# U.S. GOVERNMENT SATELLITE REMOTE SENSING PROGRAMS: 1995-2000

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**ABSTRACT:**

An overview of U.S. remote sensing satellite programs for the years 1995 to 2000 is presented. Details are provided for the NOAA, Landsat and Earth Observing System (EOS) missions.

## 1. INTRODUCTION

There has been a world-wide increase in Earth remote sensing satellite programs since the 1992 International Society for Photogrammetry and Remote Sensing (ISPRS) Congress held in Washington, D.C. It is realized, today, that the processes of the Earth and its people do not operate in isolation. Therefore, the goal of many government sponsored satellite programs includes global monitoring to enhance our understanding of the environment and to allow us to manage vital resources. In addition, there is a growing market for high resolution image data and orthoimage products for more focused studies of smaller areas. In the United States, the first issue is being addressed by the government and the second issue by commercial enterprises (Table 1). It is the government sponsored remote sensing programs that are addressed in this paper.

Government sponsored remote sensing satellite programs tend to be long-term with an emphasis on global coverage at lower spatial resolutions. Continuity with existing programs is important and applications include environmental monitoring and global change assessment. Commercial remote sensing satellite programs, on the other hand, are a more recent phenomenon with many endeavors still in the planning stages. These programs tend to: 1) emphasize the acquisition of high spatial resolution image data (e.g., 1 m) for limited areas on a demand-basis; and 2) stereo images for the production of digital elevation models (DEMs) and orthoimage products. Spectral band widths are also relatively narrow (typically 0.45 to 0.9 um) compared to those used or planned for government remote sensing satellite programs.

Table 1. A Sample of U.S. Space Programs 1995-2000

| U.S. Government | Commercial |
|---|---|
| NOAA | GDE |
| LANDSAT-7 | Space Imaging |
| EOS | Orbimage |
| | EarthWatch |
| | Resource 21 |
| | TRW Lewis |
| | CTA Clark |

## 2. NOAA

The National Oceanic and Atmospheric Administration (NOAA) is one of the oldest U.S. space satellite programs dating back to the late 1970's. Image data acquired by the Advanced High Resolution Radiometer (AVHRR) sensor with a 1.1 km spatial resolution and 5 bands are well adapted for land monitoring applications, and are widely used because of the broad area coverage and low cost (NOAA, 1995).

Table 2. NOAA Remote Sensing Satellite Program

Satellite
- 833 km Altitude
- Sun Synchronous Orbit (98.9$^0$)
- Orbit Period 102 min.
- Daily (Visible) and Twice-Daily (TIR) Coverage

Sensor
- Advanced Very High Resolution Radiometer (AVHRR)
- 1.1 km Spatial Resolution
- 4 or 5 Bands (1 Visible, 1 NOR, 3 TIR)
- 2400 km Swath Width

Data
- Full Resolution Archive as Local Area Coverage (LAC)
- Resampled Archive as Global Area Coverage (GAC)

AVHRR image data are useful for classifying general categories of land cover. The high temporal resolution and low cost of the data also are important for resource monitoring applications and input to global or regional models. The joint NOAA and National Aeronautics and Space Administration (NASA) Pathfinder Program, for example, makes use of AVHRR and Landsat image data to: 1) take advantage of currently archived image data in support of global change research; and 2) test processing and data management strategies for handling the enormous amounts of data that are expected from the Earth Observing System (EOS) program planned for later in the decade (NOAA-NASA, 1994).

## 3. LANDSAT-7

Another long-term U.S. government satellite program which began in 1972 is Landsat. Landsat-7, the next planned mission after the ill-fated unsuccessful launch of Landsat-6, will be a joint venture between NASA, NOAA and the U.S. Geological Survey (USGS). It is also a part of NASA's Mission to Planet Earth (MTPE) which is dedicated to monitoring the environment and assessing global change (Asrar and Greenstone, 1995).

Orbital parameters for Landsat-7 are designed to provide continuity of data with those obtained by previous Landsat satellites. The primary sensor is the Enhanced Thematic Mapper Plus (ETM+) (Table 3). The ETM+ will acquire data of increased spatial resolution for panchromatic (15 m) and thermal infrared (60 m) bands. This improved resolution will permit better characterization and monitoring of land cover/processes. Procedures are also in place for more rapid data dissemination to the user.

Table 3. Landsat-7

Satellite
- 1998 launch from 705 km Altitude
- Sun Synchronous Orbit ($98^0$)
- 10:00 am Descending Node Orbit
- Ground Track Repeat Interval 16 Days

Sensor
- Enhanced Thematic Mapper+ (ETM+)
- 8 Bands (1 Pan at 15 m, 6 VNIR and SWIR at 30 m, 1 TIR at 60 m)
- 3.8 Gb per Scene (185 x 170 km)
- Solid State On-Board Storage 380 Gb or 100 Scenes

Data
- USGS EROS Data Center - Process 250 Scenes per Day
- Deliver up to 100 Scenes per Day to User
- Data to be Available for Order within 24 hrs of Acquisition

## 4. EARTH OBSERVING SYSTEM (EOS)

The Earth Observing System (EOS) is the centerpiece of NASA's MTPE and a key component of the U.S. Global Change Research Program. Beginning in 1998, EOS will consist of a series of Earth remote sensing spacecraft, each carrying up to six instruments and launched every three to five years (Asrar and Greenstone, 1995). In this way, continuous data will be provided over the 15 year lifetime of the program for observation of the atmosphere, oceans and Earth's surface.

EOS AM-1 is scheduled for launch in mid-1998 and will include five sensors (Table 4). Of these, the Moderate-Resolution Imaging Spectroradiometer (MODIS) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) sensors are most applicable for land resource mapping applications.

Table 4. Sensors On-Board EOS AM-1

CERES - Clouds and Earth's Radiant Energy System

MISR - Multi-angle Imaging SpectroRadiometer

MODIS - Moderate Resolution Imaging Spectroradiometer

MOPITT - Measurements of Pollution in the Troposphere

ASTER - Advanced Spaceborne Thermal Emission and Reflection Radiometer

The 36 band MODIS sensor is designed to measure biologicaland physical processes (at 250 to 500 m spatial resolution) on a global scale every one to two days (Table 5). Slated for both EOS AM and PM satellite series, MODIS will provide long-term observations of global changes, Earth surface processes and the lower atmosphere.

Table 5. EOS MODIS Sensor

Satellite
- 705 km Altitude
- Sun Synchronous Orbit ($98.2^0$)
- 10:30 am Descending Node
- Ground Track Repeat Interval 16 Days

Sensor
- MODIS - Moderate Resolution Imaging Spectroradiometer
- 36 Bands (VNIR, SWIR, TIR at 250 m, 500 m or 1 km)
- Share of Solid State On-Board Storage of 140 Gb
- Revisit Time (with cross-track tilt) of 2 Days

Data
- Primary Data Return via TDRSS

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is a joint venture between U.S. and Japanese scientists that will provide data of high spatial resolution (15 to 90 m) from visible to thermal infrared wavelengths (Kahle, et al., 1991; Table 6). This information will be used for long-term monitoring of the land surface, water, ice and clouds (Asrar and Greenstone, 1995). A number of mapping applications are planned for ASTER data such as vegetation, land use patterns, hydrology, geology and surface topography. Of primary interest to the mapping community is the capability of generating digital elevation models (DEMs) from the along-track stereo image data made possible by simultaneous acquisition of nadir and aft pointing images (Arai, 1992; Welch and Lang, 1994; Welch, 1995).

Table 6. EOS ASTER Sensor

Satellite
- 705 km Altitude
- Sun Synchronous Orbit (98.2$^0$)
- 10:30 am Descending Node
- Ground Track Repeat Interval 16 Days

Sensor
- ASTER - Advanced Spaceborne Thermal Emission and Reflection Radiometer
- 14 Bands (3 VNIR at 15 m, 6 SWIR at 30 m, 5 TIR at 90 km)
- Along-Track Stereo (Aft and Nadir)
- Share of Solid State On-Board Storage of 140 Gb
- Revisit Time (with cross-track tilt) of 2 Days

Data
- Primary Data Return via TDRSS

## 5. CONCLUSION

U.S. government remote sensing satellite programs including NOAA, Landsat-7 and EOS are designed to acquire image data suitable for land resource mapping applications. These programs are long-term commitments to global monitoring with an emphasis on continuity with existing satellite programs. Over the next five years the increase in data acquisition will be accompanied by advances in image processing and mapping applications, particularly in the integration of remote sensing and GIS for modeling global change.

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