"Space Station"
IMAX Film

Theme: Learning to Work, and Live, in Space

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 *"Space Station!"* and its associated classroom extensions, meet specific national standards of learning.

What you will see in the *"Space Station"* program:

- How astronauts train
- What it is like to live and work in Space aboard the International Space Station (ISS)

Things to look for when watching *"Space Station"*:

- Notice how quickly astronauts adapt to free fall conditions and life on the ISS
- Reasons humans go to the cost, risk, and effort to work in Space
- The importance of "the little things" in keeping astronauts productive so far from home

Learning Elaboration While Visiting the National Air and Space Museum

Perhaps the first stop to expand on your *"Space Station"* experience should be the Skylab Orbiting Laboratory, entered from the second floor overlooking the Space Race Gallery. Skylab was America's first space station, launched in 1973 and visited by three different three-man crews. It fell back to Earth in 1979. The Skylab on display was the back-up for the Skylab that was launched; the Skylab program was cancelled before it was used.

The Space Race Gallery has a number of artifacts relating to long-term human habitation in Space, including:

- A 1:100 scale model of the ISS
- A 1:15 scale model of the Space Shuttle
- The never-flown backup of the Skylab spacecraft, America's first space station
- The Apollo-Soyuz Test Project capsules (training vehicles) and docking adapter (back-up to the unit flown on ASTP in 1975)
- A real-time display of the location and orbit status of the ISS

A similar interesting exhibit pertaining to the ISS can be found in the Explore the Universe Gallery. Near the end of the Gallery tour, next to the "Local Astronomy News and Events" Bulletin Boards, are several computer workstations offering visitors a gallery quiz. The workstation on the right-hand side is labeled "Satellite Tracker." Like the larger display in Space Race, it shows the real-time location of several major objects in Earth orbit, including the ISS. However, unlike in Space Race, the Satellite Tracker allows the visitor the ability to manipulate the orientation of the ISS in Space, and view the ISS from any "outside" perspective.

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

One subsection of this particular standard deals with the role of technology in scientific investigation: "New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science." The ISS laboratory, along with its microgravity and other unique aspects of its environment, certainly qualify as "new techniques and tools!"

S B4: Motions and Forces

Gravitational Force: Space Station footage can be used to stimulate a class discussion on what exactly is meant by the term "weightless."

- Are the ISS, its components and equipment, and its crew really without weight?
- What is the difference between weight and mass?
- In the film, the Z1 truss was described as "weighing 18,000 pounds," and astronauts were shown handling water cans "weighing a hundred pounds each." What did the narrator mean; after all, weren't those things "weightless?"
- Why are the terms "microgravity" and "free fall" used to describe the ISS environment?

S E2: Understanding Science and Technology

Space Station is a particularly useful tool to engage student interest in one subset of this particular standard, "Science often advances with the introduction of new technologies." The ISS provides scientists with an environment in which long-duration experiments can be conducted under microgravity conditions. "Growing large, pure crystals" was cited in the film, which has potential applications in medicine and electronics. Long-duration spaceflight also provides an opportunity for a lot of different medical studies.

S F3: Natural Resources

The resources Humans consider as "natural" are NOT natural to Space! When seen from afar, the thin biosphere, the only place Humans can live without the large amounts of technical and other support that allow astronauts to live a small portion of their lives on orbit, seems very small, indeed. To those serving aboard the ISS, this realization is enhanced greatly by the constant reminders they face on a daily basis about the hostility of the Space environment and their need to provide for every need (air, water, food, power, waste management, etc.) that are otherwise easily taken for granted.

S F4: Environmental Quality

The Environmental Quality standard normally deals with a natural environmental system. However, the ECLSS (Environmental Control, Life Support System) aboard the ISS must adequately duplicate a natural system in order for astronauts to be able to live there for extended periods, making the ISS system a good schematic for understanding the more complicated natural system.

Specifically mentioned in this standard is the phrase, "Many factors influence environmental quality … (including) … different ways humans view the Earth." Public recognition of the uniqueness and fragility of the Earth's biosphere upon which we all depend was greatly increased when we first gained the ability to see the Earth from orbit.

S G1: Science as a Human Endeavor

The whole point of the ISS is to allow *people*, not robots, to conduct research in a unique environment! What could be more of a "human endeavor" than that?!

S G3: Historical Perspectives

Space exploration, especially in its early days, was in part motivated by political considerations. Now, Space exploration provides a highly-visible forum for international cooperation, and perhaps even the basis for new commercial opportunities.

History: World History: Science, Technology, and Society; Standard 44, Benchmark 8: Space spinoffs have wide effect

Part of this particular standard deals with the interconnections between large-scale science/technology projects and governments, corporations, international agencies, and the scientific community. Space exploration initially was more of an international competition; with the ISS, "collaboration" is more the watchword. The change parallels the changes in geopolitical situation, and makes for a good basis for a classroom discussion.

Life Skills: Thinking and Reasoning 5: IV: 9.Problem Solving – Historical Examples

The early history of Space exploration provides many examples of decisions of "historical importance," given Space exploration's role in the prevailing political and social environment of the Cold War era. For example, the decision for the U.S. to go to the Moon was largely driven by post-Cuban Missile Crisis/Bay of Pigs geopolitics. Similarly, the Apollo-Soyuz Test Project in the mid-1970's was a technological manifestation of political changes taking place on the ground. Now, the pendulum has swung fully, with international cooperation being essential for the largest-scale Space projects such as the ISS.

Technology 4: Technological Design: IV: 2. Systems, Modeling, and Simulation

A key benchmark associated with the technological design standard reads, "Proposes designs and uses models, simulations, and other tests to choose an optimal solution." Astronauts cannot train under conditions that they will find only in Space aboard the ISS; they must use models and simulations, instead. *Space Station 3-D* provides numerous examples; each/all capable of stimulating a classroom discussion:

- Students are likely to remember the scene in the film in which ISS construction astronauts train using (then) state-of-the-art Virtual Reality technology.
- Astronauts are also shown training for their mission underwater, using the buoyancy of the water to simulate free-fall conditions.

Technology 4: Technological Design: IV: 5. Trade-offs

Design of complex systems like the ISS always requires "trade-offs," compromises between competing design constraints/requirements. One example deals with space constraints and the psychological ramifications of living in close quarters for long times. A class discussion can be used to identify and explore other such trade-offs.

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

The ISS and spaceflight in general can provide many good examples of motions and forces, however, many of those examples are beyond the middle school level. Several scenes of life inside the ISS do illustrate the subset of this particular standard dealing with inertia, or the fact that a moving object not being subject to a (net) force continues to move in a straight line. The "food sharing" scene, complete with flying jellybeans and the orange 'thrown' at the camera provide good examples.

S C1: Structure / Function of Living Systems

This particular standard deals with the structures and systems in the human body. Some cells have highly specialized functions, such as muscles, skeletal bones, etc.; all of which evolved to help the body and its systems deal with gravity. Astronauts under free fall conditions have to adjust: they grow taller, their water balance changes, their hearts have to work much less hard to circulate blood, etc. The movie can serve to stimulate a classroom discussion of how "extreme" environments affect the body's ability to function.

S E2: Understanding Science and Technology

The technology upon which the ISS is built and depends, and the international effort required to produce the ISS, provide many engaging entry points for further class discussion of the interplay of science and technology under this particular standard.

S F2: Populations, Resources, Environment

The artificial environment aboard the ISS, and the need to provide for all of the astronauts' biological needs via the ISS ECLSS, provide a highly-distilled example of the human role in (micro) environment quality and maintenance.

S F4: Risks and Benefits

Spaceflight is a risky business. Two Shuttles have been lost with all hands, other astronauts have died on missions or training for them, and there have been less severe "close calls" on several missions, notably Apollo 13 and earlier space stations. Yet the benefits, from those present and tangible to those farther in the future, are real and are significant. Are the risks worth it? What are the risks if we do not try to explore and utilize Space? Have we become so risk-averse that we would not start an Apollo or ISS-type program today? Do other countries/societies feel the same about risk? Food for thought, and a rollicking class discussion!

S G1: Science as a Human Endeavor

The whole point of the ISS is to allow *people*, not robots, to conduct research in a unique environment! What could be more of a "human endeavor" than that?!

Technology: Science, Technology, and Society, III Benchmark 3: Technology influences History

The early history of Space exploration provides many examples of decisions of "historical importance," given Space exploration's role in the prevailing political and social environment of the Cold War era. For example, the decision for the U.S. to go to the Moon was largely driven by post-Cuban Missile Crisis / Bay of Pigs geopolitics. Similarly, the Apollo-Soyuz Test Project in the mid-1970's was a technological manifestation of political changes taking place on the ground. Now, the pendulum has swung fully, with international cooperation being essential for the largest-scale Space projects such as the ISS.

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

Elementary School

See Elementary School Alignment Table
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S A2: Understanding Science Inquiry

Several aspects of scientific inquiry under this particular standard (including using "different kinds of investigations" and "simple instruments") are depicted in *Space Station 3-D*, even if they are not explicitly discussed in the context of "understanding" the process of inquiry.

S B1: Properties of Objects and Materials

Properties of objects and materials are not a specific topic of the film, but some otherwise-common materials, such as water, are depicted under free-fall conditions, and their behavior is sufficiently different from that expected by terrestrial experience that it will engage the attention of your students, and offer a learning-moment discussion opportunity after the film is seen.

S B2: Position and Motion of Objects

A rigorous treatment of object motion is not appropriate for this grade level, however, the straight-line movement of objects in free-fall is a good visual image that will help teachers address this standard in a post-movie discussion.

S C1: Characteristics of Organisms

A subset of this standard is the understanding that "organisms have basic needs…air, water, and food…" Living and working on a Space Station requires humans to duplicate their basic environmental needs artificially, providing what astronauts call "consumables," the necessities required for keeping them alive during their flight.

- Air, water, and food are basic supplies that must be provided at all times.
- Other elements of the environment are also important, even if they are not explicitly stated in the standard, including: not just oxygen to breathe, but at the right pressure; temperature control; and waste management.
- Very long-term missions would require recycling of most consumables.

The need for basic "consumables" fits under this particular standard, but also in standard S F3 and in S C3, immediately below:

S C3: Organisms and Their Environment

"Humans depend on their natural and constructed environments," is part of this standard. Life in a spacecraft does not have much in the way of a "natural" environment. Everything the astronauts need to survive has to be provided, so the kinds of environmental systems in spacecraft are the same that Nature has to provide for humans to flourish in a "natural" environment.

S D2: Objects in the Sky

Spacecraft and Space Stations are members of the class of objects whose "properties, locations, and movements can be observed and described."

S E2: Understanding Science and Technology

Spacecraft and Space Stations are examples of the tools scientists and engineers make and use to help "see, measure, and do things that they could not otherwise see, measure, and do. Spaceflight is so complicated that teams of people are needed, working together, to manage all aspects of the mission. That kind of teamwork is an explicit part of this standard.

S F3: Types of Resources

Basic resources must be provided in order for people to live and work in Space, as mentioned above: air, water, and food, and also basics not explicitly mentioned: air pressure, temperature control, and waste management.

This standard also deals with non-material resources, such as "quiet places, beauty, security, and safety." Motivated people can put up with a lot of discomfort, at least for a while. Long-duration mission planning, however, will have to take morale items into account! Our experiences with long-duration submarine missions, wintering over in Antarctica, and other cases where a few people had to live in close quarters for an extended period all demonstrate how important "non-material" considerations can be.

S F4: Changes in Environments

The environment aboard a spacecraft is, by necessity, an artificial one. Polluting that environment would rapidly make living conditions impossible, so waste management is a critical part of mission design – and a good case study of how a larger, natural system might operate.

S G1: Science as a Human Endeavor

What could be more of a "*Human Endeavor*" in the cause of Science than living and working on a Space Station?!?

Resources for Learning Elaboration after the Visit to NASM

Thousands of books and articles have been written about the International Space Station and living and working in Space, 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 and Other Web Pages on the ISS

The NASM Space Race Gallery's on-line version has information about Skylab, Salyut, Mir, and Space Station technology: http://www.nasm.si.edu/exhibitions/gal114/gal114.htm

NASM's Skylab Orbiting Laboratory exhibit: http://www.nasm.si.edu/exhibitions/gal114/#skylab

NSSDC web pages:

- Skylab: http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1973-027A
- Salyut 1: http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1971-032A
- Salyut 3: http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1974-046A
- Salyut 4: http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1974-104A
- Salyut 5: http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1976-057A
- Salyut 6: http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1977-097A
- Salyut 7: http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1982-033A
- Mir: http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1986-017A and http://liftoff.msfc.nasa.gov/rsa/mir.html

International Space Station (NASA sites unless otherwise indicated):

- http://spaceflight.nasa.gov/station
- http://www.nasa.gov/mission_pages/station/main/index.html
- http://www.shuttlepresskit.com/ISS_OVR
- http://www.hq.nasa.gov/osf/funstuff/stationoverview/npage1.html
- European Space Agency site: http://www.esa.int/esaHS/iss.html
- Russian Energiya site: http://www.energia.ru/english/energia/iss/iss.html
- Classroom of the Future site at Wheeling Jesuit University: http://iss.cet.edu/default.xml

Space Medicine

National Space Society "Space Medicine" website: http://www.nss.org/community/med/home.html
STS-95 (John Glenn mission) Press Kit: http://www.shuttlepresskit.com/sts-95/index.htm
STS-95 info: http://spaceflight.nasa.gov/shuttle/archives/sts-95/cargo/factsheets/index.html
STS-95 info: http://spaceflight.nasa.gov/shuttle/archives/sts-95/
Article by STS-95 physician: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1500940
NASA metapage: http://mediaservices.nasa.gov/audience/foreducators/topnav/subjects/lifesciences/Biology_Humans.html

Space-based Manufacturing

Shuttle Wake Shield Facility: http://www-pao.ksc.nasa.gov/kscpao/release/1996/124-96.htm
Wake Shield Facility: http://www.svec.uh.edu/wsfp.html

The Physics of Free Fall and Orbit

Newton's Cannon: Isaac Newton imagined what would happen if a very large cannon were built atop a very tall mountain. The cannon ball would travel farther and farther around the curve of the Earth's horizon as progressively more gunpowder was used, until the point is reached where the cannon ball continuously "falls around the Earth." Its horizontal speed is so great that gravity can only deflect it into an elliptical orbit. See for yourself at:

http://galileoandeinstein.physics.virginia.edu/more_stuff/Applets/newt/newtmtn.html

Supporting information is here: https://aerospacescholars.jsc.nasa.gov/HAS/cirr/ss/3/mission.cfm
Related NASA Quest activity: http://quest.nasa.gov/space/teachers/microgravity/3world.html
NASA GSC "Free Fall" webpage: http://www.grc.nasa.gov/WWW/K-12/airplane/ffall.html
NASA Feature: http://www.nasa.gov/vision/earth/everydaylife/defy_gravity.html
PBS Nova webpage on "free fall": http://www.pbs.org/wgbh/nova/station/freefalling.html

Living and Working in Space: Long-duration Missions

From the European Space Agency: http://www.esa.int/esaCP/SEMYNY6DWZE_index_0.html
Another ESA study: http://ecls.esa.int/ecls/attachments/ECLS/Perspectives/humex/tn2.pdf
NAS Space Studies Board report: http://www7.nationalacademies.org/ssb/21lsch6.html

ISS-related Technology "Spin-Offs"

Technologies created for Space exploration often have commercial value in applications not considered when the technology was developed. Called "spin-offs," such unforeseen applications can have great value, and we are not talking just Tang and Teflon, here!
NASA Spin-Off (an annual publication) webpage: http://www.sti.nasa.gov/tto
NASA's Technology Innovation e-magazine: http://nctn.hq.nasa.gov/innovation/index.html
NASA Tech Briefs (monthly publication) webpage: http://www.techbriefs.com
NASA's Techfinder website (spin-off case studies): http://technology.nasa.gov
Spinoffs webpage at SPACE.com: http://www.space.com/adastra/adastra_spinoffs_050127.html
ESA's Spin-off webpage: http://www.esa.int/esaCP/GGGIPLH3KCC_Improving_0.html

IMAX has produced a "Teachers Education Guide" for *Space Station*; available on-line here:

http://www.imax.com/ImaxWeb/static/pdf/space_station.pdf