SSWARMS: SOLAR STORM WARNING AND RADIATION MONITORING SYSTEM

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OUTLINE

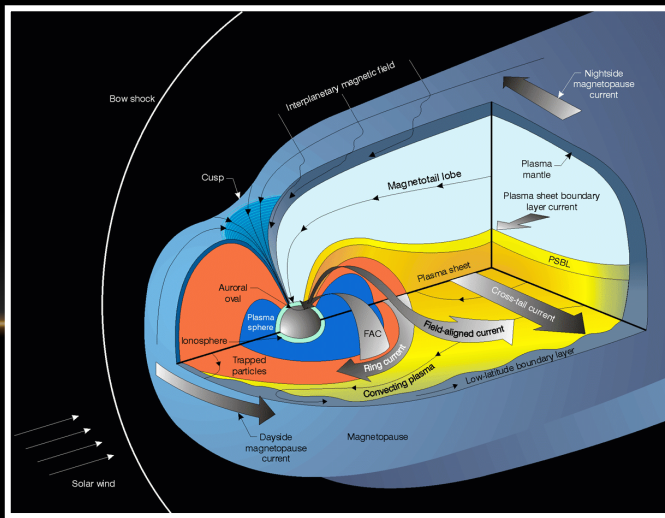
- Rationale
- Space Weather Impact on Earth
- Solar Storm Warning and Monitoring System – SSWARMS
  - Goals
  - Platform
  - Deployment
- Feasibility
- Team Members and Affiliations

RATIONALE

- To enable inter-planetary human exploration
- Master the persistent and grave danger of radiation
  - Solar Energetic Particles (SEP)
  - Galactic Cosmic Ray (GCR)
- Multi-point measurements will help constrain upstream (i.e., toward the sun) solar wind magnetic field and particle empirical models .
  - ENLIL—NASA Goddard
- SEPs stream along these field lines and pose a serious threat to humans traversing interplanetary space.
  - These are intense, directional, and potentially very hazardous.
- GCRs are modulated by the solar magnetic field, but only by a few percent.

EARTH'S SPACE WEATHER IMPACT

- Strong x-ray production from solar flares
  - Degrade or block radio communications
  - Pose a grave danger for astronauts traveling beyond Earth's orbit
- Coronal mass ejections (CME) cause geomagnetic storms
  - Degrade power grid operations
  - Degrade oil and water pipelines
  - Modify radio navigation signals; reducing accuracy
- Radiation poisoning caused by solar energetic particles (SEP)
  - Inability for humans to perform interplanetary travel

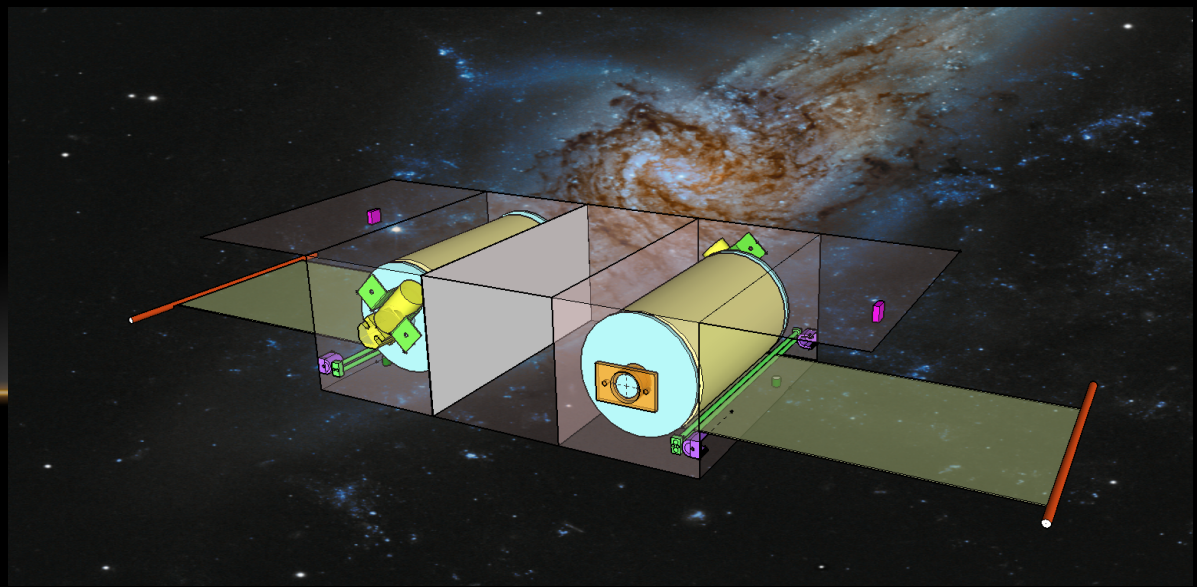


GOAL - SSWARMS

- Provide a continuous monitoring of the inner heliosphere and solar surface
- Empirical models, such as ENLIL, can be improved using continuous, multi-point measurements
  - Measuring magnetic field configuration
  - Particle output and SEPs streaming along field lines
- Inner heliosphere monitoring also provides the possibility of providing actionable information for humans in interplanetary space
  - Expected lead times of hours to days of warnings
  - System of watch/warning/alert similar to tornados allows modification of operations to maintain safety margins.
- For humans operating anywhere in the solar system without the protection of a planetary magnetic field.
  - Mars, asteroids (Ceres).

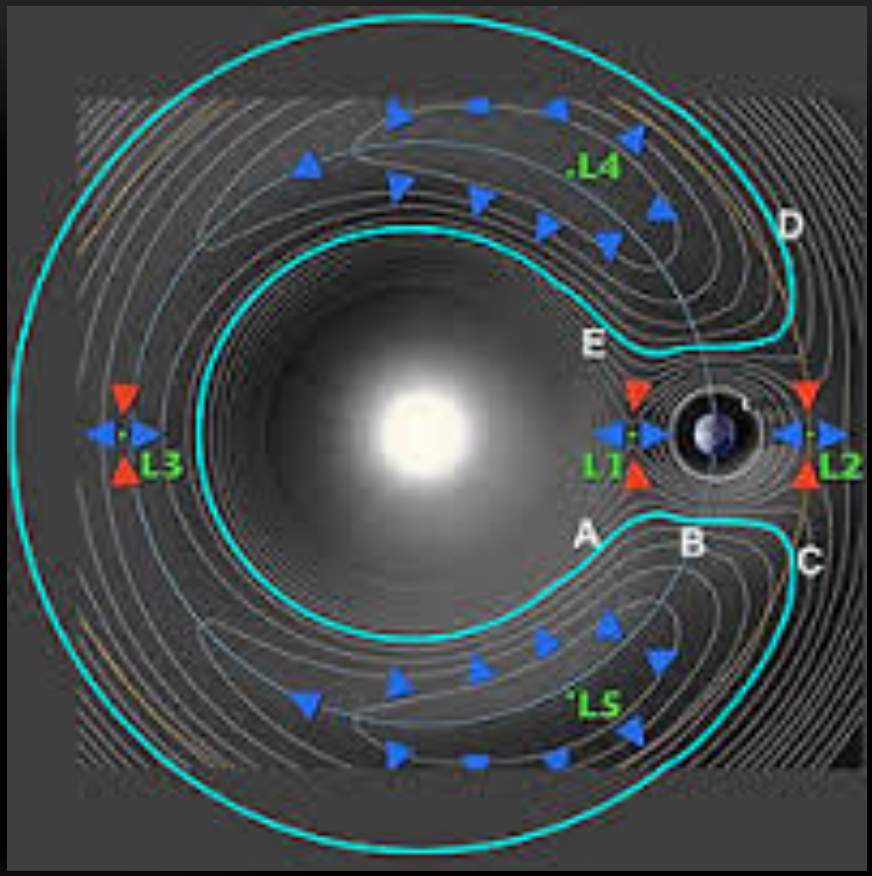
SSWARMS PLATFORM

- Multi-satellite solution
  - Heterogeneous suite
  - Replaceable
  - Helio-gyro solar sails
    - No fuel
    - Guidance and control
  - Pico-/nano-class of satellites



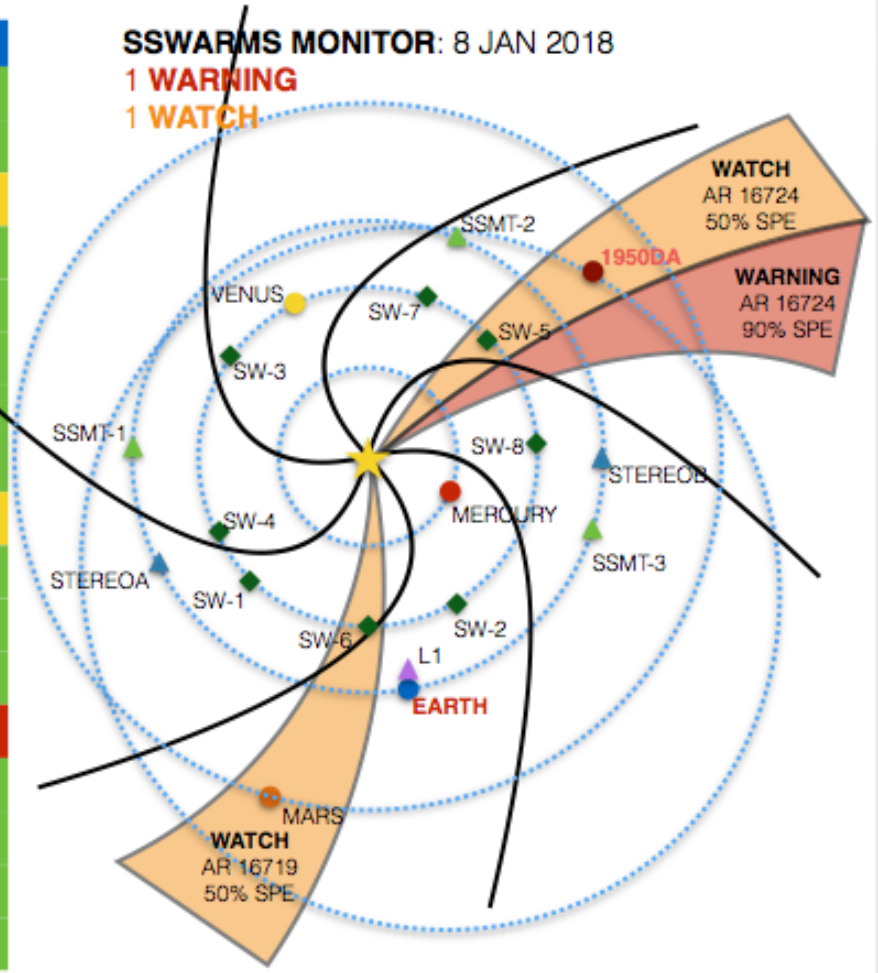
DEPLOYMENT

- Horseshoe orbits around Venus L4 and L5 LaGrange points
- Determine the distribution of the satellites
  - String of pearls like
  - Cluster
- Require a distribution that provides enough constraints for empirical models and enough coverage to provide actionable information.



DEPLOYMENT

S/C	WARN	A	STATUS
SOHO L1		0.9893	
STEREOA		0.9754	
STEREOB		1.013	
SSMT-1		1.002	
SSMT-2		0.994	
SSMT-3		0.993	
SW-1		0.721	
SW-2		0.730	
SW-3		0.734	
SW-4		0.727	
SW-5		0.724	
SW-6		0.723	
SW-7		0.731	
SW-8		0.732	
AST-1950DA		1.247	
MAVEN		1.581	
TGO		1.581	



Example forecast enabled by SSWARMS.

PROGRAM FEASIBILITY

- Implemented in a step-wise fashion
- Integrated into existing facilities
  - STEREO
  - L1 instruments
- Design as an integrated sensor network

TEAM

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QUESTIONS