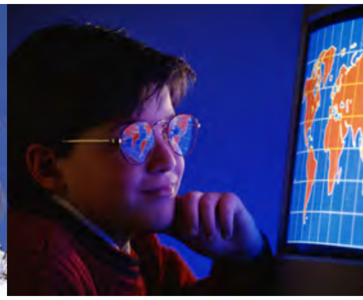
National Aeronautics and Space Administration

Lunar Colonization

Human Exploration Project I

Energy and Power

A Standards-Based Middle School Unit Guide

Engineering byDesign™

Advancing Technological Literacy

A Standards-Based Program Series

This unit coordinates with the ITEA EbD™ Course: *Exploring Technology.*

MS-6

Educational Product	
Educators	Grade 6

EP–2009–03–49–MSFC

International Technology Education Association
Center to Advance the Teaching of Technology and Science

Preface

Lunar Colonization
A Standards-Based Middle School Unit

Acknowledgments

Many individuals committed to developing middle school technological literacy made this publication possible. Their strong commitment to developing standards-based technology resources is reflected in this guide. Special thanks are expressed to the following:

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Special thanks are extended to the following expert and field reviewers who provided valuable feedback in the development of this resource.

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The ITEA-CATTS Human Exploration Project (HEP)
People, Education, and Technology

In May, 2005, ITEA was funded by the National Aeronautics and Space Administration (NASA) to develop curricular units for Grades K–12 on Space Exploration. The units focus on aspects of that theme that NASA Engineers and Scientists—as well as future generations of explorers-—must consider, such as Energy and Power, Transportation, and Lunar Growth Chambers (the STS-118 Design Challenges). Moreover, the units are embedded within a larger Model Program for Technology Education known as Engineering byDesign™.

The HEP units have several common characteristics. All units:

- Are based upon the Technological Literacy Standards (ITEA, 2000/2002/2007).
- Coordinate with Science (AAAS, 1993) and Mathematics Standards (NCTM, 2000).
- Utilize a Standards-Based Development Approach (ITEA, 2005).
- Stand alone and coordinate with ITEA-CATTS Engineering byDesign™ curricular offerings.
- Reflect a unique partnership between NASA scientists and engineers and education professionals.
- Incorporate leading-edge insight and practical experiences for students on how NASA works and plans.

These unit guides are designed to be practical and user-friendly. ITEA welcomes feedback from users in the field as we continually refine these curricular products, ensuring that the content remains as dynamic as the technological world in which we live. Please e-mail <ebd@iteaconnect.org> or call 703–860–2100.

Lunar Colonization

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Lunar Colonization

Lunar Colonization: A Standards-Based Middle School Unit

Overview

In this unit, students will understand the challenges of establishing a lunar colony. This unit requires students to work closely as a team of designers and researchers.

Big Idea

Humans have always had an innate desire to explore past the boundaries of Earth to the Moon and beyond. To that end, there are many technological, societal, and safety-related challenges that are associated with travel to, and habitation of, the lunar surface.

Standards and Benchmarks

Technology:* Standards for Technological Literacy (STL) *(ITEA, 2000/2002/2007)

- Students will develop an understanding of the characteristics and scope of technology. (ITEA/*STL* 1)
  - New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. (1F)
- Students will develop an understanding of the core concepts of technology. (ITEA/*STL* 2)
  - Trade-off is a decision process recognizing the need for careful compromises among competing factors. (2S)
- Students will develop an understanding of the relationships among technologies and the connections with other fields of study. (ITEA/*STL* 3)
  - A product, system, or environment developed for one setting may be applied to another setting. (3E)
  - Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. (3F)
- Students will develop an understanding of the effects of technology on the environment (ITEA/*STL* 5)
  - The management of waste produced by technological systems is an important societal issue. (5D)
- Students will develop an understanding of the role of society in the development and use of technology. (ITEA/*STL* 6)
  - Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. (6D)
- Students will develop an understanding of the attributes of design. (ITEA/*STL* 8)
  - Design is a creative planning process that leads to useful products and systems. (8E)
  - There is no perfect design. (8F)
  - Requirements for a design are made up of criteria and constraints. (8G)
- Students will develop abilities to apply the design process. (ITEA/*STL* 11)
  - Apply a design process to solve problems in and beyond the laboratory-classroom. (11H)
  - Specify criteria and constraints for the design. (11I)
  - Make two-dimensional and three-dimensional representations of the designed solution. (11J)
  - Test and evaluate the design in relation to preestablished requirements, such as criteria and constraints, and refine as needed. (11K)
  - Make a product or system and document the solution. (11L)

- Students will develop an understanding of, and abilities to, select and use information and communication technologies. (ITEA/*STL* 17)
  - The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message. (17J)

Mathematics: Principles and Standards for School Mathematics *(NCTM, 2000)**

- Compute fluently and make reasonable estimations. (NCTM, Number and Operations, Grades 6–8)
  - Develop, analyze, and explain methods for solving problems involving proportions, such as scaling and finding equivalent ratios.
- Represent and analyze mathematical situations and structures using algebraic symbols. (NCTM, Algebra, Grades 6–8)
  - Use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships.
  - Recognize and generate equivalent forms for simple algebraic expressions and solve linear equations.
- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them. (NCTM, Data Analysis and Probability, Grades 6–8)
  - Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.
  - Select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatterplots.
- Select and use appropriate statistical methods to analyze data. (NCTM, Data Analysis and Probability, Grades 6–8)
  - Discuss and understand the correspondence between data sets and their graphical representations, especially histograms, stem-and-leaf plots, box plots, and scatterplots.

Science: Benchmarks for Science Literacy *(AAAS, 1993)***

- Technology and Science (AAAS, 3 A, Grades 6–8)
  - Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
  - Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems. But they usually have to take human values and limitations into account as well.
- The Universe (AAAS, 4 A, Grades 6–8)
  - Nine planets of very different sizes, compositions, and surface features move around the Sun in nearly circular orbits. Some planets have a great variety of moons and even flat rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geologic activity. The Earth is orbited by one moon, many artificial satellites, and debris.

** Standards are listed with the permission of the National Council of Teachers of Mathematics (NCTM). NCTM does not endorse the content or validity of these alignments.*

*** Material reprinted from* Benchmarks for Science Literacy *(AAAS, 1993) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, D.C.*

- The Earth (AAAS, 3 A, Grades 6–8)
  - The Earth is mostly rock. Three-fourths of its surface is covered by a relatively thin layer of water (some of it frozen), and the entire planet is surrounded by a relatively thin blanket of air. It is the only body in the solar system that appears able to support life. The other planets have compositions and conditions very different from the Earth's. (12I)
- Energy Sources and Use (AAAS, 8 C, Grades 6–8)
  - Energy from the Sun (and the wind and water energy derived from it) is available indefinitely. Because the flow of energy is weak and variable, very large collection systems are needed. Other sources do not renew or renew only slowly.

Unit Objectives

Lesson 1: Understanding the Challenge (3–4 hours)

Students will learn to:

1. Define and explain the limitations and constraints of living on the Moon.
2. Conduct research related to lunar colonization, including energy considerations, shelter design, transportation, and sustainability.
3. Explain that new products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.
4. Describe how new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
5. Cite examples of how technology has been essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
6. Compare and contrast how engineers and architects use scientific knowledge to solve practical problems.
7. Recognize that space travel and colonization is extremely complicated, time consuming, and expensive.
8. Use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships.
9. Recognize and generate equivalent forms for simple algebraic expressions and solve linear equations.

Lesson 2: Experts Coming Together (3–4 hours)

Students will learn to:

1. Explain that useful products and systems result from a creative planning process.
2. Explain why there is no perfect design.
3. Analyze the requirements for a design and identify the criteria and constraints.
4. Apply a design process to solve problems in and beyond the laboratory-classroom.
5. Specify criteria and constraints for the design.
6. Explain that technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
7. Cite instances where engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems.
8. Describe the Earth's physical characteristics.
9. Define and explain the limitations and constraints of living on the Moon.

10. Conduct research related to lunar colonization in one of four following areas:
    a. Energy Considerations
    b. Shelter Design
    c. Transportation
    d. Sustainability

Lesson 3: Lunar Colony Design and Development (7–8 hours)

Students will learn to:

1. Define a tradeoff as a decision process recognizing the need for careful compromises among competing factors.
2. Explain that, throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
3. Explain that useful products and systems result from a creative planning process.
4. Explain why there is no perfect design.
5. Analyze the requirements for a design and identify the criteria and constraints.
6. Apply a design process to solve problems in and beyond the laboratory-classroom.
7. Specify criteria and constraints for the design.
8. Make two-dimensional and three-dimensional representations of the designed solution.
9. Test and evaluate the design in relation to preestablished requirements, such as criteria and constraints, and refine as needed.
10. Make a product or system and document the solution.

Lesson 4: Going Public (3–4 hours)

Students will learn to:

1. Explain that, throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
2. Cite examples of how a product, system, or environment developed for one setting may be applied to another setting.
3. Describe an instance where knowledge gained from other fields of study has a direct effect on the development of technological products and systems.
4. Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.
5. Select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatterplots.
6. Evaluate the quality and accuracy of their lunar colony model.
7. Design and develop a survey related to lunar colonization.
8. Implement their survey and explain the results of the data compilation.

Lesson 5: Putting it all Together (3–4 hours)

Students will learn to:

1. Design and deliver a cooperative presentation about the lunar colony project, including information about the lunar colony survey, model, and research.
2. Utilize presentation software to create an electronic slide show containing graphs, pictures, and text.

Selected Objective/Assessment Criteria

Big Idea/Unit Objectives	Below Target	At Target	Above Target
Explain the benefits and challenges of lunar colonization.	Is unable to articulate the benefits of lunar colonization.	Recognizes that lunar colonization has benefits and challenges but is unable to clearly give reasonable examples.	Clearly can describe and exemplify the benefits and challenges of lunar colonization for this and upcoming generations.
List and explain the types of technology that are needed to safely and efficiently colonize the Moon.	Is only able to explain one or two types of technology involved in lunar colonization.	Can list and give good examples of three or four types of technology related to lunar colonization.	Able to describe and explain numerous examples of technology used in lunar colonization and why they were chosen.
Utilize computer technology to develop print media material.	Is not computer literate enough to develop an appropriate print media material.	Can use a computer to design print media material but struggles with basic commands.	Proficiently, regularly, and easily uses various software programs to design print media material.
Communicate orally, in writing, and by graphing the results of a public opinion survey regarding colonization on the Moon.	Is unable to articulate in any form (writing, orally, or graphically), from a neutral position, public opinion data gathered from a survey.	Can articulate, from a neutral position, public opinion data. Not all material is based on survey results, and the articulation is either flawed mathematically or the articulation is not of consistent quality for oral, written, and graphical presentations.	Highly articulates, from a neutral position, public opinion data gathered from a survey using accurate information in oral, written, and graphical forms.
Design and construct a scale model of a lunar habitat by following an engineering design process.	Lunar habitat is poorly constructed, and engineering design process was not followed. No attention was paid to making the model to scale.	Engineering design process was somewhat followed, and lunar habitat was constructed. Scale was somewhat followed, but was inconsistent.	Lunar habitat is excellent, and the engineering design process carefully followed. Attention was paid to build the model to scale.

Lesson 1: Understanding the Challenge

Lesson Snapshot

Overview

Big Idea: Humans have always had an innate desire to explore past the boundaries of Earth to the Moon and beyond. To that end, there are many technological, societal, and safety-related challenges that are associated with travel to, and habitation of, the lunar surface.

Purpose of Lesson: This lesson is designed to familiarize students with space travel and exploration, the Moon and lunar colonization, and getting to the Moon: past, present, and future.

Lesson Duration: Three to four hours.

Activity Highlights

Engagement: Students are assessed on prior knowledge related to space exploration and work in groups of four to explore the ***"Lunar Colonization Design Challenge."***

Exploration: Students use the KWHL process to answer the question, "What will it take to colonize the Moon?"

Explanation: The teacher leads a discussion on the importance of planning, safety, research, careful documentation, and accountability in planning space exploration.

Extension: Students develop a plan of action to transport people and goods to and from the Moon, survey people in the community regarding lunar colonization and transportation plans, and create a print or electronic media informational piece that helps the public better understand lunar colonization.

Evaluation: Students are evaluated on their ability to use the KWHL process, completion of a ***"Moon/Earth Comparison Worksheet,"*** and their application of mathematics calculations related to space exploration.

Lesson 1: Overview

Lesson Duration

- Three to four hours.

Standards/Benchmarks

Technology:* Standards for Technological Literacy (STL) *(ITEA, 2000/2002/2007)

- Students will develop an understanding of the characteristics and scope of technology. (ITEA/*STL* 1)
  - New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. (1F)
- Students will develop an understanding the role of society in the development and use of technology. (ITEA/*STL* 6)
  - Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. (6D)

Mathematics:* Principles and Standards for School Mathematics *(NCTM, 2000)*

- Represent and analyze mathematical situations and structures using algebraic symbols. (NCTM, Algebra, Grades 6–8)
  - Use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships.
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Learning Objectives

Students will learn to:

1. Define and explain the limitations and constraints of living on the Moon.
2. Conduct research related to lunar colonization, including energy considerations, shelter design, transportation, and sustainability.
3. Explain that new products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.
4. Describe how new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
5. Cite examples of how technology has been essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
6. Compare and contrast how engineers and architects use scientific knowledge to solve practical problems.
7. Recognize that space travel and colonization is extremely complicated, time consuming, and expensive.
8. Use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships.
9. Recognize and generate equivalent forms for simple algebraic expressions and solve linear equations.

Student Assessment Tools and/or Methods

1. ***Lunar Colonization Pre/Post Test***

2. ***Lunar Colonization Design Challenge Scoring Rubric***

Resource Materials

Note: Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by the NASA.

Print Materials

Cole, M.D. (1999). *Moon base: First colony in space*. Berkeley Heights, NJ: Enslow Publishers.
Aldin, B. and Minor, W. (2005). *Reaching for the moon*. New York: HarperCollins Publishers.

Cole, D. (1995). *Apollo 13: Space emergency*. Berkeley Heights, NJ: Enslow Publishers.

Stott, C. (2004). *Space exploration*. New York: DK Publishing.

Packets or Presentation Materials

Jones, E.M. (Ed.), & O'Dea, J. (Video Ed.). (2006). *Apollo 11*: *Multimedia.* Retrieved November 14, 2008, from <http://www.hq.nasa.gov/alsj/a11/video11.html>.

Note: This site has many different QuickTime video clips of NASA space exploration.

Off to the Moon

Moon/Earth Comparison

Planning for Space Exploration

Internet Sites

Artemis Society International. (1999). *Basic statistics of the Earth and Moon*. Retrieved November 14, 2008, from <http://www.asi.org/adb/m/03/01/earth-moon.html>.

BrainyMedia.com. (2007). *Brainy history.* "Lunar Encyclopedia Timeline." Retrieved November 14, 2008, from <http://www.brainyhistory.com/topics/l/lunar.html>.

Col, J. (1996). *Enchanted learning.* Retrieved November 14, 2008, from http://www.enchantedlearning.com/graphicorganizers/KWHL/.

Jones, E.M. (Ed.), & O'Dea, J. (Video Ed.). (2006). *Apollo 11*: *Multimedia.* Retrieved November 14, 2008, from <http://www.hq.nasa.gov/alsj/a11/video11.html>.

Lunar and Planetary Institute. (2008). *Exploring the Moon.* Retrieved November 14, 2008, from <http://www.lpi.usra.edu/expmoon/>.

Munsell, K. (Ed.), Martin, D. (Webmaster), & Lindstrom, M. (NASA Official). (2006). *Solar system exploration*. November 14, 2008, from <http://solarsystem.nasa.gov/planets/profile.cfm?Object=Moon>.

Office of the Press Secretary. (2004). *President Bush announces new vision for space exploration program*. Retrieved November 14, 2008, from <http://www.whitehouse.gov/news/releases/2004/01/print/20040114-1.html>.

Pyper, J., & and Davis, R. (Eds.). (2007). *Novelinks*. Retrieved November 14, 2008, from <http://english.byu.edu/Novelinks/reading%20strategies/Anthem/KWHL%20General.htm>.

Sangillo, R. (Ed.), & Dunbar, B. (NASA Official). (2008). *National Aeronautics and Space Administration (NASA).* Retrieved November 14, 2008, from <http://www.nasa.gov/multimedia/mmgallery/index.html>.

Spudis, P.D. (2004). *World book online reference center.* "The Moon." Retrieved November 14, 2008, from <http://www.nasa.gov/worldbook/moon_worldbook.html>.

Wikimedia Foundation, Inc. (2008). *Wikipedia: The free encyclopedia.* "Colonization of the Moon." Retrieved November 14, 2008, from <http://en.wikipedia.org/wiki/Colonization_of_the_Moon>.

Wilson, J. (Ed.), & Dunbar, B. (NASA Official). (2007). *NASA's plans to explore the Moon, Mars, and beyond*. November 14, 2008, from <http://www.nasa.gov/mission_pages/exploration/mmb/index.html>.

Internet Search Criteria

1. Lunar Habitation
2. National Aeronautics and Space Administration (NASA)
3. Moon Colonization
4. Cooperative Learning
5. Moon Characteristics

Lesson 1: 5-E Lesson Plan

Engagement

1. The teacher distributes and discusses a packet or gives a multimedia presentation to the class entitled ***"Off to the Moon"*** that includes a variety of pictures.

2. Students read the two-page design brief entitled ***"Lunar Colonization Design Challenge"*** and underline three important details in the reading.

3. Students review the challenge criteria as stated in the ***"Lunar Colonization Design Challenge Rubric."***

4. The teacher organizes students into teams of four. If the groups end up uneven, groups of five are preferable to groups of three, although they require additional monitoring and management by the teacher. Each group of five may contain a student or students requiring special-need accommodations. Due to the nature of the work required for the assignment, it is recommended that groups contain the following approximate makeup:
   a. One high achiever
   b. One or two middle achievers
   c. One or two lower achievers

Exploration

1. Students use the KWHL process to address the question, "What will it take to colonize the Moon?" On the board, the teacher draws four columns or distributes the worksheet entitled ***"Off to the Moon: KWHL Chart."***
   Note: For additional information about how to use a KWHL chart, see suggested the Suggested Resources.
2. The teacher records student responses, and students record ideas on the worksheet.

Explanation

1. The teacher leads the class in a review of the Exploration activities.
2. Students view and discuss NASA video:

   Jones, E.M. (Ed.), & O'Dea, J. (Video Ed.). (2006). *Apollo 11*: *Multimedia.* Retrieved November 14, 2008, from <http://www.hq.nasa.gov/alsj/a11/video11.html>.

   Note: This site has many different QuickTime video clips of NASA space exploration.

3. Before students begin to design a lunar colony, it is important that they understand the characteristics of the Moon and its atmosphere. The teacher distributes and discusses a packet or gives a multimedia presentation to the class entitled ***"Moon/Earth Comparison."***
4. The teacher explains that:
   a. New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.
   b. Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
   c. Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection, and storage, computation, and communication of information.

   d. Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems.

5. During the presentation/discussion, students fill in the missing information on the ***"Moon/Earth Comparison Worksheet"*** dealing with the following Moon characteristics:
   a. Temperature Extreme
   b. Atmosphere
   c. Radioactivity
   d. Day/Night Cycle
   e. Surface Material Makeup
   f. Topography
   g. Size and Orbit

   Suggestion: If students are struggling with some of the calculations, the teacher may consider having them complete the ***"Let's Learn Some Algebra"*** worksheet and also the ***"Comparison Factor Questions" (Student)"*** worksheet. A teacher version is supplied as ***"Comparison Factor Questions" (Teacher)."***

6. Students may also use the following web site to ascertain the Moon characteristics:

   Spudis, P.D. (2004). *World book online reference center.* "The Moon." Retrieved November 14, 2008, from <http://www.nasa.gov/worldbook/moon_worldbook.html>.

7. The teacher distributes and discusses a packet or gives a multimedia presentation to the class entitled, ***"Planning for Space Exploration."***

   Note: When planning for space exploration, it takes years and sometimes decades to accomplish a goal. Students live in a society that provides more instantaneous gratification, and they tend to get frustrated with projects that take a couple of days to complete. The teacher should emphasize, through discussion, the importance of planning, safety, research, careful documentation, and accountability. Each of these is explained in more detail below and in ***"Planning for Space Exploration."***

   a. Long-Range Planning – Space projects can take decades to complete. There are many projects that begin under one administration and then are mothballed under the next administration that may have new goals for space travel.
   b. Cost – Space travel costs billions of dollars, and societies make choices on how the government's money will be allocated.
   c. Technology Readiness Levels (TRLs) are systematic metric/measurement systems that support assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. The TRL approach has been used on and off in NASA space technology planning for many years and was recently incorporated in the NASA Management Instruction (NMI 7100), addressing integrated technology planning at NASA. For additional information see ***"Technology Readiness Levels."***
   d. Technology Development Process – The teacher may hand out or display the ***ISRF Technology Development Process*** handout and explain that safety is the utmost concern in all space exploration. This is not only for those going into space, but also those on Earth. Students should understand that safety in all missions is critical and that they will need to address safety issues in their lunar colony model.

8. The teacher introduces students to the history of travel to the Moon.
   a. Students experience the thrill of landing on the Moon by viewing video clips of the Apollo 11 landing on July 20, 1969.

      Jones, E.M. (Ed.), & O'Dea, J. (Video Ed.). (2006). *Apollo 11*: *Multimedia.* Retrieved November 14, 2008, from <http://www.hq.nasa.gov/alsj/a11/video11.html>.

   b. The teacher leads students in a discussion of (1) the major steps that have been taken to get the Moon, (2) what has been learned during the various missions, and (3) what steps will be taken next.
9. The teacher summarizes what has been learned thus far about lunar colonization. Students review the information by answering the questions on the worksheet, "***Living on the Moon Synthesis.***"

Extension

1. Develop a plan of action to transport people and goods to and from the Moon.
2. Survey people in the community regarding lunar colonization and transportation plans.
3. Create a print or electronic media informational piece that helps the public better understand lunar colonization.
4. Deliver a group presentation.

Evaluation

1. ***Lunar Colonization Pre/Post Test***
2. ***Off to the Moon: KWHL Chart***
3. ***Moon/Earth Comparison Worksheet (Teacher)***
4. ***Moon/Earth Comparison Worksheet (Student)***

Lesson 1: Lesson Preparation

Teacher Planning

1. Review all web sites listed in the lesson.
2. Make copies of all classroom handouts and worksheets.
3. Make presentations using the provided packets, if desired.

Student "Activity" Sheets

1. ***Lunar Colonization Design Challenge***
2. ***Let's Learn Some Algebra***
3. ***Comparison Factor Questions (Student)***
4. ***ISRF Technology Development Process***
5. ***President Bush Announces New Vision for Space Program***
6. ***Living on the Moon Synthesis***

Assessment Rubric

1. ***Lunar Colonization Design Challenge Rubric***

Lesson 2: Experts Coming Together

Lesson Snapshot

Overview

Big Idea: Humans have always had an innate desire to explore past the boundaries of Earth to the Moon and beyond. To that end, there are many technological, societal, and safety-related challenges that are associated with travel to, and habitation of, the lunar surface.

Purpose of Lesson: This lesson is designed to help students understand the limitations and constraints of living on the Moon and for them to conduct research related to lunar colonization including energy considerations, shelter design, transportation, and sustainability.

Lesson Duration: Three to four hours.

Activity Highlights

Engagement: Students will discuss the lunar environment.

Exploration: This component of the lesson introduces students to the Jigsaw II cooperative learning methodology to enhance student understanding of lunar energy considerations, shelter design, transportation, and sustainability.

Explanation: The teacher assists students in the initial stages of the Lunar Colonization Design Challenge (LCDC), with emphasis on understanding the requirements and limitations.

Extension: Students, working in "expert groups," research and report on questions related to energy considerations, shelter design, transportation, and sustainability.

Evaluation: Students are assessed on participation, their ability to define and explain the limitations and constraints of living on the Moon, and on their research related to lunar colonization.

Lesson 2: Overview

Lesson Duration
- Three to four hours.

Standards/Benchmarks
Technology:* Standards for Technological Literacy (STL) *(ITEA, 2000/2002/2007)
- Students will develop an understanding of the attributes of design. (ITEA/*STL* 8)
  - Design is a creative planning process that leads to useful products and systems. (8E)
  - Requirements for a design are made up of criteria and constraints. (8G)
- Students will develop abilities to apply the design process. (ITEA/*STL* 11)
  - Apply a design process to solve problems in and beyond the laboratory-classroom. (11H)
  - Specify criteria and constraints for the design. (11I)

Science:* Benchmarks for Science Literacy *(AAAS, 1993)**
- The Earth (AAAS, 3 A, Grades 6–8)
  - The Earth is mostly rock. Three-fourths of its surface is covered by a relatively thin layer of water (some of it frozen), and the entire planet is surrounded by a relatively thin blanket of air. It is the only body in the solar system that appears able to support life. The other planets have compositions and conditions very different from the Earth's. (12I)
- Energy Sources and Use (AAAS, 8 C, Grades 6–8)
  - Energy from the Sun (and the wind and water energy derived from it) is available indefinitely. Because the flow of energy is weak and variable, very large collection systems are needed. Other sources do not renew or renew only slowly.

Learning Objectives
Students will learn to accomplish the following:
1. Explain that useful products and systems result from a creative planning process.
2. Explain why there is no perfect design.
3. Analyze the requirements for a design, and identify the criteria and constraints.
4. Apply a design process to solve problems in and beyond the laboratory-classroom.
5. Specify criteria and constraints for the design.
6. Explain that technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
7. Cite instances where engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems.
8. Describe Earth's physical characteristics.
9. Define and explain the limitations and constraints of living on the Moon.

** Standards are listed with the permission of the National Council of Teachers of Mathematics (NCTM). NCTM does not endorse the content or validity of these alignments.*

*** Material reprinted from* Benchmarks for Science Literacy *(AAAS, 1993) with permission from Project 2061, on behalf of the American Association for the Advancement of Science, Washington, D.C.*

10. Conduct research related to lunar colonization in one of four areas.
    a. Energy Considerations
    b. Shelter Design
    c. Transportation
    d. Sustainability

Student Assessment Tools and/or Methods

1. Student-generated sketches in an Engineering Design Journal (***EDJ***)
2. Research conducted on particular lunar colonization topic
3. Presentation to group related to lunar colonization topic
4. Listing of limitations and constraints
5. Development of problem/challenge statement

Resource Materials

Audiovisual Materials

PowerPoint™ Presentation: ***"LCDC Phase I"***

Internet Sites

Dismukes, Kim (Curator) & Petty, John Ira (NASA Official). (April 9, 2007). *Human space flight*. National Aeronautics and Space Administration. Retrieved May 14, 2007, from <http://www.spaceflight.nasa.gov/gallery/images/mars/lunarvehicles/ndxpage3.html>.

Jong, Diana (Staff Writer). (August 15, 2002). *NASA chooses Purdue to study colonies on Mars*. Space.com. Imaginova Corp. Retrieved May 10, 2007, from <http://www.space.com/scienceastronomy/purdue_center_020815.html>.

- This web site article describes the work that Purdue University has done with Biosphere 2, which is in the Arizona desert and is intended to simulate life on the Moon or Mars.

Knuth, William H. (Author). (March 2, 2004). "Lunar convoys as an option for a return to the Moon." *Space Daily: Your Portal to Space.* Retrieved May 10, 2007, from <http://www.spacedaily.com/news/lunar-04j.html>.

- This web site is a short article about how solar energy may be able to be used on a lunar colony.

NASA & Frassinito, John and Associates. (n.d.) *Lunar flight plan*. Retrieved May 10, 2007, from <http://www.nasa.gov/images/content/125171main_flight_plan_graphic.jpg>.

- This diagram shows how a lunar flight plan may look and could be used for lunar colony transportation.

Rudo, Brian (Author). (March 5, 2003). "Nuclear propulsion and what it means to space exploration." *Red Colony.* Retrieved May 10, 2007, from <http://www.redcolony.com/art.php?id=0303050>.

- This web site provides some easy-to-understand descriptions of how various types of nuclear energy can be used, including radioisotope decay, nuclear fission, and nuclear fusion.

Wikimedia Foundation, Inc. (May, 2007). *Wikipedia: The Free Encyclopedia*. Retrieved May 10, 2007, from <http://en.wikipedia.org/wiki/Colonization_of_the_Moon#Economic_development>.

- This site explains factors associated with economic development of a lunar colony.

Wikimedia Foundation, Inc. (May, 2007). *Wikipedia: The Free Encyclopedia.* Retrieved May 10, 2007, from <http://en.wikipedia.org/wiki/Colonization_of_the_Moon#Energy>.

- This web site provides a description of nuclear power and solar energy.

Wikimedia Foundation, Inc. (May, 2007). *Wikipedia: The Free Encyclopedia.* Retrieved May 10, 2007, from <http://en.wikipedia.org/wiki/Lunar_base#Habitat>.

- This site provides information on the moon's habitat.

Wikimedia Foundation, Inc. (May, 2007). *Wikipedia: The Free Encyclopedia.* Retrieved May 10, 2007, from <http://en.wikipedia.org/wiki/Lunar_base#Transport>.

- This site outlines the various transportation needs and possible solutions of a lunar colony.

Internet Search Criteria

1. Energy on the Moon
2. Lunar Shelter Design
3. Lunar Transportation
4. Sustainability

Lesson 2: 5-E Lesson Plan

Engagement

1. The teacher leads a discussion on the ***Lunar Colonization Design Challenge*** including:
    a. Energy Considerations – How is energy developed on the Moon? From where does the fuel come? What are safety concerns? For what will the energy be used?
    b. Shelter Design – What type of environment is on the Moon? From what do inhabitants need protection? How does temperature impact the shelter design? Radiation? Length of the day? How will structures be constructed? What will they look like?
    c. Transportation – How will you get to the Moon and back to the Earth? How will supplies be carried? As weight goes up, so does the cost and propulsion requirements. How does this impact shelter design?
    d. Sustainability – What will people eat on the Moon? From where will food come? How will they get water? Where will waste from humans be contained? What can and cannot be recycled?
2. Students take notes using the ***Lunar Challenge Note Guide*** during the discussion, as this will aid them in their research and group work later.
3. After the discussion, students meet in their groups to compare the notes to ensure understanding.

Exploration

1. Students working in groups of four will complete the lunar habitation packet that includes:
    a. ***Energy Considerations*** – The key to all space travel is energy, whether it is nuclear, solar, radio isotope, or others. This handout gives students basic information about a few energy types and their strengths and weaknesses.

    b. ***Shelter Design*** – This handout gives students some information about ideas that NASA has had regarding lunar shelter design. These designs are preliminary, and students should recognize that other ideas are very possible.

    c. ***Transportation*** – This handout helps students understand the challenges of traveling to and from the Moon and travel on the Moon itself.

    d. ***Sustainability*** – This handout provides some information about sustainability. Sustainability is being able to provide an environment that is best for people now and in the future.

This section of the lesson is important and needs to be followed very carefully. This is the first step in the Jigsaw II cooperative learning methodology. For assistance using Jigsaw II, see the web sites in the teacher's resource section.

2. Once students have had a chance to review their handout individually, they should be grouped with other students who have the same topic. These are called the expert groups.
   a. When students are in the expert groups, the teacher gives them a copy of the handout entitled ***Lunar Colony Key Questions***. This handout is designed to give the expert group some questions to discuss related to their topic. The questions are generic and the same for each group.
   b. Each group needs to select one person to fill each of the following roles. The teacher may want to consider writing these roles and descriptions on a note card so students remember what role they are fulfilling. These roles are:
      i) Facilitator – makes sure task gets done.
      ii) Summarizer – summarizes discussion points before the recorder writes the notes down.
      iii) Consensus Checker – makes sure group agrees.
      iv) Recorder – takes good notes that are legible about what was discussed.
      v) "Includer"– makes sure everyone participates.
   c. Once each expert group has finished, the teacher makes a copy of the completed ***Lunar Colony Key Questions*** for each member of the group. (They will need this when they go back to their group to explain their topic. This activity is best done at the end of the class period so the question sheets can be returned the next day; it will also give the teacher a chance assess and annotate expert group work.)

Explanation

1. Student expert groups review their responses and decide whether anything needs to be added. They also discuss the comments that the teacher wrote on the second page.
2. Students return to their base groups, and each group member takes a turn discussing (not reading) the information about their topic. It is recommended that each student be given 3–4 minutes and the topics be presented in order.
3. Student base groups synthesize information and develop four questions they would like to ask the teacher in order to clarify their understanding.
4. The teacher conducts a question/answer session in which each group will ask two of their four questions.
5. The teacher:
   a. Explains that useful products and systems result from a creative planning process.
   b. Explains why there is no perfect design.
   c. Explains that technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
   d. Cites instances where engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems.
6. Students begin the initial stages of ***Lunar Colonization Design Challenge (LCDC).***
7. The teacher defines differences between requirements and limitations. The PowerPoint™ presentation entitled ***"LCDC Phase I"*** helps to present these and other topics.
   a. Design Challenge – This is the overall problem or challenge that needs to be solved. It is critical that the entire group clearly understand the design challenge.

   b. Requirements – This refers to the need to identify what the solution to the problem must be able to do to be successful. These need to be clearly defined and explained. The requirements generally come at the beginning of the design process so the designer knows what needs to be accomplished. Other requirements may be imposed by external and internal regulations (Americans with Disabilities Act, building codes, standards, etc.) that may or may not have been called out in the requirements. Students may need to go back to the original design challenge to look for design requirements. These are also sometimes referred to as constraints.
   c. Limitations – A limitation is something the design cannot do. The design may satisfy all of the requirements, but still cannot do one thing or another. A definitive limitation for space travel is the speed a rocket cannot exceed before the materials begin to fatigue and fail. Limitations are sometimes imposed but are usually outside the realm of anyone's control.
8. Base groups record the perceived design challenge, requirements, and limitations. They can use the corresponding ***"LCDC: Phase I – Identify the Challenge"*** to assist in this activity.

Extension

1. Students return to their expert groups to research and report on the questions that were developed by the base groups.
2. Expert groups may investigate and report on the following topics:
   a. Lunar research projects
   b. Recreation activities
   c. Historical lunar missions
   d. Economic considerations
   e. Lunar colony locations

Evaluation

1. The teacher monitors the expert and base groups to ensure that all students are participating equally and to the best of their ability.
2. The teacher observes group activity to make sure they stay on task throughout the lesson. (If students are unable to comprehend the material on the resource handouts and web sites, remind them that they do not need to memorize every detail, just get the general understanding of the content.)

Lesson 2: Lesson Preparation

Teacher Planning

1. Make copies of all student handouts and worksheets.
2. Organize the room so desks are in groups of 4–5 students.
3. Gain a complete understanding of the NASA lunar colonization program. There are many locations on the NASA web site that should be reviewed.

Student "Activity" Sheets

1. ***Lunar Challenge Note Guide***
2. ***Energy Considerations***
3. ***Shelter Design***
4. ***Transportation***
5. ***Sustainability***
6. ***Lunar Colony Key Questions***
7. ***LCDC: Phase I – Identify the Challenge***

Lesson 3: Lunar Colony Design and Development

Lesson Snapshot

Overview

Big Idea: Humans have always had an innate desire to explore past the boundaries of Earth to the Moon and beyond. To that end, there are many technological, societal, and safety-related challenges that are associated with travel to, and habitation of, the lunar surface.

Purpose of Lesson: This lesson is to refresh students' knowledge and skills related to documenting ideas and to introduce concepts and processes related to modeling.

Selected Learning Objectives: Students will learn to accomplish the following:

1. Create a variety of sketches either electronically or on paper to represent possible lunar colony ideas.
2. Explain the purpose of model building.
3. Design and develop a model of a possible lunar colony.

Lesson Duration: Seven to eight hours.

Activity Highlights

Engagement: Students discuss the importance of scale and attention to detail related to sketching and modeling.

Exploration: Students list the main structures that will be needed on their lunar colony.

Explanation: The teacher provides instruction on the construction of a lunar colony model.

Extension: Students construct a lunar colony model.

Evaluation: Students are assessed on their ability to design and fabricate a lunar colony model.

Lesson 3: Overview

Lesson Duration

- Seven to eight hours.

Standards/Benchmarks

Technology:* Standards for Technological Literacy (STL) *(ITEA, 2000/2002/2007)

- Students will develop an understanding of the core concepts of technology. (ITEA/*STL* 2)
  - Trade-off is a decision process recognizing the need for careful compromises among competing factors. (2S)
- Students will develop an understanding of the role of society in the development and use of technology. (ITEA/*STL* 6)
  - Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. (6D)
- Students will develop an understanding the attributes of design. (ITEA/*STL* 8)
  - Design is a creative planning process that leads to useful products and systems. (8E)
  - There is no perfect design. (8F)
  - Requirements for a design are made up of criteria and constraints. (8G)
- Students will develop abilities to apply the design process. (ITEA/*STL* 11)
  - Apply a design process to solve problems in and beyond the laboratory-classroom. (11H)
  - Specify criteria and constraints for the design. (11I)
  - Make two-dimensional and three-dimensional representations of the designed solution. (11J)
  - Test and evaluate the design in relation to preestablished requirements, such as criteria and constraints, and refine as needed. (11K)
  - Make a product or system and document the solution. (11L)

Mathematics:* Principles and Standards for School Mathematics *(NCTM, 2000)*

- Compute fluently and make reasonable estimations. (NCTM, Number and Operations, Grades 6–8)
  - Develop, analyze, and explain methods for solving problems involving proportions, such as scaling and finding equivalent ratios.

Science:* Benchmarks for Science Literacy *(AAAS, 1993)**

- Technology and Science (AAAS, 3 A, Grades 6–8)
  - Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
  - Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems, but they usually have to take human values and limitations into account, as well.

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Learning Objectives

Students will learn to accomplish the following:

1. Define a tradeoff as a decision process recognizing the need for careful compromises among competing factors.
2. Explain that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
3. Explain that useful products and systems result from a creative planning process.
4. Explain why there is no perfect design.
5. Analyze the requirements for a design and identify the criteria and constraints.
6. Apply a design process to solve problems in and beyond the laboratory-classroom.
7. Specify criteria and constraints for the design.
8. Make two-dimensional and three-dimensional representations of the designed solution.
9. Test and evaluate the design in relation to preestablished requirements, such as criteria and constraints, and refine as needed.
10. Make a product or system and document the solution.

Student Assessment Tools and/or Methods

1. ***Lunar Colony Model Self Assessment***

2. ***Lunar Colony Final Sketch Rubric***

Resource Materials

Internet Search Criteria

1. Sketching Basics
2. 3-D Model Construction
3. Model Building
4. Design Constraints
5. Lunar Colony

Lesson 3: 5-E Lesson Plan

Engagement

1. Students make a sketch of what a lunar building may look like. This building may be used for research, living, power generation, or something else.
2. The teacher discusses the importance of sketching and reviews principles of sketching from Unit 2, Lesson 1: Documenting Ideas. Students may have forgotten the importance of adding notes, estimated sizes, color, or other features. Students complete the worksheet ***"Finding Your Scale Model Drawing Sketch Measures"*** to aid understanding of scale models.
3. The teacher exhibits a model of a building and has students identify critical design elements. The teacher and students discuss the importance of scale and attention to detail that the model shows.

Exploration

1. Students, working in groups, compare the sketches that they each made at the start of the class. This can be done by having each group member show and briefly explain their sketch to the rest of the group.
2. Students, working in groups, list the major structures that will be needed on their lunar colony. The worksheet entitled ***Exploring Ideas: Lunar Colony*** will assist in this process. Students brainstorm about ten lunar structures and then rank them from the most important (1) to the least important (10).
   a. Remind students that the list they generate should be reflective of the research they did about the Moon.
   b. They also should refer to their four research topics (energy, shelter design, transportation, and sustainability).
3. Once the buildings are listed, the teacher encourages students to remove a few that were ranked low, since each structure must be represented with a detailed sketch and then a model. Perhaps some of the structures can be combined into one structure.

Explanation

1. The teacher performs the following tasks:
   a. Defines a tradeoff as a decision process recognizing the need for careful compromises among competing factors.
   b. Explains that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
   c. Explains that useful products and systems result from a creative planning process.
   d. Explains why there is no perfect design.
   e. Analyzes the requirements for a design and identifies the criteria and constraints.
   f. Reviews the steps in the design process.
2. The teacher demonstrates techniques for making two-dimensional and three-dimensional representations of the designed solution.
3. The teacher demonstrates modeling techniques, including the safe and effective use of tools, equipment, and materials.

Extension

1. The student groups divide the task of making sketches for each of the structures. They may choose from the following:
   a. Individually make a quick sketch of all the structures and then choose the best ones.
   b. Work in pairs to make sketches of a few structures.
   c. Individually pick a structure and make a sketch of it.
   d. These sketches can be made using graph paper or on computer.
   e. The sketches need to be approved by the teacher before students can proceed.
2. The student groups organize their structures into a coherent lunar colony. Some specifications that should be followed include the following:
   a. The model must fit onto an 18" × 18" base and not exceed 9" in height.
   b. All structures should be made of readily accessible materials.
   c. All structures must be numbered and labeled clearly.
3. The student groups make a drawing that shows the entire colony. The final sketch must include the details described below:
   a. Clear labels on all structures.
   b. A written paragraph about each of the structures.
   c. Color to highlight important features.
   d. Clear indication of drawing to scale. For more information about scale drawing, see Unit 2, Lesson 1.
   e. The ***Lunar Colony Final Sketch Rubric*** can be used by the teacher to assess the quality and completeness of the final sketch.
4. Students construct a lunar colony model. This is one of the most important aspects of the entire unit. It is important because the information provided on the survey may be reflective of the quality of the model rather than the understandings of lunar colonization.
   a. Each group gives a short presentation to the class about its lunar colony sketch. The class is encouraged to ask questions that will enable the presenters to defend their ideas.
   b. The teacher copies and distributes the ***Lunar Colony Model Self Assessment*** to each group for review and discusses it with the class.
   c. The teacher reviews the specifications for constructing a model, which are listed above.
   d. Some tips that teachers can remind students of while they construct their models include:
      i) Cyanoacrylate or CA glue is fast-drying and strong.
      ii) Use markers or nontoxic paint.
      iii) Decals can be printed onto transparency paper and then glued onto the model.
      iv) Limestone dust can be used to replicate the surface of the Moon.
      v) Hobby stores usually carry miniature people that can be used to make the model more authentic.
5. Each group takes some pictures of its model. The model can be assessed by the teacher and the students using the ***Lunar Colony Model Self-Assessment***.

Evaluation

1. The teacher monitors student progress as they build their model. Each student should participate equally and safely. Five minutes before the end of the class, students clean up their work area and put all tools and materials away.

Lesson 3: Lesson Preparation

Teacher Planning

1. The teacher needs to remind students that they should bring in recyclable supplies a few days before the model building begins.
2. The teacher should gather materials, which include:
   a. Material brought from student homes.
   b. Tools and material need to construct models.
   c. ½" plywood cut into 18" × 18" pieces.
   d. Paper for student sketching.
3. Cut ½" × 18" x 18" sheets of plywood. These will be used for the bases of the lunar models. Each group will be issued one sheet of plywood for their base.
4. Obtain a bag of crushed limestone that can be used to replicate the lunar surface. Keep in mind that this should not be used until the model is complete.

Student "Activity" Sheet

1. ***Exploring Ideas: Lunar Colony***

Assessment Rubrics

1. ***Lunar Colony Final Sketch Rubric***

2. ***Lunar Colony Model Self-Assessment***

Lesson 4: Going Public

Lesson Snapshot

Overview

Big Idea: Humans have always had an innate desire to explore past the boundaries of Earth to the Moon and beyond. To that end, there are many technological, societal, and safety-related challenges that are associated with travel to, and habitation of, the lunar surface.

Purpose of Lesson: This lesson requires students to assess the quality of their design solutions and to use data from a survey to determine customer preferences.

Selected Learning Objectives: Students will learn to:

1. Evaluate the quality and accuracy of their lunar colony model.
2. Design and develop a survey related to lunar colonization.
3. Implement their survey and explain the results of the data compilation.

Lesson Duration: Three to four hours.

Activity Highlights

Engagement: Students analyze data from sample surveys.

Exploration: Students discuss the purpose of polls and surveys and how they can be used to determine public ideas and beliefs.

Explanation: The teacher discusses specific uses of polling. For instance, polling is used commonly in elections to help predict the outcome. Polling is never perfect and sometimes gives erroneous results. All polls will give a margin of error.

Extension: Students develop a survey that seeks to determine the public's opinion about lunar colonization.

Evaluation: Students are assessed on their ability to evaluate the quality and accuracy of their lunar colony model, on the design and development of a survey related to lunar colonization, and on how well they implemented their survey and explained the results of the data.

Lesson 4: Overview

Lesson Duration

- Three to four hours.

Standards/Benchmarks

Technology:* Standards for Technological Literacy (STL) *(ITEA, 2000/2002/2007)

- Students will develop an understanding of the relationships among technologies and the connections with other fields of study. (ITEA/*STL* 3)
  - A product, system, or environment developed for one setting may be applied to another setting. (3E)
  - Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. (3F)
- Students will develop an understanding of the role of society in the development and use of technology. (ITEA/*STL* 6)
  - Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. (6D)

Mathematics:* Principles and Standards for School Mathematics *(NCTM, 2000)*

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them (NCTM, Data Analysis and Probability, Grades 6–8)
  - Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.
  - Select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatterplots.
- Select and use appropriate statistical methods to analyze data. (NCTM, Data Analysis and Probability, Grades 6–8)
  - Discuss and understand the correspondence between data sets and their graphical representations, especially histograms, stem-and-leaf plots, box plots, and scatterplots.

Learning Objectives

Students will learn to:

1. Explain that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
2. Cite examples of a product, system, or environment developed for one setting that may be used in another setting.
3. Describe an instance where knowledge gained from other fields of study has a direct effect on the development of technological products and systems.
4. Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.
5. Select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatterplots.
6. Evaluate the quality and accuracy of their lunar colony model.
7. Design and develop a survey related to lunar colonization.
8. Implement their survey and explain the results of the data compilation.

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Student Assessment Tools and/or Methods

1. Critical analysis of the quality of the lunar colony model using self-reflection.
2. Development of a survey.
3. Evidence of the gathering of data from the survey.
4. Analysis of the survey data.
5. Monitoring student teamwork while in their group.

Resource Materials

Internet Sites

Cannon, Larry, Dorward, James, Heal, Robert, & Edwards, Leo (Principal Investigators). (1996–2006). National Library of Virtual Manipulatives. *Box Plot.* Retrieved May 11, 2007, from <http://nlvm.usu.edu/en/nav/frames_asid_200_g_3_t_5.html>.

- Provides explanation and instructions about box plots.

Creative Research Systems. (July, 2006). *The Survey System*. Retrieved May 11, 2007, from <http://www.surveysystem.com/sdesign.htm>.

- This site provides information on survey design including sampling, types of surveys, and writing questions.

The Shodor Education Foundation. (1996-2007). *Shodor interactivate: Box plot.* Shodor. Retrieved May 14, 2007, from <http://www.shodor.org>.

- At this site enter box plot in the search box and on the next page click on *Shodor Interactivate: Box Plot*.

International Technology Education Association. (1995). *ITEA/Gallup poll reveals what Americans think about technology: Questions of the survey conducted by the Gallup Organization for the International Technology Education Association.* International Technology Education Association. Retrieved May 14, 2007, from www.iteaconnect.org/TAA/PDFs/Gallupsurvey.pdf.

Rosenbaum, Marcus D. (Editor). (n.d). *Survey shows widespread enthusiasm for high technology*. NPR: Online. Retrieved May 14, 2007, from <http://www.npr.org/programs/specials/poll/technology/>.

Zogby International (2007). *Futron/Zogby public space travel poll.* Zogby International. Retrieved May 14, 2007, from <http://www.zogby.com/search/readnews.cfm?ID=577>.

Internet Search Criteria

1. Survey Design Tips
2. Survey Analysis Basics
3. Data Representation
4. Basic Statistics
5. Box Plot

Lesson 4: 5-E Lesson Plan

Engagement

1. The teacher presents a statistic that was gathered from a survey. A few examples are listed below:
   a. In a 2004 Gallup Poll, 68% of Americans think of the word *computer* when they hear the word *technology*, while only 2% think of *new inventions*. See <http://www.iteaconnect.org/TAA/PDFs/Gallupsurvey.pdf>.
   b. In 1999, a National Public Radio survey found that 46% of Americans say that computers have given people less free time, and 58% said that computers have led people to spend less time with their families and friends. See <http://www.npr.org/programs/specials/poll/technology/>.
   c. Futron/Zogby Public Space Travel Poll: Space travel is a new exciting option for those who can afford it; 7% of the affluent would pay $20 million for a two-week orbital flight; 19% would pay $100,000 for a 15-minute suborbital flight. See <http://www.zogby.com/search/readnews.cfm?ID=577>.
2. Students offer opinions on the accuracy of the statistic and on the quality of information it offers.

Exploration

1. The teacher leads a discussion on the purpose of polls and surveys and how they can be used to determine public ideas and beliefs.
   a. Discuss specific uses of polling. For instance, polling is used commonly in elections to help predict the outcome. Polling is never perfect and sometimes gives erroneous results. All polls will give a margin of error, such as ±3%. This means that the results can be 3% above or below the given percentage, and, therefore, the range of accuracy is 6%.
   b. Discuss and explain sampling. This basically means that students should try to get a variety of different people to respond to their survey.
2. Students brainstorm on what is needed for a good survey. The following items, minimally, should be discussed during this brainstorming exercise.
   a. Clear directions and a purpose statement should appear on the top of the page.
   b. Survey items should always be written in the positive. For instance, "I would not like to go to space" would be better written as "I would like to go to space."
   c. Be careful not to write survey items that are "double-barreled." These types of questions can have two or more meanings. For instance, "I think the lunar colony is a good idea if everyone can be safe," is an example of an item that should be divided into two different survey items.
   d. Survey items should be organized in a random order so similar subjects are not grouped together.

Explanation

1. The teacher explains that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
2. The teacher cites examples of a product, system, or environment developed for one setting that may be applied to another setting.
3. The teacher describes an instance where knowledge gained from other fields of study has a direct effect on the development of technological products and systems.
4. The teacher explains how to formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.

Extension

1. The teacher explains that students will write a survey that seeks to determine the public's opinion about lunar colonization. There should be 7–10 survey questions and demographic information, possibly including:
   a. Age range
   b. Gender
   c. Educational level
   d. Ethnicity
2. The teacher gives students time to develop their survey in a word processing program. The survey should not exceed two pages. A template is provided on the ***Survey Template.***
3. Once the survey is developed, students should also enter that information into a spreadsheet that can create graphs. They may choose to use Microsoft® Excel®. For data input purposes, students count the number of responses for each of the following categories:
   a. Strongly Agree – 1
   b. Agree – 2
   c. Neutral – 3
   d. Disagree – 4
   e. Strongly Disagree – 5
4. Once all of the responses have been recorded in Excel®, the students will graph the results using a bar graph.
5. If students want to do additional research on survey design they could also do any of the following:
   a. Conduct a basic statistical analysis of the data to determine if it is reliable. For a handout that helps students to understand statistical terminology, see the ***"Extension Activity Answers."*** Some of these basic analyses can be done in Microsoft® Excel® using these commands:
      i) MEDIAN (number 1, number 2,...) – is used to determine the middle number in a set of data.
      ii) AVERAGE (number 1, number 2,...) – is used to calculate the average or mean for a set of data.
      iii) MODE (number 1, number 2,...) – is used to determine the most frequently occurring value.
6. To represent the data for each question, students can create a pie chart to show the variety of responses.
7. Students could complete a more thorough evaluation of their lunar colony model by displaying it in the school and having students give feedback about it and lunar colonization.

Evaluation

1. To ensure that the surveys that students create are valid, it is recommended that several groups and the teacher review them.
2. Students need to be able to critically analyze their lunar colony model. This can be done by using the ***Lunar Colony Model Self-Assessment*** or having students create one of their own.

Lesson 4: Lesson Preparation

Teacher Planning

1. Look for various creative graphs that are used to represent statistical data. The *USA Today* newspaper usually has one on the front cover.
2. Become familiar with the data entry, calculations, and chart/graph making process in Microsoft® Excel® or a similar program.
3. Copy the ***Survey Template*** onto student accounts.
4. Copy the ***Survey Results Compilation*** handout.
5. Supplies and software needed include the following:
   a. Microsoft® Excel®
   b. Calculators

Student "Activity" Sheets

1. ***Survey Template***
2. ***Survey Results Compilation***
3. ***Survey Data Extension Activity***

Lesson 5: Putting it all Together

Lesson Snapshot

Overview

Big Idea: Humans have always had an innate desire to explore past the boundaries of Earth to the Moon and beyond. To that end, there are many technological, societal, and safety-related challenges that are associated with travel to, and habitation of, the lunar surface.

Purpose of Lesson: This lesson requires students to select and use information and communication technologies.

Selected Learning Objectives: Students will learn to:

1. Design and deliver a cooperative presentation about the lunar colony project including information about the lunar colony survey, model, and research.
2. Create an electronic slide show containing graphs, pictures, and text.

Lesson Duration: Three to four hours.

Activity Highlights

Engagement: Students revisit the "big picture" of the human exploration project.

Exploration: Students experiment with the usage of presentation software.

Explanation: The teacher demonstrates the use of presentation software and guides students through basic operations.

Extension: Students develop and deliver a presentation on the design and development of the lunar colony project.

Evaluation: Students are assessed on their presentation of the design and development of the lunar colony project.

Lesson 5: Overview

Lesson Duration

- Three to four hours.

Standards/Benchmarks

Technology:* Standards for Technological Literacy (STL) *(ITEA, 2000/2002/2007)

- Students will develop abilities to apply the design process. (ITEA/*STL* 11)
  - Make a product or system and document the solution. (11L)
- Students will develop an understanding of, and abilities to, select and use information and communication technologies. (ITEA/*STL* 17)
  - The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message. (17J)

Learning Objectives

Students will learn to:

1. Design and deliver a cooperative presentation about the lunar colony project including information about the lunar colony survey, model, and research.
2. Utilize PowerPoint™ to create an electronic slide show containing graphs, pictures, and text.

Student Assessment Tools and/or Methods

1. Completion of individual self-assessment.
2. Development of a PowerPoint™ presentation.
3. Evaluation of team presentation.

Resource Materials

Internet Sites

PowerPoint™ in the Classroom: <www.actden.com/pp>.

- Provides explanation and instructions for how to design and create quality presentations.

PowerPoint™ Tips and Tricks: <www.bitbetter.com/powertips.htm>.

Internet Search Criteria

1. PowerPoint™
2. Presentation Skills
3. Public Speaking
4. Communication Design
5. Multimedia

Lesson 5: 5-E Lesson Plan

Engagement

1. The teacher leads a discussion on what students have learned thus far. This is important so that students can see the big picture of the entire project.
2. The teacher lists and expands on these items as they are written on the board.

Exploration

1. The teacher presents and students analyze an effective multimedia presentation and identify elements that they found attractive and informative.
2. Students, working in pairs, list characteristics or traits of a quality multimedia presentation.

Explanation

1. Student groups present their lists of characteristics or traits of a quality multimedia presentation.
2. The teacher reviews common commands, and students will complete a worksheet entitled ***PowerPoint™ Exploration.***
3. The teacher discusses some key traits of a quality PowerPoint™ presentation. Some of these include the following:
   a. Put a minimal amount of text on each slide.
   b. Be sure graphics are large enough to see clearly, but keep in mind that some pictures will become blurry when enlarged too much.
   c. Use consistent text throughout the presentation.
   d. Use WordArt text sparingly.
   e. Keep a similar color scheme throughout the presentation.
   f. Use slide transitions and animations sparingly. Too many transitions and animations tend to become distracting.
   g. Remember that a visual aid, i.e., PowerPoint™, is only a tool to assist in the presentation. It is the presenters who make or break the quality of the presentation. For additional explanation, see "PowerPoint™ in the classroom," <www.actden.com/pp> and "PowerPoint™ Tips and Tricks," <www.bitbetter.com/powertips.htm>.

Extension

1. Students develop a multimedia presentation.
2. Students present their presentation to an audience, such as a School Board, Chamber of Commerce, or other classes. Consider asking a local newspaper visit the classroom to do an interview with the students following their presentations.

Evaluation

1. Students and teacher should use the ***Lunar Colony Final Presentation Rubric*** to assess each team's presentation and use of PowerPoint™.
2. The teacher should use the ***Lunar Colonization Design Challenge Rubric*** to assess the overall work students have done on their design challenge.

Lesson 5: Lesson Preparation

Teacher Planning

1. Become familiar with Microsoft® PowerPoint™ software.
2. Provide students an opportunity to practice their presentation.

Student "Activity" Sheets

1. ***PowerPoint™ Exploration***
2. ***Lunar Colony Model Self-Assessment***
3. ***Lunar Colony Final Presentation***

Assessment Rubrics

Team Presentation Rubric

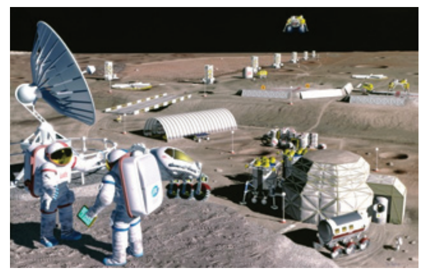
Lesson 1:
Resource Documents

Lunar Colonization Design Challenge

By 2020, the United States is hoping to have established a lunar colony. This colony would be used to conduct research, gather information about lunar soil, and be a stepping stone for travel to Mars and beyond. This challenge was presented to the public by President Bush on January 14, 2004. For a complete transcript of his speech, you can read the document entitled "President Bush Announces New Vision for Space Exploration Program" or view it online at:

Office of the Press Secretary (January 14, 2004). *President Bush announces new vision for space exploration program*. The White House. Retrieved May 14, 2007, from <http://www.whitehouse.gov/news/releases/2004/01/print/20040114-1.html>.

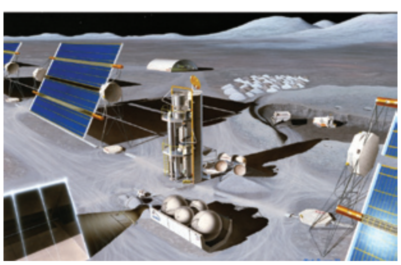
The greatest challenges to this venture are not just technological, but also sociological. Many people have very strong opinions, both positively and negatively, about lunar colonization and space travel in general. Traveling to the Moon requires that the general public is kept well aware of the challenges and risks. As a team, it is your challenge to find out what people in your locality think about colonizing the Moon. This will require that you complete the following tasks:



- Design and construct a model of a sustainable lunar colony.
- Develop a plan of action to transport people and goods to and from the Moon.
- Survey people in your community regarding your lunar colonization and transportation plans.
- Create a print or electronic media informational piece that helps the public better understand lunar colonization.
- Deliver a group presentation about your findings.

Model Lunar Colony Criteria

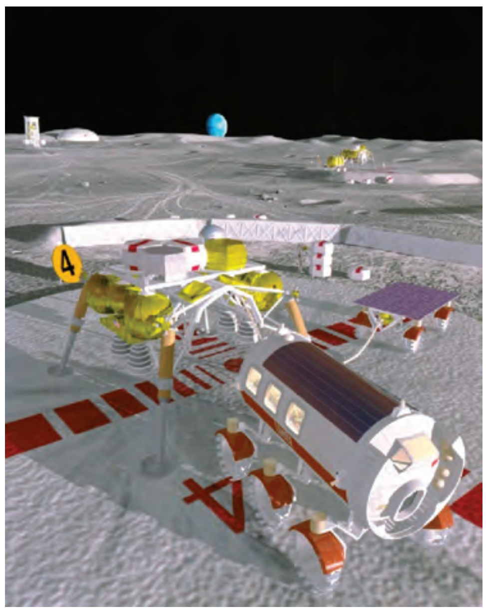
1. Each member of the group must create at least two rough sketches of a lunar colony in his or her Engineering Design Journal. This journal may be created on paper or electronically. A final sketch by the group must be approved by the teacher before construction of the model can begin.



2. Your model must fit in on 18"×18" base and not exceed 9" in height.
3. Materials to build the lunar colony model can be brought in from home and/or provided by your teacher.
4. All key components of your colony must be clearly labeled on the model.
5. A one-page written description of your colony and how it would function must accompany your model.
6. The model parts must be securely attached so that no parts can fall off.

Survey Criteria

1. The team must develop a survey that is designed to gather a sampling of the local community's opinions and beliefs about lunar colonization, transportation, and space research.
2. The survey must be word-processed and approved by the teacher. The survey will be a series of up to 10 questions that can be asked of people at school, in the community, or in your family.
3. At least 25 people must respond to your survey. They should represent a variety of ages, an equal mix of genders, and people beyond your immediate family.
4. Data compiled from the survey must be shown on a graph or chart.



Off to the Moon: KWHL Chart

In groups of four, use the KWHL chart on the following page to help you begin your quest toward designing and building a model of a lunar (Moon-based) colony. Fill in this chart with notes, calculations, and ideas, rather than complete sentences. Use this sheet to help you think through your design problem.

1. What is your topic or problem? ______________________________

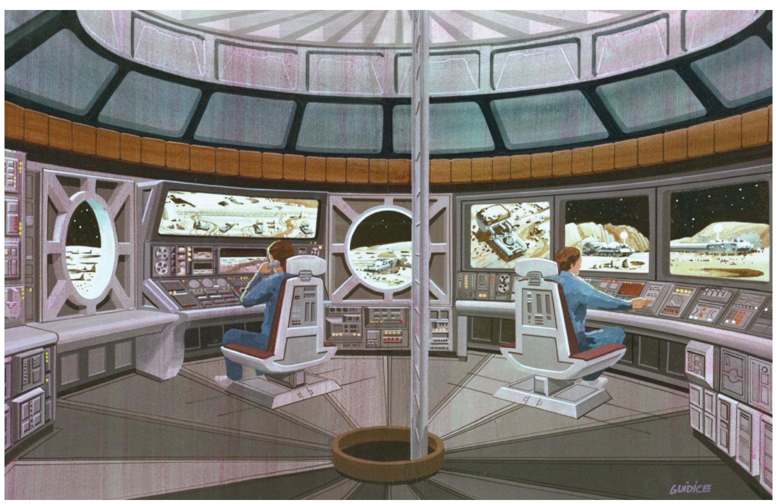
____

2. What do you hope to accomplish? ______________________________

____

3. What is your central research problem? ______________________________

____



Off to the Moon: KWHL Chart

(**NOTE:** Make sure that everything you write below will help you in this quest.)

K What I **K**now	**W** What I **W**ant to Know	**H** **H**ow I can find more information	**L** What I **L**earned
Categories of information we expect to use:			

Moon and Earth Comparison Worksheet
(Student Version)

Name: ______________________________

Date: ______________________________

Hour/Period: ______________________________

	Earth	Moon	Comparison Factor*
Orbit Distance (km)	km (average distance from Sun)	km (average distance from Earth)	=0.2724 * Earth
Radius at Equator (km)		1,737.4 km	=0.2724 * Earth
Equator Circumference (km)	km	km	
Maximum Surface Temperature (°C & °F)	°C °F	°C °F	
Minimum Surface Temperature (°C & °F)	°C °F	°C °F	
Angle of Tilt (degrees)	°	°	
Length of a Day (Earth Days)	Earth Hours	Earth Hours	
Length of a Year (Earth Days)	Earth Days	Earth Days	
Equatorial Gravity	m/sec^2	m/sec^2	
Atmosphere			N/A
Water			N/A

* The comparison factor is used to compare the Moon to Earth.

The following web sites may be used to locate data about the Moon and the Earth:

Artemis Society International (June 27, 1999). *Comparison of Earth and Moon*. The Artemis Project. Retrieved May 14, 2007, from <http://www.asi.org/adb/m/03/01/Earth-moon.html>.

Bray, Becky & Meyer, Patrick (Authors/Editors). & Koczor, Ron (NASA Official). (n.d.). *Water on the Space Station*. NASA. Retrieved January 31, 2009, from <http://science.nasa.gov/headlines/y2000/ast02nov_1.htm>.

Levy, David H. (Author), Phillips, Tony (Author/Editor), Horack, John M. (NASA Official), & Walls, Bryan (Curator). (n.d). *Moon Water. Science at NASA*. Retrieved May 14, 2007, <from http://science.nasa.gov/headlines/y2005/14apr_moonwater.htm>.

Munsell, Kirk (Editor), Martin, David (Webmaster) & Lindstrom, Marilyn (NASA Official). (July 24, 2006). *Solar System Exploration*. National Aeronautics and Space Administration. Retrieved May 14, 2007, from <http://solarsystem.nasa.gov/planets/profile.cfm?Object=Moon>.

Wilson, Jim (Editor) & Dunbar, Brian (NASA Official). (March 1, 2007). Moon, Mars, and Beyond. *National Aeronautics and Space Administration*. Retrieved May 14, 2007, from <http://www.nasa.gov/mission_pages/exploration/mmb/index.html>.

Moon and Earth Comparison Worksheet

(Teacher Version)

	Earth	Moon	Comparison Factor*
Orbit Distance (km)	149,597,890 km (average distance from Sun)	384,400 km (average distance from Earth)	=.00257 * Earth
Radius at Equator (km)	6,378 km	1,737.4 km	=0.2724 * Earth
Equator Circumference (km)	40,075 km	10,916 km	=0.2724 * Earth
Maximum Surface Temperature (°C & °F)	58 °C 136 °F	123 °C 253 °F	=2.107 * Earth °C =1.8603 * Earth °F
Minimum Surface Temperature (°C & °F)	–88 °C –126 °F	–232 °C –387 °F	=2.5341 * Earth °C =3.0714 * Earth °F
Angle of Tilt (degrees)	23.45 °	6.68 °	=.2849 * Earth °
Length of a Day (Earth Days)	23.934 Earth hours	653.9166 Earth hours	=23.934 * 27.3216 hours
Length of a Year (Earth Days)	365.24 Earth days	27.321661 Earth days	=0.0748 * Earth years
Equatorial Gravity	9.78 m/sec2	1.62 m/sec^2	=0.1656 * Earth
Atmosphere	78% nitrogen 21% oxygen 1% others (approximates)	Basically none	N/A
Water	70%–75% of surface	Unknown but basically none has been found	N/A

* The comparison factor is used to compare the Moon to Earth.

The following web sites may be used to locate data about the Moon and the Earth:

Artemis Society International (June 27, 1999). *Comparison of Earth and Moon*. The Artemis Project. Retrieved May 14, 2007, from <http://www.asi.org/adb/m/03/01/Earth-moon.html>.

Bray, Becky & Meyer, Patrick (Authors/Editors). & Koczor, Ron (NASA Official). (n.d.). *Water on the Space Station*. NASA. Retrieved January 31, 2009, from <http://science.nasa.gov/headlines/y2000/ast02nov_1.htm>.

Levy, David H. (Author), Phillips, Tony (Author/Editor), Horack, John M. (NASA Official), & Walls, Bryan (Curator). (n.d). *Moon Water. Science at NASA*. Retrieved May 14, 2007, from <http://science.nasa.gov/headlines/y2005/14apr_moonwater.htm>.

Munsell, Kirk (Editor), Martin, David (Webmaster) & Lindstrom, Marilyn (NASA Official). (July 24, 2006). *Solar System Exploration*. National Aeronautics and Space Administration. Retrieved May 14, 2007, from <http://solarsystem.nasa.gov/planets/profile.cfm?Object=Moon>.

Wilson, Jim (Editor) & Dunbar, Brian (NASA Official). (March 1, 2007). Moon, Mars, and Beyond. *National Aeronautics and Space Administration*. Retrieved May 14, 2007, from <http://www.nasa.gov/mission_pages/exploration/mmb/index.html>.

Let's Learn Some Algebra

Name: ______________________________

Date: ______________________________

Hour/Period: ______________________________

Some people are afraid when they hear the word "algebra" because they think of a bunch of letters and numbers. Some people don't know how the numbers and letters are related. It's really not that hard. In fact, the letters are pretty much just a shorthand method of representing something.

Activity 1

Describe the pattern represented below:

3 + 5
9 + 5
12 + 5
2 + 5

Put your description here:

Activity 2

In algebra, we use a letter to represent a number that changes or varies. This letter is called a *variable*. Part of the word "vary" is in this word. So, for the equations from Activity 1, we could simply write x + 5. The *x* tells us we want a number and the + 5 tells us we are going to add 5.

Write the following patterns using symbols:

a. 12 – 3
9 – 3
5 – 3
2 – 3

Write the pattern in symbols:

b. 6 ÷ 3
12 ÷ 3
15 ÷ 3
33 ÷ 3

Write the pattern in symbols:

Activity 3

The challenge of algebra is to take a symbol expression or a number pattern with a variable, make it equal to a number and then try to determine what *x* is. For example, suppose we write "a + 2 = 5". This means that when 2 is added to a particular number you get 5. It's a bit like a puzzle or riddle. Of course you know the answer to this riddle is three. 3 + 2 = 5, so this means that a = 3.

This riddle is called an equation in algebra. See if you can find the answers to these equations. Note: We now have to write multiplication in a new way so we don't get confused with our letter *x* and our multiplication symbol. So we are going to use * for multiplication.

a. 9 + x = 11 b. a * 3 = 27 c. 45 ÷ b = 5 d. 17 – c = 12

Activity 4

In all of the equations in Activity 3, you were probably able to answer by just remembering your number facts, but sometimes equations are more difficult. For example, suppose you had "b * 18 = 270." You might be able to eventually guess what the variable (b) is equal to, but we need some way to find a without guessing.

One way to determine what b is, is to go backward. When we go backward, we need to remember that we use the opposite operation from our equation. For example, suppose we have "x + 5 = 19". Working backward we start with 19. So, if we are working backward that means our number before we added 5 had to be 5 LESS than 19 or 19 -5. So using this same method for b * 18 = 270 means we start with 270. A number was multiplied by 18 to get 270 so this means the number was 1/18 of 270, or 270 ÷ 18, which is 15.

See if you can use the backward method to find the answers to these equations. Write your backward equation and your answer.

a. x – 12 = 173 b. a * 56 = 7000c. c + 245 = 346

Activity 5

This last activity will help with the Moon and Earth comparison sheet. We want to find a comparison factor. The comparison factor is the number we must multiply times the Earth number to get the Moon number.

So suppose the orbit distance of the Earth is 149,597,890 km and that the Moon orbit distance is 384, 400 km. This means we want to know what number times the Earth number gives us the Moon number.

x * 149,597,890 = 384,400

Do the backward method to find the comparison factor. Write your backward equation below. Now, complete the rest of the Moon and Earth comparison sheet. Round your answers to the nearest ten thousandth.

Comparison Factor Questions
(Student Version)

Name: ______________________________

Date: ______________________________

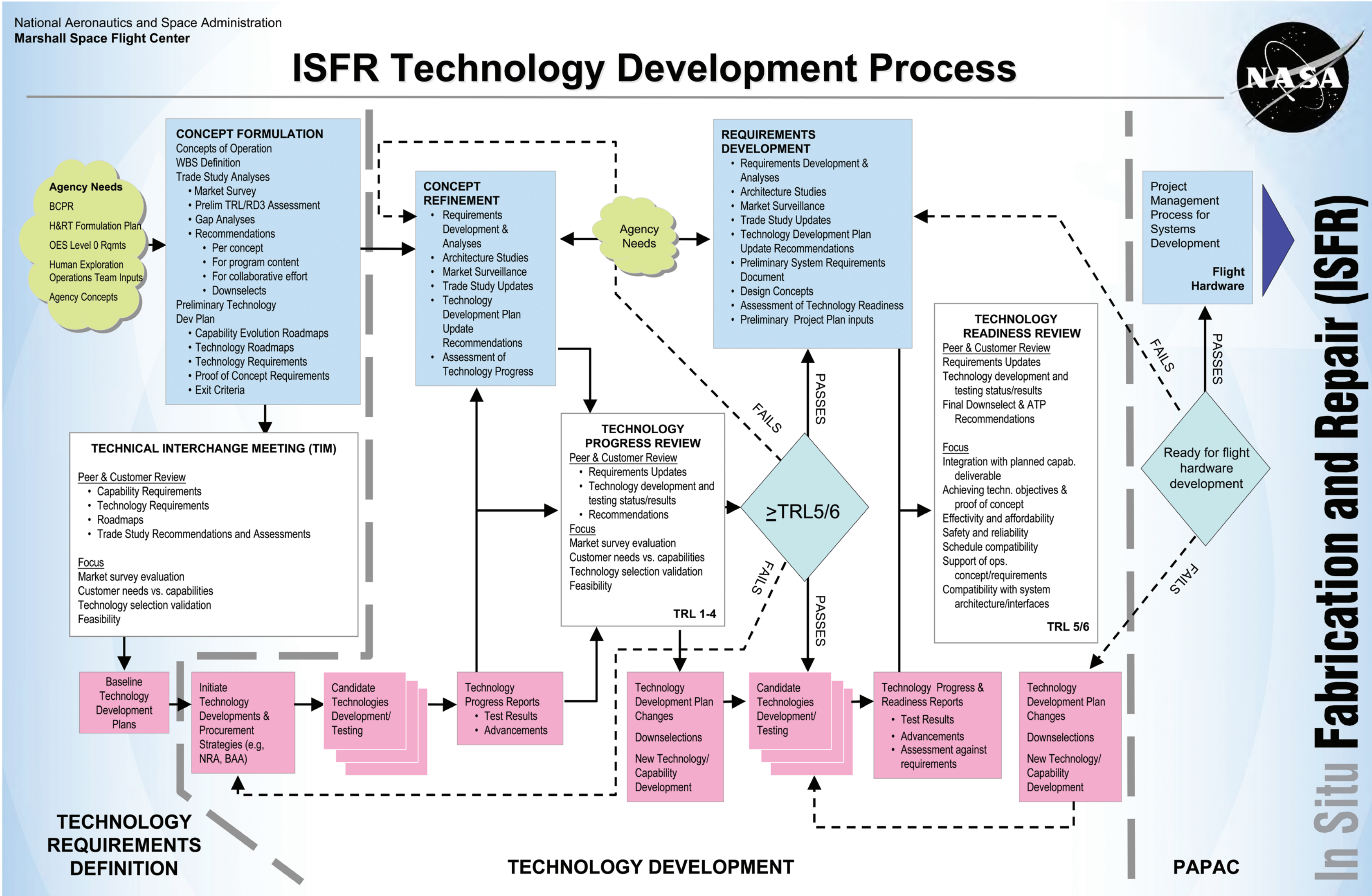
Hour/Period: ______________________________

Now that you know the comparison factors, you can use this information to calculate what would happen on the Moon. For example, you can now calculate your weight on the Moon using your weight here on Earth and multiplying it by the comparison factor. So, if you weighed 100 lbs., you would calculate 100 × 0.1656 = 16.56 lbs.

1. What is your weight on the Moon?
2. Weigh your science textbook. Calculate the weight of your science textbook on the Moon.
3. Calculate your age according to Moon years.
4. Calculate the age of a friend or relative according to Moon years.
5. How many Moon days equal five Earth days?

You can also go in the opposite direction, from Moon to Earth. For example, suppose you knew that you weighed 16.56 lbs on the Moon. To convert this to Earth pounds, take the Moon weight and divide by the conversion factor. So 16.56 ÷ 0.1656 = 100, which means you would weigh 100 lbs. on Earth.

1. If someone weighed 10 lbs. on the Moon, how much would that person weigh on Earth?
2. If someone is 12 Moon-years old, how old would this person be in Earth years?
3. If you had 405 Moon days, how many Earth days would this be?



Explore. Discover. Understand.

Living on the Moon Synthesis

Name: ____

Date: ____

Hour/Period: ____________________________________

After completing a thorough study of the Moon, complete the following questions on a separate sheet of paper. This will help you synthesize what you have learned thus far.

1. The Earth is surrounded by a blanket of air that we call the atmosphere. Which atmospheric gas is essential for human survival and what is the percent composition this gas on Earth? How does this atmospheric composition on Earth compare to the composition on the Moon.

2. Water is an essential substance for life on Earth. Since it appears that the Moon does not have any liquid water, how would people living on the Moon obtain and conserve water? Read over the "Water on the Space Station" NASA report:

- Bray, Becky & Meyer, Patrick (Authors/Editors). & Koczor, Ron (NASA Official). (n.d.). *Water on the Space Station*. NASA. Retrieved January 31, 2009, from <http://science.nasa.gov/headlines/y2000/ast02nov_1.htm>.

3. Write down the hottest and coldest temperature that you can recall experiencing. How do these temperatures compare to the maximum and minimum temperatures of the Earth and of the Moon? If you were to live on the Moon, what would you need to do to adjust to the extreme temperatures there?

4. The Earth and the Moon's gravitational forces are different. How can this difference be an advantage when living on the Moon?

5. A person weighing 120 lbs. on Earth will weigh how many pounds on the Moon? Show your calculations.

6. In order to live outside of our Earth habitat, we will need to create an artificial habitat that we can take or make. Make a list of essential components that people would need to consider when constructing a lunar habitat. In your list, consider such components as food, water and water recovery, waste management, atmosphere and air purification, energy needs, and travel within and outside of habitat.

7. What major ingredients do we need to grow plants (food sources for humans)? What can we do to duplicate these ingredients on the Moon if we wanted to build a colony?

The White House — President George W. Bush

For Immediate Release
Office of the Press Secretary
January 14, 2004

President Bush Announces New Vision for Space Exploration Program

Fact Sheet: A Renewed Spirit of Discovery

Today's Presidential Action

- Today, President Bush announced a new vision for the nation's space exploration program. The President committed the United States to a long-term human and robotic program to explore the solar system, starting with a return to the Moon that will ultimately enable future exploration of Mars and other destinations.
- The President's vision affirms our nation's commitment to manned space exploration. It gives NASA a new focus and clear objectives. It will be affordable and sustainable while maintaining the highest levels of safety.
- The benefits of space technology are far-reaching and affect the lives of every American. Space exploration has yielded advances in communications, weather forecasting, electronics, and countless other fields. For example, image processing technologies used in lifesaving CAT scanners and MRIs trace their origins to technologies engineered for use in space.

Background on Today's Presidential Action

America's history is built on a desire to open new frontiers and to seek new discoveries. Exploration, like investments in other federal science and technology activities, is an investment in our future. President Bush is committed to a long-term space exploration program benefiting not only scientific research, but also the lives of all Americans. The exploration vision also has the potential to drive innovation, development, and advancement in the aerospace and other high-technology industries. The President's vision for exploration will not require large budget increases in the near term. Instead, it will bring about a sustained focus over time and a reorientation of NASA's programs.

- NASA spends, and will continue to spend, less than one percent of the federal budget. Our nation's investment in space is reasonable for a tremendously promising program of discovery and exploration that historically has resulted in concrete benefits as well as inspiring Americans and people throughout the world.

President Bush's Vision for U.S. Space Exploration

The President's plan for steady human and robotic space exploration is based on the following goals:

- First, America will complete its work on the International Space Station by 2010, fulfilling our commitment to our 15 partner countries. The United States will launch a re-focused research effort on board the International Space Station to better understand and overcome the effects of human space flight on astronaut health, increasing the safety of future space missions.
  - To accomplish this goal, NASA will return the Space Shuttle to flight consistent with safety concerns and the recommendations of the Columbia accident Investigation Board. The Shuttle's chief purpose over the next several years will be to help finish assembly of the Station, and the Shuttle will be retired by the end of this decade after nearly 30 years of service.
- Second, the United States will begin developing a new manned exploration vehicle to explore beyond our orbit to other worlds—the first of its kind since the Apollo Command Module. The new spacecraft, the Crew Exploration Vehicle, will be developed and tested by 2008 and will conduct its first manned mission no later than 2014. The Crew Exploration Vehicle will also be capable of transporting astronauts and scientists to the International Space Station after the Shuttle is retired.

- Third, America will return to the Moon as early as 2015 and no later than 2020 and use it as a stepping stone for more ambitious missions. A series of robotic missions to the Moon, similar to the Spirit Rover that is sending remarkable images back to Earth from Mars, will explore the lunar surface beginning no later than 2008 to research and prepare for future human exploration. Using the Crew Exploration Vehicle, humans will conduct extended lunar missions as early as 2015, with the goal of living and working there for increasingly extended periods.
  - The extended human presence on the Moon will enable astronauts to develop new technologies and harness the Moon's abundant resources to allow manned exploration of more challenging environments. An extended human presence on the Moon could reduce the costs of further exploration, since lunar-based spacecraft could escape the Moon's lower gravity using less energy at less cost than Earth-based vehicles. The experience and knowledge gained on the Moon will serve as a foundation for human missions beyond the Moon, beginning with Mars.
  - NASA will increase the use of robotic exploration to maximize our understanding of the solar system and pave the way for more ambitious manned missions. Probes, landers, and similar unmanned vehicles will serve as trailblazers and send vast amounts of knowledge back to scientists on Earth.

Key Points on the President's FY 2005 Budget

- The funding added for exploration will total $12 billion over the next five years. Most of this added funding for new exploration will come from reallocation of $11 billion that is currently within the five-year total NASA budget of $86 billion.
- In the Fiscal Year (FY) 2005 budget, the President will request an addition of $1 billion to NASA's existing five-year plan, or an average of $200 million per year.
- From 1992 to 2000, NASA's budget decreased by a total of 5 percent. Since the year 2000, NASA's budget has increased by approximately 3 percent per year.
- From the current 2004 level of $15.4 billion, the President's proposal will increase NASA's budget by an average of 5 percent per year over the next three years, and at approximately 1 percent or less per year for the two years after those.

President's Commission on the Implementation of U.S. Space Exploration Policy

To ensure that NASA maintains a sense of focus and direction toward accomplishing this new mission, the President has directed NASA Administrator Sean O'Keefe to review all current space flight and exploration and direct them toward the President's goals. The President also formed a Commission on the Implementation of U.S. Space Exploration Policy to advise NASA on the long-term implementation of the President's vision.

Space Technology Affects the Lives of Every American

More than 1,300 NASA and other U.S. space technologies have contributed to U.S. industry, improving our quality of life and helping save lives.

- Image processing used in CAT Scanners and MRI technology in hospitals worldwide came from technology developed to computer-enhanced pictures of the Moon for the Apollo programs.
- Kidney dialysis machines were developed as a result of a NASA-developed chemical process, and insulin pumps were based on technology used on the Mars Viking spacecraft.
- Programmable heart pacemakers were first developed in the 1970s using NASA satellite electrical systems.
- Fetal heart monitors were developed from technology originally used to measure airflow over aircraft wings.
- Surgical probes used to treat brain tumors in children resulted from special lighting technology developed for plant-growth experiments on Space Shuttle missions.

- Infrared hand-held cameras used to observe blazing plumes from the Shuttle have helped firefighters point out hot spots in brush fires.
- Satellite communications allow news organizations to provide live, on-the-spot broadcasting from anywhere in the world; families and businesses to stay in touch using mobile phone networks; and the simple pleasures of satellite TV and radio, and the convenience of ATMs across the country and around the world.

Excerpted from:
Office of the Press Secretary (January 14, 2004). *President Bush announces new vision for space exploration program.* The White House. Retrieved May 14, 2007, from <http://www.whitehouse.gov/news/releases/2004/01/print/20040114-1.html>.

For a Windows Media and/or QuickTime video, see the following:
Wilson, Jim (Editor) & Dunbar, Brian (NASA Official). (March 1, 2007). *Moon, Mars, and Beyond.* National Aeronautics and Space Administration. Retrieved May 14, 2007, from <http://www.nasa.gov/mission_pages/exploration/multimedia/index.html>.

Technology Readiness Levels

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NASA

Introduction

Technology Readiness Levels (TRLs) are a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. The TRL approach has been used on and off in NASA space technology planning for many years and was recently incorporated in the NASA Management Instruction (NMI 7100) addressing integrated technology planning at NASA. The most useful general model must include:

(a) "Basic" research in new technologies and concepts (targeting identified goals, but not necessarily specific systems).
(b) Focused technology development addressing specific technologies for one or more potential identified applications.
(c) Technology development and demonstration for each specific application before the beginning of full system development of that application.
(d) System development (through first unit fabrication).
(e) System "launch" and operations.

Technology Readiness Levels Summary

TRL 1—Basic principles
TRL 2—Technology concept and/or application formulated
TRL 3—Analytical and experimental critical function and/or characteristic proof-of-concept
TRL 4—Component and/or breadboard validation in laboratory environment
TRL 5—Component and/or breadboard validation in relevant environment
TRL 6—System/subsystem model or prototype demonstration in a relevant environment (ground or space)
TRL 7—System prototype demonstration in a space environment
TRL 8—Actual system completed and "flight qualified" through test and demonstration (ground and space)
TRL 9—Actual system "flight proven" through successful mission operations

Discussion of Each Level

The following paragraphs provide a descriptive discussion of each TRL, including an example of the type of activities that would characterize each TRL:

TRL 1

Basic principles observed and reported

This is the lowest "level" of technology maturation. At this level, scientific research begins to be translated into applied research and development. Examples might include studies of basic properties of materials (e.g., tensile strength as a function of temperature for a new fiber).

Cost to Achieve: Very Low "Unique" Cost (investment cost is borne by scientific research programs)

TRL 2

Technology concept and/or application formulated

Once basic physical principles are observed, then at the next level of maturation, practical applications of those characteristics can be "invented" or identified. For example, following the observation of High Critical Temperature (HTC) superconductivity, potential applications of the new material for thin film devices (e.g., SIS mixers), and in instrument systems (e.g., telescope sensors can be defined). At this level, the application is still speculative; there is not experimental proof or detailed analysis to support the conjecture.

Cost to Achieve: Very Low "Unique" Cost (investment cost is borne by scientific research programs)

TRL 3

Analytical and experimental critical function and/or characteristic proof-of-concept

At this step in the maturation process, active research and development (R&D) is initiated. This must include both analytical studies to set the technology into an appropriate context and laboratory-based studies to physically validate that the analytical predictions are correct. These studies and experiments should constitute "proof-of-concept" validation of the applications/concepts formulated at TRL 2. For example, a concept for High Energy Density Matter (HEDM) propulsion might depend on slush or supercooled hydrogen as a propellant: TRL 3 might be attained when the concept-enabling phase/temperature/pressure for the fluid was achieved in a laboratory.

Cost to Achieve: Low "Unique" Cost (investment cost is borne by scientific research programs)

TRL 4

Component and/or breadboard validation in laboratory environment

Following successful "proof-of-concept" work, basic technological elements must be integrated to establish that the "pieces" will work together to achieve concept-enabling levels of performance for a component and/or breadboard. This validation must be devised to support the concept that was formulated earlier and should also be consistent with the requirements of potential system applications. The validation is relatively "low fidelity" compared to the eventual system; it could be composed of ad hoc discrete components in a laboratory. For example, a TRL 4 demonstration of a new "fuzzy logic" approach to avionics might consist of testing the algorithms in a partially computer-based, partially bench-top component (e.g., fiber optic gyros) demonstration in a controls lab using simulated vehicle inputs.

Cost to Achieve: Low-to-Moderate "Unique" Cost (investment will be technology specific, but probably several factors greater than investment required for TRL 3)

TRL 5

Component and/or breadboard validation in relevant environment

At this, the fidelity of the component and/or breadboard being tested has to increase significantly. The basic technological elements must be integrated with reasonably realistic supporting elements so that the total applications (component-level, subsystem-level, or system-level) can be tested in a "simulated" or somewhat realistic environment. From one to several new technologies might be involved in the demonstration. For example, a new type of solar photovoltaic material promising higher efficiencies would at this level be used in an actual fabricated solar array "blanket" that would be integrated with power supplies, supporting structure, etc., and tested in a thermal vacuum chamber with solar simulation capability.

Cost to Achieve: Moderate "Unique" Cost (investment will be technology dependent, but likely to be several factors greater than cost to achieve TRL 4)

TRL 6

System/subsystem model or prototype demonstration in a relevant environment (ground or space)

A major step in the level of fidelity of the technology demonstration follows the completion of TRL 5. At TRL 6, a representative model or prototype system or system—which would go well beyond ad hoc, "patch-cord," or discrete component level breadboarding—would be tested in a relevant environment. At this level, if the only "relevant environment" is the environment of space, then the model/prototype must be demonstrated in space. Of course, the demonstration should be successful to represent a true TRL 6. Not all technologies will undergo a TRL 6 demonstration; at this point the maturation step is driven more by assuring management confidence than by R&D requirements. The demonstration might represent an actual system application, or it might only be similar to the planned application, but using the same technologies. At this level, several-to-many new technologies might be integrated into the demonstration. For example, an innovative approach to high-temperature/low-mass radiators, involving liquid droplets and composite materials, would be demonstrated to TRL 6 by actually flying a working, subscale (but scaleable) model of the system on a Space Shuttle or International Space Station "pallet." In this example, the reason space is the "relevant" environment is that microgravity plus vacuum plus thermal environment effects will dictate the success/failure of the system—and the only way to validate the technology is in space.

Cost to Achieve: Technology and demonstration specific; a fraction of TRL 7 if on ground; nearly the same if space is required

TRL 7

System prototype demonstration in a space environment

TRL 7 is a significant step beyond TRL 6, requiring an actual system prototype demonstration in a space environment. It has not always been implemented in the past. In this case, the prototype should be near or at the scale of the planned operations system, and the demonstration must take place in space. The driving purposes for achieving this level of maturity are to assure system engineering and development management confidence (more than for purposes of technology R&D). Therefore, the demonstration must be of a prototype of that application. Not all technologies in all systems will go to this level. TRL 7 would normally only be performed in cases where the technology and/or subsystem application is mission critical and relatively high risk. Example: The Mars Pathfinder Rover is a TRL 7 technology demonstration for future Mars microrovers based on that system design. Example: X-vehicles are TRL 7, as are the demonstration projects planned in the New Millennium spacecraft program.

Cost to Achieve: Technology and demonstration specific, but a significant fraction of the cost of TRL 8 (investment = "Phase C/D to TFU" for demonstration system)

TRL 8

Actual system completed and "flight qualified" through test and demonstration (ground or space)

By definition, all technologies being applied in actual systems go through TRL 8. In almost all cases, this level is the end of true "system development" for most technology elements. Example: This would include DDT&E through Theoretical First Unit (TFU) for a new reusable launch vehicle. This might include integration of new technology into an existing system. Example: loading and testing successfully a new control algorithm into the onboard computer on Hubble Space Telescope while in orbit.

Cost to Achieve: Mission specific; typically highest unique cost for a new technology (investment = "Phase C/D to TFU" for actual system)

TRL 9

Actual system "flight proven" through successful mission operations

By definition, all technologies being applied in actual systems go through TRL 9. In almost all cases, the end of last "bug fixing" aspects of true "system development;" for example, small fixes/changes to address problems found following launch (through "30 days" or some related date). This might include integration of new technology into an existing system (such as operating a new artificial intelligence tool into operational mission control at JSC). This TRL does not include planned product improvement of ongoing or reusable systems. For example, a new engine for an existing RLV would not start at TRL 9; such "technology" upgrades would start at the appropriate level in the TRL system.

Cost to Achieve: Mission specific; less than cost of TRL 8 (e.g., cost of launch, plus 30 days of mission operations)

Comparison Factor Questions

(Teacher's Version)

Now that you know the comparison factors, you can use this information to calculate what would happen on the Moon. For example, you can now calculate your weight on the Moon using your weight here on Earth and multiplying it by the comparison factor. So if you weighed 100 lbs., you would take 100 × 0.1656 = 16.56 lbs.

1. What is your weight on the Moon?
   Various answers. Take weight times 0.1656 (gravitational pull factor – you may have to lead students that this is the factor to use.)

2. Weigh your science textbook. Calculate the weight of your science textbook on the Moon.
   Various answers. Take weight times 0.1656.

3. Calculate your age according to Moon years. Moon years are short. To calculate, multiply by 1/0.0748 or 13.37.
   Various answers. Take age times 0.0748.

4. Calculate the age of a friend or relative according to Moon years. Moon years are short. To calculate, multiply by 1/0.0748 or 13.37.
   Various answers. Take age times 0.0748.

5. Convert five Earth days to Moon days. Moon days are longer than Earth days.

   1 Earth day = 0.0366 Moon days
   1 Moon day = 27.32 Earth days
   5 × 27.321661 = 136.6083 days

You can also go the opposite direction, from Moon to Earth. For example, suppose you knew that you weighed 16.56 lbs on the Moon. To convert this to Earth pounds, take the Moon weight and divide by the conversion factor. So 16.56 ÷ 0.1656 = 100, which means you would weigh 100 lbs on Earth.

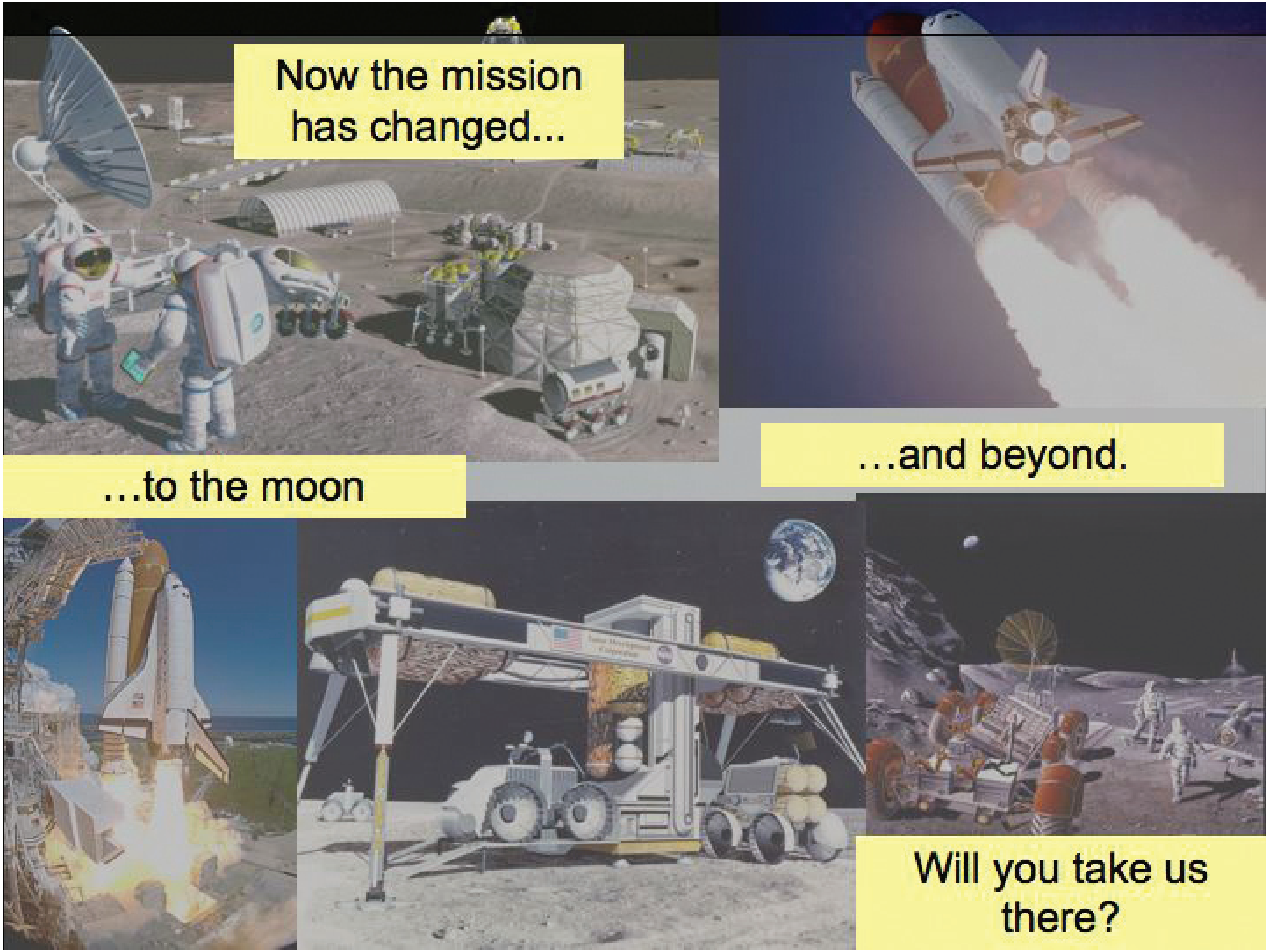
1. If someone weighed 10 lbs on the Moon, how much would that person weigh on Earth?
   10 ÷ 0.1656 = 60.38647 lbs.

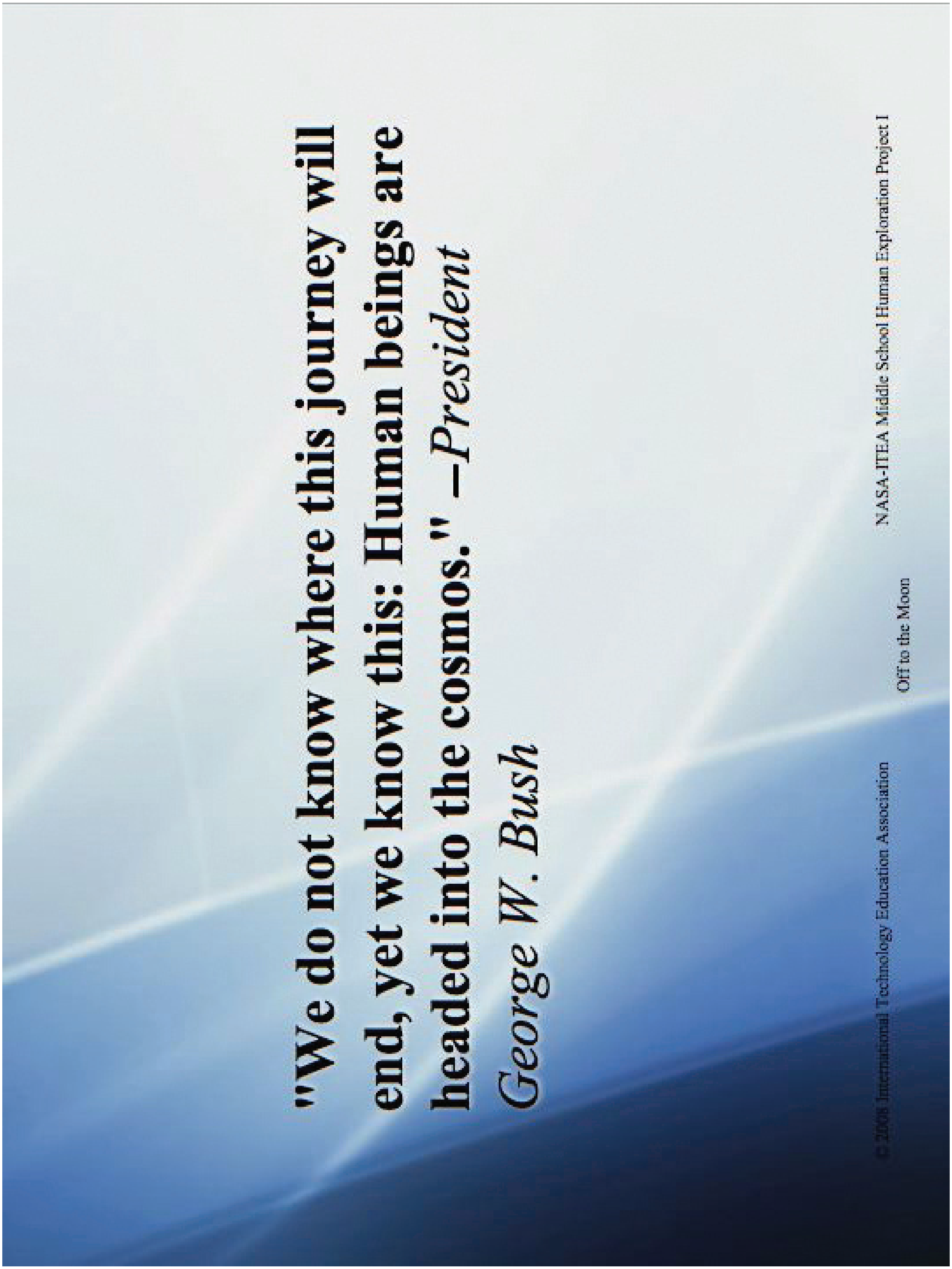
2. If someone is 12 Moon years old, how old would this person be in Earth years?
   12 ÷ 0.0748 = 160.4278 years

3. If you had 405 Moon days, how many Earth days would this be?
   405 ÷ 27.321661 = 14.8234 days

Off to the Moon


What once was a dream...
Apollo 11 Crew landed on the moon on July 20, 1969 at 4:18 PM EDT
...became a mission.


Now the mission
has changed...
...and beyond.
...to the moon
Will you take us
there?

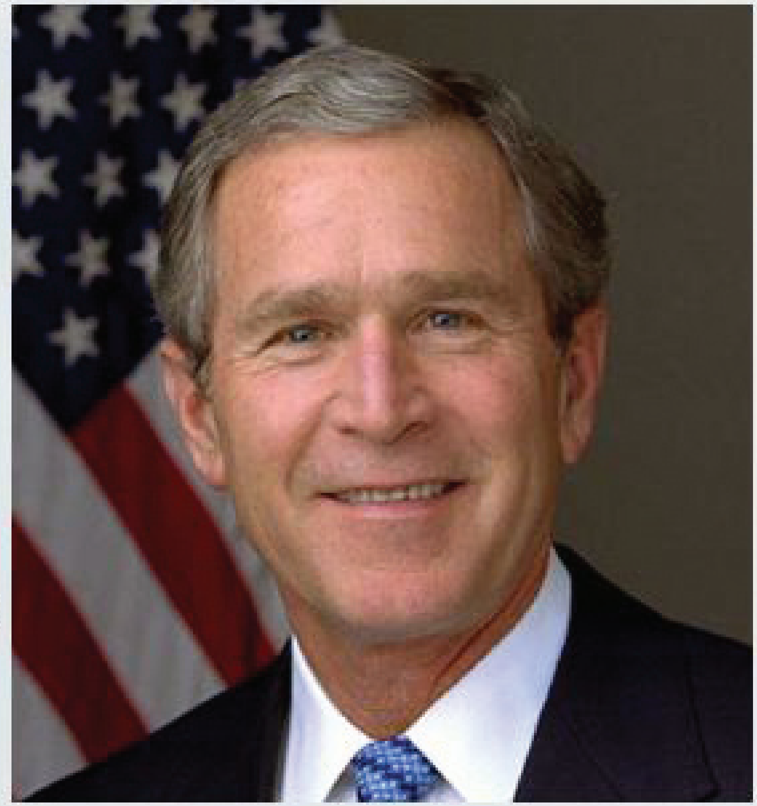

"We do not know where this journey will end, yet we know this: Human beings are headed into the cosmos." —President George W. Bush
© 2008 International Technology Education Association
Off to the Moon
NASA-ITEA Middle School Human Exploration Project I

President Bush's Vision

Complete International Space Station by 2010, retire Space Shuttle.

Develop and test new Crew Exploration Vehicle by 2008, with first crewed flight by 2014.

Study the use of Lunar Resources. Return to the moon by 2020, with robotic exploration by 2008, extended human missions as early as 2015.



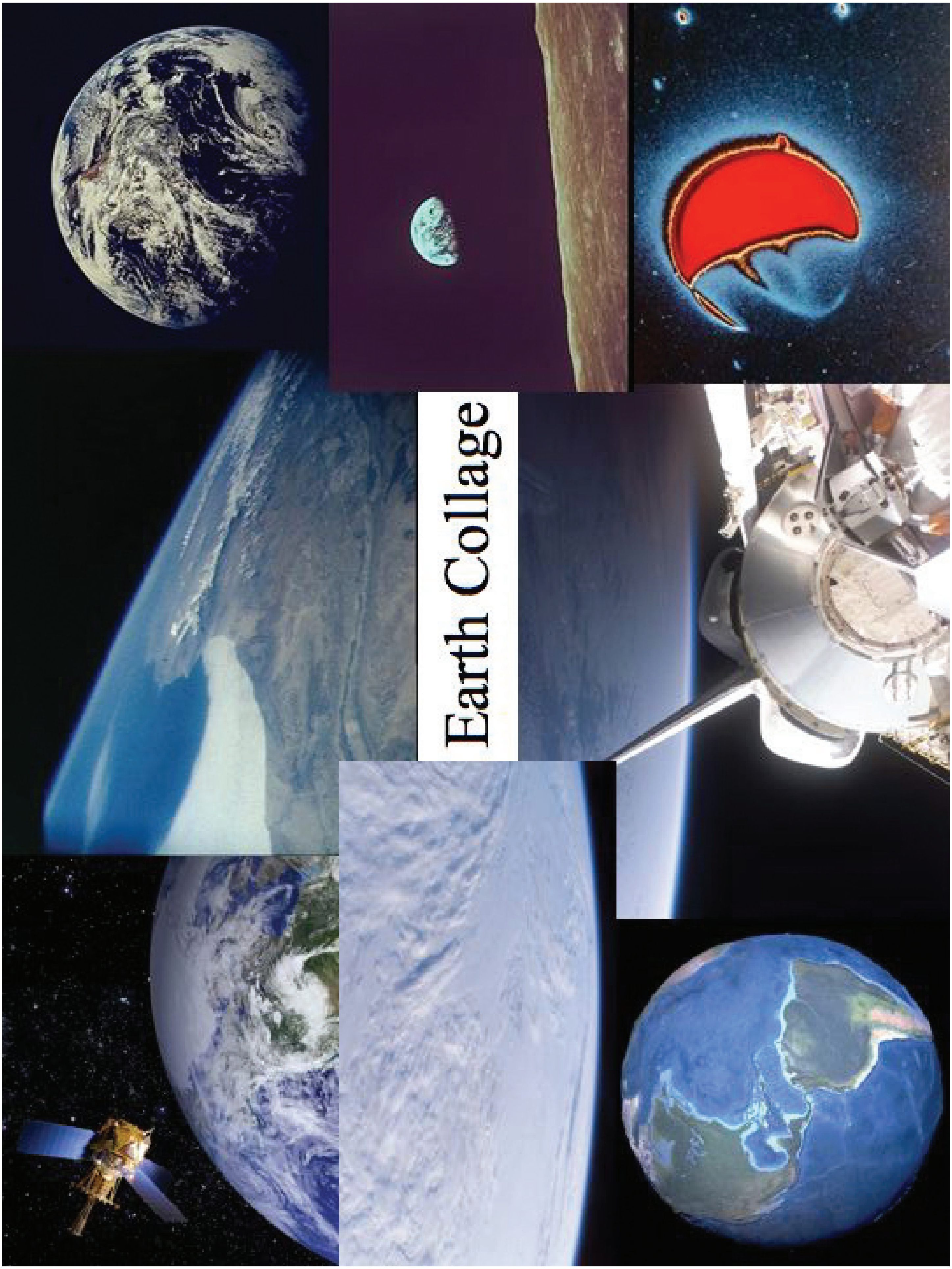
Moon-Earth Comparison

A journey toward lunar colonization.

Moon Facts

- **Length of Day: 653 Earth Hours**
- **Length of Year: 27.32 Earth Days**
- **Temperature Range: –387 to 253 °F**
- **Circumference: 10,916 km**
- **The angle of tilt (to the Earth's equator) is 23.9° .**
- **The angle to the ecliptic (the sun's motion) is 5.1°.**
- **Gravity: 1.62 m/s^2**


Earth Facts
• Length of Day: 23.9 Earth Hours
• Length of Year: 365.24 Earth Days
• Temperature Range: –126 °F to 136 °F
• Circumference: 40,075 km
• Angle of Tilt: 23.934°
• Gravity: 9.78 m/s²


Earth Collage


NASA
IN-SPACE PROPULSION
Planning for Space Exploration
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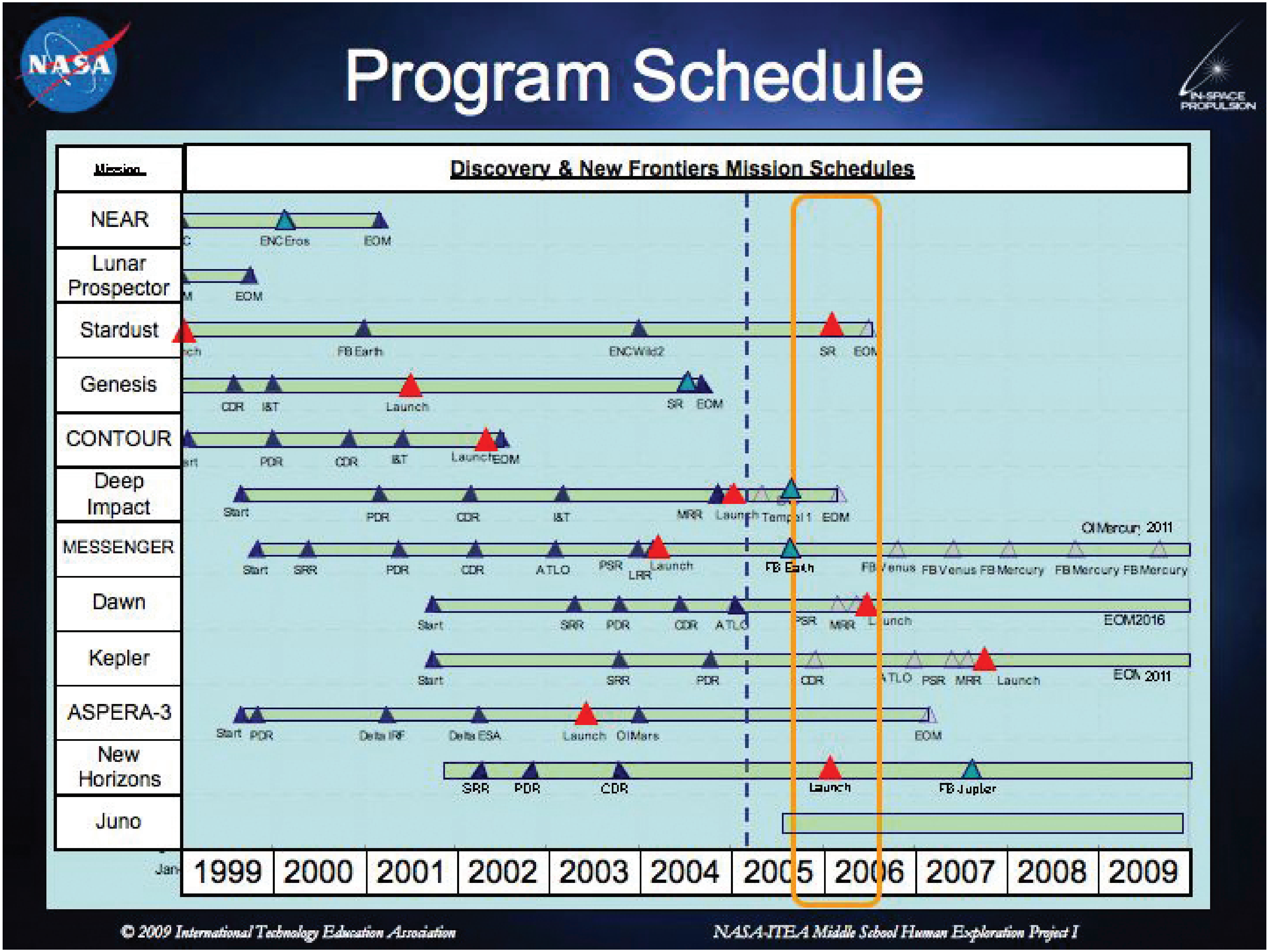

Program Schedule
IN-SPACE PROPULSION
Discovery & New Frontiers Mission Schedules
Mission
NEAR
Lunar Prospector
Stardust
Genesis
CONTOUR
Deep Impact
MESSENGER
Dawn
Kepler
ASPERA-3
New Horizons
Juno
ENC Eros
EOM
FB Earth
ENC Wild2
SR
CDR
I&T
Launch
PDR
Start
MRR
Tempel 1
OI Mercury 2011
SRR
ATLO
PSR
LRR
FB Earth
FB Venus
FB Mercury
EOM2016
EOM 2011
Delta IRF
Delta ESA
OI Mars
FB Jupiter
Jan
1999
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2006
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2008
2009
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Technology Readiness Levels

- ✓ **TRL 1** Basic principles observed and reported.
- ✓ **TRL 2** Technology concept and/or application formulated.
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- ✓ **TRL 7** System prototype demonstration in a space environment.
- ✓ **TRL 8** Actual system completed and "flight qualified" through test and demonstration (ground or space).
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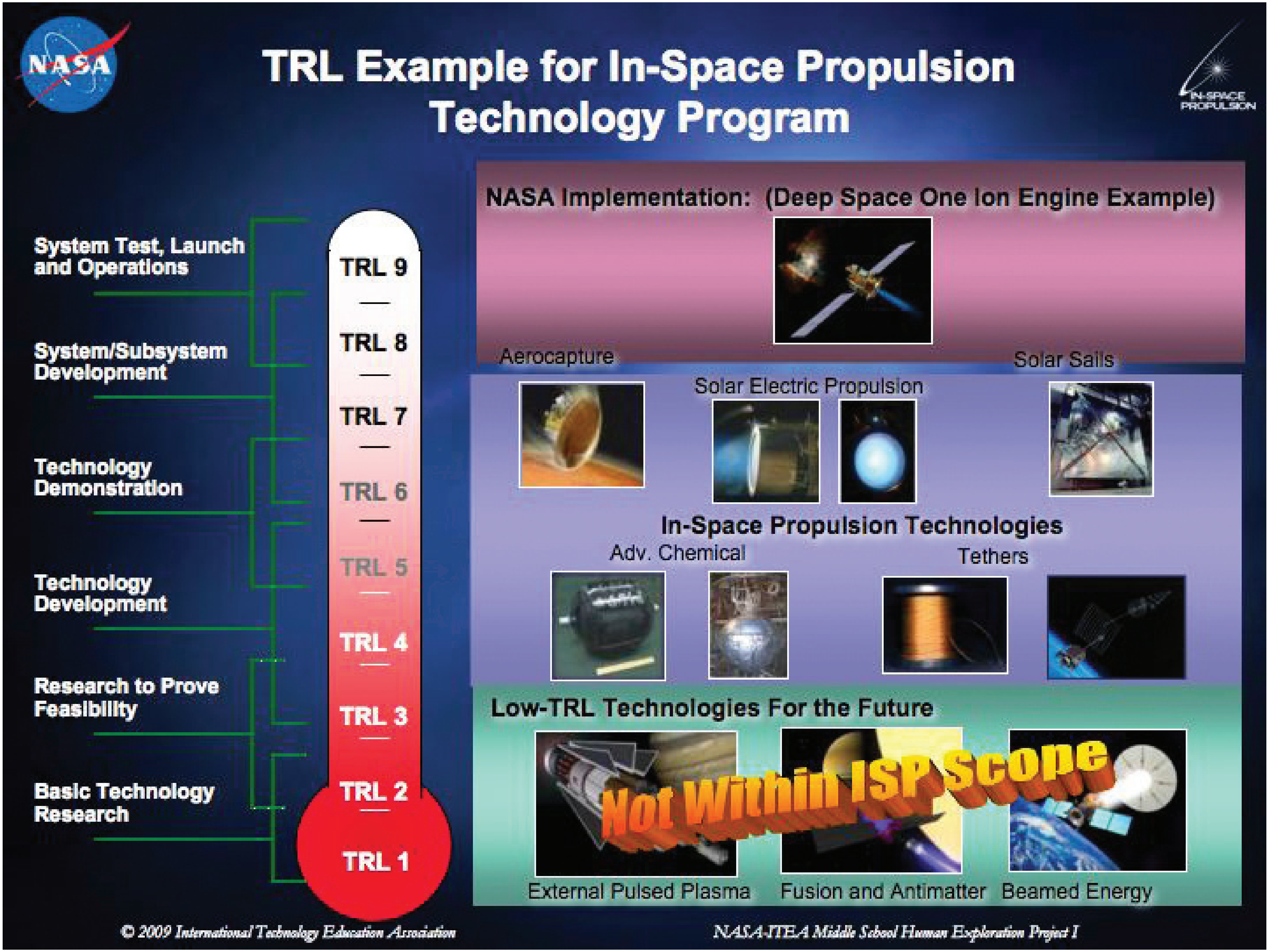
TRL Example for In-Space Propulsion Technology Program
IN-SPACE PROPULSION
System Test, Launch and Operations
System/Subsystem Development
Technology Demonstration
Technology Development
Research to Prove Feasibility
Basic Technology Research
TRL 9
TRL 8
TRL 7
TRL 6
TRL 5
TRL 4
TRL 3
TRL 2
TRL 1
NASA Implementation: (Deep Space One Ion Engine Example)
Aerocapture
Solar Sails
Solar Electric Propulsion
In-Space Propulsion Technologies
Adv. Chemical
Tethers
Low-TRL Technologies For the Future
Not Within ISP Scope
External Pulsed Plasma
Fusion and Antimatter
Beamed Energy
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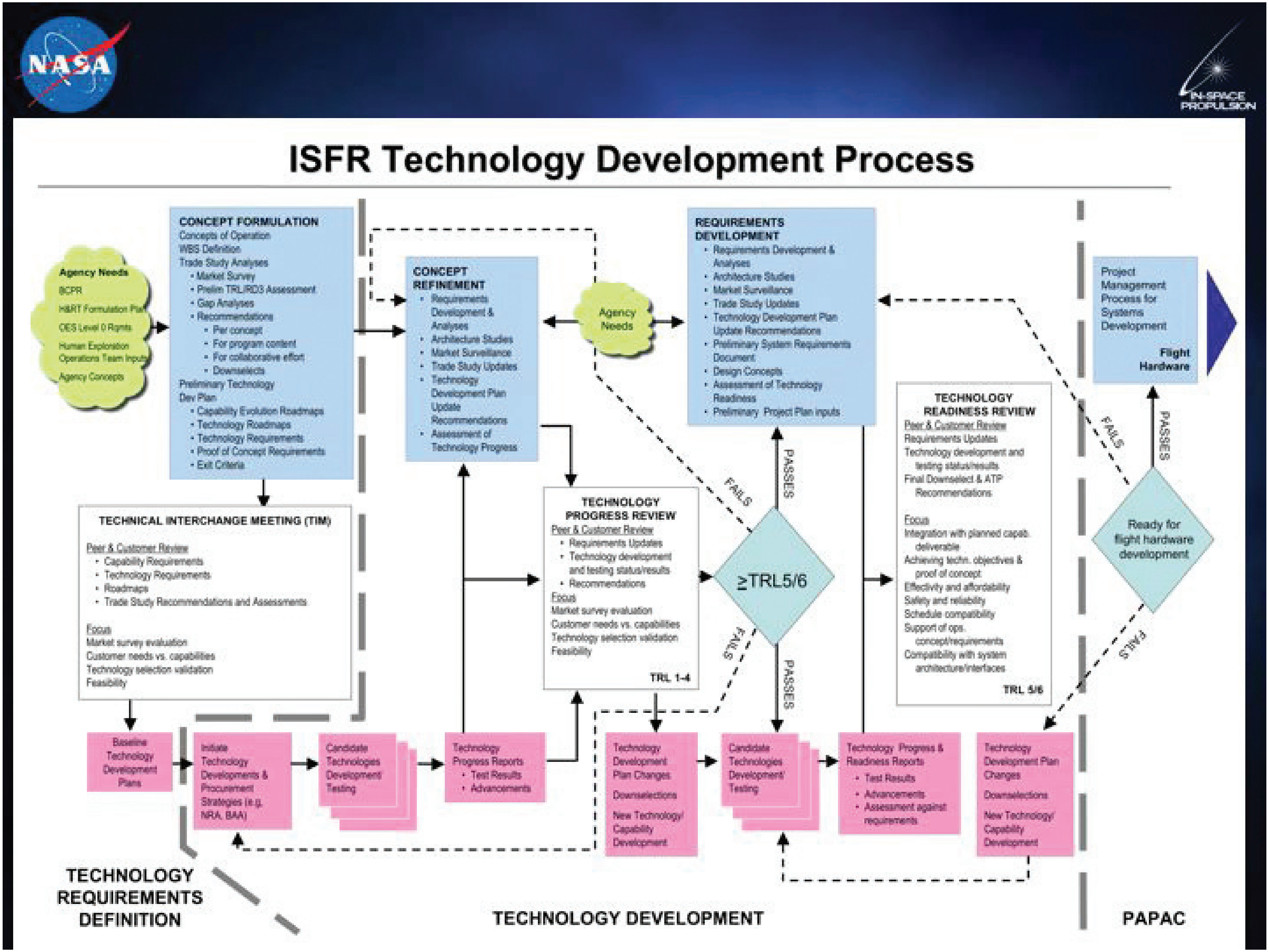


ISFR Technology Development Process
IN-SPACE PROPULSION
Agency Needs
BCPR
OES Level 0 Rqmts
Human Exploration Operations Team Inputs
Agency Concepts
CONCEPT FORMULATION
Concepts of Operation
WBS Definition
Trade Study Analyses
• Market Survey
• Prelim TRL/RD3 Assessment
• Gap Analyses
• Recommendations
• Per concept
• For program content
• For collaborative effort
• Downselects
Preliminary Technology Dev Plan
• Capability Evolution Roadmaps
• Technology Roadmaps
• Technology Requirements
• Proof of Concept Requirements
• Exit Criteria
TECHNICAL INTERCHANGE MEETING (TIM)
Peer & Customer Review
• Capability Requirements
• Technology Requirements
• Roadmaps
• Trade Study Recommendations and Assessments
Focus
Market survey evaluation
Customer needs vs. capabilities
Technology selection validation
Feasibility
CONCEPT REFINEMENT
• Requirements Development & Analyses
• Architecture Studies
• Market Surveillance
• Trade Study Updates
• Technology Development Plan Update Recommendations
• Assessment of Technology Progress
Agency Needs
REQUIREMENTS DEVELOPMENT
• Requirements Development & Analyses
• Architecture Studies
• Market Surveillance
• Trade Study Updates
• Technology Development Plan Update Recommendations
• Preliminary System Requirements Document
• Design Concepts
• Assessment of Technology Readiness
• Preliminary Project Plan inputs
TECHNOLOGY PROGRESS REVIEW
Peer & Customer Review
• Requirements Updates
• Technology development and testing status/results
• Recommendations
Focus
Market survey evaluation
Customer needs vs. capabilities
Technology selection validation
Feasibility
TRL 1-4
≥TRL5/6
PASSES
FAILS
TECHNOLOGY READINESS REVIEW
Peer & Customer Review
Requirements Updates
Technology development and testing status/results
Final Downselect & ATP Recommendations
Focus
Integration with planned capab. deliverable
Achieving techn. objectives & proof of concept
Effectivity and affordability
Safety and reliability
Schedule compatibility
Support of ops. concept/requirements
Compatibility with system architecture/interfaces
TRL 5/6
Ready for flight hardware development
Project Management Process for Systems Development
Flight Hardware
Baseline Technology Development Plans
Initiate Technology Developments & Procurement Strategies (e.g. NRA, BAA)
Candidate Technologies Development Testing
Technology Progress Reports
• Test Results
• Advancements
Technology Development Plan Changes
Downselections
New Technology/ Capability Development
Candidate Technologies Development/ Testing
Technology Progress & Readiness Reports
• Test Results
• Advancements
• Assessment against requirements
Technology Development Plan Changes
Downselections
New Technology/ Capability Development
TECHNOLOGY REQUIREMENTS DEFINITION
TECHNOLOGY DEVELOPMENT
PAPAC

Lunar Colony Design Challenge

January 14, 2004

Indeed it is the nature of humanity to explore beyond our horizons. Humanity explores in order to discover, discovers in order to gain new knowledge, and gains new knowledge to enhance the quality of life for itself. It has been by looking beyond current horizons that human civilization advances.

~ President George W. Bush

Goals and Objectives

The fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program. In support of this goal, the United States will:

- Implement a sustained and affordable human and robotic program to explore the solar system and beyond.
- Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations.
- Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration.
- Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

~ President George W. Bush

The Challenge

By 2020 the United States is hoping to establish an outpost on the Moon that could be a precursor to a self-sufficient human colony. This colony will be used to conduct research, gather information about lunar soil, and be a stepping stone for travel to Mars and beyond. It's your challenge to design and create a model of a lunar colony and determine the public's reaction to it and other space issues.

Design Requirements

Requirements are listed to show what must be done to successfully complete the design challenge.

- In your base group, list five requirements for the LCDC.

Lunar Colonization Pre/Post Test

Directions: Circle the letter that best answers the question or statement.

1. A person on the Moon will weigh _________ than on the Earth.

   a. More
   b. Less
   c. The same

2. The radius of the Moon is ______________ the radius of the Earth.

   a. More than
   b. Less than
   c. The same as

3. The difference between the surface temperature of the Moon during the day and the surface temperature of the Moon at night is _________________.

   a. More than 100 °F
   b. Less than 100 °F
   c. Equal to 100 °F

4. In the equation $\frac{x}{4} = 12$

   a. $x = 3$
   b. $x = 48$
   c. $x = 4$

5. A Moon day is ___________________ an Earth day.

   a. longer than
   b. shorter than
   c. same length as

6. Using a map of the Moon with a scale of 1/4 in = 1 mile, if two craters are 4 inches apart on the map, how many miles apart are the craters?

   a. 1 mile
   b. 2 miles
   c. 16 miles

7. You took the temperature on the Moon at the time when it was maximum temperature, four times. You have the following set of data as a result of your temperature readings:
   117 °C, 117 °C, 120 °C, 121 °C, 122 °C. The median of this set of data is _________.

   a. 117 °C
   b. 119.4 °C
   c. 120 °C

8. Solar power may be a good source of energy for a lunar colony, but there are some obstacles to using it. Some scientists propose building many solar power plants in locations spread out around the Moon. What obstacle to solar power does this proposal address?

    a. A lunar night lasts for 14 Earth days.
    b. When there are rain clouds over some parts of the Moon, other parts may be sunny.
    c. If power plants need repair there are always backup plants.
    d. The energy generated from solar power cannot be transported very far.

9. Moisture that is given off when people sweat and exhale can cause an excess of humidity in a lunar shelter. This moisture can cause damage to electronic equipment. Which of the following solutions would be the most beneficial for a lunar colony?

    a. Use exhaust fans to vent the moisture out into space.
    b. Cover all electronic equipment with plastic to keep out moisture.
    c. Have people wear masks and clothing designed to prevent moisture from entering the air.
    d. Collect the moisture from the air, clean it, and use it for drinking and washing.

10. Which of the following survey questions do you think best follows the guidelines for writing good survey questions?

    a. I would not like to spend tax money for space exploration.
    b. I think space exploration should be continued if we can cut money from our defense budget to support it.
    c. I support the use of tax money for space exploration.
    d. I am not sure if space exploration is a good use of tax money.

11. Using a conversion factor of ¼" to 1', what would be the drawing dimensions of a building that is 24 feet long and 12 feet wide?

    a. 24 inches long, 12 inches wide
    b. 6 inches long, 3 inches wide
    c. 96 inches long, 48 inches wide
    d. none of the above

12. Which of the following would NOT be an example of sustainability for a lunar colony?

    a. Use resources from Earth for building materials.
    b. Recycle the water.
    c. Use energy from solar power.
    d. Create industries or services that people would pay for on the Moon.

Scoring Rubric for: "Lunar Colonization Design Challenge"

	Acceptable without Revisions (18–20 points)	Acceptable with Minor Revisions (14–17 points)	Major Revisions Necessary (9–13 points)	Unacceptable (0–8 points)	Score
Lunar Colony Sketches	Sketches show important details, contain notes and dimensions, and are easy to understand	Sketches are easy to understand, but lack all of the necessary notes, dimensions, and details.	Sketches are adequate, but have few notes, dimensions, or details.	Sketches are sloppy, contain no details, notes, or dimensions.	
Lunar Colony Model	Great care was taken in the construction process so that the structure is neat, attractive, and follows plans accurately.	Construction was careful and accurate for the most part, but 1–2 details could have been refined for a more attractive product.	Construction accurately followed the plans, but 3–4 details could have been refined for a more attractive product.	Construction appears careless or haphazard. Many details need refinement for a strong or attractive product.	
Written Paper	• Addresses exceptionally all elements of the topic. • Writes with superior logic, clarity, and organization. • Presents detailed and significant support for topic.	• Addresses adequately all elements of the topic. • Writes with sufficient logic, clarity, and organization. • Presents adequate support for topic.	• Addresses few elements of the topic. • Writes with limited logic, clarity, and organization. • Presents little or no support for topic.	• Does not address elements of the topic. • Writes with no logic, clarity, and organization. • Presents no support for topic.	
Survey Design	• Survey items are well thought out and include all important items. • Survey questions are asked in a logical and well thought-out sequence that respondents can follow. • No misspellings or grammatical errors.	• Survey items sufficiently cover important items. • Survey questions are asked in logical sequence that respondents can follow. • No more than two misspellings and/or grammatical errors.	• Survey questions are limited and offer some information. • Survey questions are not listed or asked in a logical format. • There are four misspellings and/or grammatical errors.	• Survey questions do not adequately present enough information. • Survey questions are not appropriate for requested information. • There are more than four spellings errors and/or grammatical errors.	
Survey Data Presentation	Data tables are easy to understand and presented accurately with complete information.	Data tables show information, but some of it is incomplete or inaccurate.	Most of the data is irrelevant, inaccurate, or incomplete.	Data is incorrect and copied directly from Excel® file.	
Group Presentation	Student presents information in logical, interesting sequence that audience can follow.	Group presents information in logical sequence that audience can follow.	Audience has difficulty following presentation because group jumps around.	Audience cannot understand presentation, because there is no sequence of information. No group participation.	
				Total	

Lesson 2:
Resource Documents

Engineering Design Journal

Name:______________________________________ Grade:_______________

Teacher:_____________________________________

Guidelines for an Engineering Design Journal

An Engineering Design Journal is a daily collection of the activities that are pursued in designing, developing, and constructing an invention. It is a complete log and nothing should be erased from the journal. The journal should include all research, testing, diagrams, and ideas about the invention and problem being solved. Nothing should be erased!

- The journal needs to be a bound book with graph and lined paper available.
- The pages should be numbered.
- All entries are dated and signed by the engineer.
- If an idea is marketable, the entries should also be signed by a witness.
- Engineers use a pen instead of a pencil so ideas cannot be altered.
- Sketches should be to scale.
- Fill in large blank spaces with an X.

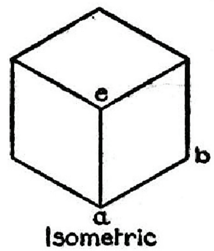
The journal should be maintained throughout the entire engineering design process. It should contain:

a. All ideas generated.
b. What needs to be considered in the design.
c. Thoughts about what could be done next.
d. Obstacles encountered.
e. Documentation of the development of the group invention using thumbnail sketches, a formal drawing of the final idea, and the process used to create a prototype.

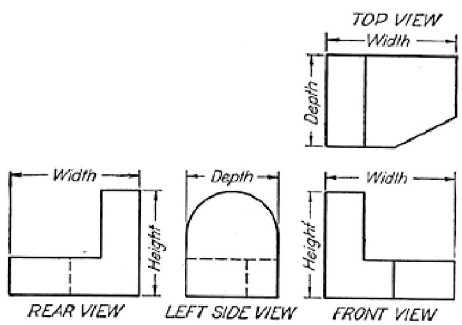
A journal is an important document that is used when applying for an invention patent. In the journal, an inventor writes a complete description of the invention accompanied by diagrams. For an inventor to protect an idea while he/she applies for a patent, he/she must write a "disclosure statement." After the disclosure statement is written, a patent search must be conducted to see if there is a patent similar to the one in the application. If the invention is unique, the inventor will likely be given a patent. The entire patent process can be very expensive and time-consuming.

Sketching Examples

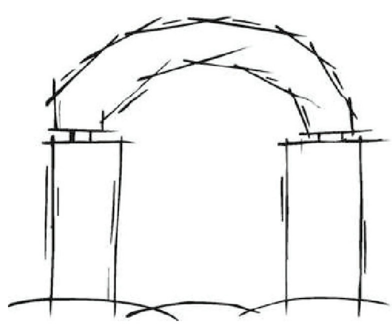
1. isometric



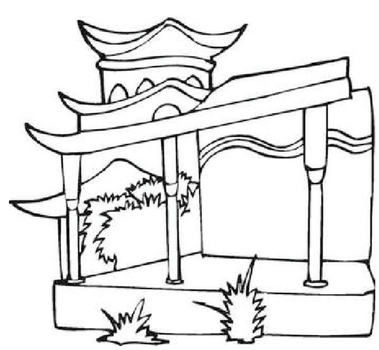
2. orthographic



3. rough sketch



4. refined sketch



Engineering Design Journal Rubric

Assessment Items	Below Target	At Target	Above Target
Sketch Entries	Sketches are incomplete, lack detail, or are not present.	Sketches are made as required but could contain additional details. Drawing not to scale.	All sketches are complete and include details to make it understandable and drawn to scale.
Annotations	Few, if any, annotations are given, and the ones written provide incomplete information. There are few, if any, measurements given.	Annotations are provided but do not enhance the sketches. Some measurements are included with sketches.	Annotations and measurements are included with sketches.
Organization	Engineering Design Journal (EDJ) is unorganized, missing key information, and messy.	EDJ contains most of the necessary information, mostly organized, and complete.	EDJ is very organized and complete. All information is included and accurate.

Engineering Design Journal Checklist

For the items below, place an appropriate mark on the line according to the quality of the work.

+ Above average work
O Average work
– Below average work

1. _______ All pages are numbered.
2. _______ Numbered pages are listed in the table of contents.
3. _______ Entries are signed.
4. _______ Entries are dated.
5. _______ Large empty spaces are crossed out with Xs.
6. _______ Pen is used instead of pencil.
7. _______ Drawings are done to scale.
8. _______ A scale is listed on the drawing by either noting measurements or listing a scale.

Lunar Challenge Note Guide

Name: ______________________________

Date: ______________________________

Hour/Period: ______________________________

During our discussion in class we will be covering a lot of topics related to lunar colonization. We may end up asking more questions than we can answer. It is your responsibility to record some key points related to the following topics:

Energy	Shelter Design
Transportation	**Sustainability**

Energy Considerations

Key Questions:

- What will the energy be used for?
- How might energy be transformed on the Moon?
- Where will the fuel come from?
- What are the safety concerns?

Energy Overview:

There are many different types of energy sources we use on a daily basis. Many people in the United States obtain their electricity from wind energy, hydroelectric dams, coal power plants, nuclear power plants, solar panels, natural gas, geothermal, and many more. When establishing a colony on the Moon, many of these alternatives are no longer possible. For instance, a hydroelectric dam would not be a good idea, because there is no water on the Moon. Solar power may be an alternative, but that would require constant solar activity. Consideration also needs to be given to the fact that all the equipment that goes to the Moon must be transported from Earth. On the next page are some web sites for you to review. They provide some good information about things that need to be considered when choosing an energy source for lunar colonization.

The following description of nuclear power and solar energy has been excerpted from Wikipedia at the following web site:

Wikimedia Foundation, Inc. (May, 2007). *Wikipedia: The Free Encyclopedia*. "Colonization of the Moon." Retrieved May 10, 2007, from <http://en.wikipedia.org/wiki/Colonization_of_the_Moon#Energy>.

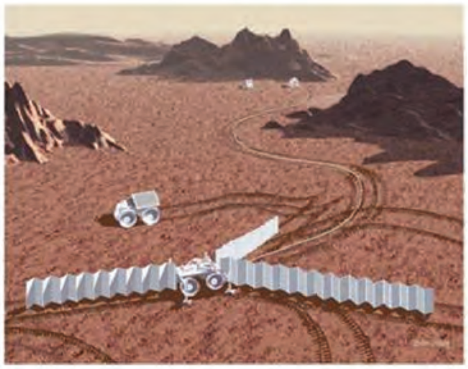
Nuclear Power

A nuclear fission reactor could fill most of the need for power. The advantage it has over a fusion reactor is that it is an already existing technology. One advantage of using a fusion reactor is that Helium-3, which is required for a type of fusion reaction, is abundant on the Moon. However, it is possible that reliable, efficient fusion reactors will not be available at the time of lunar colonization. Radioisotope thermoelectric generators could be used as backup and emergency power sources for solar-powered colonies.

Solar Energy

Solar energy could prove to be a relatively cheap source of power for a lunar base, as many of the raw materials needed for solar panel production can be extracted onsite. However, the long lunar night (14 Earth days) is problematic for solar power on the Moon. This might be solved by building several power plants, so that at least one of them is always in daylight. Another possibility is to build such a power plant where there is constant or near-constant sunlight, such as at the Malapert Mountain near the lunar south pole, or on the rim of Peary crater near the north pole. See Peak of Eternal Light.

The solar energy converters need not be silicon solar panels. It may be more feasible to use the larger temperature difference between Sun and shade to run heat engine generators. Concentrated sunlight could also be relayed via mirrors and used directly for lighting, agriculture, and process heat. The focused heat can also be employed in materials processing in order to extract various elements from lunar surface materials.



Internet Web Sites:

Rudo, Brian (Author). (March 5, 2003). *Nuclear propulsion and what it means to space exploration*. Red Colony. Retrieved May 10, 2007, from <http://www.redcolony.com/art.php?id=0303050>.

- This web site provides some easy-to-understand descriptions of how various types of nuclear energy can be used, including radioisotope decay, nuclear fission, and nuclear fusion.

Knuth, William H. (Author). (March 2, 2004). *Lunar convoys as an option for a return to the Moon*. Space Daily: Your Portal to Space. Retrieved May 10, 2007 from <http://www.spacedaily.com/news/lunar-04j.html>.

- This web site is a short article about how solar energy might be used on a lunar colony.

Shelter Design

Key Questions:

- What are some characteristics of the Moon environment?
- What are some of the potential risks to human health?
- How might temperature and radiation impact the shelter design?
- How long is a "Moon day," and how might that impact the shelter design?
- How will structures be constructed?
- What will they look like?

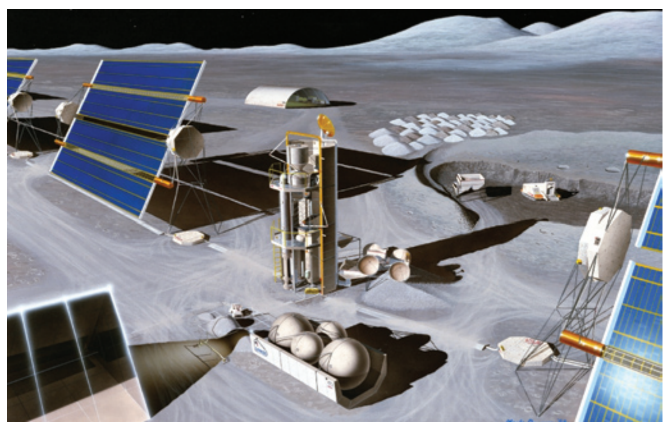
Shelter Design Overview:

Most people in the United States live in a structure made of wood, concrete, or a composite material. Some of these structures take months to construct, while others can take a few years. How will an appropriate shelter be designed for the Moon? Who or what will build it?

Before thinking about what it will look like, consider some of the constraints that the Moon's environment might place on shelter design. These constraints include the temperature, radiation, length of the day, soil composition, and more. The following information is from Wikipedia at:

Wikimedia Foundation, Inc. (May, 2007). *Wikipedia: The Free Encyclopedia*. Retrieved May 10, 2007, from <http://en.wikipedia.org/wiki/Lunar_base#Habitat>.

Habitat:



There have been numerous proposals regarding habitat modules. The designs have evolved throughout the years, as humankind's knowledge about the Moon has grown and as the technological possibilities have changed. The proposed habitats range from the actual spacecraft landers or the used fuel tanks, to inflatable modules of various shapes. Early on, some hazards of the lunar environment, such as sharp temperature shifts, lack of atmosphere or magnetic field (which means higher levels of radiation and micrometeoroids), and long nights, were recognized and taken into consideration.

Some suggest building the lunar colony underground, which would give protection from radiation and micrometeoroids. The construction of such a base would probably be more complex; a remote-controlled boring machine to excavate living quarters might need to be one of the first machines from Earth. Once created, some sort of hardening would be necessary to avoid collapse, possibly a spray-on, concrete-like substance made from available materials. A more porous insulating material also made in situ could then be applied. Inflatable self-sealing fabric habitats might then be put in place to retain air. As an alternative to excavating, it is possible that large underground extinct Lava tubes might exist on the Moon. As of 2004, existence of lava tubes on the Moon has not been confirmed.

A possibly easier solution is to build the lunar base on the surface and cover the modules with lunar soil. Others have put forward the idea that the lunar base could be built on the surface and protected by other means, such as improved radiation and micrometeoroid shielding. Artificial magnetic fields have been proposed as a means to provide radiation shielding for long range, deep-space manned missions, and it might be possible to use similar technology on a lunar colony.

Internet Web Sites:

NASA Chooses Purdue to Study Colonies on Mars

Jong, Diana (Staff Writer). (August 15, 2002). *NASA chooses Purdue to study colonies on Mars*. Space.com. Imaginova Corp. Retrieved May 10, 2007, from <http://www.space.com/scienceastronomy/purdue_center_020815.html>.

- This web site article describes the work that Purdue University has done with Biosphere 2, which is in the Arizona desert and is intended to simulate life on the Moon or Mars.

Lunar Base Designs

Smith, Linda (NASA Official). (October 25, 2006). *Lunar base designs*. NASA. Retrieved May 10, 2007, from <http://aerospacescholars.jsc.nasa.gov/HAS/cirr/em/6/8.cfm>.

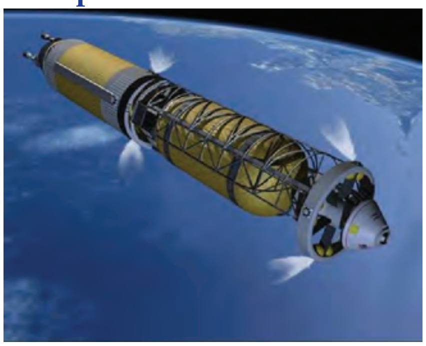
- This site describes both historic and futuristic lunar base designs. There are many pictures and additional links that provide further information.

Transportation

Key Questions:

- How will humans get to the Moon and back to Earth?
- How will supplies be carried?
- What type of transportation is possible on the Moon?
- As weight goes up, so do cost and propulsion requirements. How does this impact shelter design?

Transportation Overview:



Moving equipment, resources, materials, and humans are critical to the success of the lunar colonization mission. Factors that need to be considered include cost, time, weight, propulsion, and most importantly – safety. You need to consider transportation in three different realms. These include:

- Transportation from the Earth to the Moon.
- Transportation on the Moon.
- Transportation from the Moon to the Earth.

The following information is provided by Wikipedia and can be found at:

Wikimedia Foundation, Inc. (May, 2007). *Wikipedia: The Free Encyclopedia.* Retrieved May 10, 2007, from <http://en.wikipedia.org/wiki/Lunar_base#Transport>.

Transportation on the Surface

Lunar colonists will want the ability to move over long distances, to transport cargo and people to and from modules and spacecraft, and to be able to carry out scientific study of a larger area of the lunar surface for long periods of time. Proposed concepts include a variety of vehicle designs, from small open rovers to large pressurized modules with lab equipment, and also a few flying or hopping vehicles.

Rovers could be useful if the terrain is not too steep or hilly. The only rovers that operated on the surface of the Moon as of 2004 were the Apollo Lunar Roving Vehicle (LRV), developed by Boeing and the unmanned Soviet Lunokhod. The LRV was an open rover for a crew of two, with a range of 92 km during one lunar day. One NASA study resulted in the Mobile Lunar Laboratory concept, a manned pressurized rover for a crew of two, with a range of 396 km. The Soviet Union developed different rover concepts in the Lunokhod series (DLB Lunokhod 1-3/LEK and the L5) for possible use on future manned missions to the Moon or Mars. These rover designs were all pressurized for longer missions.

Once multiple bases have been established on the lunar surface, they can be linked together by permanent railway systems. Both conventional and magnetic levitation (Mag-Lev) systems have been proposed for the transport lines. Mag-Lev systems are particularly attractive, as there is no atmosphere on the surface to slow down the train, so the vehicles could achieve velocities comparable to aircraft on the Earth. One significant difference with lunar trains, however, is that the cars will need to be individually sealed and possess their own life support systems. The trains will also need to be highly resistant to derailment, as a punctured car can lead to rapid loss of life.

Transportation on the Moon

A lunar base will need efficient ways to transport people and goods of various kinds between Earth and the Moon and, later, to and from various locations in interplanetary space. One advantage of the Moon is its relatively weak gravity field, making it easier to launch goods from the Moon than from Earth. The lack of a lunar atmosphere is both an advantage and a disadvantage; while it's easier to launch from the Moon because there is no drag, aerobraking is not possible, which makes it necessary to bring extra fuel in order to land. An alternative that may work for supplies is to surround the payload with impact-absorbing materials, something that was tried in the Ranger program. This can be efficient if the impact protection is made of needed lighter elements that are absent from the Moon (Ranger used balsa wood).

One way to get materials and products from the Moon to an interplanetary way station might be with a mass driver, a magnetically accelerated rail. Cargo would be picked up from orbit or an Earth-Moon Lagrangian point by a shuttle craft using ion propulsion, solar sails, or other means and delivered to Earth orbit or other destinations such as near-Earth asteroids, Mars, or other planets—perhaps using an Interplanetary Superhighway. If a lunar space elevator ever proves practical, it could transport people, raw materials, and products to an orbital station. A "Pop Gun" concept has also been proposed, using heated gas to launch packets of material to orbit.

Lunar Flight Plan

NASA & Frassinito, John and Associates. (n.d.) *Lunar flight plan*. Retrieved May 10, 2007, from <http://www.nasa.gov/images/content/125171main_flight_plan_graphic.jpg>.

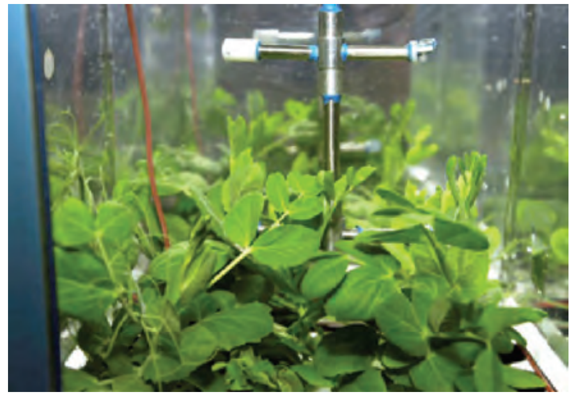
- This diagram shows how a lunar flight plan may look and could be used for lunar colony transportation.

Lunar Transport Vehicles

Dismukes, Kim (Curator) & Petty, John Ira (NASA Official). (April 9, 2007). *Human space flight*. National Aeronautics and Space Administration. Retrieved May 14, 2007, from <http://www.spaceflight.nasa.gov/gallery/images/mars/lunarvehicles/ndxpage3.html>.

- On this site there are a variety of NASA concept drawings of lunar vehicles. Explore them to gain some ideas.

Sustainability



Key Questions:

- What will people eat on the Moon?
- From where will food come?
- How will they get water?
- Where will waste from humans be contained?
- What can and cannot be recycled?

Sustainability Overview:

Imagine for a moment that you are alone on a planet. There is no vegetation, no water, and you are getting hungry. This would be a terrible situation and one that we hope never occurs on the Moon. Therefore, consideration of food, water, sleeping, recreation, ventilation, fresh air, waste treatment, and more must be carefully researched.

Design Challenge Factor:

As you begin making designs for your lunar colony proposal, you will need to be able to explain how the environment will be sustainable. For instance, if water is not on the Moon, will you need a facility that can treat the liquid waste to ensure that it is safe to drink? This and other similar decisions will impact the design of your colony. In addition, there are also financial considerations that need to be thought through. How will the lunar colony generate income to help validate its usage?

Economic Development:

For long-term sustainability, a space colony should be close to self-sufficient. Onsite mining and refining of the Moon's materials could provide an advantage over deliveries from Earth — for use both on the Moon and elsewhere in the solar system—as they can be launched into space at a much lower energy cost than from Earth. It is possible that vast sums of money will be spent in interplanetary exploration in the twenty-first century, and the cost of providing goods from the Moon could be attractive.

Exporting material to Earth in trade is more problematic due to the high cost of transportation. One suggested candidate, a Helium-3 from the solar wind, which may have accumulated on the Moon's surface over billions of years, may prove to be a desirable fuel in fusion reactors, and is rare on Earth. Neither the abundance of Helium-3 on the lunar surface nor the feasibility of its use in fusion power plants has been established, however. China has made measurement of Helium-3 abundance on the lunar surface one of the goals of its exploration program.

Other economic possibilities include the tourism industry; manufacturing that requires a sterile, low-gravity environment in a vacuum, research and processing of potentially dangerous life forms or nanotechnology, and long-term storage of radioactive materials. The low gravity may find health uses such as allowing the physically challenged to continue to enjoy an active lifestyle. Large, pressurized domes, or caverns would permit human-powered flight, which may result in new sports activities. This section was excerpted from:

Wikimedia Foundation, Inc. (May, 2007). *Wikipedia: The Free Encyclopedia*. Retrieved May 10, 2007 from, <http://en.wikipedia.org/wiki/Colonization_of_the_Moon - Economic_development>.

Lunar Colony Key Questions

As a group of lunar experts, you need to carefully discuss the following questions related to your topic. Begin by making sure each person in the group has a role they need to undertake.

1. What is your expert group topic? ______________________________

2. List four key points that each of you should remember.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

3. How will your topic impact the other three lunar colonization topics?

   ____

   ____

   ____

   ____

   ____

   ____

4. List two questions about the topic that your group does not understand.

   a. ______________________________

   b. ______________________________

5. How important is your topic to the complete development of a lunar colony? List some examples below.

   ____

   ____

   ____

6. What is concerning about your topic? For example, as you studied your topic, was there anything that you worry about or are concerned about? List some concerns below.

7. Teacher comments:

We, the undersigned, agree that we have worked together to complete this assignment.

Name

Name

Name

Name

LCDC: Phase I – Identify the Challenge

The design challenge now begins. Your group has done research. At this point it is critical that the entire group clearly understand and agree on three aspects of the problem:

1. Design Challenge – What really is being asked of the group? This should be explored from a "big picture" perspective.
2. Requirements – What things must be done in order for the final solution to be accepted as quality work? These help define the design challenge.
3. Limitations – It is important to identify some things that the solution absolutely cannot do because of factors beyond anyone's control. For instance, if the lunar colony inhabitants run out of oxygen, they can't just go outside to breathe.

Key Notes to Remember:

Exploring Ideas: Lunar Colony

Your group is now ready to begin to identify key structures for your lunar colony. As a group, brainstorm ten structures that are essential for your lunar colony design. Then rank these from most important (1) to least important (10). This will help you create designs more efficiently. Do not rank the structures until you have them all listed.

Lunar Colony Structure Name	Rank (1 to 10)
1. ______________________	____________
2. ______________________	____________
3. ______________________	____________
4. ______________________	____________
5. ______________________	____________
6. ______________________	____________
7. ______________________	____________
8. ______________________	____________
9. ______________________	____________
10. ______________________	____________

We, the undersigned, agree that we have worked together to complete this assignment.

______________________ ______________________
Name Name

______________________ ______________________
Name Name

Lesson 3:
Resource Documents

Finding Your Scale-Model Size

Name: ______________________________

Date: ______________________________

Hour/Period: ______________________________

Conversion factors can also be used to figure out a scale for a model. You must make your lunar colony sketch and model so that ¼ inch equals 1 foot (1/4" = 1'-0"). So in other words, the 1 foot is the actual lunar colony size, and the ¼ inch is your drawing and model measurement. Fill in the following to help you with your sketch.

1. What is the conversion factor that you must multiply your lunar model colony measure by in order to determine how big your sketch should be?

2. The base of your lunar colony model is 18" × 18". What should the dimensions of the actual lunar colony be?

3. Take your list of ten structures for your lunar colony and determine the dimensions you want for each one. Then determine what the dimensions should be for your sketches.

Lunar Structure	Actual Dimensions	Drawing Dimensions
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Lunar Colony Model Self-Assessment

Answer the following questions honestly and completely.

1. In which lesson did you learn the most? Why was this so? ______________________________

____

____

2. How has your curiosity and interest in space exploration changed since this unit of study began? ________

____

____

3. What do you want to learn more about? ______________________________________

____

4. What did you do to enhance the cooperation within your group? _________________________

____

____

5. Give some examples of how you managed your time on task wisely. _________________________

____

____

6. If you had to begin this unit of study again, what would you do differently? ___________________

____

____

____

Lunar Colony Final Sketch Scoring Rubric

Topic	Below Target	At Target	Above Target
Overall Sketch Quality	Sketches are very poor. They contain little detail or accuracy.	Sketches include some detail, are recognizable, and are mostly accurate.	Sketches are highly detailed, easy-to-recognize, and accurate, with three-dimensional attributes.
Structure Paragraphs	Most structures lack in-depth paragraphs about them. There are many spelling and/or grammar mistakes. Few details are included in the write-up.	Paragraphs are written but have some grammar or spelling mistakes. Most paragraphs have good explanations.	Paragraphs are written well. Details are clearly explained and valid. Ideas are clearly presented, defended, and summarized.
Correct Scale (¼" = 1' 0")	Most features are not drawn to consistent scale.	Most features are drawn to consistent scale.	All features are drawn to consistent scale. Scale is appropriate for the lunar sketches.
Labeling	Few features are labeled correctly, and labels are sloppy.	Most features are labeled correctly but lack neatness.	All important features are labeled correctly and neatly. Labels are aligned to a legend.

Lesson 4:
Resource Documents

Survey Results Compilation

Now that you have completed your survey, you can determine the results. Set up an Excel® spreadsheet to do this.

Here are the steps to create your Excel® spreadsheet.

1. Open EXCEL®. The Excel® spreadsheet will look like this table:

	1	2	3	4	5
Question 1					
Question 2					
Question 3					
Question 4					
Question 5					
Question 6					
Question 7					
Question 8					
Question 9					
Question 10					

2. To type in a cell, simply click on the cell and begin typing. If you would like to type your actual questions in the first column, you may need to widen it. To do this go to the very top of the table where you see A, B, C, etc. and place the cursor on the line between A and B until you see the cursor turn to a double arrow with a line through the middle. Click and drag the column to the desired width.

3. Now count the number of responses you have for each Question and type these into the table. For example, if you had 5 persons who circled 1, "Strongly Agree" for question 1 then you would type a 5 under Question 1 under Column 1.

4. Now you want to make a graph of your results. Take your mouse, and highlight the entire table. Then click on "Chart Wizard." The Chart Wizard looks like a little bar graph at the top of the toolbar. If you cannot find this, click on "Insert" and then "Chart."

5. Click on either "Column" or "Bar," whichever your group prefers. Choose what you want your graph to look like. Remember, you will need to explain the results, so choose a graph that you think will make it easier for people to understand your results. Once you have made your choice, click on "Finish."

6. Move the chart on your spreadsheet to where you want it, similar to how you move a picture in a Word® document. That is, click on the edge of the chart until your cursor changes to an arrowed cross, and drag the chart to where you want it. If you want to enlarge the chart, click on a side or a corner where the cursor changes to a double arrow, and drag the chart to the size that you want it to be.

7. To print your chart and table, follow this sequence of steps:
   a. Click "File."
   b. Click "Page Setup."
   c. On the Page Tab, click on "Landscape."
   d. On the Page Tab, click on "Fit to 1 Page."
   e. Click on the "Sheet" tab.
   f. Click on "Gridlines" and then "OK" at the bottom.
   g. You should now be able to print your chart and graph.

8. Now that you have a printout, write a paragraph explaining your chart, graph, and results. Use the following questions to help guide you in your writing. You may want to add other things that you see from your graph. You are not limited to these questions.
   - The question that had the most votes for strongly agree was . . .
   - The question with the least amount of votes for strongly agree was . . .
   - The question that had the most votes for strongly disagree was . . .
   - The question that had the least votes of strongly disagree was . . .
   - The question with the most neutral votes was . . .
   - The question with the least amount of neutral votes was . . .
   - Based upon our survey results, we think that . . .
   - Based upon our survey results, we think that we might possibly modify our original lunar colony model by . . .

9. You may want to experiment with the chart by right-clicking in the chart area and formatting the chart to see if you can change the colors. If you have a color printer, experiment with colors that you think make the best display.

Survey Data
Extension Activity

Name: ____________________

Date: ____________________

Hour/Period: ____________________

Internet Resource:

Cannon, Larry, Dorward, James, Heal, Robert, & Edwards, Leo (Principal Investigators). (1996–2006). National Library of Virtual Manipulatives. *Box Plot*. Retrieved May 11, 2007, from <http://nlvm.usu.edu/en/nav/frames_asid_200_g_3_t_5.html>.

Enter your results for each question. For example, for Question 1, enter the number of each response so that you have 25 entries. Take a screen shot of your box plot. To do this press Ctrl and PrtSc at the same time. Open a word processing package like Microsoft Word®. You should see the paste button light up so that you can paste your screen picture and size it to the size you want. Do this for each of the five questions. Do some research at:

The Shodor Education Foundation. (1996–2007). *Shodor Interactivate: Box Plot. Shodor*. Retrieved May 14, 2007, from <http://www.shodor.org>.

Find out what each of the five statistics mean and how you find each.

1. Minimum –

2. Lower Quartile –

3. Median –

4. Upper Quartile –

5. Maximum –

With your teacher, see if you can generate these numbers using Excel® and the function commands in Excel®.

Extension Activity Answers

1. Minimum – The lowest value of all the data values.

2. Lower Quartile – The lower quartile is the median of the lower half of the data. There are two ways to figure out the lower quartile.
   a. Method 1 – If there is an odd number of data, throw out the median and then find the median of the lower half of the data below the median (refer to "median" for the method to find the median). If there is an even number of data, simply divide the data into two equal parts and find the median of the lower half.
   b. Method 2 – If there is an odd number of data, include the median in both the lower half and upper half of the data. Find the median of the lower half of the data (refer to median for the method to find the median). If there is an even number of data, simply divide the data into two equal parts and find the median of the lower half.

3. Median – The middle value of all the data values. If there is an odd number of data, the median is the middle value after all of the data is arranged in numerical order. If there is an even number of data, the median is the average of the two middle values after the data is arranged in numerical order.

4. Upper Quartile – The upper quartile is the median of the upper half of the data. There are two methods to find the upper quartile. Refer to the methods for the lower quartile and perform these on the upper half of the data.

5. Maximum – The highest value of the set of data.

6. With your teacher, see if you can generate these numbers using Excel® and the function commands in Excel®.

Survey Template

Answer the following questions using the information provided below. For each question, you may select only one answer. There are two demographic questions followed by a series of statements asking for you to agree or disagree. In this section, SA refers to "strongly agree," A is "agree," U is "undecided," D is "disagree," and SD is "strongly disagree." Thank you for your time completing this survey.

Demographic Information

1. Age:

☐ 0–5 ☐ 6–10 ☐ 11–15 ☐ 16–20 ☐ 21–25
☐ 26–30 ☐ 31–35 ☐ 36–40 ☐ 41–45 ☐ 46–50
☐ 51 or over

2. Gender:

☐ Male ☐ Female

Survey Questions

	SA	A	N	D	SD
1. Put your first survey statement here. Hit "Tab" twice to enter your next question	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐
4.	☐	☐	☐	☐	☐
5.	☐	☐	☐	☐	☐
6.	☐	☐	☐	☐	☐
7.	☐	☐	☐	☐	☐
8.	☐	☐	☐	☐	☐
9.	☐	☐	☐	☐	☐
10.	☐	☐	☐	☐	☐

Lesson 5:
Resource Documents

PowerPoint™ Exploration

Name: ______________________________

Date: ______________________________

Hour/Period: ______________________________

Sometimes the best way to learn a new type of software program is through trial-and-error. For this assignment you will be learning to explore and determine how and why various commands in Microsoft PowerPoint™ function as they do. It will be important that you and your partner discuss and agree before you write an explanation. Good luck!

1. Insert→New Slide: ______________________________

   ____

2. Format→Slide Design: ______________________________

   ____

3. Insert→Chart: ______________________________

   ____

4. View→Slide Show: ______________________________

   ____

5. Tools→Spelling and Grammar: ______________________________

   ____

6. Slide Show→Slide Transition: ______________________________

   ____

7. Insert→Picture→From File: ______________________________

   ____

8. Insert→Text Box→Horizontal: ______________________________

   ____

9. Insert→Picture→Word Art: ______________________________

   ____

10. Format→Font (Note: Select some text first): ______________________________

    ____

AutoShapes (menu may be on the bottom of screen).

Lunar Colony Final Presentation

For the past few weeks your group has been researching, designing, and constructing a lunar colony. Now that the end of the project is near, it is your group's chance to put everything together and make a quality presentation to your teacher and peers. For this presentation you will need to include the following:

- A PowerPoint™ presentation that shows graphs from the survey
- A presentation that lasts no longer than five minutes
- A display of your lunar colony model with information about energy, shelter design, transportation modes, and sustainability
- Evidence of cooperation in your group

Begin preparation for this presentation by reviewing as a group the main information that was learned and writing it in the space provided below:

1. ______________________________ ________
2. ______________________________ ________
3. ______________________________ ________
4. ______________________________ ________
5. ______________________________ ________
6. ______________________________ ________
7. ______________________________ ________
8. ______________________________ ________
9. ______________________________ ________
10. ______________________________ ________

Team Presentation Rubric

Evaluation Criteria for Team Final Presentation				
	1	**2**	**3**	**4**
Organization	Audience cannot understand presentation because there is no sequence of information. Presentation is significantly less than allotted minutes.	Audience has difficulty following presentation because presentation jumps around. Presentation is short in length.	Information is presented in a logical sequence that audience can follow. Presentation is slightly short in length.	Information is presented in a logical, interesting sequence that audience can follow. Presentation uses allotted time to the fullest.
Subject Knowledge	Team does not have grasp of information; students cannot answer questions about subject.	Team is uncomfortable with information and is able to answer only rudimentary questions.	Team is at ease with expected answers to all questions, but fails to elaborate.	Team demonstrates full knowledge (more than required) by answering all questions with explanations and elaboration.
Technology	Team uses no technology.	Technology is used but does not aid in presentation.	Some technology to aid in presentation.	Technology is an integral part of the presentation.
Mechanics	Presentation has four or more spelling errors and/or grammatical errors.	Presentation has three misspellings and/or grammatical errors.	Presentation has no more than two misspellings and/or grammatical errors.	Presentation has no misspellings or grammatical errors.
Involvement	The audience has no involvement.	The audience has limited involvement.	Audience involvement is evident but activities are "busywork."	Audience is actively involved with activities that support the topic.
Collaboration	No teamwork evident.	Poor teamwork. Presentation done by one team member only.	Some teamwork. Presentation balance not shared equally.	Excellent teamwork evident.

National Aeronautics and Space Administration

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8-409852-B