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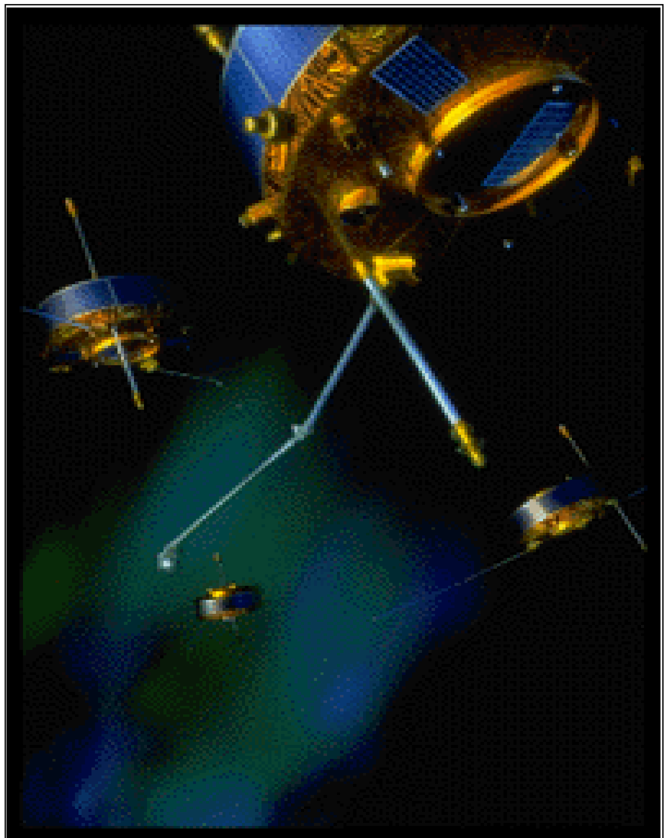
Cluster II Spacecraft to Explore Earth's Turbulent Magnetic Environs

Earth's Magnetic Field Stands Off The Solar Wind

An unseen struggle rages in space near the Earth. The million miles per hour solar wind, a gas comprised primarily of electrons and protons, relentlessly streams toward our planet. It is held at bay by the Earth's vast magnetic field, which deforms under the onslaught of this solar gale, like a jellyfish buffeted by water currents, or a large tent flapping in a wind storm.

The solar wind compresses the Earth's magnetic field to about 40,000 miles (64,374 kilometers) from Earth on Earth's dayside and stretches it to about 800,000 miles (1,287,000 kilometers) on the night side. This volume of space containing the Earth's magnetic field is known as the magnetosphere. Once solar wind particles have penetrated the magnetosphere, they are guided by Earth's magnetic field.

The electrically charged particles of the solar wind infiltrate Earth's magnetic realm with an intensity and impact that depends on solar conditions and direction of the magnetic field carried by the solar wind. Electrons and protons spiral down a funnel-like region of the magnetic field above Earth's day-side polar regions (a structure called the polar cusp) and hit the upper atmosphere, eventually creating the haunting glow that are the northern and



Artist concept of Cluster II spacecraft on orbit formation.

southern lights. At the same time, these particles generate electrical currents that distort Earth's magnetic field, especially at high northern and southern latitudes. The most severe disruptions of the magnetic field are known as geomagnetic storms, and these electric currents and energetic particles occasionally disable satellites, radio communications, and power systems.

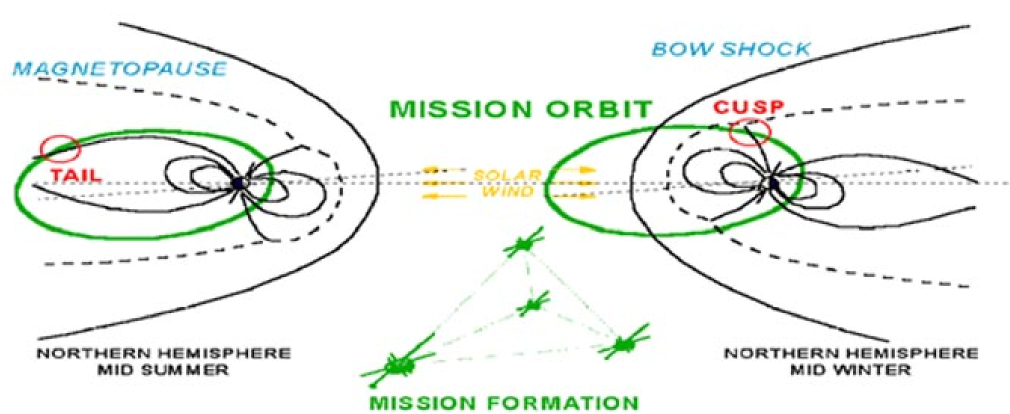
This interaction is very complex and researchers do not understand all the effects of the solar wind on the Earth. The magnetosphere's enormous size and complexity have made it impossible to understand with isolated spacecraft. Cluster II, a fleet of four identical spacecraft, will explore portions of this turbulent region beginning in the summer of 2000.

Surveying The Magnetosphere

Each Cluster II spacecraft will be positioned so that each is located at one of the four points of a pyramid. This arrangement will allow three-dimensional structures to be described, for the first time, in both the magnetosphere and solar wind. Instruments aboard Cluster II will observe the response of Earth's magnetosphere to the ebb and flow of the solar wind in ways never before possible.

Distances between the Cluster spacecraft will be adjusted throughout the mission in order to study different regions and plasma structures. Comparison of simultaneous measurements from the different spacecraft will be combined to produce a three-dimensional picture of plasma structures.

Because the separation of the four spacecraft will vary from about 400 hundred miles to more than 10,000 miles (643 to 16,093 kilometers), scientists will be able to study several of the structures which characterize the Earth's magnetosphere. These include the bow shock wave that stands in front of the magneto-



Line Drawing showing the Cluster II formation sphere as the solar wind is deflected, polar cusp regions of the magnetic field and temporal and spatial structure of the dense plasma in the center of the tail of the magnetosphere on Earth's night side called the plasma sheet.

The Cluster II fleet will be launched in pairs into a polar orbit from the Russian Aviation and Space Agency Cosmodrome, Baikonur, Kazakhstan, aboard two Soyuz-Fregat rockets. The launches, which feature a four-minute window, are scheduled for July and August 2000. The spacecrafts' intended apogee (farthest point from the Earth) will be about 74,000 miles (119,091 kilometers) and its perigee (closest point) will be about 12,000 miles (19,312 kilometers).

Each Cluster II spacecraft is cylindrically-shaped, measuring 9.5 feet (2.9 meters) in diameter and 4.3 feet (1.3 meters) high, and weighs about 1,213 pounds (550 kilograms). An additional 1,430 pounds (649 kilograms) of fuel is included for orbital maneuvering. To maintain a stable orientation in space, each spacecraft will spin like a slow gyroscope, making one complete revolution every four seconds.

Cluster II Science Instruments

During its initial two-year mission, the Cluster II spacecraft will conduct scientific investigations using a complement of 11 instruments and support provided by an international team of investigators.

Instruments onboard the Cluster II spacecraft include:

Active Spacecraft Potential Control (ASPOC) – reduces the electric charge on the spacecraft, so very low-speed electrons can be measured.

Cluster Ion Spectrometry (CIS) – measures the relative abundance of protons and helium nuclei and determines their three-dimensional distribution in the solar wind and magnetosphere.

Digital Wave Processor (DWP) – provides data processing for the plasma wave instruments.

Electron Drift Instrument (EDI) – determines the strength and direction of the ambient electric field.

Electric Fields and Waves (EFW) – measures fluctuating electric fields in the plasma surrounding the spacecraft.

Fluxgate Magnetometer (FGM) – measures static and fluctuating magnetic fields at the spacecraft.

Plasma Electron and Current Experiment (PEACE) – provides three-dimensional measurements of electron distributions in the solar wind and magnetosphere.

Research with Adaptive Particle Imaging Detectors (RAPID) – measures energetic ions and electrons.

Spatio-Temporal Analysis of Field Fluctuations (STAFF) – measures high-frequency waves in the local plasma.

Wideband (WBD) Plasma Wave Investigation – detects very high frequency plasma waves at very high time resolution.

Waves of High Frequency and Sounder for Probing of Density by Relaxation (WHISPER) – uses high-frequency plasma waves to probe surrounding plasma, determining the local density of charged particles.

Program and Mission Management

Cluster II will join the Solar and Heliospheric Observatory (SOHO), which launched December 2, 1995, as the second cooperative solar-terrestrial project between the European Space Agency (ESA) and NASA. SOHO and Cluster constitute the ESA Solar Terrestrial Science Programme, the first cornerstone mission of ESA's long-term initiative called *Space Science Horizon 2000*.

Each spacecraft will operate in concert with Geotail, a joint Japanese/NASA satellite, and NASA's Wind and Polar missions, to provide coordinated measurements throughout the geospace environment.

The Wind and Polar missions, along with NASA's contributions to SOHO, Cluster and Geotail, constitute the International Solar-Terrestrial Physics (ISTP) science initiative, whose purpose it is to understand how the Earth's geospace environment responds to changes in the solar wind.

The Cluster II mission involves an international team of investigators from six countries. NASA has agreements with the United Kingdom for the FGM investigation, Sweden for the EFW experiment, France for the WBD investigation and the CIS experiment, and Germany for EDI and RAPID.

NASA will provide Deep Space Network support for the acquisition of data from the WBD instrument, and for commanding the Cluster II spacecraft and acquiring data.

The Cluster II management team consists of the following agencies and individuals:

Dino Machi, NASA Program Manager, Goddard Space Flight Center;

John L. Christensen, NASA Project Manager, Goddard Space Flight Center;

Dr. Melvyn Goldstein, NASA Project Scientist, Goddard Space Flight Center;

Alberto Gianolio, Deputy Project Manager, ESA; and

Dr. Philippe Escoubet, Project Scientist, ESA;

ESA will manage the spacecraft and science operations, while several NASA centers provide support to the mission through collection and dissemination of scientific data.

For more detailed information about the Cluster II spacecraft and its science mission, visit these websites:

http://international.gsfc.nasa.gov/
http://sci.esa.int/cluster/