NASA Facts

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

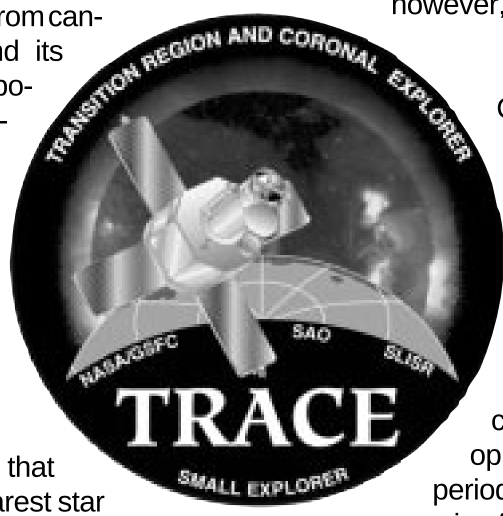
AC 301 286-8955

FS-1998-01-001-GSFC

Transition Region and Coronal Explorer (TRACE): Exploring the Upper Regions of the Solar Atmosphere

The Scientific Mission of TRACE

At the center of the solar system is a variable, magnetic star we call the Sun. Our day-to-day experience tells us that the Sun is steady, unchanging and even dependable. If we take the time to think about it, we might realize that the Sun is our sole source of energy and that all life on Earth depends on the constant flow of its life-giving heat. The Earth's atmosphere protects us from cancer-causing solar radiation and its magnetic field shields us from potentially deadly energetic particles. Without these protecting layers, life as we know it could not exist on Earth, and possibly, not even have developed in the first place. Although we rely on the benefits from the Sun, in most cases, we have ignored its dangers.



It may surprise us to learn that detailed observations of our nearest star using modern telescopes reveal that it is not only active and dynamic, but at times, even explosive. Solar flares, causing localized temperature increases of 20 million degrees Fahrenheit in a few seconds time, send enormous amounts of high energy radiation streaming towards the Earth. This activity occurs on all observable time scales — from seconds to centuries — and at all levels— from the surface, through the atmosphere, and into the interplanetary space that surrounds the Earth and the other planets of the solar system. These bursts can disrupt satellite communications and terrestrial electric power lines. As society grows more dependent on satellite-based technology, understanding the behavior of the Sun is of greater interest. Scientists have learned that this activity is the result of interactions between the Sun's magnetic field and the mass motions of its hot ionized gases. The details that connect the evolving magnetic field with this activity, however, have remained elusive.

NASA's Transition Region and Coronal Explorer (TRACE) will operate for one year in an orbit that flies over the Earth's poles in such a way that it will stay in sunlight continuously. Thus, solar scientists will be able to observe the rise of the current solar activity cycle uninterrupted. This is a particularly exciting time in the on-going development of the Sun. It will provide periods of intense solar activity with massive flaring and huge eruptions interspersed with long periods when the solar environment is relatively passive. This will allow TRACE to sample the full range of solar conditions even in its relatively short planned life. TRACE will observe temperatures within these regions from approximately 16,000 to 16 million degrees Fahrenheit. This ability to view the solar atmosphere makes TRACE unique among the current group of satellites studying the Sun which includes ACE, SOHO and Yohkoh.

The surface of the Sun is a relatively cool (5,000 degrees Celsius), placid place compared with the corona, the hot (1 million degrees Celsius), outer layers of its atmosphere. The high temperatures of the corona make it a natural source of X-rays, high energy light which is normally blocked by the Earth's atmosphere. Recent advances in technology have allowed scientists to image these X-rays with instruments on space-based telescopes. Putting these images together in a time series produces an X-ray movie where we can see that flares and mass ejections are going on almost continuously.

TRACE will observe the most visible manifestations of the magnetic field, the sunspots, which are dark areas on the Sun's surface where the field is particularly intense. Individual sunspots emerge, evolve and disappear on time scales from hours to months, and can be observed moving across the face of the Sun as it rotates (about once per month). The total number of sunspots also waxes and wanes with a period of about eleven years. At the peak of this activity cycle, the number of solar flares (explosions in the solar atmosphere), mass ejections (eruptions of huge amounts of energetic solar material which leaves the Sun and travels out into the solar system), and auroae (the northern lights, the beautiful interactions between the energetic particles from the Sun and the Earth's magnetic field) all increase dramatically. This sequence of events — flares, mass ejections, and auroae — illustrates what we now call the Sun-Earth Connection. These violent changes in our Sun have fascinated astronomers since the invention of the telescope nearly 400 years ago. With solar activity now rising to its maximum level (forecast to occur in the year 2000), scientist are attempting to understand how the radiation, particles, and magnetic fields that stream from the Sun can impact our planet — NASA's Sun-Earth Connections Program.

TRACE Spacecraft at Goddard

A Small Explorer Project

The Transition Region and Coronal Explorer (TRACE) is the fourth satellite in the series of Small Explorer (SMEX) missions. The program's goal is a flight rate of one mission per year of small scientific satellites launched on small expendable launch vehicles. The SMEX program's purpose is to provide frequent flight opportunities for scientific investigations from space. TRACE is scheduled for launch in 1998 on a Pegasus rocket released from an L-1011 jet aircraft flown out of VAFB, Calif. The SMEX missions are managed by the Goddard Space Flight Center in Greenbelt, Md. and are part of the larger Explorer Program. The Explorer Program enables missions through a variety of means to meet the needs of the scientific community and the NASA space science enterprise.

TRACE Science Objectives

- Observe the evolution of magnetic field structures from the solar interior of the corona.
- Study the heating mechanisms of the outer solar atmosphere.
- Investigate the triggers and onset of solar flares and coronal mass ejections.

The Spacecraft

The TRACE spacecraft stands nearly six feet tall, is 3.5 feet across and weighs 465 pounds. It points the ultraviolet solar telescope at selected features of the Sun with an accuracy of a fraction of a degree.

The Attitude Control System uses three magnetic Sun sensors, four reaction wheels, one three-axis magnetometer and three two-axis inertial gyroscopes to control the spacecraft orientation. The spacecraft computer controls all on-board functions. Power is provided from four deployed panels of gallium arsenide solar cells. An S-band transponder is used for ground communication.

About the Telescope

TRACE employs a telescope that is different from other telescopes in that its one foot (30 centimeters) super polished mirrors are individually coated four distinct ways to allow light from different bandwidths to be captured and analyzed. Regions of the Sun ranging in temperatures from 16,000 to 16 million degrees Fahrenheit will be detected and examined. A Charge Couple Device (CCD) detector collects images over a 3,600 x 3,600 mile field of view. This represents about 25 percent of the Sun's disk or outer edge. A powerful data handling computer enables very flexible use of the CCD array including adaptive target selection, data compression and image stabilization.

Quick Mission Facts

Mission Duration: 1 year requirements with multi-year goals.
Orbit: 373 x 404 miles (600 x 650 kilometers) Sun synchronous
Mass: 465 pounds (211 kilograms)
Power: 200 watts
Launch Vehicle: Pegasus XL
Launch Site: Western Range, Vandenberg AFB, Calif.
Launch Date: March 1998
Cost of TRACE Spacecraft: $39 million

TRACE Orbit and Targets

The Sun-synchronous TRACE orbit was selected to allow nearly continuous observations of the Sun. Therefore, the random processes associated with changes in the magnetic field have a very high probability of being observed completely. In most operational modes, TRACE will stare at a fixed location with respect to the solar limbs and collect image sequences optimized to be diagnostic of particular processes. In addition, the TRACE image processor can continuously monitor the data stream and adapt both the experimental program and the instrument pointing. Decisions on solar targets and particular experiments to be run will be made by the science team daily.

Launch Timing and SOHO Complement

The launch of TRACE coincides with the onset of solar maximum, so that there is a high probability of capturing the emergence processes in a solar atmosphere that is relatively uncomplicated. Further, the new solar cycle coincides with the flight of the NASA/ESA Solar and Heliospheric Observatory (SOHO). The two satellites provide complementary observations: TRACE produces the high spatial and temporal resolution images, while SOHO yields images and spectral data out to 30 solar radii (or 15 times the width of the Sun) or at much lower spatial and temporal resolution. Jointly they provide the opportunity to obtain simultaneous digital measurements of all the temperature regimes of the solar atmosphere, in both high-resolution imaging and spectroscopy. Merging TRACE and SOHO data will allow a more complete picture of the Sun's processes.

Science Data Collection and Analyses

TRACE will be operated from a Science Operations Center adjacent to the SOHO Experiment Operations Facility at the Goddard Space Flight Center. The science team is committed to involving students throughout the investigation and to sharing the data openly within the scientific community. A website will allow the general public to view the TRACE quick-look images in near real-time. The TRACE images will be even more dynamic than those produced by Yohkoh and will have enormous visual appeal to the general public and especially to students at all levels. Yohkoh ("Sunbeam" in Japanese) is a satellite dedicated to high-energy observations of the Sun, specifically of flares and other coronal disturbances. The Yohkoh mission was launched on Aug. 30, 1991, from the Kagoshima Space Center in southern Japan. The spacecraft carries a payload of four scientific instruments and together these instruments provide detailed information about high-energy processes in solar flares and in other forms of solar coronal activity.

TRACE is the first U.S. research mission with a completely open data policy. All data obtained by TRACE will be available to other scientists, students, and the general public shortly after it becomes available to the primary science team so that the general public can join NASA in its exploration of the solar atmosphere. This is now becoming NASA's standard data policy.

The Why of TRACE

The human race is becoming more technologically sophisticated, depending more and more on space-based satellites for communication, navigation, weather forecasting, and security. The environment in which these expensive and vital assets operate is above the protective layers of the Earth's atmosphere and magnetic field and is, therefore, controlled by the Sun. As we reach out to other worlds in our solar system to explore beyond the protected environment of the Earth, we not only need to understand the origins of solar events but must be able to predict their occurrence, size, and effects if we are to navigate safely through the treacherous conditions of interplanetary space. Even with its increasingly sophisticated computer models and fleet of space probes, modern science is still a long way from being able to protect our communication satellites, our power grids, and our astronauts from the potentially devastating and even deadly effects of these as yet unpredictable solar flares. TRACE represents a major step on the long road that leads to the understanding of our own star, the Sun.

TRACE Educational Products

As part of NASA's educational outreach program, the TRACE mission is participating in the Cooperative Satellite Learning Program (CSLP) through its association with DuVal High School in Lanham, Md. The CSLP students will follow the progress of the mission using actual flight images.

A NASA "In House" Product

The TRACE science instrument was produced by Stanford Lockheed Institute for Scientific Research (SLISR) of Palo Alto, Calif. The TRACE spacecraft that carries it was designed, fabricated, integrated, and tested at the Goddard Space Flight Center. Engineers, technicians, and support contractors performed the engineering, assembly, and testing of the spacecraft using Goddard facilities. Building spacecraft in this manner develops the skills and knowledge that young engineers and scientists need to take a complex system from design to launch. TRACE was completed on time and 20 percent under budget.

Mission Management

TRACE is managed by the Goddard Space Flight Center for the Office of Space Science at NASA Headquarters in Washington, D.C. The TRACE management team is as follows:
Alan Title, Principal Investigator, Stanford Lockheed Institute for Scientific Research;
Jim Watzin, Project Manager, NASA Goddard Space Flight Center;
Joe Burt, Mission Systems Engineer, NASA Goddard Space Flight Center;
Dick Fisher, Mission Scientist, NASA Goddard Space Flight Center

TRACE Mision Web Site

More information about this mission can be found at the following Internet address:
http:// sunland.gsfc.nasa.gov/smex/trace/