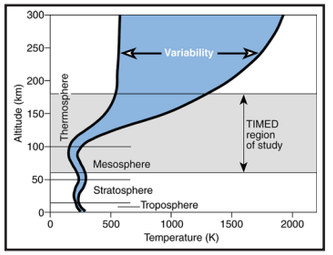
The Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics (TIMED) Mission

Why TIMED?

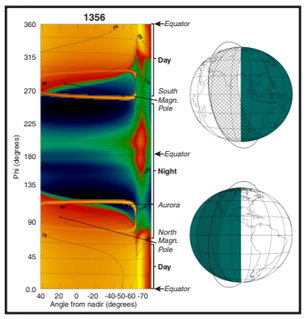
The two-year TIMED mission will focus on the portion of Earth's atmosphere located between 60 and 180 kilometers (40-110 miles) above the surface – the Mesosphere and Lower Thermosphere/ Ionosphere, or MLTI, a region where solar X-ray and far and extreme ultraviolet radiation (the most variable part of the solar spectrum) is absorbed.



TIMED will examine the entire region as a whole: its basic structure and thermal balance, how the Mesosphere is coupled to the Thermosphere/Ionosphere, how the MLTI region is coupled to space and the lower atmosphere below, and how energy is transported from one altitude or latitude to another. TIMED will gain a better understanding of the dynamics of this gateway region and its effects upon communications, satellites, and spacecraft reentering Earth's atmosphere.

A comprehensive global study of the MLTI region has never been accomplished for several reasons. This atmospheric region is too high for balloons to reach, and ground-based instruments can only see a small part of the upper atmosphere located over the observation site. Rockets flown into the region can only provide local snapshots of its activity. Without TIMED, scientists will not be able to obtain a global picture of the MLTI atmospheric region that they need to better understand the upper atmosphere and its interaction with regions above and below.

The TIMED spacecraft will observe this region and its basic structure from the spacecraft's 625-kilometer circular orbit around the Earth. With technological advances in remote sensing, TIMED will be able to observe this relatively unexplored frontier from space obtaining an unprecedented set of comprehensive global measurements of the MLTI region's temperature, pressure, winds, and chemical composition, along with its energy inputs and outputs.



TIMED will:

- Determine the temperature, density, and wind structure in the MLTI region including seasonal and latitudinal variations.
- Determine the importance of various radiative, chemical, electrodynamic, and dynamic sources and sinks of energy for the MLTI, leading to an improved understanding of the energy balance within this key region.
- Provide a better understanding of interactions between the Sun and the Earth's atmosphere and their impact on human activities in space, including:
  - impacts on satellite communications due to changing character of the Ionosphere; and,
  - satellite tracking problems due to changes in the composition and magnitude of atmospheric drag, which is caused by the solar cycle, solar flares, and tidal effects.
- Better determine the magnitude and character of human-induced effects on the lower Thermosphere, Ionosphere, and Mesosphere.

TIMED measurements will be important for understanding the basic processes involved in the energy distribution of this region and the impact of natural and human-induced changes. In a society increasingly dependent upon satellite technology and communications, it is vital to understand atmospheric variability, so its effects on satellite tracking, spacecraft lifetimes, degradation of materials, and reentry of piloted vehicles can be predicted. The Mesosphere may also show evidence of human-influenced effects that could herald global-scale environmental changes. TIMED will characterize this region to establish a baseline for future investigations of global change.

Why is this Science Important to Us?

The Sun's energy can have profound effects on Earth's upper atmospheric regions, particularly during the peak of the Sun's 11-year solar cycle when the greatest amounts of its energy are being released. TIMED is focused on understanding and characterizing exactly how the Sun interacts with the Earth's environment. TIMED will be the first mission to conduct a comprehensive global study of the MLTI region, and will allow scientists to establish the first-ever baseline against which future studies of changes within this region can be compared and analyzed.

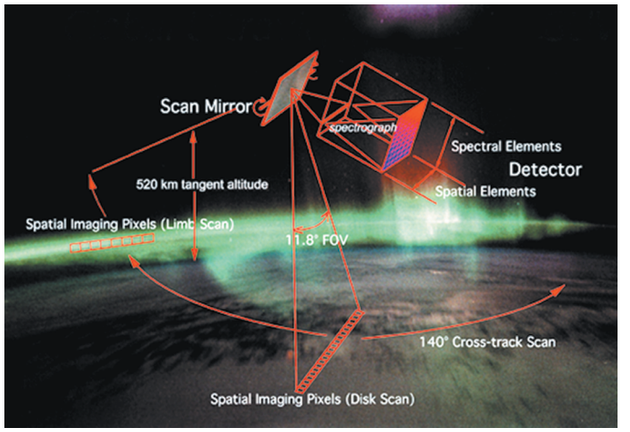
How Does TIMED Fit into the Solar Terrestrial Probes Program and the Sun-Earth Connection Theme?

The Sun-Earth Connection (SEC) Theme was created by NASA Headquarters' Office of Space Science as part of their Strategic Plan. The Solar Terrestrial Probes (STP) series of missions is a critical element under this theme. These scientific missions will obtain information to respond to the two quests or goals of the strategic science and technology roadmap for the SEC theme:

1. How and why does the Sun vary?
2. How do the Earth and planets respond?

The coordinated sequence of projects within the STP Program responds to these quests by focusing on the study of the Sun and Earth as an integrated system. The missions use a creative blend of in-situ and remote-sensing observations, often from multiple platforms, to understand the causes and effects of solar variability over vast spatial scales where effects refer to planetary and heliospheric responses.

The STP Program seeks to substantially reduce project cost and improve performance by using new technology. It enhances public awareness of and appreciation for space science by incorporating educational and public outreach activities as integral parts of space science investigations.



Scanning Imaging Technique Used by GUVI.

The TIMED spacecraft will be the initial launch in NASA's STP Program. The TIMED program is cost-capped at approximately $130 million (FY99 dollars) with a maximum three-year development cycle.

TIMED is sponsored by NASA Headquarters, Office of Space Science, Washington, D.C., and is managed by NASA's Goddard Space Flight Center (GSFC), Greenbelt, Md.

Scientific Instruments:

TIMED's payload consists of four instruments.

- Global Ultraviolet (UV) Imager (GUVI) – A spatial scanning UV spectrograph designed to measure the composition and temperature profiles of the MLTI region, as well as its auroral energy inputs.

  The GUVI instrument is a collaborative effort between The Johns Hopkins University Applied Physics Laboratory (JHUAPL) in Laurel, Md., and The Aerospace Corporation in El Segundo, Calif.

- Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) – A multichannel radiometer designed to measure the pressure, temperature, key gases in the oxygen and hydrogen families, infrared cooling, and effects of solar and chemical heating of the MLTI region.

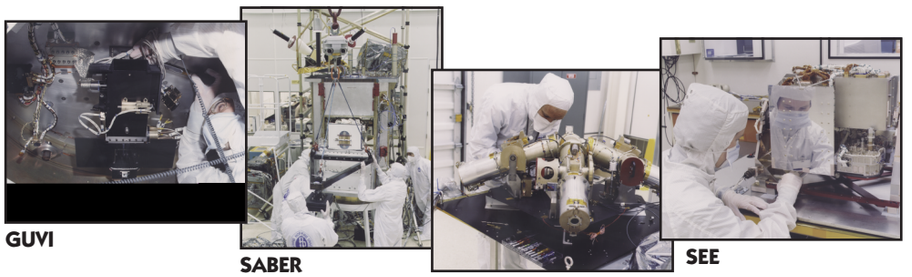
  Hampton University (Hampton, Va.) is leading the SABER science team. Utah State University (Logan, Utah) is building the instrument for NASA's Langley Research Center.

- TIMED Doppler Interferometer (TIDI) – A Fabry-Perot interferometer designed to measure the winds and temperature profiles of the MLTI region.

  TIDI is being constructed at the University of Michigan, Ann Arbor.

- Solar Extreme Ultraviolet Experiment (SEE) – A suite of photometers and a spectrometer designed to measure the solar soft X-ray, extreme ultraviolet, and far ultraviolet radiation that is deposited in the MLTI region.

  SEE is being built by the University of Colorado, Boulder.



GUVI **SABER** **TIDI (telescope assembly)** **SEE**

Science Team:

- **Mission Science**
  - NASA Program Scientist: Mary Mellott
  - APL Project Scientist: Jeng-Hwa Yee
  - NASA GSFC Project Scientist: Richard Goldberg
- **National Science Foundation Representatives**
  - Gary Swenson (University of Illinois)
  - Jeff Thayer (SRI International)
- **Instrument Principal Investigators**
  - Andrew Christensen - GUVI (The Aerospace Corporation)
  - Tim Killeen - TIDI (University of Michigan)
  - James Russell III - SABER (Hampton University)
  - Tom Woods - SEE (University of Colorado)
- **Interdisciplinary Investigators**
  - Jeff Forbes (University of Colorado)
  - David Fritts (Colorado Research Assoc./NWRA)
  - Janet Kozyra (University of Michigan)
  - Hans Mayr (NASA GSFC)
  - Anne Smith (National Center for Atmospheric Research (NCAR))
  - Stan Solomon (University of Colorado)

The TIMED Satellite

The TIMED satellite is a product of the Solar Terrestrial Probes (STP) Program at NASA's Goddard Space Flight Center (GSFC). The observatory was built at The Johns Hopkins University Applied Physics Laboratory (JHUAPL) for the STP Program.

Spacecraft Characteristics

- Mass: 660 kg
- Maximum Orbit Average Power Load: 426 W (two I-axis solar panels); 50-Ah NiH2 battery
- Science Data Downlink Rate: 4 Mbps (S-band, CCSDS compliant)

Attitude

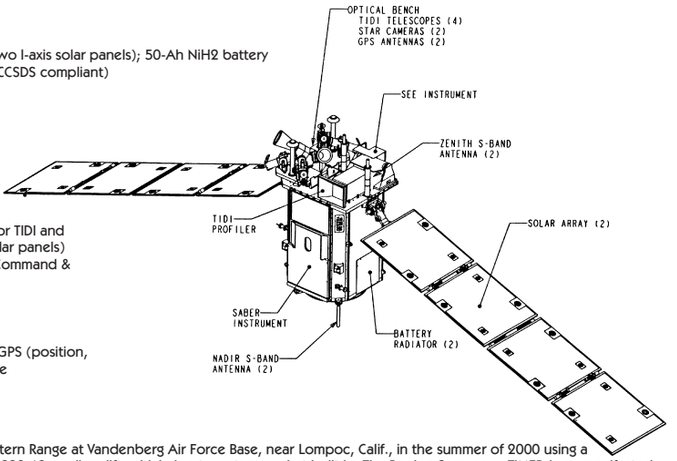
- Control: 0.5-degree, 3-sigma (3 axis stabilized)
- Knowledge: 0.03 degree, 3-sigma
- Total Memory: 2.5 GB (solid state recorder)
- Processor: Rad-hard 32-Bit RISC processor

Basic Design

- Honeycomb panel (composite optical bench for TIDI and star cameras; graphite epoxy face sheets on solar panels)
- Two MIL-STD-1553B data buses (one each for Command & Data Handling and Guidance & Control)
- Redundant spacecraft subsystems

Advanced Technology

- Integrated command, telemetry, data storage, GPS (position, velocity, and time) and communications module
- Rad-Hard 32-Bit RISC processor



TIMED Mission Management

- NASA GSFC STP Program Manager: Gilberto Colón
- NASA GSFC TIMED Project Manager: John Wolff
- JHUAPL Project Manager: David Grant

The TIMED Launch

TIMED is scheduled to be launched from the Western Range at Vandenberg Air Force Base, near Lompoc, Calif., in the summer of 2000 using a Delta II expendable launch vehicle. The Delta II 7920-10 medium-lift vehicle is a two-stage rocket built by The Boeing Company. TIMED is co-manifested on the Delta II with the Jason-1 spacecraft.

The 660-kilogram observatory will be inserted into a circular orbit 625 kilometers above Earth and inclined 74.1 degrees to the equator.

TIMED is expected to be in orbit and operate for a minimum of two years. The mission operations and science data centers, located at JHUAPL, will support data analysis for an additional two years after the conclusion of the mission.

Further information can be found on the Solar Terrestrial Probes (STP) Program, or The Johns Hopkins University Applied Physics Laboratory (JHUAPL) websites at:

http://stp.gsfc.nasa.gov

http://www.timed.jhuapl.edu

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