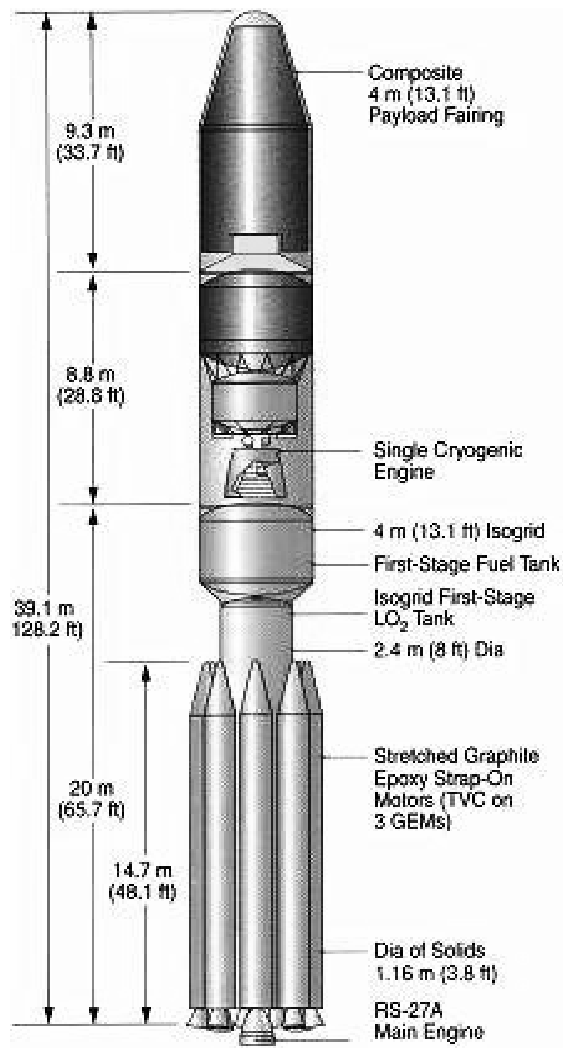
II...Design Your Own Research Satellite!

Introduction:

How do scientists design satellites? When scientists and engineers design research satellites, many different things have to be considered in order to accomplish the research they want to carry out. In this activity, students will design their own satellite. They will discover how the research goals of a satellite have to be balanced by the cost of the satellite and how much money the scientists would have to spend in order to conduct their research from space. The more you want the satellite to do for you, the heavier it will become, and the more it will cost to launch it!!

Objectives:

- The students will gain an understanding of how the research goals of a scientist have constraints such as weight, cost, materials and feasibility.
- The students will communicate their findings to classmates by drawing a picture or diagram of their research satellite.
- The students will develop an understanding of the decisions that a scientist makes when designing a satellite.



Materials:

Grades K-2

Copies of four quadrant square

Pattern blocks

Copies of the IMAGE satellite outline

Copies of the IMAGE instruments

Grades 2-6

Copies of the Procedures for the students

Copies of the Student Cost Factor Sheet

Procedure: Grades K-2

- The students are going to design their own satellite that is shaped like a square. The students will have to think like a scientist by making sure that each of the four quadrants has an equal amount of weight in it. In this activity, pattern blocks will be used to represent weights, and the hexagon shape will represent 100 pounds. Give each student a copy of the four quadrant square and a supply of pattern blocks. (This activity can easily be completed in groups also). Allow the students time to explore the pattern blocks. Direct the students to find a yellow hexagon. Then ask the students to find the ways to make the hexagon shape using other pattern block pieces. Some of the younger students may need to "build" on top of the yellow hexagon in order to find all the possiblities. When the students finish, direct them to consider each "hexagon" shape to be equal to an instrument that weighs 100 pounds. As scientists, the students will need to make 100 pound "instruments" in each of the four quadrants. There are many different combinations of pattern blocks that the students can use. When the students have completed all four of their instruments, they can record the shapes used in chart form or by drawing or stamping them onto the four quadrant square.

- The students will be given an outline of the IMAGE satellite and its instruments. The students will need to place the instruments on the outline of the satellite to meet certain criteria that can be read to the students, or have them read. Each instrument should touch the outside edge matching features in the outline. Begin by giving each student a copy of the outline and the instruments. With the exception of the RPI modules (in this case, where the antenea are released from the satellite) all of the instrument names are acronyms, so you can just call out the letters for the students to find the correct instrument or if your students are not recognizing all their letters, write them on the board or put them on the overhead. Start to discuss the shape of the satellite, how many sides does it have? Review with the students what happens on a seesaw both ends do not have the same amount of weight on them. When placing the instruments on the outline, the students will have to remember to balance the instruments on each side so that the weight is evenly spread out.

Criteria for placing the instruments on the IMAGE satellite:

1. The four RPI Antenna Modules must each be centered along the edge on different sides and no other instruments can be placed on the same side except for the HENA electronics They are the heaviest items on the satellite, remind the students that they have to be evenly distributed around the edge.

2. All of the instruments that have FUV (there are three- FUV-SI, FUV-GEO, and FUV-WIC) as a part of their name go along the same side of the satellite. No other instruments can go on this side of the satellite.

3. Have the students count how many sides do not have any instruments on them. There should be three sides left at this point that do not have instruments. The HENA, MENA, and LENA instruments each need to go on different sides.

4. The RPI electronics and the HENA electronics units can be placed on two of the sides with the RPI ANtenna Modules. The HENA electrical unit should be close to the HENA instrument.

5. Each of the remaining instruments, the RPI, CIDP, and EUV, can go on the same side as the HENA, MENA, and LENA. No instrument can be placed on top of or touching another instrument, so the students may need to do some rearranging as necessary. When you and the students feel that their satellite is "balanced" the instruments can be glued into place on the satellite outline.

6. The RPI Axial Antenna System can be placed in thye middle of the satellite.

Writing Activity:

Students will record their experiences in their learning logs.

Conclusions:

The students will gain an understanding of the decision making process that scientists use when designing a satellite. This process is not always completed by one individual, but often by teams of scientists working in many locations. The students should be aware of the constraints on designing an instrument or research satellite.

Grade K-2: Satellite Design. Four Quadrant Square

Sample Outline for the IMAGE Satellite Experiments

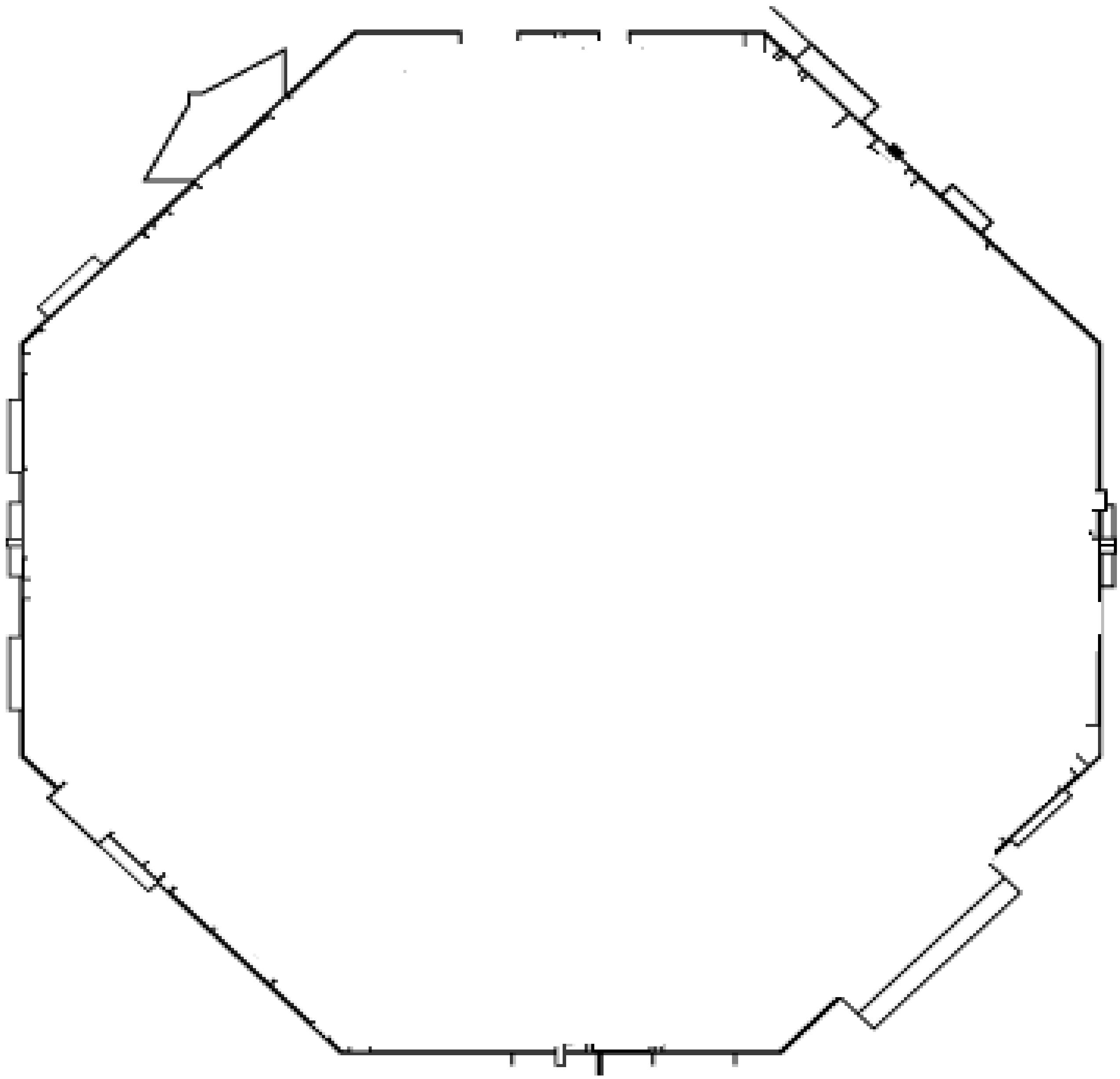
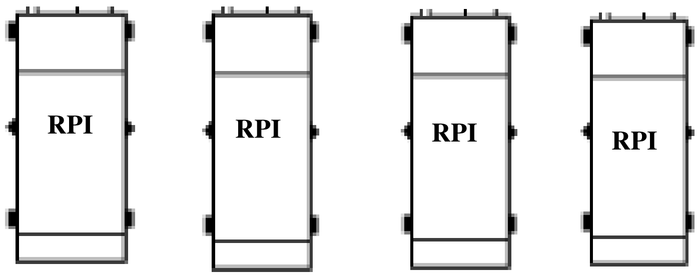
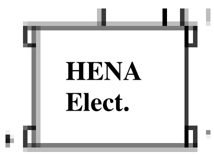


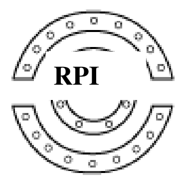
IMAGE Instrument Cutouts



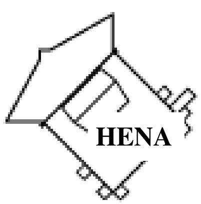
RPI Antenna Modules



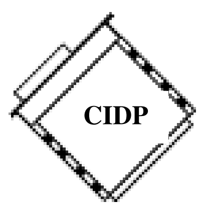
HENA Electronics



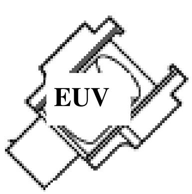
RPI Axial Antenna System



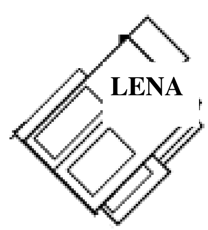
HENA Sensor Module



CIDP Satellite Electronics Module

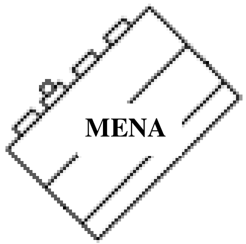


EUV Sensor Module

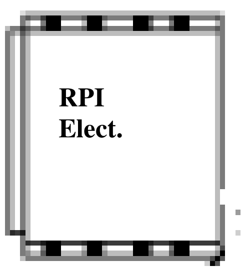


LENA Sensor Module

IMAGE Instrument Cutouts

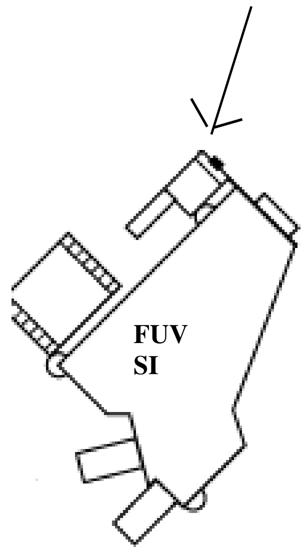


MENA
Sensor
Module



RPI
Electronics
Module

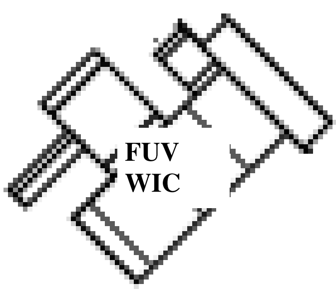
FUV / GEO



FUV
Spectroscopic
Imager
Module

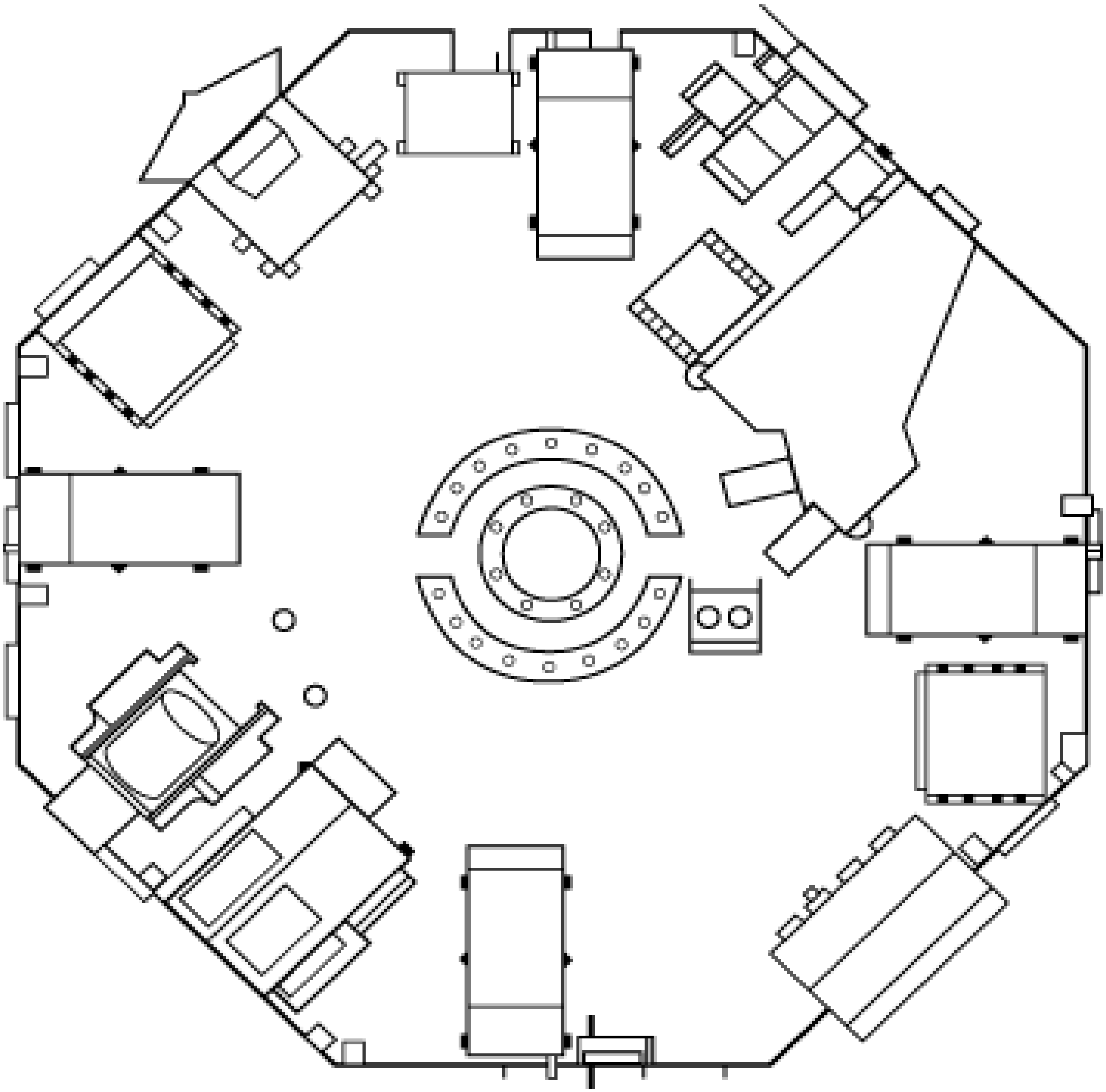
and

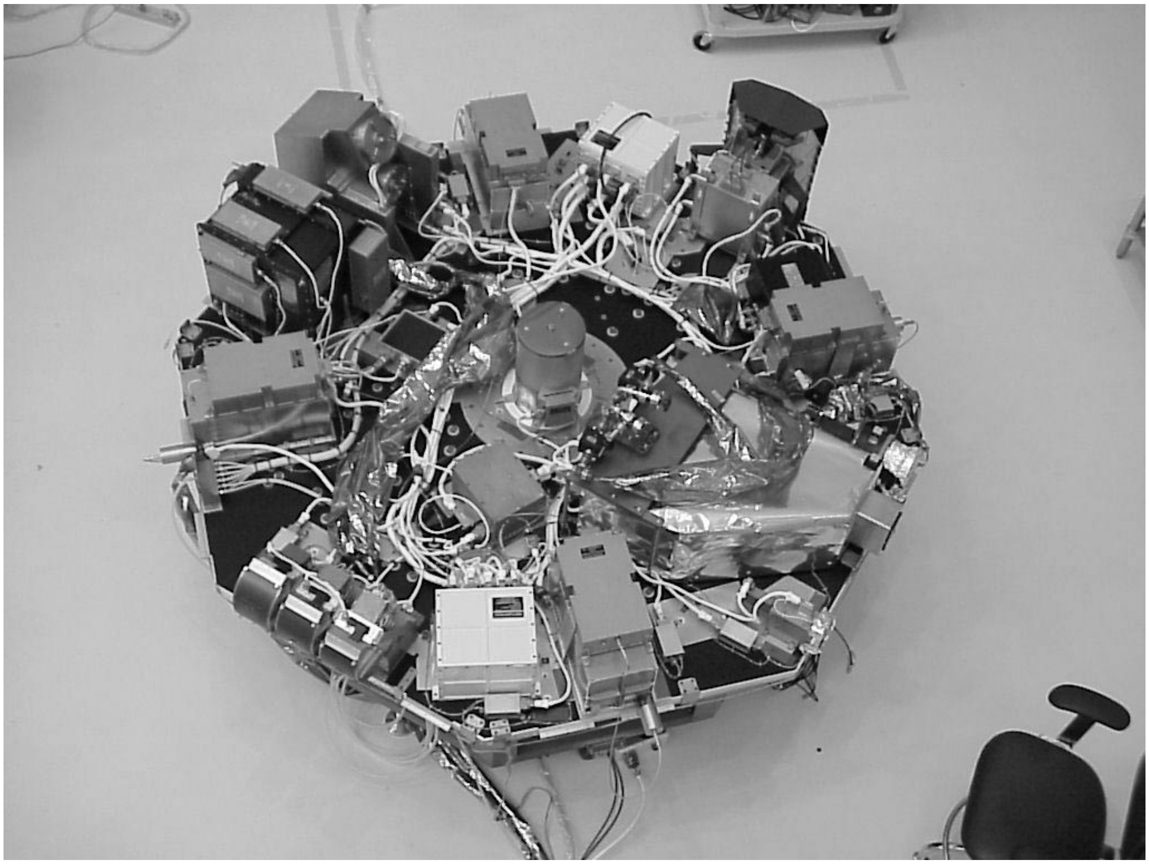
FUV-GEO
imager

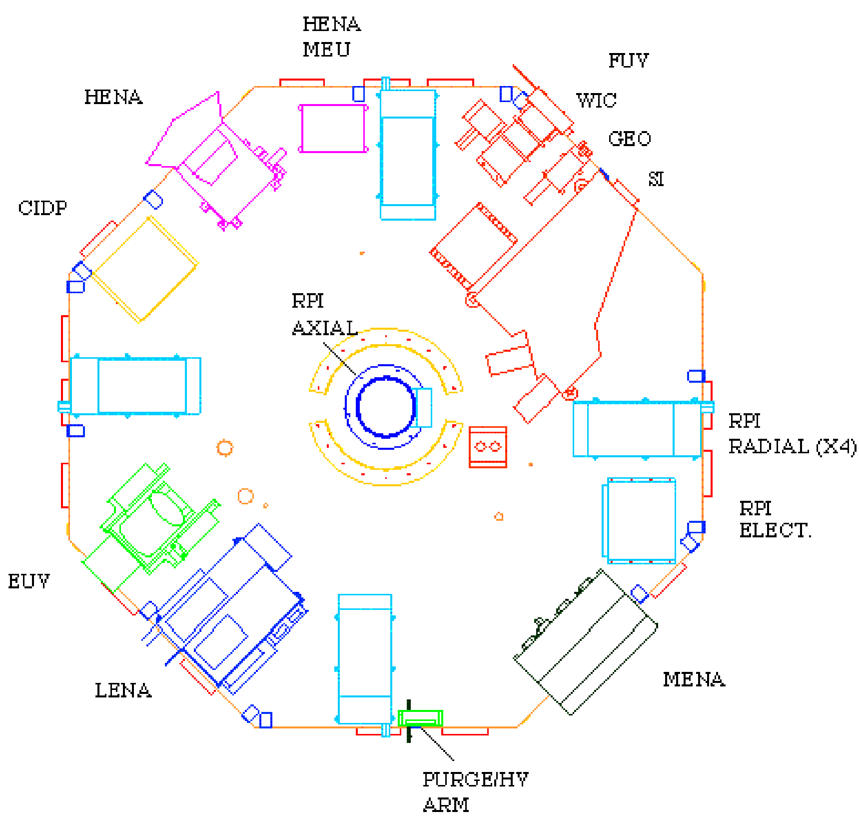


FUV
Wide Field
Camera
Module

Actual Satellite Instrument Layout.







HENA
MEU
FUV
WIC
GEO
SI
HENA
CIDP
RPI
AXIAL
RPI
RADIAL (X4)
RPI
ELECT.
EUV
MENA
LENA
PURGE/HV
ARM

Procedure: Grades 2-6

Cost factors in building a satellite.

- Select the experiments that you would like the satellite to accomplish from Chart 1. Write down the mass needed for each of your chosen experiments then find the total mass needed. You will also need to write down the required power in watts you will need for all your experiments then find the total watts needed. For example, a scientist wants to study how aurora are produced by low energy particles so he selects a WIC instrument and a LENA instrument for his satellite.
- In designing a satellite, all of the instruments listed in Chart 2 are required. Once you have decided your specific instruments from Chart 1, you will need to find the total mass and power in watts for all of the instruments in Chart 2.
- Select the spacecraft mass from Chart 3 by using the number of experiments you have chosen to complete including all those from Chart 2. The more experiments you select, the bigger and heavier you have to make the satellite to hold them.
- By looking at Chart 4 find the watts needed to power your experiment, and the additional mass needed to transport the required power. Virtually all earth orbit satellites use a combination of batteries and solar power.
- To find the grand total mass needed to launch your satellite, add your total mass from Chart 1 and Chart 2, your mass to support experiments from Chart 3, and your mass to power your satellite from Chart 4. Find your grand total mass in Chart 5 to determine the appropriate launch vehicle and its cost. (Experiments mass + Spacecraft mass + Power mass = Grand total mass)

Students can continue to complete this activity as many times as they would like by simply choosing the different experiment or experiments that the satellite could accomplish. The students can also explore what happens when they propose to build and launch 2, 3, or more identical satellites with the same launch vehicle. In order to have more than one satellite launched at the same time, the students will need to find the grand total mass for all the desired satellites. (Each satellite's experiment mass + Each satellite's spacecraft mass + Each satellite's power mass = Grand total mass for all satellites) This final grand total mass for all the satellites is used in Chart 5 to determine the appropriate launch vehicle and its cost.

Writing Activity:

Imagine that your research satellite has launched. What information or discoveries will your satellite transmit back to Earth? Write your thoughts as a narrative or informational and illustrate it.

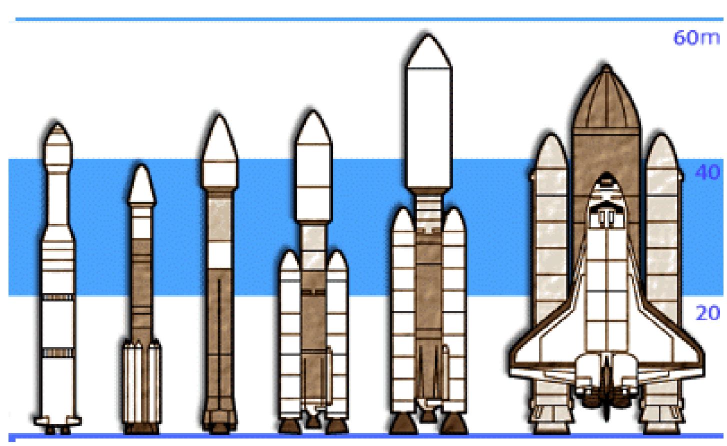


Chart 1. Select the experiments you want to use!

Instrument	Mass (kg)	Power (watts)	Experiment Function
High -Energy Neutral Atom Imager **(HENA)**	8.0	12.0	-detects and maps high-energy atoms in ring current, inner plasma sheet and substorm boundary
Medium- Energy Neutral Atom Imager **(MENA)**	7.0	7.0	-detects and maps medium-energy atoms in ring current, near-Earth plasma sheet and the nightside boundary
Low-Energy Neutral Atom Imager **(LENA)**	8.0	5.3	-detects and maps low-energy atoms from the polar ionsphere
Extreme Ultraviolet Camera (EUV)	15.6	15.5	- detects solar EUV photons in the Earth's plasmasphere
Spectrographic Imager **(SI)**	8.7	6.0	-identifies and produces images of the proton and electrons in aurora
Wideband Imaging Camera **(WIC)**	1.9	3.0	-produces images of auroral currents
Geocorona Photometers **(GEO)**	2.6	3.0	- detects light produced by hydrogen atoms.
Radio Plasma Imager (RPI)	49.8	30.8	-characterizes plasma clouds around earth using radio frequencies
Magnetometer	2.5	2.4	-measures direction strength of local magnetic field near spacecraft
Electric Field and Wave Sensor	15.5	8	-Measures electric fields near the spacecraft and detects their changes in time.
Solar Wind Plasma Analyzer	12.2	18	-composition of solar wind charged particles

Chart 2. Required components for each satellite

Instrument	Mass (kg)	Power (watts)	Experiment Function
Central Instrument Data Processor (CIDP)	11.0	11.8	-computer that processes the data from instruments
Antenna	14.4	4	- S band communication to ground
Telemetry Package	5.1	5.0	-transmits/receives data from ground
Spacecraft Electronics	18.0	18.5	-keeps spacecraft working in space
Attitude Torque Rods	15.4	5.3	-part of the spacecraft pointing system

Chart 3. Spacecraft mass to support the experiments.

Number of Experiments	Mass(kg)
1-5	100
6-10	500
11-13	1000

Chart 4. Mass of the electrical power supply.

Watts needed	Mass
1-10	10 kg
11-20	25 kg
21-35	40 kg
36-55	50 kg
56-80	60 kg
81-100	70 kg
101-200	100 kg

Chart 5. Cost of launch vehicle for low earth orbit.

Grand Total Mass	Launch vehicle	Cost
450 kg	Pegasus	$90 Million
1100 kg	Delta II-8925	$115 Million
1800 kg	Delta II- 7925	$105 Million
3000 kg	Atlas II	$150 Million
4500 kg	Atlas III	$180 Million
8200 kg	Atlas V	$290 Million
15,600 kg	Titan IV	$400 Million