1. Introduction.

The IUE spacecraft was launched in January 1978 from Cape Canaveral, Florida. It was the first astronomical satellite to have been placed into a geosynchronous orbit; and, also, the first scientific satellite that allowed a large number of visiting astronomers to make real time observations of ultraviolet spectra. The planned mission lifetime was between three and five years. In the end, IUE had accumulated 104,470 spectra images during 18.5 years of in-orbit operations.

Despite the difficulties that arised along the mission, IUE accomplished all scientific goals. When its fourth gyro failed in 1985, IUE continued its operations using only two gyros. The continuation of the mission was achieved with an innovative redesign of on-board and on-ground systems.

Even when the fifth gyro failed in the last year of the IUE, the science observing program could be completed. The spacecraft was three-axis stabilized under a 1 gyro system.

The IUE operations ended on September 30, 1996, at 18:44 U.T.

The IUE Project objectives were to design, fabricate, test and place into geosynchronous orbit an ultraviolet astronomical three-axis controlled observatory intended primarily for use as an international research facility. The design lifetime of the hardware was 3 years with a goal, including the sizing of consumables and degradable hardware, of 5 years.

Astronomers used this observatory to carry out their own observing programs without going through tedious training courses in the specialized techniques of operating a telescope in Earth orbit. In low Earth orbit, such special techniques become necessary because this geometry changes so rapidly that the observer has little opportunity to evaluate and take advantage of particular observing situations as they arise. The observer must rely on preplanned automatic sequences that are often indirectly responsive to the scientific requirements of the observation.

The choice of a geosynchronous orbit is important in achieving the objective of a guest observatory where the observers can remain experts in astronomy without the need to become experts in satellite orbit operations. The geosynchronous orbit does restrict the weight and the size of the telescope that can be considered; however, with the IUE, this restriction was largely counterbalanced by the telescope instrumentation, which had been designed to carry out the scientific objectives of the mission with considerable efficiency.

The following list is a summary of the IUE scientific goals prior to launch:

- Obtain high-resolution spectra of stars of all spectral types in order to determine more precisely the physical characteristics of these stars.

- Study gas streams in and around some binary systems.

- Observe faint stars, galaxies, and quasars at low resolution and interpret these spectra by reference to high-resolution spectra.

- Observe the spectra of planets and comets as these objects become accessible.

- Make repeated observations of objects which show variable spectra.

- Define more precisely the modifications of starlight caused by interstellar dust and gas.

To achieve the scientific goals previously stated, the spacecraft had to be able to point anywhere on the celestial sphere, except within 45° of the sun, with an accuracy of ±1 arcsecond. The control system had to be able to repoint the telescope to a new target star over a fairly wide angle (up to 60°) with a rate of 4.5 degrees per minute per axis and guarantee that the desired new target star falls within the 16 arcminute diameter field of view of the fine error sensor. To perform spectroscopy on the faint stars with the desired resolution, the control system had to hold a 1 arcsecond diameter star image within a 3 arcsecond diameter spectrograph entrance aperture long enough to permit an integrated exposure of 1 hour duration by the spectrograph camera. Battery storage was required on the spacecraft to provide sufficient power to maintain attitude control and critical spacecraft subsystems during solar eclipses.

IUE was an international undertaking. The satellite and optical instrumentation were provided by the National Aeronautics and Space Administration’s (NASA) Goddard Space Flight Center (GSFC), and the vidicon cameras used as detectors in the scientific instrument were provided by the United Kingdom Science Research Council. The European Space Agency (ESA) supplied the solar arrays for the satellite and also constructed the European control center Villafranca Satellite Tracking Station (VILSPA).

This international cooperation continued during control operations, which were mainly conducted in the two mentioned ground station, GSFC and VILSPA.

- The GSFC ground system comprises three major sites: the Greenbelt tracking station (BLT), the IUE Operations Control Center (IUEOCC) which houses the operations computers and the Mission Operations Room (MOR), and the Scientific Operations Center (SOC). The MOR in the IUEOCC was used by spacecraft analysts to monitor the status of the spacecraft. The SOC was used for the telescope operators, resident astronomers and guest observers to conduct scientific operations and scientific data processing. Around October 1985, Wallops Flight Facility (WPS) replaced the Greenblet tracking station as primary US ground station.

- The VILSPA ground system houses the MER (Main Equipment Room) and control rooms (Observatory and Control Room), which consists of elements functionally identical to the BLT and IUEOCC; however, both scientific and spacecraft operations were conducted in the IUE dedicated control rooms at VILSPA.

The following sections will describe the characteristics of the orbit, the spacecraft, the spacecraft subsystems and the thermal design, and their evolution along the mission; as well as the technical problems, constraints and problem solving techniques used during the IUE program.