Key Student Learnings:

Tour Objective:

Students will be able to learn how technology such as voice artificial intelligence and two way video communication are being tested on NASA's Artemis I mission to potentially help future astronuats navigate challenges of space.

Key Vocabulary:

The following vocabulary will be introduced in audio and visual format during the tour:

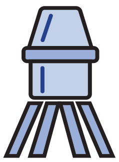
- **Payload:** anything that a vehicle or spacecraft carries such as people, equipment, food, experiments, supplies, and more.
- **Deep Space Network:** a worldwide radio system responsible for communicating to NASA spacecraft during far away space missions.
- **Radio waves:** type of invisible energy often used to send information to and from technologies, such as television, mobile phones and radios.
- **Telemetry:** the process of a using a computer system to automatically collect measurements and information even from far away places.
- **Latency:** the delay between an action and a computer's response OR the time it takes for data to be transferred from its original source and its destination OR a time delay due to computer processing or communication.
- **Bandwidth:** the maximum amount of information (or data) that can transfer in a given amount of time.
- **Codec:** technology that squeezes video into a digital form to make it easier to send.
- **Voice artificial intelligence:** Technology that recognizes human voices, interprets their meaning, and offers a response in return.
- **Radiation:** energy that comes from a source and travels through space at the speed of light.

Key Learnings by Tour Stop:

Below is an outline of the tour's key learnings by tour stop. Each tour stop contains one or more interactive question. The tour guide reveals the answer and explains how it relates to a specific computer science term. The tour guide will then provide real-life context of how this scientific learning is important to the Callisto payload.

Stop:	Interactive Questions:	CS Learnings and FC Context Summary:
Welcome 	**1) What do you already know about the challenges astronauts face in deep space travel?** Open response.	NASA's Artemis Missions will land the first woman and first person of color on the Moon. These expeditions will use innovative technology to explore the lunar surface and establish a long-term presence on the Moon. Eventually, NASA will use the learnings from Artemis to help send the first astronauts to Mars! Watch this tour stop in Video 1 and Video 2.

Key Student Learnings:

Stop:	Interactive Questions:	CS Learnings and FC Context Summary:
Getting to Space 	**3) How much liquid propellant (fuel) does the Space Launch System Rocket need to reach space?** **Answer:** 735,000 gallons **4) How long does it take for the Space Launch System to burn that fuel? Answer:** 8 minutes **5) Which of the following will NOT be a part of a payload in Artemis I?** **Answer:** musical instruments	The Space Launch System (SLS) is the most powerful rocket in the world and will be used for Artemis missions. The SLS stands at 322 ft tall and weighs over 5.75 million pounds and is responsible for carrying spacecraft, equipment and cargo to space. To get this rocket off the ground, it's going to take 735,000 gallons of liquid propellant, used in just 8 minutes!! On top of the Space Launch System sits the Orion spacecraft. the vehicle that carries the crew and instruments up to space and back to Earth again. The Artemis I mission will be the first time Orion will fly out into deep space aboard the SLS rocket. Orion will be uncrewed (no people on it), but there will be a manikin on board – Commander Moonikin Campos. There's also two other non-human passengers, Helga and Zohar, aboard for a radiation experiment. The spacecraft will also carry many different payloads to the Moon. A **payload** is anything that a ship or spacecraft carries such as people, equipment, experiments, food, supplies, and more! Artemis I has more than a dozen different payloads and each has a different function. One of the payloads, the Callisto payload, will demonstrate technology created by engineers at Lockheed Martin, Amazon, and Webex. The new technologies were designed to demonstration ways future astronauts could communicate and will be tested for the first time on the uncrewed, Artemis I mission. Watch this tour stop in Video 2 , Video 3, and Video 4.
Deep Space Communication 	**6) What is the farthest a spacecraft has communicated with Earth using the Deep Space Network?** **Answer:** Over 14 billion miles **7) How long does it take for a radio wave from Earth to reach a spacecraft near the moon?** **Answer:** about 1 to 2 seconds **8) Satellites, crew members, science experiments, and equipment that fly onboard spacecraft are known as __.** **Answer:** payloads **9) The 3 sites of the _ are spaced out so no matter where Earth is in its rotation, spacecraft can communicate with Earth.** **Answer:** Deep Space Network **10) Digital information is sent to spacecraft over the Deep Space Network as __.** **Answer:** radio waves	The **Deep Space Network** (DSN) is a worldwide radio system responsible for communicating to NASA spacecraft during far away space missions. The network consists of three giant radio antennae located in California, Spain, and Australia. Due to the rotation of the Earth and DSN site locations, there will always be an antenna pointing towards the spacecraft to send and receive signals. The antennae communicate long distances by sending and receiving information in the form of **radio waves**. Radio waves are a type of invisible, electromagnetic energy often used to send information to and from communication technologies, such as television, mobile phones and radios. During Artemis I, engineers will be communicating with the payload from NASA's Johnson Space Center. For example, if an engineer wants to give a voice command to the Callisto payload, their command is broken down into digital bits. The closest DSN antennae then sends the digital bits to Orion in the form of radio waves. Once received, technology in the Callisto payload interprets the information, performs the task, and may send a response back to Earth using radio waves once again. The DSN antennae pick up the response and relay it back to scientists and engineers for interpretation. Radio waves travel at the speed of light, but since space is so vast, it takes time for the radio waves to reach the spacecraft. The further out from Earth, the longer it will take. Watch this tour stop in Video 4 , Video 5, and Video 6.

Key Student Learnings:

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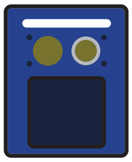
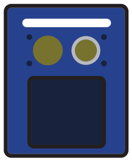
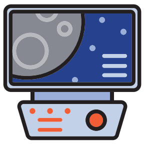
Callisto Payload 	***Telemetry*** **11) Which of the following telemetry data points will be accessible by the Callisto payload?** **Answer:** All of the answers are correct. **12) How many total telemetry data points are available on Orion Flight Software?** **Answer:** Over 10,000	When traveling in space, NASA's Orion spacecraft is capable of flying without any people onboard. How is the flight software onboard and flight operations crew on Earth know how to make adjustments to keep the vehicle on track? NASA uses telemetry to understand what a spacecraft is doing and how it is performing. **Telemetry** is the process of using a computer system to automatically collect measurements and information, even from far-away places. Engineers from Lockheed Martin designed and installed the Callisto payload to be able to have access to the Orion telemetry data used by the flight software. Throughout the Artemis I mission, over 10,000 data points can be accessed by the payload to test out new displays and even enable the voice assistant Alexa to respond to questions about where the vehicle is or how fast it is traveling. At the end of this step, meet 2 engineers from Lockheed Martin that made Callisto's telemetry technology possible. Watch this tour stop in Video 6 and Video 7.
	Video Communication **13) What is the world record for amount of time a human has stayed in space?** **Answer: 437 days (~1 year 2 months)** **15) An engineer draws on the board a mission control but it doesn't show up on Callisto right away. This delay is called __.** **Answer:** latency **16) Engineers had to design a solution for the limited _ (the amount of data that can transfer at a given time) in space.** **Answer:** bandwidth **17) A _ allows video to be compressed and decompressed to be able to be sent over the Deep Space Network.** **Answer:** codec	The longest a human has ever stayed in space is 437 days, a record set in 1995. To make life better in space, engineers at Webex have been working to figure out how to enable video communication in Deep Space. The further the spacecraft travels into space, the less instantaneously communication occurs. When bringing video to space, engineers needed to solve many challenges including figuring out how to reduce latency with limited bandwidth**.** **Latency** is the time it takes for data to be transferred from its original source and its destination. Reducing latency is challenging in space due to the great distances data must travel. Long latencies are often the result of limited bandwidth. **Bandwidth** is the maximum amount of information (or data) that can transfer in a given amount of time. Bandwidth is limited when communicating in space due to the long-distance information has to travel. Streaming video in space is incredibly challenging – it's like trying to squeeze ten lanes of highway traffic into one bike lane! A video compression technology called a **codec** is being used to test video and whiteboard collaboration onboard Orion. A codec can be hardware or software that takes speech or video and puts it in digital form (1 and 0's!) to transmit. The codec used in deep space communication uses an algorithm, or a set of instructions, to encode (or shrink) video before sending, and then decode (or expand) it later for viewing and editing at the new location. This ensures that video will be as clear as possible in the limited bandwidth of a space environment (about 1/10th of the bandwidth that would typically be used in video conferencing on Earth!). The Webex Callisto solution has custom technologies that account for this delay and will test how the deep space solution can handle extreme latencies while preserving the continuity of interactions. At the end of this stop, meet 2 engineers from Webex that made Callisto's video communication and whiteboard collaboration technology possible. Watch this tour stop in Video 7 , Video 8, and Video 9

Key Student Learnings:

Stop:	Interactive Questions:	CS Learnings and FC Context Summary:
Callisto Payload (Continued) 	***Voice Artificial Intelligence*** **18) Which of the following words will not wake up Alexa?** **Answer:** Commander Moonikin Campos **19) A student asks their device "Alexa, tell me a space fact." The full sentence they spoke is called __.** **Answer:** an utterance	When traveling inside a spacecraft, astronauts have a lot of sensors, controls, and programs to monitor. Juggling lots of controls and materials in zero-gravity can be hard! But what if the astronaut could use their voice to control the cabin? Or ask for step-by-step directions to be read aloud? Engineers worked to install a version of Alexa into the Callisto payload to test if **voice artificial intelligence** (voice AI) could potentially improve space travel for astronauts. Voice AI is technology that recognizes human voices, interprets their meaning, and offers a response in return. Engineers program Voice Assistant AI technology to start working when a special wake word is spoken. A wake word triggers the device to "wake up" and listen for a command. A spoken command is called an utterance (think: a person "utters" the command). Many utterances have the same meaning. For example, a person might utter, "What time is it?", "What is the hour?", or "What's the time?" when wanting to know the time. These different utterances have the same intent – or desired response – to know the time! Engineers use computer code to program voice AI devices with the ability to receive millions of different utterances, decipher their intents, and respond accordingly. At the end of this step, meet 2 engineers from Amazon that made Callisto's voice AI technology possible. Watch this tour stop in Video 9 and Video 10.
Technology Demo 	**20) Poll: Vote on the telemetry utterance you want tested.** **21) Poll: Vote on the fun utterance you want tested.**	**Kahoot! (pre-Artemis I launch)**: Students watch a recording of facilitators live from Ops Suite 5 in Mission Control at Johnson Space Center. Students watch how the payload was tested. Students could also view a Q&A with engineers. Highlights Video Video 11. Full Video Video 11.

Key Student Learnings:

Stop:	Interactive Questions:	CS Learnings and FC Context Summary:
Closeout	Artemis I is just the first in a series of missions. Studying computer science and engineering can lead to a career that may include working on future missions and deep space exploration. Watch this tour stop in Video 12.	
Rapid Fire Trivia + Survey	At the end of the tour, students will be asked the following questions in Kahoot!. Amazon Future Engineer uses these responses to help improve future Tech Tours. **22) What is the name of the NASA missions that aim to put the first woman and person of color on the Moon?** **Answer:** Artemis **23) Before the tour, I was interested in career opportunities in computer science and engineering. (Poll)** **24) Humans (the crew) will be a payload on Artemis I. Answer:** False **25) After this tour, I am interested in career opportunities in computer science and engineering. (Poll)** **26) __ data allows engineers on Earth to monitor the spacecraft when it's in flight. Answer:** telemetry **27) On a scale from 0-10, how likely are you to recommend the Callisto Tour to a friend or peer? (Poll)** **28) __ may give future astronauts the ability to control spacecraft or obtain information using their voice.** **Answer:** Voice AI **29) Alexa starts listening when it hears __. Answer:** A wake word **30) Someone wants Alexa to play music when they ask. This desired response (playing music) is called ___.** **Answer:** an intent	

After the tour (optional):

- **Get free swag for your classroom!** Complete this tour survey and you'll receive free items for you and your classroom.
- **Quiz:** Play this Kahoot! with students to test their new space and computer science vocabulary knowledge.
- **Celebrate:** Print and distribute student certificates to celebrate completing the tour!
- **Lead a discussion:** Use these discussion questions to debrief with your students after the tour.

Standards Alignment:

The Callisto: Space Innovation Tour is aligned to a variety of educational standards:

- **CSTA K-12 Standards**
- **Next Generation Science Standards (NGSS)**
- **ISTE Standards**

CSTA K-12 Standard Alignment

(See the standards here.)

The following standards are fully or partially addressed during the tour:

1B-CS-01: Describe how internal and external parts of computing devices function to form a system.

1B-NI-04: Model how information is broken down into smaller pieces, transmitted as packets through multiple devices over networks and the Internet, and reassembled at the destination.

1B-IC-18: Discuss computing technologies that have changed the world, and express how those technologies influence, and are influenced by, cultural practices.

1B-IC-19: Brainstorm ways to improve the accessibility and usability of technology products for the diverse needs and wants of users.

2-CS-01: Recommend improvements to the design of computing devices, based on an analysis of how users interact with the devices.

2-NI-04: Model the role of protocols in transmitting data across networks and the Internet.

2-AP-17: Systematically test and refine programs using a range of test cases.

2-IC-20: Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options.

3A-AP-23: Document design decisions using text, graphics, presentations, and/or demonstrations in the development of complex programs.

3B-CS-02: Illustrate ways computing systems implement logic, input, and output through hardware components.

3B-AP-08: Describe how artificial intelligence drives many software and physical systems.

3B-AP-21: Develop and use a series of test cases to verify that a program performs according to its design specifications.

3B-IC-25: Evaluate computational artifacts to maximize their beneficial effects and minimize harmful effects on society.

Next Generation Science Standards

(See the standards here.)

The following standards are fully or partially addressed during the tour:

4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

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.

MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a 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.

HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

HS-PS4-2: Evaluate questions about the advantages of using a digital transmission and storage of information.

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.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Standards Alignment:

ISTE Standards Alignment
(See the standards here.)

The following standards are fully or partially addressed during the tour:

Empowered Learner: Students leverage technology to take an active role in choosing, achieving, and demonstrating competency in their learning goals, informed by the learning sciences.

1a: Students articulate and set personal learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process itself to improve learning outcomes.

1d: Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

Digital Citizen: Students recognize the rights, responsibilities and opportunities of living, learning and working in an interconnected digital world, and they act and model in ways that are safe, legal and ethical.

2b: Students engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices.

2c: Students demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property.

Knowledge Constructor: Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.

3d: Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.

Innovative Designer: Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.

4a: Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

4c: Students develop, test and refine prototypes as part of a cyclical design process.

4d: Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.

Computational Thinker: Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.

5a: Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

5d: Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

Global Collaborator: Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.

7c: Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.

7d: Students explore local and global issues and use collaborative technologies to work with others to investigate solutions.