PART 6. EXTENDED MISSION

1. INTRODUCTION

The New Millennium Program Earth Observing-1 (EO-1) program completed its baseline mission requirements successfully after one year of operations on November 20, 2001. In December 2001, NASA Headquarters approved a plan to permit the EO-1 Program to embark on an Extended Mission operations phase. The objectives of the Extended Mission are to maximize the infusion of EO-1 technology by simultaneously increasing utilization of the on-orbit resource and to reduce the cost of operations through a Continuous Improvement Program that is further described in Part 8 of the Validation Report.

To accomplish this objective, a collaborative partnership between NASA and the U.S. Geological Survey (USGS) was forged to take advantage of the inherent strengths of each agency. The partnership began officially in January 2002 via an Implementation Agreement (IA).
NASA-DOI.pdf

During the latter part of the Extended Mission period, there were activities to define the expected remaining lifetimes of EO-1 critical components and based on the date of reentry start, to compute the time period for reentry. In addition, two highly significant presentations were made at NASA Headquarters on maintaining mission continuity beyond fiscal year 2005 and to solicit additional funds from the National Reconnaissance Office (NRO) and the National Geospatial-Intelligence Agency (NGA).

Documentation of these activities and presentations follow:

1. EO-1 Mission Continuity FY05 and Beyond (Oct. 4, 2004)
2. EO-1 NRO/NGA Presentation (Jan. 13, 2005)
3. Reentry Variance Memorandum
4. Reentry Parameter Table – JSC
5. Reentry Lifetime Graph
6. Life Limiting Components Table
7. Total Ionizing Dose Environment for the EO-1 Spacecraft
8. Refinement of Orbital Debris Assessment Report

2. NASA/USGS PARTNERSHIP

2.1 Roles and Responsibilities

Basically, the IA instituted the commercial sale of ALI and Hyperion imagery and allowed the USGS EROS Data Center (EDC) to assume the responsibility for all customer interface services related to the acquisition, archival, and distribution of EO-1 image data. EO-1 archives of ALI and Hyperion data can be directly queried and ordered with the Earth Explorer interface (**http://earthexplorer.usgs.gov**). Data

Acquisition Requests (DARs) for tasking the spacecraft are to be made through the USGS, should archive data not be available for an area of interest. Further information can be obtained from the USGS website at **http://eo1.usgs.gov**.

Pricing for new image acquisition tasks, as well as sale of data sets from the archive, were set based on Landsat imagery prices. Each agency invested FY02 funds to start the partnership. NASA funding was applied to continuing satellite operations and science support activities. USGS funding established the ground station downlink operations, level 0 and level 1 processing, archive, distribution, user services, and observatory scheduling functions at EDC. The roles and responsibilities for each agency in implementing this agreement are listed below.

NASA's role in the EO-1 Extended Mission partnership is as follows:

- *Maintain ownership of spacecraft*
- *Conduct command and control operations*
- *Eventually perform satellite decommissioning and de-orbit maneuver*

The USGS role is as follows:

- *Serve as customer interface*
- *Manage data capture operations*
- *Perform ALI/Hyperion scheduling and tasking*
- *Perform data processing and product distribution*
- *Function as long term archive facility*

The NASA role is performed by spacecraft and systems engineers at GSFC in Greenbelt, Maryland and the USGS role is performed by engineers and technicians at the Earth Resources Observing Systems (EROS) Data Center (EDC) in Sioux Falls, South Dakota.

A high level overview of the ground system and related operations, prior to the NASA/USGS partnership agreement, is depicted in Figure 1. Figure 2 illustrates the above stated division of roles that took effect after start of the partnership agreement.

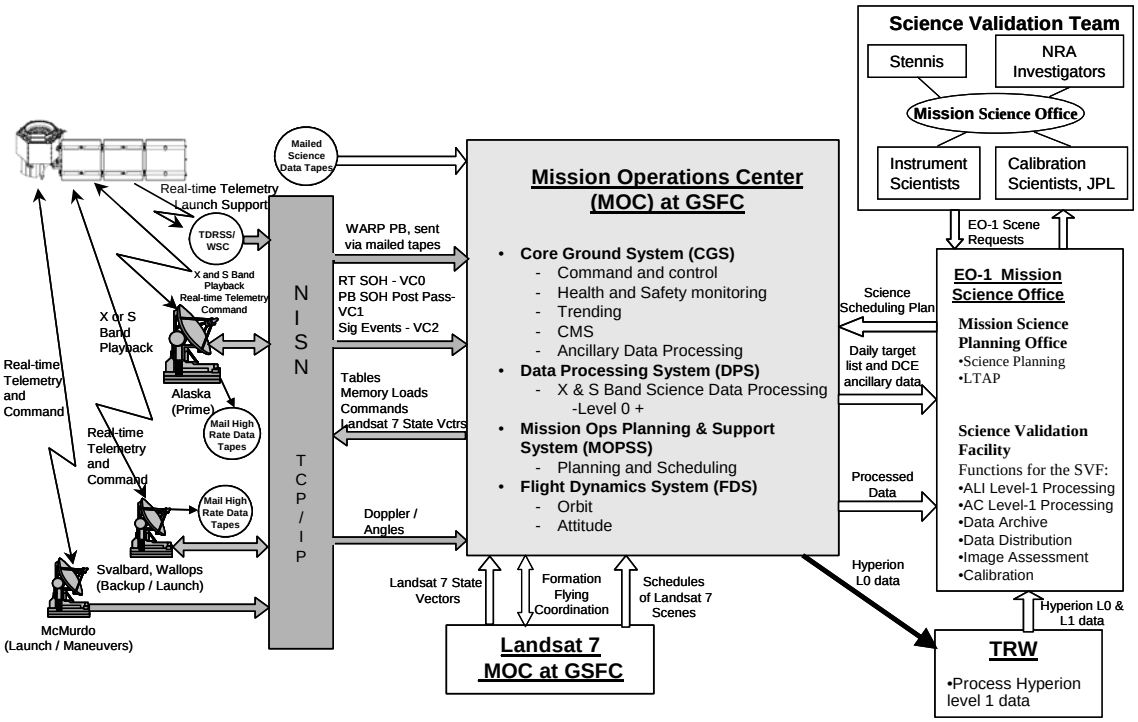

Figure 1. Ground System Configuration Prior to NASA/USGS Partnership Agreement

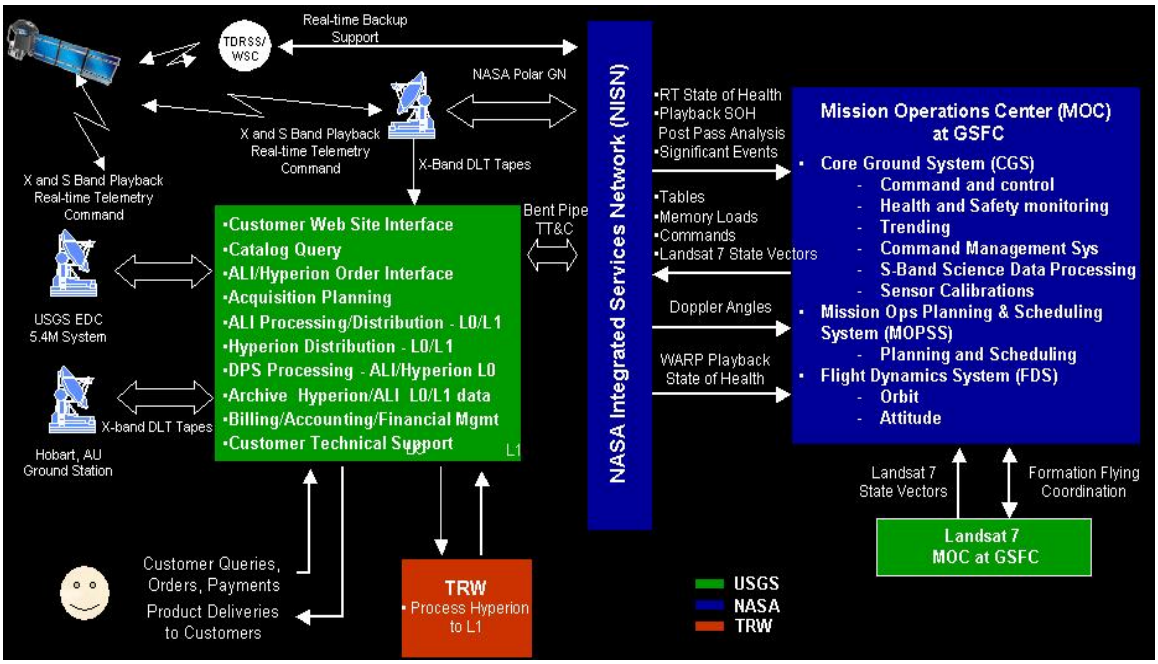

Figure 2. Ground System Configuration After NASA/USGS Partnership Agreement

2.2 Streamlining Operational Procedures

It was determined, that to make EO-1 commercially viable, the following four inter-related changes would be needed: increase the number of daily Data Collection Events (DCE's); decrease the cost of

taking a DCE; increase the customer base; and decrease the turnaround time to process scenes. The target is to earn enough revenue to pay for the operations, or at least to the degree possible, minimize the cost to each of the agencies. At the start of the Extended Mission phase, data processing equipment, procedures, existing archive data sets (approx. 2000), and science algorithms were transferred from GSFC to EDC. An operations transition plan was co-written to better delineate the roles and responsibilities for the two sites.

GSFC engineers traveled to EDC to setup operations. EDC worked with their customer base to begin sales of EO-1 imagery on an over-the-counter basis. NASA science validation team members and new users began immediately to purchase acquisitions of areas of interest to them. NASA retained the right to task the spacecraft for engineering tests and further calibration and validation activities, but the majority of time on the observatory was for the purpose of increasing the number of archived images and the resulting revenue that would come from those increases.

In locations where no customers were requesting data acquisitions, science advice was sought to identify and schedule targets most likely to be purchased from the archive. As a result, the archive was populated with such targets, especially for the hyperspectral archive inventory. Workshops were held to increase user awareness of data availability. Labor and equipment costs were held to a minimum by reusing equipment and by judicious staffing selections. Additional ground stations were sought and agreements made to use non-NASA ground antennae to decrease the turn-around time of data delivery. By increasing the number of scenes per day and maintaining the labor and equipment costs as flat or decreasing, the cost of each scene continued to drop.

Image sequences were modified so that two or three different scenes per orbit could be imaged by maneuvering to re-point the satellite in less than five minutes. This also allowed for an increase in the number of scenes per day that as a result continued to push down the cost per scene.

In the interest of increasing the number of DCE's EO-1 acquired daily, decreasing the cost of taking a DCE, increasing the customer base, and decreasing the turnaround time to process scenes, both USGS and NASA have worked to continuously improve their operational processes. As the result of continuous improvements to operations, starting shortly after launch, instead of the planned 1,000 images, over 3000 images were acquired after 18 months on-orbit. The data collection rate was increased by a factor of approximately four times the rate envisioned in the original flight validation plan. Figure 3 shows a consolidated chart of improvements made over time to bring the average cost of a DCE down by a factor of approximately seven. This reduced cost has facilitated widespread availability of EO-1 imagery.

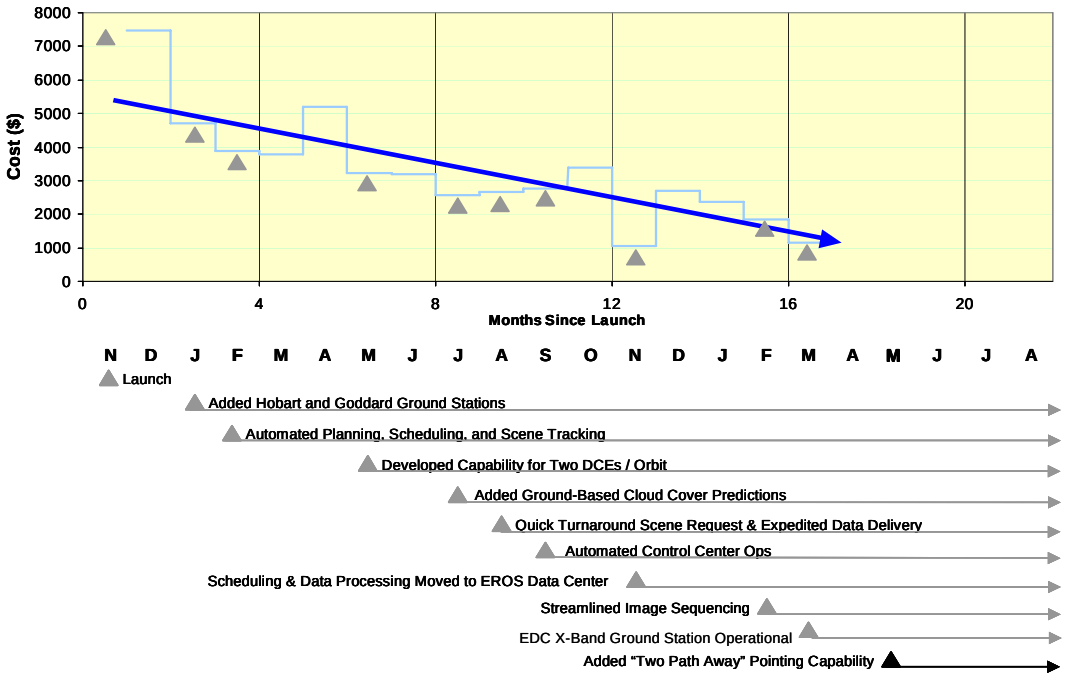

Figure 3. Process Improvements at NASA and USGS and Resultant Reduction of DCE Cost

The total revenue received for extended mission images as of August 2, 2002 was $677K with actual sales beginning January 31, 2002. By the end of FY03, nearly $2M in sales had been accomplished with over 10,000 combined ALI/Hyperion image DCEs in the archive. The number of users continues to expand and the costs per scene continue to plummet, but the revenue from image sales alone only covers the USGS part of the operations and science costs of flying the mission. NASA's operations costs had to be covered by NMP's dwindling EO-1 budget. To overcome the pending shortfall in NASA funding, the following two bold moves were made that would provide additional funding for NASA to continue to operate the mission.

1. New technology initiatives were proposed by the EO-1 team to utilize the satellite as an on-orbit testbed for mutlispectral and hyperspectral research (discussed further in Part 7 of this report).

2. New collaborative partnerships were forged between the NASA/USGS team and other U.S. Government agencies.
Several agencies became interested in both purchasing EO-1 images in bulk for their target areas and in sharing in the scientific research and instrument calibration./validation activities involved in exploring the use of EO-1 as an on-orbit testbed capability for advancing the state of the art in system autonomy, automatic feature detection, and other experimental "sensor web/virtual observatory" development activities. NASA and the USGS re-cast their agreement to account for the new arrangements needed to handle funds transfers directly to NASA to support satellite operations and science support activities for these "bulk customers". NASA arranged to reimburse USGS for any revenue shortfall incurred in continuing to support the USGS EO-1 activities while handling the new bulk customer requests.

The USGS annual revenue from "over-the-counter" sales to the public remains fairly steady at just over $1M per year. This covers all but about $100K of their support costs for EO-1 per year. Bulk customer inter-agency transfers to NASA covered almost all of the operations and science costs incurred at GSFC

during FY03. Plans for FY04 are for continued science and operations support funded by bulk customers and for nearly break even over the counter sales at EDC.

2.2 Conclusions

The partnership established between NASA and USGS is serving at least two useful purposes. First of all, the science community is being better served because of increased awareness of opportunities to perform new science. Secondly, technology infusion is being maximized because, by lowering the cost of obtaining EO-1 data, the number of users of EO-1 technology is maximized. The model that is being used in this partnership is the one used for Landsat between the two agencies. The use of this NASA/USGS partnership in the Extended Mission phase may establish a precedent for setting up more similar partnerships in the future and thus stretch the taxpayers' dollar further.

The lifetime of the EO-1 Extended Mission is somewhat indeterminate since it is dependent upon the income generated from the purchase of EO-1 products and collaborative support and on identifying the degree that EO-1 is satisfying NASA's Earth Science Enterprise strategic goals. The remaining orbit maintenance fuel will allow EO-1 to stay within the AM constellation of satellites following Landsat-7 through FY04 and possibly into FY05.