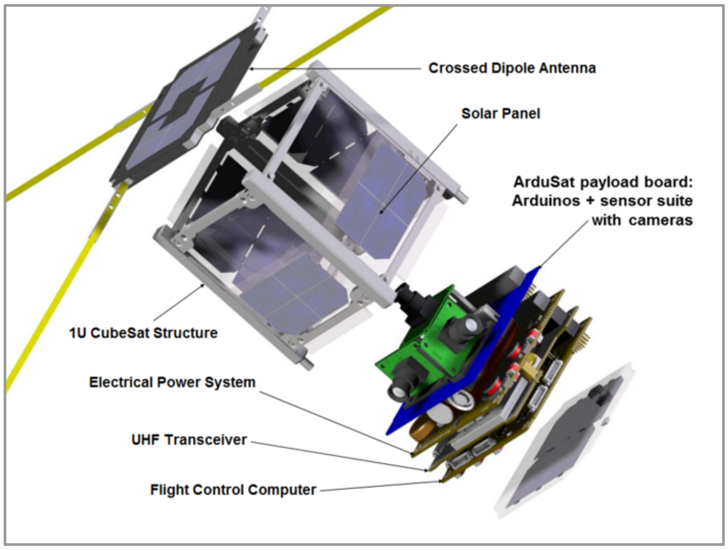
Lesson 2: Student Handouts

1) Payload Options Sheet
2) CubeSat Payload Add-ons
3) Payload Justification Grid
4) Proposal Slide Template
5) Example - Initial CubeSat Prototype
6) How Will My CubeSat Orbit?

Payload Options Sheet

When scientists and engineers work together to design a CubeSat, they must take into consideration what **payload** they wish to include in their CubeSat design. The **payload** is the part of the satellite included to complete the specific mission. For example, if a scientist wishes to monitor atmospheric temperature as a CubeSat moves through the atmosphere, the payload would need to include a temperature sensor. All CubeSats have a frame, solar panels, a control system, an onboard computer, and antennae. These components are called the CubeSat **platform**. Engineers work to add the desired payload to their CubeSat platform. There are specific size and weight constraints with this process.



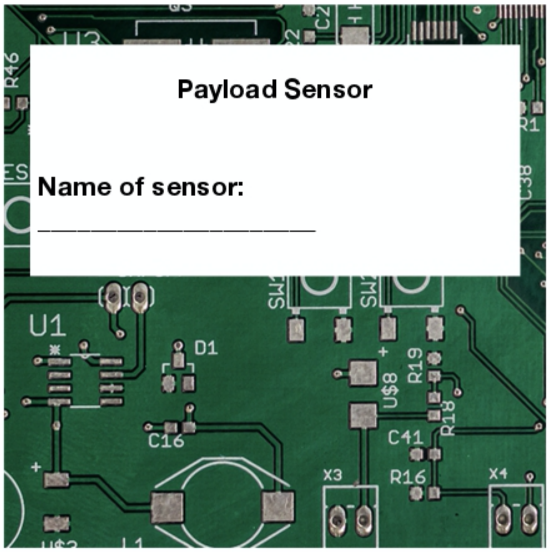
This diagram displays a typical 1U CubeSat with antennae, solar panels, control components, and payload.

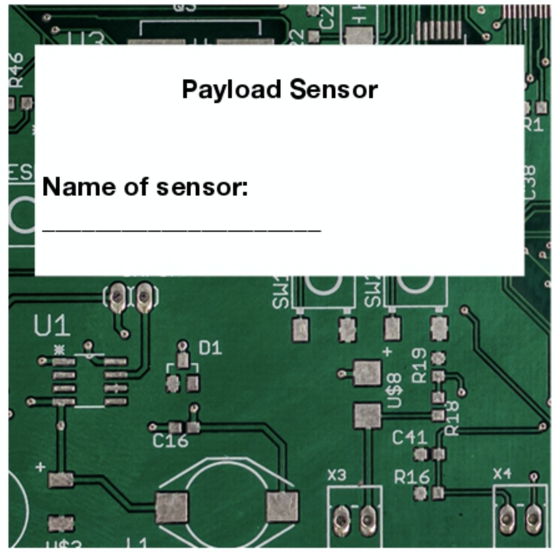
Below is a list of general payload options you and your team may select from when designing your CubeSat. Consider the purpose of your mission: What human impact data are you hoping to collect? Which payload options should you include to collect this data?

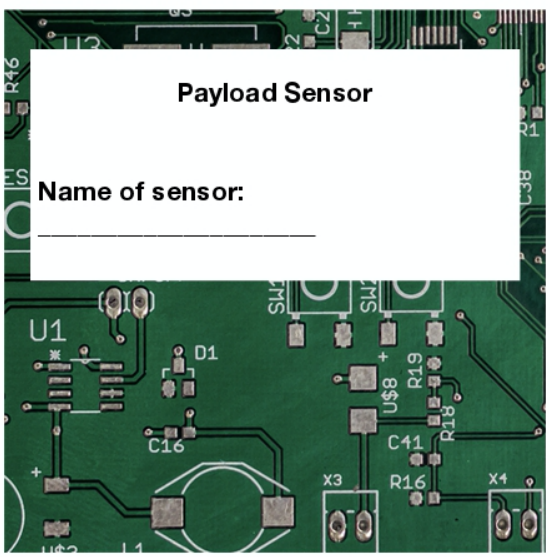
Possible Payload	Purpose	Considerations
High Resolution Camera	To take images with high detail	• Camera opening must be on the outside of the CubeSat • Requires at least four solar panels to power
Low Resolution Camera	To take images with less detail required	• Camera opening must be on the outside of the CubeSat • Requires at least two solar panels to power

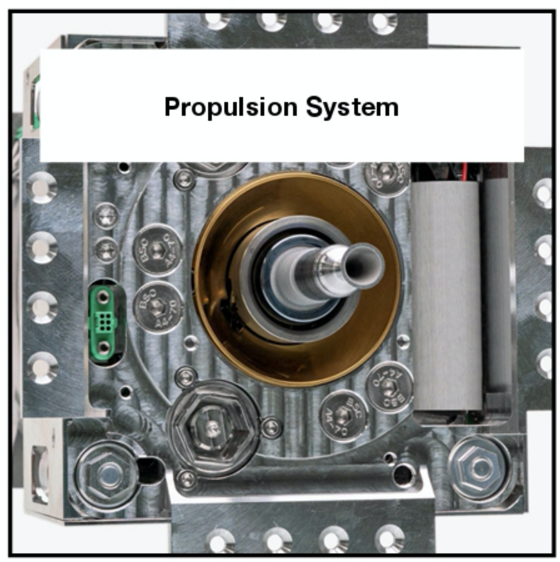
Global Positioning System (GPS)	Allows the CubeSat to communicate with GPS satellites to locate the position of things on Earth's surface	• Can be mounted inside the CubeSat • Requires at least two solar panels to power
Various orbital weather sensors	Humidity, temperature, pressure recorded from where the CubeSat is located	• Can be mounted on a circuit board inside the CubeSat
Various surface sensors	To detect temperature, humidity, pressure from varying locations in the atmosphere or on Earth’s surface	• Can be mounted on a circuit board inside the CubeSat
Propulsion System	Allows control of changing the orbit of the CubeSat to view varying locations	• Can be mounted inside the CubeSat • Requires at least four solar panels

CubeSat Payload Add-ons










High Resolution Camera
SWD
COM
MG
SD1
ADC


Low Resolution Camera
SWD
COM
MG
SD1
ADC
EPS

CubeSat Prototype Justification Grid

Monitoring your impact

What human impact did your group select to collect data on?

In the space below, brainstorm possible data you would need to collect to monitor this impact. Data can include images, weather data, position of objects, etc.

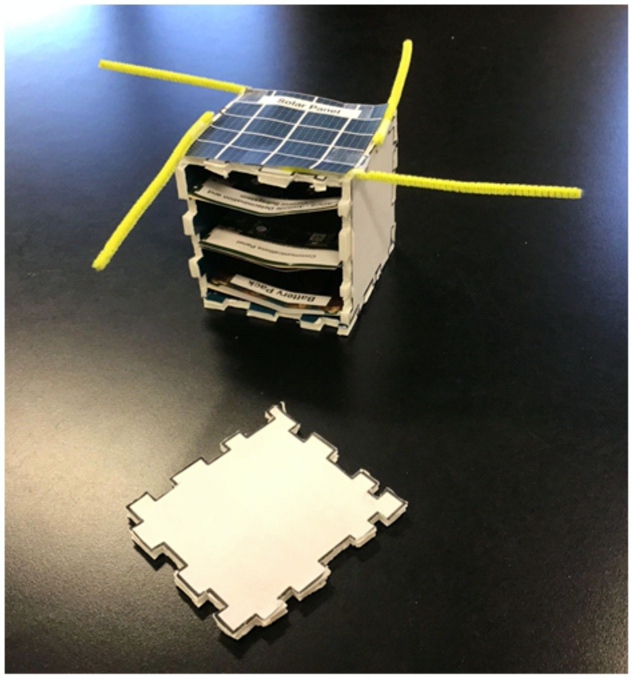
Designing your payload

Look through the provided Payload Options Sheet. Read with your groupmates what a payload is and look through the list of possible payloads for your CubeSat prototype. Make decisions on which payload options you would like to include in your CubeSat.

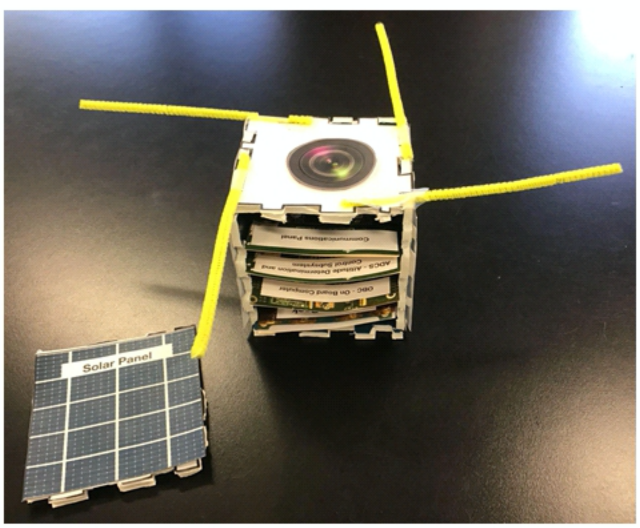
Complete the justification grid below to explain why each component is included in your CubeSat prototype.

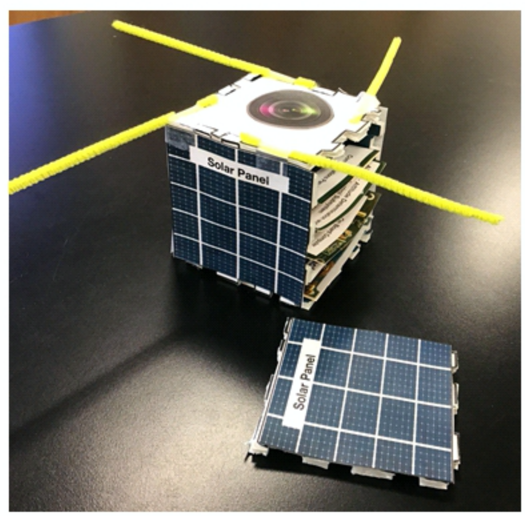
Payload Component	How will this payload component assist in collecting the human impact data you are interested in collecting?

Example - Initial CubeSat Prototype



Example - Final CubeSat Prototype





How Will My CubeSat Orbit?

Determining the best orbit for your CubeSat will ensure that it will collect the appropriate data, stay in orbit, and get the data back to Earth. Read each explanation below about CubeSat orbits. Make a claim regarding that CubeSat orbit specification. Support your claim with evidence from the reading and your specific goal for data collection. While you are reading, keep in mind the human impact you are trying to monitor. Feel free to use this graphic (Orbital Comparison from Wikimedia Commons) to help your decision making process.

<u>Specification 1: Type of Orbit</u>

There are three main types of orbits: low Earth orbit, middle Earth orbit and geosynchronous or high Earth orbit. The type of orbit determines how far the CubeSat is from Earth and therefore, how long it takes for the Cubesat to complete one orbit.

Low Orbit: This orbit starts right outside of Earth's atmosphere and is the best orbit to get high resolution images of Earth's surface. It starts approximately 180km above and can extend to 2,000km above the Earth's surface. Due to the closer proximity to Earth and its gravitational pull, these are the fastest orbits. They can move at 27,500km per hour and get around in 120 minutes and sometimes faster. CubeSats at this level will "de-orbit" or come down and disintegrate in 25-30 years.

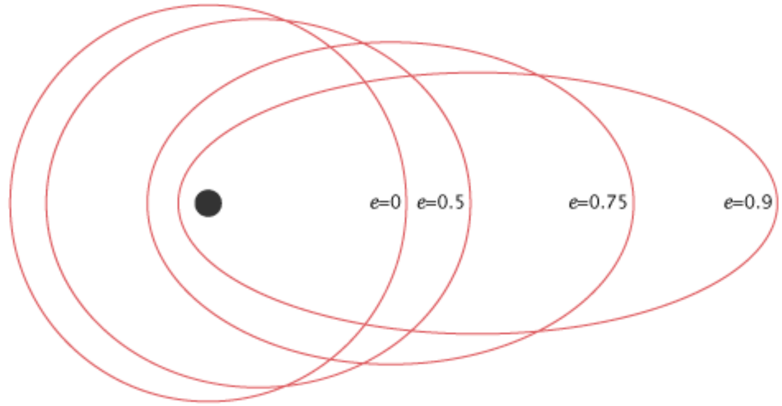
Middle Orbit: This orbit ranges from 2,000 km (1,243 mi) to 35,786 km (22,236 mi) above sea level and is the orbit of the Global Positioning System (GPS) constellation of satellites. Middle orbit is all of the space between the low orbit and high orbit. One issue of the middle orbit is the solar radiation pressure that is the main force on the satellites besides gravity.

High Orbit: This type of orbit is for weather and some communication satellites. Since it is approximately 375,800km from Earth, it takes the longest to orbit (around 23 hours). Another reason for the longer orbit is the less gravitational pull due to its distance from Earth decreasing the speed of the satellite. This orbit is about 1/10th the distance to Earth's natural satellite - the moon. A specific high orbit called Geosynchronous Earth orbit takes exactly 24 hours to complete one orbit.

Make a claim about which type of orbit will be best for your CubeSat.
List reasons or evidence from the reading why this will be the most appropriate type of orbit.

Specification 2: Eccentricity

This refers to the shape of the orbit. Eccentricity (e) is a range from zero to one. The smaller the number, the more circular the orbit. For example, e-0.75 is shaped like a chicken egg. The black dot in the picture ("Catalog of Earth Satellite Orbits" by Holli Riebeek; design by Robert Simmon) represents the Earth. If the orbit has a higher eccentricity, then it will get closer and farther away from the Earth in the same orbit. A highly eccentric orbit can be used to spend more time over the Northern or Southern Hemisphere because the speed slows down when the orbit gets to a point where it is farther from Earth.



Make a claim about the eccentricity of your orbit. Should it be circular (smaller e) or elliptical (larger e)?
List reasons or evidence from the reading to support the eccentricity.

Specification 3: Inclination

Inclination is the angle of the orbit when compared to the equator. If the inclination is 90 degrees, then it orbits directly over the North and South Poles. If the inclination is zero, then it is above the equator. All other values are called "inclined orbits"; 180 degree orbits above the equator, but in the opposite direction of Earth's rotation or spin. The inclination can be chosen to monitor a specific area of Earth.

Make a claim about the inclination of your orbit. Should it be zero degrees, 90 degrees or another value?
List reasons or evidence from the reading to support the inclination.