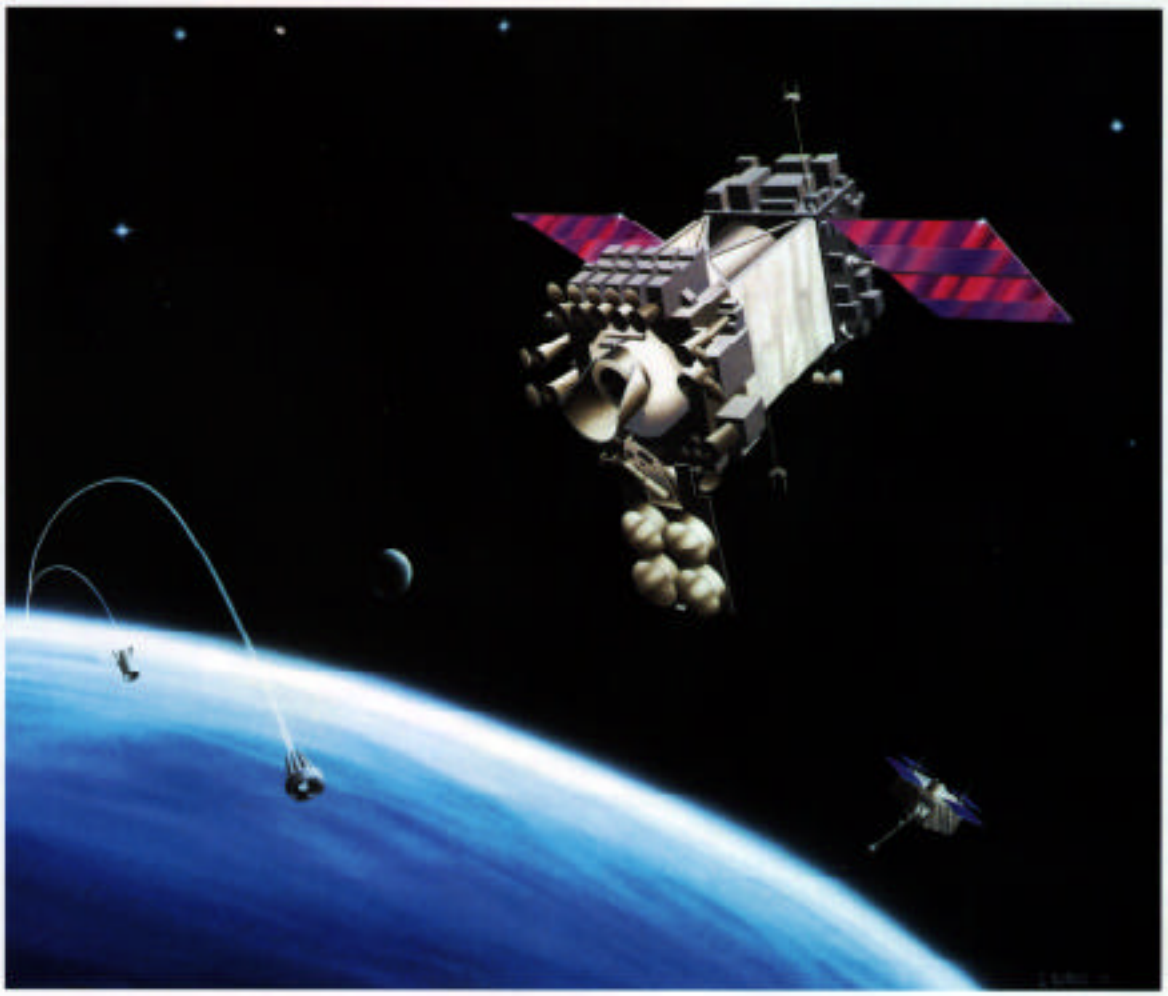
MSX

Midcourse Space Experiment

The Midcourse Space Experiment (MSX) observatory is a Ballistic Missile Defense Organization project which offers major benefits for both the defense and civilian sectors. With a solid heritage in the successful Delta series, MSX represents the first system demonstration in space of technology to identify and track ballistic missiles during their midcourse flight phase. The spacecraft features an advanced multispectral image capability to gather data on test targets and space background phenomena. MSX will aid future spacecraft design by monitoring on-orbit contamination of optical instruments. In addition, its investigation of the composition and dynamics of Earth's atmosphere promises increased understanding of the environment.



Artist's conception of MSX observatory in orbit. MSX is capable of observations at a wide range of ultraviolet, visible and infrared wavelengths, from 110 nm to 28 μm.

Program Management

The Sensor Technology Directorate (DTS) of the Ballistic Missile Defense Organization (BMDO) has overall responsibility for MSX. The Johns Hopkins University Applied Physics Laboratory (JHU/APL) serves as systems engineer and technical adviser. JHU/APL is under contract to BMDO to develop, integrate, test, launch, and operate the MSX spacecraft and several of its primary sensors.

Why MSX?

Designers of future operational space- and ground-based surveillance and tracking systems require simultaneous, wideband optical data on midcourse missile flight, the trajectory phase between burnout and reentry. The precision MSX platform will collect that data over a wide-wavelength range during its long-duration mission, building on previous short-term SDI tests. MSX experiments will provide critical first-time observations of missile target signatures against Earth-limb, auroral, and celestial-cluttered backgrounds.

One of the MSX instruments being assembled in a cleanroom at JHU/APL

Mission Design

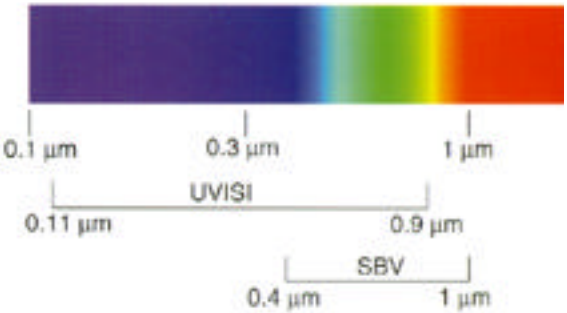
MSX is to be launched aboard a Delta II booster from Vandenberg Air Force Base in California. Insertion altitude is approximately 900 km, in a high-inclination, circular, near-sun synchronous orbit. Mission design lifetime is 4 years, with the SPIRIT III infrared telescope limited by coolant supply to 18–20 months of operation. Approximately 50% of MSX's weight and power is allocated to instrument use. During its primary mission, or "cryogen" phase, MSX is designed to gather data on backgrounds and to detect and track test-ICBMs launched from the Western Test Range (WTR) and targeted at the Kwajalein Missile Range in the Pacific. Other targets include IRBMs launched from Barking Sands in Hawaii, satellites, and objects deployed from MSX itself. The "post-cryogen" phase will focus on celestial and terrestrial backgrounds, surveillance demonstrations, and contamination and environmental research.

Spacecraft Design

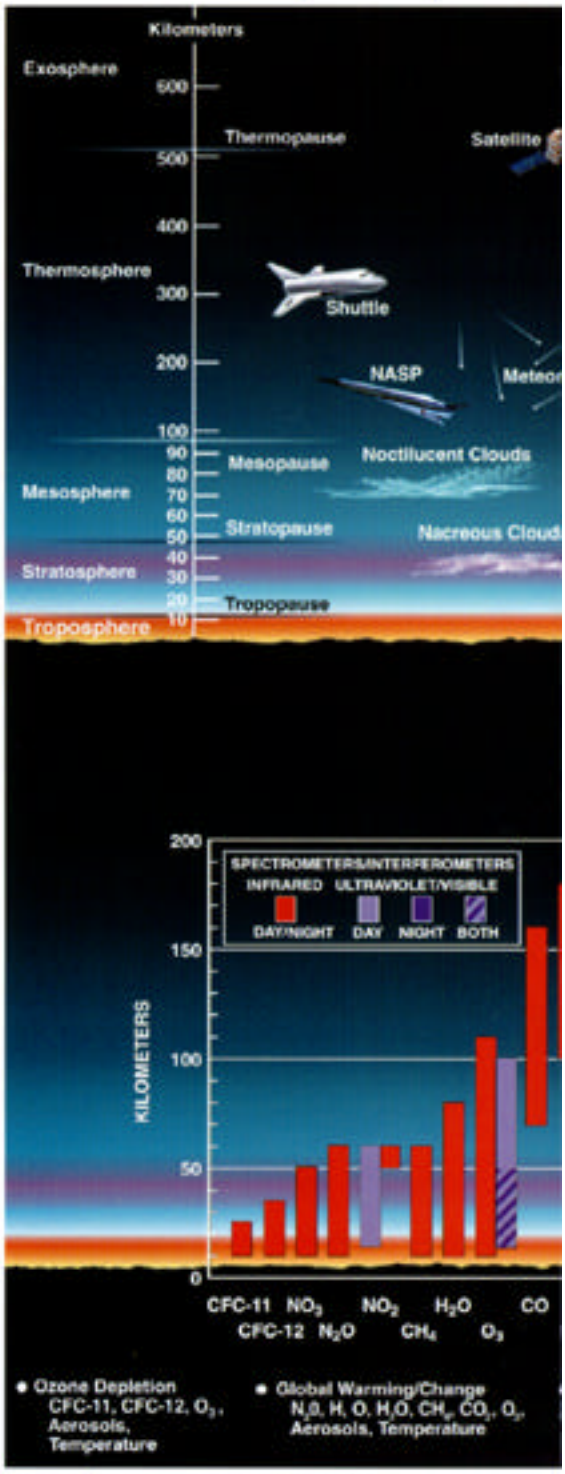
The 2,700-kg, 510-cm-long MSX spacecraft includes three major sections, each with a 150-cm by 150-cm cross section:

- The versatile electronics section features state-of-the-art attitude control, power, and command and telemetry systems, including rotatable solar arrays, nickel/hydrogen battery power, steerable X-band antennas, and 108-Gbit data storage. The reaction wheel-driven attitude control system achieves real-time pointing accuracy of better than 0.1° and postprocessing knowledge of 9 μrads. Line-of-sight jitter is held to ±9 μrads over instrument integration durations of approximately 1 second. MSX will operate in the background data-gathering mode an average of 20 minutes per orbit, with target-tracking tests lasting 35 minutes. The system provides a "parked" safe mode for thermal recovery, cryogen conservation, and battery recharge between test cycles.

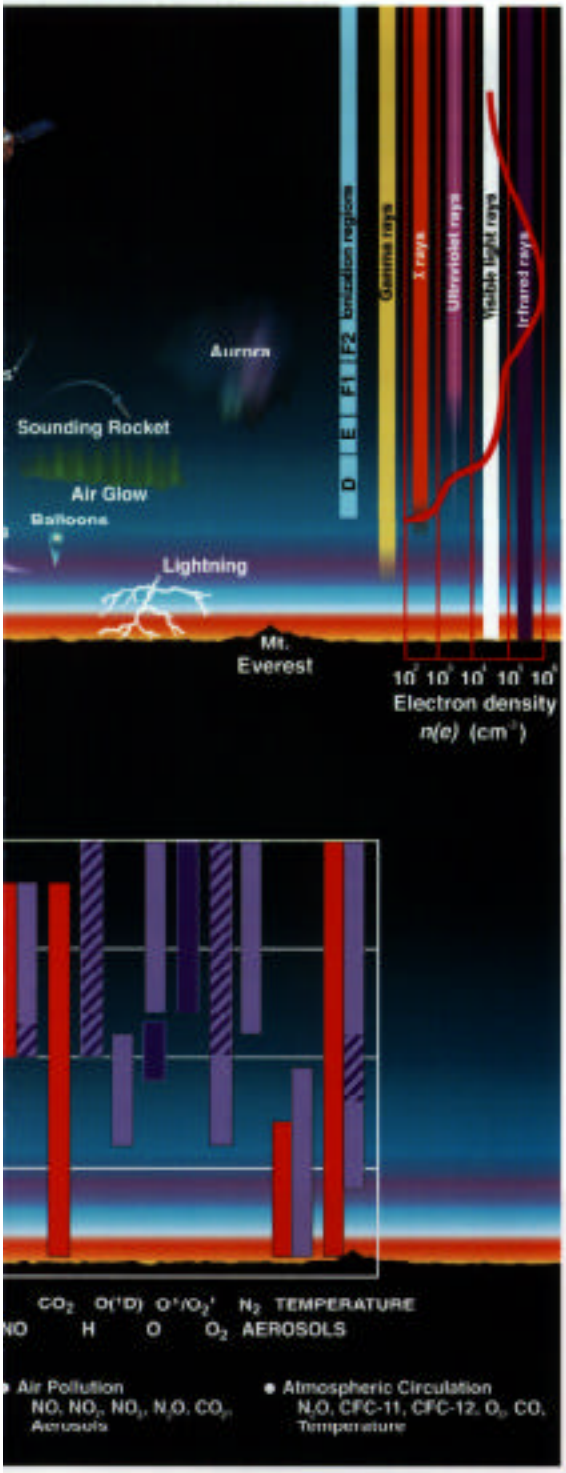
- The mid-section graphite epoxy truss supports the large cryogenic dewar, which contains frozen hydrogen at approximately 8.5 K.



MSX Instrument Wavelength Coverage



MSX Measurement Capabilities



The thermal design of the mid-section maintains the outer shell of the dewar at approximately 200 K. The 200-cm-long truss thermally isolates the heat-sensitive instrument section from the much warmer spacecraft bus.

- The instrument section houses 11 optical sensors, which are precisely aligned so target activity can be viewed simultaneously by multiple sensors. MSX is capable of observations at a wide range of infrared, visible and ultraviolet wavelengths from 110 nm to 28 µm.

Primary Instruments

- SPIRIT III (Space Infrared Imaging Telescope) — The cryogenically cooled long-wave infrared sensor (LWIR) in SPIRIT III is the most advanced infrared instrument yet launched into space. Developed by the Space Dynamics Laboratory of Utah State University, SPIRIT III includes a five-color, high-spatial-resolution scanning radiometer and a six-channel, high-spectral-resolution, Fourier-transform spectrometer.

- UVISI (Ultraviolet and Visible Imagers and Spectrographic Imagers) — A JHU/APL-built instrument with five spectrographic imagers and four UV and visible imagers, UVISI affords complete spectral and imaging capabilities from the far ultraviolet through visible wavelengths.

- SBV (Space-Based Visible) Instrument — The SBV, equipped with a charge-coupled device, is a visible band telescope with a 6-inch aperture and image processing electronics. Built by the MIT/Lincoln Laboratory, SBV will demonstrate an above-the-horizon surveillance capability in visible wavelengths from a space platform.

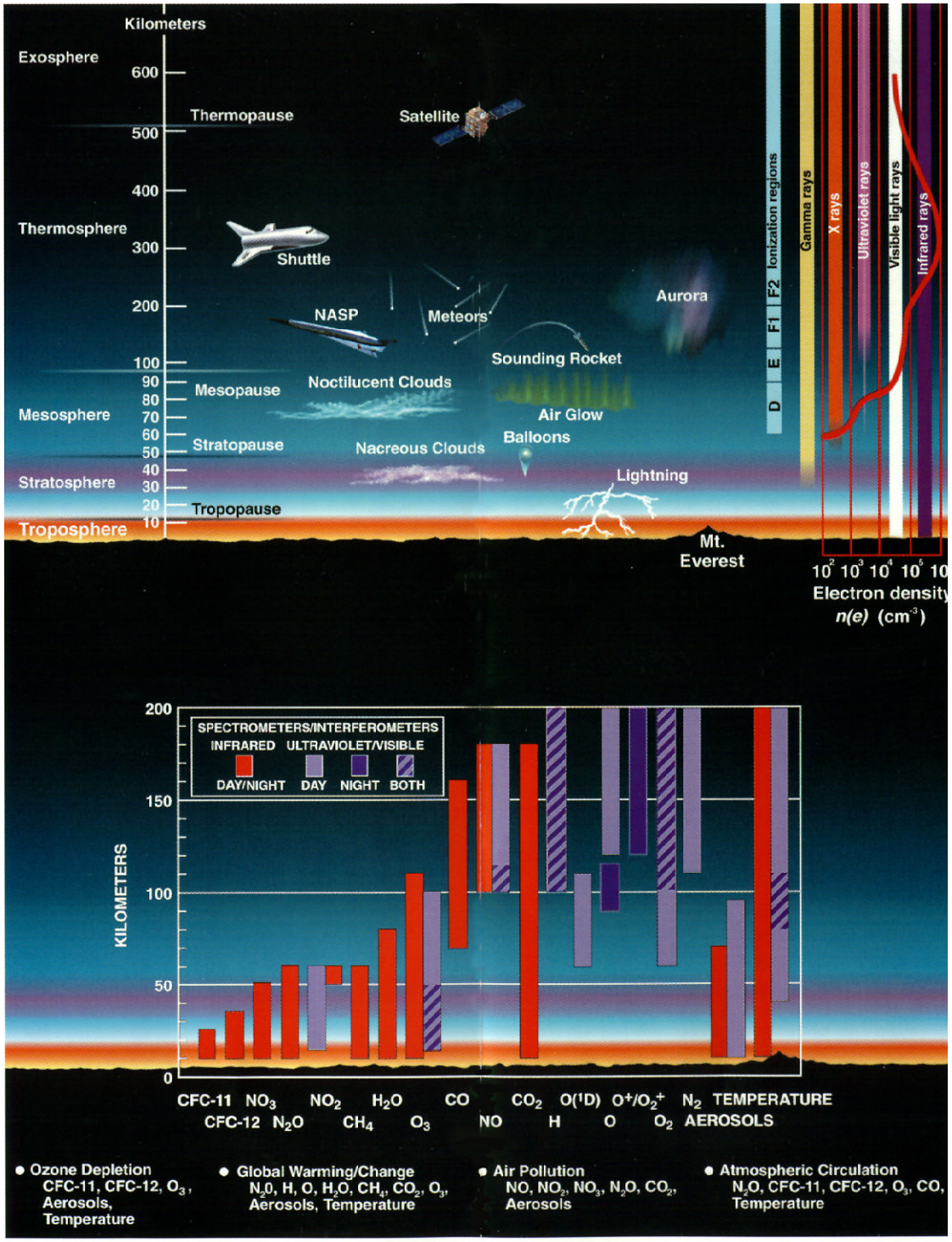
- OSDP (On-board Signal and Data Processor) — Built by Hughes Aircraft Co., the OSDP uses data from SPIRIT III in real-time signal processing for target detection and tracking. It also will provide information about radiation effects on state-of-the-art semiconductor devices.

- REFERENCE OBJECTS — These small (2.0 cm) reference spheres, provided by the MIT/Lincoln Laboratory, will be deployed from MSX for instrument calibration.

Spacecraft Assembly at JHU/APL

Contamination Experiments

Optical sensor performance is degraded when particles and gas molecules — largely from the spacecraft itself — are deposited on mirrors and windows. MSX was constructed at JHU/APL in an ultraclean environment with low-outgassing materials. It carries a full set of sensors to monitor and measure contamination during the mission. The sensors include a mass spectrometer, cooled quartz crystal microbalances, xenon and krypton flashlamps, and a pressure sensor.



MSX Measurement Capabilities

Atmospheric Experiments

MSX can be pointed so that all its instruments simultaneously view the Earth's atmosphere in any allowed direction. This represents an unparalleled scientific opportunity to study the composition, dynamics, and energetics of the atmosphere, including small annual changes in such chemicals as ozone, carbon dioxide, and chloro-fluorocarbons. Global atmospheric changes following major solar disturbances and environmental events such as volcanic eruptions, forest fires, and agricultural burnoffs also can be monitored.

Operations Management

The MSX Mission Operations Center is located at JHU/APL, which is responsible for primary operations planning, control, and spacecraft performance assessment. The Test Support Center at Onizuka AFB, supported by the U.S. Air Force Satellite Control Network, provides tracking as well as command and control support. Planning of surveillance experiments is provided by the MIT/Lincoln Laboratory. All activities associated with the acquisition and execution of target launches are coordinated by the U.S. Army Space and Strategic Defense Command. Sandia National Laboratory will provide midcourse targets. Target launch vehicles and launch services are provided by Sandia and the U.S. Air Force Ballistic Missile Office.

Data Recovery and Processing

Capabilities of the JHU/APL operations center include command uplink at 2 kbps and reception of science, health and status telemetry at 16 kbps, 1 Mbps, and 25 Mbps through a dedicated 10-m dish antenna. The combination of 11 optical instruments, 5 contamination experiment instruments, and the telemetry associated with the spacecraft bus requires recording data rates of 5 Mbps and 25 Mbps. The spacecraft X-band transmitter is capable of data modulation rates equal to tape recorder playback at 25 Mbps and provides for timely transmission of data without excessive ground station contact time. The U.S. Air Force Phillips Laboratory is data manager, responsible for establishing the science data-processing and archival centers. The primary archives for MSX data will be at the Naval Research Laboratory.

Science Investigations

Principal investigators for the MSX mission are assigned according to major program experiment areas: Early Midcourse, Late Midcourse, Surveillance, Shortwave Terrestrial Backgrounds, Contamination, Data Certification and Technology Transfer, Celestial Backgrounds, and Earth-limb/Auroral Backgrounds.

Delta II Launch Vehicle for the MSX

Richard B. Kershner Space Integration and Test Facility at JHU/APL

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