# *"Fighter Pilot: Operation 'Red Flag'"*

**IMAX Film**

*Theme: You, too, Can Become a Fighter Pilot, or At Least Imagine You are One*

The educational value of NASM Theater programming is that the stunning visual images displayed ***engage*** the interest and desire to learn in students of all ages. The programs do not substitute for an in-depth learning experience, but they do facilitate learning and provide a framework for additional study elaborations, both as part of the Museum visit and afterward. See the "Alignment with Standards" table for details regarding how *"Fighter Pilot!"* and its associated classroom extensions, meet specific national standards of learning.

*"Fighter Pilot: Operation Red Flag"* gives viewers a detailed, behind-the-scenes look at a major military aviation training program. "Red Flag" and programs like it provide fighter pilots with the equivalent of ten combat missions-worth of training. Rookie pilots are most vulnerable during their first few missions, so this training could prove invaluable.

Things to look for when watching *"Fighter Pilot":*

- The teamwork required among pilots in the air.
- The teamwork required among the many "behind-the-scenes" elements, on the ground and elsewhere, supporting pilots and flight operations.

## Learning Elaboration While Visiting the National Air and Space Museum

Perhaps the first stops to expand on your *"Fighter Pilot!"* experience should be these galleries related to (military) aviation"

- How Things Fly
- Legend, Memory, and the Great War in the Air (World War 1)
- World War II Aviation
- Sea-Air Operations
- Jet Aviation

Thousands of books and articles have been written about the air combat; and a good starting point is the many books and related materials available at the **Museum Store** in each NASM building.

# Post-Visit Discussion Points to Align Program Material with National SoLs

## High School

see High School Alignment Table
"Strong alignment" is shown in red on the Table and in bold-faced text below

**S A2: Understanding Science Inquiry**

At this grade level, "understanding inquiry" consists of why and how scientific investigations are conducted, and particularly on the role technology plays in enhancing the observational abilities of the investigator, the central importance of mathematics in all aspects of scientific inquiry, the logic behind the inquiry process, and the "scientific method." *Fighter Pilot* could be used to engage students in a post-film discussion of the development of the flight hardware and the tactics shown in the film, from the perspective of "flight test" and how what a test pilot does is similar to what a scientist does in the course of their jobs.

**S B4: Motions and Forces**

Students at this level can address the movement of the aircraft shown in *Fighter Pilot* in a more sophisticated way than can students without the necessary exposure to Physics and Math. The forces associated with flight and maneuver would make excellent discussion points for a class activity dealing with "F = ma."

S B5: Conservation of Energy; Entropy

Successful flight of a high-performance aircraft involves a constant interchange of kinetic and gravitational potential energy – the classic trading of "speed for height" and vice-versa, as amply illustrated in the flying sequences in *Fighter Pilot*.

**S E2: Understanding Science and Technology**

"Creativity, imagination, and a good knowledge base are all required in … engineering" reads part of this particular standard. Fighter aircraft design illustrates both creativity and engineering elegance, but also a solid understanding of the aerodynamics of flight. Even the Wright Brothers made models, performed wind tunnel and other engineering tests, built prototypes, etc. "Operation Red Flag" is but part of the test/refinement process needed to create and maintain high-performance military aircraft.

"Trade-offs" in aircraft design are an example of how a creative approach to engineering can result in the desired performance. Engineers refer to the choices they face because of these competing capabilities and requirements as "trade-offs." For example, a single type of fighter aircraft cannot perform well in all possible areas, because the characteristics needed to excel in one area probably are not so good for performance in other areas. Classic examples of design trade-offs for (military) aircraft include:

- Trading range (fuel capacity) for load-carrying capability
- Trading range and/or load capabilities for maneuverability
- Trading range, load, and/or maneuverability for armor protection
- Trading any/all of above for structural durability (*e.g.* carrier landings)

Trade-offs are the primary reasons for specialization in military aircraft.

Another kind of trade-off in the design process for military aircraft can be triggered by the need for the design team to react to advances in technology made by their opposition. A feature might have to be added to a fighter's design in order to counter a new capability in the fighter's likely opponent, even though the feature to be added might subtract in some way from previous performance.

- One example is protective measures such as self-sealing fuel tanks and cockpit armor. U.S. fighter airplanes in World War 2 had both, Japanese planes had neither. As a consequence, Japanese fighters were lighter and much more maneuverable, but were easily destroyed; U.S. fighters were slower and clumsier, but could take a beating and get their pilots safely back to base.
- Another example is the flares dropped by fighters, as shown in *Fighter Pilot*. The flares are vitally important as decoys for a plane attacked by heat-seeking missiles; the missile "thinks" the flares are the engine exhaust of its target and homes in accordingly. The flares and their launching apparatus take up volume and weight, but those penalties are minor compared to the need for decoys.

Another example is the radar needed for a successful defense against modern anti-aircraft missiles. Early threat detection requires a sophisticated radar and radar detector, both of which come with volume, weight, and power requirements that could be used elsewhere.

**S F5: Natural and Human-induced Hazards**

Piloting high-performance aircraft is very dangerous. Risks come from mechanical failure, pilot error, error of other pilots, or other causes beyond the control of the pilot. High-performance military flight makes a good starting point for a class discussion of risks and benefits.

# Post-Visit Discussion Points to Align Program Material with National SoLs

## Middle School

see Middle School Alignment Table
"Strong alignment" is shown in red on the Table and in bold-faced text below

**S B2: Motions and Forces**

At this grade level, students describe an object's motion in terms of position, direction of motion, and speed; recognize that a moving object experiencing no net force will travel in a straight line at constant speed, and that changes in motion are caused by net forces. The mental images of a fast-moving, low-flying fighter plane assists the learning process on each aspect of this standard.

S C1: Structure / Function of Living Systems

This standard deals with cells as the fundamental unit of life. Specialized cells, organized into mutually-interactive systems provide our basic metabolic capabilities. *Fighter Pilot* shows the human organism under physical conditions that make its normal operation difficult, if not impossible (pilots at high altitude require an oxygen system to breathe; high-g turns require some sort of system to protect the pilot's body).

**S F4: Risks and Benefits**

Piloting high-performance aircraft is very dangerous. Risks come from mechanical failure, pilot error, errors made by other pilots, combat, or other causes beyond the control of the pilot. High-performance military flight makes a good starting point for a class discussion of risks and benefits.

# Post-Visit Discussion Points to Align Program Material with National SoLs

## Elementary School

see Elementary School Alignment Table
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### S B2: Position and Motion of Objects

*Fighter Pilot* demonstrates the importance of items covered under this standard, including:

- An object can be located relative to another object and/or background: Keeping track of "friendly" and "non-friendly" fighter aircraft depends critically on this particular skill!
- Motion defined as change of position with time is easier to visualize for students who can recall seeing a mental image of a low-flying, fast-moving fighter plane.
- "Position changes result from pushing and/or pulling an object" can be more readily visualized in the context of fighter aircraft and the thrust of their engines.
- The notion that steering a fighter is possible due to the forces exerted by the plane's control surfaces.
- Advanced students at this grade level might be able to understand all four forces associated with flight: lift, gravity, thrust, and drag.

### S E2: Understanding Science and Technology

*Fighter Pilot* demonstrates several of the elements of this particular standard, including:

- The use of "tools and techniques" to solve engineering and other technical problems.
- People from a diversity of backgrounds collaborate in teams to build complex systems.

S G1: Science as a Human Endeavor

At this grade level, these particular standards deal with how scientists and engineers from a variety of backgrounds work together to accomplish objectives beyond the reach of any single scientist or engineer. *Fighter Pilot* goes into the concept of teamwork at great length, both on the ground and in the air.

# Resources for Learning Elaboration after the Visit to NASM

Thousands of books and articles have been written about military aviation and military aviation history, but two good starting points are the many books and related materials available at the **Museum Store** in each NASM building, and the list of research and publications of NASM's expert curators:

- ***Aeronautics***: http://www.nasm.si.edu/research/aero/research.cfm
- Center for Earth and Planetary Studies: http://www.nasm.si.edu/research/ceps/research/research.cfm
- Space History: http://www.nasm.si.edu/research/dsh/research.cfm

## National Air and Space Museum Gallery Web Pages

How Things Fly: http://www.nasm.si.edu/exhibitions/gal109/gal109.html
Legend, Memory, and the Great War in the Air: http://www.nasm.si.edu/exhibitions/gal206/gal206.html
World War II Aviation: http://www.nasm.si.edu/exhibitions/gal205/gal205.html
Sea-Air Operations: http://www.nasm.si.edu/exhibitions/gal203/gal203.html
Jet Aviation: http://www.nasm.si.edu/exhibitions/gal106/gal106.html

## Other Military Aviation Websites

National Museum of the U.S. Air Force: http://www.nationalmuseum.af.mil
U.S. Army Aviation website: http://www.redstone.army.mil/history/aviation/welcome.html
U.S. Naval Aviation History Branch: http://www.history.navy.mil/branches/nhcorg4.htm
National Museum of Naval Aviation (Pensacola): http://www.navalaviationmuseum.org
Air & Space Magazine articles on military aviation: http://www.airspacemag.com/issues/military-aviation.php
Royal Air Force Museum: http://www.rafmuseum.org.uk
Nellis AFB: http://www.nellis.af.mil