

Report on Satellites in Orbit for Solar and Solar Terrestrial missions

SSWG January 2006

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ULYSSES

Mission Status

As reported earlier, Ulysses was one of the missions reviewed by NASA's Sun-Solar System Connections Senior Review panel at its meeting on 14-15 November. As requested by the panel, the presentation by the NASA Project Scientist focused on recent science highlights not included in the formal proposal, while the ESA Mission Manager summarized the status of Ulysses in ESA. Both presentations were well received, and questions from the panel were confined to technical clarifications. The formal recommendations from the Review are expected to be made known early in the New Year.

All spacecraft subsystems are operating nominally. On 1 February 2006, Ulysses will be at a radial distance of 4.35 AU from the Sun, and heliographic latitude 40° south of the solar equator.

Operations and Archive

All science operations during the reporting period have been nominal. Payload operations are being conducted according to the pre-determined power-sharing plan. The current payload configuration will be maintained until Spring 2007, when the spacecraft is close enough to the Sun to allow the Cold Case Heater (needed to keep critical parts of the spacecraft platform at a safe temperature) to be switched off. The ESA Ulysses archive is accessible via the World Wide Web at URL: <http://helio.esa.int/ulysses>.

Science Highlight

A recurring theme in many of the results obtained by Ulysses is the unexpectedly large degree to which the heliospheric magnetic field deviates from the pattern expected from the combination of radial solar wind outflow and rotation of the foot point fixed in the solar photosphere (an Archimedean spiral). Existing models of systematic deviations from the spiral pattern require radial distances of several AU for a deviation of order 1 AU to develop. However, observations of "jets" of energetic electrons from Jupiter's magnetosphere, acquired by Ulysses during the 2003/4 distant encounter, show that such deviations are common within a radial interval of as little as 0.1 AU. Electron Jets were discovered during Ulysses' first Jupiter flyby in 1992, and were identified as brief (time scale of minutes to hours), highly anisotropic increases in intensity of MeV electrons flowing away from Jupiter along the heliospheric magnetic field. Jets were observed up to distances of order an AU from Jupiter, and were interpreted as evidence for direct magnetic connection to Jupiter's magnetosphere.

In the recent cases, the position of Ulysses relative to Jupiter was such that magnetic connection along the average spiral field could not have occurred, implying large

deviations. If such large deviations are indeed common, they may play a significant role in distribution of particles throughout the heliosphere by providing paths for particles to propagate parallel to the local field while crossing the average field. On average, the spiral heliospheric magnetic field still provides strong guidance to particle propagation, but individual field lines or flux tubes may deviate strongly over large distances normal to the average field. It is not yet clear how or why such large-scale deviations develop, whether they are consistently present throughout the solar cycle, or how to incorporate them into models of particle propagation.

Solar and Heliospheric Observatory (SOHO)

Mission Status

The spacecraft status is nominal, with the High Gain Antenna (HGA) Z-axis in a fixed position. On 15 December a nominal manoeuvre (station keeping, momentum management and roll) will be performed. Estimated fuel usage is 0.0723 kg. The remaining hydrazine is 118 kg. The solar array degradation after 119 months of flight is 17.9%, which corresponds to 1.81% per year.

The SOHO presentation to the NASA Sun-Solar System Connections Senior Review took place on 14 November. As in the case of Ulysses above the inquiry was tough, and cost-costs may result from the outcome.

Operations and Archiving

All instruments are nominal and SOHO science operations are progressing smoothly. Links to the SOHO archives (including mirrors) are accessible at <http://soho.esac.esa.int/data/>.

Science Highlights

On 2 December we celebrated the 10th launch anniversary of SOHO. The ESA main portal featured a SOHO 10-year special, and the SOHO home page listed some amazing numbers from SOHO's first decade:

- **140** Ph.D. theses have been written on or about SOHO data.
- **289** scientific meetings on subjects related to SOHO appear on our meetings pages.
- **944** news stories appear on our newsroom pages (only recorded between 1997 and 2005!).
- **1000** comets have been found. SOHO is the most prolific comet-finder observatory of all times, and has identified almost half of all comets for which an orbit determination has been made.
- **2300** reviewed papers using SOHO data have been published.
- **2300** scientists (approximately) appear in the author lists of those papers (we like to say that every current solar scientist has had the chance to work with SOHO data).

- **3230** science planning meetings have been held.
- **2 000 000** command blocks have been sent to the spacecraft by the ground system.
- **5 000 000** distinct files have been served by the web server.
- **10 000 000** exposures (almost!) have been made by the CDS instrument.
- **16 000 000** distinct hosts have been served by the web server.
- **100 000 000** exposures have been taken by MDI! They're probably quite high on the list of "the world's most durable camera shutters". Don't try to beat it with your favourite SLR camera!
- **266 000 000** web page requests have been served.
- **16 000 000 000 000** bytes (16 Terabytes) of data are contained in the SOHO archive (including MDI data at Stanford).
- **85 000 000 000 000** bytes (85 Terabytes) of web pages/data have been served from the GSFC archive.
- **114 000 000 000 000** bytes (114 Terabytes) of web pages/data have been served over the internet when the Stanford MDI archive is included. The total amount of data given to users is quite a bit higher when offline requests are accounted for.

CLUSTER:

Mission Status

The four spacecraft and instruments are operating nominally. The phasing manoeuvres were executed in November 2005. The spacecraft multi-scale configuration (C1, C2 and C3 spacecraft separated by 10000 km and C3 and C4 separated by 1000 km), which was used in the tail period, was changed to a perfect tetrahedron of 10000 km to observe the polar cusp in February/March 2006. The solid state recorder capacity was increased from 5 to 7.5 Gbit by switching on a 3rd memory module, which had been kept as spare part up to now. This will allow more flexibility in the data dumps, what was required for the switch from Vilspa to Perth ground station in January 2006.

Operations and Archiving

JSOC and ESOC operations are continuing nominally. Work is progressing for the switch from VILSPA to Perth ground station starting early 2006. The data return from September 2005 to mid November 2005 was on average 99.8 %.

The Cluster Active Archive (CAA) is in beta testing phase since 26 September. Up to now, 63 software problems have been reported of which 19 are still open but none of them are critical; these are mostly related to the ingestion processes. The CAA will be opened on 1 February 2006. A new activity on cross-calibration between different instruments has been started. The first meeting was held in September and the next one will be in January 2006. (see separate report at this meeting by H. Laakso)

Science Highlight

A new multi-spacecraft method to estimate the magnetic reconnection rate has been developed and applied to the Cluster data. This requires at least two spacecraft in the reconnection layer at the same time. The results from one magnetopause crossing by Cluster showed that the reconnection rate is significantly lower than the rate obtained from previous observations. This finding could come from the fact that a certain type of reconnection called “component reconnection” was occurring at that time.

Double Star:

Mission Status

The two spacecraft and the instruments are operating nominally. The drift of the spin axis is continuing as predicted, TC-1 spin axis is about 3.5° from the ecliptic pole and TC-2 around 16° . It should not cause problems before July 2006 for TC-2 and December 2006 for TC1. TC-1 has entered the eclipse season that will last 7 months and payload operations will be reduced during eclipses longer than one hour.

Science operation

The European Payload Operation System (EPOS) co-ordinates the operations for the seven European instruments on TC-1 and TC-2 and is running smoothly. The new contract for the extension of EPOS, starting 1 January 2006, is being signed by RAL. ESOC acquired on average about 3 hours of data per day using the VILSPA 2 ground station and covered around 80% of the passes. The rest of the passes were acquired by the Chinese stations in Shanghai and Beijing.

Science Highlight

The 24 Double Star papers have been published in the special issue of *Annales Geophysicae* of November 2005. This includes papers on the mission, the description of the instruments and the first results.

On 27 December 2004, radiation from the biggest starquake on a neutron star ever recorded reached Earth. Unique data obtained by Double Star TC-2 and Cluster satellites have shown the first observational evidence of cracks in the neutron star crust, during the initial phase of the starquake. The intensity of this major peak was hundreds of times stronger than any other observed so far (only two other giant flares have been recorded in the past 35 years). For the first 200 ms it saturated almost all instruments on satellites equipped to observe γ -rays. Although designed to study the Earth's magnetosphere, the PEACE instruments onboard Double star TC-2 and Cluster satellites performed unsaturated observations of this initial flare rise and decay. This result, published in the *Astrophysical Journal*, will help to discriminate between current theories on the physical origin of such massive starquakes.