STEREO

Solar TErrestrial RElations Observatory

THE SUN IN 3-D: A New Frontier in Solar Research

A Guide to STEREO's Twin Observatories

JOHNS HOPKINS UNIVERSITY Applied Physics Laboratory

Media Contacts

The Johns Hopkins University Applied Physics Laboratory
Kristi Marren
(240) 228-6268 or (443) 778-6268
kristi.marren@jhuapl.edu
Twin Observatories: Design, Assembly, Orbits and Post-launch Operations

NASA Headquarters
Grey Hautaluoma / Erica Hupp
(202) 358-0668 / (202) 358-1237
grey.hautaluoma-1@nasa.gov / erica.hupp-1@nasa.gov
Policy/Program Management

NASA Goddard Space Flight Center
Rani (Chohan) Gran
(301) 286-2483
rani.d.chohan@nasa.gov
Mission Management, Instruments and Science Operations

NASA Kennedy Space Center
George Diller
(321) 867-2468
george.h.diller@nasa.gov
Launch Site Operations

Boeing Company
Paula Shawa
(714) 372-1694
paula.r.shawa@boeing.com
Delta II Launch Vehicle

Education & Public Outreach Contacts

The Johns Hopkins University Applied Physics Laboratory
Kerri Beisser
(240) 228-6050 or (443) 778-6050
kerri.beisser@jhuapl.edu
Twin Observatories: Design, Assembly, Orbits and Post-launch Operations

NASA Goddard Space Flight Center
Kim Higgins
(301) 286-8613
khiggins@hst.nasa.gov
Mission Management, Instruments and Science Operations

The Johns Hopkins University Applied Physics Laboratory
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http://stereo.jhuapl.edu • http://www.nasa.gov/stereo

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Johns Hopkins University Applied Physics Laboratory

"With the design, construction and delivery of the nearly identical twin STEREO observatories to NASA, we're very excited to help the agency get one step closer to launch and capturing the first-ever 3-D images of the sun and solar wind. STEREO's observations will help improve our understanding of, and ability to forecast, space weather, which will help protect both Earth- and space-based systems from the effects of coronal mass ejections — the most powerful eruptions in our solar system."

– Ed Reynolds
STEREO Project Manager
The Johns Hopkins University Applied Physics Laboratory

A New Frontier in Solar Research

STEREO (**S**olar **TE**rrestrial **RE**lations **O**bservatory) is a 2-year NASA mission employing two nearly identical space-based observatories to provide the first-ever, 3-D "stereo" images of the sun to study the nature of coronal mass ejections. These powerful solar eruptions are a major source of the magnetic disruptions on Earth and a key component of space weather, which can greatly affect satellite operations, communications, power systems, the lives of humans in space, and global climate.

STEREO is the third mission in NASA's Solar Terrestrial Probes Program. The twin observatories are scheduled to launch aboard a single Boeing Delta II rocket from Cape Canaveral Air Force Station, Fla., in fall 2006.

STEREO is sponsored by NASA Headquarters' Science Mission Directorate, Washington, D.C. NASA Goddard Space Flight Center's Solar Terrestrial Probes Program Office, in Greenbelt, Md., manages the mission, instruments and science center. The Johns Hopkins University Applied Physics Laboratory (APL), in Laurel, Md., designed and built the spacecraft and will operate the twin observatories for NASA during the mission.

Johns Hopkins University Applied Physics Laboratory

The Johns Hopkins University Applied Physics Laboratory (APL), in Laurel, Md., designed, built, tested and will operate NASA's twin STEREO observatories.

Johns Hopkins University Applied Physics Laboratory

Mission Overview

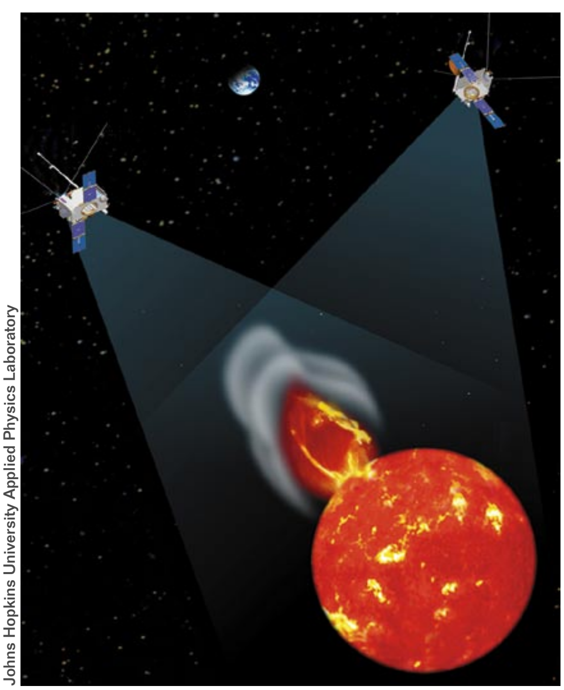
STEREO — the third mission in NASA's Solar Terrestrial Probes program — is scheduled to launch in fall 2006 aboard a single Boeing Delta II 7925 launch vehicle. This 2-year mission will employ two nearly identical space-based observatories to provide the first-ever, 3-D stereoscopic images of the sun. These images will help scientists study the nature of coronal mass ejections or CMEs — powerful eruptions that can blow up to 10 billion tons of the sun's atmosphere into interplanetary space.

Traveling away from the sun at speeds of approximately one million mph, CMEs can create major disturbances in the interplanetary medium and trigger severe magnetic storms when they collide with Earth. Large geomagnetic storms can cause electrical power outages and damage communications satellites.

Despite the importance of CMEs, scientists don't fully understand their origin or evolution, nor their structure or extent in interplanetary space. STEREO's unique 3-D images of the structure of CMEs will enable scientists to determine their fundamental nature and origin.

Mission Design

The STEREO mission will provide a totally new perspective on solar eruptions by imaging CMEs and background events from two observatories simultaneously. To obtain unique views of the sun, the twin observatories must be placed into a rather challenging orbit where they will be offset from one another. Using a series of lunar swingbys, one observatory will be placed ahead of Earth in its orbit around the sun and the other behind. Just as the slight offset between your eyes provides you with depth perception, this placement will allow the STEREO observatories to obtain 3-D images of the sun.



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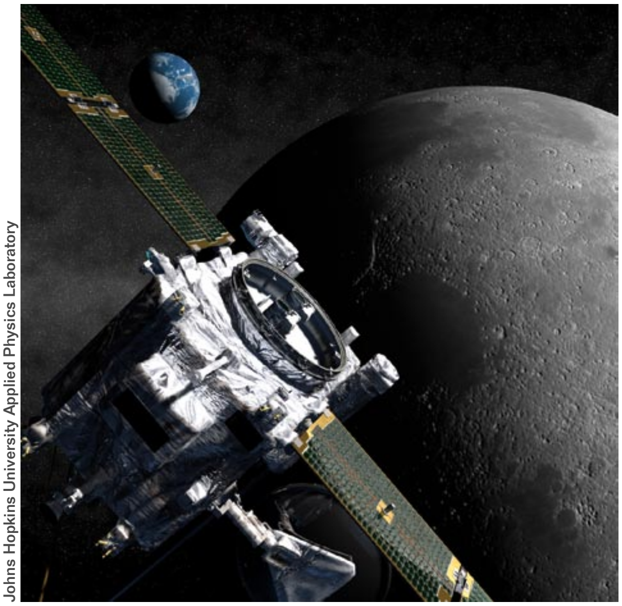
Artist's concept of the twin STEREO observatories studying the sun.

Lunar Swingbys

STEREO mission designers determined that the most efficient and cost-effective way to get the twin observatories into space is to launch them aboard a single rocket and use lunar swingbys to place them into their respective orbits. This is the first time lunar swingbys have been used to manipulate orbits of more than one spacecraft. Mission designers will use the moon's gravity to redirect the observatories to their appropriate orbits — something the launch vehicle alone can't do.

After launch, the observatories will fly in an orbit from a point close to Earth to one that extends just beyond the moon. Approximately two months later, mission operations personnel at APL will synchronize spacecraft orbits, directing one observatory to its position ahead of Earth in its orbit around the sun. Approximately one month later, the second observatory will be redirected to its position trailing Earth in its solar orbit.



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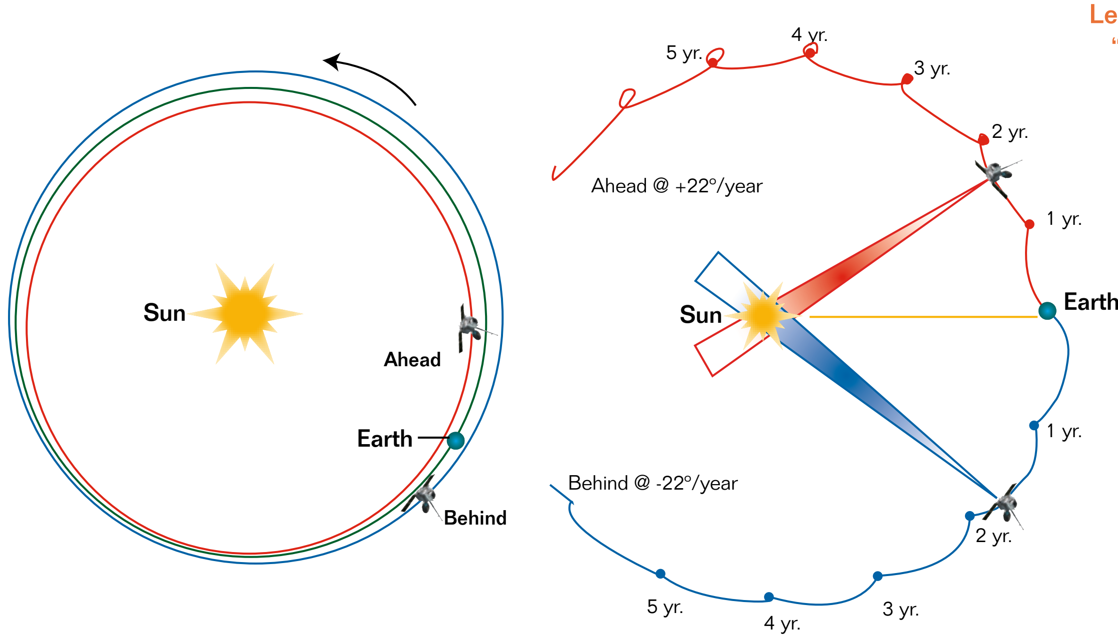
Artist's depiction of a STEREO observatory's lunar swingby maneuver.

When combined with data from observatories on the ground or in space, STEREO's data will allow scientists to track the buildup and lift-off of magnetic energy from the sun and the trajectory of Earth-bound CMEs in 3-D.



Left graphic shows orbits of the "Ahead" (red) and "Behind" (blue) observatories relative to the Earth's orbit (green). "Ahead's" elliptical orbit fits inside Earth's orbit and transits around the sun faster than Earth; "Behind's" is larger than Earth's orbit and transits around the sun more slowly. Right graphic shows drifting of the observatories (at a rate of 22 degrees per year) away from Earth relative to an Earth-sun reference line (yellow). The "scalloped" lines are caused by the spacecraft's elliptical orbits.

Mission Operations

STEREO's mission operations approach reduces costs while enhancing science return by using two spacecraft designed to operate autonomously, and by separating spacecraft and instrument operations.

Each of the twin observatories can carry out many functions on its own, including sensing its position, orientation and orbit, and react accordingly. Since autonomous spacecraft are easier to operate, the spacecraft and instruments can be controlled from separate locations.

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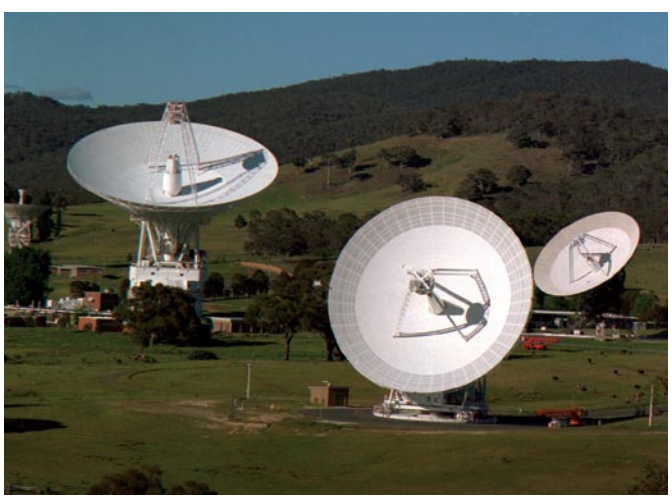
Mission operations personnel at APL conduct a prelaunch simulation.

Worldwide experts over a wide range of specialties are teaming to carry out the STEREO mission. Each of the four instrument principal investigators will have direct control of their instruments and experiments from payload operations centers situated at four locations worldwide:

- Naval Research Laboratory, Washington, D.C. – **S**un **E**arth **C**onnection **C**oronal and **H**eliospheric **I**nvestigation **(SECCHI)**
- University of California, Berkeley – **I**n situ **M**easurements of **PA**rticles and **C**ME **T**ransients **(IMPACT)**



NASA

NASA's Deep Space Network station in Canberra, Australia, will be the first station to communicate with the twin observatories after launch.

- University of New Hampshire – **PLA**sma and **S**upra**T**hermal **I**on **C**omposition **(PLASTIC)**
- Paris Observatory, Meudon, France – **S**TEREO/**WAVES** **(S/WAVES)**

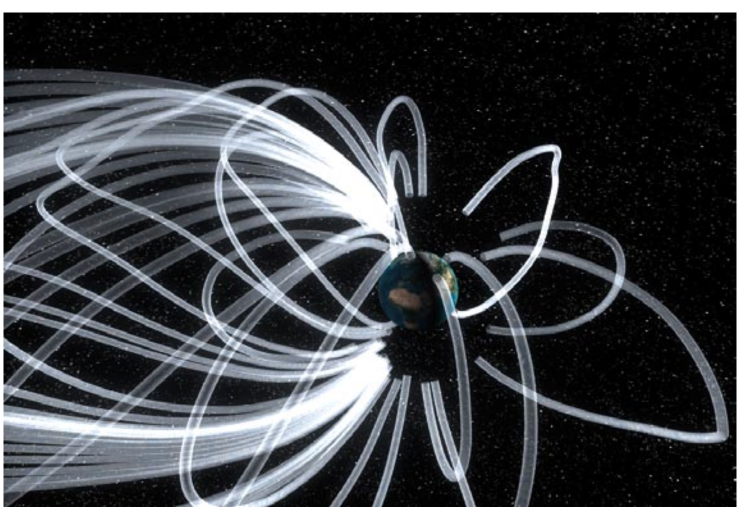
The payload operations centers will forward commands daily to the STEREO mission operations center located at APL, in Laurel, Md. Here, instructions for the instruments and spacecraft will be combined and uplinked to each of the observatories once daily using NASA's Deep Space Network. The APL-based mission operations center will also oversee downlinking data from both observatories, forwarding it electronically to the STEREO science center at NASA Goddard Space Flight Center in Greenbelt, Md., and to each of the payload operations centers.

Science Objectives

The overall objective of the STEREO mission is to obtain the necessary measurements and observations to develop an understanding of the fundamental nature and origin of coronal mass ejections — the most energetic eruptions on the sun and primary cause of major geomagnetic storms. The mission will use stereoscopic vision to construct a global picture of the sun and its influences.

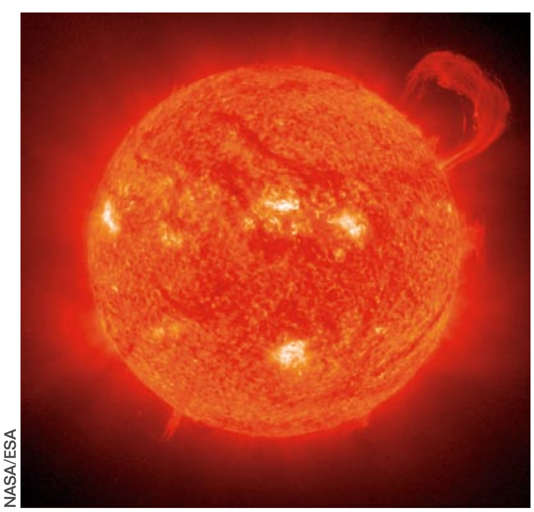
STEREO's specific science objectives are to:

- Understand the causes and mechanisms triggering coronal mass ejections
- Characterize the propagation of coronal mass ejections through the heliosphere
- Discover the mechanisms and sites of energetic particle acceleration in the low corona and the interplanetary medium
- Develop a 3-D, time-dependent model of the magnetic topology, temperature, density and velocity structure of the ambient solar wind



NASA

Artist's rendition of the Earth's magnetic field.



NASA/ESA

Erupting handle-shaped prominence captured by the Solar & Heliospheric Observatory (SOHO) on Sept. 14, 1999.

Observatories

Twin Observatory Design

The STEREO mission includes two nearly identical spacecraft designed, built and operated by APL for NASA Goddard Space Flight Center, which manages the mission. The twin observatories each carry two instruments and two instrument suites for a total of 16 instruments per observatory. The scientific instruments come from institutions around the world, including the Naval Research Laboratory; the University of California at Berkeley; the University of New Hampshire; and the Paris Observatory.

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Artist's concept illustrating deployment of the twin observatories' panels shortly after the spacecraft separate from the launch vehicle.

Onboard each spacecraft, six operational subsystems support the instruments and instrument suites. The subsystems include: command and data handling, radio frequency communications, guidance and control, propulsion, power, and thermal.

Each of the two solar-powered, 3-axis-stabilized spacecraft have a launch mass — including propellant — of approximately 1,412 pounds (642 kilograms). The spacecraft will communicate with the APL-based mission operations center via NASA's Deep Space Network.

Design Challenge

The significant number and wide range of instruments onboard each of the twin observatories is notable for spacecraft of their size. The significant challenge facing spacecraft designers was coupling the large number of instruments and their differing fields of view with their competing design requirements to ensure successful science observations.

More like fraternal than identical twins, the instruments onboard the "nearly identical" observatories are positioned a bit differently on each spacecraft to ensure the high-gain dish antennas remain pointed at Earth for command

and telemetry, and the instruments remain pointed at the sun. Neither observatory has to be rotated to accommodate instruments' viewing angles.

The "B" observatory's main structure is a little thicker so that it can support the weight of the "A" observatory during launch. (The "A" observatory is the one that will be placed "ahead" of Earth in its orbit around the sun; "B" will be placed "behind.") The "B" observatory will retain a portion of the separation fitting or ring used to connect the two spacecraft during their ride into space.

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The twin STEREO spacecraft inside an APL clean-room facility where they were built.

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APL STEREO mission personnel prepare the twin observatories for prelaunch checks at NASA Goddard Space Flight Center.

Key Characteristics of the Twin STEREO Observatories

Dimensions

With solar arrays, booms and antennas extended, each measures approximately:
24.5 feet (7.4 meters) long
28.6 feet (8.6 meters) wide
19.2 feet (5.8 meters) tall

Mass

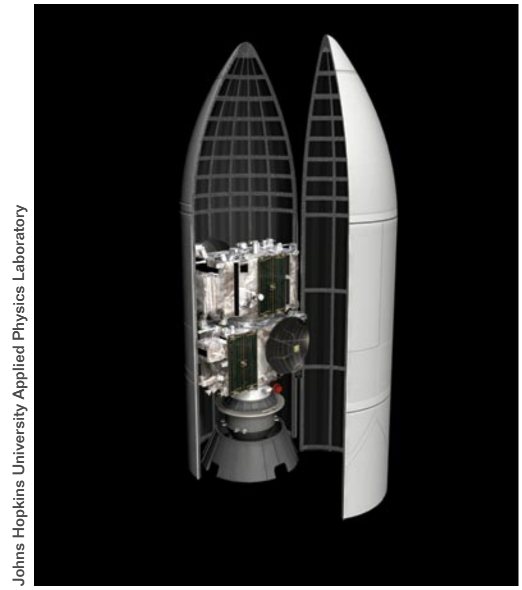
Each weighs approximately 1,412 pounds (642 kilograms)

Launch Configuration

The twin STEREO observatories will lift off from Launch Complex 17B at Cape Canaveral Air Force Station, Fla., in fall 2006, on a single Boeing Delta II 7925 launch vehicle. A spacecraft separation system allows one STEREO observatory to sit atop the other within the third stage of the Delta II launch vehicle.

Seeing with STEREO

The twin STEREO observatories will carry two instruments and two instrument suites aboard each craft. This combination provides a total of 16 instruments per observatory, most of which are housed in the **SECHHI** (**S**un **E**arth **C**onnection **C**oronal and **H**eliospheric **I**nvestigation) and **IMPACT** (**I**n situ **M**easurements of **PA**rticles and **C**ME **T**ransients) suites.

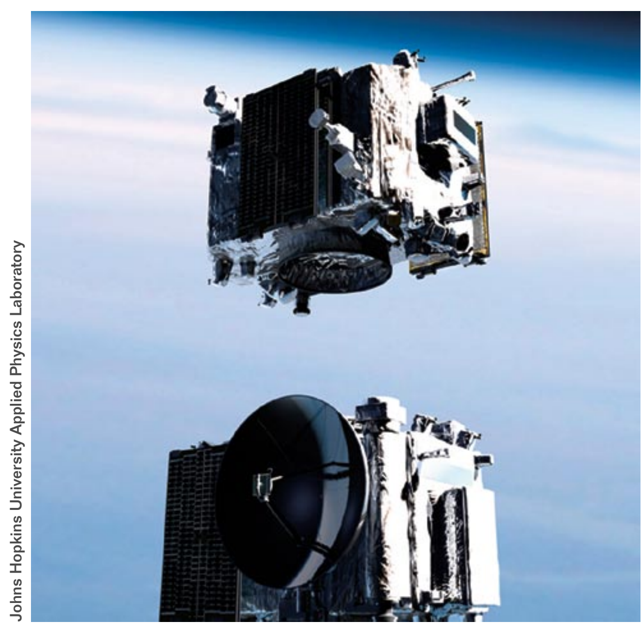


Artist's concept of the STEREO observatories in their launch configuration.

The instruments are being built by numerous organizations worldwide with a principal investigator leading each instrument team. After launch, the principal investigators will directly control their instruments from payload operations centers situated at four locations across the globe.

APL designed and built the spacecraft platform that houses the instruments onboard the twin STEREO observatories. The Laboratory will also operate the twin observatories for NASA during the 2-year mission from the APL-based mission operations center.

When combined with data from observatories on the ground or in space, STEREO's data will allow scientists to track the buildup and liftoff of magnetic energy from the sun and the trajectory of Earth-bound coronal mass ejections in 3-D.



Artist's concept depicting separation of the twin STEREO observatories.

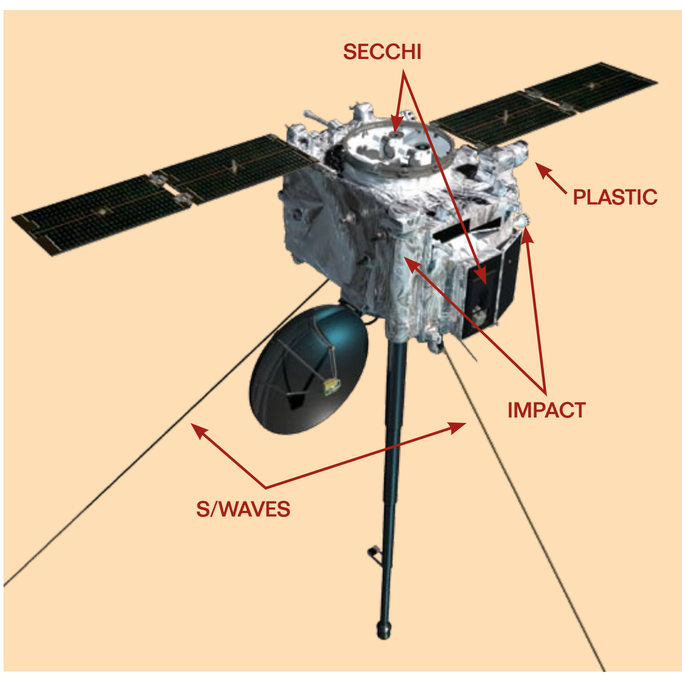
Instrument Suites

The **S**un **E**arth **C**onnection **C**oronal and **H**eliospheric **I**nvestigation **(SECCHI)** is a suite of remote-sensing instruments consisting of an extreme ultraviolet imager, two white-light coronagraphs, and a heliospheric imager. These instruments will study the 3-D evolution of coronal mass ejections — the most energetic eruptions on the sun and primary cause of major geomagnetic storms — from their origin at the sun's surface through the corona and interplanetary medium to their eventual impact at Earth. The principal investigator for the SECCHI instrument suite is Russell Howard of the Naval Research Laboratory.

The **In** situ **M**easurements of **PA**rticles and **C**ME **T**ransients **(IMPACT)** investigation provides measurements of the solar wind electrons, interplanetary magnetic fields, and solar energetic particles. IMPACT comprises seven instruments including a solar wind electron analyzer, a magnetometer, and an array of particle detectors measuring the energetic ions and electrons accelerated in coronal mass ejection (CME) shocks and in solar flares. IMPACT's principal investigator is Janet Luhmann of the University of California, Berkeley.

Instruments

The **PLA**sma and **S**upra**T**hermal **I**on **C**omposition **(PLASTIC)** instrument is slated to study coronal-solar wind and solar wind-heliospheric processes. PLASTIC will provide in situ plasma characteristics of protons, alpha particles and heavy ions. It will supply key diagnostic measurements of mass and charge state composition of heavy ions and will characterize the coronal mass ejection plasma from ambient solar wind plasma. The University of New Hampshire's Antoinette Galvin is the principal investigator for PLASTIC.



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STEREO/**WAVES (S/WAVES)** is an interplanetary radio burst tracker that will trace the generation and evolution of traveling radio disturbances from the sun to Earth's orbit. A radio and plasma wave receiver, S/WAVES is both a remote-sensing and an in situ instrument. Jean-Louis Bougeret, of the Paris Observatory, Meudon, is the principal investigator.

Program Management

NASA's Heliophysics Division

The Heliophysics Division, within NASA's Science Mission Directorate, manages science flight programs that carry out the exploration of the sun, its effects on the planets within the solar system, and space environmental conditions and their evolution. Specifically, it seeks to understand the transfer of energy from the sun to the Earth, and the interaction of solar plasma and radiation with Earth, the other planets and the galaxy.

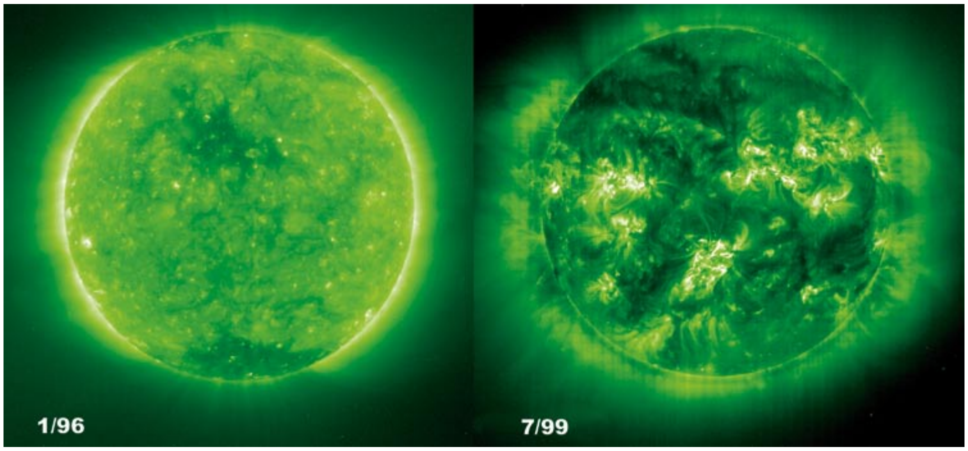
The Solar Terrestrial Probes (STP) Program within the Heliophysics Division focuses on specific scientific areas required to advance our fundamental understanding of the sun-solar system connection. STP missions will focus on studying the sun and Earth as an integrated system using a blend of in situ and remote-sensing observations, often from multiple platforms. The major goals of the STP program are aligned with the Heliophysics Division's science goals and objectives which include: (1) understanding the changing flow of energy and matter throughout the sun, heliosphere and planetary environments, and (2) exploring the fundamental physical processes of plasma systems in the solar system.

STEREO is the third mission within the Solar Terrestrial Probes Program. APL also designed, built and operates the first STP spacecraft, TIMED (Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics), which was launched on Dec. 7, 2001 (www.timed.jhuapl.edu).

For more information about NASA's Science Mission Directorate or Solar Terrestrial Probes Program, please visit:

http://science.hq.nasa.gov/index.html

http://stp.gsfc.nasa.gov/



NASA/ESA

False-color images, captured by the Solar and Heliospheric (SOHO) Extreme Ultraviolet Telescope (EIT) camera, showing solar minimum in 1996 (left) and solar maximum in 1999 (right). Solar maximum is the 2- to 3-year period around the peak of the sun's 11-year cycle when activity is most complex and turbulent, and the space around Earth is most disturbed. Solar minimum is the opposite.

Mission Management & Instrument Leads

NASA STEREO Mission Management

Solar Terrestrial Probes Program Executive .... Victoria Elsbernd (HQ)
Solar Terrestrial Probes Program Manager .... Gilberto Colón, acting (GSFC)
Program Scientist. .... Eric Christian (HQ)
Program Scientist. .... Madhulika Guhathakurta (HQ)
Project Manager .... Nick Chrissotimos (GSFC)
Deputy Project Manager .... Jim Adams (GSFC)
Deputy Project Manager-Instruments .... Mike Delmont (GSFC)
Project Scientist .... Mike Kaiser (GSFC)
Observatory Manager .... Mark Jarosz (GSFC)
Mission Systems Engineer .... Shane Hynes (Swales Aerospace)

The Johns Hopkins University Applied Physics Laboratory STEREO Project Management

Space Department Head .... Larry Crawford
Programs Manager .... Ted Mueller
Project Manager .... Ed Reynolds
Deputy Project Manager .... Ron Denissen
System Engineer .... Andy Driesman
Mission Design .... Dave Dunham
Software System Engineer .... Benjamin Ballard
Mission Operations Manager .... John Eichstedt
Education and Public Outreach Lead .... Kerri Beisser
Public Relations Lead .... Kristi Marren

Instrument Team Leads

Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI)

Principal Investigator .... Russell Howard, Naval Research Laboratory
Project Manager .... Dale Harris, Naval Research Laboratory

In situ Measurements of PArticles and CME Transients (IMPACT)

Principal Investigator .... Janet Luhmann, University of California-Berkeley
Project Manager .... Dave Curtis, University of California-Berkeley

PLAsma and SupraThermal Ion and Composition (PLASTIC)

Principal Investigator .... Antoinette Galvin, University of New Hampshire
Project Manager .... Steve Turco, University of New Hampshire

STEREO/WAVES (S/WAVES)

Principal Investigator .... Jean-Louis Bougeret, Paris Observatory, Meudon
Project Manager .... Keith Goetz, University of Minnesota

This list is maintained on our Web site at
http://stereo.jhuapl.edu/mission/team.php

Resources

Media Services Information

STEREO on the Web

STEREO information — including an electronic copy of this booklet and press releases, fact sheets, mission details and background, status reports, images and educational information — is available at http://stereo.jhuapl.edu.

NASA Television

In the continental United States, NASA Television's Public, Education and Media channels are carried by MPEG-2 digital C-band signal on AMC-6, at 72 degrees west longitude, Transponder 17C, 4040 MHz, vertical polarization. They're available in Alaska and Hawaii on an MPEG-2 digital C-band signal accessed via satellite AMC-7, transponder 18C, 137 degrees west longitude, 4060 MHz, vertical polarization. A Digital Video Broadcast compliant Integrated Receiver Decoder is required for reception. Analog NASA TV is no longer available.

The schedule of television transmission for STEREO will be available from NASA TV at http://www.nasa.gov/multimedia/nasatv/index.html and APL at http://stereo.jhuapl.edu/launch/launch.php.

NASA's Solar Terrestrial Probes

Information about NASA's Solar Terrestrial Probes Program is available at http://stp.gsfc.nasa.gov/; and the STEREO Program at www.nasa.gov/stereo.

Directory of Products

An array of media- and educational-related resources is available at http://stereo.jhuapl.edu.

Photos

The online image gallery (http://stereo.jhuapl.edu/gallery/images/images.php) contains pictures of the twin observatories' development from construction through launch.

Artist's Concepts

A variety of artist's concepts depicting the twin observatories in their launch configuration, in orbit, as well as the location of their instruments can be found at http://stereo.jhuapl.edu/gallery/images/artConcepts.php.

Videos

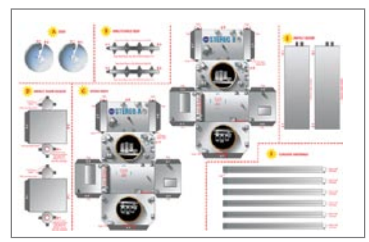
Ever wonder why two spacecraft are needed to study the sun or how you build them to operate in the extreme conditions they'll experience in space? How do you launch two spacecraft on one rocket? Using a broadcast news approach, a 6-minute video, "Solar News Network: NASA Gets a Double Dose of the Sun," can help answer these questions, and can be viewed online at http://stereo.jhuapl.edu/gallery/video/video.php. It has been distributed nationwide to middle school teachers, museums and science centers.

Another Solar Terrestrial Probes-related video, "TIMED — Closing the Link in the Sun-Earth Connection," focuses on how violent eruptions on the sun's surface and human-induced changes to our atmosphere affect life on Earth. Take a look at the first of NASA's Solar Terrestrial Probes (Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics, or TIMED) and find out how it will help scientists learn more about Earth's last atmospheric frontier. This 26-minute video is available online at http://www.timed.jhuapl.edu/press2/theMovie.html.

Animations

A variety of animations of the twin observatories and the lunar-swingby technique used to place them in their respective orbits can be found at http://stereo.jhuapl.edu/gallery/animation/animation.php.

B-roll Video



Broadcast media can acquire a b-roll video containing footage of spacecraft construction and animations by contacting APL STEREO Public Affairs Officer Kristi Marren, 240-228-6268. Tapes can be made in a variety of formats.

Paper Spacecraft Models

Ever wanted to build a spacecraft? How about two of them? Download and assemble models of the twin STEREO observatories by visiting http://stereo.jhuapl.edu/education/activities/pdfs/STEREOModel.pdf.

Fact Sheet

A 2-page fact sheet on the STEREO mission is available at http://stereo.jhuapl.edu/press/factSheet.php. A copy is also included on page 20 of this booklet.

Quick Facts

Key facts about the observatories and the overall mission are included in this booklet on page 16. They're also available online at http://stereo.jhuapl.edu/common/content/pdfs/quickFacts.pdf.

Educational Activities

A variety of online educational events and activities for middle-school students are available at http://stereo.jhuapl.edu/education/activities/act_prVi.php. Teachers and students can learn about 3-D images and download materials to build stereograms and stereoscopes; learn about a variety of space-related careers; and participate in several NASA interactive projects about the sun and auroras.

STEREO QUICK FACTS

About the Mission

What is STEREO and its purpose?

STEREO is an acronym for Solar TErrestrial RElations Observatory. This mission will employ two nearly identical observatories to provide the first-ever, 3-D stereoscopic images to study the nature of coronal mass ejections (CMEs). These powerful solar eruptions are a major source of the magnetic disruptions on Earth and a key component of space weather, which can greatly affect satellite operations, communications, power systems, the lives of humans in space, and even global climate over the long term.

The science objectives of the STEREO mission are to understand the causes and mechanisms of the origins of CMEs and characterize their propagation through the heliosphere; discover the mechanisms and sites of energetic particle acceleration in the low corona and the interplanetary medium; and develop a 3-D time-dependent model of the magnetic topology, temperature, density and velocity structure of the ambient solar wind.

How does STEREO fit into NASA's science program?

The Heliophysics Division, within NASA's Science Mission Directorate, manages science flight programs that carry out the exploration of the sun, its effects on the planets within the solar system, and space environmental conditions and their evolution.Specifically, it seeks to understand the transfer of energy from the sun to the Earth, and the interaction of solar plasma and radiation with Earth, the other planets and the galaxy.

The Solar Terrestrial Probes (STP) Program in the Heliophysics Division focuses on specific scientific areas required to advance our fundamental understanding of the sun-solar system connection. STP missions will focus on studying the sun and 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 aligned with the Heliophysics Division's science goals and objectives which include: (1) understanding the changing flow of energy and matter throughout the sun, heliosphere and planetary environments, and (2) exploring the fundamental physical processes of plasma systems in the solar system.

STEREO is the third mission within the Solar Terrestrial Probes Program. APL also designed, built and operates the first STP spacecraft, TIMED, which was launched on Dec. 7, 2001 (www.timed.jhuapl.edu).

When and from where will the observatories be launched?

The twin STEREO observatories are scheduled to launch aboard a Boeing Delta II 7925 rocket from Launch Complex 17B at Cape Canaveral Air Force Station, Fla., in fall 2006.

How long will the mission last?

STEREO is expected to operate for a minimum of two years. An additional one year of data analysis will be supported by STEREO's science team and by the mission's science center, located at NASA Goddard Space Flight Center, Greenbelt, Md.

Payload operations will be conducted remotely from each of the instruments' facilities:

- **S**un **E**arth **C**onnection **C**oronal and **H**eliospheric **I**nvestigation **(SECCHI)** – Naval Research Laboratory
- **S**TEREO**/WAVES (S/WAVES)** – Paris Observatory, Meudon/University of Minnesota
- **I**n situ **M**easurements of **PA**rticles and **C**ME **T**ransients **(IMPACT)** – University of California, Berkeley
- **PLA**sma and **S**upra**T**hermal **I**on **C**omposition **(PLASTIC)** – University of New Hampshire

What are the mission costs?

The total cost for STEREO is approximately $480 million for the spacecraft, all instruments, the launch vehicle, as well as ground operations, mission operations and data analysis.

Who is sponsoring and managing the mission? Who is building and operating the spacecraft?

STEREO is sponsored by NASA Headquarters' Science Mission Directorate, Washington, D.C. NASA Goddard Space Flight Center's Solar Terrestrial Probes Program Office, in Greenbelt, Md., manages the mission, instruments and science center. The Johns Hopkins University Applied Physics Laboratory (APL) in Laurel, Md., designed and built the spacecraft and will operate the twin observatories for NASA during the 2-year mission.

About the Science

What are coronal mass ejections and why is it important to study them?

Coronal mass ejections (CMEs) are powerful eruptions that can blow up to 10 billion tons of the sun's atmosphere into interplanetary space. Typically, CMEs eject about one billion tons of solar particles into space and travel at about one million mph. They can create major disturbances in the interplanetary medium (the space between planets containing electromagnetic radiation, dust, gas and plasma) and trigger severe magnetic storms if they reach Earth.

CME-driven shocks may also play a significant role in the acceleration of solar energetic particles, which can damage spacecraft and harm astronauts. CMEs are often associated with solar flares and prominence eruptions, but they can occur when neither is present.

Despite their importance, scientists don't fully understand the origin and evolution of CMEs, nor their structure or extent in interplanetary space. STEREO's unique 3-D images and movies of the structure of CMEs will enable scientists to determine their fundamental nature and origin.

About the Mission Design

How will the twin STEREO observatories be placed into their respective orbits?

The twin STEREO observatories will be launched together aboard a Boeing Delta II rocket. To place them into orbit in the most efficient and cost-effective manner possible, STEREO mission designers are using lunar gravity to redirect the observatories to their appropriate orbits — something the launch vehicle alone cannot do.

After launch, the observatories will fly in an orbit from a point close to Earth to one that extends just beyond the moon. Approximately two months later, mission operations personnel at APL will synchronize spacecraft orbits, directing one observatory to its position ahead of Earth in its orbit. Approximately one month later, the second observatory will be redirected to its position trailing Earth.

Is this the first time lunar swingbys have been used to manipulate spacecraft orbits?

The STEREO mission is the first to use lunar swingbys to manipulate orbits of more than one spacecraft. This technique enables multiple payloads to be launched aboard a single vehicle, saving a great deal of money.

Lunar swingbys have been used, however, to manipulate orbits of single spacecraft. In fact, APL was part of the first mission team to use lunar swingbys as they maneuvered the ISEE-3 (International Sun-Earth Explorer-3) spacecraft for its exploration of Earth's magnetotail in 1983.

About the Observatories

How will the STEREO observatories obtain the first-ever "stereo" or 3-D views of the sun?

The STEREO mission will offer a totally new perspective on solar eruptions by imaging coronal mass ejections and background events from two nearly identical observatories simultaneously. To obtain unique views of the sun, the twin observatories must be placed into a rather challenging orbit where they will be offset from one another. One observatory will be placed ahead of Earth in its orbit around the sun and the other behind. Just as the slight offset between your eyes provides you with depth perception, this placement will allow the STEREO observatories to obtain 3-D images of the sun.

Why do you use "nearly identical" to describe the twin observatories?

The twin STEREO observatories fly as mirror images of each other in order to obtain "stereo" views of the sun's activities. This requires the identical instruments on each spacecraft to be placed in slightly different locations. This ensures the high-gain dish antennas on each observatory remain pointed at Earth for command and telemetry, and the instruments remain pointed at the sun. Neither observatory has to be rotated to accommodate the instruments' viewing angles.

The main structure of the observatory that will be placed behind Earth in its orbit around the sun (the "B" observatory) is a little thicker so that it can support the weight of the other spacecraft during launch. The "B" observatory will retain a portion of the separation fitting or ring used to connect the two during their ride into space.

How many and what types of instruments are onboard the observatories?

Each twin STEREO observatory will carry two instruments and two instrument suites. This combination provides a total of 16 instruments per observatory. APL designed and built the spacecraft platform that houses the instruments.

STEREO's instruments include **PLA**sma and **S**upra**T**hermal **I**on and **C**omposition **(PLASTIC)** and **S**TEREO/**WAVES (S/WAVES)**.

The instrument suites onboard each observatory include the **S**un **E**arth **C**onnection **C**oronal and **H**eliospheric **I**nvestigation **(SECCHI)** and the **I**n situ **M**easurements of **PA**rticles and **C**ME **T**ransients **(IMPACT)**.

What are the key characteristics of each STEREO observatory?

Each observatory has a launch mass, including propellant, of approximately 1,412 pounds (642 kilograms).

When stacked together on the rocket, the observatories measure approximately:

- 8.9 feet (2.7 meters) long
- 8.5 feet (2.6 meters) wide
- 10.5 feet (3.2 meters) high

In space, once solar arrays, booms and antennas are extended, each observatory measures (from tip to tip) approximately:

- 24.5 feet (7.4 meters) long
- 28.6 feet (8.6 meters) wide
- 19.2 feet (5.8 meters) tall

STEREO

Solar TErrestrial RElations Observatory

The Sun in 3-D: A New Frontier in Solar Research

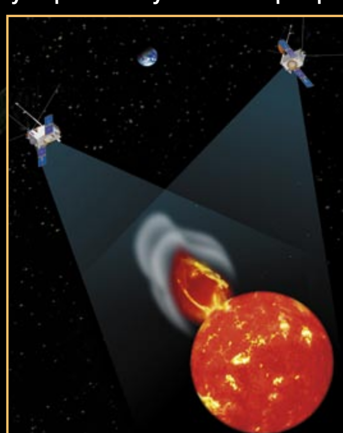
STEREO Views of the Sun

STEREO is a 2-year mission employing two nearly identical space-based observatories to provide the first-ever, 3-D “stereo” images of the sun to study the nature of coronal mass ejections. These powerful solar eruptions are a major source of the magnetic disruptions on Earth and a key component of space weather, which can greatly affect satellite operations, communications, power systems, the lives of humans in space, and global climate.

STEREO is the third mission in NASA’s Solar Terrestrial Probes Program. The twin observatories are scheduled to launch aboard a single Boeing Delta II rocket from Cape Canaveral Air Force Station, Fla., in fall 2006.

Capturing the Sun in 3-D

The twin observatories will fly as mirror images of each other to obtain unique “stereo” views of the sun’s activities. They must be placed into a rather challenging orbit where they’re offset from one another. One observatory will be placed ahead of Earth in its orbit around the sun and the other behind. Just as the slight offset between your eyes provides you with depth perception, this placement will allow the STEREO observatories to obtain 3-D images and particle measurements of the sun.



Placing STEREO into Orbit

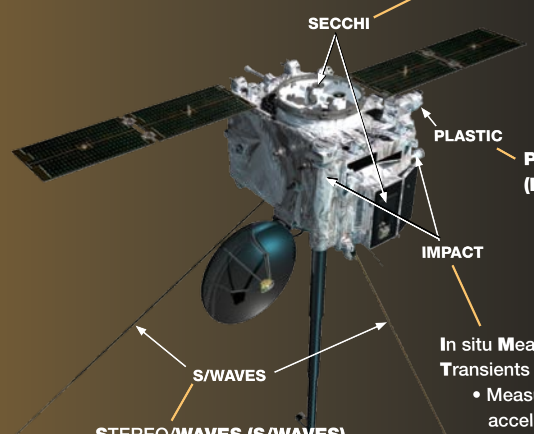
STEREO mission designers determined that the most efficient and cost-effective way to get the twin observatories into space was to launch them aboard a single rocket and use lunar swingbys to place them into their respective orbits. This is the first time lunar swingbys have been used to manipulate orbits of more than one spacecraft. Mission designers will use the moon’s gravity to redirect the observatories to their appropriate orbits – something the launch vehicle alone can’t do.

After launch, the observatories will fly in an orbit from a point close to Earth to one that extends just beyond the moon. Approximately two months later, mission operations personnel at the Johns Hopkins University Applied Physics Laboratory (APL), in Laurel, Md., will synchronize spacecraft orbits, directing one observatory to its position ahead of Earth in its orbit. Approximately one month later, the second observatory will be redirected to its position trailing Earth.

Seeing with STEREO

Each twin STEREO observatory will carry two instruments and two instrument suites. This combination provides a total of 16 instruments per observatory. APL is designing and building the spacecraft platform housing the instruments. When combined with data from observatories on the ground or in space, STEREO's data will allow scientists to track the buildup and liftoff of magnetic energy from the sun and the trajectory of Earth-bound coronal mass ejections in 3-D.

Observatory Design



Sun **E**arth **C**onnection **C**oronal and **H**eliospheric **I**nvestigation **(SECCHI)**
- Studies 3-D evolution of coronal mass ejections (from their origin on sun's surface to their impact at Earth)
- Principal Investigator: Russell Howard, Naval Research Laboratory, Washington, D.C.

PLAsma and **S**upra**T**hermal **I**on and **C**omposition **(PLASTIC)**
- Studies coronal-solar wind and solar wind-heliospheric processes
- Principal Investigator: Antoinette Galvin, University of New Hampshire

In situ **M**easurements of **PA**rticles and **C**ME **T**ransients **(IMPACT)**
- Measures energetic ions and electrons accelerated in coronal mass ejection shocks and in solar flares
- Principal Investigator: Janet Luhmann, University of California, Berkeley

STEREO/**WAVES (S/WAVES)**
- Tracing the generation and evolution of traveling radio disturbances from the sun to the Earth's orbit
- Principal Investigator: Jean-Louis Bougeret, Paris Observatory, Meudon

Mission Management

NASA Program Scientists
Eric Christian
Madhulika Guhathakurta

NASA Project Manager
Nick Chrissotimos

APL Project Manager
Edward Reynolds

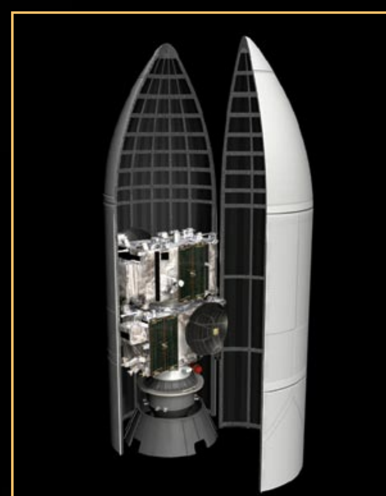
Key STEREO Characteristics

Mass: Approximately 1,412 pounds (642 kilograms) each

Dimensions (approximate)**:**
When stacked together on the rocket:
8.9 feet (2.7 meters) long
8.5 feet (2.6 meters) wide
10.5 feet (3.2 meters) high

When deployed (solar arrays, booms, antennas extended):
24.5 feet (7.4 meters) long
28.6 feet (8.6 meters) wide
19.2 feet (5.8 meters) tall

Launch Configuration

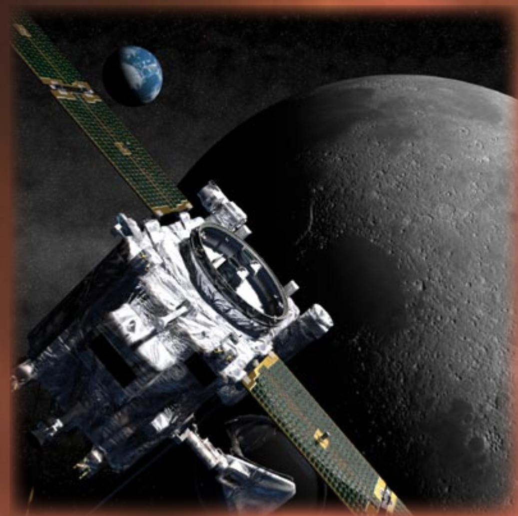


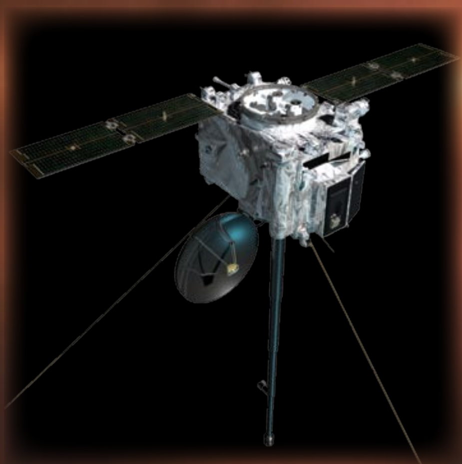
A spacecraft separation system allows one STEREO observatory to sit atop the other within the third stage of the Delta II launch vehicle.

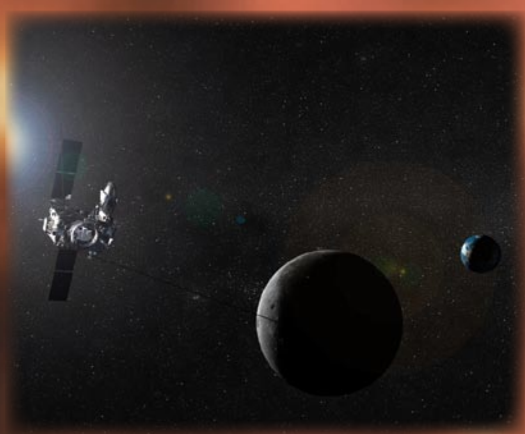
http://stereo.jhuapl.edu
http://www.nasa.gov/stereo

04-06185
Rev 10/20/06
(Oct. 25 - Nov. 2
launch window)

STEREO is sponsored by NASA's Science Mission Directorate, Washington, D.C. NASA Goddard Space Flight Center's Solar Terrestrial Probes Program Office, in Greenbelt, Md., manages the mission, instruments and science center. The Johns Hopkins University Applied Physics Laboratory, in Laurel, Md., designed and built the spacecraft and will operate the twin observatories for NASA during the 2-year mission.







Follow STEREO as it Captures the Sun in 3-D

http://stereo.jhuapl.edu
http://www.nasa.gov/stereo