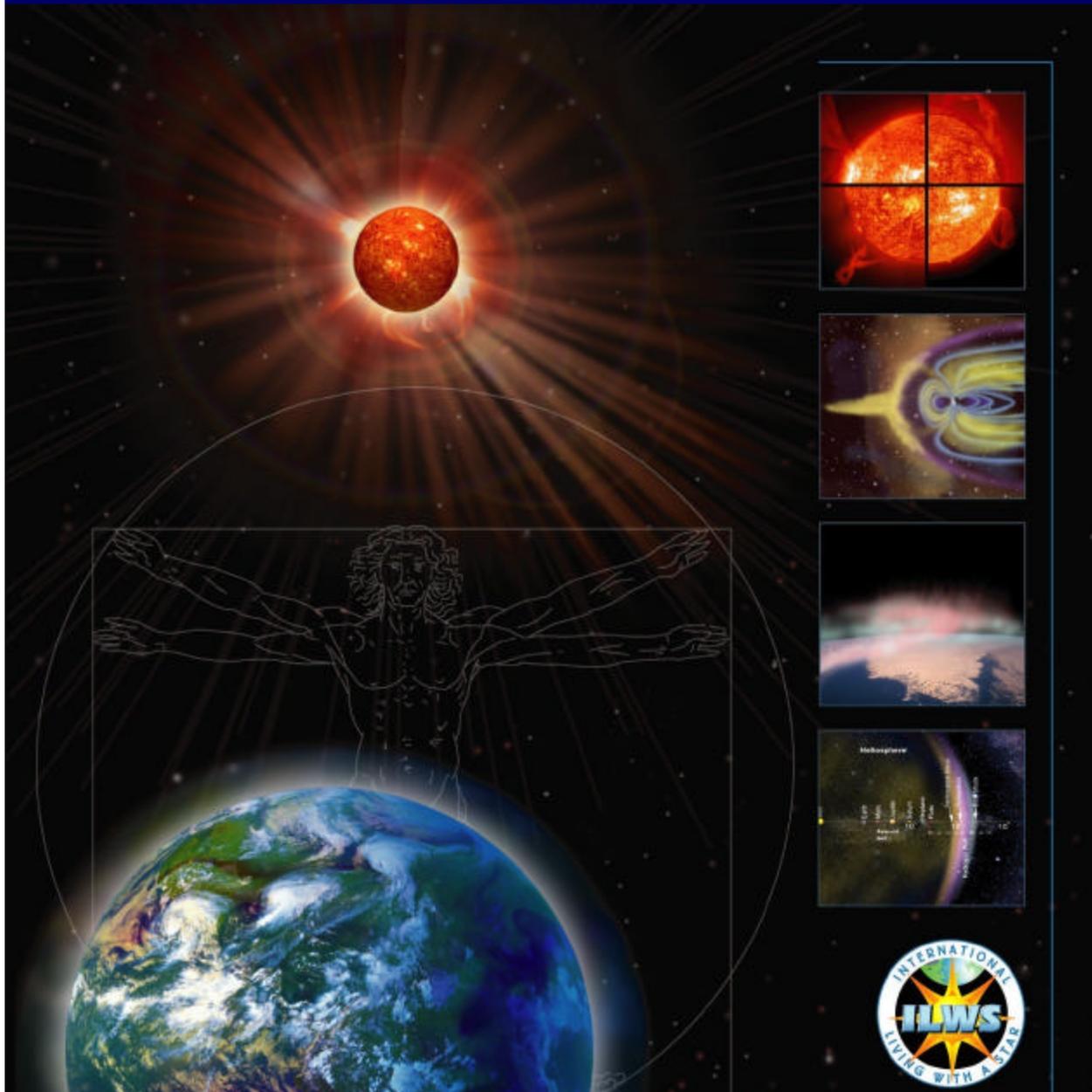


International Living With a Star



George Withbroe
Madhulika Guhathakurta
NASA Headquarters

INTERNATIONAL LIVING WITH A STAR (ILWS)

Brief History

- **Fall, 2000:** NASA proposes LWS program which is funded starting fall of 2001.
- **IACG establishes Task Group** to study prospects for developing an ILWS program.
- **May, 2001:** Task Group meets in Tenerife (in conjunction with ESA Solar Orbiter Workshop). Task Group includes:
 - Four IACG agencies (ESA, ISAS, NASA, RSA) & IACG secretary.
 - CSA, CRL (Communications Research Laboratory, Japan), & NOAA (U.S.).
- **Task Group concludes:**
 - ILWS program has substantial potential for stimulating and enabling a new international effort in solar-terrestrial research.
 - ILWS provides umbrella for forging necessary international coordination, cooperation, and bilateral and multilateral agency collaborations.
- **January 2002:** IACG accepts recommendation of Task Group to establish ILWS program.
- **September 2002:** First meeting of ILWS Working Group in Washington DC.

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Why Do Science?

For Utility

Yes

For

Yes

Pasteur

Understanding

The Sun-Earth Connection -- Science in the Pasteur Mode

- *How a star works*
- *How it affects humanity's home*
- *How to live with a star*

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The Sun-Earth Connected System

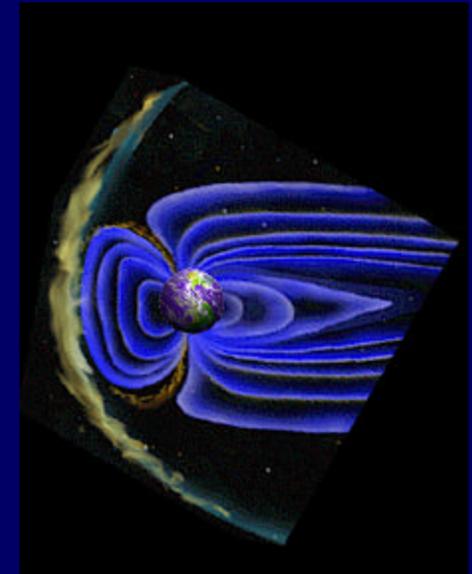
Variable Star



Varying

- Radiation
- Solar Wind
- Energetic Particles

Planet



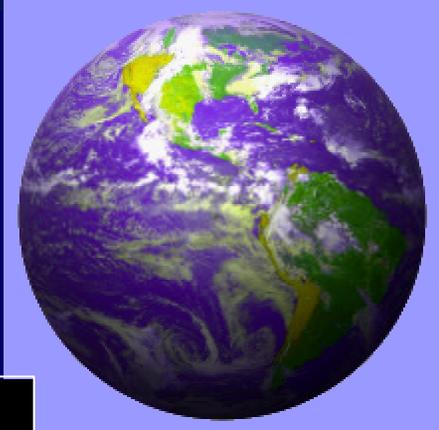
Questions:

- *How and why does the Sun vary?*
- *How does the Earth respond?*
- *What are the impacts on humanity?*



Why Do We Care?

- **Solar Variability Affects Human Technology, Humans in Space, and Terrestrial Climate.**
- **The Sphere of the Human Environment Continues to Expand Above and Beyond Our Planet.**
 - Increasing dependence on space-based systems
 - Permanent presence of humans in Earth orbit and beyond



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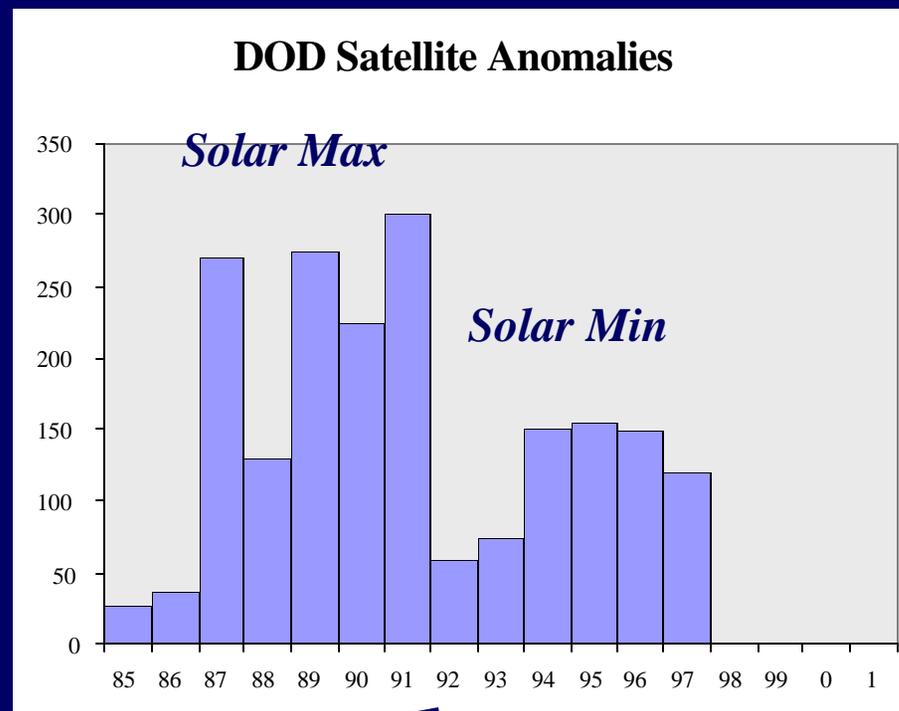
Solar Variability Can Affect Space Systems

How?

- Spacecraft charging.
- Solar cell damage.
- SEU's & damage to electronics.
- Atmospheric drag.

So What?

- Society's dependence on space assets is increasing.
- Space assets vital to world economy, communications, weather forecasts.
- *Prudence demands that we understand the space environment affecting space systems.*



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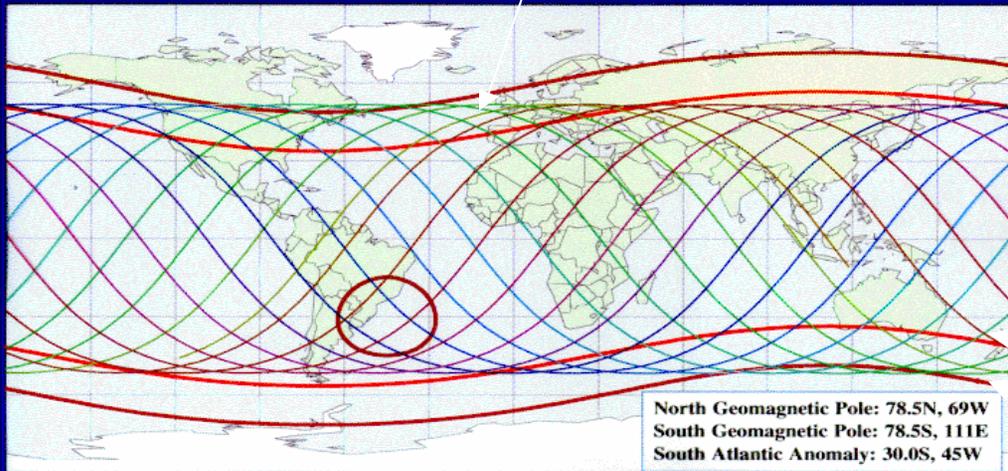


Solar Variability Can Affect Human Space Flight

- **Biological effects of energetic particle radiation are largely unknown.**
[Goal: To make radiation exposure *As Low As Reasonably Achievable.*]
- **Space Station:** "Solar energetic particle events have a significant impact on crew exposures and station operation related to crew safety."
- **Mars:** "The capability to predict solar particle events 8 hours in advance of their occurrence is thought to be an operational requirement for a safe interplanetary mission."



Space Station Orbit is Exposed to High Energy Solar Particles



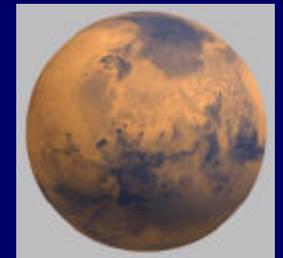
Exclusion Regions: 30.0, 45.0 For Geomagnetic Poles
15.0 For South Atlantic Anomaly

Chart courtesy Ron Turner, ANSER



Geomagnetic Storm

Quiet Conditions



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Solar Variability Can Affect Where We Live

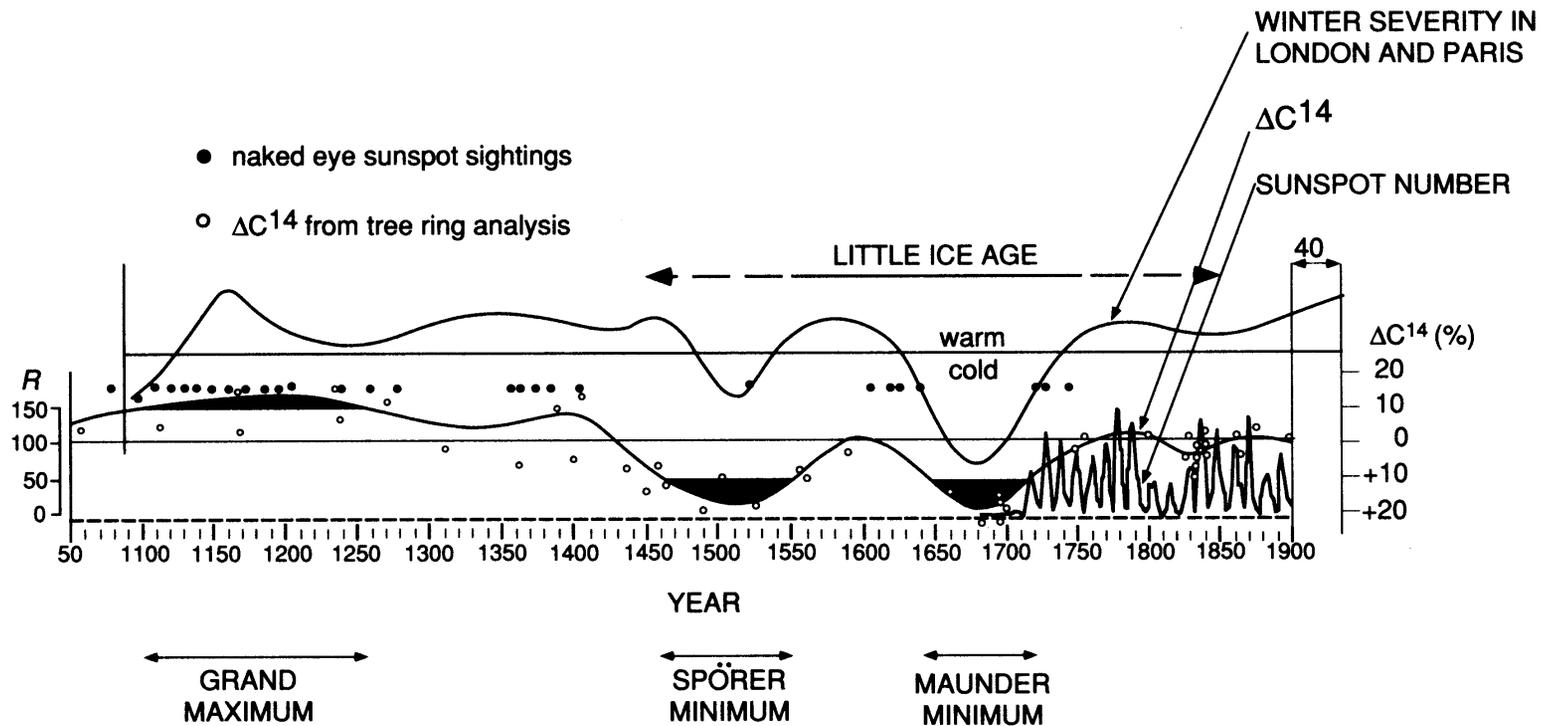
- Electric grid disruption and power transformer damage.
- GPS signals, high frequency (HF and VHF) radio communications, and long range radar.
- Microelectronics and humans in high altitude aircraft.
- Telecommunication cables.
- High precision electronic chip fabrication.



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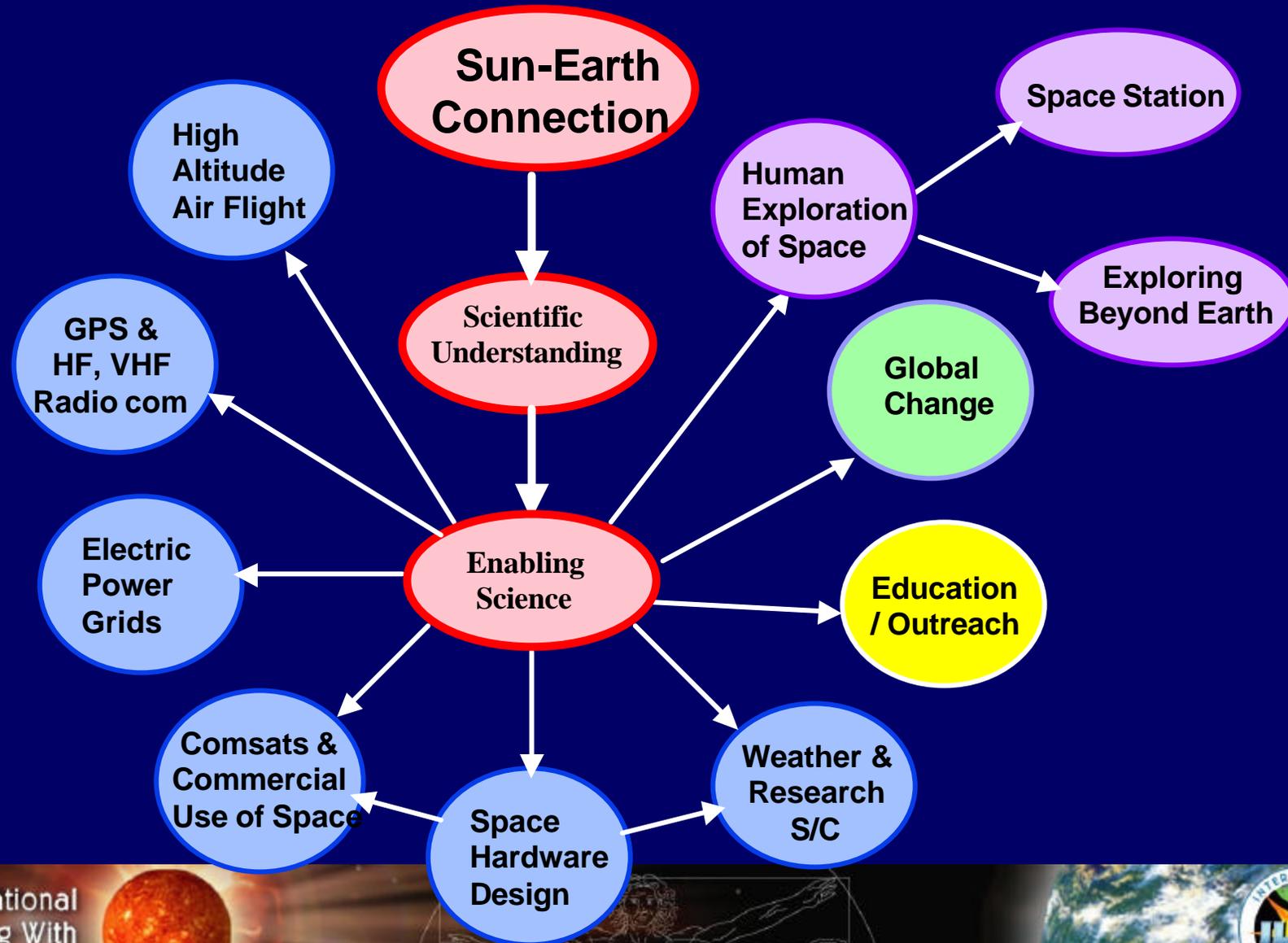
Solar Variability Can Affect Terrestrial Climate



Given the massive economic impact of small changes in climate, we should fully understand both natural and anthropogenic causes of global change.



Sun Earth Connections



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What can we do about it?

Apply a systems approach.

1. Quantify physics, dynamics, and behavior of Sun-Earth connected system through the range of conditions occurring in the 11 year solar cycle.
 - Obtain improved measurements.
 - Better understand Sun-Earth disturbances.
 - Understand the solar cycle.
For long-range space weather forecasting & assessing solar role in climate change.
 - Determine space environmental conditions vs location, time in solar cycle.
Needed for design of systems to minimize sensitivity to space weather.
2. Develop predictive models for the system that:
 - Demonstrate understanding of physics.
 - Have utility for prediction of space weather.
3. Minimize impact of space weather on technology and astronauts.
 - Develop improved space weather predictions and space environmental design specifications.
 - Fly low cost flight test beds for validation of rad-hard, rad-tolerant systems.

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INTERNATIONAL LIVING WITH A STAR (ILWS) GOAL

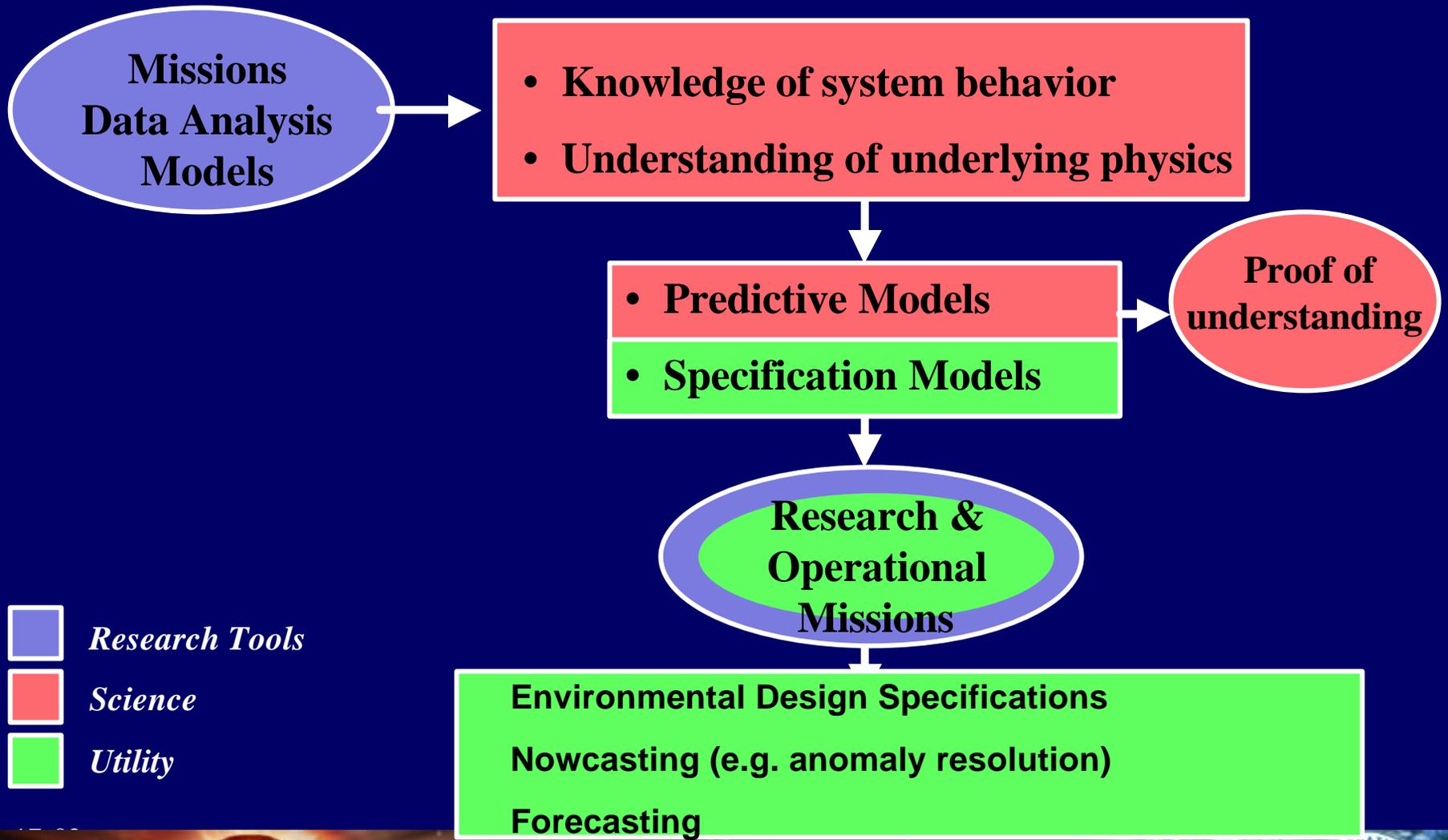


Stimulate, strengthen and coordinate space research to *understand* the governing processes of the *connected* Sun-Earth System as an integrated entity.

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The Result: Scientific Understanding and Utility

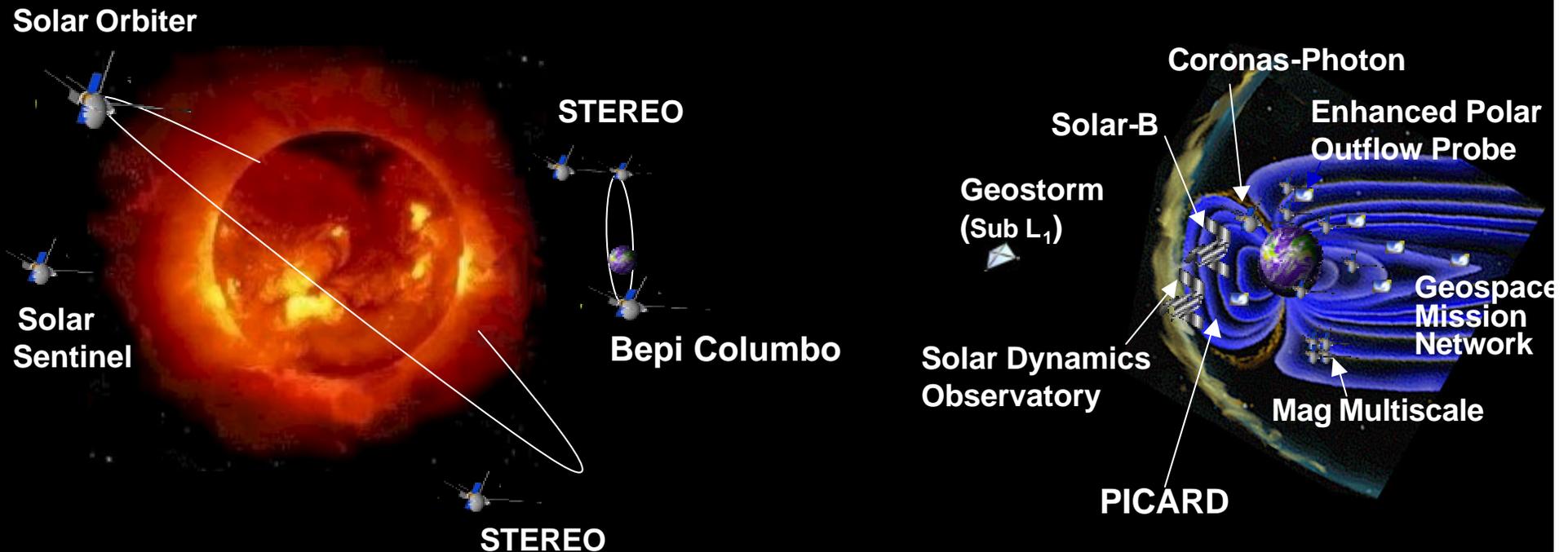


-  *Research Tools*
-  *Science*
-  *Utility*



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Some Candidate Missions



Distributed network of spacecraft providing observations of Sun-Earth system.

- ***Solar-Heliospheric Network*** observing Sun & tracking disturbances from Sun to Earth.
- ***Geospace Mission Network*** with constellations of smallsats in key regions of geospace.



What Will ILWS Accomplish?

- Delineate key processes involved in the generation and propagation of solar and geomagnetic disturbances.
- Characterize & quantify dynamics and evolution of solar interior, surface, corona that:
 - Generate solar disturbances (flares, CME's) and variable solar outputs that impact geospace environment and humans in space.
 - Drive the solar dynamo and solar activity cycle , the “solar magnetic engine”.
- Characterize and quantify dynamics of Earth's upper atmosphere and low earth orbit current systems, electric fields, and particle populations that:
 - Affect GPS and other radio/radar signals
 - Affect spacecraft operating in LEO, MEO, and GEO.
 - Determine access of solar energetic protons to Space Station orbit.
 - Induce currents in electric power grids.
- Characterize and quantify global dynamics that cause:
 - Enhanced radiation zones as a result of magnetospheric acceleration and solar wind shock propagation effects.
 - Satellites in LEO, MEO and GEO to repeatedly transit enhanced radiation zones.

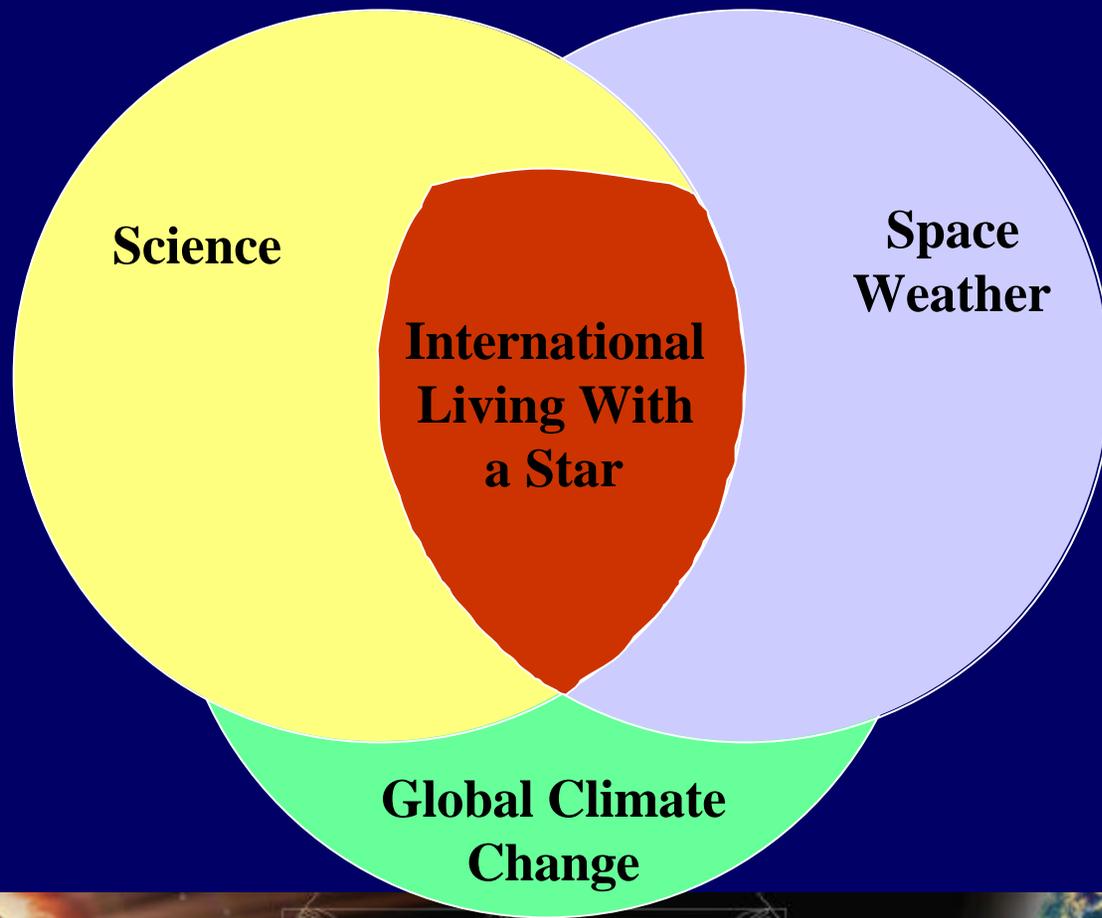


Some Gaps in Currently Planned Mission Fleet

- Insufficient spacecraft to sample simultaneously all critical regions & phenomena of complex, time-varying geospace environment
 - Imaging of upper terrestrial atmosphere, Earth's magnetosphere are severely limited in currently planned mission fleet.
 - Insufficient number, inadequate spatial distribution of spacecraft making *in situ* measurements.
- Solar wind to be sampled at only a few points; no replacement for ACE (launched in 1997) at L1 in an approved (funded) program.
- Inadequate measurement of solar high energy phenomena (e.g. flares and energetic particles) currently planned for next solar maximum.



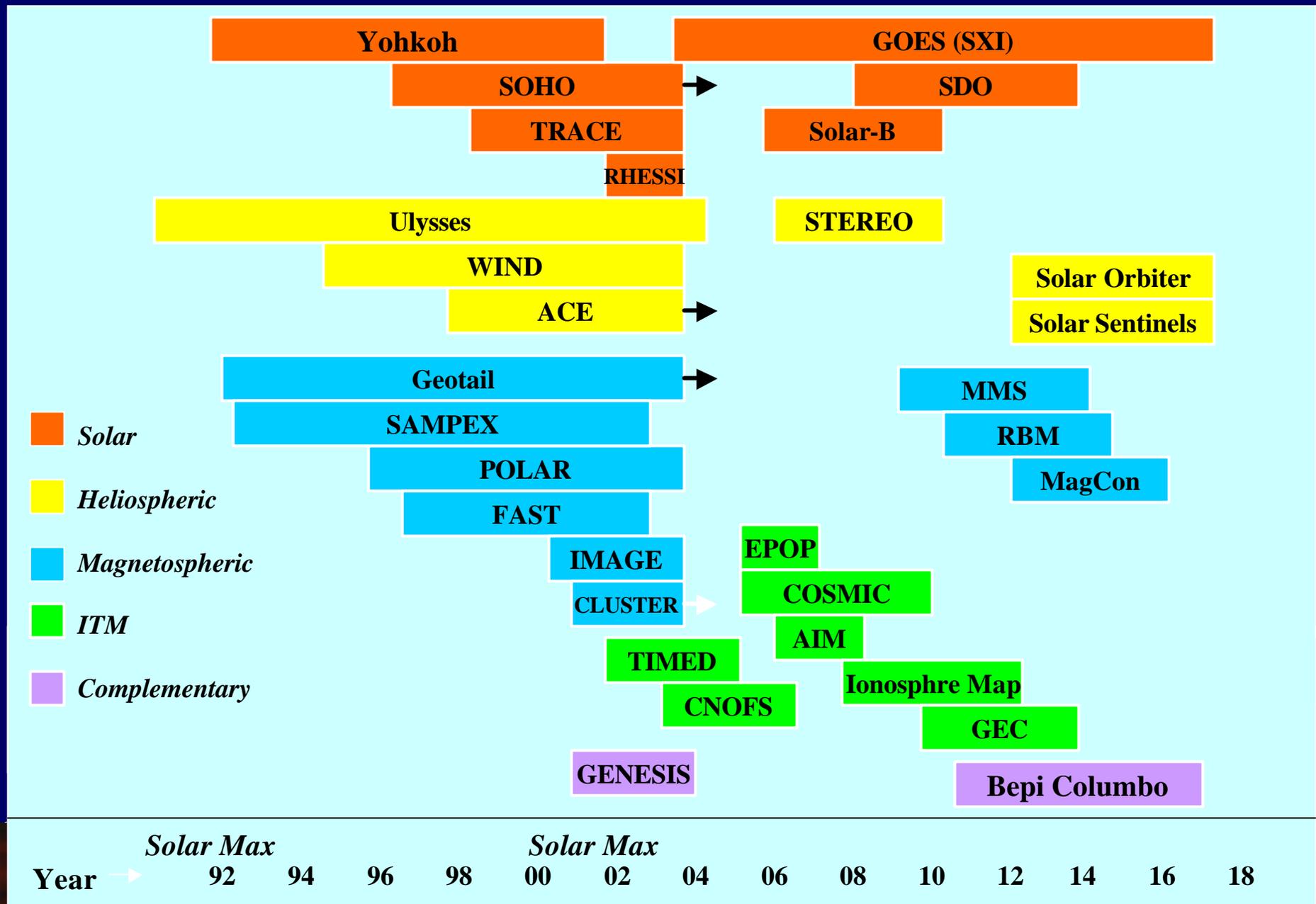
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Operating & Some Planned* New Solar -Terrestrial Missions



Initial Meeting of the International Living With A Star Group (ILWS-WG)



Inter-Agency
Consultative
Group

- Convened as per IACG
- First meeting held 4 - 6 September 2002, Washington D.C. (29 attendees -27 agencies invited)
- 4 IACG members
- 7 National Space Agencies
- R. Fisher (NASA SEC Director) Acting Chair

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Inter-Agency
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Group

Charter of the ILWS-WG I

ILWS-WG MISSION

- Stimulate, strengthen and coordinate space research to understand the governing processes of the connected Sun-Earth System as an integrated entity

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Inter-Agency
Consultative
Group

Charter of the ILWS-WG II

ILWS-WG Objectives

- To stimulate and facilitate:
 - Study of the Sun Earth connected system and the effects which influence life and society
 - Collaboration among potential partners in solar-terrestrial space missions
 - Synergistic coordination of international research in solar-terrestrial studies, including all relevant data sources as well as theory and modeling.
 - Effective and user driven access to all data, results and value-added products

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Inter-Agency
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Charter of the ILWS-WG III

ILWS-WG Membership

- Space organizations committed to contribute to ILWS over the next decade
- Contributions to include any of the following
 - Space Flight Missions
 - Mission payloads or subsystems
 - Mission launch or tracking services
 - Additional data sources supporting flight missions (sounding rockets, balloon, or ground-based)
 - Data dissemination, storage, distribution and value adding systems
 - Supporting theory and modeling

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Provisional Guidelines ILWSP Structure - I



Inter-Agency
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Group

- The ILWSP shall have a steering committee comprised of one member each from CSA, Russia, Japan, ESA and NASA
- The ILWS shall have a working group comprised of one member from contributing agencies
- Topical ILWS Task Groups will be established as necessary to support specific ILWS-WG projects/studies.
- The ILWSWG shall have a single executive secretary.
- Initial Chair: ESA

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Provisional Guidelines ILWS-WG Structure - II



Inter-Agency
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- Meetings of the ILWS-WG to be held once per year or more often as necessary
- Each meeting chaired by national representative of host country.
- Meetings scheduled by consensus of membership of ILWS-WG

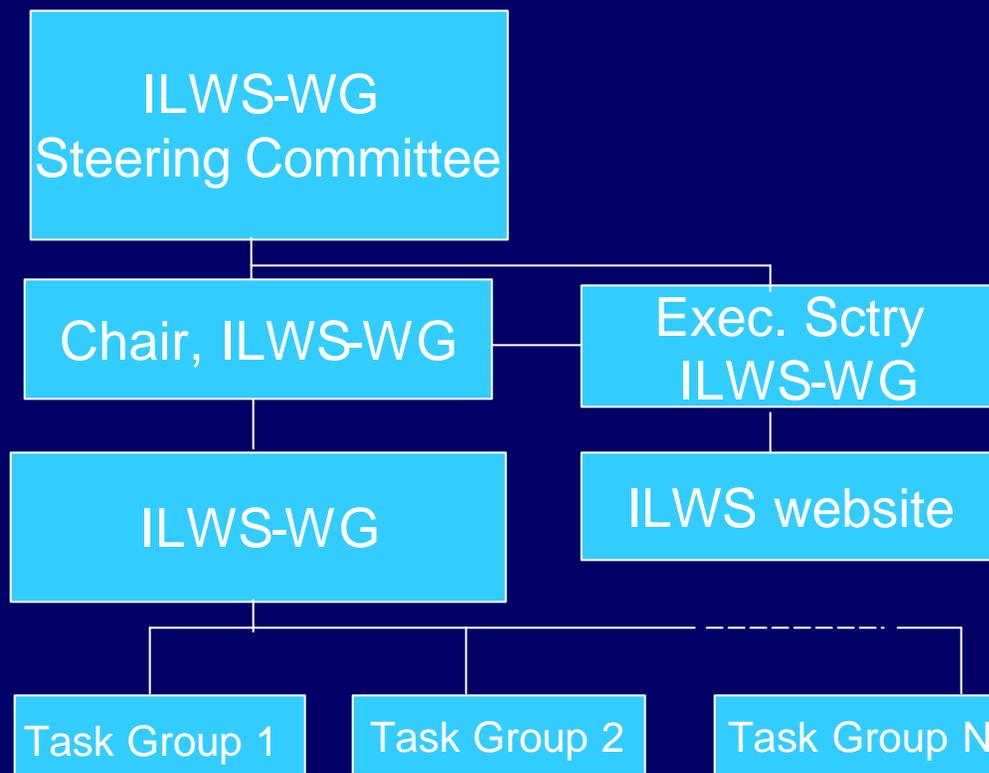
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Provisional Organization ILWS-WG



Inter-Agency
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Facilitation

System Concept
Coordination
Prioritization
Findings

Resources and
Opportunities
Data Systems

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ILWS Contacts

Chair, ILWS Steering Committee:

Herman Opgenoorth, ESA

E-mail: opg@irfu.se

Chair, ILWS Working Group:

Designated by agency hosting meeting.

Acting ILWS Executive Secretary:

Madhulika (Lika) Guhathakurta, NASA

E-mail: mguhatha@hq.nasa.gov

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Backup Viewgraphs

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