AN EDUCATOR GUIDE TO

Operation Comet

CHALLENGER LEARNING CENTER

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Boeing Academy for
STEM LEARNING

THE MUSEUM OF FLIGHT

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UPDATED 8.2023
OVERVIEW

MISSION

Details
Participants: 5th to 6th grade
Time: 2 hours
Minimum capacity: 10 participants
Maximum capacity: 28 participants

Storyline
With a large Comet passing close to Earth in a short period of time, the International Space Station crew has the chance to send out a robotic probe to study this Comet. The study could be groundbreaking! Our Challenger Learning Center simulation-based learning experience will transform your students into NASA scientists and engineers with a single common purpose—the success of the mission! Essential skills including teamwork, communication, problem-solving, reading comprehension, interpreting visual information, and more will be put to the test in our mission to save the world!

Mission Objectives
Mission Control (MC):
- Monitor health and safety of the crew
- Collect data
- Conduct tests and experiments
- Monitor internal environment: radiation, air quality, and life support needs.
- Monitor external environment: solar flares and space debris

Spacecraft (SC):
- Launch Crew aboard Atlas V.
- Conduct experiments in ISS
- Search for long-period comets
- Launch ROV to collect data from comets
- Safely return crew to Earth

Major STEM Concepts
- Geological materials property tests
- Analyzing the carrying capacity of the robotic arm
- Completing the engineering design process to design and launch an ROV

OPERATION COMET SLIDESHOW
This slideshow is to be used in the classroom by the teacher. It contains important information that is critical to the Operation Comet mission and that will be necessary for preparing the students to get a successful mission. All critical information will be in red. If you do not have time to go over the whole PowerPoint, please focus on slides 8 though 11 they are critical for the students to be successful in the mission.

1. Operation Comet and Challenger Logos (slide 1)
After several previous failed attempts, the crew is tasked with a mission to observe, research, and analyze long-period comets that have entered our Solar System. Astronauts in both Mission Control and Spacecraft conduct experiments to study comets to help scientists better understand how they are formed and how they could potentially impact Earth. During the mission, however, a shocking discovery is made, and the crew must brainstorm together to solve the emergency, ensuring the safety of the crew and the success of the mission.
2. Long-Period Comets (slide 2)
   - Long-period comet (what we will be studying):
     » From Oort Cloud, outer edge of the Solar System that is 50X further away from the Sun than the Kuiper Belt.
     » Highly eccentric orbits!
     » Take between 200 years to millions of years to orbit the Sun.

3. Parts of a comet (slide 3)
   - Nucleus (heart):
     » Solid core of rock, dust, water ice, frozen carbon dioxide, methane, and ammonia.
     » Surface is dusty or rocky, suggesting ice is hidden beneath a surface crust several meters thick.
     » Usually less than 30 miles across.
   - Coma:
     » Water and dust!
     » Force exerted by the Sun’s radiation pressure and solar wind makes it start heating up. The ice turns to gas with dust, forming a fuzzy cloud around the nucleus.
   - Tails:
     » Ion Tail (bluish):
       * Made of electrically charged gas molecules.
       * Always point directly away from the Sun because this gas is strongly affected by the solar wind, following magnetic field.
     » Dust Tail
       * Made of dust.
       * Gently curved path behind the comet
Let’s talk about our mission now! During their visit to the Challenger Learning Center, your students will be broken up into two groups.

4. Mission Control Team (slide 4)

With a permanent human presence aboard the International Space Station, nine teams of highly trained and experienced engineers and technicians (students) are on duty 7 days a week, 24 hours a day, 365 days a year. Flight controllers keep a constant watch on the crew’s activities and monitor spacecraft systems, crew health and safety as they check every system to ensure operations proceed as planned. These highly trained flight controllers have the skills needed to closely monitor and maintain increasingly complex missions and to respond to unexpected events. Located at 1601 E NASA Pkwy in Houston, the ISS Mission Control is an addition from NASA Johnson Space Center. For the storyline, we’ve placed the ISS Mission Control in Cape Canaveral, Florida. The Flight Director oversees Mission Control during a Challenger Center mission.

5. Spacecraft Team (slide 5)

Flying to the International Station, nine teams (9 to 15 students) will conduct experiments and build and program a Remote Operated Vehicle (ROV) to fulfill their objectives to learn more about the long-period comet. The crew is in the CST-100 Starliner, a mix of crew and cargo, for missions to low-Earth orbit or for NASA service missions to the International Space Station! It is designed for a land-based return and can be reused up to 10 times. The CST-100 Starliner is attached to the Atlas V rocket and is approximately 172 ft high. They are leaving from Cape Canaveral, Florida. The Mission Commander oversees the Spacecraft team during a Challenger Center mission.

6. International Space Station (slide 6)

- A spacecraft can arrive at the space station as soon as 4 hours after launching from Earth.
- A crew of 7 people live and work while orbiting Earth about every 90 minutes
  » That makes 16 sunrises and sunsets or 16 orbits around the Earth in 24 hours.
  » The space station travels an equivalent distance to the Moon and back in about a day
More than 50 computers control the systems in the space station and 8 miles of wire connects the electrical power system aboard the space station.

The living and working space in the station has 6 sleeping quarters, 2 bathrooms, a gym, and a 360-degree view bay window.
  » The space station is 356 feet end-to-end, the full length of a football field!
  » To mitigate the loss of muscle and bone mass in the human body in microgravity, astronauts work out at least 2 hours a day.

7. Milestones (slide 7)

**Spacecraft**
- Launch Crew aboard Atlas V.
- Conduct experiments in ISS
- Search for long-period comets
- Launch ROV to collect data from comets
- Safely return crew to Earth

**Mission Control**
- Monitor health and safety of the crew.
- Conduct tests and experiments
- Monitor Internal Environment: radiation, air quality, and life support needs
- Monitor External Environment: solar flares and space debris

8. Review the SIM3+ Interface (slide 8)

- Notes: you can take notes throughout the mission.
- Station Tools: lists of the tasks that must be completed. The lesson will pop up on the screen once you click on it.
9. COMlink (slides 9/10)
   - Messaging (also called, COMlink) has text and audio connection capabilities:
     » Text: Move your cursor over the COMLINK tab at the bottom right of your screen. Make sure to select “T”. Type or copy/paste your message and then click send. **If you are in Spacecraft, you will send messages to SC COM. If you are in Mission Control, you will send messages to MC COM.** Play video slide 9 to learn how to send a message to **COM officer**.
     » Audio: ROV will need to connect via audio.
       * Click the button that looks like a speaker and then Connect.
       * Wait for their teammates to connect.

10. Special Tools (Slide 11)
    - Operation Comet offers some accessibility features for students:
      » **Dictionary**: a digital resource giving information on a particular word. If the scientific or technical word is underlined in the software, students will just click on it and its definition will appear.
      » **Read Aloud**: instructional practice where the computer will read the text aloud to students through their headsets. Students will be able to listen to the voice and follow the texts with a yellow background highlighting the words pronounced.

11. Light and Sound (Slide 12)
    - For some students, the use of loud sounds effects and flashing lights in the Challenger Learning Center can create anxiety. In this slide, we share two short videos (10 seconds each):
      » A red siren that is triggered during the main Emergency (light effect, no sound).
      » An alert alarm that can be triggered during the mission depending on Life Support results but also from other space issues.
    - The Challenger Learning Center is fully ADA accessible!
12. Team Objectives (Slides 13/14/15)
You can use these 3 slides to introduce the Job Application for Students document if you would like to explore the Operation Comet mission and if you have time.

<table>
<thead>
<tr>
<th>Team Name</th>
<th>Job Description</th>
<th>Areas of Interest</th>
<th>Career Connections</th>
</tr>
</thead>
</table>
| Biology (BIO)   | Responsible for conducting experiments and collecting data on microorganisms and space radiation. | • Environmental Science  
• Life sciences (plants, animals, organisms) | • Biologist  
• Environmental Researcher  
• Botanist |
| Robotics (BOT)  | Responsible for using the robotic arm to conduct experiments and code programs for rover tasks. | • Engineering design  
• Problem-solving and troubleshooting | • Mechanical Engineer  
• Software Engineer |
| Geology (GEO)   | Responsible for conducting experiments with rocks and minerals.                  | • Geology (physical features of rocks and minerals)                               | • Geologist  
• Environmental engineer |
| Life Support (LS)| Responsible for maintaining the life support systems on the spacecraft.        | • Engineering design  
• Hands-on experiments | • Industrial Engineer  
• Chemist |
| Medical (MED)   | Responsible for conducting medical tests on the crew to ensure their health and safety. | • Human anatomy and physiology  
• Nutrition, exercise, and health | • Nurse/Doctor  
• Emergency Medical Technician  
• Nutritionist |
| Navigation (NAV)| Responsible for commanding the spacecraft and adjusting the orbit.             | • Flight paths and orbits of celestial bodies.  
• Space debris | • Pilot  
• Aerospace Engineer  
• Mathematician |
| Communications (COM)| Responsible for communicating critical messages between the Spacecraft and Mission Control. | • Leadership role-comfortable with quick thinking and decision-making  
• Monitoring space debris | • Communication Systems Engineer  
• Information Technologist |
<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibilities</th>
<th>Required Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rover (ROV)</td>
<td>Responsible for troubleshooting and assembling the rover</td>
<td>• Engineering design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Hands-on experimentation and troubleshooting with lab materials</td>
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<td></td>
<td></td>
<td>• Computer Scientist</td>
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<tr>
<td></td>
<td></td>
<td>• Mechanical Engineer</td>
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<tr>
<td>Weather (WX)</td>
<td>Responsible for researching solar weather using telescopes to capture images of long-period comets.</td>
<td>• Meteorology</td>
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<tr>
<td></td>
<td></td>
<td>• Analyzing data and tracking information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Meteorologist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Astronomer</td>
</tr>
</tbody>
</table>
**OPERATION COMET PRE-MISSION CONTENT**

This extra set of activities are not critical for the mission but are great ways to learn more about comets in a fun way!

<table>
<thead>
<tr>
<th>Pre-Mission Resource</th>
<th>Link to Activity</th>
<th>Estimated Length of Activity</th>
<th>Summary of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comet on a Stick</td>
<td><a href="https://spaceplace.nasa.gov/comet-stick/en/">https://spaceplace.nasa.gov/comet-stick/en/</a></td>
<td>1 hour</td>
<td>Students build a craft-style model of a comet. Students learn the parts of the comet which are discussed heavily during the Operation Comet mission.</td>
</tr>
<tr>
<td>NASA E-Clips Video</td>
<td><a href="https://nasaecliclips.arc.nasa.gov/video/realworld/real-world-comets-its-done-with-math">https://nasaecliclips.arc.nasa.gov/video/realworld/real-world-comets-its-done-with-math</a></td>
<td>5 minutes</td>
<td>A brief introductory video that explains the history of comets and how scientists study them.</td>
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<tr>
<td>Cosmic Art</td>
<td><a href="https://www.jpl.nasa.gov/edu/teach/activity/art-the-cosmic-connection/">https://www.jpl.nasa.gov/edu/teach/activity/art-the-cosmic-connection/</a></td>
<td>1-2 hours</td>
<td>A media art lesson where students use a variety of art tools to better understand the geologic and atmospheric features of our solar system.</td>
</tr>
<tr>
<td>Use Dry Ice to Build a Comet</td>
<td><a href="https://www.jpl.nasa.gov/edu/teach/activity/create-a-comet-with-dry-ice/">https://www.jpl.nasa.gov/edu/teach/activity/create-a-comet-with-dry-ice/</a></td>
<td>30 minutes, but include about 1 hour for prep.</td>
<td>A hands-on experiment where students build a comet and make observations on its features.</td>
</tr>
<tr>
<td>Planetary Poetry</td>
<td><a href="https://www.jpl.nasa.gov/edu/teach/activity/planetary-poetry/">https://www.jpl.nasa.gov/edu/teach/activity/planetary-poetry/</a></td>
<td>1 hour</td>
<td>This is a language arts lesson where students create their own poetry inspired by the Solar System.</td>
</tr>
</tbody>
</table>