Midcourse Space Experiment: Guest Editor's Introduction

Max R. Peterson

This issue of the *Johns Hopkins APL Technical Digest*, which is the second issue describing the Ballistic Missile Defense Organization (BMDO) Midcourse Space Experiment (MSX), focuses on the technology used to implement the MSX Spacecraft Observatory. In last quarter's issue, we presented an overview of mission- and system-level design and development aspects of the MSX Program. A third issue is being planned to present scientific results of the MSX mission.

We begin this issue with a description of the technology utilized to implement several of the processors required in spacecraft and instrument subsystems. The article by Frank et al. describes the expanded-mode general-purpose computer designed around the Performance Semiconductor 1750A integrated circuit chip set, which was chosen because of its radiation hardness and its resistance to single-event upset and potentially damaging latch-up. In addition, the chip set provides advanced throughput and memory capacity, and also offers commercially available software development tools. This single-board computer is the heart of MSX's attitude processor, tracking processor, and command processor, as well as of the image processor used for the Ultraviolet and Visible Imagers and Spectrographic Imagers (UVISI) instrument. Use of a common processor design presented savings in both hardware and software development.

To accommodate the variety and quantity of data that MSX sensors will collect over their lifetime, and to provide the flexibility to control the spacecraft and instruments, a sophisticated Command and Data Handling (C&DH) System had to be developed. Storage for data collected during target tracking events and while MSX is out of sight of a receiving station is provided by two tape recorders, each of which can record up to 54 gigabits of data at 5 or 25 megabits per second. Of prime concern is reliability and fault tolerance of the system, as well as flexibility in controlling the Observatory. The characteristics and capabilities of the various C&DH subsystems in the MSX are described by Stott et al.

The MSX attitude determination and control system (Mobley et al.) must be able to point the sensors at the desired object to within less than 0.1°, and it must very precisely determine, after the fact, where the sensor line-of-sight (LOS) was pointed. The system must maintain a smooth motion to avoid "smearing" of data on the sensing elements of the instruments; it must not contaminate the optical elements of the sensors; and it must operate over the lifetime of the spacecraft. To furnish information on where the LOS was pointed, a state-of-the-art star camera is used in conjunction with two ring laser gyroscopes. Four reaction wheels with torque capability twice that of the Hubble Space Telescope eliminate any possibility of contamination, since they require no fuel other than electrical power. The four-wheel configuration provides graceful degradation in capability should one wheel fail, thus assuring performance over the life of MSX.

Testing of a spacecraft the size and complexity of MSX was indeed a significant effort. Wilson describes the design and use of the MSX testbed simulator in the development of the tracking and attitude processor subsystems. This article also explains the means by which the spacecraft was "tricked" into believing that it was in space during all ground testing and performance validation of the entire tracking system.

Smola et al. outline the significant effort in logistics associated with ground processing of MSX, starting early in the integration phase and ending with processing at the launch site. An important part of processing MSX was associated with the cryogenic gases and liquids required to support the Spatial Infrared Imaging Telescope III (SPIRIT III). The significant planning effort allowed the spacecraft to be processed through environmental testing and at the launch site with few difficulties.

As with any space program, parts, materials, and processes play an important role in the manufacture of a highly reliable product. The article by Goss presents the performance assurance program developed for MSX. APL's philosophy of parts selection and design reviews to "build-in" reliability are discussed, along with the monitoring of processes for hardware developed at APL and at subcontractors' sites. Comprehensive safety measures during ground processing and at the launch site were uppermost in our minds, and a great deal of effort focused on assuring that no mishap would endanger human life or property.

The primary reason for the MSX spacecraft is, of course, the sensors that it supports. The UVISI instrument covers the short-wavelength bandwidth from approximately 110 through 900 nm. In addition to describing its capability to gather data and perform real-time tracking of certain targets in this waveband, Heffernan et al. focus on the hardware aspects of this hyperspectral imaging sensor and on its flexibility.

The primary sensor of the MSX instrument suite, SPIRIT III, covers the infrared bandwidth (as its name implies) from 4.2 to 26.0 μm. SPIRIT III will provide sensitive measurements for future DoD tracking and discrimination systems using a radiometer with six measurement bandwidths and an interferometer–spectrometer. Design details covered by Bartschi et al. include a discussion of each major component of the sensor, as well as an overview of ground testing and on-orbit operation.

The Space-Based Visible (SBV) sensor is designed to demonstrate the feasibility and utility of an above-the-horizon surveillance capability from a space platform. Harrison and Chow discuss design, testing, and operation, including details of a state-of-the-art focal plane that gives SBV its sensitive detection capability.

Concluding this issue, two articles discuss collateral instruments. The Onboard Signal and Data Processor, described by Pfeiffer and Masson, will use data from the SPIRIT III sensor to demonstrate real-time tracking of targets, and the reference objects, described by Burdick et al., are an essential component of the on-orbit calibration of the SPIRIT III sensor.

Earlier publication of articles in this and other journals represents a notable part of the technology used to develop MSX. The reader is directed in particular to the references at the end of this introduction. Although not included in this issue, these articles are important to the MSX design. They provide information on the X-band transmitter, software for the tracking processor, the beacon receiver tracking system, and the contamination monitoring instruments. Finally, a wealth of information can be found in the references of the individual articles of both this and the preceding issue of the *Digest*.

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THE AUTHOR

MAX R. PETERSON is Program Manager for the Midcourse Space Experiment Program at APL, and a Principal Professional Staff engineer in the Space Department. He received a B.S. degree in electrical engineering from Kansas State University in 1961 and an M.S. degree in engineering from The Johns Hopkins University in 1968. Mr. Peterson joined APL in 1961 and worked on the Polaris Fleet Ballistic Missile Readiness Program. In 1963, he was employed by Texas Instruments, returning to APL in 1964. He supervised the Data Systems Design Section in the Space Telecommunications Group from 1969 until 1975. His activities have encompassed data instrumentation and overall data handling system design and test of several near-Earth spacecraft. He served as the Assistant Program Manager for the AMPTE/CCE spacecraft and was the Polar BEAR Program System Engineer. Mr. Peterson lectured at the U.S. Naval Academy and G.W.C. Whiting School of Engineering on integration and test of space systems. He also taught space communications at the JHU Evening College at APL. His e-mail address is Max.Peterson@jhuapl.edu.