TIMED

Thermosphere · Ionosphere · Mesosphere · Energetics and Dynamics

A NASA Mission to Explore One of the Last Frontiers in Earth's Atmosphere

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Thermosphere
Ionosphere
Mesosphere
Energetics and
Dynamics

A Guide to the Mission, the Spacecraft and the Mission Team

The TIMED mission is sponsored by the National Aeronautics and Space Administration's (NASA) Office of Space Science, Washington, D.C., and is managed by the NASA Goddard Space Flight Center's Solar Terrestrial Probes Program Office, Greenbelt, Md. The Johns Hopkins University Applied Physics Laboratory, in Laurel, Md., designed, built and will operate the spacecraft and lead the project's science effort during the mission.

TIMED Mission Web Site — www.timed.jhuapl.edu

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Introduction

For centuries, scientists have realized that Earth's natural environment is greatly impacted by the abundance of solar energy striking the Earth from a constantly changing sun. Over the last few years, they have begun to realize that human activities are also playing a role in changing our environment.

By studying portions of Earth's atmosphere, scientists believe global change is occurring, primarily due to variations in the sun's cycle and from the release of gases, such as methane and carbon dioxide, into our atmosphere from human-induced activities. Despite signs of global change, scientists haven't had a benchmark against which future variations in Earth's upper atmosphere can be globally compared, analyzed or predicted because there are still portions of this solar-terrestrial chain, including regions within Earth's atmosphere, that are poorly understood.

TIMED will study the least explored and understood region of Earth's atmosphere.

The 2-year TIMED (Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics) mission will study the influences of the sun and humans on the least explored and understood region of Earth's atmosphere – the Mesosphere and Lower Thermosphere/Ionosphere (MLTI). The MLTI region is a gateway between Earth's environment and space, where the sun's energy is first deposited into Earth's environment. TIMED will focus on a portion of this atmospheric region located approximately 40-110 miles (60-180 kilometers) above the surface.

In a society increasingly dependent upon satellite technology and communications, it is vital to understand the variability within this critical region of our atmosphere so scientists can predict its effects on communications, satellite tracking, spacecraft lifetimes, degradation of spacecraft materials and on the reentry of piloted vehicles. TIMED's study of space weather will help scientists gain a better understanding of the dynamics of this gateway region.

A comprehensive global study of the MLTI region has never before been accomplished. Ground-based instruments can only observe a small portion of the upper atmosphere located over an observation site. This region is too high for balloons to reach. Sounding rockets (rockets that fly into the upper atmosphere for just a few minutes before falling back down) can only provide a brief snapshot of the MLTI region's activity near the rocket.

Other spacecraft have studied portions of the MLTI region, but TIMED will be the first mission to obtain a global picture of it, which scientists need to better understand our upper atmosphere. The TIMED mission will establish a baseline against which future studies of changes within this region can be compared and analyzed.

The TIMED spacecraft will observe this relatively unexplored frontier from its 388-mile (625-kilometer) circular orbit around the Earth. Employing advances in remote-sensing technology, the spacecraft's instrument suite will work with a worldwide network of ground-based observation sites to obtain an unprecedented set of comprehensive global measurements of the region's temperature, pressure, wind and chemical composition, along with its energy inputs and outputs.

The TIMED spacecraft is the initial mission in NASA's Solar Terrestrial Probes Program, part of NASA's initiative to lower mission costs and provide more frequent access to space to systematically study the sun-Earth system.

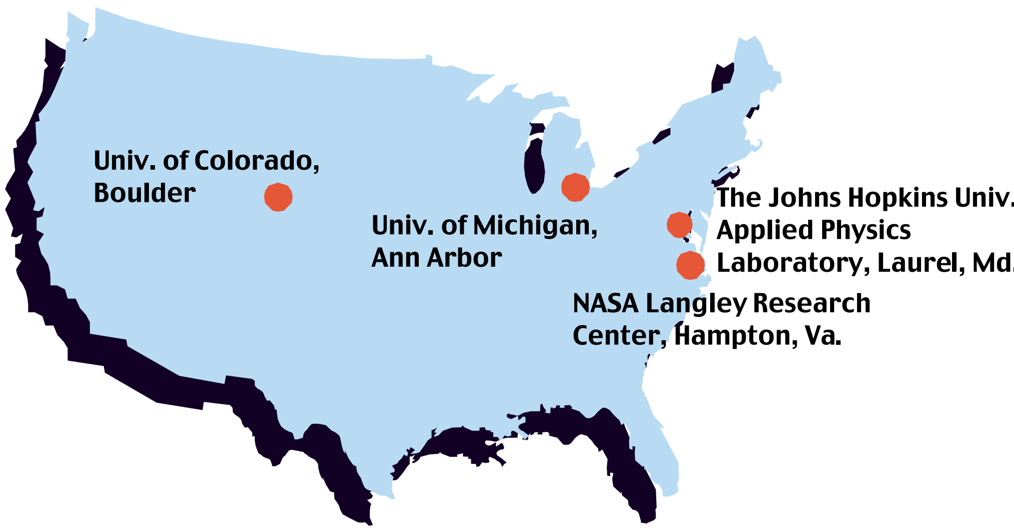
Mission

Launch and Orbit

The TIMED spacecraft will be boosted into its 388-mile (625-kilometer) circular orbit around the Earth (inclined 74.1 degrees from the equator) aboard a Delta II launch vehicle from the Western Range at Vandenberg Air Force Base, Calif., in December 2001.

The Delta II 7920-10 is a medium-lift, two-stage, liquid-propellant rocket built by The Boeing Company. The 1,294-pound (587-kilogram) TIMED spacecraft will be launched aboard a Delta II with the Jason-1 spacecraft.

TIMED Payload Operations Centers



Mission Operations

The TIMED mission utilizes an innovative mission operations system consisting of a combination of the spacecraft, instruments, ground system and the supporting science and engineering teams. This system, combined with TIMED's interdisciplinary approach, lowers mission costs while enhancing science return.

TIMED's interdisciplinary approach brings together worldwide experts over a wide range of disciplines to carry out the mission. Each of the four instrument Principal Investigators, or PIs, will have direct control of their instruments and experiments via Payload Operations Centers situated at four locations across the country.

This interdisciplinary approach is possible, in part, due to the spacecraft's autonomous design. The spacecraft can carry out many functions on its own, including sensing its position, orientation and orbit, and react accordingly. Since a more autonomous spacecraft is easier to operate, the spacecraft and its instruments can be controlled from separate locations.

TIMED's Payload Operations Centers will be located at: The Johns Hopkins University Applied Physics Laboratory (APL), Laurel, Md. (Global Ultraviolet Imager); NASA Langley Research Center, Hampton, Va. (Sounding of the Atmosphere using Broadband Emission Radiometry); the University of Colorado in Boulder (Solar Extreme Ultraviolet Experiment); and at the University of Michigan in Ann Arbor (TIMED Doppler Interferometer).

This approach is quite different from traditional spacecraft operations. Typically, instrument PIs submit requests for measurements they want to make, which must be balanced with other spacecraft activities including daily maintenance operations and positioning of the spacecraft. But TIMED's design helps avoid potential conflicts between PI requirements and other spacecraft operations. TIMED's instruments won't interfere with one another nor will daily spacecraft maintenance operations interfere with data collection activities.

TIMED's interdisciplinary approach enables a low-cost data collection process with a fast turnaround of data products. The PI institutions will send commands daily to the TIMED Mission Operations Center located at APL, where instructions for the instruments and the spacecraft will be combined and uplinked to the spacecraft once a day.

Data Management

Spacecraft Instruments

Similar to its mission operations approach, TIMED employs a unique distributed data management system, where spacecraft instrument teams will individually process data, generating products for distribution, from their respective Payload Operations Centers. This approach is unique compared to traditional space science missions and to most remote-sensing programs.

Traditionally, space science missions maintain one central data center, which has full control of the data – from downloading it from the spacecraft to processing, archiving and distributing data products. This approach typically requires larger staffs working around-the-clock shifts.

But within TIMED's distributed data management system, the Mission Data Center (part of the Mission Operations Center) will be responsible for downlinking raw data from the satellite and then sending it, via direct links, to processors at each of the remote Payload Operations Centers. These centers will process their instrument's raw data and turn it into data products that can be used by the public, and scientific and educational communities. Due to TIMED's more efficient data management system, the Mission Data Center and remote data processing sites will operate with one shift per day.

Once a remote site completes a data product, a notice is sent to the Mission Data Center indicating that the product is available for distribution. The Mission Data Center maintains a central catalog of TIMED data products, which incorporates query capabilities and a Web-based interface so the public, science teams and educational communities can quickly and easily retrieve products from the remote sites via TIMED's Web site (www.timed.jhuapl.edu).

In addition to saving program dollars by reducing staff sizes and the number of daily shifts, TIMED's distributed data management approach enables rapid turnaround of data products available for distribution. Total turnaround time – from the spacecraft acquiring data to development of a final product and its distribution online – is within 54 hours. Traditionally, a mission could take up to several days or weeks to get similar products distributed.

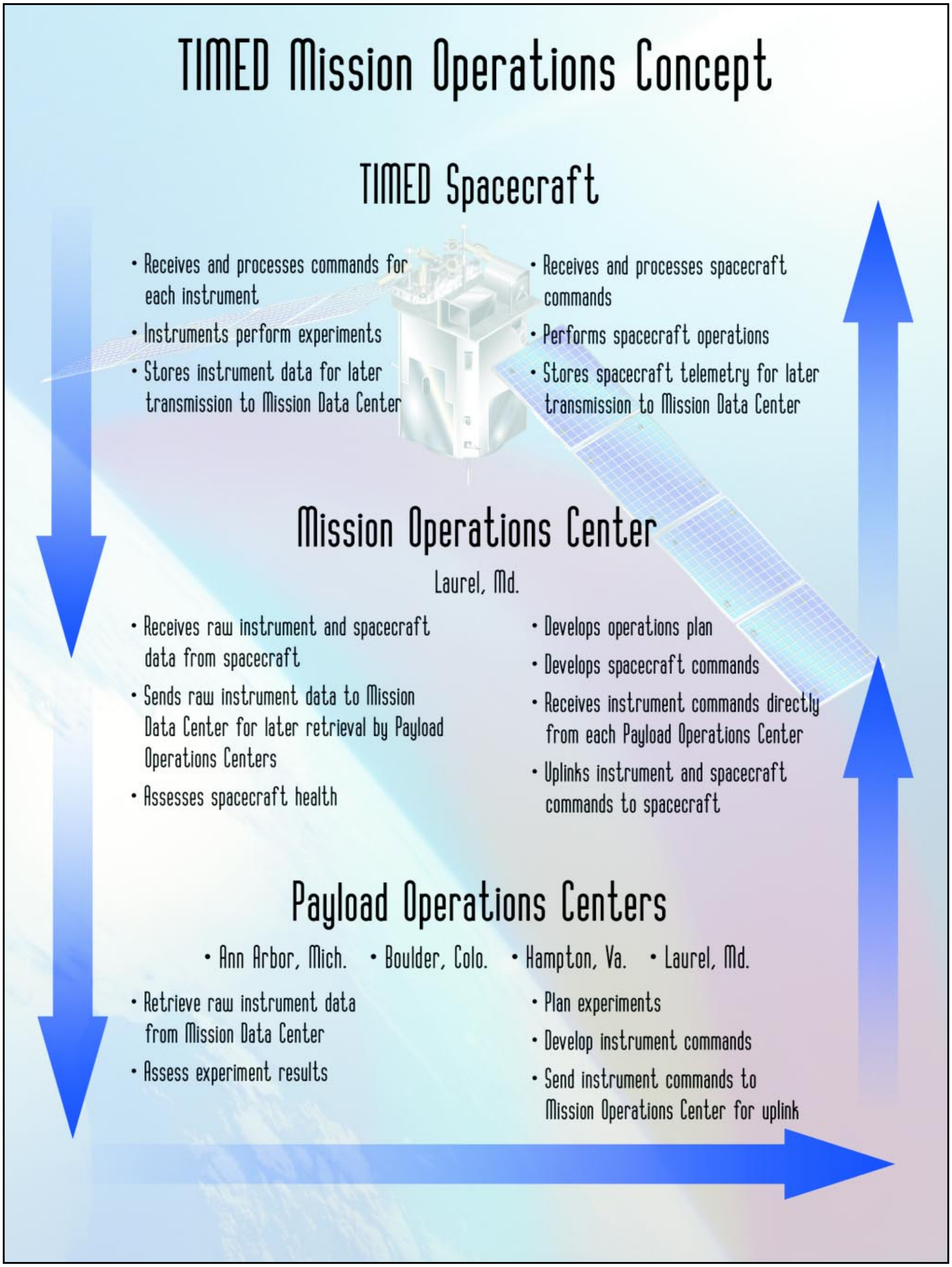
Collaborative Investigators

In addition to TIMED's instrument Principal Investigators and interdisciplinary scientists, the TIMED team includes a set of collaborative investigators jointly funded by TIMED and the National Science Foundation's Coupling, Energetics and Dynamics of Atmospheric Regions (CEDAR) program.

Data products created by the collaborative investigators will also be reflected in TIMED's central catalog, which can be queried from TIMED's Web site. Collaborative investigators have the option of archiving their own data and maintaining a Web site (accessible via a link from TIMED's Web site) or their data can be managed by CEDAR. Like the remote Payload Operations Centers, CEDAR will send catalog information to the Mission Data Center regarding any collaborative investigators' data products they manage.

Costs

The total cost for the TIMED spacecraft, its instruments and the launch vehicle is approximately $193 million. An additional $42 million has been set aside for mission operations, ground-based operations and data analysis during the mission's lifetime.


TIMED Mission Operations Concept
TIMED Spacecraft
• Receives and processes commands for each instrument
• Instruments perform experiments
• Stores instrument data for later transmission to Mission Data Center
• Receives and processes spacecraft commands
• Performs spacecraft operations
• Stores spacecraft telemetry for later transmission to Mission Data Center
Mission Operations Center
Laurel, Md.
• Receives raw instrument and spacecraft data from spacecraft
• Sends raw instrument data to Mission Data Center for later retrieval by Payload Operations Centers
• Assesses spacecraft health
• Develops operations plan
• Develops spacecraft commands
• Receives instrument commands directly from each Payload Operations Center
• Uplinks instrument and spacecraft commands to spacecraft
Payload Operations Centers
• Ann Arbor, Mich. • Boulder, Colo. • Hampton, Va. • Laurel, Md.
• Retrieve raw instrument data from Mission Data Center
• Assess experiment results
• Plan experiments
• Develop instrument commands
• Send instrument commands to Mission Operations Center for uplink

Science Objectives

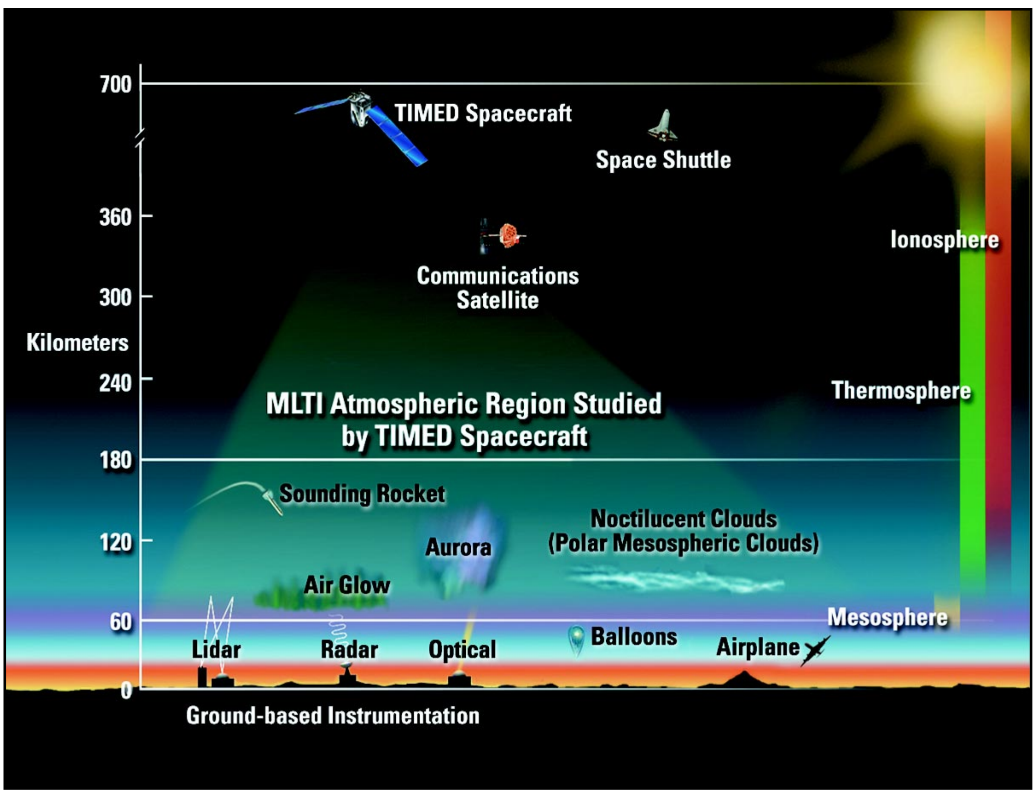
The science objective of the TIMED mission is to understand the MLTI (Mesosphere and Lower Thermosphere/Ionosphere) region's basic pressure, temperature and wind that result from the transfer of energy into and out of this region.

Located approximately 40-110 miles (60-180 kilometers) above the Earth's surface, the MLTI region is sensitive to external influences from the sun above and atmospheric layers below it. Its chemical and thermal balance can change rapidly due to naturally-occurring and/or human-induced changes to the energy contained within this region.

Human-induced changes in the lower atmosphere can have a significant impact on Earth's upper atmosphere. When released, gases, such as carbon dioxide (from burning fossil fuel) and chlorofluorocarbons (from Freon, cleaning solvents and/or aerosol propellants), are transported to high altitudes within the upper atmosphere where they ultimately affect its chemistry and composition.

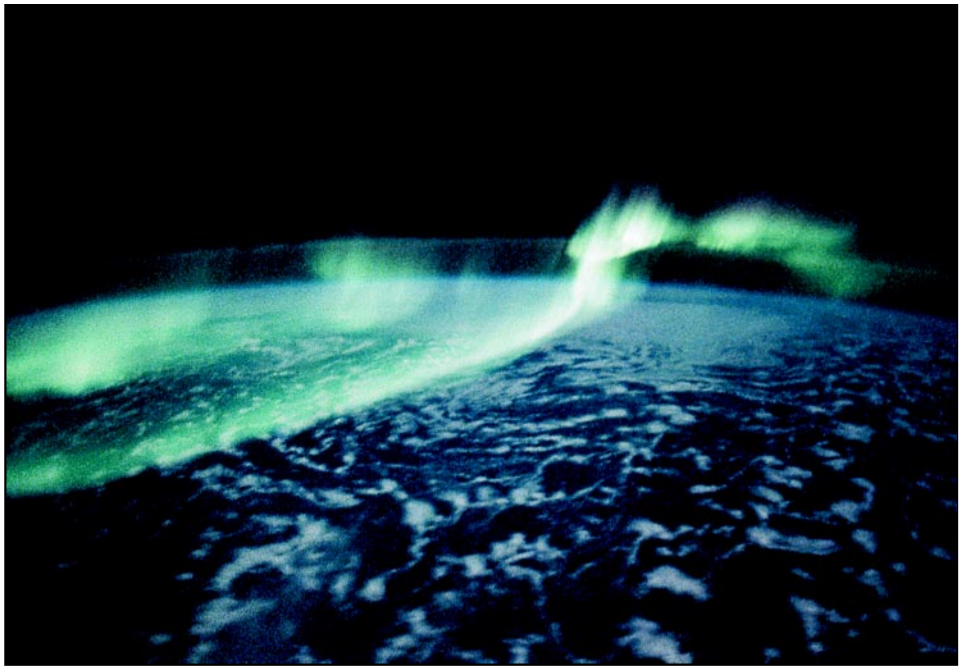
Particles and energy emitted from the sun also alter Earth's upper atmosphere when deposited into the MLTI region. These components change this region's energy input and balance, affecting its chemistry and temperature. Since Earth's upper atmospheric regions are connected to the lower portion of the atmosphere where we live, scientists need TIMED to help them better understand the connections between these atmospheric regions.

The MLTI region is an area of transition where many important processes change dramatically. It's where energetic solar radiation is absorbed, energy input from the aurora maximizes, intense electrical currents flow and upward propagating waves and tides break. With all of these volatile processes taking place within the MLTI region, some scientists believe it is acting as an early indicator of global change. One example, some scientists say, is the increasing occurrence of noctilucent clouds at latitudes closer to the equator.



The TIMED spacecraft, located 388 miles (625 kilometers) above the Earth's surface, studies the MLTI atmospheric region using advances in remote sensing. Ground-based systems, balloons and sounding rockets can only study small portions of this region. But together, TIMED and a worldwide network of ground-based observation sites will obtain an unprecedented set of comprehensive global measurements of this region.

Noctilucent clouds are thin, luminous clouds located at extremely high altitudes (50 miles, or 80 kilometers, above the surface) and are visible only against a twilight sky. They usually form at latitudes closer to the poles (50-60 degrees in both hemispheres), but are now beginning to appear in locations closer to the equator (as low as 40 degrees north latitude), which scientists say is unprecedented. Scientists believe this implies that the upper atmospheric regions, which TIMED will be studying, are getting colder. TIMED will provide significant information that will help scientists find out why such a phenomena is occurring at lower latitudes and what effects it might have on lower altitudes where we live.



Auroras occur within the MLTI region of Earth's atmosphere, which TIMED will be studying during its 2-year mission.

TIMED will employ advances in remote-sensing technology to globally observe this relatively unexplored frontier from space, making direct measurements of the MLTI region's various energy inputs and outputs and acquiring measurements of its wind, density and temperature profiles. These measurements will provide critical empirical data to help scientists better understand this region's energy balance. The 2-year mission will establish a baseline for future investigations of the MLTI region, providing a basis for early warning of global change.

Noctilucent clouds, as the name implies, are clouds that shine at night. They are found at much higher altitudes (approximately 50 miles or 80 kilometers) than most clouds (9 miles or 15 kilometers). Photo courtesy of Oscar van der Velde.

Spacecraft

TIMED is the first spacecraft to study the MLTI region on a global basis and the first mission to provide a baseline for future investigations of this region. It has a design lifetime of two years and will study the MLTI region, using advances in remote-sensing technology, from its orbit located approximately 388 miles (625 kilometers) above the Earth's surface.

The key criterion driving the design of the TIMED spacecraft was to lower mission operations costs while enhancing science return by enabling TIMED's instruments to operate at their full capacity around-the-clock. Several technological innovations are incorporated into TIMED's design providing a more efficient and inexpensive spacecraft that's easier to use. Several of these technological developments can enhance future science and commercial endeavors.

Increased Autonomy

The TIMED spacecraft is designed to be highly autonomous – able to carry out certain functions on its own – which results in more efficient spacecraft operations. It has a number of sensors to monitor many variables including its position, the amount of sunlight falling on its arrays, its temperature and power, and react accordingly. Just as an automobile monitors its oil supply and engine temperature, and switches on a light to alert the driver when there's a problem, the TIMED spacecraft is smart enough to monitor many of its own functions, take some corrective actions and alert Mission Operations personnel when a problem occurs. TIMED's ability to make the best use of its onboard resources makes the spacecraft easier and less expensive to operate.

Onboard Orbit Determination

One key difference between TIMED and most conventional spacecraft is TIMED's ability to determine its own orbit using a Global Positioning System (GPS) receiver located onboard the spacecraft.

Most spacecraft detect their orbits from ground-based crews, who uplink position information to the spacecraft using time-based predictions regarding the spacecraft's position and its data collection opportunities.

To more accurately determine and relay the spacecraft's position to ground-based crews, TIMED automatically feeds its GPS data into an onboard model containing a special filter (Kalman filter), which averages out errors that are sometimes experienced by GPS systems used onboard spacecraft. This is the first time such a filter has been incorporated into a GPS system for onboard orbit determination.

The spacecraft's ability to determine its orbit helps reduce mission life-cycle costs. The conventional time-based method of operations requires many people working from multiple ground stations worldwide to gather the information downlinked from the spacecraft, which is then routed to an operations center. TIMED, however, will require only one ground station – located at TIMED's Mission Operations Center at APL – which reduces the personnel and facility costs.

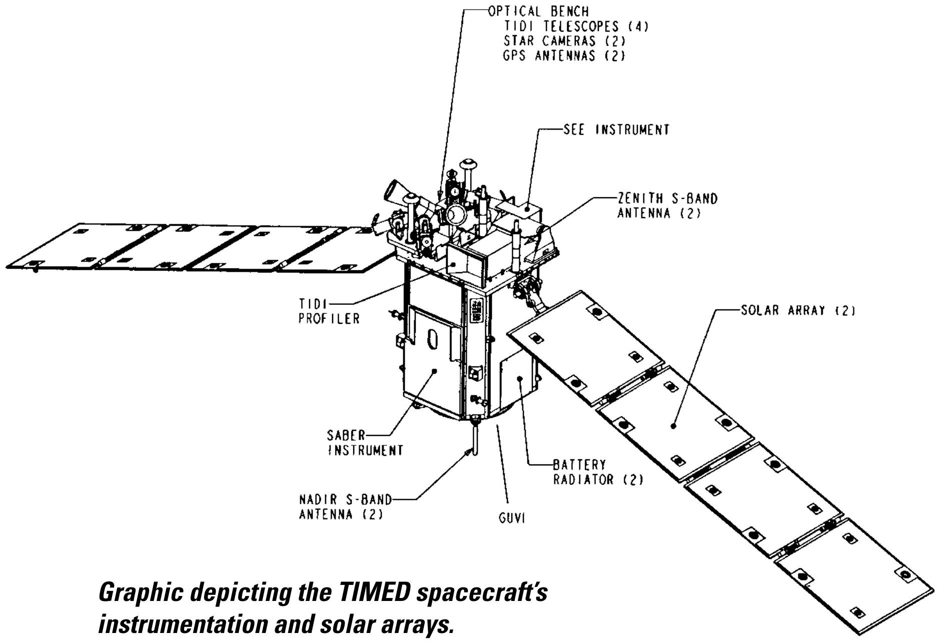
Event-based Commanding

For the first time, a space mission is using GPS to drive its mission operations – a cornerstone of the low-cost operations approach incorporated into the TIMED mission.

Because the TIMED spacecraft has a GPS receiver onboard, scientists can use a mode of operations known as event-based commanding, which enables a more simplified, reliable and cost-effective approach. With GPS onboard, the spacecraft knows its position at all times and can trigger events based on its position. For example, the spacecraft can be instructed to turn on its transmitter when it flies over the ground station; or to change the mode of instrument number one to mode B when it flies over the North Pole.

The traditional time-tagged method used by most spacecraft, however, tries to predict what time certain things will happen and issues spacecraft commands based on a timeline developed around those expectations.

For example, if you give someone directions to the nearest convenience store based on a timeline rather than on landmarks, you would give them instructions like: drive north on state Route 12 for 40 seconds, turn right in 30 seconds, make a left turn in 10 seconds, and then turn right into the parking lot in another 5.5 seconds. Just as several drivers could make errors finding the convenience store using this approach, so too, can missions using the time-based commanding methods of operations.



Graphic depicting the TIMED spacecraft's instrumentation and solar arrays.

Using the traditional time-tagged operational method, commands have to be uploaded for each orbit throughout the day, which requires around-the-clock shifts in the Mission Operations Center. But with event-based commanding, a set of commands used for each orbit is uploaded only once and used over and over again. This helps reduce overall mission operations costs by reducing the number of shifts needed to upload commands to the spacecraft on a daily basis.

With event-based commanding, TIMED is helping pave a new way of operating future scientific and commercial spacecraft.

Integrated Electronics Module (IEM)

The TIMED program is using an innovative technology called the Integrated Electronics Module (IEM), which enables smaller, lighter and more compact spacecraft to be launched on smaller launch vehicles.

The complex circuitry of most conventional spacecraft is housed on multiple circuit cards within multiple boxes. Typically, one box is used for each separate function that the spacecraft has to perform electronically.

The TIMED program has reduced each box to one or two cards and all cards have been placed within one box. TIMED's Integrated Electronics Module does the job of 10-12 separate boxes used on conventional missions. This key technology will enhance future space missions by helping create smaller, lighter and more compact spacecraft.

GPS Navigation System

One of the key subsystems contained within the IEM is the APL-developed GPS Navigation System (GNS), which autonomously generates, in real time, highly accurate estimates of TIMED's position, velocity and time. GNS will permit the realization of TIMED's event-based commanding mission operations concept, which was selected to reduce program life-cycle costs.

TIMED's GNS provides critical system functions for the mission, including onboard autonomous navigation, time recovery, position-based event detection, autonomous onboard orbit propagation and future event predictions. This newly developed system can be optimally applied for other low-earth- and/or medium-earth-orbiting missions.

Peak Power Tracker

As sunlight falls on a spacecraft's solar arrays, the arrays convert solar energy into electricity, which powers the spacecraft. Gallium arsenide solar panels alone, like those used on TIMED, are approximately 18-20 percent efficient in converting energy into electricity.

TIMED's Peak Power Tracker allows more efficient use of a spacecraft's solar arrays by loading them in the most efficient manner so peak power will be flowing from the arrays into the spacecraft. This means a spacecraft can fly with the smallest panels possible for the amount of power required to operate the spacecraft. This technique can be used on other missions to reduce overall spacecraft weight and provide more efficient solar array power utilization.

Instruments

TIMED's science payload consists of a tightly focused set of four instruments – the minimum set necessary to achieve the highest priority TIMED science.

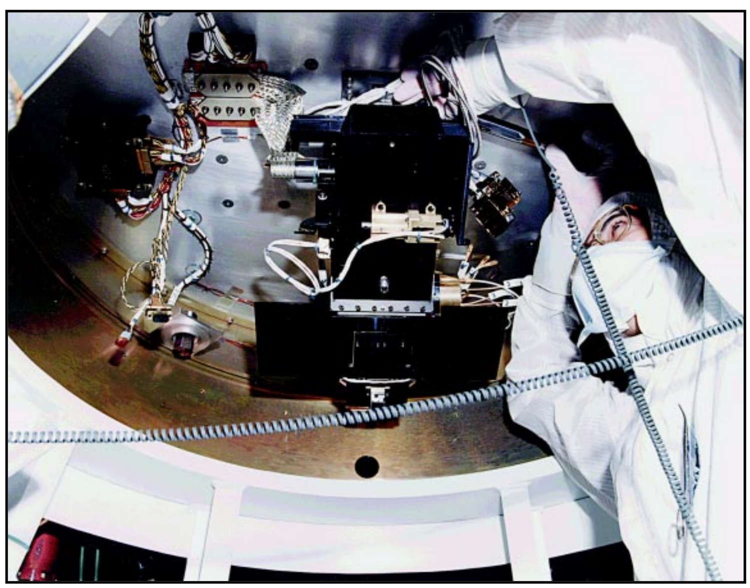
The science payload will allow scientists to look, for the first time in detail, at composition changes in the upper atmosphere; acquire unique measurements of atmospheric cooling as gases radiate energy back into space; measure the primary energy that's deposited into the MLTI region; and measure the speed and direction of wind in this region.

TIMED's four instruments are the:
- Global Ultraviolet Imager (GUVI);
- Sounding of the Atmosphere using Broadband Emission Radiometry (SABER);
- Solar Extreme Ultraviolet Experiment (SEE);
- TIMED Doppler Interferometer (TIDI).

Global Ultraviolet Imager (GUVI)

The GUVI instrument is designed to observe the glow of the Earth's upper atmosphere in ultraviolet light so scientists can better understand the properties of this atmospheric region. The upper atmosphere is known to respond to both external influences, such as solar variations, and internal motions originating in the atmosphere near the Earth's surface.

GUVI will be used to determine energy inputs from the sun into a region of the upper atmosphere where ultraviolet light ionizes the atoms and molecules. This area of Earth's atmosphere is home to the aurora and electrical currents that heat the upper atmosphere during magnetic storms. It's where radio waves are reflected back to Earth making long-distance radio communication possible.



The GUVI instrument is being integrated with the TIMED spacecraft.

GUVI, a spatial-scanning far-ultraviolet spectrograph, will globally measure the composition and temperature profiles of the MLTI region, as well as its auroral energy inputs. GUVI will look at sources of far-ultraviolet light originating in the Earth's upper atmosphere, such as the aurora, and will count individual particles of light, or photons, emitted by the atmosphere. GUVI is the first instrument sensitive enough to look, in detail, at composition changes in the upper atmosphere.

GUVI will globally scan the MLTI region looking for aurora and other sources of ultraviolet light every 1.5 hours – the time it takes to complete an orbit cycle. During each orbit cycle, GUVI will acquire day, night and auroral observations. Its very sophisticated, sensitive optical devices will enable scientists to see extremely minute amounts of light from space, for the first time, and create images of the upper atmosphere's composition changes.

Sounding of the Atmosphere using Broadband Emission Radiometry (SABER)

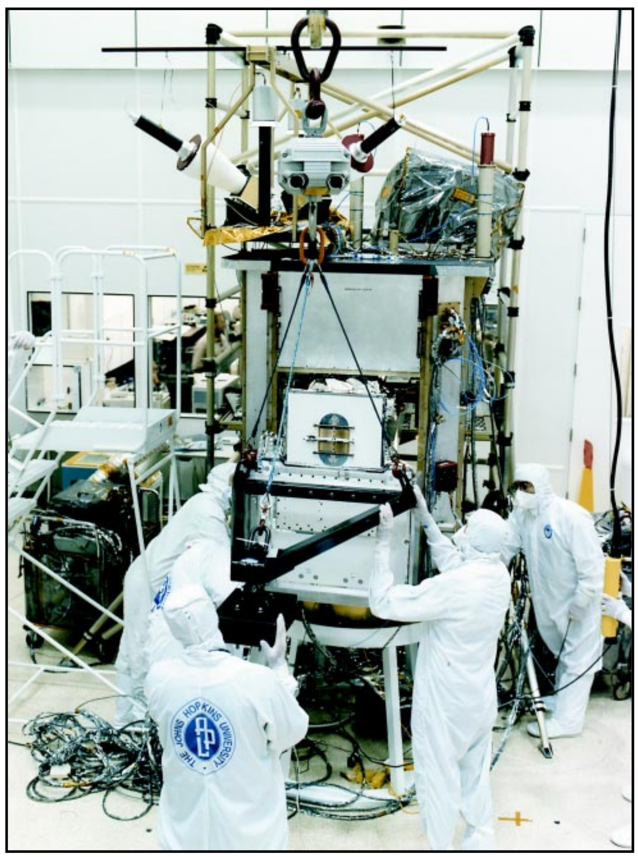
SABER is an instrument, known as a multichannel infrared radiometer, designed to measure heat emitted by the atmosphere over a broad altitude and spectral range.

SABER's primary science objectives are to explore the MLTI region to determine its energy balance; atmospheric structure (how temperature, density and pressure vary with altitude); chemistry (variations of key gases in the oxygen and hydrogen families); and the movement of air, or dynamics, between atmospheric regions (lower to higher altitudes, pole to equator, and east-west direction). It will also measure global temperature profiles and sources of atmospheric cooling, such as the "air glow," which occurs when energy is radiated back into space.

The technique that SABER will use on TIMED to sound, or make measurements in, the atmosphere has never before been used to study the MLTI region in such detail. Once every 58 seconds, SABER will scan up and down the Earth's horizon collecting data over an altitude range from approximately 112 miles (180 kilometers) down to the Earth's surface. It will measure the vertical distributions of elemental constituents, such as ozone, water vapor, carbon dioxide, and nitrogen and hydrogen gases, as well as temperature.

Over the course of one orbit, SABER will observe polar regions in one hemisphere to high latitudes in the opposite hemisphere. Over the course of a day, SABER will make measurements covering 15 longitude bands. During the course of the mission, the instrument will assemble a global picture of how the MLTI region is changing with latitude, longitude, altitude and time.

SABER's observations will open up a new area in the field of radiation balance. It will



The SABER instrument is being placed onto the TIMED spacecraft.

acquire measurements in a range of the atmosphere where the radiation and chemistry are much different than in the lower atmospheric regions due to molecules being more sparse and less active.

SABER will be the first instrument to measure the global-scale distribution of carbon dioxide concentrations within the MLTI region. Carbon dioxide, a greenhouse gas that's transported to Earth's upper atmosphere from the ground level where it's produced, results from natural emissions, burning fossil fuel needed for heating, electric power generation and a host of other industrial processes. SABER will also measure nitric oxide emissions, which scientists now believe is one of the primary gases responsible for the cooling of the upper atmospheric regions that TIMED will be studying.

A member of the SEE team prepares the instrument for integration with the spacecraft.

Solar Extreme Ultraviolet Experiment (SEE)

SEE is comprised of a spectrometer and a suite of photometers designed to measure solar ultraviolet radiation – the primary energy that's deposited into the MLTI atmospheric region. Examples of solar ultraviolet radiation that SEE will focus on are solar soft X-rays (which contain less energy than a traditional X-ray you would get in a doctor's office), extreme-ultraviolet and far-ultraviolet radiation.

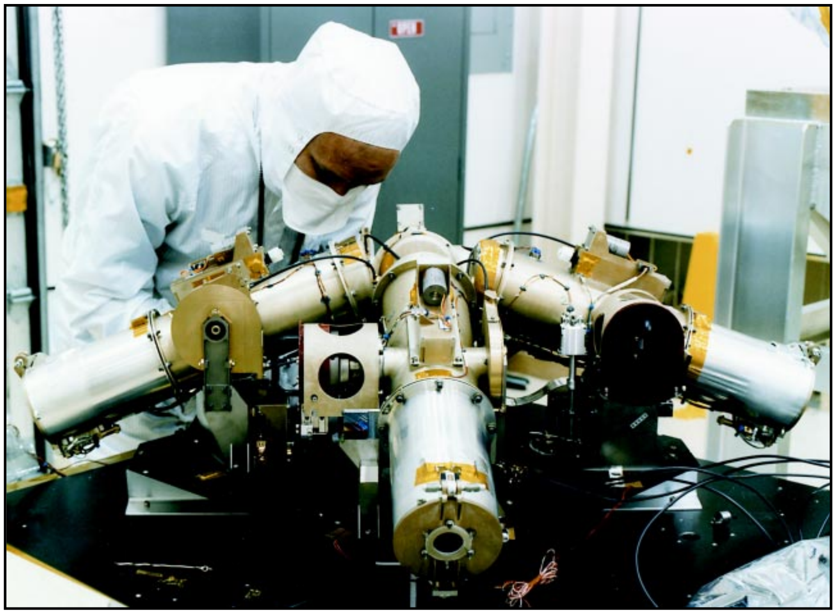
The primary objectives of the SEE instrument are to study the solar ultraviolet irradiance – how much it varies and how it affects the atmosphere; how much it heats the atmosphere and changes its composition; and to understand and establish an index of the solar variabilities so scientists can understand the solar ultraviolet changes occurring in this region, even after the TIMED mission is over.

SEE will observe the sun about three minutes per orbit while the sun is in full view. When possible, it will view the sunset through the atmosphere, which will help scientists determine the atmosphere's density. Data collected from SEE's observations of the sun will show where the solar energy, or radiation, is coming from as a function of wavelength and how each wavelength varies with time.

A device known as a soft X-ray photometer was developed to provide SEE scientists with the most precise measurements of the spectral region containing soft X-rays – the least understood and most difficult part of the solar spectral region to measure. Developed initially for SEE, these X-ray photometers are now being developed for ground-based plasma experiments.

TIMED Doppler Interferometer (TIDI)

TIDI will globally measure the wind and temperature profiles of the MLTI region. It will determine, on a global basis, the speed and direction of wind in the atmosphere by measuring tiny changes in the color of light emitted from individual chemical constituents in the



TIDI's telescopes are prepared for placement onto the spacecraft.

atmosphere, such as atomic oxygen, molecular oxygen, oxygen-hydrogen and sodium. Similar to how the change in pitch from a passing ambulance's siren helps determine its speed, scientists will use changes in color of light emitted by atmospheric particles to determine atmospheric wind speed and direction.

TIDI employs a spectrally-resolving optical element to determine the color, or wavelength, of light to a tremendously high degree of precision. Its high sensitivity and precise observations are accomplished by four telescopes looking simultaneously in perpendicular directions – two in front of the satellite at 45 degrees and two in the opposite direction at 135 degrees.

TIDI will measure wind at a few meters per second, and like all of the instruments onboard the spacecraft, TIDI will continuously collect data throughout the duration of the mission. Its continuous data collection allows TIDI to make the best possible use of available light in the atmosphere.

Collaborative Investigators

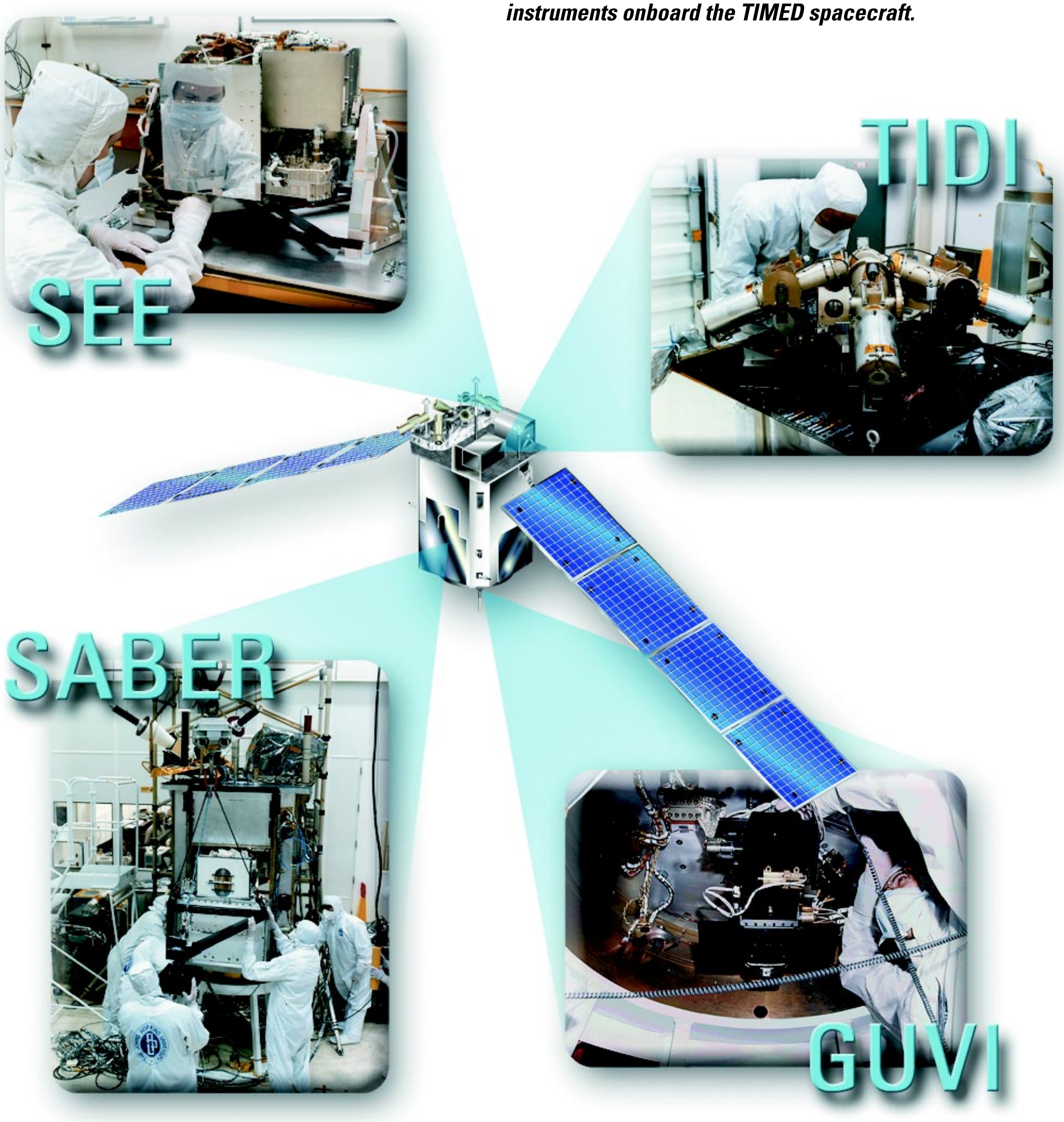
NASA and the National Science Foundation (NSF) are jointly sponsoring a program that will enable the TIMED science team to closely collaborate with other members of the scientific community studying the MLTI region. This program takes advantage of the synergy between ground- and space-based instruments and of the scientific contributions made by data assimilation and modeling.

Providing ground-based data complementary to that provided by the TIMED satellite will be one of the most significant contributions made by the collaborative investigators' program. The participating ground stations will play a key role in helping mission scientists clarify time and location ambiguity in data acquired by the satellite.

Many of the effects the spacecraft will be observing change with location and time. For example, if TIMED flies over a mountain range at 4 p.m. and records a change in wind, scientists will want to know if the change is due to the time of day (more air movement in daytime as the sun warms the earth; less at night when the ground is cooler) or the location (air travels up a mountain range rather than across flat land). The spacecraft needs a second point, such as the ground-based observations, to differentiate between time and location to help determine the cause for such a change in measurements.

The ground-based participants can observe some, but not all, of the same phenomena the satellite will observe within the MLTI region, such as the aurora, wind and some temperature and composition changes. But the satellite is the only way to obtain global coverage of the MLTI region since the number and location of ground stations are limited and each can only provide a single data point. Together, however, the spacecraft and ground stations will collaborate to unravel variations in the data regarding time and location to ensure the TIMED mission provides the most accurate data possible.

Graphic showing the location of the four instruments onboard the TIMED spacecraft.



Mission Management and Science Team Leaders

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Programs Manager .... Thomas Coughlin
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Project Scientist .... Jeng-Hwa (Sam) Yee
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Spacecraft Integration and Test .... Stanley Kozuch
Ground System Lead Engineer .... Elliot Rodberg
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Sounding of the Atmosphere using Broadband Emission
Radiometry (SABER) .... James Russell III, Hampton University
Solar Extreme Ultraviolet Experiment (SEE) .... Thomas Woods, University of Colorado
TIMED Doppler Interferometer (TIDI) .... Timothy Killeen, National Center for Atmospheric Research

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NASA's Sun-Earth Connection and Solar Terrestrial Probes Program

The Sun-Earth Connection (SEC) is one of four principal science themes around which missions within NASA's Office of Space Science are organized. The Sun-Earth Connection focuses largely on explaining the physical processes that link the sun and the Earth. Specifically, it seeks to understand the transfer of energy from the sun to the Earth, and how Earth's magnetosphere-ionosphere-atmosphere system responds to this transfer of energy. TIMED is the first mission within the Solar Terrestrial Probes (STP) Program, which falls under the SEC theme. It will investigate one of the Sun-Earth Connection's quests: How does the Earth's upper atmosphere respond to solar inputs?

The Solar Terrestrial Probes Program was created by NASA's Office of Space Science as a new element for the SEC theme. The STP Program offers a continuous sequence of flexible, cost-capped missions designed to systematically study the Sun-Earth system. STP missions will focus on studying the sun and the Earth as an integrated system using a blend of in situ and remote-sensing observations, often from multiple platforms. The major goals of the STP program are to: (1) understand the causes and effects of solar variability over vast spatial scales, and (2) determine the planetary and heliospheric responses to this variability.

Solar Terrestrial Probes Missions

The goal of understanding solar variability will be addressed from varying perspectives by TIMED and two other upcoming missions.

Solar-B, scheduled for launch in 2005, is a joint mission with Japan's Institute of Space and Astronautical Science. It will use optical, extreme-ultraviolet and X-ray measurements to provide, for the first time, quantitative measurements of the solar magnetic field on small spatial scales. It will enable the investigation of the interaction between the sun's magnetic field and its atmosphere. Solar-B's objective is to understand the mechanisms that give rise to solar variability and how this variability modulates the total solar output and creates the driving forces behind space weather.

Solar-B will be followed by the **Solar Terrestrial Relations Observatory (STEREO)**, which consists of two spacecraft to be launched into a solar orbit to provide dual viewing of the sun and its coronal mass ejections. STEREO will gather the first 3-D images of coronal magnetic field geometry, making it possible to understand the field evolution that precedes solar eruptions. These eruptions lead to coronal mass ejections, which STEREO will track out to Earth's orbit. Coronal mass ejections that hit the Earth cause geomagnetic storms and are a key phenomenon in space weather.

APL will build both spacecraft and maintain STEREO's Mission Operations Center, while NASA's Goddard Space Flight Center will manage the Science Data Center. The twin STEREO observatories are slated for launch in 2005.

Other STP missions under study would focus on the responses of near-Earth space to solar input. **Magnetospheric MultiScale**, for instance, would study simultaneously the fine-, medium-, and large-scale structure of the Earth's magnetosphere. The connections between the ionosphere and magnetosphere would be studied by the **Geospace Electrodynamic Connections** mission, which would follow the influences of solar activity on the upper atmosphere and the electrical connections between the solar wind/magnetosphere and ionosphere. **Magnetospheric Constellation** would fly tens to hundreds of nano-satellites in a constellation to make remote and in situ measurements in space.

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