Lesson Overview	Career Highlight
Students will begin the lesson by watching an entry event video. The video engages students with the challenges a growing human population is causing on our planet and the need to further investigate human impacts on the environment. A project from The Aerospace Corporation will be highlighted as an example of how data from above can help monitor human impacts below. The video ends with the challenge to students to develop the next research project for Aerospace to help understand human impacts on the planet. Students are presented with the question: "What human impacts can be monitored from space?"	Software Developer (Aerospace Employee Ruben) Physicist (Aerospace Employee Christine) Aerospace Expert-career depends on who visits classroom

STEM Course Connections	21st Century Skills
Middle School Earth Science Middle School General Science	Critical Thinking Communication Creativity Collaboration

Science and Engineering Practices	
Asking questions & defining problems	Students will engage in asking questions about different human impacts on the planet. Then, they will think about how the issues in the questions can be monitored with data from space.
Constructing Explanations and Designing Solutions	Students will apply their understanding of human environmental impacts to design a cubesat satellite to monitor a specific example. They will also identify why it has value and develop a proposal for their project.

Materials

Teacher Notes: See Lesson 1: Student Handouts and Lesson 1: Teacher Resources for specific attachments.

Day 1
Entry Event Video
Question Board Resources-Sticky Notes, Chart Paper, White Boards (varying sizes depending on teacher choice)
Teacher List of Possible Human Impacts
Driving Question Board Teacher Sheet

Day 2
Student Image Sheet from Student Handouts
Image Data Observation Sheet from Student Handouts

Day 3
Sticky Notes
Aerospace Video of Collaboration of Scientist and Engineer
Proposal Slide Template

Day 4
ESRI Satellite Map
Image of Different Sized Satellites
Device with Internet Access (optional)
CubeSat Instructions from Student Handouts
CubeSat Template from Student Handouts

- Foam board or corrugated cardboard
- Scissors or scoring knife

Day 5
Aerospace Visit Slide Deck (Invite employee to modify and make their own before presenting)
CubeSat Constraints and Platform Design Planning Sheet from Student Handouts
Key - CubeSat Constraints and Platform Design Planning Sheet
CubeSat Standard Components from Student Handouts - these will need to be printed for each group

- In addition to these printouts, students will need two pipe cleaners per group to represent the antennae.
- The teacher may also want to provide cardboard that students can mount the components to so they are more stable when being placed into their CubeSat model.

Day 1: What human impacts can be monitored from space?

Part 1: Entry Video (10 mins)
Students will watch an entry video that sets up the challenge that a growing human population is having on the planet. They will see how scientists and engineers are working together at Aerospace to use information collected from space to help answer questions about how humans are impacting the planet below. Students are presented with the challenge to pitch the next project funded through Aerospace.

Part 2: Driving Question Board (20 mins)

Once the video is completed, the teacher will restate the question for the students: "If you could propose a research project to Aerospace to study the impacts of humans, what would it be?"

To start the Driving Question Board (DQB) process, the teacher asks the students what they need to investigate or learn more about to accomplish the task. The teacher provides each student with a stack of cards (sticky notes or pieces of scratch paper) to write their questions/ideas on. Students are given five minutes to individually brainstorm. After the five minutes are completed, students form groups of four. They will take turns sharing out their cards to their group members. As a team, they will combine any cards that are similar and write any new cards that they thought of during their discussion.

The remaining five minutes, students will elect a group sponsor to bring their cards to the DQB at the front of the room. The teacher will have an available whiteboard (that can stay up during the duration of the unit) or a sheet of butcher or chart paper for students to compile their questions. Students from all sections of the teacher's class will add their questions to the board.

Teacher Notes: If the teacher is unfamiliar with the DQB process, the What is the Driving Question Board in IQWST?" by ActivateLearning video can provide a better understanding of the process. After the first day, the teacher will need to sort through the student cards on the DQB and arrange them by theme. Use the Driving Question Board Teacher Sheet to help with this process.

Part 3: Small Group Brainstorm (12 mins)
After the DQB, the teacher will re-engage students by asking them to brainstorm possible human impacts they would be interested in investigating.

Students will do a "Think-Pair-Share" to devise a list. After the initial brainstorm and partner brainstorm, then the students will share out to make a cumulative list of topics.

Teacher Notes: To help guide students, teachers can use this non-exhaustive list of potential topic areas: Teacher List of Possible Human Impacts. Do not give the list to the students, but use it to facilitate the brainstorm session.

Part 4: Preference Exit Slip (3 mins)
After brainstorming possible problems or questions to explore, the teacher will have students choose their top three areas of interest. They will turn in their preferences on the way out of class.

Day 2: Why are we collecting data from space versus land? What is the value of space?

Part 1: Reference to DQB (5 mins)
The teacher will engage students with the question "Why are we collecting data from space?" by referring to the DQB from the day before. Students will brainstorm their initial thoughts and the teacher will list them on the board to collect the thinking.

Part 2: Image Data Observation (25 mins)

1. Students will investigate this question further by observing data sets of images both from space and from Earth's surface.

2. The teacher will pair students or allow students to pick their partner. Each student pair will get a Student Image Sheet from the Student Handouts. With this information, they will complete the Image Data Observation Sheet, also in the Student Handouts.

Teacher Notes: The Value of Space by The Aerospace Corporation can be used by the teacher to develop their own background knowledge of the value of collecting data from space. Depending on your students, the report, or sections from the report could be used as an optional in-class reading or homework assignment.

Part 3: Share Out (15 mins)

1. Each student pair will join another group to share. The teacher will have students identify what they have in common with the other group by highlighting all the similarities. The pairs will combine their conclusions on the value of collecting data from space into one statement.

2. Each combined group will share their concluding statements on the value of collecting data from space.

3. The teacher can lead a discussion at the closure of the share out session to conclude why collecting data from space is a valuable endeavor. The teacher may go into other areas to be studied from space that are outlined in the report which were not represented in the image data sets.

Day 3: What data will our engineering team propose to collect from space?

Part 1: Reference to Purpose (3 mins)
The teacher will remind the students of the introductory event video where students are presented with the challenge to pitch the next project funded through Aerospace. The teacher will write the following on the board: "What human impact could you monitor from space?" so that students can reference it during the lesson.

Part 2: Choosing the Team and Your Topic (10 mins)
To facilitate choosing a topic, the teacher will hand back the exit slips from Day One. The teacher should give students time to reflect on their topic of interest and add or remove topics. Once they have finalized their topic, give each student three different colored sticky notes. Each color represents the level of preference. For example, students should put their first preference for their topic on the blue sticky note, second preference on the red and third on the yellow (see Figure 1 below). The teacher will instruct the students to place the sticky notes on their arms and then stand up and mingle the room. The teacher will give the students one to three minutes to move around the room and read each other's topic ideas and preferences. The teacher will ask students to start making affinity groups. Students who have similar topics at similar preference levels will join together to create groups of three students. The teacher can facilitate this by pointing out similarities. To help with grouping, students can also decide to join an affinity group with topics they don't have a sticky note for, but that they think sounds interesting. The teacher should record the groups and their general topic when completed.

Student's 1st Preference	Student's 2nd Preference	Student's 3rd Preference

Figure 1: Sticky Note Examples for Affinity Grouping

Part 3: Determining the Appropriate Data (12 mins)
The teacher will then show the Falling Stars video of an Aerospace scientist and engineer working together on a project. Before starting, the teacher should ask students to try to figure out the different job or role of the scientist versus the engineer in the video. When completed, the teacher will ask students to share what they observed. The teacher will ask students to assume the role of the scientist and focus on what data they will need to collect in order to monitor and learn about their chosen human impact. Students can brainstorm ideas on scratch paper and then put their finalized ideas in the proposal.

Teacher Notes: Depending on student need, more scaffolding may be necessary for students to come up with appropriate data. Providing examples of data that can be collected from space may be beneficial for some groups.

Part 4: Start Proposal (20 mins)
At this point, students are ready to begin the proposal. Teachers should provide each group with the Proposal

Slide Template or allow them to use the template to make their own slide deck. The teacher should remind students that the directions are in the notes section of the slide deck and they will use the slides to help with their proposal pitch. Once students have finished the first three slides, they should check in with the teacher for final approval.

Day 4: How do you collect data from space?

Part 1: Introduction (15 mins)
The teacher will engage students with the question "How do you collect data from space?" by referring to the DQB from Day One. After the teacher proposes the question, the teacher can ask students if they know about satellites. The teacher will explain that a satellite is anything that orbits or goes around a planet. They can ask the students if they know of any examples of satellites. If students have access to an electronic device with internet capability, have students explore the ESRI Satellite Map. After students have time to investigate, the teacher will show them the Image of Different Sized Satellites from NOAA (click on the image in this article to see a larger version) and their comparison to objects on Earth's surface. In groups of two students with each person taking turns being a scribe, the teacher will have them compare the benefits of a small satellite versus a large satellite. The scribe can write on scratch paper, poster paper, or a personal whiteboard.

Teacher Notes: The ESRI Satellite Map can also be projected for students and can use the 'help' and 'about' function to familiarize themselves with the website. If time allows, the teacher can work in more extension discussion and activities to explore satellites.

Part 2: CubeSats (10 mins)
Once students have completed their comparison, the teacher will show them the What Is A CubeSat? video from NASA's Kennedy Space Center. Have students place a checkmark next to all the items they had on their list for the benefits of smaller satellites. Students can also add to their paper. When completed, the teacher needs to recap the benefits and set the stage for the student challenge: "How can a CubeSat monitor human impacts on Earth?"

Teacher Notes: Discussion of the new James Webb Space Telescope or other large satellite (Hubble) could be added to further the discussion.

Part 4: Build the CubeSat Template (20 mins)
Students will use the CubeSat Instructions and CubeSat Template from their Student Handouts to build 1U or one CubeSat. When completed, teachers should save these for students to use during the next class period.

Teacher Notes: Depending on time, students could build any 10x10x10 cm cubic unit square box to serve as the CubeSat template.

Day 5: How do we design a CubeSat to collect data for the proposal?

If possible, Day Five is designed to invite a visiting expert from Aerospace to the classroom to share with students their work at Aerospace and guide students through the CubeSat design process. If a visiting expert is not possible, the teacher can lead the learning and the expert presentation can be bypassed.

Part 1: Expert Presentation (15 mins)
An invited scientist will lead students through a presentation on their work at Aerospace. The expert will discuss their role at Aerospace, their work with CubSats, and career connections to aerospace engineering.

Teacher Notes: The expert can use this editable Aerospace Visit Slide Deck to help guide the students through the lesson.

Part 2: Expert Brainstorms with Students the Requirements for CubeSat Design (30 mins)
Aerospace expert (or teacher) will guide students through a discussion on what elements must be included in a CubeSat platform to support the CubeSat payload.

1. The expert will ask the guiding question: "What components should be included in a standard CubeSat platform so that it can be sent to space to collect data?"

2. Students will get together with their design teams that were determined on Day Four. They will read the introduction to the CubeSat Constraints and Platform Design Planning Sheet from their Student Handouts and will complete the first column in the table.

3. Students will share their ideas with the expert/teacher, who will list them on the board. They will develop a consensus list together and record this together on the back of the page. The teacher/expert can use Key - CubeSat Constraints and Platform Design Planning Sheet to assist students in this conversation.

4. The students will be provided with a set of CubeSat Standard Components from their Student Handouts. They will work as a team to predict which component would serve each CubeSat task. Students will get their list verified by the teacher/expert before recording their final list on the table.

Part 3: Students Design Their CubeSats Based on the Prototype Requirements

1. Once students have completed their table on the tasks a CubeSat must perform and the component that completes that task, they can begin assembling their CubeSat platform prototype.

2. Students will glue the solar panel to the surface of their CubeSat (they will add one solar panel for now; later in the design process, students will determine if they must add additional solar panels). Students will mount the pipe cleaners to the exterior of their CubeSat to serve as the antennae for communication.

3. Students will mount the other components onto 10x10x10 cm cubic unit cardboard or foam board, or the teacher can print the CubeSat Standard Components onto cardstock. Students will slide these into their CubeSat prototype. This task may move into Day Six, if necessary.

Teacher Note: Use the Example - Initial CubeSat Prototype as a sample of what students initial CubeSat prototype could look like after Day Five.

CA NGSS Standards
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Lesson 1: Teacher Resources

1) Teacher List of Possible Human Impacts
2) Driving Question Board Teacher Sheet
3) Key - CubeSat Constraints and Platform Design Planning Sheet
4) Example - Initial CubeSat Prototype

Teacher List of Possible Human Impacts

Includes those from the MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Air pollution
Urbanization
Dam and levee construction
Land usage
Spread or storage of wastes/trash
Urban development
Agriculture
Removal of wetlands
Water pollution
Land pollution
Ice coverage
Habitat degradation
Habitat fragmentation
Animal migration
Habitat range
Forest cover or health
Coral reef decline
Permafrost
Storm intensity/tracking
Natural disasters
Wildfires
Weather patterns
Changes in climate
Greenhouse gas emissions ("Seizing the Day and Night with Carbonwatch" by Aerospace)
Ocean monitoring
Energy use
Transportation
Illegal fishing ("Episode 80: Fishing with Satellites - Illegal, Unreported, Unregulated" by Aerospace)

Driving Question Board Teacher Sheet

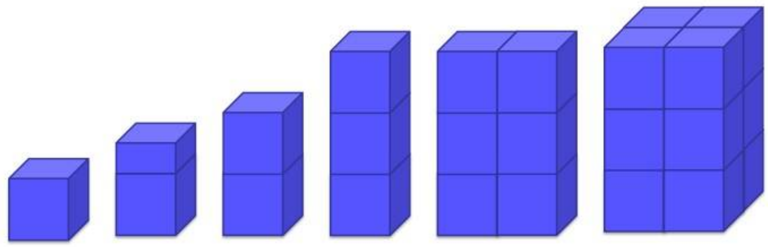
Use this framework to help students compile appropriate questions and then compile these questions into topic themes.

This is a list of key questions that are necessary to guide the unit. If students do not ask one to two key questions from each theme below on their own, the teacher may guide students to put these questions on the board or the teacher may add them when they are compiling question themes before Lesson Two.

Question Theme	Possible Student Questions or Ideas
Human Impacts	• What are key human impacts on the Earth?
Satellites and Data Collection from Space	• What types of data can be collected from space? • Why are we collecting data from space? • What will we use to collect the data?
Pitch	• How are we going to share our ideas with Aerospace? • Budget • Teaming
Data Collection Logistics	• How do we collect data from the correct height? • How do we collect data from the correct part of the world? • What data will we collect? • What will we do with our data?
Other	• Place questions that do not directly fit with the themes at left in a section called "other"

What Goes Into Designing a CubeSat?

CubeSats are designed with a set of standard criteria. The standard size is a 10×10×10 cm cubic unit. This single unit is called a U, which is the unit of measurement for CubeSats. CubeSats can be combined together to be 2U, 3U, even 12U in size. For this project, you are limited to a 1U CubeSat.



CubeSats also have a weight parameter. Each CubeSat unit can be no more than 1.33 kilograms.

These size and weight constraints limit the payload you can include.

Design Question: What components should be included in a standard CubeSat platform so that it can be sent to space to collect data?

1. Brainstorm the tasks that a CubeSat must perform to complete its data collection mission in the space below.

   Energy/power/electricity
   Battery
   Orientation
   Propulsion/movement
   Stabilization
   Data collection (could state a variety of options here)
   Communication
   Computer/processing

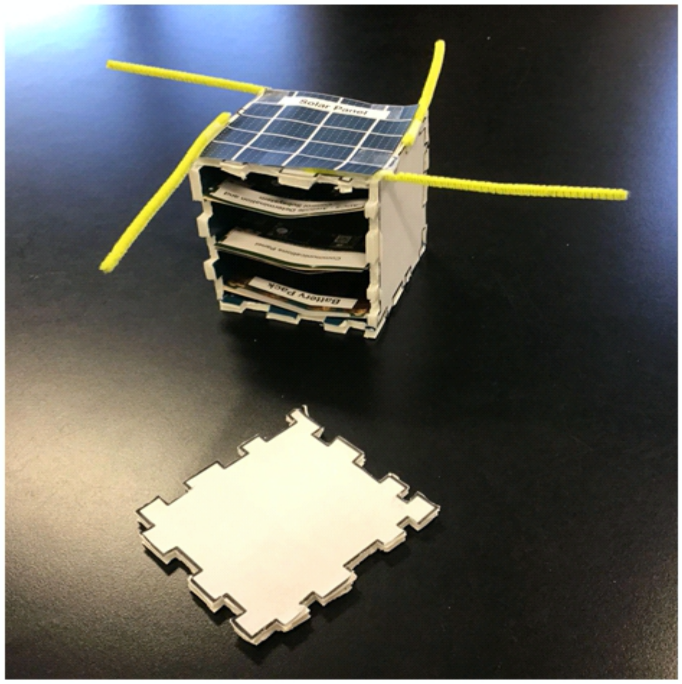
2. Complete the first column with the list of components from the class consensus. Use the provided components to predict which would fulfill each task. Verify your ideas with your teacher before recording them in the second column.

Task a CubeSat must perform	Component in the CubeSat platform to fulfill this task
Source of energy	*Solar panel*
Storage of energy	*Battery*
Control of orientation/propulsion	*ADCS unit, Attitude Determination and Control Subsystem*

Computing	*Computer/circuit board*
Payload	*Sensors and cameras for the specific data collection of the CubeSat*

Example - Initial CubeSat Prototype

Example - Initial CubeSat Prototype



Example - Final CubeSat Prototype