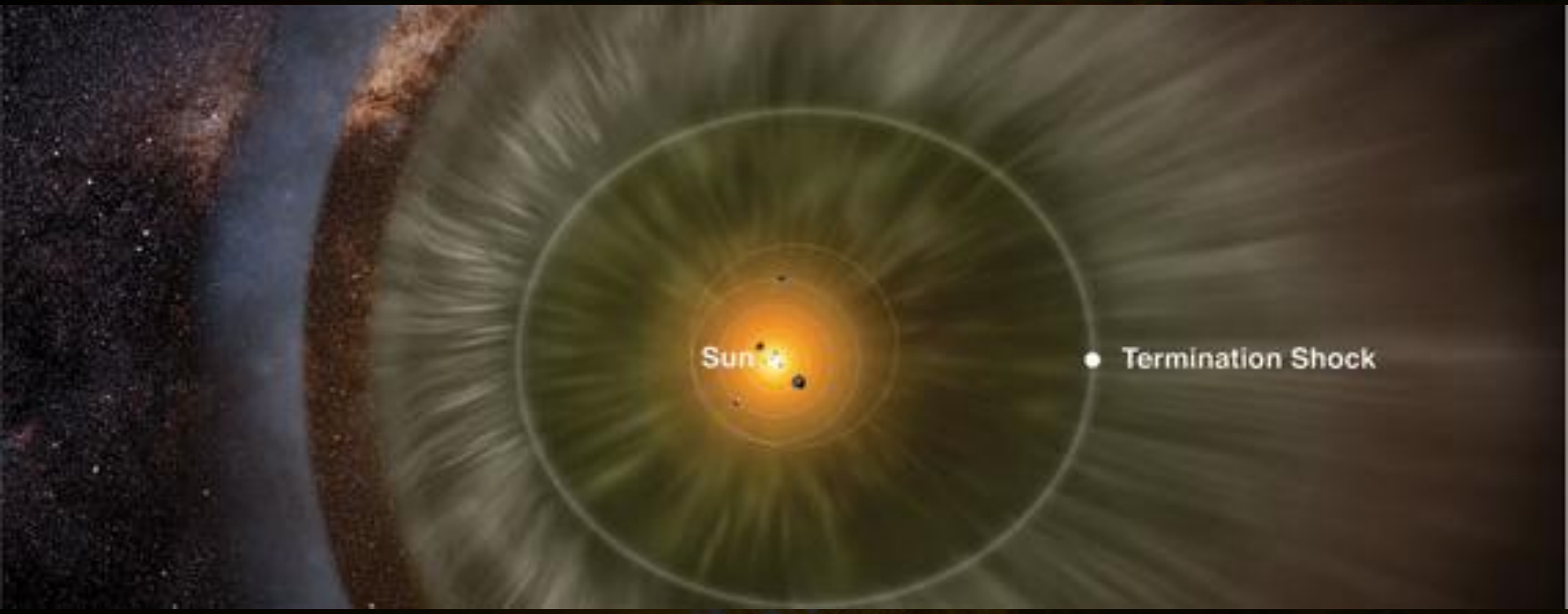
National Aeronautics and Space Administration



Heliophysics

Committee on Solar and Space Physics

March 7, 2013

John Lee

OUR JOB:

NASA Outcome 2.2: Understand the Sun and its Interactions with Earth and the Solar System

In the FY12 and FY13 budgets, NASA has stated that it will provide this outcome by making progress, each year, toward these three objectives:

Objective 2.2.1: *Improve understanding of the **fundamental physical processes of the space environment** from the Sun to Earth, to other planets, and beyond to the interstellar medium*

Objective 2.2.2: *Improve understanding of how human society, technological systems, and the habitability of planets are affected by **solar variability interacting with planetary magnetic fields and atmospheres**.*

Objective 2.2.3: *Maximize the safety and productivity of human and robotic explorers by **developing the capability to predict** the extreme and dynamic conditions in space*

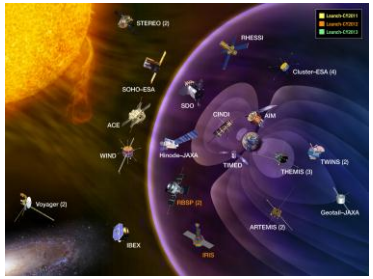
These are being revisited via our Roadmap Process now that we have the Decadal Survey

Our Division has been provided four assets to use to fulfill these Objectives:

Explorers

Smaller, Competed Flight Program

Research



Research tasks utilizing suborbital and existing assets

Objective 2.2.1: ***Understand the fundamental physical processes of the space environment*** *– from the Sun to Earth, to other planets, and beyond to the interstellar medium*

Objective 2.2.2: ***Understand*** *how human society, technological systems, and the habitability of planets are affected by* ***solar variability interacting with planetary magnetic fields and atmosphere****s.*

Objective 2.2.1: Maximize the safety and productivity of human and robotic explorers by ***developing the capability to predict*** *the extreme and dynamic conditions in space*

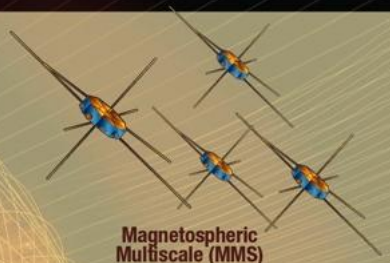
Strategic Mission Flight Program

Strategic Mission Flight Program

These are being revisited via our Roadmap Process now that we have the Decadal Survey

Heliophysics Program 2013-2018

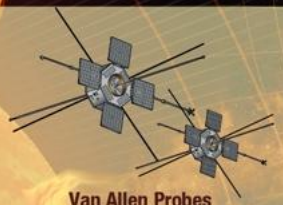
Solar Terrestrial Probes



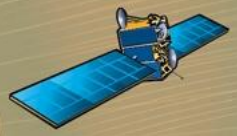
Magnetospheric Multiscale (MMS)
March 2015

STP #5

Living With a Star



Van Allen Probes
August 2012



Space Environment Testbeds (SET)
August 2015

Solar Orbiter Collaboration (with ESA)
January 2017

Solar Probe Plus
July 2018

Explorers

Interface Region Imaging Spectrograph (IRIS)
June 2013

Future Explorer Mission(s)
2016-2018

Research Program

Uplink Test - February 2013
VISIONS - February 2013
HYPE - April 2013
EVEX - April 2013

SLICE - April 2013
EUNIS - April 2013
FORTISS - May 2013
CIBER - May 2013

VERIS - May 2013
RockOn - June 2013
DayDynamo - July 2013
MOSES - August 2013

RAISE - September 2013
VESPR - November 2013
ACCESS - January 2014
CHESS - April 2014

DFS - May 2014
MOSES - June 2014

Ongoing

ASTRA - August 2012/New Mexico
NSCAP - September 2012/New Mexico
BARREL #1 - January 2013/Antarctica

GRIPS - September 2013/New Mexico
BARREL #2 - January 2014

Heliophysics Missions
Astrophysics Missions
Planetary Missions

2012 2013 2014 2015 2016 2017 2018

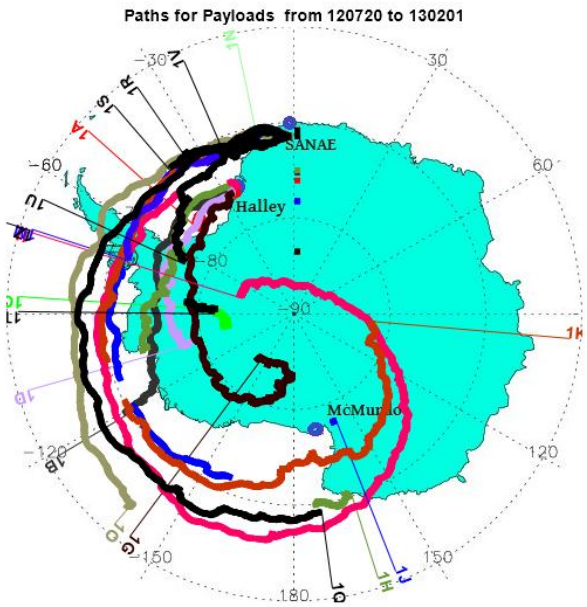
Living With a Star Program

Project	Overall previous months				This Month					
	-4	-3	-2	-1	**O**	C	S	T	P	
OVERALL	G	G	G	G	G	G	G	G	**G**	
SOC 2017	G	G	G	G	G	G	G	G	G	**KDP-C planned for March 28, 2013.**
SET 2015	G	G	G	G	G	G	G	G	G	**In storage.**
BARREL 2012	G	G	G	G	G	G	G	G	G	**First Antarctic science campaign completed.**
SPP 2018	G	G	G	G	G	G	G	G	G	

- **Solar Orbiter Collaboration** draft Request for Launch Service Proposal released
- **Solar Probe Plus:** Successful Mid- Phase B Status Update Meeting at APL Feb 13
- **Space Environment Testbed (SET)** - The Air Force has announced that the DSX vehicle containing our SET payload (referred to as the Space Test Program -2 (STP-2) mission) will be launched on SpaceX's new Falcon Heavy from KSC SLC-40
  - The targeted launch date is now in mid-2015.

Balloon Array for RBSP Relativistic Electron Losses (BARREL)

PI: Robyn Millan, Dartmouth College PM: Linda Thompson, WFF



Purpose: BARREL, a Living With a Star (LWS) Mission of Opportunity (MoO), will quantify and reveal the processes responsible for catastrophic losses of electrons from Earth's outer radiation belt. BARREL is managed out of WFF.

Status: The BARREL Launch Campaign successfully concluded on February 1

- Threshold Mission and Science Objectives Exceeded!
- Coronal Mass Ejection and a Coronal Hole Solar Storms Observed
- 20 Launches Conducted
  - 7 Payloads Launched from Halley Bay
  - 13 Payloads Launched from SANAE IV

Next Steps: Lessons learned from 2013 campaign; buildup of payloads for 2014.

Early BARREL results at Science Brown Bag, noon, MIC3 on Mar 4

Solar Terrestrial Probes Program

Project	Overall previous months				This Month					
	-4	-3	-2	-1	**O**	C	S	T	P	
OVERALL	G	G	G	G	Y	Y	G/Y	Y	G	
Magnetospheric Multiscale (MMS) 10/2014	Y	Y	Y	Y	Y	Y	G/Y	Y	G	**Cost Risk - High burn rate coupled with modest reserves and a very complex I&T. Cost reserves at 15.1%.**

- Earned value Estimate At Completion (EAC) trend within Management Baseline Commitment
- Dispositioning FPI Amptek HV801, EDI Optocoupler, and DES metallic debris issues will impact schedule.
  - Schedule assessment does not reflect impact of FPI and EDI/GDU rework
    -- Final plan and cost/schedule impacts are expected by late March/early April

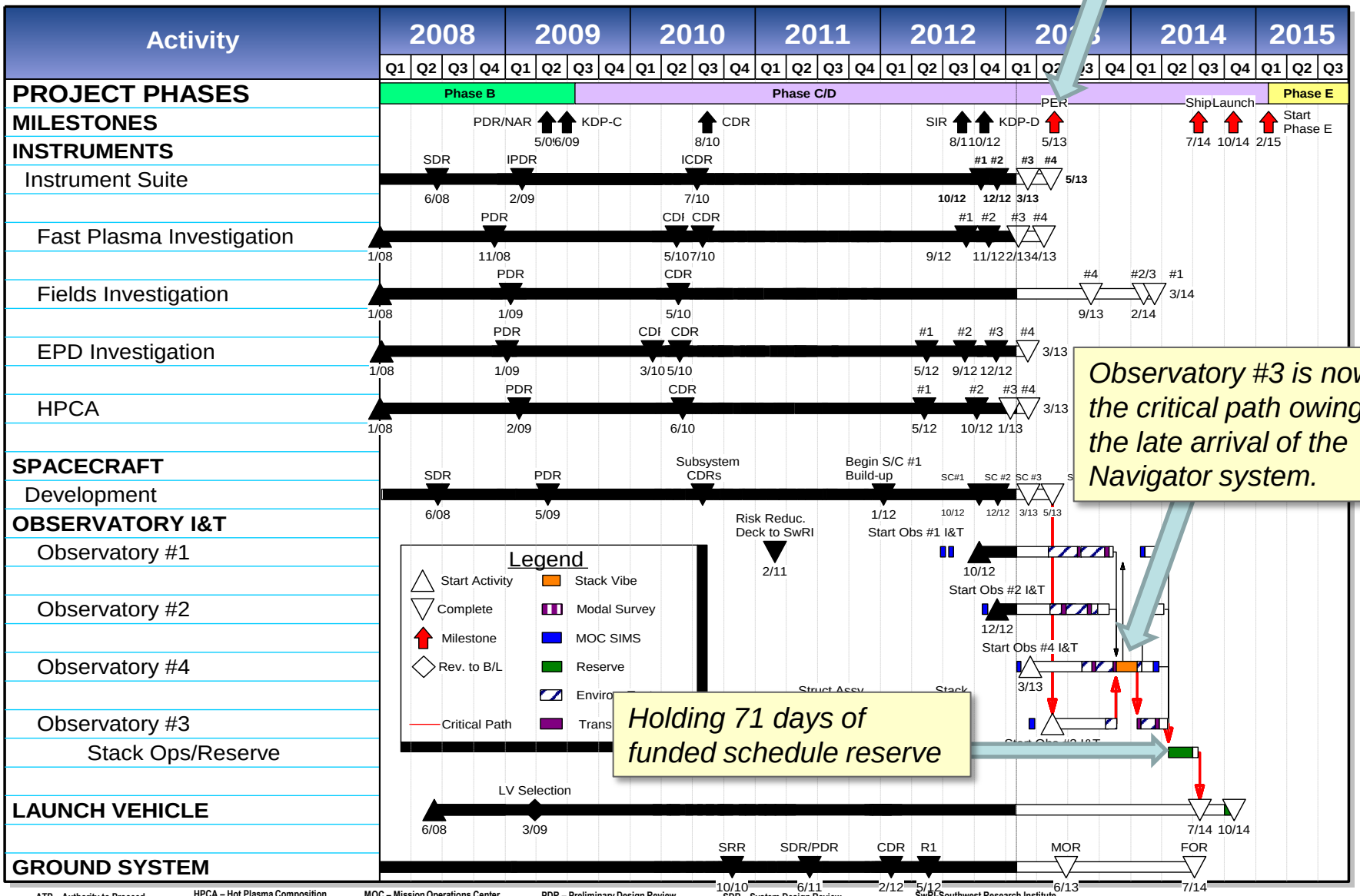
O: overall C: Cost, S: Schedule, T: Technical, P: Programmatic

G	On plan, adequate Margin**
Y	Problems, working to resolve within planned Margin**
R	Problems, not enough margin to recover**

MMS MASTER SCHEDULE

PER now planned for June 2013.

1/31/13



Observatory #3 is now the critical path owing to the late arrival of the Navigator system.

Holding 71 days of funded schedule reserve

ATP – Authority to Proceed
AO – Announcement of Opportunity
CDR – Critical Design Review
Dev - Development
DT – Demonstration Test
EPD – Energetic Particle Detection
FOR – Flight Operations Review
HPCA – Hot Plasma Composition
I - Instrument
IS – Instrument Suite
KDP-Key Decision Point
LSTO – Launch Services Task Order
LV – Launch Vehicle
MDR – Mission Definition Review
MOC – Mission Operations Center
Mod - Modification
MOR – Mission Operations Review
NAR – Non-Advocacy Review
Obs - Observatory
Ops - Operations
ORR – Operations Readiness Review
PDR – Preliminary Design Review
PER – Pre-Environmental Review
Pre-NAR – Preliminary NAR
PRR – Production Readiness Review
R - Release
RFP – Request for Proposal
SC - Spacecraft
SDR – System Design Review
Sims - Simulations
SIR - System Integration Review
SOC - Science Operations Center
Sp - Spares
SRR - System Requirements Review
STM – Structural Test Model
SwRI-Southwest Research Institute
TVAC – Thermal Vacuum
Obs – Observatory
B/L – Baseline

MMS Significant Accomplishments/Upcoming Events

Observatories:

- **Observatory #1** The first of the two flight Mag Booms installation has started
  - CPT planned May 13
- **Observatory #2** Functional Test was successfully run
  - Optical benches were installed
  - CPT planned to start June 3
- **Observatory #4 -** the low-pressure functional test of the Propulsion System was completed
  - IS#4 CPT: – March 4-8
  - IS#4 Delivery to Obs#4: March 28
- **On Observatory# 3** (last observatory), Navigator #3 competed FFTB testing and in in environmental testing

Upcoming Events and Milestones

- Instrument Suite # 4 CPT 4-8 March
- Observatory #1 CPT May 2013
- Mission Operations Review, now 26-28 June 2013 at GSFC
- MMS Pre-environmental Review (PER), June 2013 at GSFC.

Observatory 1 on tilt table

MMS Significant Progress

IS #1 Status

Investigation	Component	SN	PER Date	Baseline CPT	EMI/EMC	Vibration	TVAC	Post Test CPT/Calibration	PSR Date
FIELDS	AFG	5	10/20/10		N/A				05/22/12
	DFG	4	10/20/10		N/A				05/22/12
	ADP Boom	1,2	04/05/11		N/A		Thermal		05/23/12
	SCM Sensor	1	05/20/11		N/A				05/22/12
	SCM Preamp	1	08/08/11						05/22/12
	SDP	3,4	11/15/11						10/04/12
	SDP	9,10							
	CEB	1	01/18/12						05/22/12
	RE	3,4	01/23/12		N/A				05/23/12
	AEB	1	01/31/12						05/23/12
	EDI/GDU								
	EDI/GDU	3	11/20/12						
	EDI/GDU	5							
FPI	FPI/IDPU	2	11/28/11						06/20/12
	FPI/DES	5	04/02/12						08/09/12
	FPI/DES	6	04/02/12						08/09/12
	FPI/DES	8	04/02/12						08/09/12
	FPI/DES	10	06/15/12						08/09/12
	FPI/DIS	1	11/30/11						11/01/12
	FPI/DIS	2	11/30/11						11/01/12
	FPI/DIS	5,6	08/17/12						11/01/12
EPD	EIS	3	09/22/11						04/24/12
	FEEPS	1,2	11/21/11						03/15/12
	ASPOC	1,2	11/02/11						02/13/12
	HPCA	1	12/13/11						05/15/12
	CIDP	1	02/16/12						08/14/12

*Installed as a risk mitigation integration

Complete | In Progress | Issue/ Closure | On Deck

IS #4 Status

Investigation	Component	SN	PER Date	Baseline CPT	EMI/EMC	Vibration	TVAC	Post Test CPT/Calibration	PSR Date
FIELDS	AFG	9	01/05/12		N/A				1/18/13
	DFG	7	01/05/12		N/A				1/18/13
	ADP Boom	5,6	11/09/11		N/A		Thermal		1/18/13
	SCM Sensor	5	01/09/12		N/A				1/18/13
	SCM Preamp	4	01/09/12						1/18/13
	SDP	11,12							SN1
	SDP	13,14							ETU
	CEB	3	10/29/12						1/18/13
	RE	1,2	09/07/12						1/18/13
	AEB	3	09/07/12						1/18/13
	EDI/GDU	2	05/21/12						TEMP
	EDI/GDU	8							
FPI	FPI/IDPU	3	11/29/12						5 - TEMP
	FPI/DES	9	06/15/12						6 - TEMP
	FPI/DES	11	08/31/12						8 - TEMP
	FPI/DES	12	09/20/12						10 - TEMP
	FPI/DES	14							
	FPI/DIS	9	09/21/12						
	FPI/DIS	10	09/21/12						
	FPI/DIS	11	11/08/12						
	FPI/DIS	12	11/13/12						
EPD	EIS	4	09/22/11						04/24/12
	FEEPS	5,6	11/07/12						
	ASPOC	4	02/29/12						11/27/12
	ASPOC	6	08/03/12						11/27/12
	HPCA	3	12/06/12						
	CIDP	4	11/13/12						11/30/12

Complete | In Progress | Issue/ Closure | On Deck

IS #2 Status

Investigation	Component	SN	PER Date	Baseline CPT	EMI/EMC	Vibration	TVAC	Post Test CPT/Calibration	PSR Date
FIELDS	AFG	6	09/02/11		N/A				09/10/12
	DFG	8	09/02/11		N/A				09/10/12
	ADP Boom	3,4	09/23/11		N/A		Thermal		09/10/12
	SCM Sensor	2	01/09/12		N/A				09/10/12
	SCM Preamp	2	01/09/12						09/10/12
	SDP	7,8	10/17/12						AR
	SDP	5,6	08/07/12						10/04/12
	CEB	2	07/12/12						09/10/12
	RE	5,6	04/30/12						09/10/12
	AEB	2	04/30/12						09/10/12
	EDI/GDI	1	09/28/12						1/17/13
	EDI/GDU	4							
FPI	FPI/IDPU	1	11/28/11						12/21/12
	FPI/DES	1,2	11/29/11						11/15/12
	FPI/DES	3,4	11/29/11						11/15/12
	FPI/DIS	3,4	11/30/11						
	FPI/DIS	7,8	08/17/12						
EPD	EIS	2	09/22/11						04/24/12
	FEEPS	3,4	06/29/12						09/06/12
	ASPOC	3	02/29/12						08/03/12
	ASPOC	5	04/19/12						08/03/12
	HPCA	2	07/12/12						10/17/12
	CIDP	3	10/24/12						11/13/12

Complete | In Progress | Issue/ Closure | On Deck

IS #3 Status

Investigation	Component	SN	PER Date	Baseline CPT	EMI/EMC	Vibration	TVAC	Post Test CPT/Calibration	PSR Date
FIELDS	AFG	10	06/26/12		N/A				
	DFG	11	06/26/12		N/A				
	ADP Boom	7,8	11/30/11		N/A		Thermal		
	SCM Sensor	4	09/17/12						
	SCM Preamp	5	09/17/12						
	SDP	15-18							
	CEB	4							
	RE	7,8	10/26/12						
	AEB	4							
	EDI/GDU	7,8							
FPI	FPI/IDPU	4							
	FPI/DES	7	04/02/12						
	FPI/DES	13	10/23/12						
	FPI/DES	15							
	FPI/DES	16							
	FPI/DIS	13	12/14/12						
	FPI/DIS	14	12/14/12						
	FPI/DIS	15							
	FPI/DIS	16							
EPD	EIS	1	09/22/11						04/24/12
	FEEPS	7,8							
	ASPOC	7	08/03/12						
	ASPOC	8	10/19/12						
	HPCA	4	01/23/13						
	CIDP	2	12/13/12						01/15/13

Complete | In Progress | Issue/ Closure | On Deck

Heliophysics Explorer Program

Project	Overall previous months				This Month					
	-4	-3	-2	-1	O	C	S	T	P	
OVERALL	Y	Y	Y	Y	G	G	G	G	G	**Program Plan being updated**
IRIS LRD 5/18/13	Y	Y	Y	Y	Y	R	Y	G	G	**TVAC completed. Agency commitment is June 2013.**
EX/MO - next	G	G	G	G	G	G	G	G	G	**In Review Process "blackout"**

Interface Region Imaging Spectrograph (IRIS)

- Working 3 open issues following completion of TVAC:
  - (1) X-Band oscillator repairs have been completed – penalty testing is underway.
  - (2) Integrated Avionics Unit (IAU) repairs have been completed.
  - (3) Cracked resistors found on flight battery. Under repair at Yardney.
- Due to these technical issues, project cannot be completed within the current baseline cost.
  - Detailed cost assessment is being developed.
  - FPB requested LRD of May 18 – current range earliest opportunity is June 23, 2013.
  - IRIS will continue working toward Initial launch Capability of May 18

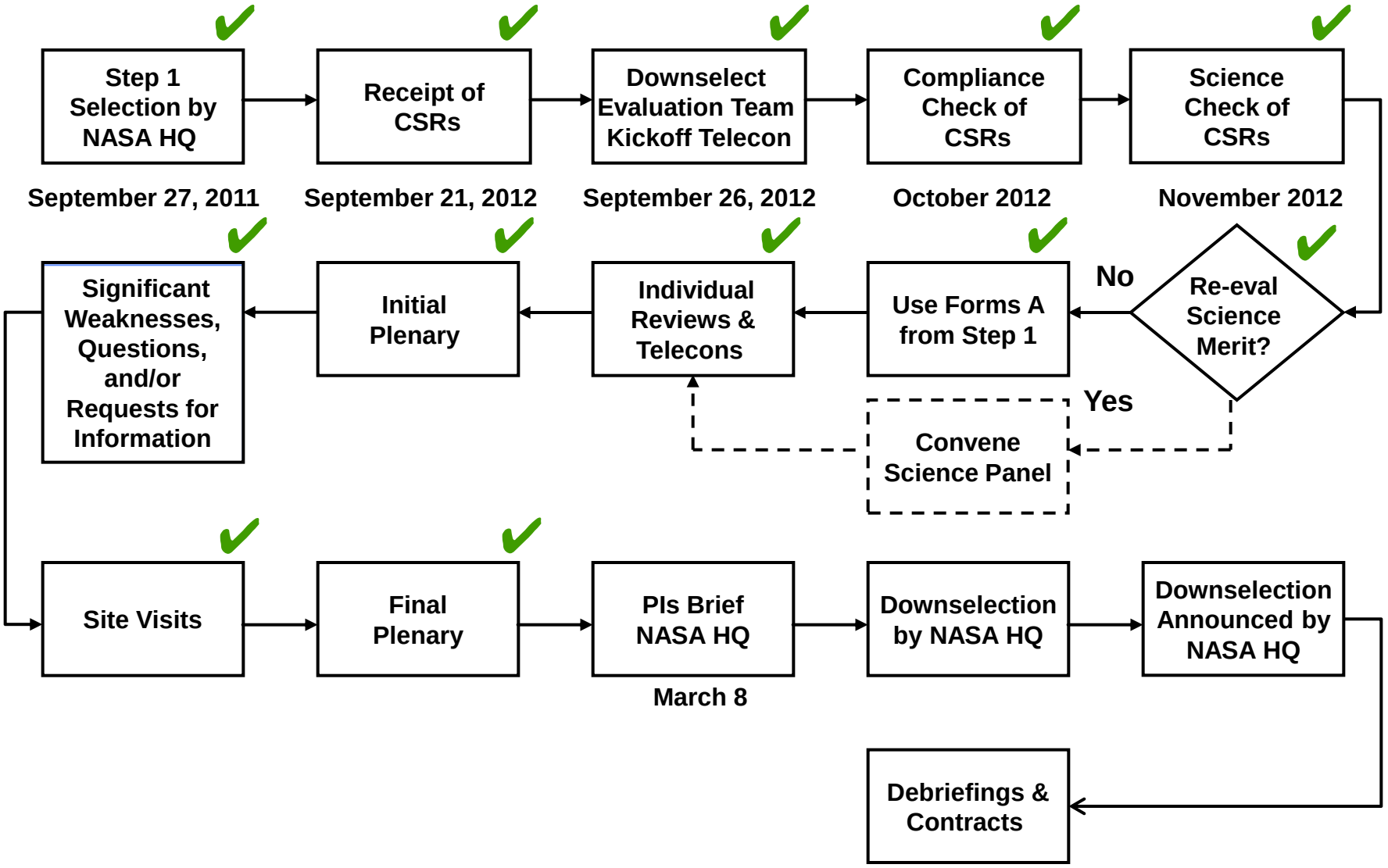
O: overall C: Cost, S: Schedule, T: Technical, P: Programmatic

G — On plan, adequate Margin**

Y — Problems, working to resolve within planned Margin**

R — Problems, not enough margin to recover**

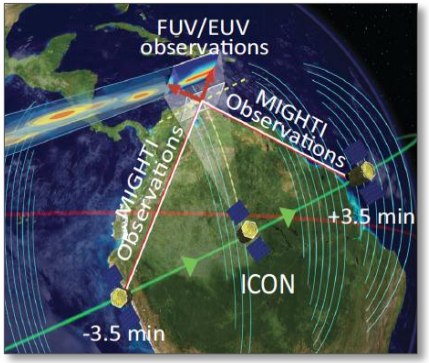
Explorer Downselect CSR Evaluation Flow



Explorer Full Mission Selections
3 mission concepts; 3 approaches to ionosphere–magnetosphere coupling

ICON

Ionospheric Connection Explorer



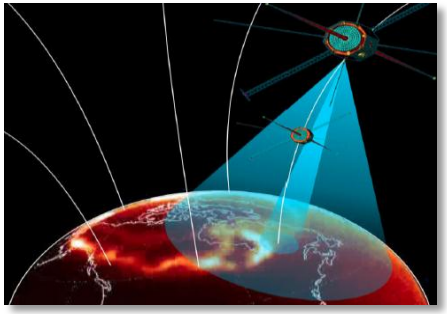
- **How neutral atmosphere affects the ionosphere**
- **How solar wind and magnetosphere affect the ionosphere**

Neutral winds, FUV/EUV imaging of atmosphere and ionosphere, ion velocities and electric fields
Orbit: 550 km at 24^{o} inclination

PI: **Thomas Immel** / UC Berkeley

OHMIC

Observatory for Heteroscale Magnetosphere–Ionosphere Coupling



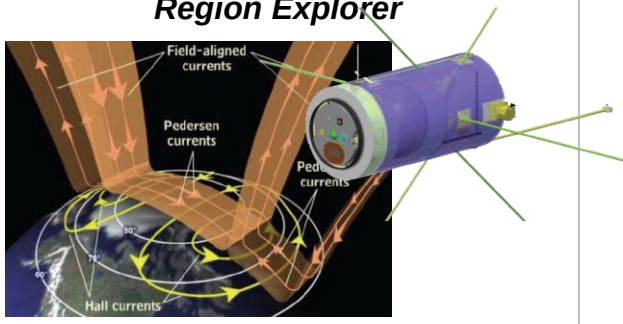
- **How magnetospheric EM energy flows downward to power aurora**
- **How ion outflows are initiated and modify the underlying ionosphere**

FUV/VIS imaging of ionosphere, particle distributions, electric & magnetic fields and waves. Orbit: 300 x 6000 km w/ several separation changes

PI: **James Burch** / SWRI

ASTRE

Atmosphere-Space Transition Region Explorer



- **How magnetospheric electric fields drive neutral atmospheric motions**
- **How the neutral-ion transition region regulates the magnetosphere**

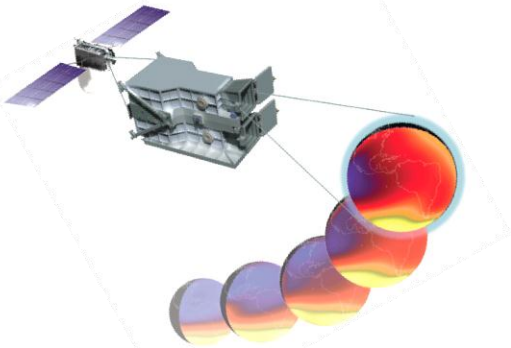
Neutral winds, temperatures, ion velocities, energetic particles, electric and magnetic fields. Orbit: 250 x 1500 km w/ excursions to 150 km.

PI: **Robert Pfaff** / GSFC

Explorer Mission of Opportunity Selections
3 MO concepts; 3 opportunities to augment the Helio System Observatory

GOLD

Global Scale Observations of the Limb and Disk



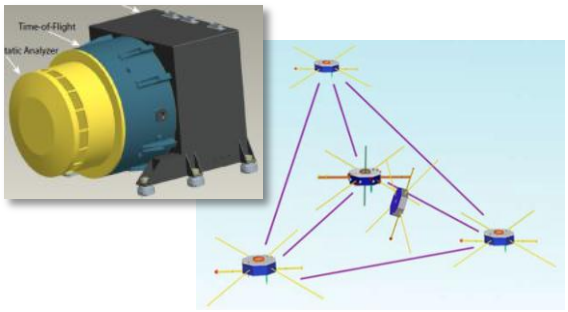
… how the ionosphere and thermosphere responds to geomagnetic storms, solar radiation, and upward propagating atmospheric tides

Two identical scanning imaging spectrographs on a geosynchronous commercial communication satellite.

PI: **Richard Eastes** / U. Central Florida

IMSA on SCOPE

Ion Mass Spectrum Analyzer



… fundamental processes of reconnection, particle acceleration, and turbulence … focused on the feedback mechanisms between ion and electron scale lengths

Single plasma composition instrument contributed to the Japanese SCOPE mission. Scope consists of 5 satellites in a near equatorial, 10x25 R_E orbit.

PI: **Lynn Kistler** / U. New Hampshire

CPI on the ISS

Coronal Physics Investigator

… processes that heat and accelerate the plasma components of the slow and fast solar wind

CPI is an internally occulted telescope with a high resolution spectrometer Deployed on the ISS, CPI acquires the Sun each orbital day and observes for ~30min.

..”

PI: **John Kohl** / SAO

Operating Missions

Mission	Launch	Phase	Extension to (*)	M-3	M-2	M-1	Cur. M.	Remarks
Geotail	7/24/92	Extended	9/30/2014					
Artemis (Helio)	7/15/10	Extended	9/30/2014 (+)					
STEREO	10/25/06	Extended	9/30/2014					Data loss due to DSN contention.
THEMIS	2/17/07	Extended	9/30/2014					
AIM	4/25/07	Extended	9/30/2014					
Hinode	9/23/06	Extended	9/30/2014					
Cluster	7/16/00	Extended	9/30/2014 (+)					
ACE	8/27/97	Extended	9/30/2014					
RHESSI	2/05/02	Extended	9/30/2014					
SOHO	12/02/95	Extended	9/30/2014					
TIMED	12/07/01	Extended	9/30/2014					
Voyager 1 + 2	8/20/77	Extended	9/30/2014					
TWINS A + B	6/06 & 3/08	Extended	9/30/2014					
CINDI:C/NOFS	4/16/08	Extended	9/30/2014					
IBEX	10/19/08	Extended	9/30/2014					
Wind	11/01/94	Extended	9/30/2014					
SDO	2/11/10	Prime	2/11/15					
Van Allen	8/30/12	Prime	11/30/14					RBSPICE-A Tiger Team report pending

Mission proceeding to meet science requirements

Area of concern - possible reduction in capability

Significant problem - possible or probable loss of mission

Operating Missions

DSN Contention

- Over the past couple of weeks STEREO A and B have lost substantial data due to contention. Now record data loss by Gbits, as opposed to contact time lost.

- Other Heliophysics assets using DSN may also be affected by DSN contention: ACE and Wind. Also, Voyager 2 is affected by the Canberra 70-m outage because it is planned for 6 months: there can be no command uplinks during this time, only downlinks by ganging 2 or 3 of 34-m antennas.

Senior Review

- **Senior Review** will be held April 23-26
  - Proposals due March 8
  - Final report targeted to be issued in June 2013

Van Allen Probes Highlights

- NASA's Radiation Belt Storm Probes **launched on August 30, 2012**.

- On September 1, 2012, the Relativistic Electron Proton Telescopes (REPT), part of the Energetic Particle, Composition, and Thermal Plasma Suites (ECT) on board the twin Probes were **powered on** so that their observations would overlap with another mission called SAMPEX (Solar, Anomalous, and Magnetospheric Particle Explorer), that was soon going to de-orbit and re-enter Earth's atmosphere. That same day, the most powerful solar proton event in the past two months occurred, giving researchers data to study how the radiation belts respond to solar activity.

- The **Radiation Belt Storm Probes were renamed Van Allen Probes** by NASA on November 9, 2012 after successful commissioning of the spacecraft.

- In January and into February 2013, researched **successfully completed the first BARREL (Balloon Array for Radiation belt Relativistic Electron Losses) campaign.** BARREL works in conjunction with NASA's Van Allen Probes to study how particles behave and are lost when they escape the radiation belts.

- **On February 28, 2013, researchers published the discovery of a third transient radiation belt around Earth** in the journal *Science.* Previous observations of Earth's Van Allen belts have documented two distinct regions of trapped radiation surrounding our planet. The new observations by the REPT instrument revealed there can be three distinct belt structures with the emergence of a second empty slot region, or space, in between. Scientists observed the third belt for four weeks before a powerful interplanetary shock wave from the sun annihilated it.

Sounding Rocket/Range Status

• **Sounding Rocket Program:** Sounding Rocket Program: Last occurrence of combustion instability with the Brant motor requires more constrained flight rules before flights can resume at WSMR, now in development with SRPO, WFF Flight Safety and WSMR Flight Safety. March 23 slot lost; will try to reschedule within 2-4 weeks.

• Manifest has been re-worked with Program Scientists & PI's. Stand down period used for facility upgrades at WSMR and acceptance testing of new Brant and Oriole motors.

• **Research Range:** Antares passed hot fire tests February 22

-- The "hot fire" test consisted of igniting the Antares rocket's dual AJ26 rocket engines for 29 seconds while the rocket is securely attached to the launch pad.

Sounding Rockets: Significant Progress

VISualizing Ion Outflow via Neutral atom imaging during a Substorm (VISIONS), PI: Rowland/GSFC launched successfully Feb 6, Poker Flat

- Objective: determine the characteristics of ions accelerated to escape velocities in the auroral zone below 1,000 Km following a sub-storm onset.
- First flight of the Talos/Terrier/Oriole/Nihka; near nominal performance
- First flight employing ACS on two separate free flying sub payloads
- All payload support systems and scientific instruments performed nominally

VISIONS Launch, Feb 6

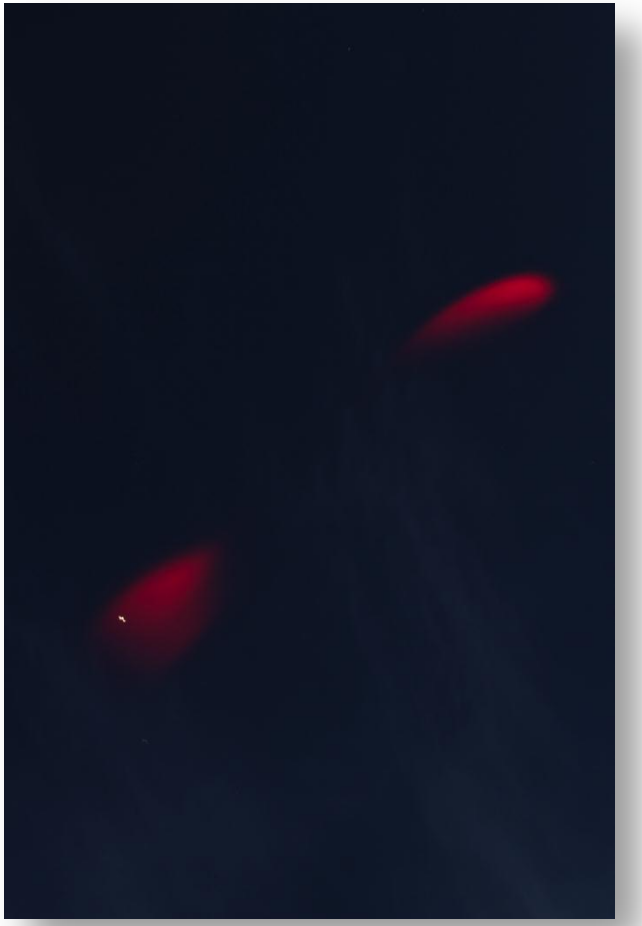
Sounding Rockets: Significant Progress

Lithium Canister Test launched successfully Jan 29, WFF

- Objective: test the loading methods for lithium canisters to be flown on the upcoming Kudeki (Kwajalein, April, 2013) and Pfaff (Wallops, June, 2013) missions and verify their functionality under sounding rocket launch and space flight conditions
- Test results were positive: Both deployment events were readily observable from the airplane, onboard payload camera, and ground. Reports of the lithium cloud sighting came from North Carolina, Pennsylvania & New Jersey.

Uplink Test launched successfully Feb 15, WSMR

- Objective: Test flight for uplink resources relocated to WSMR LC-36 VAB facility with multiple technology experiments



Lithium Clouds

Space Weather Items of Interest

- **National Space Weather Program Activities:**
  - **The Unified National Space Weather Capability** (UNSWC) Memorandum of Understanding (MOU) and Annex was approved February 8, 2013.
  - MOU Parties include NOAA, USAF, USGS, NASA, and NSF

- **United Nations Space Weather Activities:**

  - In 1958, the UN General Assembly established the Committee on the Peaceful Uses of Outer Space (COPUOS).

  - In February 2013, Space Weather was added to the regular agenda of the UN COPUOS Science and Technical Subcommittee, an important milestone that will harness the effort of all Members to ensure coordinated global action.

  - The elevation of space weather on COPUOS's agenda coincides with **the 10th anniversary of the International Living With a Star Program on Feb. 14.** The program is an ad hoc group of nations that got together in 2003 to lay the groundwork for worldwide cooperation in the study of space weather. The UN activities will help take their efforts to the next level.

Lika Guhthakurta reading the US space weather statement at the 2013 UN COPUOS meeting in Vienna, Austria. Credit: K. Concole, NASA

Heliophysics FY13 Planned Accomplishments

- ✓ **Completion of the first BARREL balloon campaign.**
- ➢ Selection of the next Heliophysics Explorer
- ➢ IRIS Launch
- ➢ MMS has started Phase D and will make progress on assembly, integration and observatory environmental testing.
- ➢ Solar Orbiter and Solar Probe Plus missions will retire technology development risks before moving from formulation into development.
- ➢ Conduct Senior Review of Heliophysics Missions, issuing instructions for an in-guide program to support the Heliophysics Systems Observatory.
- ➢ Review NRC Decadal Survey and conduct strategic planning activities for in-guide deployment of highest priority recommendations.

FY13 and FY14 Key Milestones

Key Decision Points

✓ October 2012	MMS KDP-D
March 2013	Solar Orbiter KDP-C
March - May 2013	IRIS KDP-E
April 2013	Heliophysics Explorer KDP-B
March 2014	SPP KDP-C

Solicitations

February 2013	ROSES NRA including technology studies for future STP/LWS
February 2014	ROSES NRA

next Heliophysics Explorer solicitation anticipated in FY2015

FY14 Budget Status

- FY14 budget is embargoed – no schedule for release yet.
- Sequestration Impact ???