Heliophysics Integrated Observatory

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Heliospheric & Planetary Data

Version 1.1

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Revision History

Version	Date	Released by	Detail
Draft	2010-01-04	R.D. Bentley	First cut of what data should be included in HELIO
1.0	2010-01-12	R.D. Bentley	Reworked and tidied text
1.1	2010-02-08	R.D. Bentley	Included suggestions from King

Note: This document will continue to undergo revisions during the implementation phase of HELIO to incorporate changes and improvements.

Introduction

Heliophysics is the effects of Sun on the Solar System. In order to support studies that address science problems in heliophysics, HELIO must provide access to observations of the Sun and heliosphere, and to observations of magnetospheres and ionospheres for those planets with magnetic fields and/or atmospheres.

This document discusses which heliospheric and planetary missions could provide information about conditions in the heliosphere and planetary environments and that should therefore be considered for inclusion the HELIO infrastructure.

It may not be possible to include everything because of limits in the resources available to the project. However, since most planetary data are available through a handful of data providers, if we can provide access to these all the data might become available by default. The main question would then be whether these providers are able to actually provide the suitable means of access.

Initially, priority of which datasets should be included first will be determined by the science problems selected for the HELIO Coordinated Analysis Workshops (CDAW).

Which data should be included?

We have examined the instrument compliments of most relevant missions and have determined that those listed in Table 1 carry suitable instruments; the instruments themselves are listed in Table 2.

In-situ Observations

The principal types of observations include parameters related to:

- Particles
- Cosmic rays
- Plasma
- Solar wind
- Magnetic field
- ***What else???***

Near the gas giants, *in-situ* observations also see plasma that is local, rather than solar in origin. Some magnetospheric and ionospheric effects can also have a local stimulus. This complicates which instruments we ought to include.

Remote-Sensed Instruments

For the most part, the remote-sensing instruments on the planetary mission are directed towards the planets. It is unlikely that they are directly relevant to heliophysics but in principle HELIO could provide access to them.

The recent[1] Heliophysics Roadmap produced by NASA includes and objective that looks at the effect of energetic solar particles on the chemistry of the upper atmosphere of the Earth

[1] Spring 2009; URL?

because of potential effect this could have on climate. This suggests there could be a case for including access to instruments studying the upper layers of planetary atmospheres.

Additional remote-sensed observations of the heliosphere by coronagraphs (and heliospheric imagers) are included under the solar access.

Designation	Name	Launch	End Cruise	Object		Start Operations	End Operations	
1972-012A	Pioneer 10	1972-03-03		Jupiter	H	1972-03-03	2000-08-01	US
1973-019A	Pioneer 11	1973-04-06		Jupiter/Saturn	H	1973-04-06	1995-09-30	US
1973-085A	Mariner 10	1973-11-03		Venus/Mercury	H	1973-11-03	1975-03-24	US
1977-076A	Voyager 2	1977-08-20		Heliosphere	H	1977-08-20	0000-00-00	US
1977-084A	Voyager 1	1977-09-05		Heliosphere	H	1977-09-05	0000-00-00	US
1985-056A	Giiotto	1985-07-02		Comet	H	1985-07-02	1992-07-23	Eu
1989-033B	Magellan	1989-05-04	1990-08-10	Venus	O	1990-08-10	1994-10-12	US
1989-084B	Galileo Orbiter	1989-10-18	1995-12-07	Jupiter	O	1995-12-07	2003-09-21	US
1989-084E	Galileo Probe			Jupiter	P	1995-07-12	1995-12-07	US
1990-090B	Ulysses	1990-10-06	1992-02-08	Sun	H	1992-02-08	0000-00-00	Eu
1996-062A	Mars Global Surveyor	1996-11-07	1997-09-12	Mars	O	1997-09-12	2006-11-02	US
1997-061A	Cassini	1997-10-15	2004-07-01	Saturn	O	2004-07-01	0000-00-00	US
1998-001A	Lunar Prospector	1998-01-07		Moon			1999-07-31	US
1998-061A	Deep Space 1	1998-10-24		Asteroid and comet	H		2001-12-18	US
2001-014A	Mars Odyssey	2001-04-07	2001-10-24	Mars	O	2001-10-24	0000-00-00	US
2003-022A	Mars Express	2003-06-02	2003-12-25	Mars	O	2003-12-25	0000-00-00	Eu
2004-006A	Rosetta	2004-03-02		Comet	H		0000-00-00	Eu
2004-030A	Messenger	2004-08-03	2011-03-18	Mercury	O	2011-03-18	0000-00-00	US
2005-029A	Mars Reconnaissance Orbiter	2005-05-12	2006-03-11	Mars	O	2006-03-11	0000-00-00	US
2005-045A	Venus Express	2005-11-09	2006-04-11	Venus	O	2006-04-11	0000-00-00	Eu
2006-001A	New Horizons	2006-01-19		Pluto & Kuiper Belt	H		0000-00-00	US
2006-047A	STEREO-A	2006-10-25		Sun	H	2006-10-25	0000-00-00	US
2006-047B	STEREO-B	2006-10-25		Sun	H	2006-10-25	0000-00-00	US
2007-039A	Kaguya	2007-09-14		Moon			2009-06-11	Jp
2009-031A	Lunar Reconnaissance Orbiter	2009-06-18		Moon			0000-00-00	US

Table 1: Heliospheric and planetary missions relevant to HELIO

Are there other relevant observations?

Should HELIO also provide access to?:

- Radio science and plasma wave experiments from various missions
- Planetary images taken by the Hubble Space Telescope, XMM, etc. (only?) in wavelengths that show phenomena relevant to heliophysics.
- Other planetary observations made by ground-based observatories, for example radio observations.

Note: We will not include any planetary probes or landers?? However, the disruption of communications between landers and relay spacecraft in orbit can be an indication of space weather effects.

Instrument	Mission	
Radio Science (RSS)	Voyager 1 & 2	1977-084A
Triaxial Fluxgate Magnetometer (MAG)	Voyager 1 & 2	1977-084A
Plasma Spectrometer (PLS)	Voyager 1 & 2	1977-084A
Low-Energy Charged Particles (LECP)	Voyager 1 & 2	1977-084A
Cosmic Ray System (CRS)	Voyager 1 & 2	1977-084A
Planetary Radio Astronomy (PRA)	Voyager 1 & 2	1977-084A
Plasma Wave System (PWS)	Voyager 1 & 2	1977-084A
Magnetometer (MAG)	Galileo Orbiter	1989-084B
Plasma Detector (PLS)	Galileo Orbiter	1989-084B
Energetic Particles Detector (EPD)	Galileo Orbiter	1989-084B
Plasma Wave Spectrometer (PWS)	Galileo Orbiter	1989-084B
Radio Science: Propagation (RS)	Galileo Orbiter	1989-084B
Solar X-Rays and Cosmic Gamma-Ray Bursts (HUS/GRB)	Ulysses	1990-090B
Cosmic Ray and Solar Particles (SIM/COSPIN)	Ulysses	1990-090B
Low-Energy Ions and Electrons (LAN/HI-SCALE)	Ulysses	1990-090B
Solar Wind Ion Composition Spectrometer (GLG/SWICS)	Ulysses	1990-090B
Solar Wind Plasma (BAM/SWOOPS)	Ulysses	1990-090B
Unified Radio and Plasma Waves (STO/URAP)	Ulysses	1990-090B
Magnetic Field (HED/VHM/FGM)	Ulysses	1990-090B
Coronal Sounding (radio science) (SCE)	Ulysses	1990-090B
Ulysses Energetic Particle Composition (EPAC) Experiment	Ulysses	1990-090B
Ulysses Interstellar Neutral Gas (GAS) Experiment	Ulysses	1990-090B
Radio Science Investigations (RS)	Mars Global Surveyor	1996-062A
Magnetometer/Electron Reflectometer (MAG/ER)	Mars Global Surveyor	1996-062A
Radio Science Subsystem (RSS)	Cassini	1997-061A
Radio and Plasma Wave Science (RPWS)	Cassini	1997-061A
Plasma Spectrometer (CAPS)	Cassini	1997-061A
Magnetospheric Imaging Instrument (MIMI)	Cassini	1997-061A
Dual Technique Magnetometer (MAG)	Cassini	1997-061A
Plasma Circulation and Magnetosphere-Ionosphere Coupling (IDS)	Cassini	1997-061A
The Plasma Environment in Saturn's Magnetosphere (IDS)	Cassini	1997-061A
Plasma Experiment for Planetary Exploration (PEPE)	Deep Space 1	1998-061A
Mars Radiation Environment Experiment (MARIE)	2001 Mars Odyssey	2001-014A
Radio Science	2001 Mars Odyssey	2001-014A
Analyzer of Space Plasmas and Energetic Atoms (ASPERA)	Mars Express	2003-022A
Mars Radio Science Experiment (MaRS)	Mars Express	2003-022A
Radio Science Investigations (RSI)	Rosetta	2004-006A
Langmuir Probe (LAP)	Rosetta	2004-006A
Ion and Electron Sensor (IES)	Rosetta	2004-006A
Fluxgate Magnetometer (MAG)	Rosetta	2004-006A
Ion Composition Analyser (ICA)	Rosetta	2004-006A
X-ray Spectrometer (XRS)	MESSENGER	2004-030A
Energetic Particle and Plasma Spectrometer (EPPS)	MESSENGER	2004-030A
Magnetometer (MAG)	MESSENGER	2004-030A
Radio Science (RS)	MESSENGER	2004-030A
Venus Radio Science (VeRa)	Venus Express	2005-045A
Analyzer of Space Plasmas and Energetic Atoms (ASPERA-4)	Venus Express	2005-045A
Magnetometer (MAG)	Venus Express	2005-045A
Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI)	New Horizons	2006-001A
Solar Wind Analyzer around Pluto (SWAP)	New Horizons	2006-001A
Radio Experiment (REX)	New Horizons	2006-001A
Venetia Burney Student Dust Counter (Venetia)	New Horizons	2006-001A
Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI)	STEREO A & B	2006-047A
Stereo/Waves (Swaves)	STEREO A & B	2006-047A
In-Situ Measurements of Particles and CME Transients (IMPACT)	STEREO A & B	2006-047A
Plasma and Supra-Thermal Ion Composition (PLASTIC) Investigation	STEREO A & B	2006-047A
Lunar Magnetometer (LMAG)	Kaguya	2007-039A
Charged Particle Spectrometer (CPS)	Kaguya	2007-039A
Plasma Analyzer (PACE)	Kaguya	2007-039A
Upper Atmosphere and Plasma Imager (UPI)	Kaguya	2007-039A
Radio Science, RSAT, and VRAD	Kaguya	2007-039A
Lunar Exploration Neutron Detector (LEND)	LRO	2009-031A
Cosmic Ray Telescope for the Effects of Radiation (CRaTER)	LRO	2009-031A

Table 2: Instruments identified as relevant to HELIO

Including the Data

Types of access required

HELIO needs to support two forms of access to planetary and heliospheric data:

- In order to support the search for interesting events and phenomena, we require access to summary data – medium to low cadence time series data – from instruments/observatories located throughout the solar system. These data would be used by the MetaData Evaluation Service (MDES) to generate plots and to allow the user to manipulate the data in order to generate new event lists.
- Once a user has selected an interesting event or phenomenon and has decided which instrument/observatories could provide useful observations, HELIO needs to be able to locate these data and provide the user the means to access the. In this case the data would be at full resolution.

Sources of data

The main sources of planetary data are NASA's Planetary Data system (PDS) and ESA's Planetary Science Archive (PSA); of the two, the PDS holds greatest amount of data.

The PDS and PSA use the same standards defined by the International Planetary Data Alliance (IPDA) and in principle if HELIO can use data from one source, it can use them from both sources. However, on initial inspection the means of access appears to differ: the PSA can be accessed directly through FTP while the PDS only seems to have a form based Web interface.

- NASA's Planetary Data System (PDS) – http://pds.jpl.nasa.gov/
- ESA's Planetary Science Archive (PSA) – http://www.rssd.esa.int/psa/

Data from some heliospheric instruments can also be accessed through the Space Physics Data Facility (Ulysses) and the Virtual Solar Observatory (STEREO), both located at NASA-GSFC. During EGSO, access to Ulysses files was available but no attempt was made to explicitly use the time series data.

- NASA-GSFC Space Physics Data Facility – http://cdaweb.gsfc.nasa.gov/
- Virtual Solar Observatory (VSO) – http://virtualsolar.org/

Steps needed to include the data

In order to enable access by HELIO to these instruments (observatories), it is necessary to make entries for each in the Data Registry within the *Data Provider Access Servic*e (DPAS) and at least one record in the Dynamic Search Registry (DSR; part of the OCS).

In order to allow the enable the HELIO search capabilities, it is necessary to make entries in the *Instrument Capabilities Service* (ICS):

- In observatory table, include (relevant) missions that were operational from 1990 onwards; this will include missions (such as Voyager) launched before that date. The missions that we propose to include are shown in Table 1.

- Only populate the instrument table with relevant instruments from missions that are active from 2003 onwards. The instruments that we propose to include from each mission are shown in Table 2.

Information on the ephemeris of the each spacecraft and/or planet needed to define the location of the relevant observatories should also be added to the *Instrument Location Service* (ILS).

For missions that have an ultimate objective of making observations of one of the planets, the ILS has to handle two distinct phases: the cruise phase and orbiting phase.

- During the cruise phase, some instruments may be making observations – those of the in-situ instruments are of most interest. The ILS needs to know where the spacecraft is at a given time.
- During the orbiting phase, the emphasis is mostly on the planet itself; in addition, the in-situ instruments are not observing the conditions in solar wind but rather the response of the planetary environment to stimulating events that could be either planetary or solar in origin. For most heliophysical studies, the location of the spacecraft can be assumed to be the same as the planet; *whether we need to know the location more accurately needs to be discussed.*

The remaining missions are on some sort of trajectory through interplanetary space and are (most likely) observing all the time. The ILS needs to know where the spacecraft is at a given time.

Issues that need investigation or discussion

- Discuss with experts in planetary and heliospheric data:
    - The proposed list of instruments
    - Accuracy of what is said in this document and other issues
- Access mechanisms to the PDS and PSA (other sources?)
- Access to summary time-series data for MDES and CXS
- Are there event lists for planetary domain that can be included in the HEC?

- Not sure whether IBEX fits here – investigates heliopause, but from Earth orbit