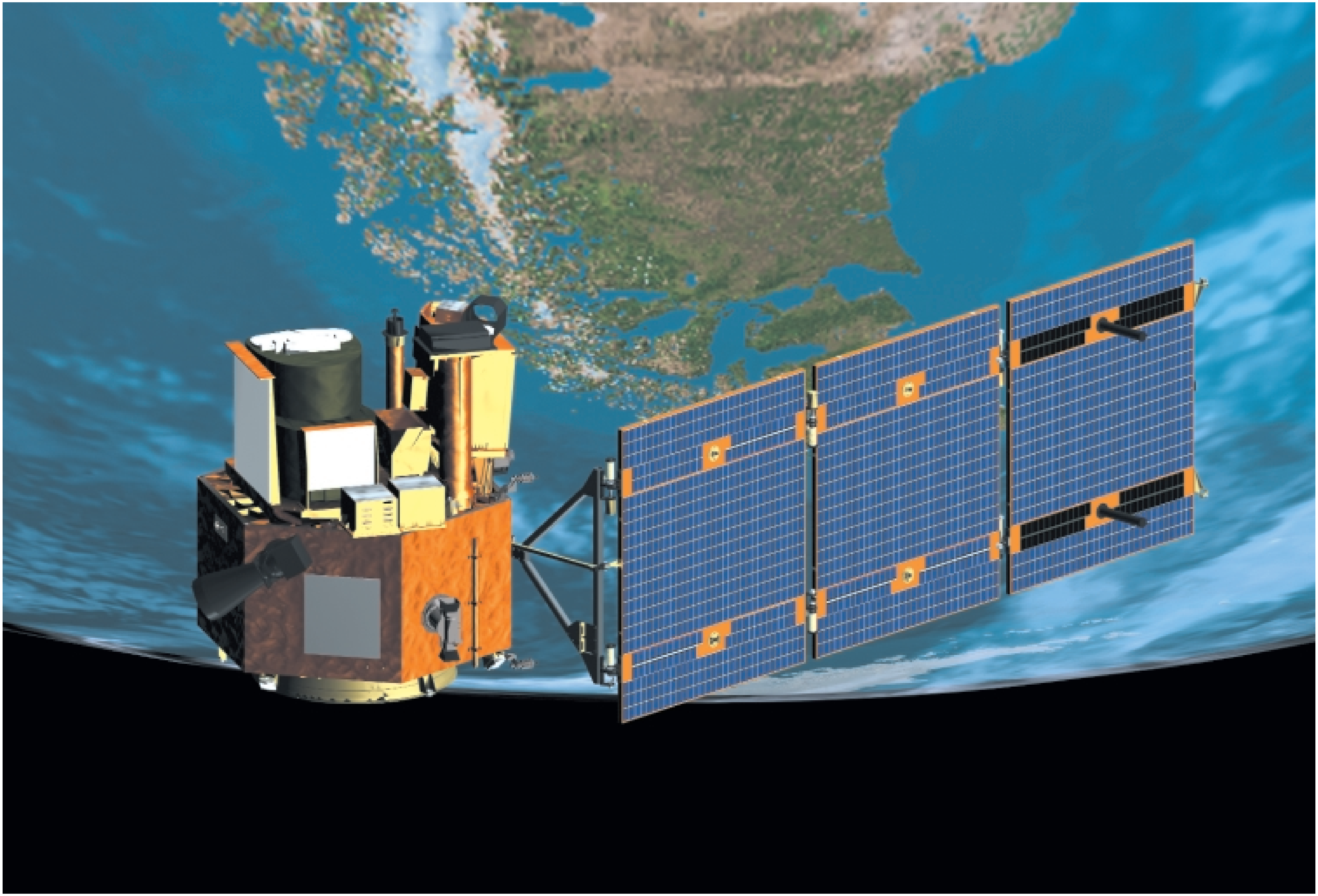
National Aeronautics and
Space Administration

Goddard Space Flight Center

New Millennium Program EO-1



National Aeronautics and Space Administration

Goddard Space Flight Center

New Millennium Program EO-1

The Program

Despite the successful history of the Landsat missions and other remote sensing missions, scientists and engineers saw a need for "leaner" and less expensive remote sensing satellite missions. In 1996, NASA started the New Millennium Program (NMP), designed to identify, develop, and flight-validate key instrument and spacecraft technologies that can enable new or more cost-effective approaches to conducting science missions in the 21st century.

The first of these NMP Earth-orbiting missions is Earth Observing-1 (EO-1), an advanced land-imaging mission that will demonstrate new instruments and spacecraft systems. EO-1 will validate technologies contributing to the significant reduction in cost of follow-on Landsat missions. EO-1 is scheduled to launch on a Delta 7320 from Vandenberg Air Force Base, California, in the fall of 2000. EO-1 has a 1-year primary mission but was designed to operate for an additional year.

Spacecraft and Instruments

The three remote sensing instruments on the EO-1 observatory are the Advanced Land Imager, the Hyperion Imaging Spectrometer and the Linear Imaging Spectrometer Array Atmospheric Corrector.

Advanced Land Imager (ALI)

The ALI instrument will feature 33-feet (10-meter) ground resolution in the panchromatic (black & white) band, and 98-feet (30-meter) ground resolution in its nine other multispectral bands. The ALI uses a four-chip multispectral focal plane array that covers seven of the eight bands of the current Landsat imagers. The swath width of the ALI is 23 miles (37 kilometers). It was developed by Massachusetts Institute of Technology/Lincoln Laboratory, under project management from NASA's Goddard Space Flight Center, Greenbelt, Maryland. MIT/LL will provide open access to U.S. industry regarding the design and performance of the ALI instrument with the explicit purpose of expediting technology transfer to the commercial sector. Performance of the EO-1 multispectral imaging capability is expected to yield almost four times better performance at only one-fourth the cost and weight of the Landsat ETM+.

Hyperion (Hyperspectral)

The Hyperion provides a class of Earth observation data leading to improved surface spectral characterization. The Hyperion capabilities provide resolution of surface properties into hundreds of spectral bands. Through 220 channels, the Hyperion will demonstrate the ability to perform detailed spectral mapping with high radiometric accuracy. In the future, an operational version of the Hyperion will allow complex land ecosystems to be imaged and accurately classified. The swath width of the Hyperion is 5 miles (7.6 kilometers) and is aligned to view some of the same ground, at the same spatial resolution (30 meters), as the ALI instrument to aid in cross-comparisons between these instruments. The Hyperion instrument was developed by TRW, Redondo Beach, California, under project management by NASA Goddard.

Linear Etalon Imaging Spectrometer Array (LEISA) Atmospheric Corrector

The Linear Etalon Imaging Spectral Array/Atmospheric Corrector (LEISA/AC) is an infrared camera. Images from the AC can be used to remove the effects of the atmosphere from surface pictures obtained by instruments such as the Advanced Land Imager (ALI) on EO-1 and Landsat.

Observing the surface through the atmosphere is conceptually the same as viewing the bottom of a lake through cloudy water. The AC provides data on the amount of atmospheric water vapor. These data can be used to clear the view. The AC on EO-1 will be the first use of a dedicated instrument to perform this function on a real-time basis. This instrument will provide scientific return both in terms of improved imagery and hyperspectral sensing capabilities. It will also test a number of new technologies. Because the AC is small and adaptable to different spacecraft configurations, it is a bolt-on instrument, which can be attached to any future Earth imaging spacecraft.

The LEISA AC instrument was developed by Goddard's Applied Engineering and Technology Directorate (AETD). AETD will provide open access to U.S. industry regarding the design and performance of the LEISA AC instrument with the explicit purpose of expediting technology transfer to the commercial sector.

Validating Revolutionary Spacecraft Technologies

The future of Earth science measurements requires that spacecraft have ever-greater capabilities packaged in more compact and lower cost spacecraft. To this end, EO-1 tests, for the first time, five new technologies which will enable new or more cost-effective approaches to conducting science missions in the 21st Century. These are: the X-band Phased Array Antenna, used for downlinking data gathered by the EO-1 science instruments; Enhanced Formation Flying, an autonomous, onboard, relative navigation and formation flying control; the Pulse Plasma Thruster, used for fine attitude precision control; the Lightweight Flexible Solar Array, an advanced photo-voltaic solar array which utilizes a lightweight solar blanket and shockless, shaped-hinge deployment mechanism to achieve two to three times the specific power over conventional solar arrays; and the Carbon-Carbon Radiator, which has superior thermal radiating properties over conventional materials.

Other EO-1 Technology Challenges

The EO-1 imaging instruments presented a significant challenge to traditional spacecraft development. Because of EO-1's high-rate imaging (almost 1 gigabit per second when all three instruments are on), a specific subsystem on the EO-1 observatory needed to be designed and crafted to handle the data rate while still maintaining flight constraints of compact size and low power usage.

Although not officially part of the NMP/EO-1 validation list, the Wideband Advanced Recorded Processor (WARP) is a solid-state recorder with capability to record data from all three instruments simultaneously and store up to 48 Gbits (2-3 scenes) of data before it is transmitted to the ground. WARP's compact design, advanced solid-state memory devices (3 dimensional RAM stacks) and packaging techniques enable EO-1 to collect and downlink all recorded data.

Management

The New Millennium Program is managed by NASA's Jet Propulsion Laboratory in Pasadena, California, for NASA's Office of Space Science and Office of Earth Science in Washington, D.C.

NASA's Goddard Space Flight Center has project management and implementation responsibility for technology flight validation of EO-1. Goddard's other supporting roles include integration of Argentina' Satélite de Aplicaciones Cientificas-C (SAC-C) satellite with the EO-1 launch vehicle, Integrated Product Development Team co-leadership and participation in the NMP Architecture Development Team.

For the Classroom:

Objective:
The student will be able to calculate the velocity of a polar-orbiting satellite given the altitude and period of the orbit.

Materials: paper
pen (pencil)
calculator

Backg round:
Assume you are working with a circular orbit for ease of calculation. If a satellite is orbiting the Earth at an altitude of 750 miles and completes an orbit every 3 hours, 45 minutes, what is the velocity of the satellite?

Step 1: Change 3 hours, 45 minutes to

$$3\frac{45}{60}\text{ hours} = 3\frac{9}{12}\text{ hours}$$

$$= 3\frac{3}{4}\text{ hours}$$

$$= 3.75\text{ hours}$$

The radius of an orbit is calculated from the center of Earth. Consequently, the radius of an orbit equals the radius of Earth plus the altitude of the satellite above Earth.

Step 2. According to the formula $C = 2 \times \pi \times r$, the distance traveled is

$$C = 2 \times \pi \times (3960.5 + 750)\text{ miles} \approx 29581\text{ miles.}$$

Step 3. This distance is traveled each 3.75 hours. Therefore, the velocity of the satellite is

$$\frac{29{,}581\text{ miles}}{3.75\text{ hours}} \approx 7{,}888\text{ miles per hour}$$

Procedure:

1. Have students investigate Earth-orbiting satellites and report on the purpose of the satellite. For each satellite, have them include their calculations for determining the velocity using the metric system.

2. Have students investigate previous or current satellites orbiting other planets in the solar system. Calculate the velocities of the satellites reported in the investigation.

3. Students can then explore how the size of the planets affect velocity and the distance the satellite travels in orbit by designing their satellite for each planet in the solar system.

Discussion

1. Engage the class in a large-group discussion about the satellite images they see on local television news broadcasts. In the discussion, help the students distinguish among animations of Shuttle missions, photographs from the Space Shuttle, and satellite images of Earth.

2. Discuss the challenges associated with a satellite following another satellite in the same orbit. Discuss how they would calculate the velocity of the satellites down to the minute and second.

Additional satellite images can be found at
http://landsat.gsfc.nasa.gov/main/education.html

For more information on EO-1, visit: http://eo1.gsfc.nasa.gov

LG-2000-6-011-GSFC