Living With a Star Architecture Committee

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LWS Objectives

- Understand how the Sun varies and what drives solar variability
- Understand how the Earth and planetary systems respond to dynamic external and internal drivers
- Understand how and in what ways dynamic space environments affect human and robotic exploration activities

HQ is re-evaluating the LWS mission line

Current missions

- Solar Dynamics Observatory
- Space Environment Testbed
- Parker Solar Probe
- Solar Orbiter Collaboration

Upcoming missions

- Heliophysics Environmental & Radiation Measurement Experiment Suite (HERMES)
- Geospace Dynamics Coupling (GDC)

LWS Architecture Committee

- HPD formed a 10-member committee to:
  - assess the current state of the mission aspect of the LWS program
  - propose a future LWS program mission architecture
  - not reviewing the TR&T program
- Scheduled time with JHUAPL and GSFC to perform a few mission concept studies

Strategic Science Areas (SSAs)

I. Origins and Variability of Global Solar Processes
II. Solar Eruptive and Transient Heliospheric Phenomena
III. Acceleration and Transport of Energetic Particles in the Heliosphere
IV. Variability of the Geomagnetic Environment
V. Dynamics of the Global Ionosphere and Plasmasphere
VI. Ionospheric Irregularities
VII. Composition and Energetics of the Neutral Upper Atmosphere
VIII. Radiation and Particle Environment from Near Earth to Deep Space
IX. Solar Impacts on Climate
X. Stellar Impacts on Planetary Habitability

- https://lwstrt.gsfc.nasa.gov/strategic-science-areas-ssas

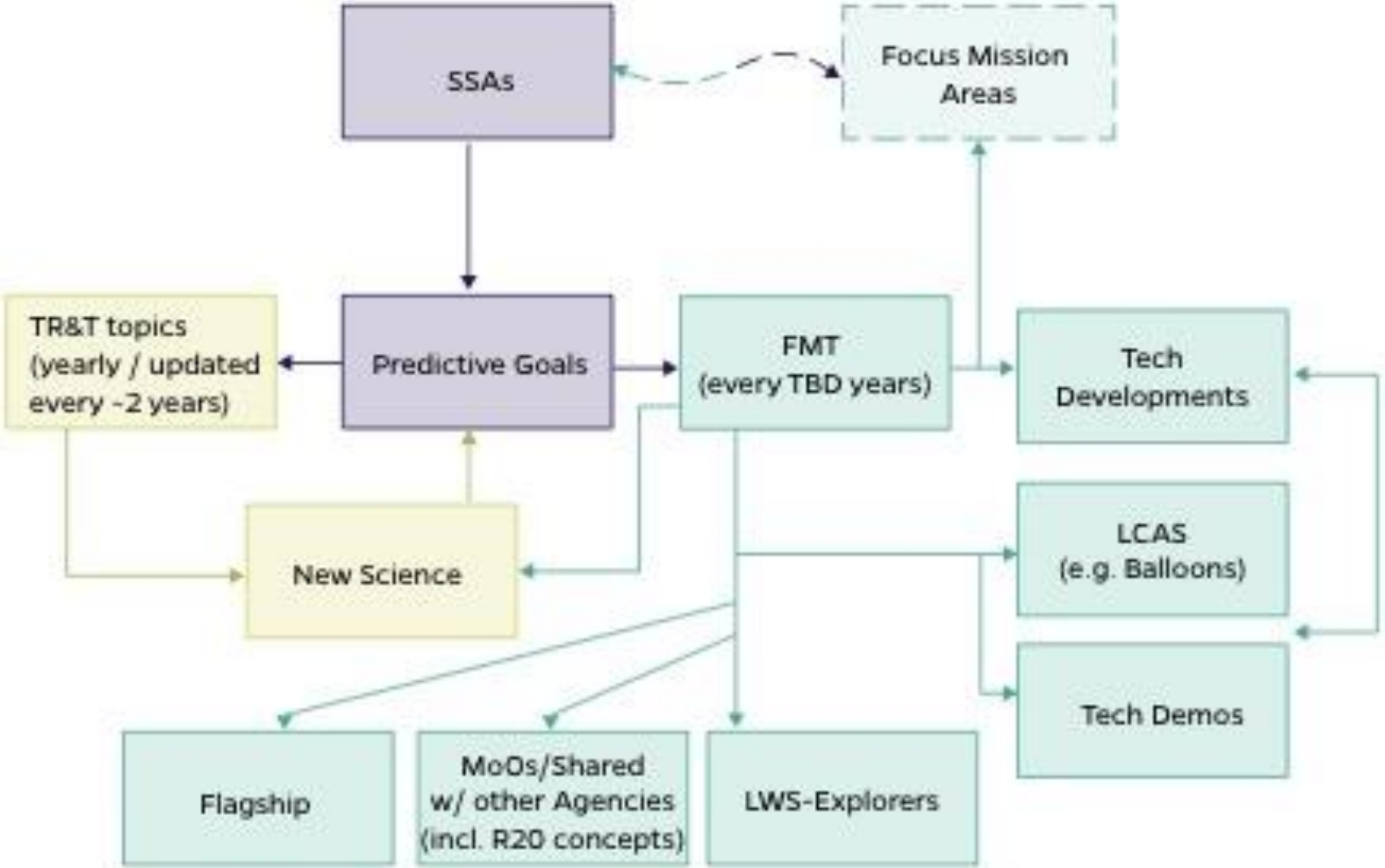
Focused Mission Topics (FMTs)

Process

- Examine the SSAs and formulate related Science Objectives
- Identify the Phenomena to be examined
- Determine the Physical Quantities to be measured
- Suggest Sample Implementations
- Identify needed Technological/Modeling Development

FMTs

- Combined set of science objectives *(LWS, not STP!)*
- Implementation strategies


SSAs
Focus Mission Areas
TR&T topics (yearly / updated every ~2 years)
Predictive Goals
FMT (every TBD years)
Tech Developments
New Science
LCAS (e.g. Balloons)
Tech Demos
Flagship
MoOs/Shared w/ other Agencies (incl. R20 concepts)
LWS-Explorers

Activities

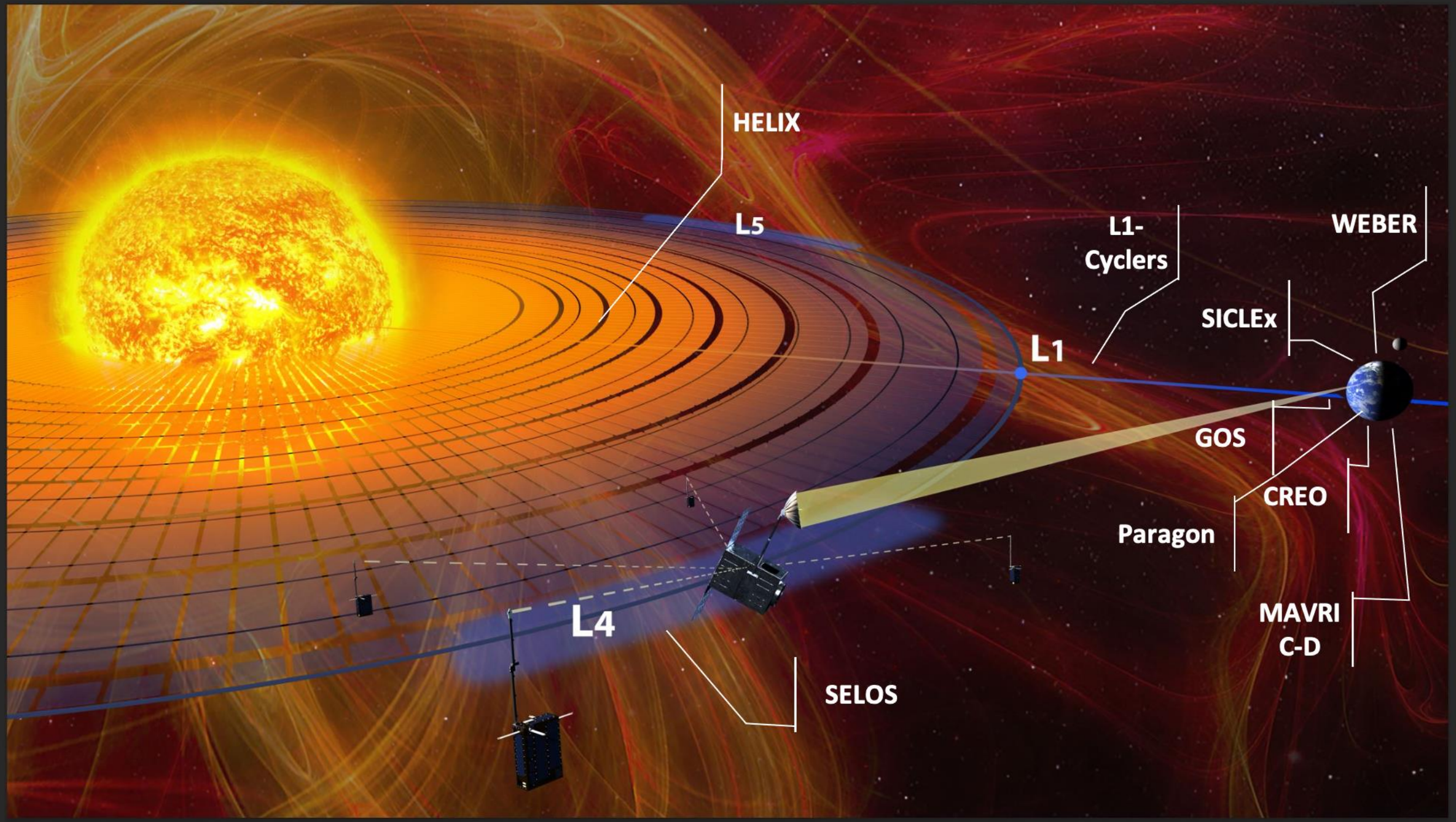
Community input

- Aug-Sep 2021, web form on SSA-related Science Objectives
  - Measurement strategy, physical parameters, required measurements, envisioned implementation
- LWS Townhall, Jan 2022
  - Update
  - Feedback at event and via email

Formulated 12 FMTs

- NASA/GSFC MDL has studied 4
- APL ACE has studied 2 and orbits for 1
- 2 based on HMCS studies
- 3 described as best we could
- Not prioritized, but identified synergies between FMTs and existing/future missions

FMT	Study Name	Generic Name	Center	Primary Target
1	SELOS	Sun Earth Observing System	MDL	Solar-Heliospheric
2	HELIX	Inner Heliospheric Constellation	ACE Lab	Solar-Heliospheric
3	4pi	3D Sun & Heliosphere	HMCS-based	Solar-Heliospheric
4	GOS	Plasma Irregularity	MDL	Geospace
5	MagCon	Multipoint magnetosphere	HMCS-based	Geospace
6	WEBER	Magnetospheric imaging	MDL	Geospace
7	MAVRIC-D	Thermospheric density and composition	MDL	Geospace
8	Plasmasphere	Plasmasphere	---	Geospace
9	CREO	Inner magnetosphere & Radiation Belts	ACE Lab	Geospace
10	SICLEx	Space Climate	---	Solar-Geospace-Earth
11	Earth-as-Exo	Earth-as-ExoPlanet	---	Geospace-Astrophysics
12	PeriGeospace Cyclers	PeriGeospace Observing System	ACE-orbit	Solar-Heliospheric-Geospace


HELIX
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Cyclers
WEBER
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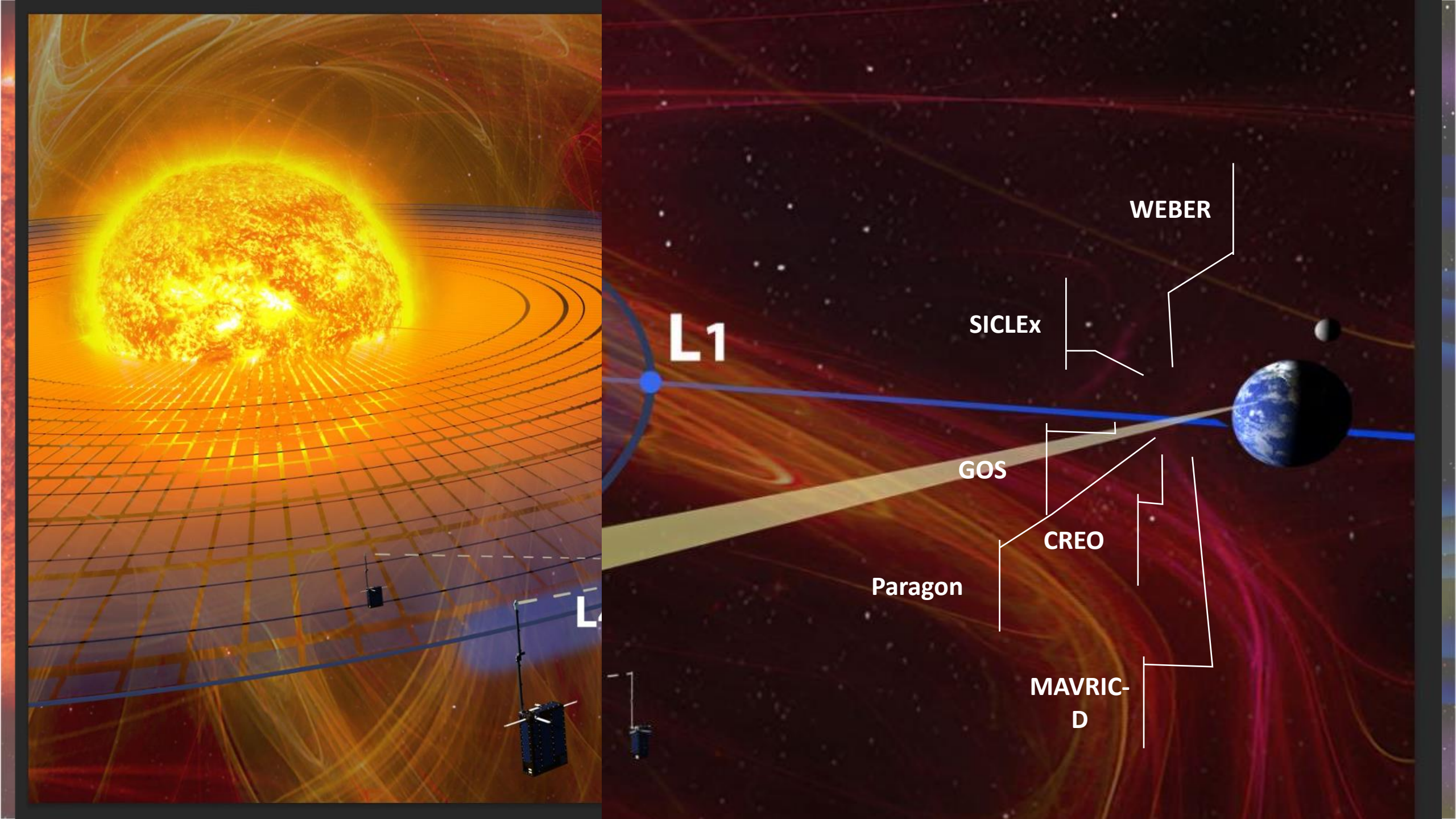
L1
GOS
CREO
Paragon
MAVRI
C-D
L4
SELOS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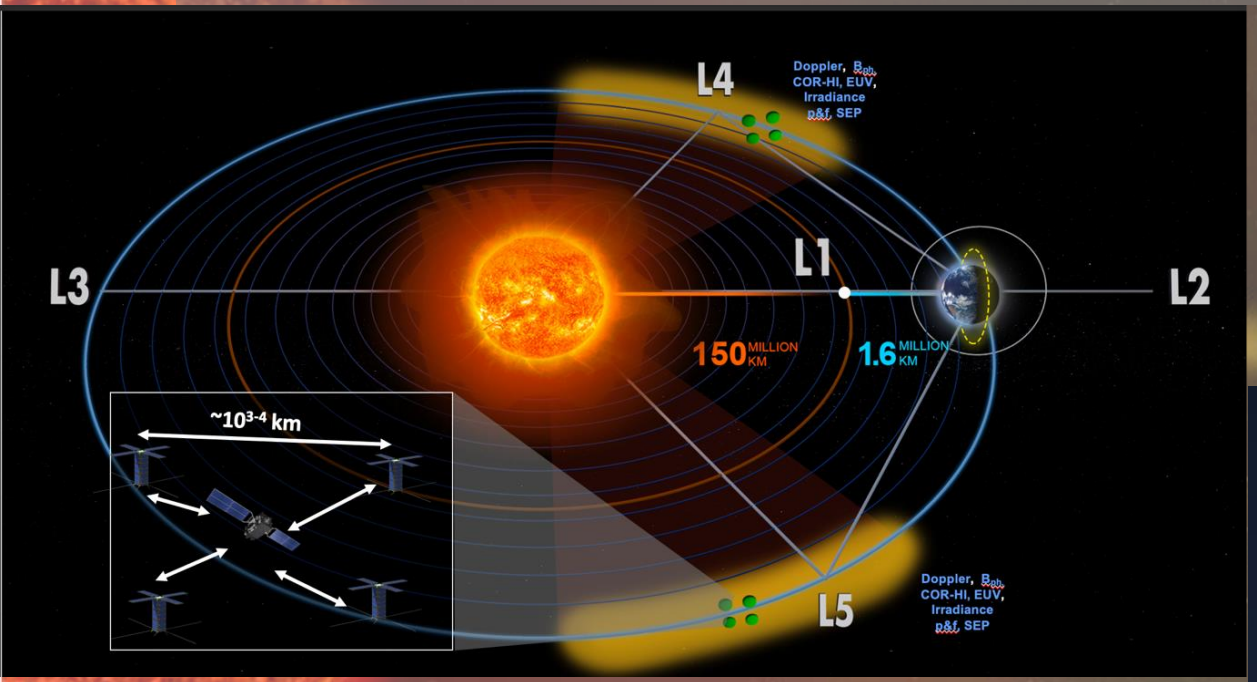
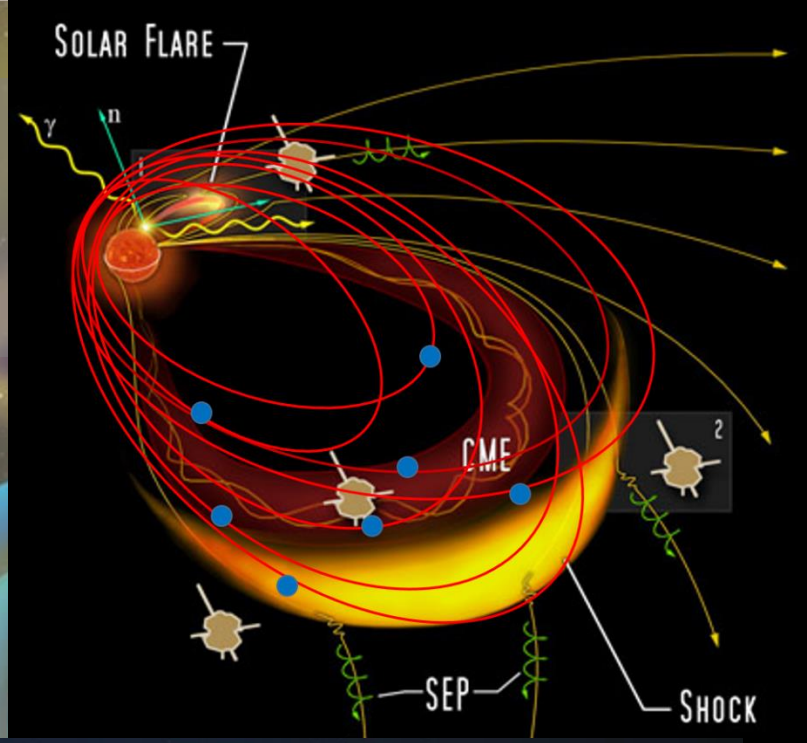
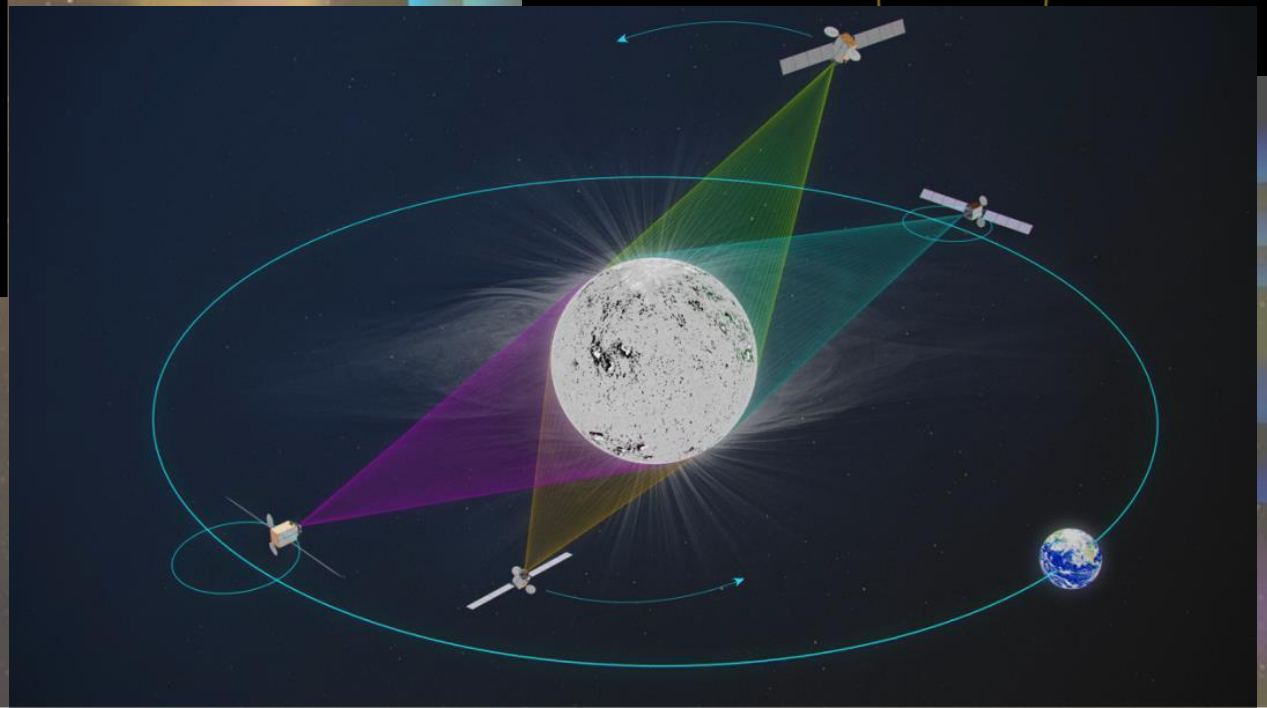
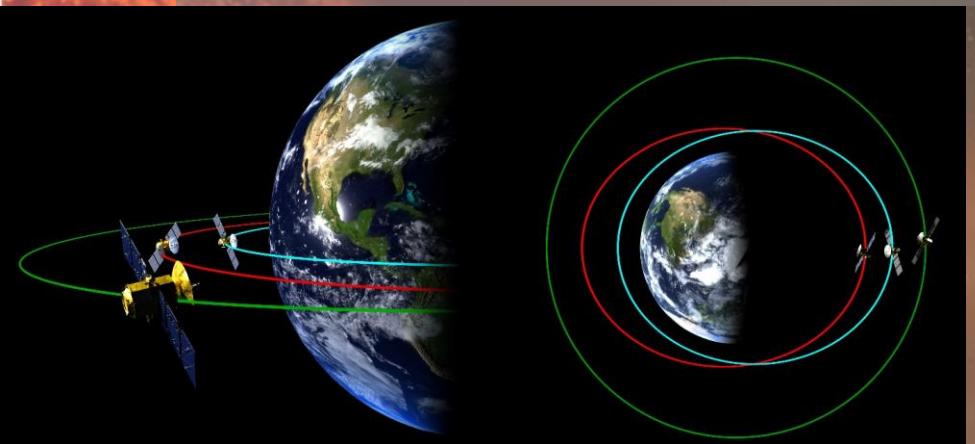
Solar-Heliospheric FMTs

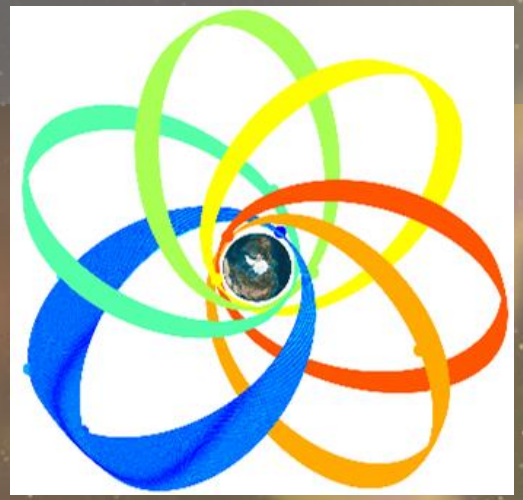


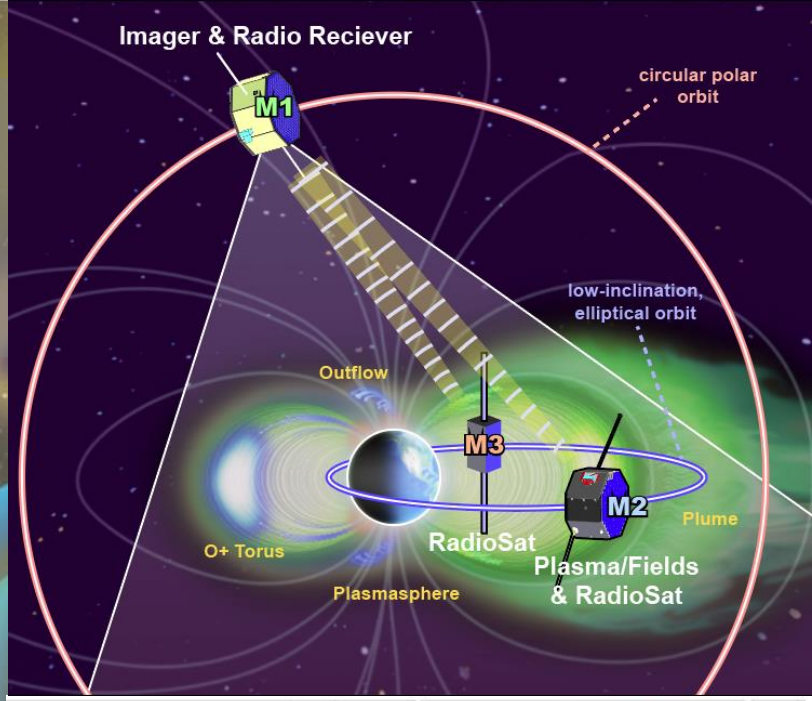




Geospace FMTs







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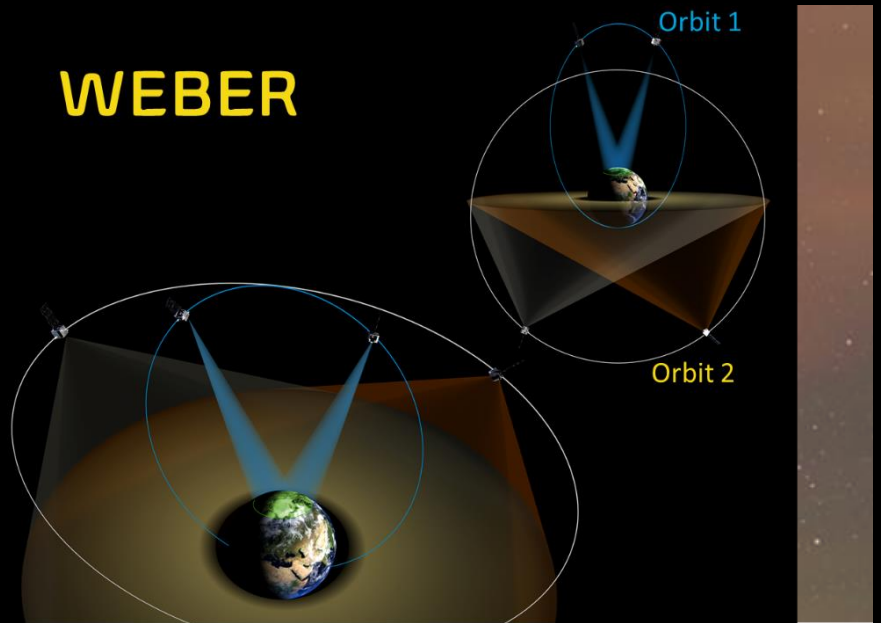
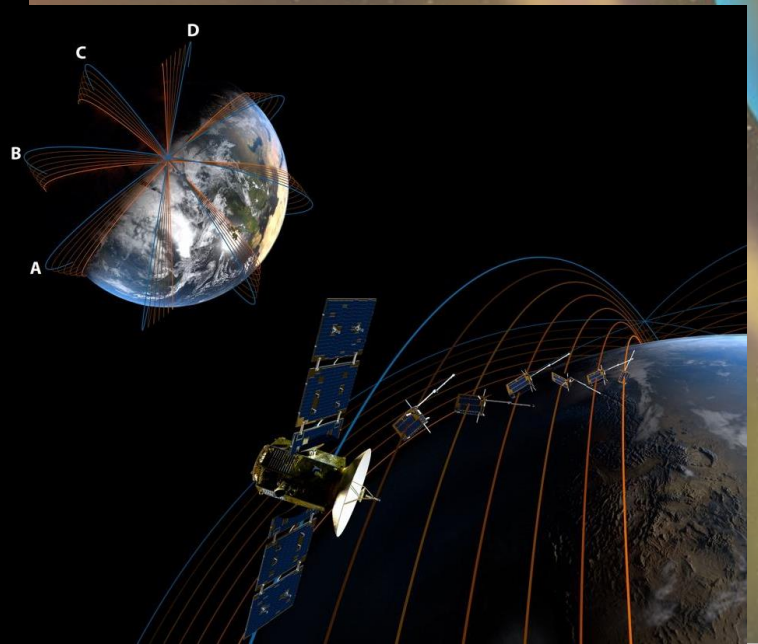
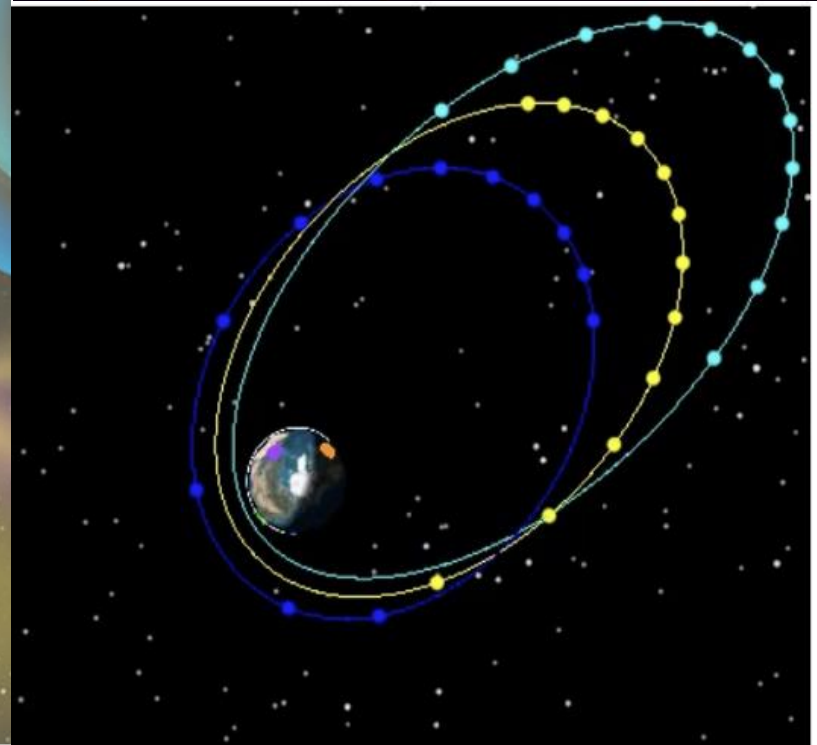
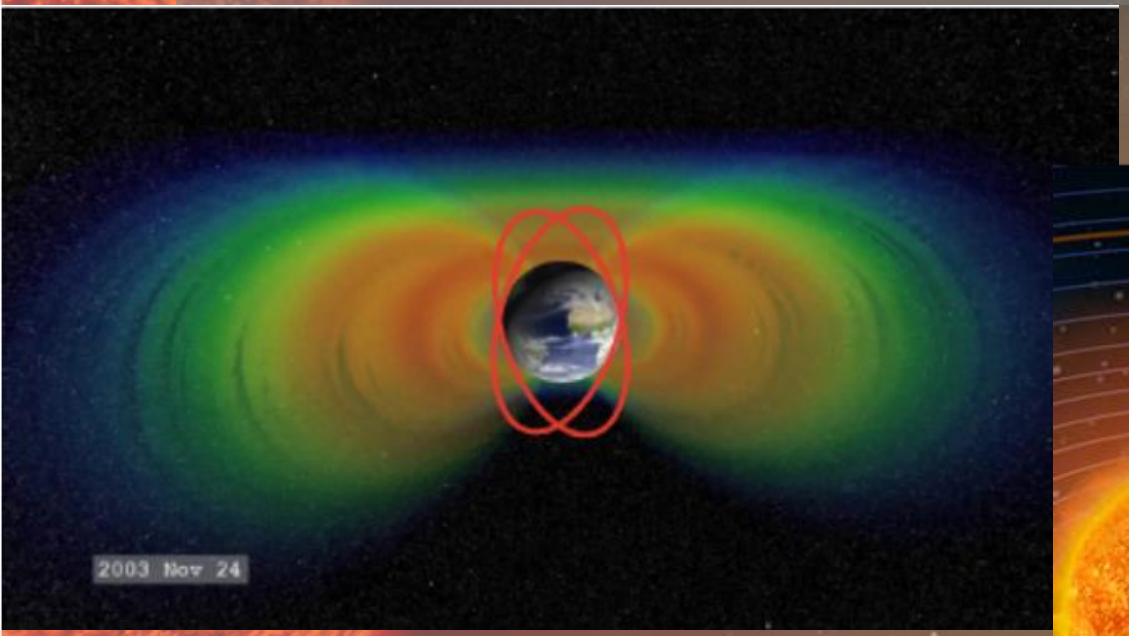
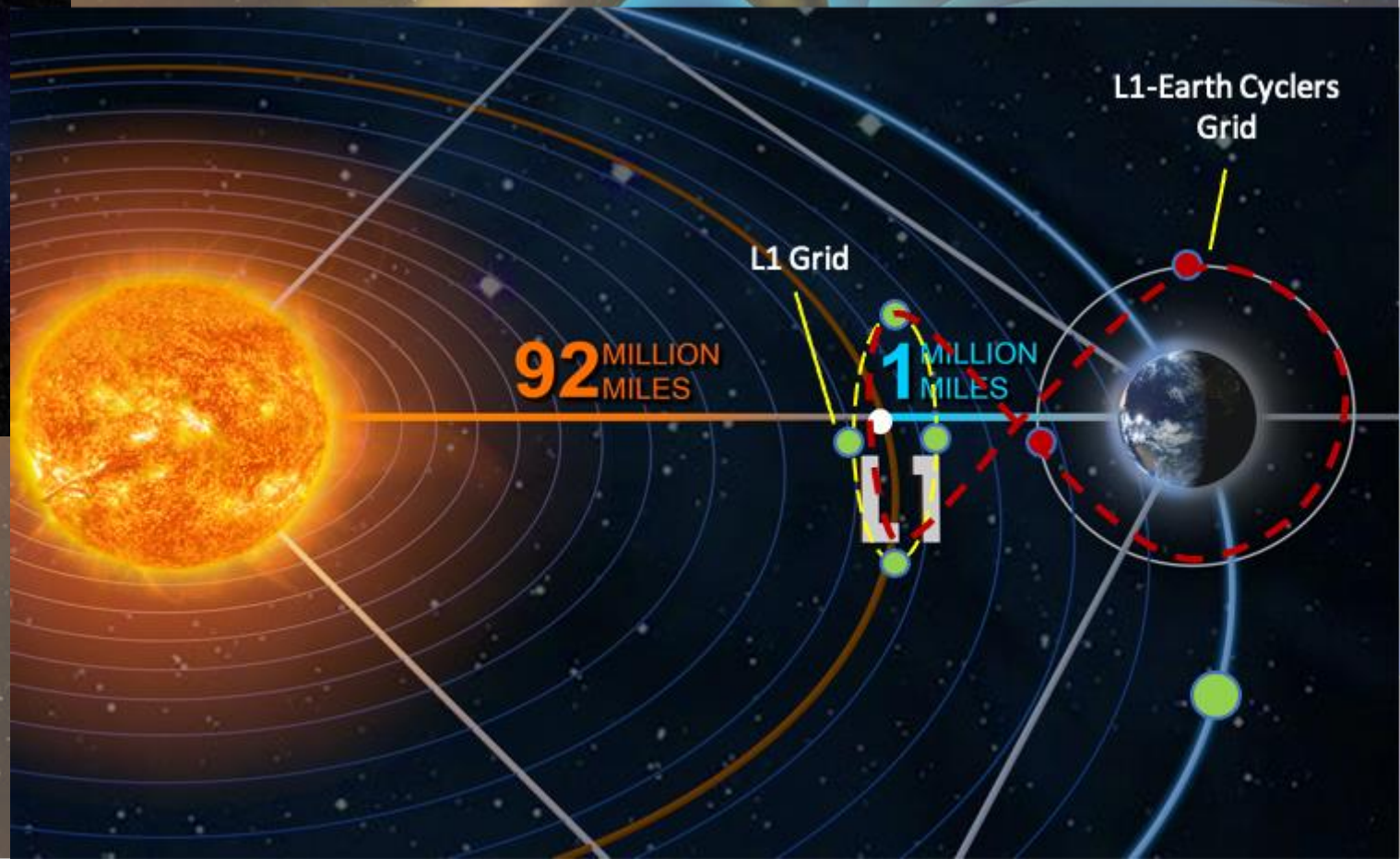






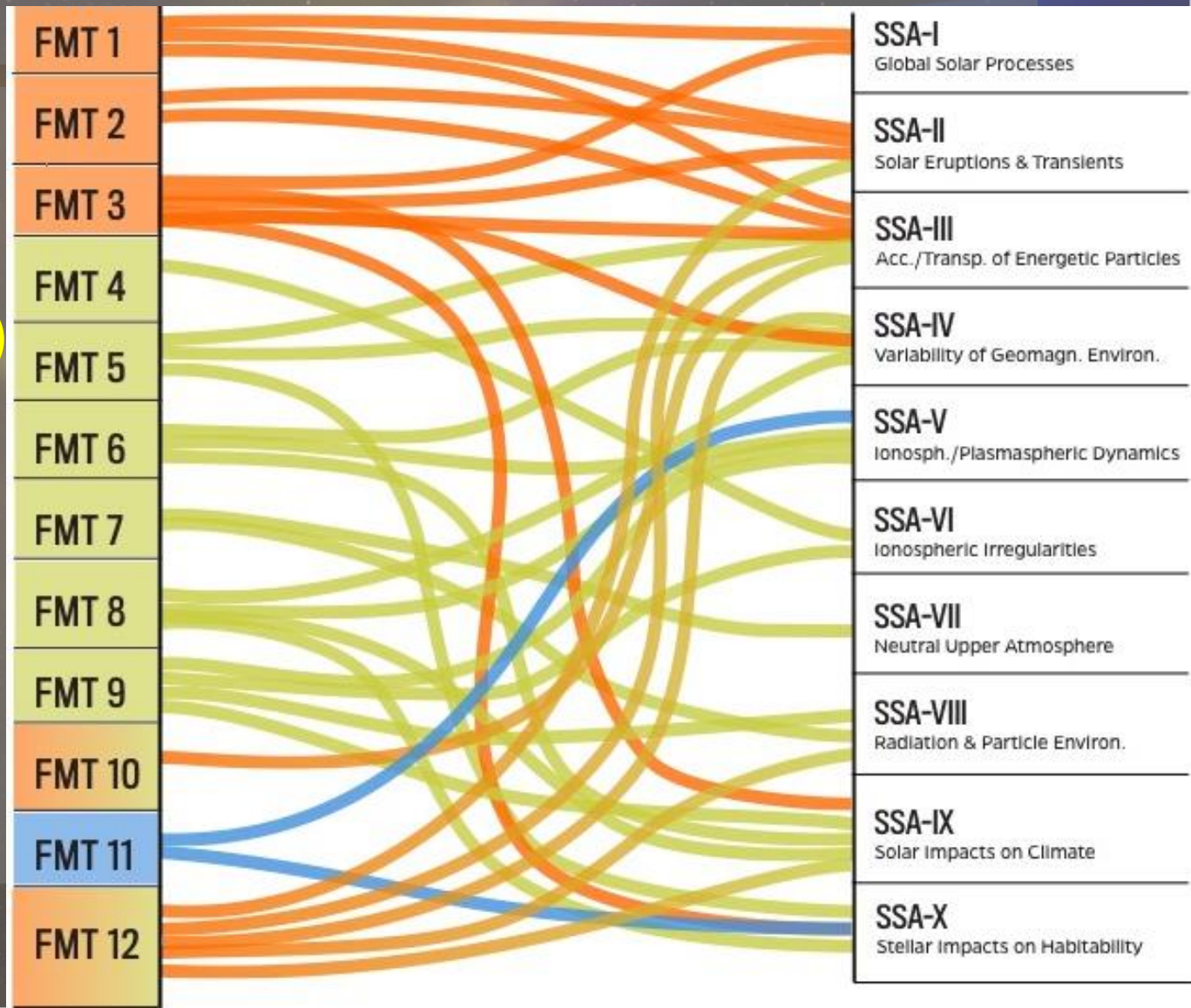
Combination FMTs





Mapping FMTs to SSAs

- Every FMT connects to at least one SSA
  - Typically there are multitude of connections (primary/secondary)
- Every science objective of SSA has an FMT addressing it



Mapping FMTs to S

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SSA	Science Objective	FMT
SSA-I Origins and Variability of Global Solar Processes	Determine the characteristics of convective flows and meridional circulation at all latitudes and depths down to the tachocline, the location and strength of the toroidal magnetic flux belts, and characterize the strength, structure, and evolution of the polar fields to enable predictive models of solar cycle magnitudes and phases	**FMT-3**
	Determine the signatures of imminent active region emergence in surface and sub-surface flow and magnetic field structures. Understand the origin of active region formation in terms of sub-surface flows as a function of depth. Determine the global coronal connectivity of active regions and the mechanisms that lead to their eventual decay.	**FMT-1** **FMT-3**
	Determine how chromospheric and coronal magnetic field dynamics and energy inputs from the convection zone/photosphere create solar wind variations on global scales to create "fast" and "slow" solar wind. Understand the mechanisms leading to solar wind stream interactions in the heliosphere, both within and out of the ecliptic plane.	**FMT-1** FMT-2 **FMT-3**
	Understand global solar spectral and total irradiance variation as a function of magnetic field activity at a level sufficient to enable predictive models of planetary atmospheric responses to active region evolution. Enable the transition from empirical characterizations via indices (e.g., F10.7) to measured solar spectral irradiance inputs driving advanced physics-based models of planetary atmospheres.	**FMT-1**
SSA-II Solar Eruptive and Transient Heliospheric Phenomena	Understand what triggers flares	**FMT-1** **FMT-3**
	Determine what is the impact of flares on Earth's atmosphere	**FMT-4** FMT-7
	Determine what conditions lead to CME initiation and what is the process of CME release from the Sun	**FMT-1** **FMT-2** **FMT-3**
	Determine the propagation and evolution of ICMEs in interplanetary space	FMT-1 **FMT-2** **FMT-3** FMT-12
	Determine the formation and evolution of stream interfaces (CIRs, SIRs, HCS) and meso-scale structures.	FMT-1 **FMT-2** FMT-3
SSA-III Acceleration and Transport of Energetic Particles in the Heliosphere	What properties of shocks, and at what scales, controls the SEP variations in composition, spectra and time profiles?	FMT-1 **FMT-2** FMT-3 FMT-12
	What properties of the background medium, and at what scales, affect the shock acceleration process? (this would reflect on CIR/SIRs, ESPs and SEPs)	FMT-1 **FMT-2** FMT-3
	What is the role of suprathermal ions, over what energy range, in SEP acceleration?	**FMT-2**
	What is the source(s), distribution, and properties (e.g., composition, spectrum) of suprathermal ions and how does it vary?	**FMT-2**
	How are particles transported in 3D space, over what spatial and temporal scales?	FMT-1 **FMT-2** FMT-3 FMT-5 FMT-6 FMT-7 FMT-10 FMT-12
	What properties (including transient structures) of the background medium affect/control the particle transport?	FMT-1 **FMT-2** FMT-3
SSA-IV Variability of the Geomagnetic Environment	How does the solar wind drive the state of the magnetosphere globally and in mesoscale (few Re spatial scale)? How do the magnetosphere and the solar wind together determine the dynamics of the ionosphere that drive the GIC?	FMT-2 FMT-4 **FMT-5** **FMT-6** FMT-7 **FMT-8** FMT-9 FMT-10 **FMT-12**
	How is energy stored in the magnetosphere during storms and substorms released to the high latitude upper atmosphere? What are the MI coupling processes that drive the strength, location and dynamics of the generated auroral currents? Which ionospheric dynamic processes give rise to the geoelectric fields that drive the GIC?	**FMT-4** **FMT-5** **FMT-6** **FMT-7** **FMT-8**
	What is the solar wind and/or magnetospheric information needed to develop (physics based or machine learning) models to predict the GIC occurrence in space and time? What are the factors that contribute to the spatial location / distribution of the peak GIC?	FMT-2 **FMT-5** FMT-6 FMT-8
	Which solar wind, magnetospheric or ionospheric processes and conditions cause extreme GIC events? Is there a correlation between the magnitude of the ground disturbance (deltaB or AL) and the peak GIC (dB/dt)?	FMT-2 FMT-4 **FMT-5** FMT-6 FMT-7 **FMT-8** FMT-12
SSA-V Dynamics of the Global Ionosphere and Plasmasphere	Understand the fundamental processes that govern the flow of mass and energy of cold plasma (hidden population in the magnetosphere) between ionosphere and magnetosphere?	**FMT-6** FMT-7 **FMT-8** FMT-9 FMT-10
	How can ionospheric variablity be characterized? What are the different sizes of the temporal and spatial scales of the variabilities depending on latitudes and altitudes? How does different scales couple with each other?	**FMT-6** FMT-7 **FMT-8** FMT-10
SSA-VI Ionospheric Irregularitie	Determine the complete set of plasma instabilities for generating or supressing ionospheric irregulaties	**FMT-4** FMT-7 FMT-9
	Determine the interaction between radio waves and ionospheric irregulaties for scintillation and absorption	**FMT-4**
SSA-VII Composition and Energetics of the Upper Neutral Atmosphere	Understand and quantify the thermospheric response (variations in density, composition and temperature) to the energy input from the mangetosphere, variation in solar radiation, radiative cooling and impact from lower atmosphere	FMT-1 **FMT-4** **FMT-7** FMT-8 FMT-10
SSA-VIII Radiation and Particle Environment from Near Earth to Deep Space	Understand the physical processes that cause the spatio-temporal variability of GCRs	**FMT-2** **FMT-5** FMT-6 FMT-7 FMT-8 **FMT-9** FMT-10 FMT-12
SSA-IX Solar Impacts on Climate	How does the Earth's whole neutral atmosphere respond to solar irradiance variations over the solar cycle through dynamical and/or chemical processes? How does the solar variability impact energetics of the atmosphere (including CO2)? What are their temporal and spatial scales of those mechanisms? How can we separate out the solar impact from other possible sources of climate change(e.g., ice melting)?	FMT-1 FMT-4 FMT-7 **FMT-10**
	How are the lower and middle atmosphere coupled through dynamics? How does the dynamical coupling depend on the solar variability? How does galactic cosmic ray modulation by the solar magnetic cycle influence lower atmospheric dynamics (e.g. cloud formation) and/or chemistry?	FMT-4 FMT-6 **FMT-10** FMT-12
	How does the lower and middle atmosphere respond to solar irradiance variability in hours to years' timescales?	FMT-1 FMT-4 FMT-6 **FMT-10**
	How does NO evolve during storms? What are the time scales and solar cycle dependence?	FMT-7 **FMT-10**
	What are the mechanism by which energetic particle precipitation lead to impacting the ozone layer? How do Solar Proton Events (SPE) impact middle atmosphere chemistry that lead to impacting the ozone layer? What are their spatial and temporal scales?	**FMT-10**
SSA-X Stellar Impacts on Planetary Hability	Assess planet hability based on solar activity and planetary characteristics	FMT-4 FMT-6 **FMT-11** FMT-12

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	Determine the interaction between radio waves and ionospheric	FMT-4
	{variations in input from the cooling and	FMT-1 FMT-4 FMT-7 FMT-8 FMT-10
	tio-temporal	FMT-2 FMT-5 FMT-6 FMT-7 FMT-8 FMT-9 FMT-10 FMT-12
	ond to solar amical and/or pact energetics of poral and spatial it the solar impact e melting}?	FMT-1 FMT-4 FMT-7 FMT-10
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	Determine how chromospheric and coronal magnetic field dynamics and energy inputs from the convection zone/photosphere create solar	FMT-1

Additional Comments

- Many of the FMTs have ‘augmentations’ to allow more science coverage
- To realize maximum science return
  - Need support for data analysis and modeling
- Did not address ground-based assets
- Technology developments identified
  - Constellations, Data downlink, Onboard processing, Smallsat/Cubesat capabilities
- Not full concept studies (trade study level)

Report Status

- Draft being assembled this week (and last)
- Revision by committee next week (May 9-13)
- Review by external committee (May 14-25)
- Final revision by committee (May 26-31)
- Submission to NASA (May 31)