



A European ILWS Strategy Outline

- **Results** of the 2nd and 3rd European ILWS meetings Sept 18/19, 2003 and Jan 9, 2004
- **Issue:** To develop a significant, credible and realistic plan for the European contributions to ILWS, as requested by ESA's SSWG
- **Attendance:** **22 representatives** of the space agencies and scientific communities of **11 ESA member states** (apologies - but interest - from E, Eire, NL and P), ESA's Solar and STP Division at ESTEC, two ILWS Task Groups, and the ESA Space Weather Study within D/TOS.
- *Assessing an un-prioritized catalogue of options and possibilities emerging from the ILWS-WG meeting in Nice and several ILWS-SC meetings,*
- *and reviewing the national plans and scientific priorities throughout the various ESA member-states,*





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It was recognised

- that the ILWS is a timely and relevant program, aiming to achieve a deeper understanding of the governing processes in the interactions within a complex and coupled system - involving a star, the interplanetary medium, a planetary magnetosphere and an atmosphere with ionised and neutral components,
- that the variability of this system-intrinsic interaction is of vital importance for mankind and its future biological and technological development in space,
- that one space agency alone cannot address all scientific problems posed nor explore all regions in space spanned by the system, and
- that the European science community must maintain and further develop its expertise and word leadership in certain key areas,



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Prime Criteria:

- mission uniqueness and relevance to the ILWS mission,
- to develop or maintain European leadership,
- balance of disciplines ,
- balance of European national interests,
- affordability and practicability,
through a mixture of mission sizes and contributions, thus involving
both cornerstones and ESA support to international and national initiatives,
- the opening of timely opportunities,
- simultaneous “end-to-end” measurements of the solar terrestrial environment,
- and laying foundations beyond the present ILWS and Cosmic Vision plans.



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In summary - three major items for European ILWS contributions emerged

(... along with a number of minor contributions to missions of considerable European interest)

1. **Solar Orbiter** as the European ILWS Flagship
2. **Swarm** as a unique possibility for ESA's first IT mission at virtually no cost for the ESA Science program
3. Contributions to the 3-D multi-scale exploration of the magnetosphere - "**M³**"
- which needs to be defined and then prepared for, also utilising ILWS opportunities of member or partner agencies.

... however, in more detail, there are 5 priority areas for ESA support of ILWS



1. Identifying the sources and variability of Solar energy and their modification in the corona and heliosphere on the way towards 1 AU.

MISSIONS:

- **Solar Orbiter** as ESA's prime contribution, without which ESA cannot maintain a leading role in ILWS.
- **BepiColombo/MMO** is seen as an important complementary heliospheric ILWS mission (Solar Sentinel).
- On the way towards Solar Orbiter there will be several opportunities for **small scale collaborations with missions of other space agencies**, as demonstrated with the recently approved **ESA ground-support for Solar-B**.
- Opportunities exist (and are presently pursued) within the **STEREO** and **Coronas-Photon** projects of NASA, resp. FSA





2a. Deposition of this energy into the upper atmosphere and its global impact through coupling with the biosphere (the “Living” with a Star - aspect).

MISSIONS:

- across divisional boundaries opportunity of developing an outstanding European-led **Ionosphere Thermosphere (IT) mission** at very little extra cost.
- achievable by adding complementary IT instrumentation like plasma and field instruments to the **SWARM** mission within ESA D/EOP.
- the Canadian **Ravens** mission is a strong complement to this ESA IT mission as it will monitor the global auroral energy deposition in one hemisphere in an unprecedented way.
- high priority (2a) justified by the very timely opportunity for an IT mission.



2b. The transport and modification of Solar energy within the magnetosphere, including mechanisms of particle acceleration, energy conversion and cross-scale coupling.

MISSIONS:

- long-term objective to develop **M³**, a true 3-dimensional Multi-scale Multi-spacecraft Magnetospheric mission concept, emerged from reassessment in early 2002.
- **M³** was considered as a mission beyond the scope of “Cosmic Vision”, but well within “Vision 2020” (see SSWG reassessment document 2002).
- New medium-term studies and other activities like deomonstrator mission are needed to provide the building blocks for this long-term goal.
- It is essential to maintain and develop European capability in strategically important areas for future missions involving **multiple nested s/c formations**.
- **M³** and **Road-to-M³** activities need to be defined in more detail !

Planning and Definition Working Group to be established





3. The effects of Solar variability on the present climate change.

MISSIONS:

- **Total Solar Irradiance (TSI)** is a critical measurement for the fulfilment of the overall ILWS mission.
- Considering the European leadership in this field ESA should ensure that there are no gaps in the data acquisition for TSI.
- This may mean supporting the implementation of a TSI experiment on a **mission of opportunity**
- **Earthshine** (UK) and **Picard** (France) are examples of National Missions in this context.



4. The maintenance of European expertise in data exploitation and data analysis (+ support of modelling and theory efforts)

MISSIONS:

Recommended are contributions in support of missions with strong European interest, achieving:

- more complete datasets, as e.g. provided by the provision of an **additional ground station for Solar-B**,
- easier European access to vast Solar data-sets, stimulating advanced analysis methods, automatisisation and event search routines (either through **European mirror data bases** of key ILWS missions or via a **European access node** to a **Virtual Solar Observatory**)
- procurement of future community-wide access to multi-instrument multi-satellite data - the **Cluster Active Archive**
- stimulation of initiatives within Space Weather, and other end user activities like **models, predictions, and studies of more statistical nature**



ILWS Strategy in an Overview

Panasonic

Source of short term variability (1) **Pro** Solar Orbiter OR NO ILWS-ESA even better with B/C/M/O (Sentinel 2 may miss)

Energy sink (2) **Pro** Support of European IT mission **SOHO ext** (SWARM/ACE instr. or merger)

Energy transport (2) **b** Support of science and technology towards M3E cross-scale coupling. (long term plan)

Europe (3) **Ship** Cluster ext (DSE Themis) + **NLM** (3) PART - ACE. Platform nono sat IRAS LISA INSTR. -

T S I (500 - Coronal) **Earthlike** (Piaor)

Contr. Data ^{5/6} **base** Data bases ^{SOHO} (3) → modelling European leadership in science exploitation comparison Probe 2

Pro cost 5. 1





ILWS Strategy in an Overview

	Major ESA Support or ESA – led	Modest ESA Support	Strong ESA Endorsement
1 Sun and Solar Wind Energy Source	Soho & Ulysses ext. Solar Orbiter BC–MMO SolarSent.	Stereo grnd stat. Solar – B grnd. stat.	L1 mission(s) Proba - 2
2a Ionosphere - Thermosphere Energy deposition	Swarm	To be identified	Compass Demeter Ravens
2b Magnetosphere Energy conversion	Cluster / DSP ext. "M³ development"	NLM's candidates tbi	Frisbee Heracles Auroral Quartet, etc.
3 Sun and Climate End-to-End Observat.	–	TSI M.Opp SDO/CPh Picard & Earthshine	–
4 Data Exploitation, Analysis & Models	Cluster Active Archive	SDO DB or EN-SVO Stereo/Solar–B GSt	Model and Theory/ Space Weather / GB



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SWARM (Living Planet ESA-EOP)

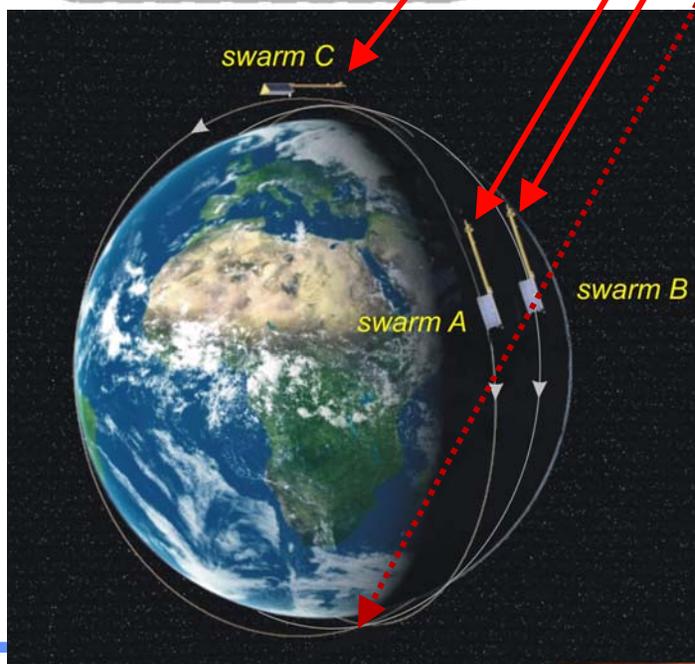
Earth's Interior

- Core dynamics and geodynamo processes
- Lithospheric magnetisation
- 3D Mantle conductivity
- Ocean circulation

- Satellite D level 1b data
- Satellite C level 1b data
- Satellite B level 1b data
- Satellite A level 1b data

Earth's Environment

- Ionosphere-magnetosphere current systems
- Magnetic forcing of the upper atmosphere



- Unanimously proposed as first priority for full implementation by EOP Adv. Structure
- Decision of Programme Board pending on May 27
- Electric field instruments (Ion Drift Meter) to be provided by CSA in Collaboration with ESA Science Programme
- Outcome for GEOSPACE science needs to be optimised after selection



International Living With a Star





Progress on Magnetospheric Mission

...from the recent SSWG resolution on new missions:

- The SSWG reiterated its long term science goal to probe the Solar System Connections through the study of the coupling between the smallest (e.g., electron), intermediate (ion) and largest (interplanetary) scales.
- As amplified in SOL(2002)10), a multi-scale multi-point mission to the Earth's magnetosphere is seen as the most important step in this area.



Progress on Magnetospheric Mission

The SSWG noted that:

This genre of mission builds directly on the European strengths in multi-point space plasma investigations. Cluster results have elucidated the intermediate scale structure.

Simultaneous measurements on a multiplicity of scales requires a large number of spacecraft (8-10 or more). This poses several key technological challenges, including spacecraft and payload miniaturisation, sharing of onboard services, fast time resolution, and multi-spacecraft communication.



Progress on Magnetospheric Mission

... and furthermore

A **technology demonstrator** mission is therefore needed and one possible science target could be the **radiation belts**.

This would contribute towards meeting the **magnetospheric requirements of International Living With a Star**,

perhaps in a **formation similar to the STORMS concept** highly ranked by the SSWG during the 2000 F2/F3 selection process.





Other SSWG Recommendations

(3) The SSWG discussed the **solar observing requirements** up to 2010, particularly in the context of the important **coronagraph observations**.

The SSWG noted that an **extension of SOHO** that keep even a limited number of instruments (and in particular LASCO) operating would fill this requirement, but would wish to **return to this issue were SOHO to cease operations**.





CONCLUSIONS

ESA and European Member Agencies have made progress in all three areas identified as high strategic priority:

Solar Orbiter

Swarm

and hopefully even the **inner magnetosphere** leading to multi-scale study of the **entire magnetosphere (M³)**





Additional Observations beyond the 5 Priority Areas:

- ... this list of priorities contains strong implicit support (at no extra cost for ESA) to missions like **Ravens**, and **Proba 2**. The former might achieve European payload support and the latter needs assistance in identifying a proper launch opportunity (dawn-dusk orbit required).
- ... the strategy outline does **not** contain **MMS**, **Themis**, **SWISE**, **Roy**, **E^{pop}**, etc, even if some of these missions may become parts of the implementation plan for **M³**
- ... the recent loss of the **Coronagraph on SDO** could not be considered here, but will have implications for future **NASA-ESA** collaboration procedures.
- ...our Priority Area 1 – the Sun and Heliosphere – deserves a special highlighting, as it contains ESA's prime contribution to ILWS – **Solar Orbiter** without which ESA's ILWS participation is questionable as a whole.
- ... the proposed ESA investments in ILWS represent a **wide range of cost levels**, from major mission(s) to minor contributions on missions of opportunities.