GSFC Space Science Mission Operations (SSMO) and Space Weather

Rick Harman

Space Science Mission Operations

SSMO Spacecraft

Mission	Launch Year	MOC Location	Mission Director	Science Type	# s/c	Orbit Regime	Catalog #
ACE	1997	GSFC	B. Pumphrey	Heliophysics	1	L1	N/A
AIM	2007	LASP	O. Cuevas	Heliophysics	1	LEO	31304
ARTEMIS*	2007	UC Berkeley	G. Marr	Heliophysics	2	P1, lunar orbit; P2, Lunar Lagrange Point 1	30581, 30582
Fermi	2008	GSFC	B. Pumphrey	Astrophysics	1	LEO	33053
IBEX	2008	Orbital	O. Cuevas	Heliophysics	1	HEO (T = 9 days)	33401
IRIS	2013	ARC	D. Knapp	Heliophysics	1	LEO	
LRO	2009	GSFC	S. Odendahl	Planetary (Lunar)	1	Lunar Orbit	N/A
Van Allen (RBSP)	2012	APL	D. Quinn	Geospace / Heliophysics	2	HEO	38752, 38753
RHESSI	2002	UC Berkeley	D. Knapp	Heliophysics	1	LEO	27370
SDO	2010	GSFC	D. Fink	Heliophysics	1	GEO	36395
SOHO***	1995	GSFC	D. Quinn	Heliophysics	1	L1	n/a
STEREO	2006	APL	D. Quinn	Heliophysics	2	Heliocentric	n/a
Swift	2004	Penn State	B. Pumphrey	Astrophysics	1	LEO	28485
THEMIS	2007	UC Berkeley	D. Knapp	Heliophysics	3	HEO	305880, 30584, 30585
TIMED	2001	APL	D. Quinn	Heliophysics	1	LEO	26998
WIND	1994	GSFC	O. Cuevas	Heliophysics	1	L1	n/a

* ARTEMIS is a bifurcation of the THEMIS extended mission.
*** SOHO is a cooperative program between ESA and NASA.

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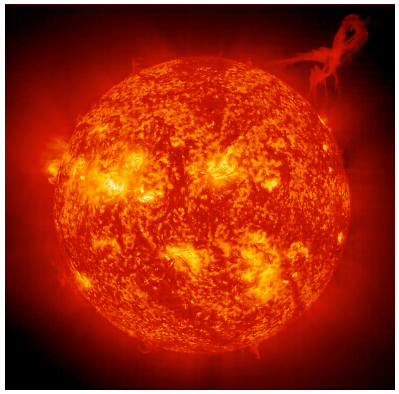
MAVEN	2013	Lockheed, Littleton, CO	J. Nagy	Planetary	1	Mars	N/A
MMS	2015	GSFC	M. Woodard	Geospace / Heliophysics	4	HEO	TBD

Future SSMO Mission

Mission	Launch Year	MOC Location	Mission Director	Science Type	# s/c	Orbit Regime	Catalog #
Osiris Rex	2016	Lockheed, Littleton, CO	A. Calloway	Planetary	1	Bennu	N/A
ICON	2017	UCB	TBD	Heliophysics	1	LEO	TBD
NPP	2018	APL	TBD	Heliophysics	1	Heliocentric	N/A

SSMO Spacecraft

Heliocentric:
Stereo Ahead



MAVEN

GEO: *SDO*

HEO:
THEMIS,
IBEX, Van
Allen, MMS

LRO,
ARTEMIS

L1: *ACE,*
SOHO, WIND

LEO: *AIM,*
Fermi, IRIS,
RHESSI,
Swift,
TIMED

Heliocentric:
Stereo Behind

Heliocentric:
ORex

STEREO Solar Conjunction

- Background
  - Both AHEAD and BEHIND behind the Sun relative to the Earth and out of contact with the ground for a period of weeks in 2015
  - AHEAD: March 24, 2015 – July 7, 2015
  - BEHIND: January 22, 2015 – September 28, 2015

- Issue
  - Each Spacecraft has a Hardware Command Loss Timer (HCLT) that resets the spacecraft if commands are not received in 72 hours.
  - Conjunction Operations for Each Spacecraft lasted for weeks and resulted in multiple HCLT spacecraft resets with the instruments and the star tracker powered off each time.

FRB: Anomaly Cause/Sequence of Events

- On October 1, 2014, Spacecraft HCLT reset as expected during a pre-solar conjunction test.
- After reset, the Star Tracker did not output attitude solutions.
- As programmed, the Spacecraft used Inertial Measurement Unit (IMU) data for rate information.
- The IMU x-axis failed.
- Spacecraft likely spun up as a result of autonomous momentum dump in response to erroneous x-axis IMU rate measurements.
  - No telemetry exists beyond a single frame that shows the IMU x-axis failed w/ an erroneous x-axis rate

FRB Assessment

- Post-Anomaly State
  - The spacecraft is in a probable spin about Y-axis
    - Unknown rate
    - Unknown spin axis orientation
    - Likely in a cycle of power system collapse and partial recovery when SAs illuminated
  - Solar array illumination is
    - Governed by the final orientation of the spin axis
    - Seasonal as BEHIND moves about Sun

- Recovery efforts consist of commanding
  - Increased battery charge rate
  - Subsequently powering on the transmitter
  - If spin rate is too high, the spacecraft will be incapable of receiving commands until January 2020 as BEHIND-Earth range
    - Multiple commands need to be received to stabilize power system recovery
    - Jan 2020: the command rate increases due to decreased Earth range

Failure Review Board's Recommendations

- DSN developed faster frequency segmented acquisition sequence
  - 18 one kHz segments
  - Send short critical commands multiple times each segment
  - Successfully tested on AHEAD on Sep 29, 2015
- Battery state of charge recovery
  - Increase battery SOC by removing loads
  - Procedure developed and tested on flatsat in April 2015
- Downlink carrier recovery
  - Power on TWTA, carrier only
  - Procedure developed and tested on flatsat in April 2015
  - Determine rotation rate and BLF
- Utilizing other antennas to detect downlink
  - Arecibo Observatory, Green Bank Radio Telescope, and Allen Telescope Array are being used when available
- Periodically perform recovery operations to maximize the chance of the Sun illuminating the arrays
  - From modeling, minimal solar array input when anomaly occurred (2014-274). Seasonal effect may increase solar array input.

STEREO Update

AHEAD

- Conjunction: 3/24-7/7/15
- Instrument Recommissioned: 12/31/15

BEHIND

- Contact lost 10/1/14 during Conjunction Operations Testing
- Contact regained on 8/21/16
- First Telemetry: 8/26/16
- Attempted Momentum Unload and Sun Pointing on 9/7/16
- Current State: Spinning with ~50 second period, Damaged Battery, Possibly Compromised Propulsion System, No Communication Since 9/20/16
- Plan Ahead:
  - Continue to characterize spin
  - Continue attempt to upload macro to protect battery
  - Telemetry if possible

STEREO BEHIND Orbit Timeline