far the missions of the special laboratories have been directed mostly to military weapons problems, in particular the Lincoln Laboratories.

The Panel has accepted the need for a university to involve itself in such missions. To have universities active in defense work is to underline our heritage of civilian participation in military direction. Further, the highest levels of technical competence reside in our universities. But the Panel finds that mission work in the military field is more hazardous to the traditional and cherished role of the university. It therefore recommended strongly that the special laboratories redirect a major fraction of their activities into other directions.

The Panel was unanimous that greatly increased efforts must be spent on our tragic internal problems. A partial list would include:

The urban problem

The minority problem

The transportation problem

The air pollution problem

The stream pollution problem

The medical problems

The agriculture problems

These suggest some of our needs. M.I.T. must be willing to accept mission-oriented programs in these directions.

There remains the question as to how the university can influence public policy towards certain goals such as the solution of the above-mentioned problems.

What the university as a university should do in expressing itself in the public forum is an issue by itself.

There is no doubt that individuals within the university have this privilege and M.I.T. jealously protects this privilege.

Suggestions have been made within the Panel that a significant number of universities might form a "Council of Judgment" and when unanimity was found, issue a position paper. If one says unanimity could never be reached, we suggest it might have been reached in the dark days of Senator Joe McCarthy.

The subject of university activity in the area of public opinion is one that has many sides and complications. It also includes great differences of opinion.

However, it is without doubt that a great university has prestige and can bring influence to the government when programs of the university involving federal funds are being considered. The preliminary report of the Panel obviously hoped this would develop in the immediate future.

In conclusion, the Panel spent much time on the interaction of public opinion, public policy and the university.

Our recommendations are an attempt to lead the way towards an interaction of the three factors to help solve our national problems--externally and internally.

September 1969

V. Background and Historical Information about the Special Laboratories

1. Introduction

Additional background and historical information on the special laboratories, which has been prepared by several M.I.T. staff members, is presented in this section. This material constitutes some of the background material available to the Panel, and should not be construed as reflecting the conclusions of the Panel.

Subsection 2 of this section is taken from a larger document prepared for the M.I.T. Corporation by the Office of the Chairman. It traces the origins of the two laboratories through World War II and provides some background on the evolution of the current relationship between M.I.T. and the Federal Government. Subsections 3 and 4 of this section contain brief histories of the two special laboratories.

2. The Record 1940-1945

World War II was concluded in August, 1945, and the most concise summary of M.I.T.'s contributions to that effort was prepared by Dr. Karl T. Compton, then President of the Institute, for his annual report of October, 1945. The following excerpts, relating to M.I.T.'s research during those years, are taken from that report:

"Two months ago, final and complete victory crowned four years of desperate struggle, into which every element and section of our nation poured its life, its labor, and its resources.

"In this cooperative, all-out effort, our educational institutions have played a notable role. Whereas the Army and Navy constitute our first line of national defense, I venture the statement that our educational institutions rank with our manufacturing industry and transportation system as the principal supporting lines of military power in time of war and of reserve strength in time of peace . . . .

"Within this general structure of the national war effort, the Massachusetts Institute of Technology has played a role in which we can justly take satisfaction and pride . . . .

"In the past five years, M.I.T. has engaged in a total of 400 contracts for work in furtherance of the national war effort.

"Of these, 161 have been directly with the Army, Navy or other governmental agencies, 89 with the Office of Scientific Research and Development, and 150 with industrial firms excluding 275 orders for wind tunnel work. Contracts for research and development totaled \$93,031,000, and those for special training courses totaled \$5,217,500, giving a combined total for research and training of \$98,248,500 . . . .

"Both in money spent and in staff engaged, research and development to produce new instrumentalities or materials for warfare composed the Institute's largest war activity. Certain high spots of these achievements can now be told; regretfully only a few high spots can be included within the compass of this report; the rest will be related in due time.

"Radar and the Radiation Laboratory. Prior to the summer of 1940 our Army and Navy, and also Great Britain and Germany, had newly developed, highly secret radar equipment and had proved the military value of this new weapon, especially in the Battle of Britain.

"In the fall of 1940 the Radiation Laboratory was established at Technology under OSRD contract, as a distinctly cooperative enterprise. Staffed by scientists and engineers made available from institutions all over the country, it embarked on a new approach to radar development, involving equipment, methods, and scientific knowledge that were then largely unknown. This venture proved to be one of the most productive and useful enterprises of the war, and out of it grew a new art, with applications the variety and importance of which were not even dreamed of at the start. Its success is a tribute not only to the practical creative genius of "academic" scientists but also to the wholehearted, effective cooperation of many industrial companies and of forward looking officers of the Army and Navy. Exchange of information, and even of personnel, was maintained with the radar groups of the United Kingdom.

"From its small beginnings late in 1940, this laboratory grew to a scientific and technical staff of 1,200 plus 2,700 technicians, assistants, mechanics, stenographers, business staff. It occupied 15 acres of floor space in Cambridge; it operated large sublaboratories at the East Boston and Bedford airports and smaller ones at various times in Quonset, New London, Orlando, Panama, and elsewhere. It maintained a very active branch laboratory in England and smaller stations in France and Australia. At the close of the war it was organizing a section of over a hundred men and several hundred tons of equipment for Manila, to serve the forward Pacific areas. Its staff have operated in every war theater, from North Africa to China, from the Aleutians to Australia. It was visited by some 86 officials daily from Army, Navy, or manufacturing concerns, and 180 Army and Navy officers were in residence at the laboratory for liaison purposes. Its operating expenses during the last year ran about $3,000,000 a month. With the exception of the atomic bomb activity, it was the largest of the civilian research and development agencies . . . .

"Back of these developments went an enormous amount of painstaking scientific research, theoretical and experimental, often on subjects which to the uninitiated would appear to have no relation to radar -- subjects like the quantum theory of molecular spectra, or electron optics, or the oscillations of coupled systems."

Beginnings of the Instrumentation Laboratory

"Next to radar, the M.I.T. development most extensively used in the war was probably the Draper gun sight, which introduces the proper lead angle in firing at moving targets, be they tanks or airplanes. Some 80,000 are reported to be installed on naval vessels for direction of the vessels' lighter, fast-firing antiaircraft guns, and they have turned in fine performance records against attacking Jap aircraft, especially the suicide planes.

"This is one of a series of devices employing gyroscopic principles which were invented and built by Professor C. Stark Draper and his able associates in the Instruments Laboratory of the Department of Aeronautical Engineering.

"The Instruments Laboratory has been continuously occupied with advanced fire-control research for both services; the program undertaken during the war, which will continue in part until certain specific tasks are completed, provides the basis for a fundamental attack on peacetime problems of control and instrumentation. The prime objective of this laboratory is the education of students on an advanced level in the philosophy and techniques of instrumentation, and the specific research projects undertaken for government and industry by the group have led to advances in the art which will be reflected in the educational program . . .

"For some years, the Institute has pioneered in the theory of servomechanisms, and, as far as I know, has been the only educational program in this little-known engineering field, a field evidently destined to increase rapidly in importance as automatic controls of machinery multiply. This laboratory, under the leadership of Professor Gordon S. Brown of the Department of Electrical Engineering, has been an important national asset during the war, both in developing equipment and in raising the level of the art of servomechanisms among the chief manufacturing concerns involved in production of devices for transmitting rotational motion with power amplification.

"Not the least important and far from the least difficult and time consuming of the Institute's war activities has been its work in formulating and negotiating war contracts and developing policies for the administration of these contracts. There were few precedents. The accepted simple rule of "no-profit, no-loss" as applied both to the institution and to its employees under the contracts, sounded well but was of no practical value until translated into specific terms of allowable expense, overhead, property accountability, reserve for terminating expenses, insurance, authority for actions, pay scales, handling of patents and reports, auditing, and an infinity of similar items, large and small.

"The Institute also adopted the policy that it would accept no profit on the war work it undertook for the Government. It deposited with its chief govermental contracting agency, the Office of Scientific Research and Development, a vote of its Executive Committee to return to the Government any net profit, if it should find on termination of the contracts that there had been a profit.

"The term'epoch' is not customarily used to designate so short a period as five years. Yet in many ways the term is appropriate to these war years. In these five years the Institute spent on its war contracts as much money as it had spent on its normal activities during its previous 80 years of existence.

"One thing has been accomplished during this epoch besides the winning of the war: The performance of the Massachusetts Institute of Technology, through her alumni, staff, and organization, has demonstrated more vividly than ever before the essential soundness of her conception, the public value of her work, and the justification for her continued endeavor to pioneer in the oncoming lines of technological progress. It is in times of stress that strength is proved, but God grant that our future demonstrations of strength may be made with full effect under the stress of a strong urge to be useful in peace, and never again under the dread compulsion of war.

With the end of the war, M.I.T. like the rest of the country began the elaborate conversion from wartime to peacetime activities. In much of the country there was the belief that, as after the first World War, there would be a rapid return to "normalcy." There could be no such illusions among the scientists and engineers at M.I.T. By the very nature of their wartime activities they were aware, more than most, of the lesson that had been learned under the spur of wartime emergency. The lesson, enormous as it was, could be stated simply: it was possible and indeed even straightforward for scientists and engineers, provided with adequate resources and enabled to chart their own courses, to turn scientific knowledge over a relatively short period of time into services and material that would satisfy human needs and human purposes. During the war, those needs and purposes had been inextricably involved with winning the war, but it was obvious that the same approaches and the same techniques would be at least as serviceable in meeting the needs and purposes associated with peacetime activities.

At M.I.T., the lesson was symbolized by the Radiation Laboratory and by the host of other wartime efforts. In the country at large, the symbol of the change was the Manhattan Project, which had its intellectual origins a short year before the war with a handful of discoveries at the very frontier of nuclear physics and which had grown into what was until then the most intensive engineering effort in the history of man.

In hindsight, the consequences of these new approaches and massive organizational arrangements were hardly clear at the time. On the one hand, it was scarcely arguable that R & D of the fundamental sort considered here is best conducted in close association with pure scientific research -- this, too, was one of the lessons of the war. That much of it would accumulate in institutions such as M.I.T. could be safely predicted. It was clear also that the cost of the necessary increase in basic research would be of an order of magnitude to which universities were simply not accustomed, and which could scarcely be wrested (even if it were appropriate) out of student fees, or private foundations, or the good graces of alumni. Nor was it clear how it could appropriately come from industry itself, without altering in some very fundamental way the nature of the academic institution.

It is not evident that this dilemma was clearly seen in 1945, and it is certainly true that the solution, which in time was to be the predominance of government money in sponsored research and in accompanying dizzying growth in the total amount of that research, was nowhere clearly envisaged in the days that immediately followed the war. Yet it was in those days that the development began to take place.

Vannevar Bush was one of the few who had a clear vision of the future. In July, 1945, he foresaw in particular the special need for Federal support. "New impetus," said Dr. Bush, "must be given to research in our country. Such new impetus can come promptly only from the Government. Expenditures for research in the colleges, universities, and research institutes will otherwise not be able to meet the additional demands of increased public need for research."

In the years immediately following the war, it became national policy to provide Federal funds for research in our colleges. The first funding came principally from the military agencies and was carried out according to the fiscal and other principles developed during the war and summarized earlier in this paper. These principles were later liberalized and strengthened by the Navy through the Office of Naval Research, which represented an extraordinary achievement in successful and enlightened government research sponsorship.

The policies and procedures of the O.N.R. set the standard for the Army and the Air Force and were of assistance to the Atomic Energy Commission, to the greatly expanded activities of agencies like the National Institutes of Health, and to other agencies that were created later, such as the National Science Foundation and the National Aeronautics and Space Administration. And over these years - first slowly, then more rapidly -- came the flow of funds in the support of research in our colleges and universities that Dr. Bush had recommended as one of the fundamentals of national science policy in the postwar years.

3. A Brief History of the Instrumentation Laboratory

The series of research interests of Dr. C. Stark Draper of the Department of Aeronautics and Astronautics that developed into the Instrumentation Laboratory began in the late 1920's with his interest in internal combustion engine cylinder events. It was clear that a very real handicap for studies of engine operation was the lack of fundamental information on pressure, temperature, gas composition, chemical reactions and physical effects. During the first part of the 1930 decade Dr. Draper devoted his principal efforts toward better instruments for improving this situation. High speed pressure indicators and spectographic equipment for analysis of fuel flames seen through quartz windows were designed, built and applied to the processes of engine operation. Support for these projects came from the National Advisory Committee for Aeronautics (N.A.C.A.).

Starting in 1934, a project for the U.S. Navy to measure linear and torsional vibration in aircraft engines and propellers occupied the efforts of Dr. Draper and a half dozen assistants. Results from this project set the pattern that now involves extensive industrial production of sensors and oscillographs to record vibration, and led to the manufacture of the Sperry-M.I.T. Vibration Recording Equipment that was later transferred to Consolidated Engineering.

During the later 1930's, the need for means to indicate the intensity of detonation in engines with minimum fuel consumption requirements became apparent. Accepting the request of the N.A.C.A. to develop an Engine Analyzer for continuously showing flight engineers the essential working conditions in each cylinder of their multiple engines, Dr. Draper, working with two assistants, conceived and developed an instrument that was manufactured in considerable numbers, and was almost universally used on trans-oceanic flights of United States military planes during World War II.

The ideas that some fifteen years later became the basic principles of inertial guidance for aircraft, submarines, missiles and space craft were laid out in general forms during the 1930's by Dr. Draper and his collegues and were associated with concepts suitable for well defined projects. One such early project involved using experimental gyro units to sense angular velocity of lines of sight and generate lead angles for correcting misses due to target motion while projectiles were moving from the gun to the aim point. Under support from the Sperry Company this notion was developed into a Gyro Gun Sight for a .22 rifle.

During a visit from Professor Fowler, a chance remark brought up the subject of lead computing gunsights. He showed an immediate strong interest and was given a working demonstration. As a result of Professor Fowler's action after his return to the United Kingdom, the Sperry Company was given a contract from the British Admiralty to manufacture three of the M.I.T. sights. Firing tests showed indifferent results. As a result of demonstrations to the United States Navy, a contract was received to design and build 12 Gyro Gunsights suitable for combat trials on ship-carried machine guns in the Pacific. The time allowed for the development was six weeks.

Under urgent orders from the Bureau of Ordnance, the Sperry Gyroscope Company contracted with Dr. Draper and his associates to design for production the second M.I.T. experimental gunsight, known as the Mark 14. This sight was being manufactured at the rate of several hundred a month by the end of 1941. The first combat test of the Mark 14 came on the machine guns of the battleship South Dakota in an encounter during which thirty-two aircraft out of thirty-two were destroyed.

The success for the Mark 14 established the reputation of the laboratory and led to a sequence of other tasks. After the Mark 14 came the Gunsight Mark 15 and the Gun Director Mark 63 which added radar to the optical tracking means of earlier sights. The Director Mark 51 gave the sights an off-mount capability for controlling larger guns and the Director Mark 52 added radar range. An after-the-war gun fire control system called the GUNAR was followed in the laboratory by the X-1 Director and the start of a system to control both guns and missiles.

During late 1943, conversations between Dr. Draper and Colonel L. I. Davis led to a contract to the Instrumentation Laboratory to design, build and test three Fire Control Equipments to control bombs, guns and rockets from fixed gun fighters. The design, testing and blueprints for the Gun-Bomb-Rocket sight were complete and in the hands of the AC Spark Plug Division of General Motors for manufacture when V-J day occurred and all orders were cancelled. Manufacture and testing of the Sight under the name of A-1 Gun-Bomb-Rocket-Sight was continued by AC and the

Sperry Gyroscope Company for several years. During the Korean War the A-1 Sight became the A-4 Sight and saw wide use on the F-86 Day Fighters. Various test reports credited the A-4 Sight with being a strong factor in the approximately 15 to 1 superiority in fighting scores of F-86's over the Russian MIGs.

Work on the Airborne Gunsights started many activities in the Instrumentation Laboratory. Tail defense fire control for bombers were designed based on the A-1 Sight and manufactured in some quantity by the Emerson Electric Company of St. Louis, Missouri. Later versions of tail defense systems derived from improved equipment for fixed gun fighters were used for defense of the B-52 and the B-50 Bombers. As these equipments were fairly straightforward modifications of other systems, the Instrumentation Laboratory role in tail defense was largely that of consultation.

The Airborne Fire Control System work afforded the Laboratory many opportunities to begin significant activities in work with flying systems. In particular, it became apparent that the limiting factor in tracking targets with fixed gun fighters lay in the ability of the human pilot to control accurately the motion of his machine. This was the genesis of flight control studies that started during the last years of the 1940's and continue today as an essential part of Laboratory activities.

With the termination of airborne fire control technology projects in 1945, limited funds became available for other areas. Dr. Draper and Dr. Walter Wrigley remembered their earlier interest in better navigation for flying vehicles, and were eager to work actively with enough support to provide for the design, construction and testing of equipment based on the application of all available natural principles to the determination of position, velocity and acceleration. The great desirability of self-contained navigation systems was obvious. Inertial principles applied in patterns of gyro units and accelerometers that had already been well established in theory offered reasonable solutions to the bombing navigation problem. In late 1945 the Laboratory received a contract to design, build, and test an inertial bombing navigation system. The first flights of the FEBE (short for Phoebus, the Sun) were made between Boston and Wright Field during 1948. The system was not completely inertial since it depended upon contact with at least one celestial body, it weighed some 4,000 pounds, but it worked well enough (some 10 miles error in four hours of flight) to show that practical inertial navigation equipment could be built.

FEBE was followed in 1953 by SPIRE, weighing 2,800 pounds, completely inertial and giving some 10 miles error in 12 hour flights from

Boston to Los Angeles. SPIRE JUNIOR, weighing 1,400 pounds in 1957 flew the same course in 10 hours with less than two miles error. Today the SEAL SYSTEM weighing some 200 pounds shows an error build-up rate of 0.3 nautical miles per hour of flight with significant improvements to be expected in the near future.

With the preliminary success of FEBE in 1948, it appeared reasonable to expect that mechanizations of inertial systems similar to those used in aircraft could be applied in submarines and other naval vessels. The Instrumentation Laboratory submitted a proposal to the Office of Naval Research for the study of possibilities for a combined gyroscopic compass-stable vertical unit for submarines and other naval vessels. By 1950 the so-called MAST system study was finished with the conclusion that the combination instrument could be built with performance improvements over the much more bulky separate compass and stable vertical units then in use. Extensive testing of MAST on small navy ships under conditions of rough seas in winter showed superior performance and clearly demonstrated the feasibility of realizing high navigational performance for significant time periods by a self-contained inertial system. In the early 1950's the Instrumentation Laboratory received a contract to design, construct, and test SINS (Submarine Inertial Navigation System) equipment. This task was completed by 1955 with an experimental system tested and delivered with a final report to the Bureau of Ships. The performance achieved represented a build-up of about one mile error over a period of eight hours with continuous good indications of azimuth.

During the mid-1950's the Navy carried out extensive studies of Fleet Ballistic Missile Systems. On the basis of results from MAST and SINS tests it was felt that the problem of designing a control, navigation, and guidance system for submarine-launched ballistic missiles could be solved by engineering applications of existing technology. These facts proved essential to the Navy decision to start design and construction of the POLARIS system.

After the demonstration of inertial system possibilities afforded by the FEBE tests of 1948, the Laboratory began work on guiding ballistic missiles with high accuracy between designated points on the earth's surface. Support of this project made it possible for Mr. Philip Lapp to complete a doctoral thesis on the generalized theory of guidance for ballistic missiles. Other studies followed and many staff members of the Laboratory became intrigued with the new concepts in pioneering technology that could be developed with inertial reactions instead of aerodynamics providing support against the effects of gravity for vehicles moving in space.

The Instrumentation Laboratory had already entered into a contract with CONVAIR for the development of an inertial guidance system for the proposed ATLAS Intercontinental Ballistic Missile. Work under this contract had just started when the Air Force Ballistic Missile Division was established. The Air Force took over both ATLAS and the Laboratory's inertial guidance project. The deicsion to use radio guidance for ATLAS continued for about one year until experience had been gained with radio guidance which proved that it would work well enough but was complex, expensive, subject to interference and not adapted to salvo firing of many missiles in response to massive attacks. For various reasons it was decided to develop an Intermediate Range Ballistic Missile to be called THOR with an all-inertial guidance system. In THOR, inertial guidance proved its especial suitability for ballistic missiles. All later missiles have been guided in this way.

As a result of success with THOR, an Air Force project was set up to' design a new system which, with the incorporation of new concepts and technology, became the basis for manufacture of a guidance system for the TITAN ICBM by the AC Spark Plug Division of General Motors. Flight tests demonstrated good performance and the production equipment has been successfully applied in the TITAN II and TITAN III series of missiles. In 1969 the system remains basically unchanged from the design completed during the late 1950's. By current standards it is large and heavy but still provides instrumental performance not much inferior to that associated with some much later designs.

The discussions of fleet ballistic missile system possibilities during 1955 involved not only submerged navigation for missile carrying submarines, but also guidance for the missiles themselves. Because of essential mobility of launching submarines and their considerable depth under water, radio guidance was certainly not possible as a solution for the Navy Guidance Problem. With the background of ATLAS, THOR and TITAN guidance successes by the Laboratory, a contract was received to work out theory, design, build engineering models, test and document for production an all-inertial guidance system for the POLARIS missile. The Lockheed Company received the prime contract for POLARIS missiles from the Navy with the General Electric Company as subcontractor for guidance systems and Raytheon as subcontractor for computers. On July 20, 1960, less than twenty-four months after the POLARIS contract for the Instrumentation Laboratory was received, MARK I, a production guidance system was successfully fired from the GEORGE WASHINGTON. Instrumental performance was approximately five times better than original specifications and production rates were adequate to equip new submarines as they entered the fleet.

After the POLARIS MARK I guidance system task was completed, the Laboratory received contracts to develop the MARK II and A-3 Guidance Systems. Success with these systems led to the MARK III Project for the Laboratory with plans for later work on a MARK IV system to provide improved performance for the Multiple Independently Targeted Re-entry Vehicles (MIRV) of the POSEIDON missile. During 1968 and 1969 the MARK III system has become available in production from the General Electric Company and has already demonstrated in field tests its ability to dispense accurately the individual units of an operational MIRV package.

The MARK III system design and production documentation work of the Laboratory was completed early in 1968 with the usual continuation of a decreasing level of consultation to help the Navy with the practical problems that always appear during the introduction of any new equipment into operational use.

Shortly after President Kennedy announced that the United States had set the goal of sending a man to the moon and returning him safely to earth by 1970, the Instrumentation Laboratory received its initial contract under the APOLLO project. Guidance and navigation for the Apollo Command Module and the Apollo Lunar Module has been a most spectacular success for the Instrumentation Laboratory. Manned trips to the moon with separation and exercise of the Lunar Module have shown that the Laboratory's efforts are not only theoretically correct but produce designs from which industry can manufacture systems that work in space flight operations without significant flaws.

Poseidon guidance systems designed by the Laboratory are now in production. Firing tests with complete missile have encountered some difficulties, but are now demonstrating excellent performance. Stabilization and angular control systems for the NASA Orbiting Astronomical Observatory have been designed and built and have passed laboratory performance tests before being installed in vehicles for flight operations.

Deep submergence rescue submarine systems for control, navigation and guidance have been designed and built in the form of engineering models by the Laboratory and delivered to Lockheed Aircraft for sea tests. The Laboratory retains a simulator that is being used to train the first crews of hydronauts. The action of the system as demonstrated by the simulator is excellent and appears to have started a train of thought in the Navy that may well revolutionize control arrangements for all submarines and ships.

SEAL, a system based on geometry provided by inertial components has been built for the Federal Aviation Authority and is now installed in an airplane for shakedown tests. This system is intended to provide geometrical references so accurate that it will be possible to plot radiation field intensities on a map to give consistent locations of radio navigational aids.

Advanced gyro units and specific force integrating sensors have been under engineering study in the Laboratory for two years. The data to be taken under the original arrangement with NASA are now substantially complete. Engineering prototype units are now either under construction or already in test. It appears that the original goal of two order of magnitude improvement in performance can be achieved.

Tests of the Sabre guidance system are well along on engineering models. Results are most encouraging. Work is now going forward on a new Sabre-type unit based on applications of the new inertial sensors. These designs will have improved the performance and be smaller in size than the systems now under tests. It is to be expected that ballistic missile effectiveness could be greatly improved by use of these advanced systems.

A most interesting development in the Laboratory has been the VTOL system being carried out for the Army and NASA by Mr. Ralph Trueblood under the supervision of Professors Rene H. Miller and H. Philip Whitaker. Recent demonstration tests for Army and NASA personnel with a helicopter have been quite successful. This field of control, navigation and guidance for VTOL craft has far reaching implications for increased safety in both commercial and military applications.

Two years ago, with the establishment of the Division of Scientific Technology in the Laboratory under the direction of Philip N. Bowditch, the Instrumentation Laboratory formally accepted the responsibility for emphasizing and expanding interaction and collaboration with scientific and academic interests both within and outside M.I.T. as a significant part of the Laboratory's efforts. During the past two years activities within this Division have amply demonstrated the potential and interest both inside the Laboratory and in the academic and scientific communities. Projects initiated and continued in the past year include the following: support to the Woods Hole Oceanographic Institute in the engineering problems associated with their major mid-water offshore ocean current program; design, construction and development of a major oceanographic instrumentation array off Bermuda in collaboration with the Department of Earth and Planetary Sciences; the development, construction and checkout of novel soil mechanics instrumentation in support of the soil mechanics division of the Department of Civil Engineering; design, engineering and construction of a bio-telemetric instrumentation system in collaborative support of a project in the Life Sciences Center; a collaborative project with the Department of Metallurgy and Materials Science and the Harvard School of Public Health on computer control of an electron microscope for particulate matter identification and monitoring; the engineering, design, and construction and installation of a Beneoff Tiltmeter instrument at the Agassiz Seismology Station in Harvard, Massachusetts, in support of the Department of Earth and Planetary Sciences.

One project deserves special mention as it represents to the Laboratory the desired end objective of continuing collaboration with the M.I.T. campus. This project, named CARS (a demand-responsive public transportation system) was conceived and worked on by the students and faculty of several departments under the charter of the Urban Systems Laboratory. During the last year the Instrumentation Laboratory was invited to participate with the leaders of the project in the Urban Systems Laboratory as a full collaborator in a major program of implementation of this transporation concept. This project promises to involve a major effort of the Instrumentation Laboratory together with a major involvement of faculty and students from many departments in an exciting and rewarding project of social consequence.

The Instrumentation Laboratory has recently been asked by the Urban

Systems Laboratory to collaborate with them in responding to a novel dual mode transporation concept involving the CARS system with a line-haul automated highway link. This effort could well involve a major consortium of academic staff and students together with full-time professional Instrumentation Laboratory staff and private industries.

4. A brief history of Lincoln Laboratory

The following is an abbreviated history of M.I.T. Lincoln Laboratory, from its origins in 1950 until the present time, May 1969.

Subsequent to the detonation of the first Soviet nuclear device in September 1949, it became apparent that the United States lacked an air defense system capable of coping with a Soviet airborne nuclear attack. At that time, Professor George R. Valley of the M.I.T. Department of Physics and a member of the Air Force Scientific Advisory Board (SAB) suggested to the chairman of the SAB that a small group of experts be convened to study the pressing problem of designing an adequate air defense system. As a consequence, the Air Defense Systems Engineering Committee (ADSEC) was set up by the SAB with the direct support of the Air Staff. The Committee membership was as follows:

C. S. Draper	MIT	SAB	Aircraft Control
J. Marchetti	AFCRL		Radar
A. Donovan	CAC	SAB	Aerodynamics
G. Comstock	AIL		Radar
H. G. Stever	MIT	SAB	Guided Missiles, Aero. Engr.
H. Houghton	MIT	SAB	Meteorology
G. E. Valley, Chm	MIT	SAB	Physics
W. Hawthorne	MIT	SAB	Aircraft Propulsion

The ADSEC group met weekly throughout 1950. During the course of its study, the Committee requested additional technical advice from the following scientists in the Boston area:

H. Nyquist	BTL
J. V. Harrington	AFCRC
E. Bivans	AFCRC
T. F. Rogers	AFCRC
S. B. Welles	AFCRC
R. E. Rader	AFCRC
J. W. Forrester	MIT Whirlwind
R. R. Everett	MIT Whirlwind
C. R. Wieser	MIT Whirlwind
R. M. Fano	MIT Research Laboratory of Electronics
L. D. Smullin	MIT Research Laboratory of Electronics
R. V. Pound	Harvard University
P. D. Crout	MIT Department of Mathematics

By the fall of 1950 it became apparent that an adequate attack on this problem could only be achieved by the establishment of a large-scale organization devoting its full attention to the problem. As a consequence, General Vandenburg of the Air Force wrote to President James R. Killian of M.I.T. in December 1950 to urge the Institute to set up a laboratory which would concentrate intensively on the urgent problems of air defense. He pointed out that M.I.T. was almost uniquely qualified in this regard because of its pioneering work with the Whirlwind digital computer and other advanced electronics research derived from the World War II M.I.T. Radiation Laboratory.

In January 1951, Major General G. P. Saville, USAF, and his staff met with President Killian and the M.I.T. academic council. The M.I.T.

representatives agreed that the Institute would manage a laboratory devoted to this important problem. During the spring of 1951, M.I.T. conducted a more detailed study of air defense (Project Charles) which defined the technical approach to the problem. In March of that year, M.I.T. requested that the Air Force provide 320,000 sq. ft. of laboratory space, with 20% of the space available by January 1952. By July of 1951, some $2 million in construction monies had been allocated. In July and August of that year the basic contract AF18(600)-11 was signed and a charter adopted which said in part:

> "The three Departments of the National Military Establishment propose to establish, under the management of the Massachusetts Institute of Technology, a program of research and development to be known as Project LINCOLN. The project will be under prime contract with the Air Force.
>
> "The primary mission of the Project will be air defense...
>
> "It is agreed that this Project will serve the Air Force, the Army, and the Navy and it is anticipated that each of the Services will allocate funds under this contract in proportion to its interest...
>
> "The Air Force has planned the establishment of a research center in the Bedford - Lincoln - Lexington area. Within this installation a facility known as the Air Defense Research Laboratory will be made available to Project Lincoln..."

By 1952, the major Lincoln programs and organizations had taken shape. The principal program was the development of the Cape Cod system which was to be the pilot plant for the eventual SemiAutomatic Ground Environment (SAGE) system. This system development program was supported by applied research in the fields of digital computer data processing, long-range radar techniques, and digital communications systems. In addition, programs were initiated on a defense system to protect against low-flying aircraft (Porcupine) and an Airborne Early Warning (AEW) radar.

The Laboratory was organized into seven Divisions as follows, where asterisks after names denote members of M.I.T.

Director	Prof. A. G. Hill*
Assistant Director	M. M. Hubbard*
Assistant Director	Prof. G. E. Valley*

Steering Committee: The above plus the Heads of the Divisions (below) plus the following:

Prof. G. S. Brown*
R. R. Everett*
H. H. Mott-Smith, Jr.
R. O. Rollefson
N. McL. Sage*
J. B. Wiesner*
Prof. J. R. Zacharias*

Division 1	Business Administration - P. V. Cusick*
2	Aircraft Control & Warning - Prof. G. E. Valley* (Quick Fixes, Cape Cod, MTI and Radar, Data Transmission)
3	Communications & Components - Prof. W. H. Radford* (Presentation, Radar Techniques, Long-Range Communications, Communication Techniques, Solid State, Tubes and Components)
4	Weapons - Prof. L. D. Smullin* (System Components, Radar, Mechanical Engineering, Ordnance, Airborne Early Warning)

5 Special Systems - M. M. Hubbard*

6 Digital Computer - J. W. Forrester*
(Cape Cod, Whirlwind I, Whirlwind II, Magnetic Materials, Storage Tubes)

7 Engineering Design & Technical Services - J. A. Vitale*

In addition to the main effort on continental air defense, Lincoln also conducted during 1952 the Beacon Hill Study (on reconnaissance) and hosted a Summer Study which recommended the establishment of a Distant Early Warning (DEW) Line in the Far North.

Technical developments during 1952 included the demonstration of remote surveillance radars operating with the Whirlwind computer by means of digital signals transmitted over telephone lines. Of particular significance at this time was the development of the ferrite-core digital computer memory at M.I.T. which has subsequently provided the high-speed memory for most of the digital computers built in this and foreign countries over the past seventeen years. Other achievements included demonstration of a noise-modulation anti-jamming high-frequency radio-teletype system which was developed for the Signal Corps, and the demonstration of a 1000-mile high-reliability 30-megacycle radio-communication circuit which utilized propagation by forward scatter in the ionosphere.

During 1953, President Killian asked the Air Force about its intentions for the future of the SAGE system then under development at the Laboratory. In May of that year, Air Force Secretary Finletter announced that the

Transition System (precursor of the SAGE system) would be the sole air defense system to be developed by the country. During this same year the Laboratory received a subcontract from Western Electric which covered the Laboratory's assistance to the Bell Telephone Laboratories in connection with applied research on the DEW line radar and communication problems. This collaboration was to continue until 1957. During 1953 the Laboratory continued to work on the development of digital computers, radar data processors, and communications which were to be used in the prototype SAGE Experimental Subsector. In addition, the Laboratory designed a modification of the TPS-1D radar which created the first automatic-alarm radar which was subsequently used on the DEW line.

In 1954 the majority of the Laboratory personnel moved from the old Radiation Laboratory buildings on the M.I.T. campus to the newly constructed facility at the Hanscom Field in Lexington. During this same year the Laboratory began its initial studies on Anti-InterContinental Ballistic Missile (AICBM) systems. In addition, the Laboratory was a consultant to the General Electric Company on the AN/FPS-17 ballistic missile radar. The Laboratory also hosted Project Lamp Light which was a study of techniques for extending the air defense battle away from the shores of North America. Some of the technical achievements during the year included the design of a stored-reference noise modulation radio-teletype system for the Signal Corps, the demonstration of a ground-wave high-frequency radar which could see over the horizon, the design and construction of the first coded-pulse radar receivers and exciters in connection with the FPS-17 radar, and the invention of the rigid space-frame radome.

During 1955, two groups were established at the Laboratory to work on the AICBM problem. In addition, the Laboratory embarked on a program to improve the design of the nation's air defense radars. Building F was added to the Laboratory in order to house the first SAGE computer which at that time, and for some years after, was the largest computer in the world. Some of the technical highlights of 1955 include the initial operation of the Jug Handle Hill radar which was a high-power UHF early-warning radar employing the first large rotating antenna of over 100 ft. aperture. Other achievements during the year included the testing of the Sentinel radar for DEW line use. This radar was operated at UHF with automatic alarms and used the first high-average-power klystron transmitter.

Some of the first pattern recognition work in the country was carried out at this time using the Laboratory's Memory Test Computer (MTC). The Fine Grain Data radar data processor began automatic transmission of radar target coordinates over telephone lines that year. In addition, the first Texas Tower was put in place on Georges Bank off the coast of Cape Cod.

During 1956 the AEW work was expanded to include development of

S-band and 425-megacycle airborne MTI radar processors. In addition, a major involvement began on ICBM warning radars which supported the Air Force in the development of an operational anti-missile detection and prediction system (BMEWS) which was to be in operation by 1960.

Some of the technical highlights during the year included the initial shakedown tests of the experimental SAGE system, the start of construction on the Millstone Hill ICBM radar facility, the development of the TX-O computer which employed a 65,000-word memory and which also used high-speed transistor circuits in the arithmetic unit. During the same year the Laboratory developed a very small transportable radar, Chipmunk, for use by the Ground Observer Corps. Other achievements included the development of the Cryotron computer memory element and work on the first solid state laser. In the communications fields, work continued on VHF ionospheric scatter propagation to the problem of reliable long-range communication.

In 1957, Division 4 turned its attention exclusively to radar development as the Porcupine work was phased out. The Laboratory hosted a symposium on BMD radars. Construction was begun on a high-power UHF radar component test facility which was the first of its kind in the United States. An outstanding significant technical achievement that year was the radar detection of the first Russian Sputnik satellite by the Millstone Hill radar facility. Another significant achievement was the initial operation of the CG 24 computer which was the first alltransistorized computer in the world.

1958 was a year of change at the Laboratory. During this year the Mitre Corporation was formed to provide the Air Force with technical support for the SAGE system. About 200 technical staff and 300 supporting personnel were transferred from the Laboratory to the new organization. The Laboratory divisions were reorganized at this time as shown in the attached chart.

The Air Force agreed to continue to support the Laboratory under the original line item set up in 1951. The charter of this new program was research and development in advanced electronics related to problems of national defense.

During this period the AEW program was revised and continued, and a new program on re-entry physics begun with sponsorship from the Advanced Research Projects Agency (ARPA) of the Department of Defense. Under this program the Laboratory was to investigate, in the laboratory and at the Wallops Island missile range, the radar and optical phenomena associated with the high-speed re-entry of objects into the earth's atmosphere.

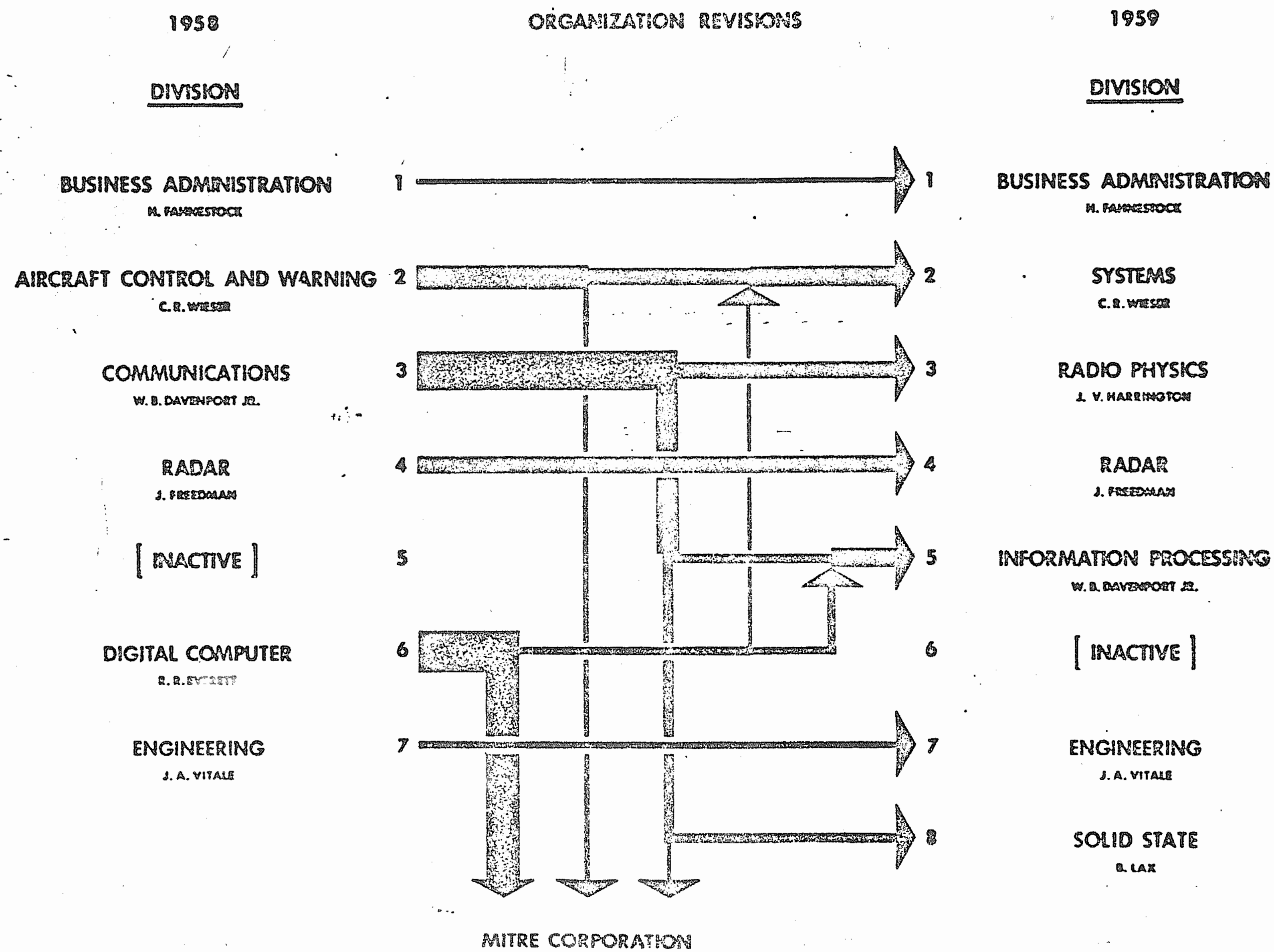
During the summer of 1958, M.I.T. and Lincoln Laboratory sponsored Project Barnstable for the Army. The study considered the problems of data processing and communications for future field armies. From this study evolved the Laboratory's Project West Ford which involved the demonstration of reliable long-range communication by means of the scattering of microwave radiowaves from a belt of tiny dipoles in orbit about the earth.

Some of the technical highlights during 1958 included the operation of the first SAGE sector, the activation of the Boston Hill high-power UHF research radar which utilized a 13-ft. diameter ball-bearing, the operation of a 700-mile long UHF tropospheric scatter radio circuit between Massachusetts and North Carolina, and the first attempt to achieve radar contact with Planet Venus by means of the Millstone Hill radar. This latter effort involved the first practical application of a UHF solid state low-noise maser.

During 1959 a number of new projects were initiated. These included the ADPS project which was a study of data processing for the future field army, a program for NASA in support of the Project Mercury ground tracking network, a program sponsored by ARPA on high-power tubes for AICBM, and a radar techniques study for ARPA. During this same year initial funding was received from the Air Force for Project West Ford. That year the Laboratory hosted Project Atlantis which was a review of new approaches to the antisubmarine warfare problem.

Some of the technical highlights during the year included the initial operation of the TX-2 computer which contained the largest magnetic-core memory in existence at that time (2.5 million bits). Other achievements included the testing of the MAUDE which was a special-purpose pattern recognition computer which converted hand-sent Morse code into printed

M.I.T. LINCOLN LABORATORY



text. That same year the Laboratory completed a Canadian duplicate of the Millstone Hill radar.

During 1960 a number of additional programs were initiated. The largest of these was the Pacific Range Electronic Signature Study (PRESS) program under ARPA sponsorship. This program involved radar and optical measurements on full-scale re-entry bodies during their re-entry into the atmosphere. The measurement equipment was and is located in the Kwajalein Atoll at the end of the Western Test Range in the Central Pacific.

Another significant program which began in 1960 was a Penetration Aids study for the Air Force. The object of this study was the measurement of the effectiveness of re-entry system penetration aids. A program for ARPA was initiated on the problem of radar signal processing for ABM target discrimination radars. Other programs included a NASA deep-space communications study, a hardened radome study, and an Air Force study of data handling and communications for surveillance satellites.

During 1960 the Bedford Antenna Test Range and the National Magnet Laboratory were established. The Wallops Island radar complex began operations for the Re-entry Physics program. Development was begun on the 120-ft. diameter X-band Haystack radar. The Laboratory hosted the International Symposium on Application of Low Noise Receivers to Radar and Allied Equipment. In addition, the Laboratory staff gave an M.I.T.

Summer Course on Radar Astronomy.

Some of the technical highlights during the year include the first radar mapping of the moon using the Millstone Hill radar and the CG 24 computer, the first measurement of the ELF ionospheric-cavity resonance, the invention of the induction plasma torch, and the first observations of Thomson backscatter from the ionosphere by the Millstone Hill radar.

In 1961 the NASA Mercury support program was shifted to the problem of Apollo communications and data handling. Following a study for the Navy, a Polaris communications program was undertaken. It was during this year that the Laboratory established and manned a field site on Kwajalein for Project PRESS. The Laboratory's Re-entry Simulating Range began operations, and the Millstone Hill radar upgrading from 400 megacycles to L-band was started.

Some of the technical achievements during the year included the FX-1 computer which employed a high-speed thin-film storage, the Millstone Hill radar contact with Venus which resulted in a refinement of the Astronomical Unit, and the El Campo radar contact with the sun's corona.

During 1962 the Penetration Aids program became formalized into the BMD Systems program. During this year Building L was added to support the PRESS program. The TRADEX UHF radar became operational on Kwajalein and the 48-inch telescope began operation. Some of the technical achievements included the development of the LINC computer, one of the first small research computers in the country; the completion of the 8-millimeter lunar radar; the development of gallium arsenide diodes for low-noise parametric amplifiers; the demonstration of sequential coding and decoding for high-speed error-free digital-data transmission; the demonstration of the first semiconductor optical maser; and the first radar contact with Venus at 50 megacycles using the El Campo radar.

During 1963 the Laboratory's divisions were reorganized into a form that was to last until 1969. The significant changes made that year included the combination of groups from Divisions 2 and 5 to form a Data System Division, and the organization of Division 6, Communications, from parts of Divisions 2, 3 and 5. Division 6 was organized to undertake a new Space Communications program which grew out of Project West Ford. Funding of this program was by the Air Force and was included in the line item. Other program changes that year included the initiation of work for ARPA on the problem of seismic discrimination of earthquakes and underground nuclear explosions, and ARPA-sponsored Radar Discrimination Technology program which was a continuation and expansion of earlier work in this area. The Laboratory's programs for 1963 which were to remain relatively unchanged for the next five or six years were as follows:

- Re-entry Technology
  - Re-entry Physics, PRESS
  - Radar Discrimination Technology
  - Ballistic Missile Re-entry Systems
- Space Communications
- General Research
- Apollo
- Vela Uniform

Some of the technical highlights of 1963 include: the successful launching and testing of the West Ford orbiting dipole belt, the initial operation of the Millstone Hill radar at L-band, El Campo radar contact with Mars, the first radar returns from the moon at 8 millimeters, successful operation of a semiconductor laser, and the detection of the OH radical in interstellar space by the Millstone Hill facilities.

During 1964 the only programmatic change was the consolidation of the ARPA-sponsored Re-entry Physics and PRESS programs. During that year the Haystack research facility was dedicated and Lincoln took on the responsibility for the AMRAD radar at White Sands. During the year Lincoln hosted a symposium on Radar Reflectivity Measurements. Some of the technical highlights included the development of a low-power laser radar, the radar measurement of Venus by the El Campo 50-megacycle radar, and the first X-band measurements of Venus by the West Ford facility.

During 1965 a program for ARPA on Graphics was initiated. The purpose of this program was the development of computer graphic techniques. In addition, a program was initiated for NASA on lunar-surface studies by means of radar and radiometric measurements.

The Laboratory began participation in the Cambridge Radio Observatory Committee (CAMROC) and initiated studies of a 440-ft. radio telescope. The Laboratory also developed the specifications for the long-range tracking and instrumentation radar (ALTAIR) which was to be added to the Kwajalein complex.

Some of the technical highlights during the year included the launching of the Lincoln Experimental Satellites, LES-1, LES-2 and LES-4, which were the first X-band communications satellites to be launched by the United States. In addition, LES-3, a UHF propagation experiment, was launched, and a 1-sq.-meter precision calibration sphere was placed in orbit. A Lincoln Experimental Terminal (LET) was completed and operated with the X-band LES satellites. This same year the Large Aperture Seismic Array (LASA) was put into operation in Montana.

In 1966 the programs and organization of the Laboratory were continued essentially without change from the previous year. A new facility was completed, called the Space Laboratory, which contains a complete set of fabrication and testing equipment to permit the fabrication of spacecraft up to 5 ft. in size.

During 1966 a number of technical achievements are to be noted. Plans were completed for a new Laboratory computational facility employing an IBM360-67 computer which offered three to four times the capacity of the previous 7094 installation and which also permitted time-shared operation with a very large number of consoles. That same year, the design of a wideband C-band radar, ALCOR, was begun for ARPA. Very detailed L-band radar measurements with Venus were carried out at Millstone Hill. The Lincoln Reckoner system was developed on

TX-2. This system permits simple user manipulation of large numerical data bases.

In 1967 two new programs were undertaken. The first of these, under ARPA sponsorship, involved research on MTI radars which were applicable to problems in Southeast Asia. The second program, under Navy sponsorship, involved applied research on improved communications to submerged submarines. Late in 1967 the Laboratory was informed by DDR&E that certain portions of the PRESS and RDT programs, which up to then had been supported by ARPA, would be turned over to sponsorship by the Army.

Some of the technical achievements during the year included the successful launch and operation of LES-5, a UHF satellite designed to permit communication to small, inexpensive mobile terminals. Communication was successfully passed through this satellite to aircraft at ranges of up to 8,000 miles. A Tactical Transmission System (TATS) was also demonstrated with LES-5. This equipment permits large numbers of small mobile terminals to operate simultaneously through a single satellite.

During 1968 the details of the changing sponsorship of the PRESS and RDT programs were worked out with representatives from the Services. During this same period the remaining ARPA program was modified to include studies on the strategic aspects of offense and defense systems.

During this year, the ARPA-sponsored Vela Program was moved to the M.I.T. campus and a Joint Center for Research in Solid Earth

Geophysics was established in cooperation with the M.I.T. Geology and Geophysics Department.

One of the significant technical achievements during the year was the launch of LES-6 into synchronous orbit. This satellite was the most powerful UHF space-craft launched as of that date. It contained a 100-watt UHF solid state transmitter and a system for automatically maintaining its position in synchronous orbit by means of pulsed plasma thrusters. Other technical achievements of significance included the development of an integrated circuit mask layout capability using the TX-2 graphic system. This system received national attention because of its speed and flexibility. During the year, several long base-line interferometer observations of radio stars were carried out using the Haystack facility together with distant radio observatories.

In the early part of 1969, a new Division, 5 (Optics), was created. The ARPA sponsorship of the MTI radar work was terminated with the completion of several demonstrations. Some of the techniques demonstrated in the ARPA program were of interest to the long-range plans of the Air Force and, as a consequence, the Air Force decided to sponsor a long-range research program into basic investigations of radar signal processing and antenna techniques. During this same year, several studies were completed on possible non-DOD programs in the fields of medical care, air traffic control, and computer-aided instruction. As a result of one of these, a program on medical care has been initiated in cooperation with the Beth Israel Hospital.

VI. Appendix

1. Statistics on Panel operation

The Review Panel on Special Laboratories included a total of twenty-two members; eighteen appointed by M.I.T. President Howard W. Johnson and four added by the original Panel. This group included ten faculty members, four members of the Laboratories' staffs, four students, two members of the M.I.T. Corporation, one alumnus, and one member not otherwise associated with M.I.T.

During late April and the month of May, 1969, the Panel met twenty times in formal sessions for a total of 109 hours. Outside the formal sessions, members of the Panel worked essentially continuously from April 26 to May 30 including weekends and holidays. A conservative estimate of manhours expended by Panel members would be 4500. Other members of the M.I.T. community supported the Panel in various ways which involved many additional hours of work. A group of Panel members made a trip to Washington, D.C. to interview various government officials and one member interviewed several people in California.

During the intesive sessions in April and May a total of 104 persons met with the Panel. This group included eight members of the administration, thirty-one M.I.T. faculty members, twenty-four staff members and employees of Lincoln Laboratory, thirteen staff members and employees of the Instrumentation Laboratories, sixteen students, and twelve people from outside M.I.T.

The Panel received 247 position papers and five petitions from members of the community.

Transcripts were kept of all Panel proceedings and copies are available at the M.I.T. libraries.

Date Due

Lib-26-67