Human and Machine Communication

Challenge Guiding Question: *How can we use experiments, models, and rehearsals here on Earth to understand other solar system objects and plan a successful mission to Icy Worlds?*

Unit Level Question: *How can robotic systems aid in the exploration of our Earth and other solar system objects?*

Lesson Level Question: *What are different ways robotic systems communicate, and what are their limitations?*

Lesson Summary: *Students will explore various aspects of wireless communication including the ways in which NASA communicates with technologies in space. Then, they will connect that knowledge to the technologies used for the ROADS on Icy Worlds Challenge (drone, robot) to observe the ways those systems communicate, including possible limitations.*

Notes for Adapting This Lesson to Remote Learning: *The hands-on investigations on this experiment are best carried out by small groups of students interacting in person so that they can make decisions about what to test and observe the results in real-time. However, it may be possible for one student to record or live-stream their investigations and be directed by other students. At all points in this lesson, students will benefit from the ability to engage in discussions with their peers.*

Materials Needed

Available from NESSP	***Supplied by the Teacher***
Robot Drone	Cellphone, Tablet, Computer

Before the Lesson

Remind students to have MDL readily available for this lesson.

- **Engage:** Prepare to watch the first 2:35m of ‘How Information Travels Wirelessly’ video, ‘What Wi-Fi Would Look Like If We Could See It’ article and discussion prompts.
- **Explore:** Have printed or electronic copies of images for students to reflect on
    - In Person - Provide printed copy of article for review, share link or review article as a class
    - Remote - Display prompt questions on screen and put in chat with article link for review

- **Explain:** Split students into two groups - reading one article per group; have printed or electronic copies of 'Communicating from Mars' (provide link for video access) and 'Responsive Science on Europa Clipper' articles
    - In Person - Display prompts on screen or board
    - Remote - Display prompts on screen and put in chat for reference. Create 2 breakout rooms for group discussion per article
        - *Don't have breakout rooms?* Create a slide deck with 2 slides, one per group/article, for students to write responses
- **Elaborate:** Display list of tests on screen or board and create space for students to come up with their own relevant tests.
    - Remote - Put list of tests in chat for reference
- **Evaluate:** Provide link to website for exploration
    - In Person - Display and discuss items to consider and guiding questions on screen/board
    - Remote - Display items to consider and guiding questions on screen and put in chat for reference

Middle School Standards

<table>
<tr><td colspan="3">MS-PS4-3 Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.</td></tr>
<tr><td>Developing and Using Models (Engage)
Develop a model to describe unobservable mechanisms.

Constructing Explanations and Designing Solutions (Explore and Evaluate)
Construct an explanation using models or representations.

Obtaining, Evaluating, and Communicating Information (Explain)
Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).

Planning and Carrying Out Investigations (Elaborate)
Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.</td><td>Supporting DCI
Digitized information transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. (4-PS4-3)

Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)</td><td>Cause and Effect
Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td></tr>
<tr><td colspan="3">Other Content Standards (Math, Computer Science, ELA, 21st Century)</td></tr>
</table>

English Language Arts (Common Core State Standards)
CCSS.ELA-LITERACY.W.6.1
Write arguments to support claims with clear reasons and relevant evidence.
CCSS.ELA-LITERACY.W.6.1.A
Introduce claim(s) and organize the reasons and evidence clearly.
CCSS.ELA-LITERACY.W.6.1.B
Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.
CCSS.ELA-LITERACY.W.6.1.C
Use words, phrases, and clauses to clarify the relationships among claim(s) and reasons.
CCSS.ELA-LITERACY.SL.6.3
Delineate a speaker's argument and specific claims, distinguishing claims that are supported by reasons and evidence from claims that are not.
CCSS.ELA-LITERACY.SL.6.4
Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

21st Century Skills
Make Judgments and Decisions
2.C.1 Effectively analyze and evaluate evidence, arguments, claims and beliefs
2.C.3 Synthesize and make connections between information and arguments
2.C.4 Interpret information and draw conclusions based on the best analysis

Communicate Clearly
3.A.1 Articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a variety of forms and contexts

Collaborate with Others
3.B.1 Demonstrate ability to work effectively and respectfully with diverse teams

High School Standards

HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.		
Developing and Using Models (Engage) Develop a model to describe unobservable mechanisms. (Middle School element) **Constructing Explanations and Designing Solutions (Explore and Evaluate)** Construct an explanation using models or representations. (Middle School element)	Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and	**Cause and Effect** Systems can be designed to cause a desired effect. (HS-PS4-5)

Obtaining, Evaluating, and Communicating Information (Explain) Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. **Planning and Carrying Out Investigations (Elaborate)** Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.	interpreting the information contained in them. (HS-PS4-5)	

Other Content Standards (Math, Computer Science, ELA, 21st Century)

Mathematics -

21st Century Skills

Make Judgments and Decisions

2.C.1 Effectively analyze and evaluate evidence, arguments, claims and beliefs

2.C.3 Synthesize and make connections between information and arguments

2.C.4 Interpret information and draw conclusions based on the best analysis

Communicate Clearly

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Lesson Plan

Phase	Middle School	High School	Materials/Prep

Engage (15 Min)	**Students will watch the first 2:35 minutes of the video "How Information Travels Wirelessly" and create a diagram of the room they are in or the area immediately surrounding their drone or robot if the wireless signals were visible to the human eye.** If WiFi and Bluetooth were visible to the human eye, what might that look like in your space? After students are done, show them images from "What Wi-FI Would Look Like If We Could See It" https://www.vice.com/en_us/article/9an9m7/heres-what-wi-fi-would-look-like-if-we-could-see-it ● How does their diagram differ? ● Did they include any obstacles for their wireless signals? ● What might this mean for how the drone or rover can receive information? Encourage students to update their drawing as they see fit based on any new information they've gathered.		**How Information Travels Wirelessly (watch from 0:00m - 2:35m):** https://www.youtube.com/watch?v=Ax7dYaRiY6o What Wi-Fi Would Look Like If We Could See It
Explore (30 Min)	***Students examine common pieces of technology to identify the inputs and outputs.*** Display images (or print on cards) of objects that have various inputs and outputs (for example, wired and wireless speakers, microphone, computer monitor, traffic light, cell phone, airpods, hearing aid, etc). Ask students to identify how information and commands get IN (inputs) and how information gets out (outputs) of each device, as well as if those inputs and outputs are wired or wireless. Have students reflect individually and then share with a partner before discussing with the group. Guiding questions could include: ● What kinds of information (words, pictures, noises, etc) go IN and OUT? ● What do you think are the limitations of this device (ie, length of cord, for corded, but what about wireless)? Focus on wireless connections. Review "How Does Wi-Fi Work" If students are unfamiliar. Have students revisit and update their drawings.		How Does Wi-Fi Work?
Explain (30 Min)	***Students will read one of the two provided articles, then share ideas with a student who read the other article.*** Split students into two groups and assign each group one of these articles. Make sure students know that they will each be responsible for summarizing their article for someone who read a different article. 1. Communicating from Mars 2. Responsive Science on Europa Clipper (use graphic at the bottom of the page, full report not accessible for middle school level) After students have had a chance to read and discuss with those who read the same article using the prompts below, then pair	***Students will read one of the two articles, then share ideas with a student who read the other article.*** Split students into two groups and assign each group one of these articles. Make sure students know that they will each be responsible for summarizing their article for someone who read a different article. Can use Middle School articles but here are two more complex readings for High School: 1. Deep Space Network 2. Messages to and from Outer Space	**MS:** Communicating from Mars Responsive Science on Europa Clipper **HS:** Deep Space Network Messages to and from Outer Space

	them with someone who read the other article to share what they learned. *Students should explore how NASA communicates to space craft and answer the following:* ● What are the advantages to using wireless communication? ● Would NASA be able to accomplish their missions without this technology? ● What are the challenges to using wireless communication? ***For remote instruction:*** Create two breakout groups - one for each article so students can read individually and then discuss prompts as a group. **If you don't have access to breakout rooms**, you could create a slide deck with 2 slides (one article per slide) and have students write their responses on the slide that corresponds with the article they read. Select 1-2 people from each group to present their group's responses. There may only be a space for students to discuss as a larger group rather than the article-specific groups. To hear both groups, have 1-2 people present each slide and share their group's responses?	After students have had a chance to read and discuss with those who read the same article using the prompts below, then pair them with someone who read the other article to share what they learned. *Students should explore how NASA communicates to space craft and answer the following:* ● What are the advantages to using wireless communication? ● Would NASA be able to accomplish their missions without this technology? ● What are the challenges to using wireless communication? ***For remote instruction:*** Create two breakout groups - one for each article so students can read individually and then discuss prompts as a group. **If you don't have access to breakout rooms**, you could create a slide deck with 2 slides (one article per slide) and have students write their responses on the slide that corresponds with the article they read. Select 1-2 people from each group to present their group's responses. There may only be a space for students to discuss as a larger group rather than the article-specific groups. To hear both groups, have 1-2 people present each slide and share their group's responses?	
Elaborate (20 Min)	***Students should try communicating with a robot or drone connected to their computer, tablet, or phone.*** Tests should include: ● Adding barriers in between computer, tablet or laptop and the drone ● Finding maximum distance until connection is lost ● Picking up and holding an object, or putting the object somewhere else ● Turning and navigating the landscape ● Taking a picture Students should refer to the first diagram made in the Explore Section and create a new diagram showing what the waves of communication could look like between their computer, tablet or phone and robot/drone based on these tests. This		Robot Drone Cell phone/computer/ tablet

	diagram should be recorded in the Mission Development Log.	
Evaluate (30 Min)	***Allow students to identify a piece of technology on a NASA rover analogous to technology on their robot or drone. For example, an ultrasonic sensor on a LEGO EV3 might serve the same purpose as the "eyes" of the Europa Clipper (https://europa.nasa.gov/)*** Have students research what the inputs and outputs are of their selected technology and how that piece of technology communicates with other objects or with NASA personnel What is useful for that type of communication, what could possible issues be?	
Extend (Optional)	N/A	