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INTERNATIONAL SOLAR-TERRESTRIAL PHYSICS PROGRAM

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A PLAN FOR THE CORE SPACEFLIGHT MISSIONS

esa ISAS NASA

Foreword

This brochure has been prepared by NASA on behalf of the European Space Agency (ESA), the Institute of Space and Astronautical Science (Japan) (ISAS), and the U.S. National Aeronautics and Space Administration (NASA) to describe the scope of the science problems to be investigated and the mission plan for the core International Solar-Terrestrial Physics (ISTP) Program. This information is intended to stimulate discussions and plans for the comprehensive worldwide ISTP Program.

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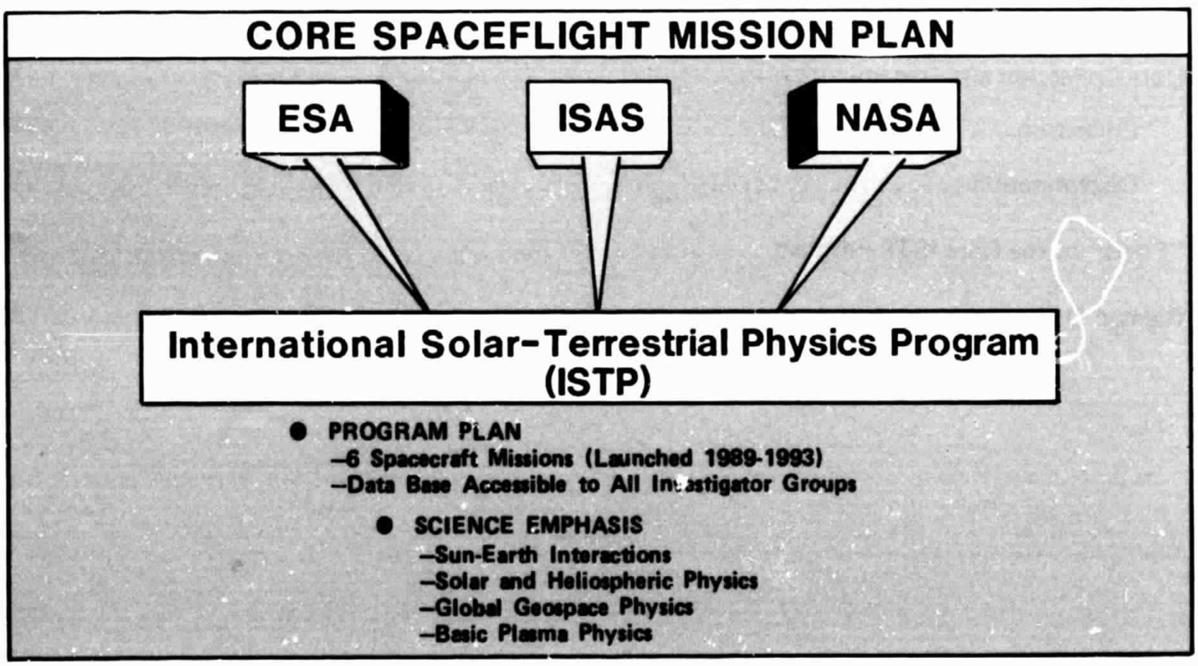
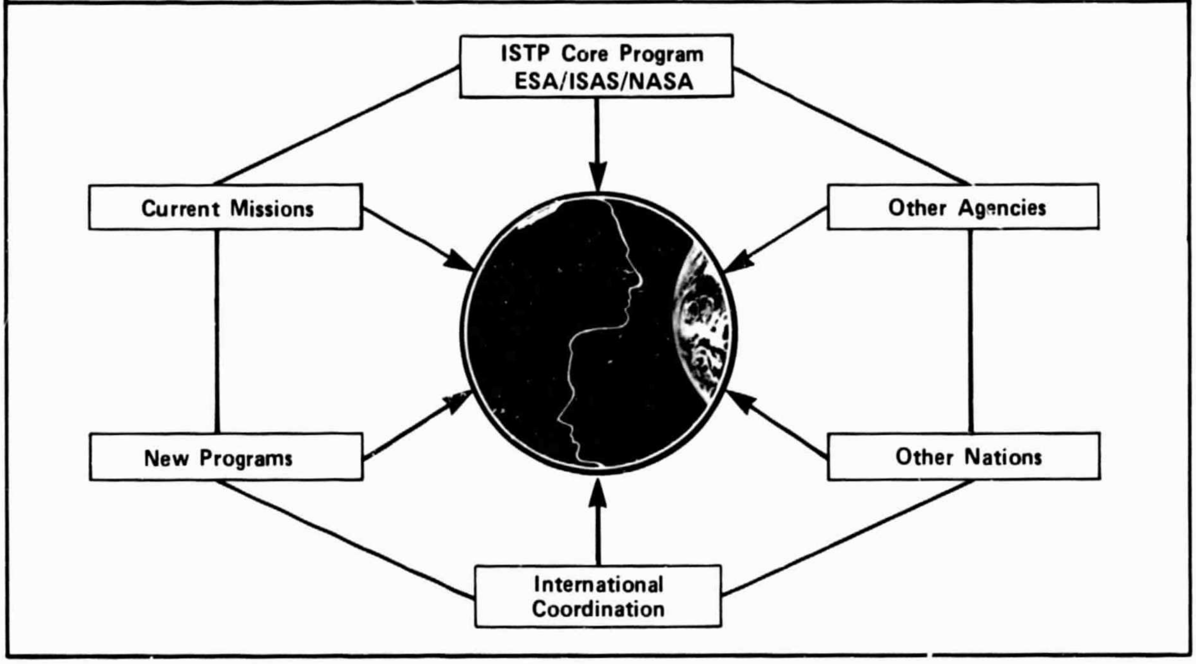
Plan for the Study of the Solar-Terrestrial System

The International Solar-Terrestrial Physics (ISTP) Program is an effort to draw on the resources of a worldwide scientific community to make a concentrated and coordinated study of the interactions in the Sun-Earth system and to extrapolate this knowledge to the other planets and to the universe beyond. The foundations arose essentially in parallel in three subdiscipline areas:

- From the late 1970's through the early 1980's, both the U.S. and European solar physics communities identified a variety of high priority science objectives for which free-flying space missions would be necessary. These objectives were studied unilaterally, and the projected missions emerging from the studies became known by a variety of abbreviated names: SCADM, SCE, and SDO in the U.S.; DISCO and SOHO in Europe. By 1983, however, it became apparent that the objectives of these missions, while diverse in many respects, could be accomplished by a single mission if it was conducted in the proper orbit. This one mission is now called SOHO (for Solar and Heliospheric Observatory) and embodies a variety of solar and solar wind investigations which attack a broad spectrum of science objectives.
- In 1977, a U.S. science study group began the task of defining a major program in space plasma physics for the 1980's, the result of which led to the formulation of the Origins of Plasmas in the Earth's Neighborhood (OPEN) Program. In 1982 and 1983, while the OPEN Science Working Group conducted detailed definition studies to refine the requirements and mission plan, space plasma physicists in Japan were formulating their plans for two supplementary flight missions, EXOS-D and OPEN-J. Finally, in 1983, a series of discussions between the U.S. and Japanese science working groups culminated in a proposal to merge elements of the OPEN and OPEN-J Programs into a joint endeavor.
- In the early 1980's, another U.S. science working group developed the concept for a Plasma Turbulence Explorer Mission nearly simultaneous with a proposal for a CLUSTER Mission by a European science working group. Both mission concepts were aimed to study fundamental physical processes associated with turbulence. Today, both the U.S. and European communities agree that the CLUSTER Mission is the preferred one to study microscale plasma processes within the Earth's magnetosphere.



WORLDWIDE CONTRIBUTIONS TO THE ISTP PROGRAM



In September 1983, three-way discussions between the European Space Agency (ESA), the Institute of Space and Astronautical Science (Japan) (ISAS), and the U.S. National Aeronautics and Space Administration (NASA) led to the proposal of an International Solar-Terrestrial Physics (ISTP) Program that would provide the basis for a cost-effective and scientifically vigorous international collaboration in solar-terrestrial physics in the 1990 timeframe. Such a collaboration would avoid needless competition, enlarge the overall scope of science to be addressed, and allow each agency the ability to contribute its strongest assets and resources.

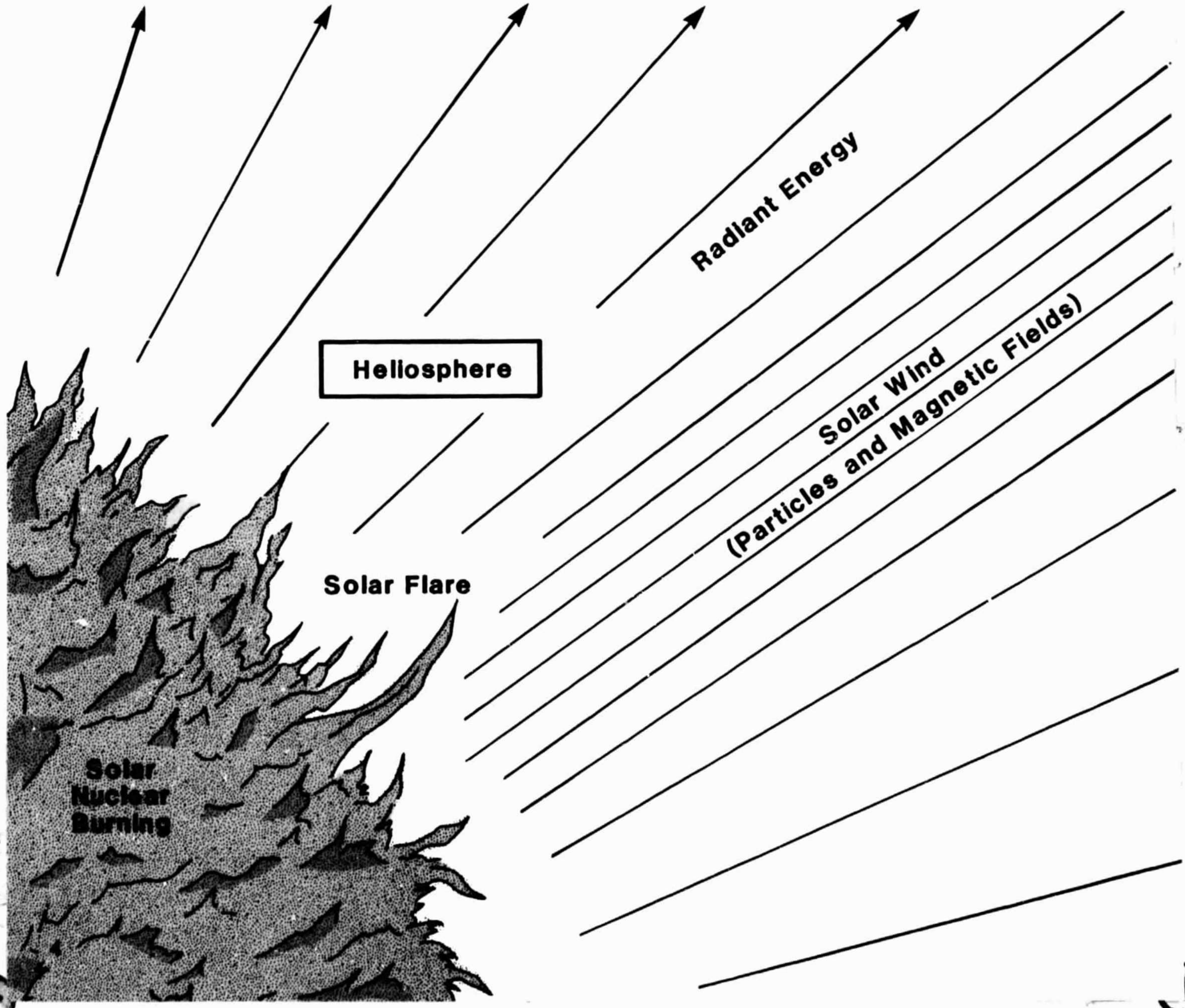
ESA, ISAS, and NASA make up the core ISTP Program and have agreed to plan together and to develop the overall mission. Joint science working groups in the areas of solar physics, global geospace physics, and basic plasma physics have met to define the specific science emphases. These same groups are advising their respective space agencies on the payloads, spacecraft characteristics, and data handling systems necessary to carry out this core ISTP Program. The plan now includes up to six new spaceflight missions, with one or more spacecraft provided by each agency, and a data networking system to make the collected data base accessible to the worldwide science community within a timescale of several weeks. It must be stressed that none of these programs is yet approved by the agencies.

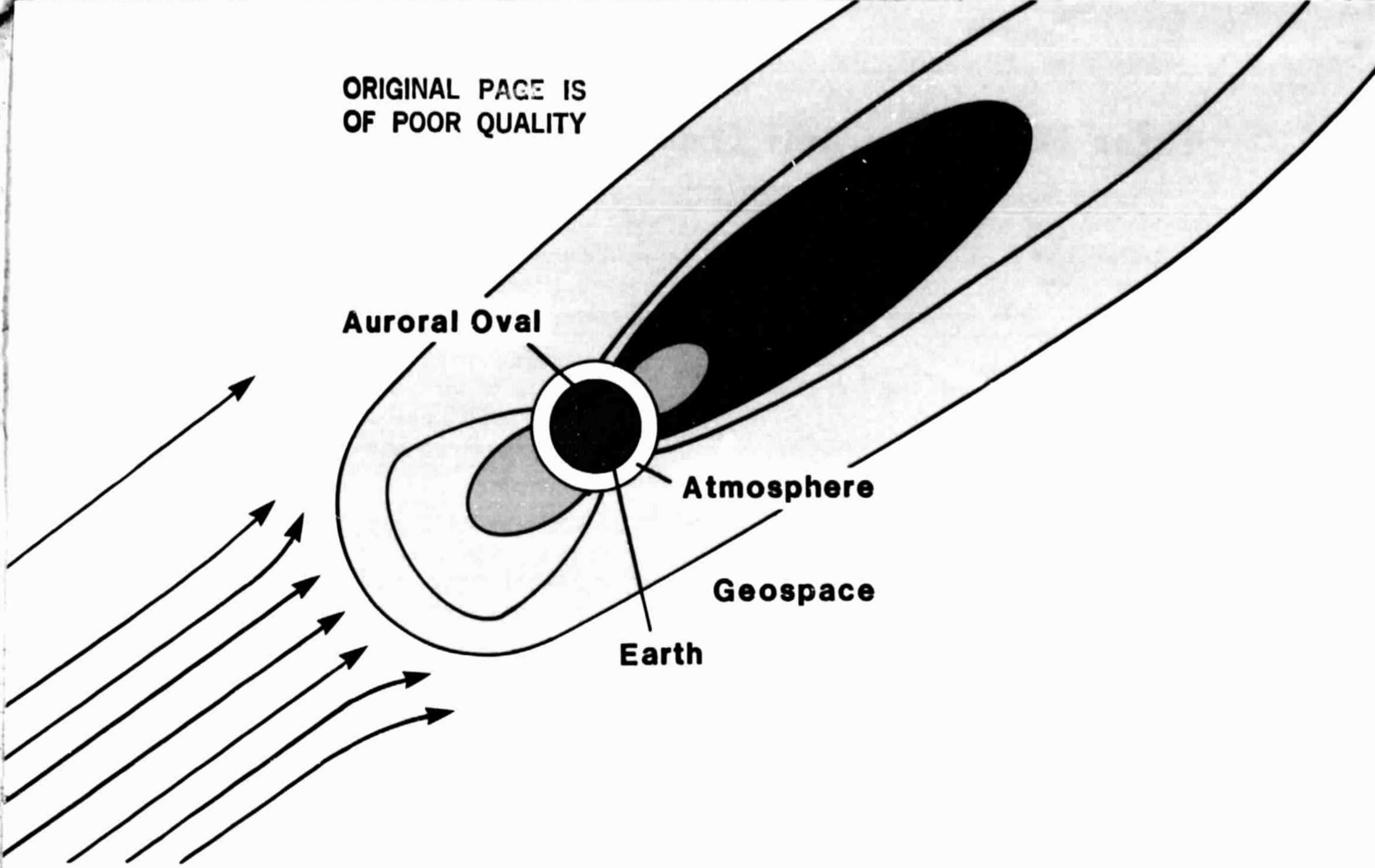
The core ISTP Program is a central part of a more comprehensive ISTP effort that includes currently planned missions (such as ISPM, EXOS-D, and UARS) and future missions by other agencies and other nations that are highly complementary. In addition, many ground-based facilities, airborne observatories, balloon and rocket campaigns, and other spaceflight missions can provide data for collaborative research projects. It is anticipated that a comprehensive worldwide ISTP Program will develop by the 1990's that will be coordinated by an international scientific organization.

The Sun, Geospace, and Sun-Earth Interactions

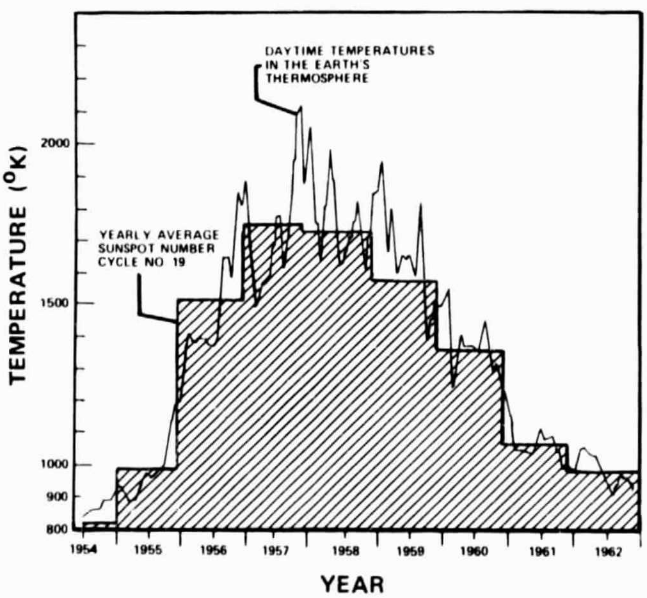
The Sun is the only star that can be studied in detail from within our solar system. It is a variable star—its activity varies over time. This variation arises because the Sun both rotates and possesses an internal convection zone that physically transports hot gas from the solar interior to its surface. The interaction of these two motions, rotational and convective, generates powerful magnetic fields through a complicated mechanism (not yet fully understood) that is generally called the solar dynamo process. Furthermore, this "dynamo" is cyclic, as demonstrated by the ebb and flow of sunspots and energetic events called solar flares, with roughly an 11-year period. Today, we know that many stars—indeed, perhaps most—also possess activity cycles, many of which would dwarf that of our own Sun.

Whereas its periodic activity alone makes the Sun quite an interesting astronomical object, other features make it of more practical interest to the Earth. In particular, the Sun also has an extended atmosphere—the solar corona, the pearly white halo of gas seen at solar eclipses, which generates the "solar wind." The solar wind is an invisible but hot, high-velocity solar gas (or plasma) that is constantly being expelled from the Sun and that streams out through the solar system. And, just as the corona is highly irregular in shape, so is the solar wind.





Now the fact that this gusty solar wind envelops the Earth and all the other planets in the solar system has been known since the early 1960's discoveries by the Mariner 2 spacecraft. What makes it of more than intellectual interest for us is the fact that our planet also possesses a magnetic field. The interaction of the structured, time-varying solar wind with the Earth's magnetic field creates a whole range of effects—aurorae, geomagnetic storms, disruptions in shortwave radio communications, power surges in long transmission lines—which are collectively called solar-terrestrial phenomena, and which occur in the region now known as "geospace."



Heating of Earth's upper atmosphere by solar activity.

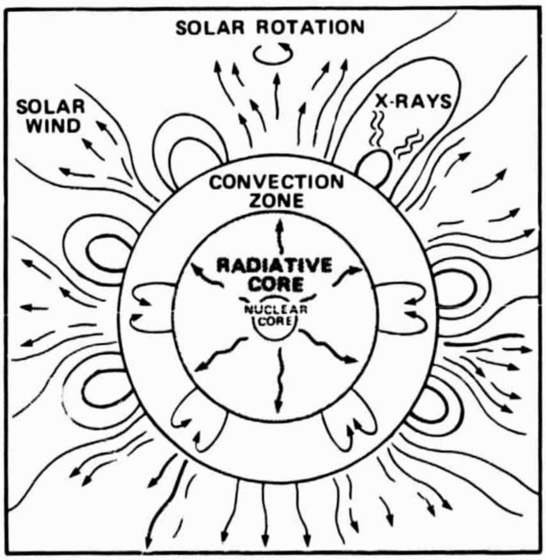
Thus, the general subject of solar-terrestrial physics can be thought of as encompassing the Sun as a variable star, the origin and transmission of the solar wind, the interaction of this solar wind with the Earth's magnetic field, and the subsequent time-varying magnetic and atmospheric effects in the Earth's lower atmosphere. It is a subject that is breathtaking both in the scope of the physics involved—all the way from the working of the solar dynamo to the origin of the aurorae in the Earth's atmosphere—and in its potential for application to routine activities on Earth, including the increasingly routine operation of our near-Earth spacecraft.

Solar Dynamics and Origins of the Solar Wind

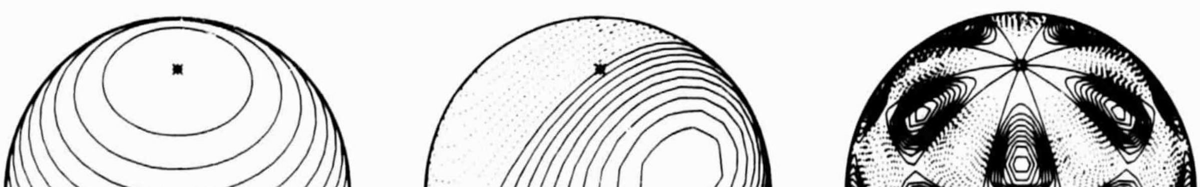
The Sun and the heliosphere—the nearest star and its sphere of influence—harbor a large number of fundamental questions that are of consequence not only for the solar system, but also for astrophysics as a whole. Mankind now has the intellectual curiosity and technical capability to investigate the many basic and interconnected questions regarding the internal structure of the Sun, the heating of the corona, and its expansion into the fast and slow streams of the solar wind.

Helioseismology concerns the study of the Sun's internal dynamics and structure through observing oscillations of the Sun's surface—similar to the use of earthquakes to infer the interior structure of the Earth. A complete understanding of these oscillations would ultimately lead to knowledge of the interior composition of the Sun and of the dynamo processes that drive the Sun's 11-year activity cycle.

In addition, short-term decreases (on the order of a few tenths of a percent in a few days) in solar luminosity can occur with the appearance of large sunspots. Thus it is of great interest to systematically study the mechanism by which the Sun blocks, stores, and then ultimately releases this energy, and also to look for long-term trends (decreases or increases) that may be linked to the solar cycle.



Schematic diagram of the interior structure of the Sun including the core, where nuclear burning occurs, and the deep outer convection zone.



Contour plots of selected modes of oscillation of the Sun. The solid lines represent zones of expansion; the dotted lines, contraction. Only three of thousands of possible modes are shown. l is the degree of the mode. This selection of modes illustrates the increasingly complex oscillatory motions seen with increasing degree. Oscillations occur with periods ranging from minutes to at least hours.

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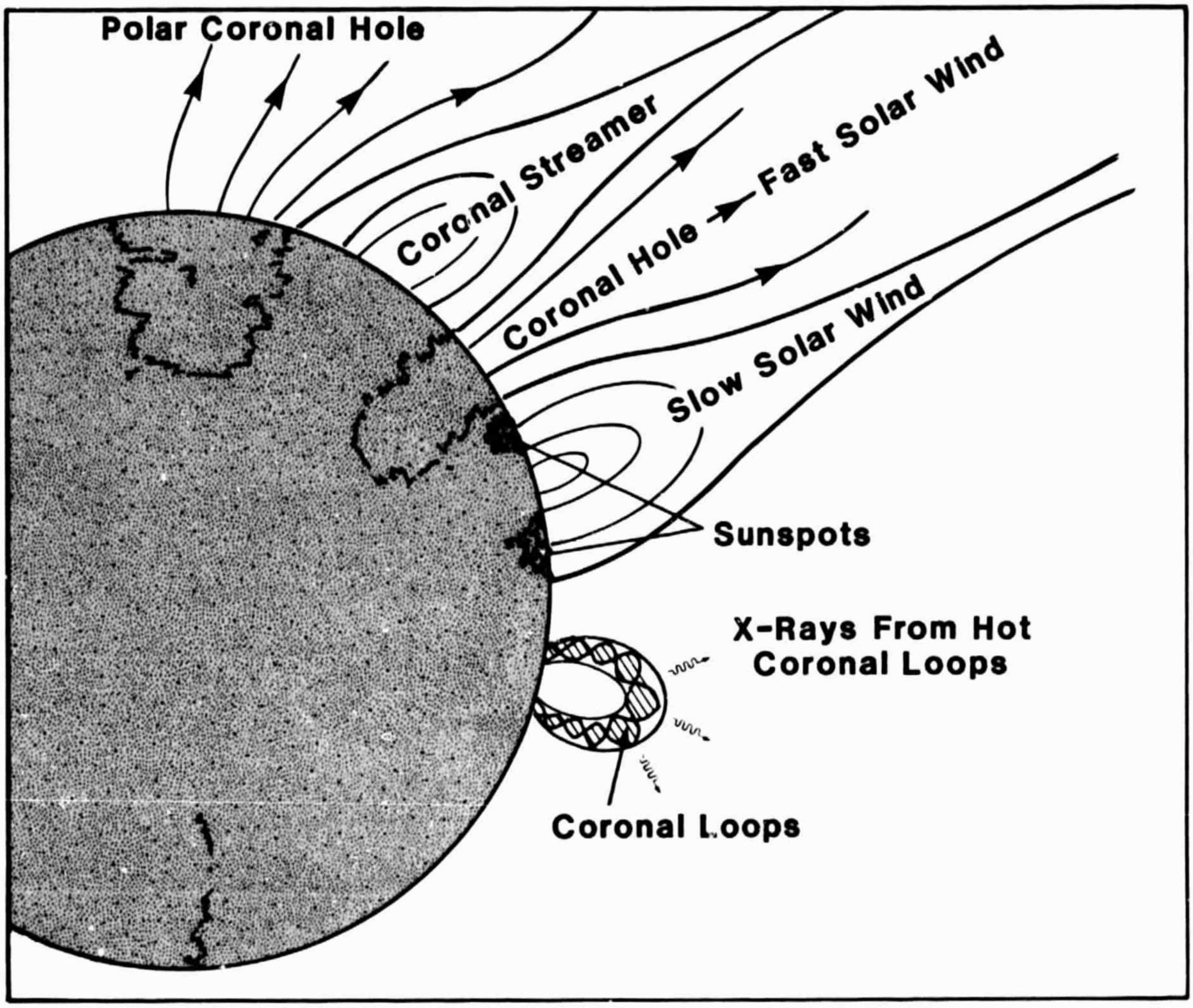


Extending from visible features on the solar surface such as sunspots are a variety of magnetic field structures. These structures in the solar atmosphere, called the corona, involve energetic atomic particles, light and X-ray emissions, and acceleration of the solar wind.

Observations of the solar surface and its nebulous atmosphere—the corona—reveal a variety of features including sunspots, solar magnetic flares, polar coronal holes, coronal streamers, and plasma jets. Although these features are caused by the interaction of solar convection and magnetic fields, their interrelationship is not well established.

Measurements reveal that the temperature of the solar atmosphere rises from 5,000° K in the photosphere to over a million °K in the corona. Coordinated measurements of densities, temperatures, velocities, and magnetic fields in coronal loops are necessary as inputs to understanding just how this high coronal temperature occurs and where the solar wind is accelerated.

To advance our knowledge of Sun-Earth interactions requires that we measure the cause-and-effect relationship between the solar surface features, the coronal dynamical features, and the characteristics of the solar wind as it envelops the Earth to create the geospace.

Plasma Flows and Interactions in Geospace

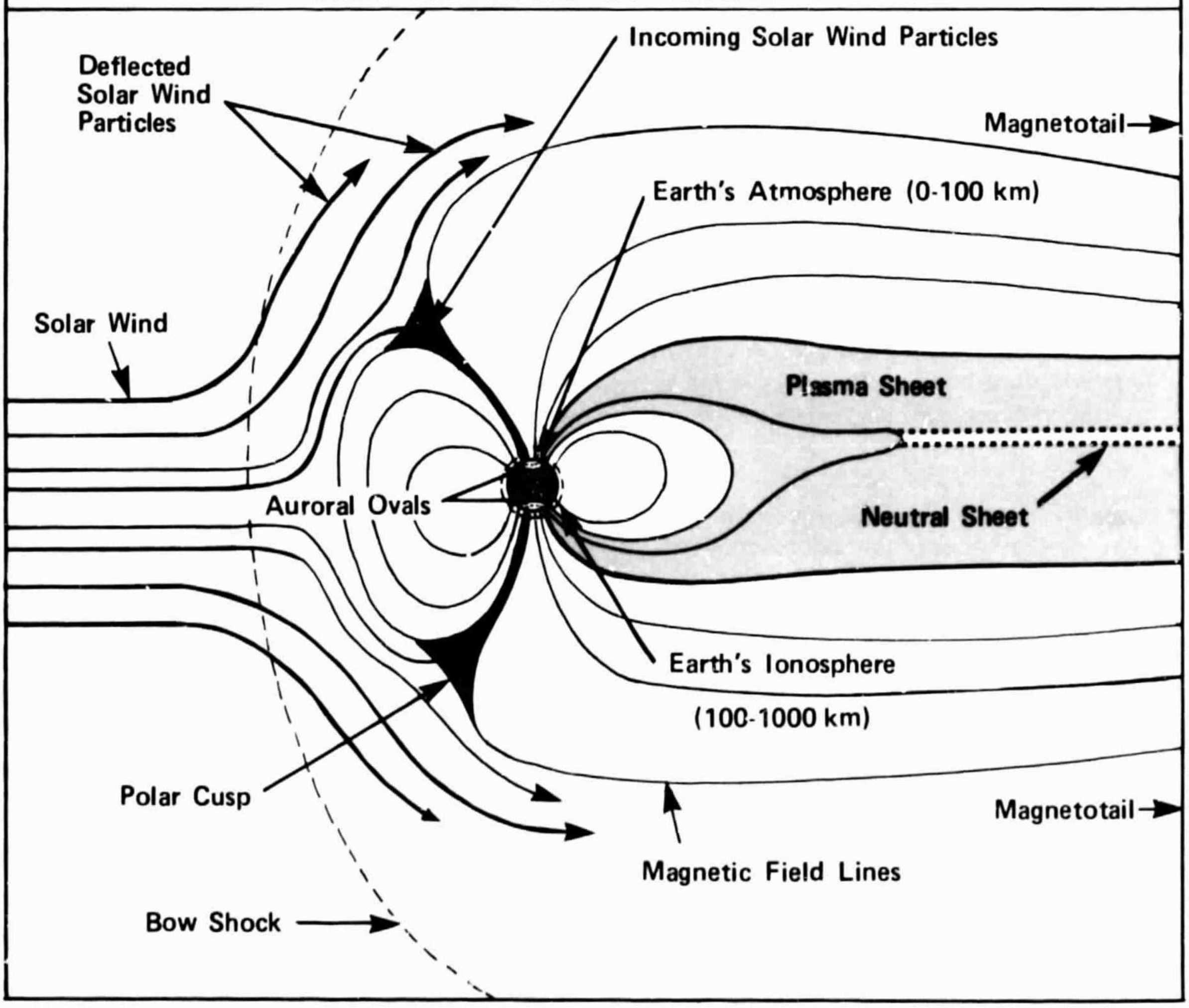
Roughly 99 percent of all the matter in the universe exists in a form called plasma. Plasma is an electrically charged gas in which each atom has been stripped of one or more of its electrons, thus leaving it with a net positive electrical charge. This assemblage of charged atoms and electrons carries mass, momentum, and energy between the Sun and the planets. It pervades the region between the stars and other astrophysical entities.

Exploration of the Earth's nearby space environment has revealed a dynamic and complex system of plasmas interacting with magnetic fields and electrical currents surrounding our planet. This region, comprising the magnetized solar wind plasma plus the perturbation in the heliosphere caused by the presence of the magnetic Earth is the region we have defined as geospace.

Solar influence shapes and links the three major regions of geospace: the magnetosphere, the ionosphere, and the Earth's neutral atmosphere, where life exists.

The magnetosphere is the volume of space dominated by the Earth's magnetism. Solar wind compresses the dayside magnetosphere and stretches the nightside into a comet-like tail millions of miles long. Some solar wind plasma penetrates this magnetic shield and mixes turbulently with local plasmas. When these "magnetic storms" jolt the magnetosphere, charged particles stored in the tail region hurtle toward the Earth along magnetic field lines and release their energy as aurorae.

KEY REGIONS OF GEOSPACE



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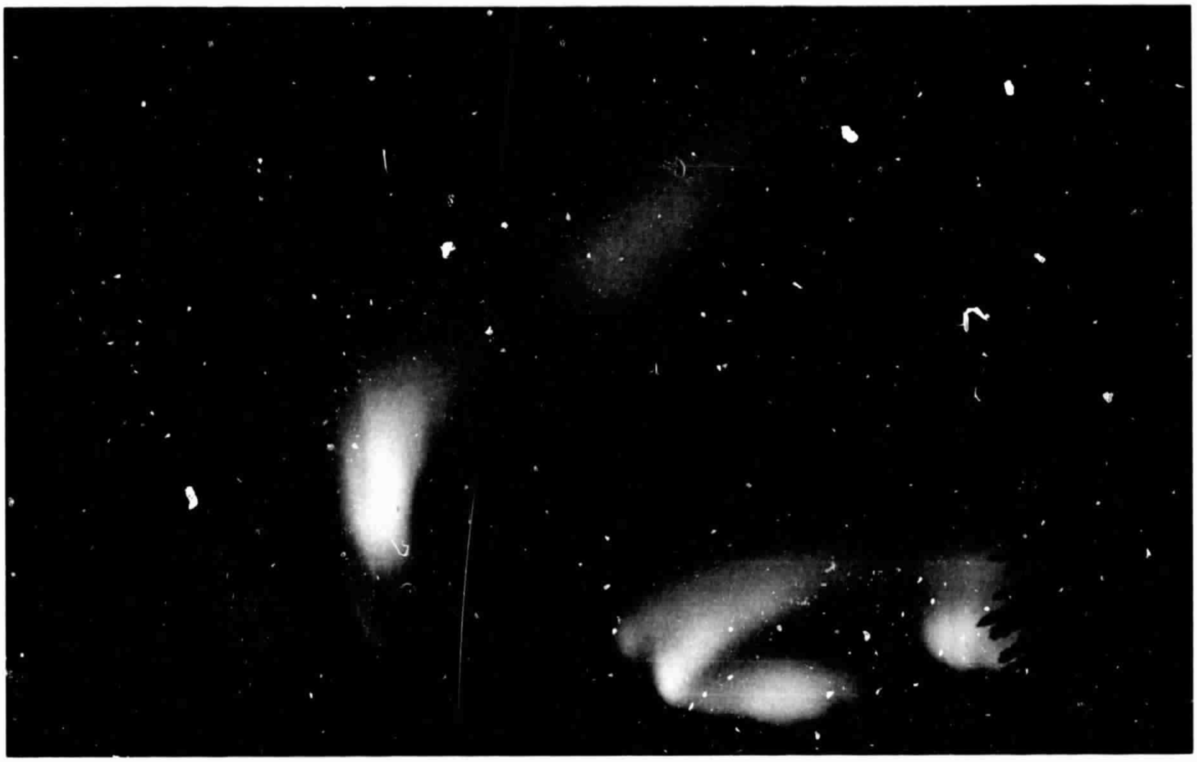


The Alaskan sky is lit by the aurora as energy from solar wind plasmas enters the upper atmosphere to create the shimmering "curtains of fire."

The ionosphere is a zone of plasma created by the effect of solar radiation on gases in the Earth's upper atmosphere (60-100 km altitude). Aurorae occur at 100 km, heat the ionosphere, and temporarily alter its electrical properties. Magnetic storms and aurorae may disrupt the transmission of radio and telecommunications signals in the ionosphere. Plasma motions and electric currents in this region affect, and are affected by, processes occurring in the magnetosphere above and the atmosphere below. Thus, the ionosphere is the interface or transition zone in geospace.

The atmosphere, an envelope of electrically neutral gases, sustains life on Earth and is the theater for terrestrial weather. Chemical reactions and wind patterns in the lower atmosphere are influenced by ionospheric currents, aurorae, and uneven solar heating at high altitudes. Events in the magnetosphere and ionosphere often stimulate atmospheric emissions in X-ray, visible, and ultraviolet wavelengths. These "footprints" of activity in geospace can be observed meaningfully only from above the filtering atmosphere.

Because geospace resembles the plasma environments that exist around distant planets and stars, plasma processes common throughout the universe can be sampled and studied in Earth's own backyard. Geospace is an accessible natural laboratory for astrophysical investigations and for basic research in plasma physics.

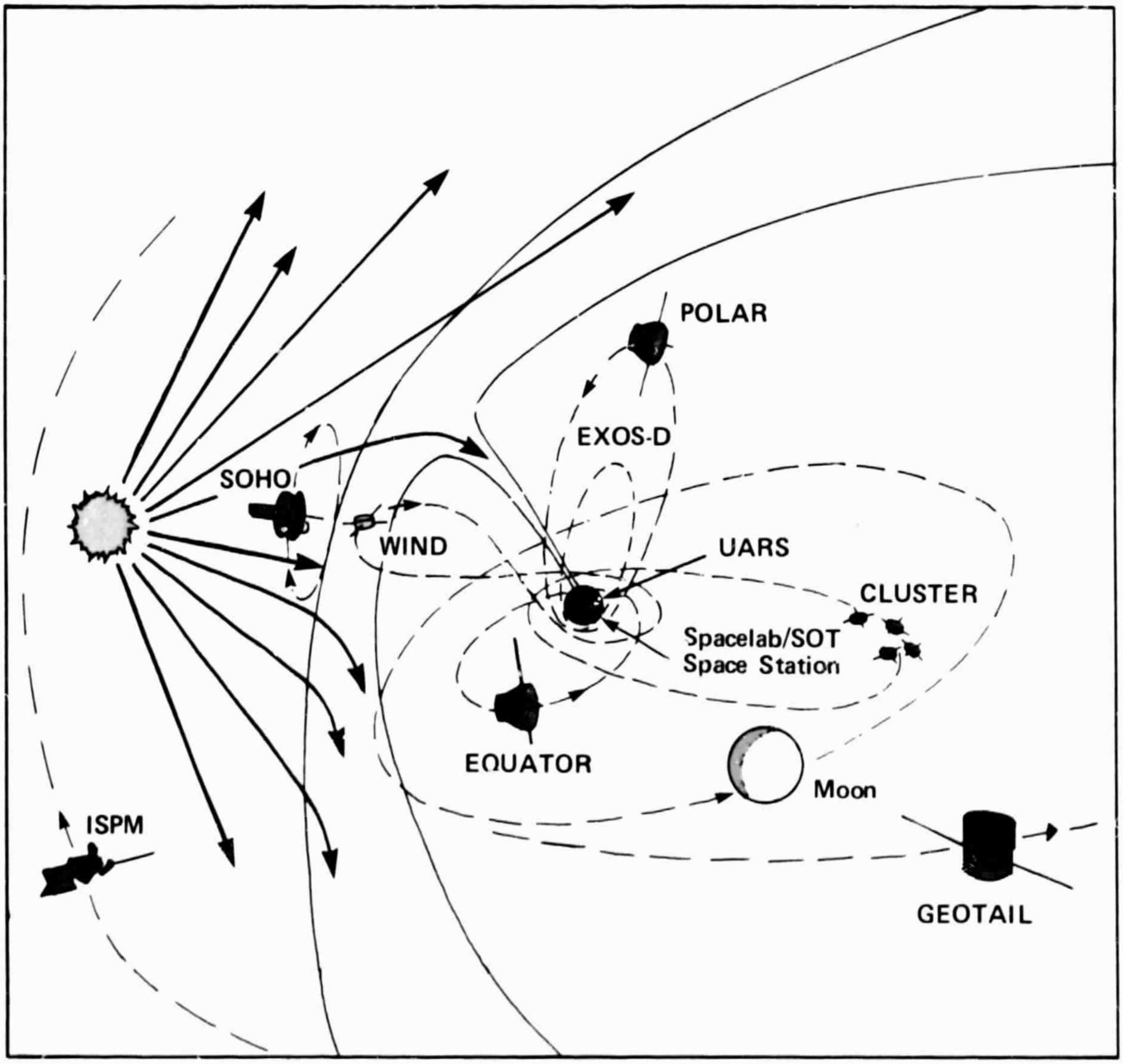
Furthermore, geospace is a laboratory for the study of solar-terrestrial relationships. The aurora, for example, is part of a complex chain that links the regions of geospace and responds to solar influence.

Solar-terrestrial science also involves the assessment of human (as well as solar) influence on Earth's space environment. This environment may be as vulnerable to abuse as the planet's surface ecology. The interactive nature of geospace suggests that pollution or disruption of one region may alter the balance of the entire system. With increased understanding of the physical processes that govern geospace we can learn how to interact prudently with the Earth's vast, invisible environment.

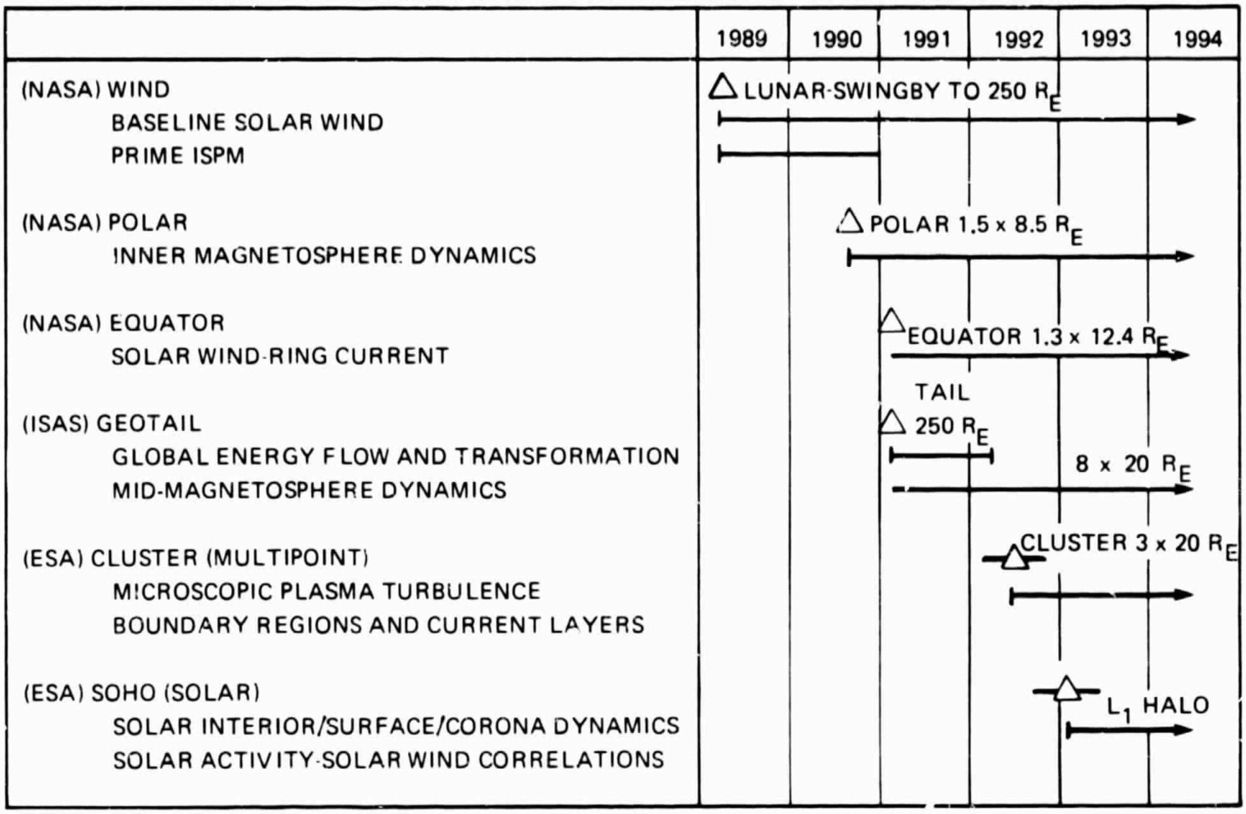
ISTP Program Plan

Representatives from ESA, ISAS, and NASA have recommended a minimum of six spacecraft missions. The SOHO spacecraft would investigate solar oscillatory and coronal features and monitor the solar wind. Four global geospace spacecraft—WIND, EQUATOR, GEOTAIL, and POLAR—would provide measurements in the two plasma sources and two plasma storage regions in geospace. Finally, the CLUSTER mission would provide information on small-scale structure and on plasma turbulence throughout the polar and middle magnetosphere as well as in the solar wind.

These six systems are proposed to provide a space measurement core augmenting planned programs which are complementary in scope and which may overlap somewhat in time, such as the ISAS EXOS-D; the ESA/NASA ISPM; and the NASA UARS, Spacelab, SOT, and Space Station. It is fully expected that other collaborative spaceflight missions will be created by other nations and space agencies and that complementary data will be collected from ground-based observations, balloon payloads, and rocket experiments. The spacecraft thus expected to be available for solar-terrestrial research in the 1990's are depicted in the figure below.



OPTIMUM ISTP PROGRAM LAUNCH AND OPERATIONS SCHEDULE



Each of the six spacecraft systems of the core ISTP Program is expected to be constructed using flight-proven hardware and engineering techniques. The WIND, EQUATOR, POLAR, and GEOTAIL spacecraft are to be launched by the Space Shuttle and placed in transfer orbits through the use of upper stage boosters. The SOHO and CLUSTER systems are being designed for either an Ariane IV or Space Shuttle launch.

The launch schedule for these spacecraft is dictated by a number of factors, including selection processes, technical design status, and funding availability. WIND will be built by the U.S., with a payload consisting of NASA and European instrumentation. It is to be launched in mid-1989 or earlier to provide in-ecliptic solar wind measurement in front of the terrestrial magnetosphere. WIND data will thus support the ISPM solar passages in late 1989 and 1990, as well as the EXOS-D polar magnetosphere mission, the UARS terrestrial atmosphere mission, and the Galileo Jupiter orbiter mission. By 1990, or 1991 at the latest, the U.S. will launch POLAR, with instrumentation from NASA and Europe, that will provide complete coverage of the inner magnetosphere and will obtain global images of the polar aurora which are of particular value to UARS. EQUATOR, built by the U.S. with NASA and European instrumentation, will be launched within one year of POLAR to begin monitoring the ring current and to complement EXOS-D. The GEOTAIL spacecraft is to be built by ISAS with an instrumentation payload from ISAS and NASA science groups. For one year, starting in 1991, the distant magnetotail will be explored; then the orbit will be changed to examine the near-Earth tail and the middle magnetosphere, in order to identify regions of explosive plasma transformations. CLUSTER and SOHO are candidates for inclusion in the scientific program of ESA, with launches possible in 1992 and 1993, respectively.

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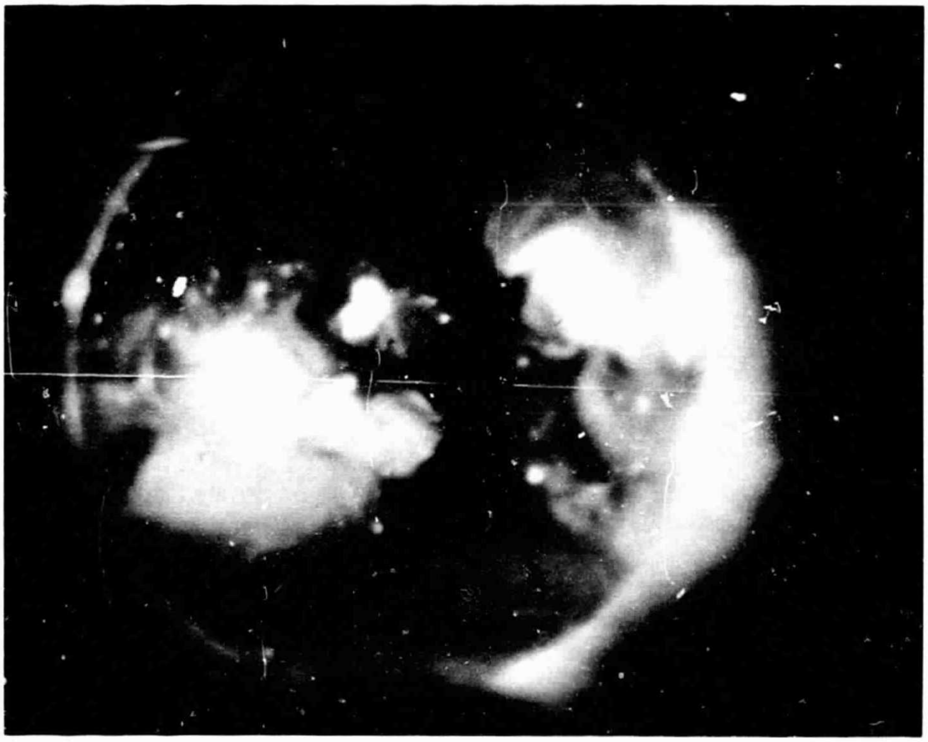
Solar and Solar Wind Missions

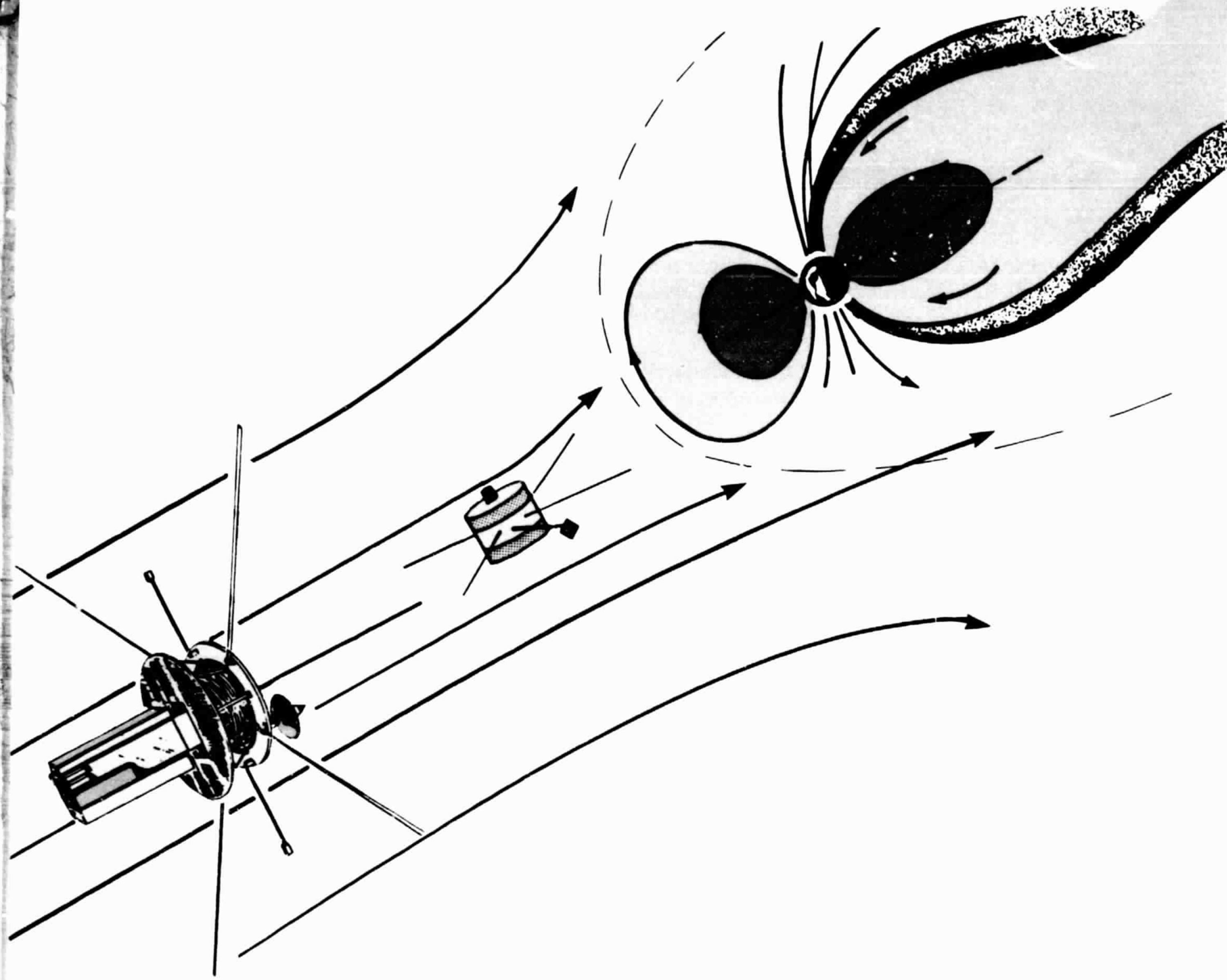
SOHO

The SOHO spacecraft is three-axis stabilized to direct a variety of telescopes to within 10 arc seconds of the solar center. The spacecraft will orbit around the L_1 libration point to permit continuous viewing of the Sun and to minimize the Doppler shift between the spacecraft and the Sun. SOHO will:

- measure with high precision the spectral and total luminosity of the Sun;
- probe the interior structure of the Sun by monitoring the velocity and luminosity oscillations of the solar "surface," i.e., by the methods of helioseismology;
- investigate the outer layers of the Sun—the chromosphere, transition region, and corona—by powerful spectroscopic diagnostics at high spectral resolution;
- measure the outflow velocities in the inner, visible corona in order to understand the origin of the solar wind; and
- study the solar wind shock and irregularity features in conjunction with WIND.



Soft X-ray photograph of the Sun. Note the dark "coronal hole" region at the north and the several bright regions of emission near the equator.



WIND

WIND will utilize lunar-swingby orbit adjustments to maintain apogee on the Earth's dayside so as to survey the upstream region to distances of 250 Earth radii (R_E) during the first year or two after launch. It may then be placed in a small (about 3×10^5 km) halo orbit at the L_1 libration point. WIND will:

- investigate sources, acceleration mechanisms, and propagation processes of energetic particles and the solar wind in correlation with SOHO;
- provide the complete plasma, energetic particle, and magnetic field input for magnetospheric and ionospheric studies to support POLAR, EQUATOR, GEOTAIL, and CLUSTER; and other earth-orbiting, planetary, and interplanetary spacecraft;
- determine the magnetospheric output to interplanetary space in the upstream region;
- investigate basic plasma processes occurring in the near-Earth solar wind; and
- provide baseline in-ecliptic plane observations to be used in heliosphere studies in correlation with observations made at high heliospheric latitudes from ISPM.

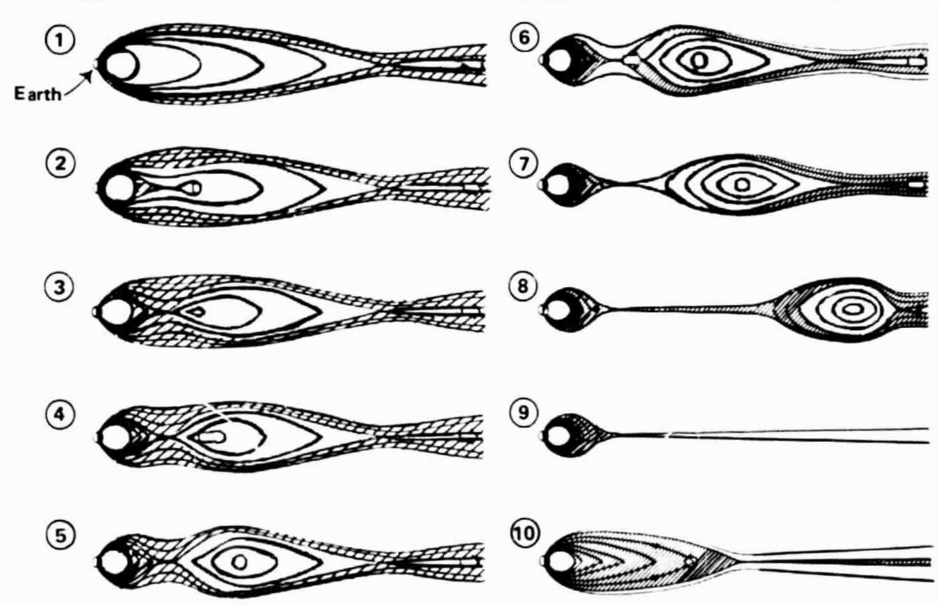
Geospace and Plasma Processes Missions

GEOTAIL

GEOTAIL will utilize lunar-swingby orbit adjustments in order to maintain a distant apogee (80-250 R_E) in the magnetotail for a period of at least one year. Following the deep-tail observations the orbit-adjust engine will be used to place GEOTAIL in an 8 R_E x 20 R_E equatorial orbit. GEOTAIL will:

- determine for the first time the overall plasma characteristics of the distant geomagnetic tail;
- determine the role of the distant and near-Earth tail in substorm phenomena and in the overall magnetospheric energy balance in conjunction with EQUATOR, POLAR, and WIND;
- study the processes that initiate reconnection to the near-Earth tail and observe the microscopic nature of the energy conversion mechanism in this reconnection region, especially in conjunction with CLUSTER and EQUATOR;
- separate the ionospheric and solar wind contribution to geomagnetic tail plasma; and
- study plasma entry, energization, and transport processes in interaction regions such as the inner edge of the plasma sheet, the magnetopause, and the bow shock.

MAGNETOTAIL RECONFIGURATION (TIMESCALE = 1 HOUR)



EQUATOR

EQUATOR will be located in an equatorial orbit of 1.3 R_E x 12.4 R_E . EQUATOR will:

- determine the overall magnetospheric energy balance and the effects of the substorm trigger mechanism in populating the ring current and inner magnetospheric particle population, in conjunction with GEOTAIL and POLAR;
- provide direct observations of the interactions of geomagnetic tail and ionospheric plasmas in the equatorial magnetosphere;
- measure the transport and storage of ionospheric and tail plasma in the near-Earth plasma sheet and ring current, in conjunction with CLUSTER; and
- measure the coupling of the solar wind to the magnetosphere at the subsolar magnetopause, in conjunction with WIND and SOHO.

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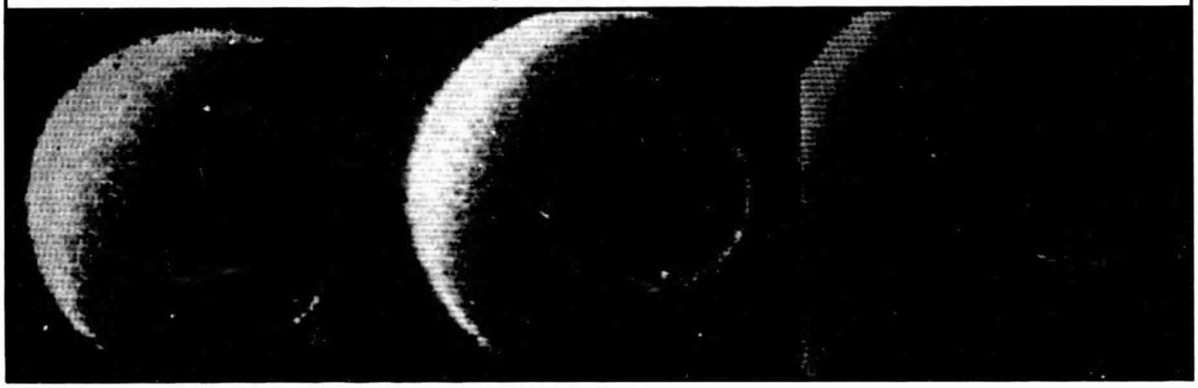
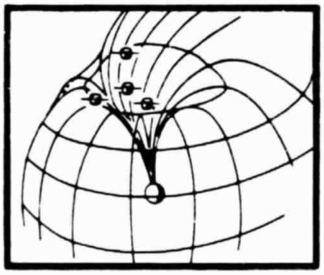
POLAR

POLAR will be placed in an eccentric polar orbit having a perigee radius of about 1.5 R_E and an apogee radius of 8.5 R_E. POLAR will:

- determine the role of the ionosphere in substorm phenomena and in the overall magnetospheric energy balance, in conjunction with GEOTAIL and EQUATOR;
- measure plasma energy input through the dayside cusp, in conjunction with WIND and SOHO;
- determine characteristics of ionospheric plasma outflow and energized plasma inflow to the atmosphere, in support of UARS;
- study characteristics of the auroral plasma acceleration regions, in conjunction with CLUSTER; and
- provide global multispectral auroral images of the footprint of the magnetospheric energy disposition into the ionosphere and upper atmosphere.

3 VIEWS OF AURORA FROM DE-1





CLUSTER in the polar cusp region.

CLUSTER

CLUSTER consists of one main and three companion spacecraft, each with an orbit-adjust capability to provide separations from 100 km to several Earth radii. The cluster of spacecraft will be injected into a polar orbit of 3 R_E x 20 R_E with apogee initially on the dayside at 30° N latitude. CLUSTER will:

- explore the boundary regions of the Earth's magnetosphere as an example of the interface of two cosmical plasmas and investigate the detailed nature of the processes by which mass, momentum, and energy are transferred across boundaries such as the magnetopause;
- study the magnetic reconnection process and the small-scale MHD structures and plasma acceleration associated with the processes;
- study MHD turbulence, vortex formation, and eddy diffusion particularly in the polar cusp and boundary regions;
- investigate structure and properties of collisionless shock waves, including the bow shock, and the associated particle acceleration and wave generation;
- determine the small-scale structure of the solar wind flow around the Earth; and
- utilize the four-spacecraft configuration to unambiguously determine the three-dimensional shape and dynamics of magnetic structures ranging in scale from 0.1 to 10 R_E.

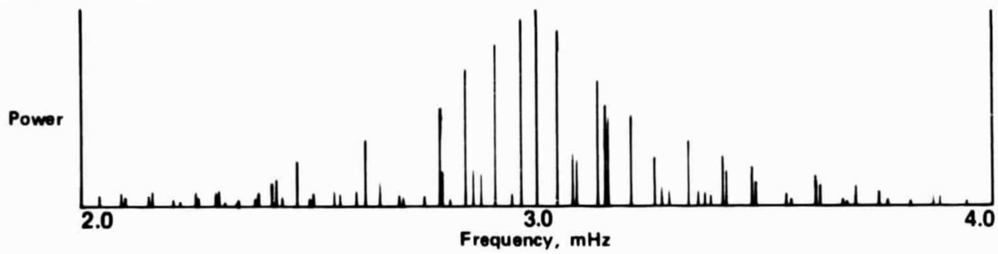
Measurements, Analyses, and Models

The measurements planned for each spacecraft system of the core ISTP Program are listed in the table below.

Core ISTP Scientific Measurements

Measurement	Spectral Range	WIND	SOHO	EQUATOR	GEOTAIL	POLAR	CLUSTER
Vector magnetic fields	DC to 10 Hz	XX	XX	XX	XX	XX	XX
Vector electric fields	DC to 10 Hz			XX	XX	XX	XX
AC plasma waves	10 Hz to 1 MHz	XX	XX	XX	XX	XX	XX
Cold plasma ion distribution & mass composition	0.1 eV to 100 eV			XX		XX	XX
Hot plasma electron & ion distribution & ion composition	0.1 to 30 keV	XX	XX	XX	XX	XX	XX
Energetic electron & ion distribution & ion composition	0.02 to 3 MeV	XX	XX	XX	XX	XX	XX
Global auroral imaging	UV, Visible, X-ray					XX	
Cosmic ray electron & ion distribution & ion composition	0.1 to 200 MeV	XX	XX	XX	XX	XX	
Cosmic gamma ray bursts	0.02 to 8 MeV	XX					
Plasma RF Sounder					XX		XX
Grazing incidence spectrometer	66 - 1750 Å		XX				
Normal incidence spectrometer	584 - 1300 Å		XX				
EUV imaging telescopes	304 Å (He II) 284 Å (Fe XV)		XX				
UV coronal spectrometer	1025 - 1220 Å		XX				
White light coronograph	4000 - 7000 Å		XX				
Soft X-ray telescope	2 - 100 Å		XX				
High resolution spectrophotometer	Visible light		XX				
Solar irradiance monitor	UV to IR		XX				
Imaging solar seismology instrument	Visible light		XX				

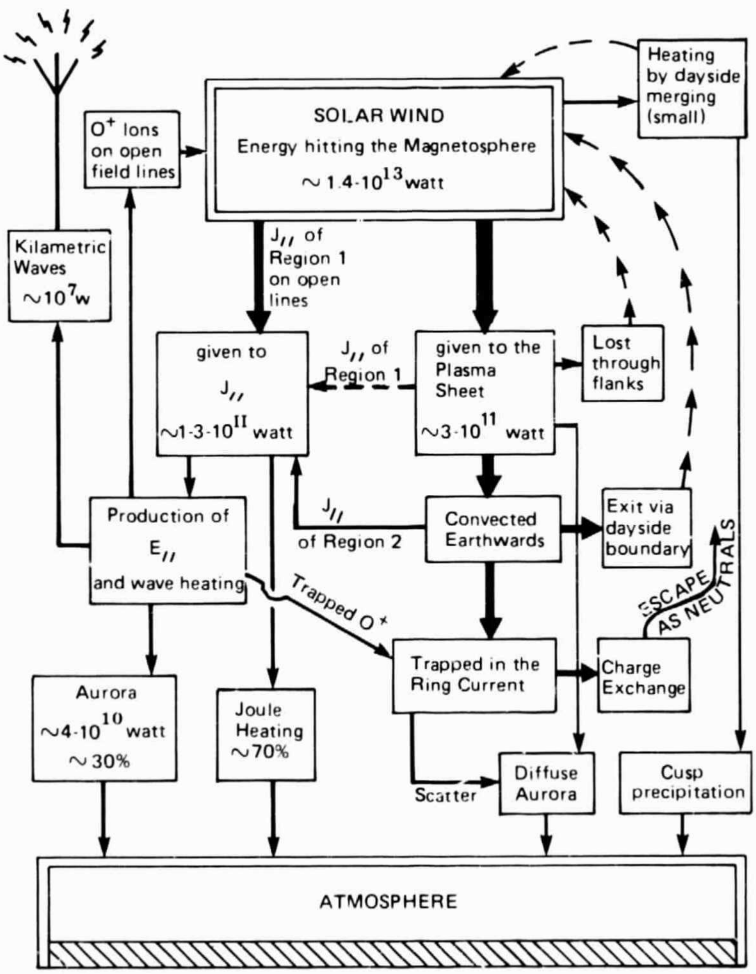
Theoretical models are being developed in order to test directly the cause-and-effect relationships to be revealed in the solar-terrestrial system. With appropriate theoretical work it will be possible to join localized models of solar dynamics, solar wind processes, and plasma flows in geospace in order to attempt an overall model of the Sun-Earth interactions. To carry out such quantitative theoretical studies and modeling, the science team will utilize a central accessible data base in which resides all the appropriate geophysical parameters obtained from the measurements listed above. Detailed analyses are to be carried out by the various investigator groups at their respective institutions.



Power spectral analysis of the solar plasma velocity variations, indicating solar oscillations with a frequency of 3 mHz or about a 5 minute period, coherent over regions of the order of 1/100 of the Sun's visible surface.

Above is shown the type of computer-generated power spectral analysis required to deduce the period of solar oscillations for a series of solar-surface velocity measurements. This type of analysis can reveal periods ranging from minutes to hours.

Below is illustrated a process model for the chain of interactions that occur between the outer magnetosphere of the Earth and its atmosphere. A quantitative model can be developed based on the ISTP measurements in the solar wind and at points inside the magnetosphere, along with global images of the upper atmosphere.



Schematic diagram to illustrate a model for the chain of processes that occur between the solar wind impingement onto the magnetosphere of geospace and the energy deposited into the Earth's atmosphere.

Data Collection and Dissemination

A particularly important element of the ISTP Program will be the special provisions for handling the data collected by the spacecraft. To successfully attack the scientific problems that bear on solar dynamics and the global behavior of geospace, investigators will need to be able to compare and combine measurements obtained with multiple instruments and from multiple spacecraft. Therefore, a ground data system has been defined that would permit all investigators to have access to all data by means of remote analysis terminals. The feasibility of implementing such a system is now under study. All measurements, including both spaceflight data and certain correlative ground-based observations, would be stored in a central archive at each agency. The central data-handling facility would also generate summary data files composed of key parameters extracted from the data stream from each instrument, and these data summaries would be used by investigators to identify particular events or times of interest which are candidates for detailed processing and analysis. Certain kinds of processed data can also be returned from the remote investigator sites to the central archive, where they would become available for use by other ISTP researchers.

Collection

The scheme being studied for collecting data and for controlling the spacecraft includes the following elements:

- ESA will command and control the SOHO and CLUSTER spacecraft systems.
- ISAS will command and control the GEOTAIL spacecraft.
- NASA will command and control the WIND, POLAR, and EQUATOR spacecraft.
- ESA will collect data from the SOHO and CLUSTER spacecraft.
- ISAS will collect data from the GEOTAIL spacecraft in the real-time mode during both the distant magnetotail (deep-tail) and the near-Earth tail phases.
- NASA will collect from the WIND, POLAR, and EQUATOR spacecraft and from the GEOTAIL spacecraft in the playback mode.
- All collected raw data and associated orbit information will be exchanged among all three central data handling facilities.
- In addition, methods of collecting selected ground-based, balloon, aircraft, rocket, and satellite data for collaborative research are being investigated.
- NASA will collect the helioseismology data from the SOHO spacecraft using the DSN in a dedicated form, and store the data on laser video discs for transmittal to a central data handling center.

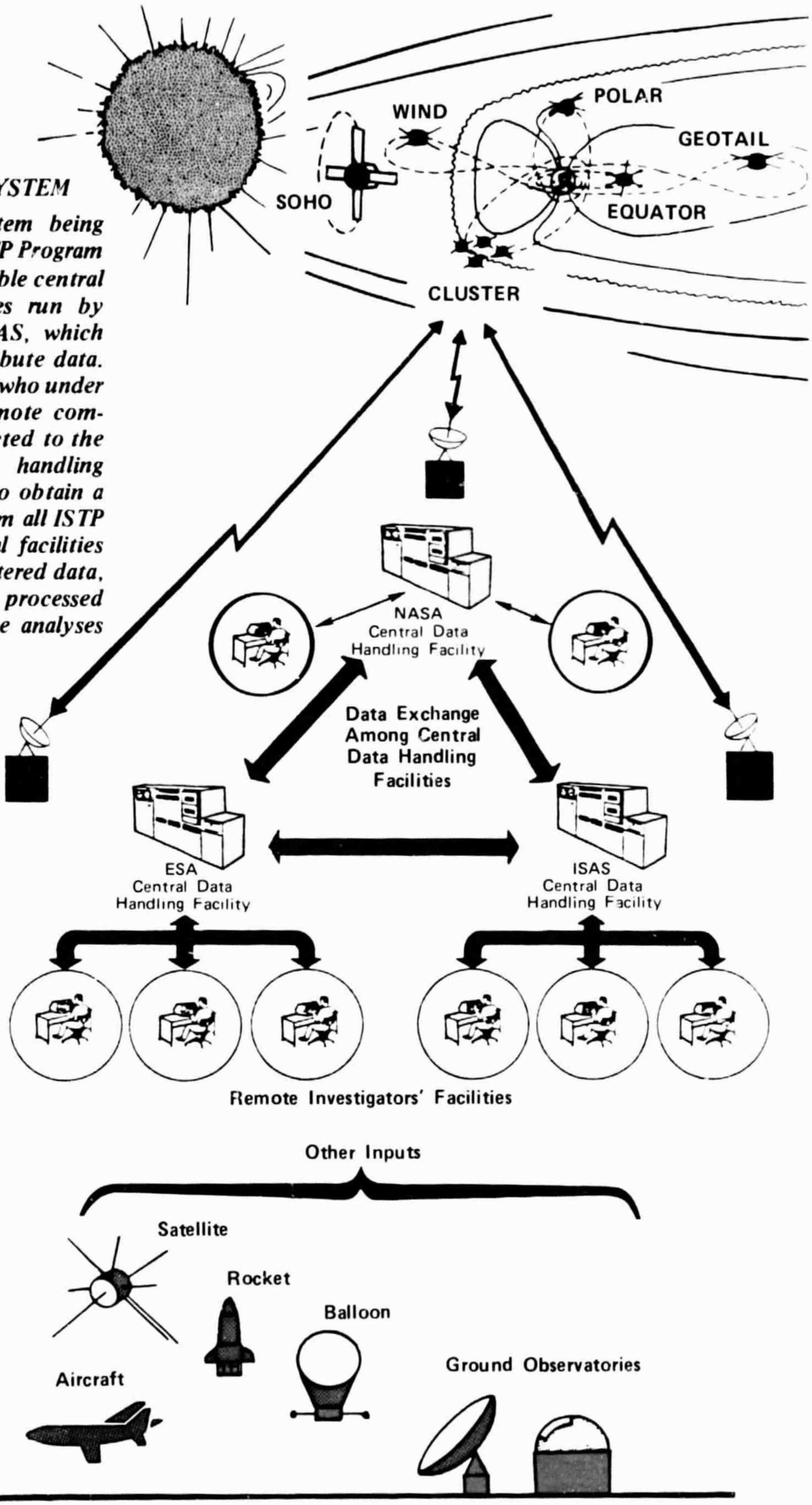
Dissemination

The plans under study by NASA for archiving, processing, and disseminating the collected data are as follows:

- Raw data will be exchanged among the central data handling facilities using optical disc technology.
- Command, control, data catalog, and key parameter files will be exchanged by communications links.
- Each agency will process its raw instrument data to produce the key parameter files.
- Each agency will distribute raw instrument data to its investigators for scientific processing.
- Each investigator is responsible for scientific data processing, archiving, and cataloging, whether done at a local facility or at the central data facility.
- Scientific data are exchanged between investigators upon request.
- Oversight for the overall science program and the collaborative research will be provided by an international steering committee.
- Data analysis on selected topics will be carried out at international workshops.

SCIENCE DATA SYSTEM

The ground data system being considered for the ISTP Program would have three flexible central data handling facilities run by NASA, ESA, and ISAS, which would share and distribute data. Scientific investigators, who under this plan will have remote computer terminals connected to the nearest central data handling facility, will be able to obtain a unified set of data from all ISTP spacecraft. The central facilities will receive raw telemetered data, maintain archives of processed data, and facilitate the analyses by investigators.



"Firsts" of the Core ISTP Program

The core ISTP Program plan builds on the discoveries of the past, the technologies of today, the resources of three partner space agencies—ESA, ISAS, and NASA—and the skills of a worldwide scientific community to achieve a series of "firsts":

- FIRST GEOSPACE SURVEY WITH COMPREHENSIVE MEASUREMENTS OBTAINED SIMULTANEOUSLY IN KEY REGIONS OF GEOSPACE.
- FIRST GLOBAL AURORAL IMAGING WITH TIME RESOLUTION NECESSARY TO RESOLVE CAUSE-EFFECT RELATIONSHIPS.
- FIRST PLASMA ION COMPOSITION MEASUREMENTS OVER THE FULL ENERGY RANGE FOR GEOSPACE PLASMAS.
- FIRST HIGH-RESOLUTION ENERGY AND COMPOSITION MEASUREMENTS TO STUDY MAGNETIC FIELD-ALIGNED PLASMA ACCELERATION AND TRANSPORT PROCESSES.
- FIRST GLOBAL X-RAY IMAGING OF THE AURORA.
- FIRST COMPREHENSIVE STUDY OF THE EQUATORIAL MAGNETOSPHERE.
- FIRST STUDY OF THE GEOMAGNETIC TAIL WITH COMPLETE PLASMA DIAGNOSTICS.
- FIRST HIGH-RESOLUTION AND TOTAL DISC SOLAR SEISMOLOGY MEASUREMENTS FROM SPACE.
- FIRST COMPREHENSIVE SPECTRA AND SOLAR IMAGES FROM X-RAY TO VISIBLE WAVELENGTHS TO UNDERSTAND HEATING MECHANISMS OF CORONA.
- FIRST LONG-TERM MEASUREMENTS OF THE SOURCE REGION FOR SOLAR WIND ACCELERATION AND DIRECT ASSOCIATION TO *IN SITU* SOLAR WIND FLOW.
- FIRST FOUR-POINT MEASUREMENTS OF NATURAL PLASMA TURBULENCE AND SMALL-SCALE STRUCTURE.
- FIRST SMALL-SCALE, MANY-POINT MEASUREMENTS OF MAGNETIC MERGING PROCESSES.

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