NASA News

National Aeronautics and
Space Administration

Washington, D.C. 20546
AC 202 755-8370

For Release IMMEDIATE

Press Kit

RELEASE NO: 77-213

Project International Sun Earth Explorers (ISEE)

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Mailed:
October 13, 1977

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Space Administration

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RELEASE NO: 77-213

MOTHER-DAUGHTER SATELLITES SET FOR LAUNCH

Two spacecraft will be launched by a single rocket this month as part of a cooperative program by NASA and The European Space Agency (ESA) to gain a better understanding of how the Sun controls the Earth's near space environment.

Called International Sun Earth Explorers, the mother-and-daughter satellites will be launched about Oct. 19 from Kennedy Space Center, Fla., into looping trajectories around the Earth, ranging in distance from 140,000 kilometers (87,000 miles) to 280 km (174 mi.).

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The mission involves 117 scientific investigators, 35 universities and 10 nations.

Circling our planet for three years or more, the instrument-laden spacecraft are expected to provide detailed data on how solar wind particles control the boundaries between Earth space and interplanetary space. This will lead to a better understanding of a variety of solar-terrestrial phenomena, including weather and climate, energy production and ozone depletion in the atmosphere.

ISEE-A, managed by NASA, and B, managed by ESA (to be designated ISEE-1 and ISEE-2 after orbital insertion), are the first set of spacecraft designed to be used together to investigate Earth's immediate space environment.

Shortly after third stage burnout, when the two spacecraft have attained the required trajectory, they will be separated from each other but will remain in the same orbit. The separation distance between ISEE-1 and ISEE-2 will be varied by the controllers between a few hundred to a few thousand kilometers during the lifetime of the mission.

For reasons of energy conservation, the smaller spacecraft, ISEE-2, weighing 158 kilograms (348 pounds), will be the maneuverable spacecraft. The orbit of ISEE-1 will not be changed. Initially, however, both spacecraft will undergo attitude maneuvers so that both point to the same place in space.

All maneuvers will be conducted by a NASA/ESA team at NASA's Goddard Space Flight Center, Greenbelt, Md.

The use of two spacecraft, separated by a variable distance, will allow scientists to study the boundaries in near-Earth space and the nature of their fluctuations. These include the plasma pause -- the position at which there is a dramatic drop in the density of the magnetosphere -- the magnetic envelope which surrounds the Earth; the magnetopause, where the magnetic field of the Earth meets that of the solar wind; the bow shock, a sort of bow wave created by the motion of the solar wind past the Earth, and several less obvious features of the Earth's magnetic tail.

Measurements by instruments on a pair of spacecraft will permit ambiguities associated with the motion of these boundaries to be resolved.

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In the past, a large number of phenomena measured by single instruments on spacecraft were not clearly understood. For example, did the sudden increase in energetic particles noted from measurements by one spacecraft come from an eruption on the surface of the Sun, perhaps a solar flare, or did it come from some other source? Perhaps the particles were suddenly released from the Earth's radiation belts or were bounced back from the bow shock front that extends hundreds of thousands of kilometers out from Earth. With two spacecraft at different points on a similar trajectory with similar instrumentation, time and space aspects associated with such problems can be solved.

Even greater scientific returns will be possible when a third spacecraft, ISEE-C, is launched by NASA next summer to what is called the libration point -- about 1.5 million km (932,055 million mi.) from Earth toward the Sun -- where the satellite will remain with only minor onboard gas adjustments. At that point in space, the forces of gravity and the dynamic force exert an equal pull.

ISEE-C (to be called ISEE-3 in heliocentric orbit) will obtain nearly continuous data on the fluctuating solar wind, and on special solar phenomena, such as solar flares, about an hour before the solar particles flow past ISEE-1 and 2 in Earth orbit.

In certain instances, this will give scientists on the ground time to make inputs to onboard instrumentation on the mother-daughter spacecraft to look for correlating phenomena. At the same time, sounding rockets could be fired from any global location on cue from Goddard Center at different launch areas around the world to investigate other aspects of onrushing solar wind. As part of a program called the International Magnetospheric Study (IMS), ground stations, sounding rockets, balloons, aircraft and satellites, including the ISEE spacecraft, will look at the same phenomenon simultaneously from different parts of the Earth, including polar areas and space.

ISEE coordination is designed to fit into the IMS program, which is a world-wide three-year investigation begun in 1976. ISEE-A, B and C are major contributions to the IMS by the U.S. and Europe. Data exchange offices have been established in Meudon, France, and Boulder, Colo. Meanwhile, a sophisticated Satellite Situation Center (SSC) at Goddard will calculate satellite orbits which will be published through the Boulder office. The published SSC orbits are designed for correlation with the various IMS systems to indicate when spacecraft data are likely to be especially fruitful.

Much of the data returned by ISEE is expected to be of immediate interest in areas of practical application.

For example, a growing mass of evidence suggests that events on the Sun (Sun spots, solar flares, high-speed solar wind streams) may affect our weather. Long-term variations of the Sun's energy output as well as more subtle changes in the solar wind and its magnetic field structure affect our climate. Is the Earth growing warmer or colder? Will certain parts get more or less moisture? Are severe storms and hurricanes in some way linked to solar mechanisms?

Solar and terrestrial exploration can help establish the physical cause and effect relationships between solar stimuli and terrestrial responses. When these relationships are understood, a new tool will be available for weather and climate prediction.

The Earth's ionosphere and ozone layer which protects us from dangerous solar ultraviolet rays are influenced by solar events and conditions in the magnetosphere which these satellites will investigate. The ionosphere must be better understood because of the major impact it has on worldwide communications and precision navigation systems as well as the amount of global ozone.

Although numerous other spacecraft have been probing the magnetosphere since the early 1960s, the ISEE satellites carry instrumentation 10 times more sensitive than previously flown. Five years ago, the ISEE series couldn't be flown simply because the required technology did not exist. As a result, much fine detail information essential to understanding the range of Sun-Earth phenomena, the entire environmental system of Earth, and the interactions between the two is now available with the ISEE spacecraft for the first time.

The earlier missions have shown that our space environment is very dynamic and exhibits changes more drastic than the weather patterns seen near the ground. It is precisely these changes which need to be studied, using instruments designed to operate in close coordination, to establish the complex interrelationships which control our "space weather."

ISEE-A is a 16-sided cylindrical body measuring approximately 1.73 meters (5 feet 8 inches) across and 1.61 m (5 ft. 4 in.) high. Its main body consists of an 84-centimeter (1 ft. 9 in.) conical center tube, an aluminum honeycomb equipment shelf supported by eight struts. The lower end of the center tube mates with the launch vehicle and the upper end with the ISEE-B.

Certain exposed areas of the ISEE-A and C spacecraft are coated with a conductive green paint developed at Goddard as passive electrical as well as thermal protection to keep the voltage buildup to no more than one to two volts, even as they pass through the radiation belts.

ISEE-B is a circular cylinder, with a diameter of 1.27 m (4 ft.) and a height of 1.14 m (3 1/2 ft.). Solar cells are mounted on three detachable curved panels. An aluminum honeycomb platform supported by eight struts and center tube are the main load-carrying portions.

NASA is responsible for the A and C spacecraft, Delta launch vehicle, tracking and data acquisition and data processing. ESA is responsible for the ISEE-B spacecraft and its operation.

Goddard will provide orbital computation, attitude determination and spacecraft control support to the ISEE missions during the planned three-year lifetime of the satellites. ESA, in coordination with Goddard, is responsible for preparing, testing and operating the ISEE-B spacecraft and software for maneuver determination and computation.

There are a total of 117 investigators on all three spacecraft representing 35 university, government and industrial organizations in 10 countries.

ISEE-A is a Goddard Center designed spacecraft built, fabricated and tested at Goddard with all its components either made at Goddard or supplied by industries or universities. ISEE-B is an ESA-European Space Technology Center (ESA-ESTEC) satellite whose design was determined through competitive concepts.

The STAR consortium of 10 countries supervised construction under contract to ESA. STAR consists of industries in Belgium, Denmark, France, Spain, Germany, Italy, Netherlands, Sweden, Switzerland and the United Kingdom. Dornier Systems in Frederickshaven, Germany, heads the contractor team.

Goddard directs the Delta rocket program for NASA's Office of Space Flight and McDonnell Douglas Astronautics Co., Huntington Beach, Calif., is prime contractor.

Estimated cost of the two spacecraft and the scientific instrumentation is about $45 million, exclusive of launch and tracking and data acquisition costs.

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The launch window opens Oct. 12, 1977, and closes Oct. 27, 1977. There is a 20-minute opportunity in the early part of the launch window each day starting between about 10:00 a.m. EDT and 10:30 a.m. EDT, depending on the day. The launch window begins to narrow on Oct. 20 and is reduced to five minutes on Oct. 29.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

ISEE-A, -B and -C SCIENTIFIC INSTRUMENTS

ISEE-A

Instrument	Principal Investigator	Affiliation
*Fast Plasma	S. J. Bame	Los Alamos Scientific Laboratory
*Low Energy Proton and Electron	L. A. Frank	University of Iowa
*Fluxgate Magnetometer	C. T. Russell	University of California, Los Angeles
*Plasma Waves	D. A. Gurnett	University of Iowa
*Plasma Density	C. C. Harvey	Paris Observatory
*Energetic Electrons and Protons	D. J. Williams	National Oceanic and Atmospheric Administration
*Electrons and Protons	K. A. Anderson	University of California, Berkeley
D.C. Electric Field	J. P. Heppner	Goddard Space Flight Center
Ion Composition	R. D. Sharp	Lockheed Electronics Co.
VLF Wave Propagation	R. A. Helliwell	Stanford University
Fast Electrons	K. W. Ogilvie	Goddard Space Flight Center
Low Energy Cosmic Ray	D. Hovestadt	Max Planck Institute
Quasi-Static Electric Fields	F. S. Mozer	University of California

*The instruments of A and B that are interrelated.

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ISEE-B

Instrument	Principal Investigator	Affiliation
*Fast Plasma	G. Paschmann	Max Planck Institute
*Low Energy Proton and Electron	L. A. Frank	University of Iowa
*Fluxgate Magnetometer	C. T. Russell	University of California, Los Angeles
*Plasma Waves	D. A. Gurnett	University of Iowa
*Plasma Density	C. C. Harvey	Paris Observatory
*Energetic Electrons and Protons	E. Keppler	Max Planck Institute
*Electrons and Protons	K. A. Anderson	University of California, Berkeley
Solar Wind Ion Measurements	G. Moreno	Laboratorio Plasma Spazio, Frascati, Italy

ISEE-C

Instrument	Principal Investigator	Affiliation
Solar Wind Plasma	S. J. Bame	Los Alamos Scientific Laboratory
Magnetometer	E. J. Smith	Jet Propulsion Laboratory
Low Energy Cosmic Ray	D. Hovestadt	Max Planck Institute
Medium Energy Cosmic Ray	T. von Rosenvinge	Goddard Space Flight Center
High Energy Cosmic Ray	H. H. Heckman	University of California
Plasma Waves	F. L. Scarf	TRW

ISEE-C (cont'd.)

Instrument	Principal Investigator	Affiliation
Cosmic Ray Electrons	P. Meyer	University of Chicago
Protons	L. D. de Feiter	Space Research Laboratories, Utrecht
X-Rays and Electrons	K. A. Anderson	University of California
Radio Mapping	J. L. Steinberg	Meudon Observatory
Plasma Composition	K. W. Ogilvie	Goddard Space Flight Center
High Energy Cosmic Ray	E. C. Stone	California Institute of Technology
Ground Based Solar Studies	J. M. Wilcox	Stanford University

MISSION DESCRIPTION

The ISEE-A and B spacecraft are the first set of spacecraft designed to be used together to investigate the physical structures surrounding the Earth. It is hoped that these spacecraft will be able to resolve questions related to the detailed structure of the magnetosphere, magnetopause and shock front that cannot be answered by a single spacecraft. The orbit was selected to nearly maximize the number of bow shock crossings. The separation distance of the two spacecraft is intended to have the spacecraft separation be 100 kilometers (62 miles) at 15 Earth radii as the starting position and let the distance drift to 2 or 3 thousand km (1,240 to 1,865 mi.) before restoring it. The spacecraft are much closer at apogee and very far apart at perigee using this control point.

Solar Wind and Upstream Phenomena

The elemental and isotopic abundances in the solar wind show strong time variations. These could result from diffusion processes in the solar photosphere-corona boundary, from dynamic friction, from wave-particle interactions or from separation processes that depend primarily on ionization and energy.

Energetic solar protons and electrons are observed in the interplanetary medium during solar events. Investigation of these is aimed at discovering how they originate in the Sun and how they are affected by the medium in which they travel. Care is needed to differentiate between source and propagation effects, and in this respect the observations of the heliocentric ISEE-C spacecraft will be very useful.

It is known that the presence of the Earth has a disturbing effect in interplanetary space in front of the bow shock and for quite large distances upstream. By using ISEE-A and B it should be possible to look for the types of particles and waves that are reflected from the bow shock. A study can also be made of the effect of the backstreaming protons and electrons on the solar wind itself.

A great variety of these interplanetary discontinuities exist, traveling with characteristic speeds of the order of hundreds of kilometers per second, making large separations necessary for good observation. Simultaneous "mother" and "daughter" measurements will be able to distinguish shock-accelerated from solar-accelerated protons. ISEE-A and B spacecraft carry electron density measuring equipment which should be able to resolve density variations in shock structures and discontinuities.

Neutral magnetic and current sheets in the solar wind will be studied as they sweep past ISEE-A and B. The ISEE mission will also be able to distinguish solar co-rotating features from others.

A major part of the ISEE mission is the study of wave-particle interactions. Because of the variability of the solar wind, the characteristic frequencies of the plasma are also highly variable. Using two spacecraft, it should be possible to remove some of the ambiguities.

The complexity and variability of the solar wind velocities, composition and densities together with the presence of particles and waves backstreaming from the bow shock ensures that many known and unknown wave-particle interactions will take place in the near-Earth interplanetary medium. The ISEE twin spacecraft investigation is expected to unravel some of the basic processes.

The Bow Shock

This feature of the Earth's environment has been known to exist since 1963 when it was first seen by IMP-1 but identification of even the dominant mechanisms has not yet been accomplished. A basic problem here is that the bow shock apparently moves back and forth with an amplitude of about one Earth radius and the velocity of this movement seems to vary between 10 and 200 km per second (6 to 125 mi. per second). Both ions and electrons are heated in the shock and the mechanism is thought to be a retardation and heating by some form of electrostatic turbulence.

Detections of regions of this size by a single-point measuring system in the fast-moving bow shock is extremely difficult. Assuming shock speeds of about 100 km/s (62 mi./s), simultaneous measurements at two points about 100 km (62 mi.) apart by instruments with reasonable time resolution should be able to detect the larger scale features.

The bow shock may also be the source of electron spikes seen in the magnetosheath and movement of both ions and electrons towards the Sun upstream of the shock. The mechanism for acceleration and reflection of these particles is not understood at present and in particular the transient nature of the observations is baffling.

Because of space-time ambiguities, the extent and wavelengths of these phenomena have not been determined and so they too are suitable objects for a twin spacecraft study. These spacecraft must spend sufficient time outside the bow shock region for a wide range of solar wind effects to be encountered to evaluate their influence on the upstream phenomena and the bow shock.

The Magnetosheath

Magnetic field fluctuations which occur in different modes and have many different frequencies characterize the Earth's magnetosheath. This complex situation is further complicated because the plasma frame is convecting past the spacecraft at a velocity which is influenced by the solar wind and the position of the spacecraft in the magnetosheath.

The dominant mechanisms by which the turbulences in this region are created have not yet been clearly identified and it is accepted that techniques of correlating field and plasma measurements on a single spacecraft are not adequate for an analysis of this structure. Measurements by ISEE-A and B will be able to identify propagation velocities which should clarify the picture considerably.

The Magnetopause

For many years the nature of the magnetopause boundary has provided a motive for magnetospheric research. Nevertheless, the answers to most of the key questions are still unclear: such problems as the way in which mass and energy are transferred across the boundary, how reconnection works or the mechanism of viscous interaction have not been solved. Is the oscillation of this boundary a simple "breathing" of the magnetosphere or is it the result of the solar wind blowing past?

Theories of reconnection and viscuous interaction are incomplete because the treatment of viscuous interaction needs more detail of the magnetosheath magnetic fields than is available and reconnection studies have not been able to demonstrate that the process works over a sufficient range of interplanetary field angles because of lack of magnetopause information.

Again the problem is associated with the movement of the boundary and with the question of whether the features observed are propagating or not. It is hoped that identification of motions by the ISEE mission will make a large contribution to our understanding of this boundary.

The Plasma Sheet and the Tail

The ISEE mission is uniquely fitted to study the dynamics of particle acceleration in the tail. Qualitative measurements of the flow of plasma and energetic particles up and down the tail will be made and compared with incoming solar wind parameters as observed by the heliocentric ISEE-C spacecraft.

Single satellite magnetic measurements imply that a thin neutral sheet is embedded in the much thicker plasma sheet. Detection of the neutral sheet is difficult since the field strengths are very weak and there is considerable upward and downward movement of this region, with velocities of between 10 and 100 km/s (6 to 62 mi./s). Twin spacecraft measurements should be able to identify the structural features of the inner plasma sheet by separating out the velocity.

Ring Current and Plasmasphere

The ISEE-A and B spacecraft will be able to provide the first comprehensive observations of the total ring current energy spectrum, pitch angle and spatial distributions during quiet times. They will also allow observation of the drift into this region of the low-energy (tens of keV) protons during the main phase of magnetic storms. It is hoped that the way in which these particles filter around the Earth to form a symmetric ring current will be discovered.

Magnetospheric Substorms

The understanding of the substorm phenomenon is one of the key steps to the understanding of the dynamics of the magnetosphere. However, substorms in themselves are very complex. Violent rearrangements of magnetic fields during the substorm expansion phase associated with strong electric induction fields have drastic effects on plasma flow, charged particles and on the ionosphere.

It seems probable that the energy needed to drive these processes is extracted from the solar wind by some mechanism in the tail, but this mechanism has not been identified. It is not known how or why substorms are triggered. Although particles are accelerated, the region and source of this acceleration have not been discovered. Because geomagnetic substorms involve a large part of the magnetosphere, correlated global measurements will be necessary for any attempt at understanding.

These measurements must include, as well as ISEE-A and B in the tail, inner magnetospheric observations by GEOS and ATS-6, upstream solar wind measurements by ISEE-C, suitable rocket flights to investigate the ionosphere with other worldwide high-latitude ground-based measurements and assistance from other spacecraft.

INTERNATIONAL MAGNETOSPHERE STUDY SUPPORT

The ISEE project, from its inception, has been designated to support the International Magnetospheric Study (IMS). The IMS is an international cooperative enterprise with a principal scientific objective of achieving a comprehensive, quantitative understanding of key processes associated with energy, mass and momentum transfer from the solar wind to the magnetosphere and atmosphere. IMS is the first attempt to use a systems approach to Sun-Earth study on a large scale.

The system approach in the IMS case is a conscious plan to accumulate data simultaneously so that correlative studies can be made on a worldwide and outer space basis. This requires that spacecraft be located in orbits advantageous to earthbound observations and that prediction of spacecraft positions be available to make sure that ground base data is collected at the appropriate time.

Sounding rocket campaigns will be planned to coincide with spacecraft positions and, in some cases, spacecraft data will be used to determine sounding rocket launch times.

The ISEE-C spacecraft, from its vantage point a million miles in front of the Earth, can measure the parameters of the solar wind unperturbed by the Earth's presence and can do it one hour in advance of that portion of the solar wind's arrival at the Earth's physical boundaries. These data can be compared to the Earth's reaction to this portion of the solar wind as it impinges on the bow shock and the magnetosphere.

In short, ISEE-C measures the solar input function; ISEE-A and B measure its impact on the magnetic field about the Earth; and the ground-based magnetometers measure the resultant changes at the Earth's surface. It is hoped that by obtaining this and similar spacecraft and sounding rocket data over large space and time variations, better models can be established for the behavior of the Earth's fields and radiation belts.

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