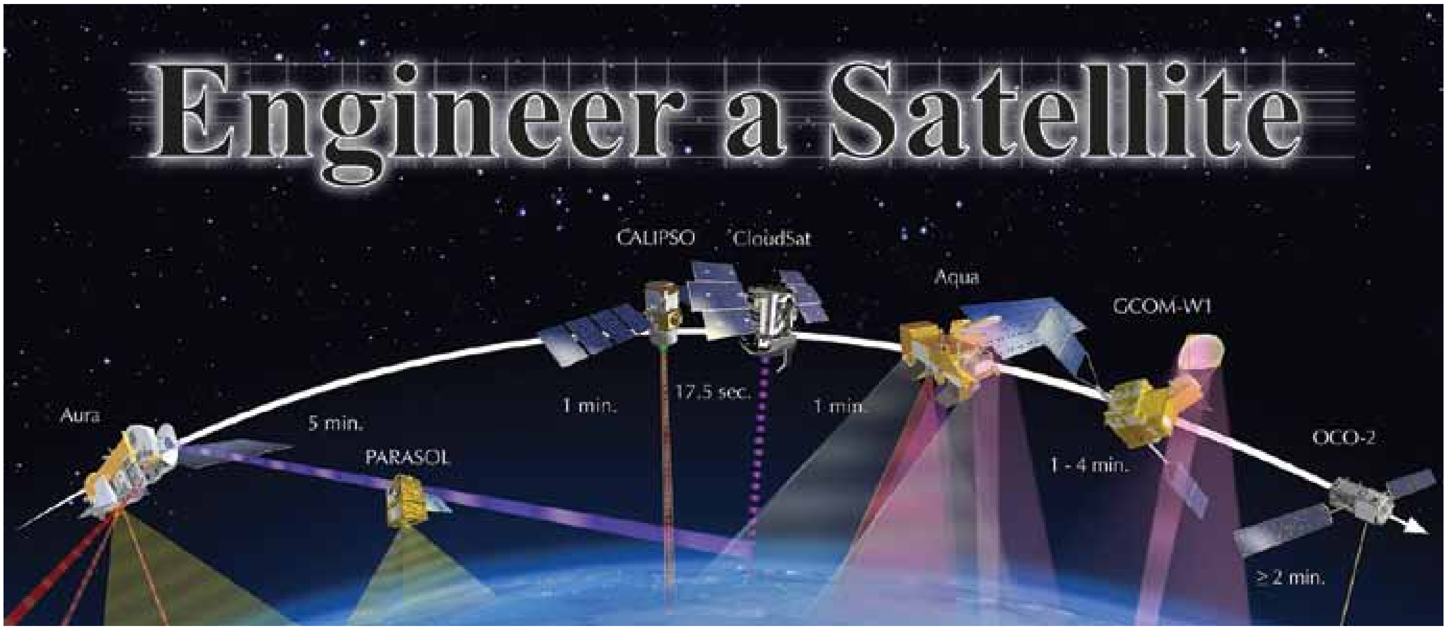


Is the ozone hole getting smaller? How much rain is in the cloud of a hurricane? How do forest fires and volcanoes impact air quality around the globe? Compelling questions like these are driving NASA scientists and engineers to answer them for the benefit of people everywhere. Engineers and scientists are essential partners in this process.

Engineers design instruments to measure energy across the electromagnetic spectrum. This energy travels in waves and these waves behave in predictable ways. They can be reflected, absorbed, scattered, and transmitted. Instruments measure how these waves behave when they interact with matter such as the Earth's surface or particles in the atmosphere. Scientists use this information to answer questions about the physical and chemical composition of our planet.

Some instruments are passive in that they sense energy emitted from the Earth's surface or solar energy reflected off the surface of the Earth. Mappers, or imaging instruments, measure light reflecting off the surface of the Earth to create images somewhat like an image from a digital camera. Sounders measure the vertical structure of the atmosphere either by observing the edge of the atmosphere (limb) or measuring the absorption of radiation vertically. These passive instruments use spectrometers to break apart and measure multiple bands of the spectrum like a prism, or use radiometers with filters to measure a specific band of energy.

Other instruments actively send infrared light or microwave pulses toward the Earth surface. Scientists can determine the heights of features on the Earth's surface such as mountains, sea level, and ice sheets by measuring the amount of time it takes for the signal to return. Scientists can also learn about the composition of the atmosphere by measuring how that signal interacts with the atmosphere as it returns to the instrument. Lidar and Radar are examples of active instruments.

Just as you can use data from a thermometer, barometer, and a hygrometer to get a clearer picture of the weather outside, scientists use a variety of instruments to get the bigger picture of our Earth system. Since one satellite can only carry a few of these instruments each, multiple satellites are used to collect data over the entire globe every day.

In 2004, NASA launched the Aura satellite to study the chemistry of the Earth's atmosphere. The instruments onboard Aura are helping scientists study air quality, the changing size of the ozone hole, and links between ozone chemistry and climate.

Aura is just one in a constellation of polar-orbiting satellites and together they collect data about the atmosphere, ocean, land, ice, and snow, and their influence on climate and weather. Data from these instruments are helping improve weather forecasts, manage agriculture and forests, inform fishermen and local planners, and expand our understanding how the Earth's climate is changing.

For printable worksheets, materials list, and more resources, visit the Aura mission website:
http://aura.gsfc.nasa.gov/outreach

NP-2012-05-878-HQ

Satellite Subsystems

All spacecraft require systems to operate properly. From capturing and storing energy to transmitting data, these systems are essential to a successful satellite mission and its contribution to science.

Attitude Control — 150 Watts

The attitude control subsystem calculates the satellite's orientation with respect to the Earth and generates information necessary for adjusting the orbit and attitude of the satellite.

Communications — 100 Watts

The receiving antenna, the main component of the communications subsystem, receives instructions from scientists on the ground. Scientists typically send 2 signals to the satellite per orbit, which require 50 Watts of power for each reception.

Data Handling — 200 Watts

The data handling subsystem handles the recording and transmission of the data collected by the instruments. Power is required to playback the data for transmitting to the ground station via X-band microwave frequency.

Thermal Control — 75 Watts

The thermal control subsystem maintains the temperature on board the satellite. Typical components include temperature sensors, thermostats, control electronics, and heaters - together requiring 75 Watts of power per orbit. Additional components such as fixed radiators, louvers, multi-layer blankets, coatings, and tapes are used to control for the effects of heat from both the Sun and the Earth's reflected sunlight.

Propulsion — 25 Watts

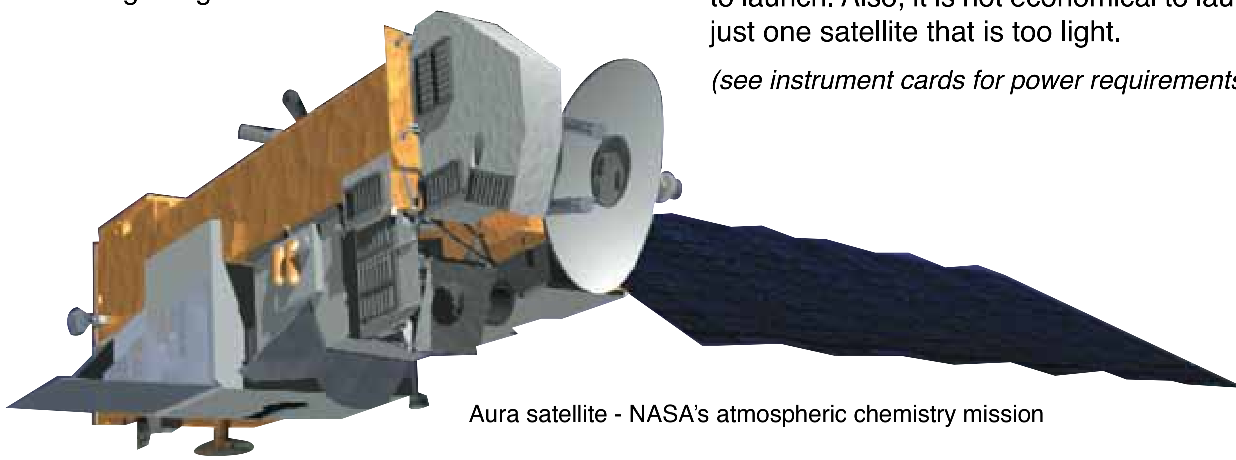
The propulsion subsystem generates the thrust necessary for adjusting the orbit and attitude of the satellite. Small mono-propellant rockets give the spacecraft the capability to adjust its orbit periodically to compensate for the effects of atmospheric drag, so that the orbit can be precisely controlled to maintain altitude and the assigned ground track.

Instrument subsystem

The instrument subsystem contains all the sensors used to gather information about the Earth. This subsystem also includes a computer and calibration instruments.

The number of instruments on a satellite is critical to both its purpose and its design. Having too many instruments on one satellite can cause problems such as being too heavy to launch. Also, it is not economical to launch just one satellite that is too light.

(see instrument cards for power requirements)



Aura satellite - NASA's atmospheric chemistry mission

Electrical Power subsystem

This subsystem generates and distributes the electrical power required for operating the satellite. Determine the size of the solar array and battery after calculating your satellite's total power requirements.

Batteries store energy to power the satellite for half of each orbit where the satellite is not exposed to the sun.

The solar array is a collection of solar panels that work together to convert energy from the sun to power the satellite. A solar array must generate two times the total power required. This enables the array to not only power the satellite half the time, but also recharge the batteries.

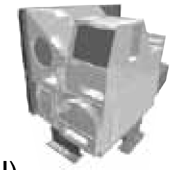
Sounding Spectrometer
Power: 250 Watts
Mass: 175 kg

The Atmospheric Infrared Sounder (AIRS) instrument on board the Aqua satellite, takes measurements of the gases in our atmosphere at different heights. The information from AIRS helps scientists lear more about our weather and climate.

The image on this card shows the distribution of water vapor in the atmosphere. Water vapor at higher altitudes appears brighter.

http://airs.jpl.nasa.gov/
http://aqua.nasa.gov

Imaging Spectrometer
Power: 100 Watts
Mass: 50 kg

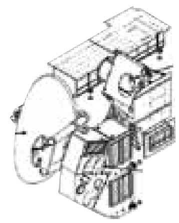


The Ozone Monitoring Instrument (OMI) spectrometer onboard the Aura satellite measures ultraviolet and visible light to measure particles and gases in the atmosphere and to track pollution near the Earth's surface.

The image on this card shows OMI data of ozone in the stratosphere for October of 2010. These data help scientists monitor the changes in the ozone hole above Antarctica.

http://ozonewatch.gsfc.nasa.gov/
http://aura.gsfc.nasa.gov/

Sounding Spectroradiometer
Power: 550 Watts
Mass: 450 kg

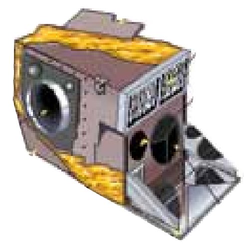


The Microwave Limb Sounder (MLS) instrument onboard the Aura satellite measures five different bands in the microwave region of the electromagnetic spectrum. This microwave radiometer has a unique ability to measure the presence and vertical distribution of gases in our atmosphere.

The image on this card shows ozone (left) and chlorine monoxide (right) over the Arctic.

http://aura.gsfc.nasa.gov/

Imaging Spectroradiometer
Power: 250 Watts
Mass: 225 kg

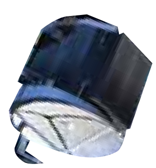


The Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the Aqua and Terra satellites measures visible and infrared energy. This instrument can provide images similar to what our eyes can see of the Earth's surface.

The image on this card shows the distribution of vegetation and ice in North America.

http://modis.gsfc.nasa.gov/

Radar
Power: 300 Watts
Mass: 250 kg
Antenna diameter: 1.85m

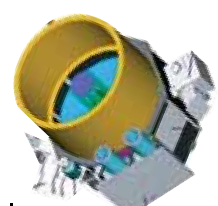


The Cloud Profiling Radar (CPR) instrument on the Cloudsat satellite uses microwave pulses at 94-GHz to determine the structure of clouds and the amount of liquid water or ice water in the clouds.

The image on this card shows a storm cloud. The more water in the cloud, the stronger the reflected signal. The red colors in this image show more water content.

http://cloudsat.atmos.colostate.edu/

Lidar
Power: 250 Watts
Mass: 150 kg
Telescope diameter: 1m

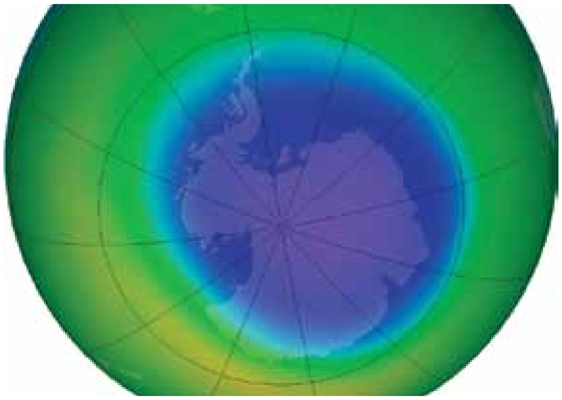


Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) can measure the distribution of aerosols and clouds over the globe by measuring how water vapor, ice and other particles scatter light differently.

The image on this card shows how the plume from a volcanic eruption in Iceland traveled over Europe. This event caused delays of flights in and around Europe in 2010.

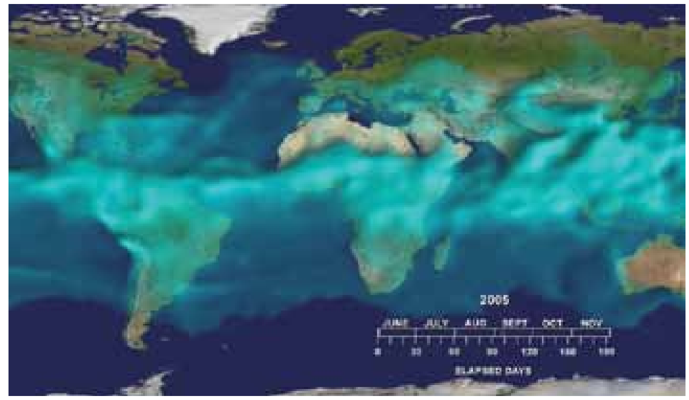
http://www-calipso.larc.nasa.gov/outreach/

Imaging Spectrometer **100 Watts**



An imaging spectrometer uses diffraction to separate light into a range of wavelengths to create images, or maps, of the Earth's surface or atmosphere.

Sounding Spectrometer **250 Watts**

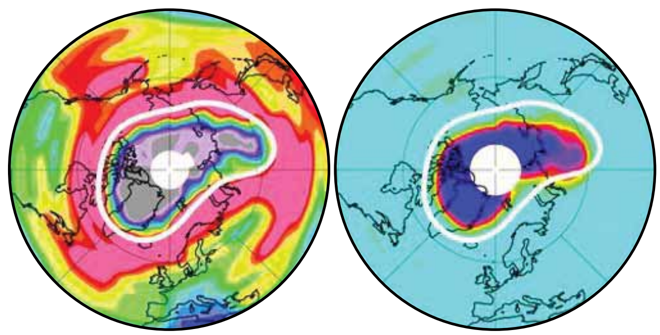


A sounder can take measurements at different levels of the atmosphere to determine the vertical distribution of gases such as water vapor.

Imaging Spectroradiometer **250 Watts**

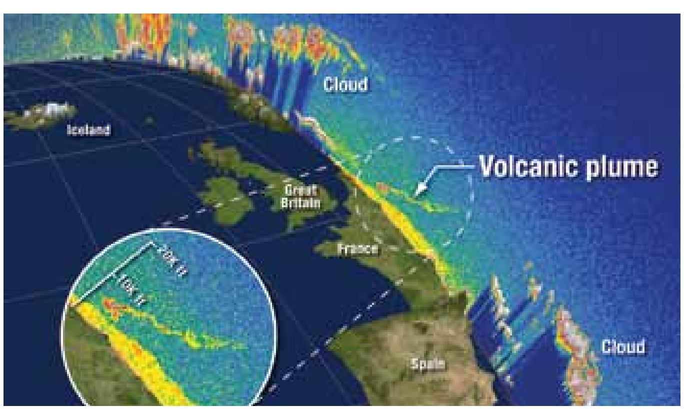
An imaging spectroradiometer creates images using different filters to isolate and measure energy within specific bands of energy.

Sounding Spectroradiometer **550 Watts**



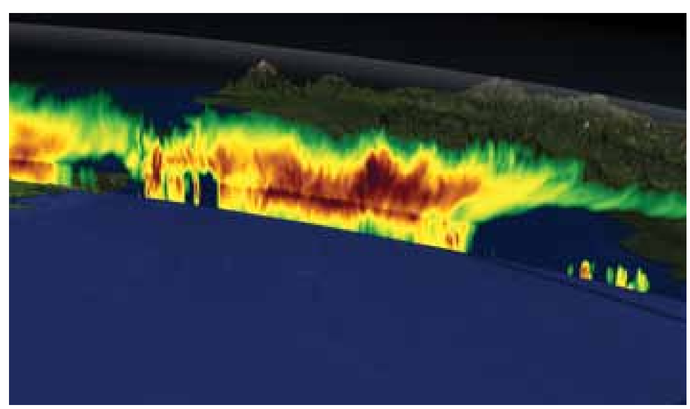
A sounder spectroradiometer can take measurements from different levels of the atmosphere using filters to isolate specific bands of energy.

Lidar **250 Watts**



Lidar sends infrared light pulses and measures the reflection and scattering to image the distribution of aerosols and gases in the atmosphere.

Radar **300 Watts**



Radar actively sends microwave pulses and measures the reflection and scatter behavior of the energy returned.