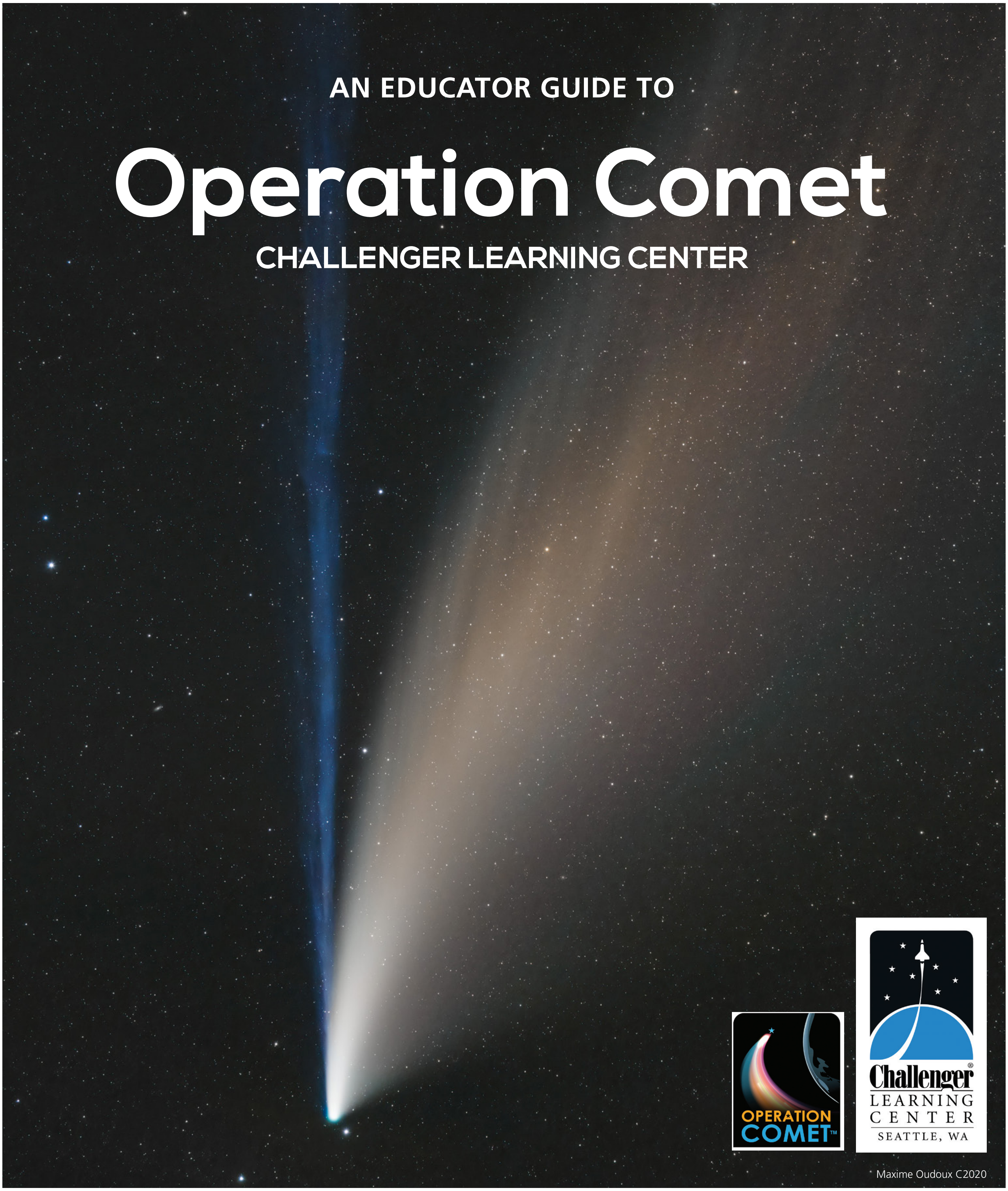
AN EDUCATOR GUIDE TO

Operation Comet

CHALLENGER LEARNING CENTER



Maxime Oudoux C2020

Boeing Academy for
STEM LEARNING
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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):

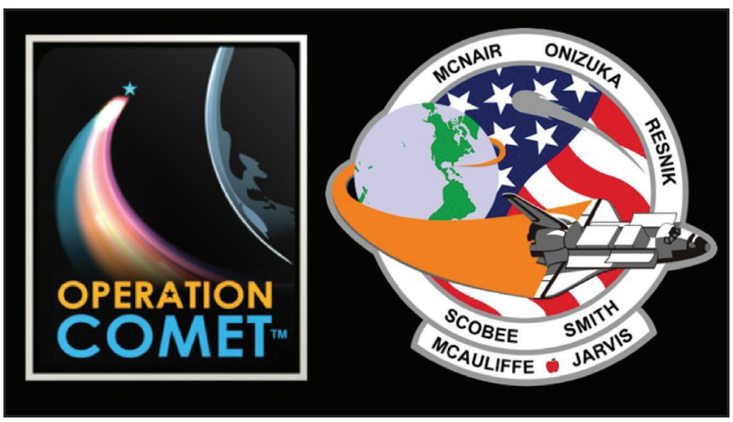
- Launch Crew aboard Atlas V.
- Conduct experiments in ISS
- Search for long-period comets
- Launch ROV to collect data from comets
- Safely return crew to Earth

Major STEM Concepts

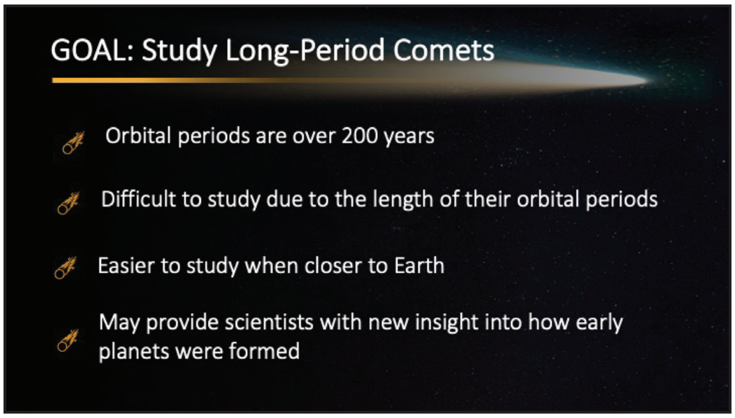
- Geological materials property tests
- Analyzing the carrying capacity of the robotic arm
- Completing the engineering design process to design and launch an ROV

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.**

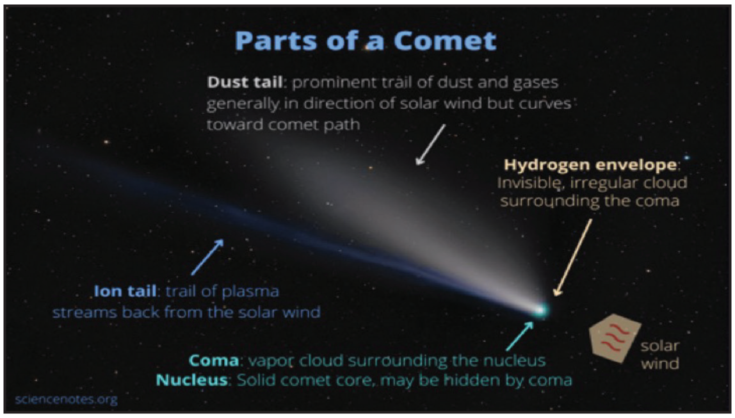


1. **Operation Comet and Challenger Logos (slide 1)**
   After several previous failed attempts, the crew is tasked with a mission to observe, research, and analyze long-period comets that have entered our Solar System. Astronauts in both Mission Control and Spacecraft conduct experiments to study comets 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.



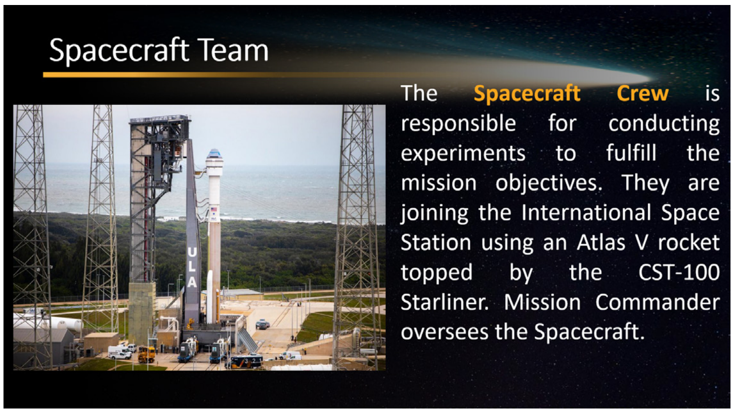
3. Parts of a comet (slide 3)

- 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.

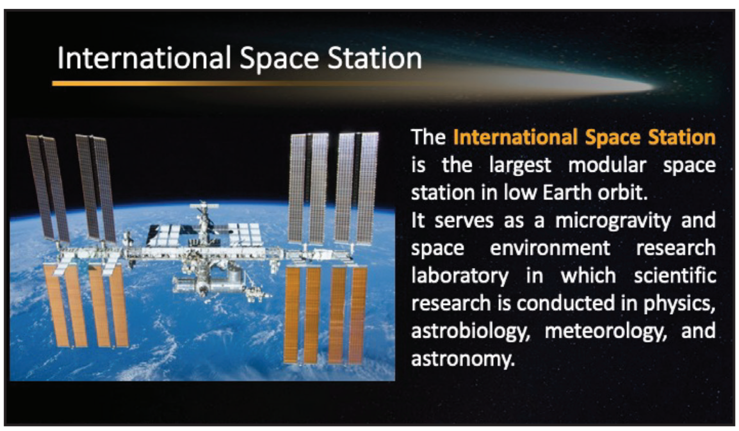
4. Mission Control Team (slide 4)

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.**



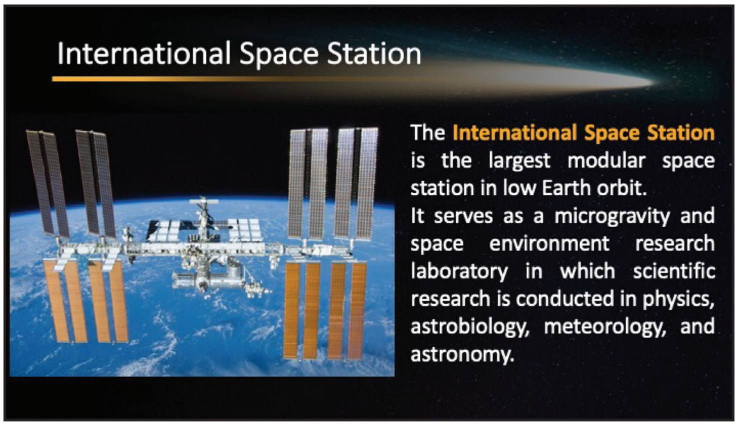
5. Spacecraft Team (slide 5)

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.**

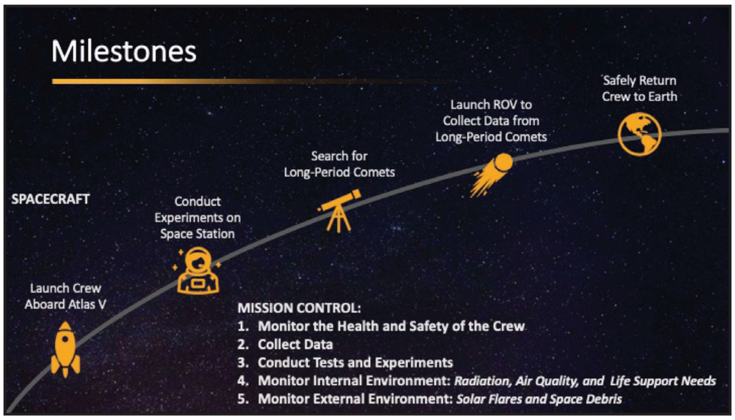


6. International Space Station (slide 6)

- 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.



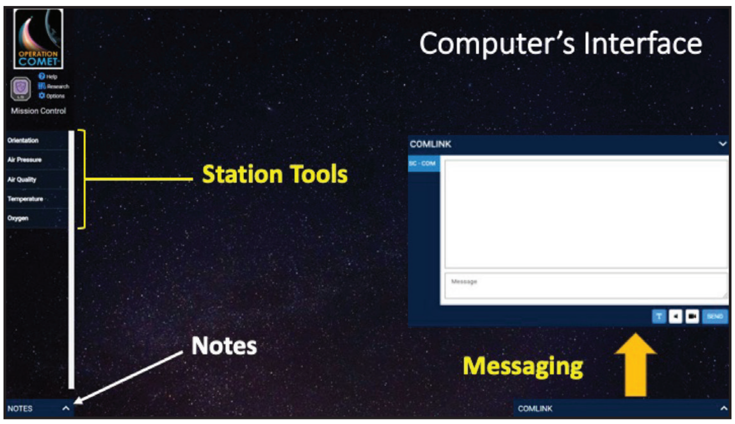
7. Milestones (slide 7)

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

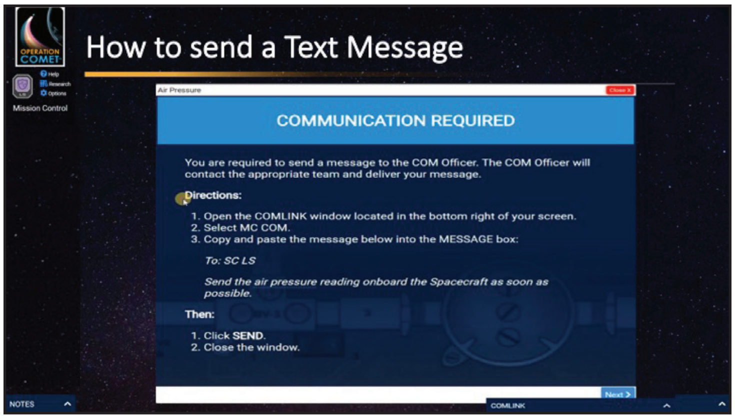
Mission Control

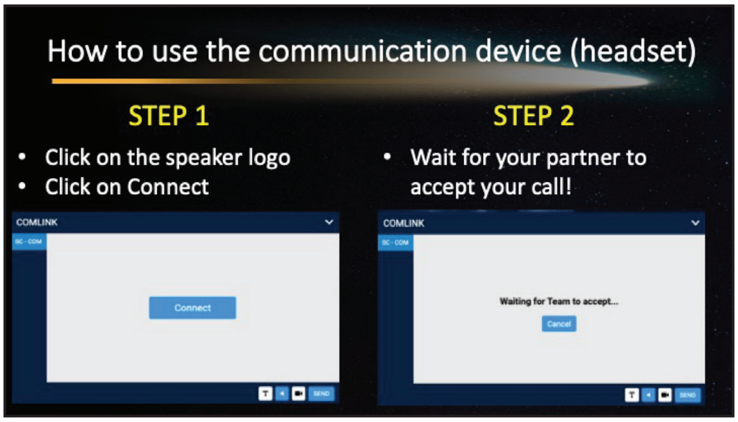
- Monitor health and safety of the crew.
- Conduct tests and experiments
- Monitor Internal Environment: radiation, air quality, and life support needs
- Monitor External Environment: solar flares and space debris



8. Review the SIM3+ Interface (slide 8)

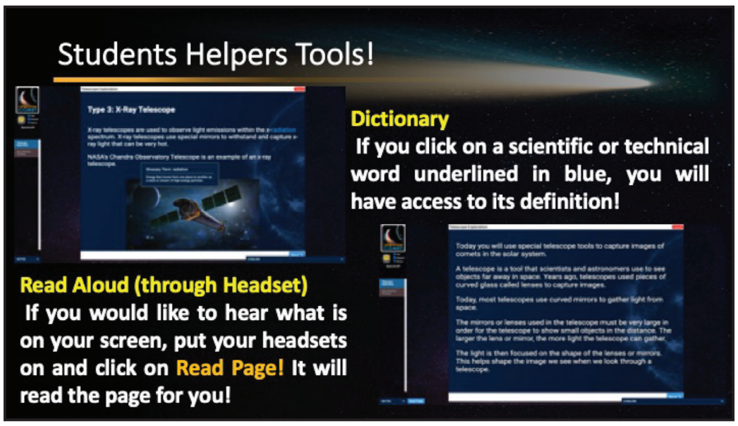
- Notes: you can take notes throughout the mission.
- Station Tools: lists of the tasks that must be completed. The lesson will pop up on the screen once you click on it.





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.

Team Name	Job Description	Areas of Interest	Career Connections
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

Rover (ROV)	Responsible for troubleshooting and assembling the rover	• Engineering design • Hands-on experimentation and troubleshooting with lab materials	• Computer Scientist • Mechanical Engineer
Weather (WX)	Responsible for researching solar weather using telescopes to capture images of long-period comets.	• Meteorology • Analyzing data and tracking information	• Meteorologist • Astronomer

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!

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

Standards

During this mission, the teams are exposed to the following Next Generation Science Standards (NGSS) and Common Core State Standards (CCSS):

NEXT GENERATION SCIENCE STANDARDS

- **MS-SEP 6-8:** Analyze and interpret data to determine similarities and differences in findings.
- **MS-SEP 6-8:** Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.
- **MS-SEP 6-8:** Construct a scientific explanation based on valid and reliable evidence obtained from sources.
- **MS-SEP-6-8:** Obtain and combine information from books and/or reliable media to explain phenomena or solutions to a design problem.
- **MS-SEP-6-8:** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomena.
- **3-5-ETS1-1:** Engineering Design: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **3-LS4-3:** Biological Evolution: Unity and Diversity: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive.
- **5-PS1-3:** Matter and Its Interactions: Make observations and measurements to identify materials based on their properties.
- **5-PS2-1:** Support an argument that the gravitational force exerted by Earth on objects is directed down.
- **MS-ESSI-1:** Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
- **MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient prevision to ensure successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- **MS-ETS1-4:** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
- **MS-LS1-5:** Construct an explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

COMMON CORE STATE STANDARDS

- **CCSS.ELA.SL.6.1:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.
- **CCSS.ELA.RST.6-8.3:** Follow precisely a multistep procedure when carrying out experiments, taking measurements or performing technical tasks.
- **CCSS.ELA.RI.6.7:** Integrate information presented in different media formats as well as in words to develop a coherent understanding of a topic or issue.
- **CCSS.ELA.SL.7.4:** Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.
- **CCSS.ELA.SL.7.6:** Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.
- **CCSS.ELA.L.7.6**: Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or a phrase important to comprehension or expression.
- **CCSS.ELA-LITERACY.RI.5.4:** Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.

COMMON CORE STATE STANDARDS CONTINUED

- **CCSS.ELA-LITERACY.RI.5.7:** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently
- **CCSS.ELA-LITERACY.RST.6-8.3:** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- **CCSS.MATH.CONTENT.5.NBT.A.3:** Read, write, and compare decimals to thousandths.
- **CCSS.MATH.CONTENT.5.MD.C.5:** Relate volume to the operations of multiplication and addition and solve real-world and mathematical problems involving volume.
- **CCSS.MATH.CONTENT.5.MD.A.1:** Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.
- **CCSS.MATH.CONTENT.7.G.B:** Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.
- **MP1:** Make sense of problems and persevere in solving them.
- **MP4:** Model with mathematics.
- **MP5:** Use appropriate tools strategically.