NASA's Planetary Science Program Overview

James L. Green, Director Planetary Science

Presentation to VEXAG

November 21, 2013

Outline

- Planetary Budget
- Upcoming Planetary Events
- FY14 EPO Status and Activities
- Selected Planetary Missions Status
- Upcoming Senior Review
- Suborbital Flights
- Radioisotope Power Systems Update
- Research & Analysis Status and Plans

President's FY14 Planetary Science Budget Plus an Approved FY13 Budget

* Notional

Planetary Science Division	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
				*			
Planetary Research	$174,087	$192,672	$220,600	$233,300	$229,100	$230,400	$232,200
Lunar Quest	$139,972	$71,845	$17,700	$0	$0	$0	
Discovery	$172,637	$207,414	$257,900	$268,200	$242,300	$187,500	$215,000
New Frontiers	$143,749	$158,770	$257,500	$297,200	$266,500	$151,000	$126,200
Mars Exploration	$587,041	$369,529	$234,000	$227,700	$318,400	$504,700	$513,200
Technology	$161,899	$123,434	$150,900	$142,800	$144,700	$154,400	$140,000
Outer Planets	$122,054	$147,836	$79,000	$45,600	$24,400	$26,400	$26,000
	$1,501,439	**$1,271,500**	**$1,217,600**	**$1,214,800**	**$1,225,400**	**$1,254,400**	**$1,252,600**

- President's FY14 budget contains:
  - NEO observations enhancement of $20M/yr ($40M/yr total)
  - $50M/yr support of DoE PU-238 infrastructure support

Planetary Science Missions and Outreach Events

2013

* Completed

May – November – *Mars As Art* Exhibit at Dulles Airport Gallery
July 19 – Wave at Saturn and MESSENGER's Earth image from Mercury
August 6 – One Year Anniversary of Curiosity Landing on Mars
September 6 – LADEE launch from Wallops Flight Facility, VA
September 28 – BRRISON launch – Payload Anomaly
October 1 – Close approach of Comet ISON to Mars – *Campaign Science*
October 9 – Juno flyby of Earth
November 18 - Launch of MAVEN from Cape Canaveral, FL
November 19 – FORTIS rocket launch observing Comet ISON
November 25 – VESPER rocket launch observing Venus
November 28 – Comet ISON Perihelion. Brightest view from Earth of Comet ISON

2014

January – EXCEED-HST observations of Io – *Campaign Science*
August – Rosetta arrive at Comet Churyumov–Gerasimenko
October 19 – Comet Siding Spring encounters Mars

FY14 EPO Status and Activities

Current SMD EPO Policy

- Under a CR, SMD projects are to continue planned EPO activities at the same level of effort and budget as during FY13
  - Except where decreases were already planned or where directed otherwise by their sponsoring HQ division
- NASA will not implement the proposed consolidation at this time but will continue to make changes during a CR in alignment with the COSTEM strategic plan
- Office of Education and Communications will still oversee a waiver process to approve all education and public outreach activities

Selected Mission Status

Photo: Buddy Secor

Lunar Atmosphere and Dust Environment Explorer

Objective:

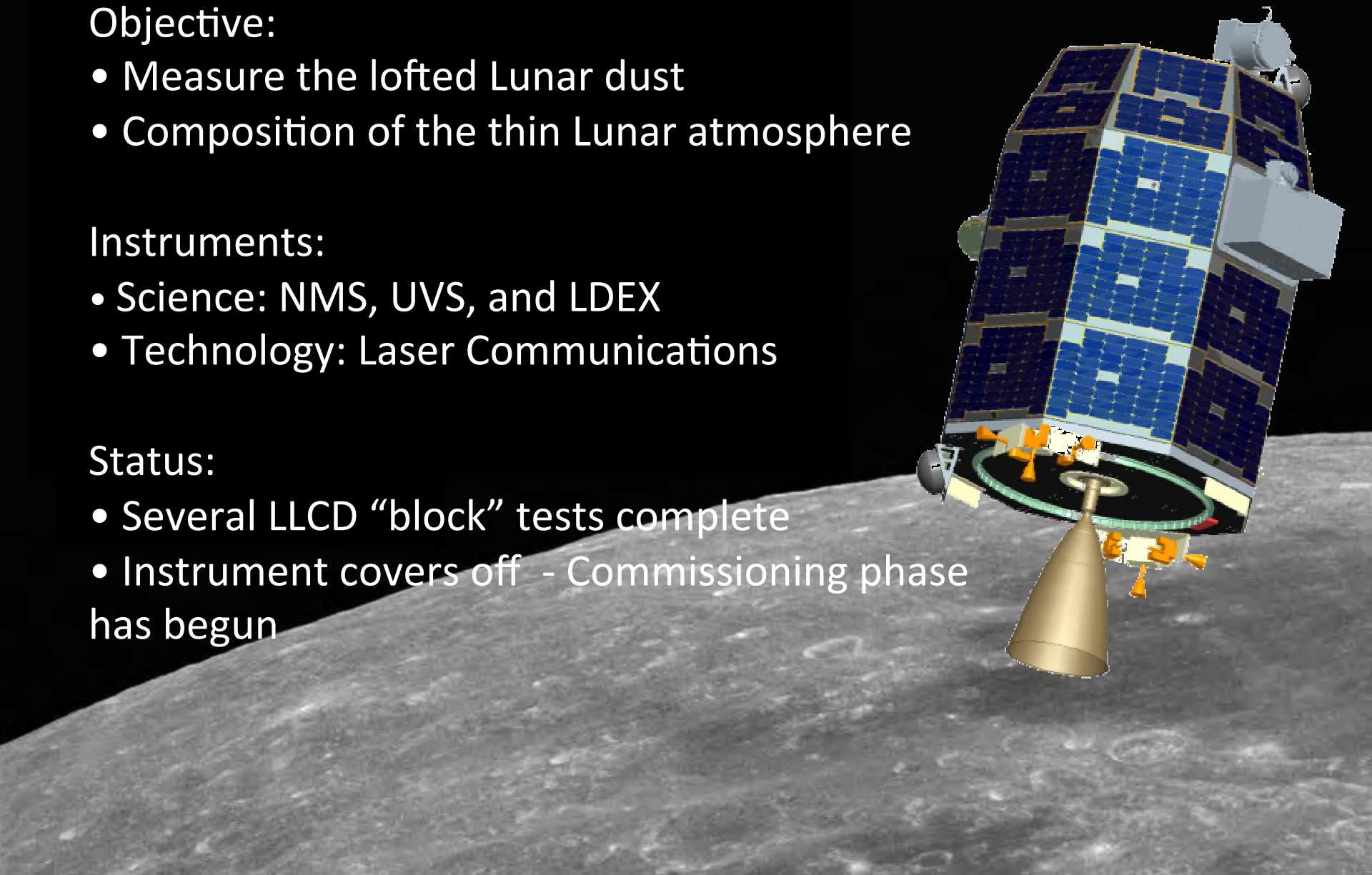
- Measure the lofted Lunar dust
- Composition of the thin Lunar atmosphere

Instruments:

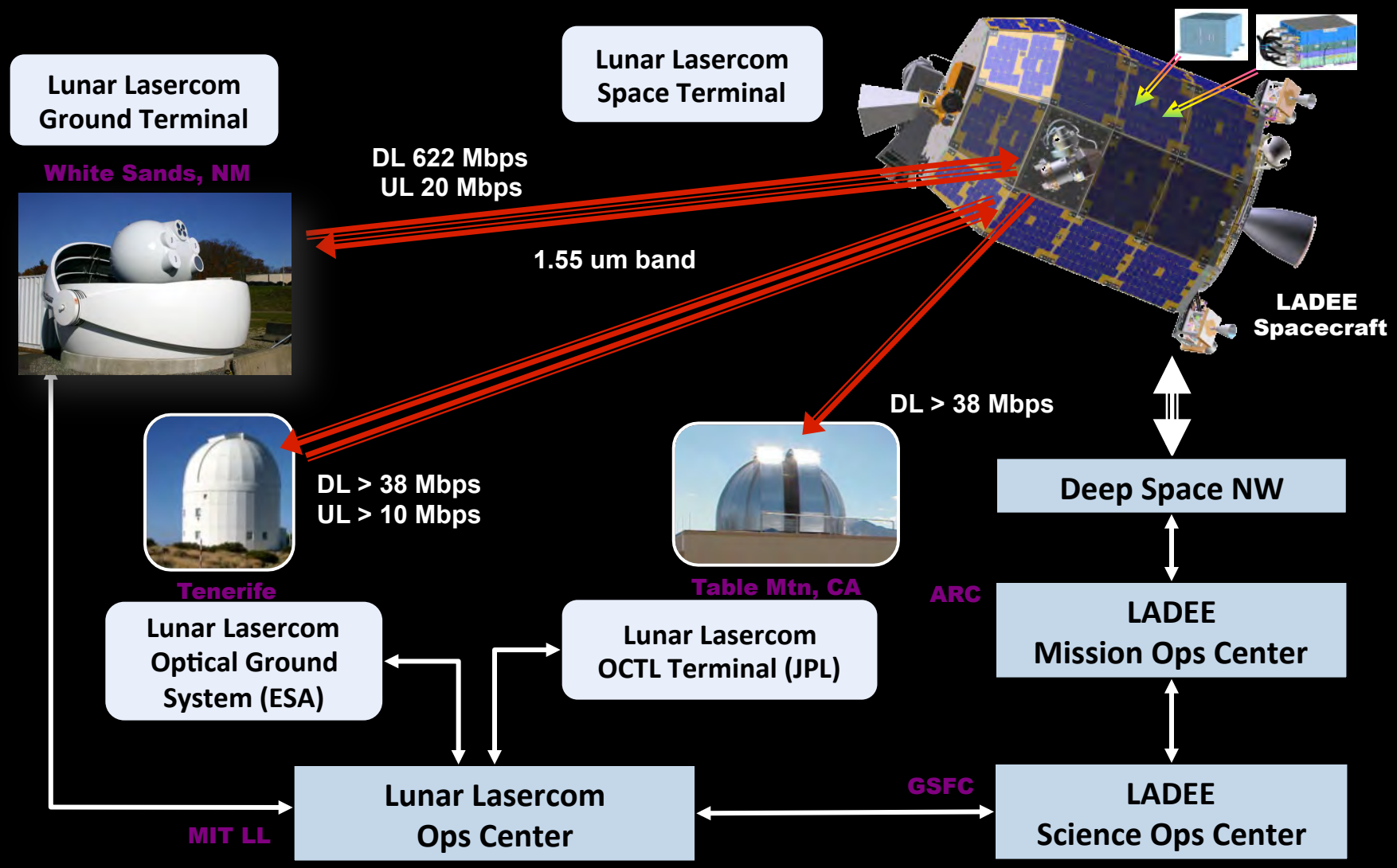
- Science: NMS, UVS, and LDEX
- Technology: Laser Communications

Status:

- Several LLCD “block” tests complete
- Instrument covers off - Commissioning phase has begun



Lunar Laser Communication Demonstration



Over 50 Official Launch Viewing Events Held

- Over 30 sites registered on http://moon.nasa.gov/ladee
- 20 locations in the DelMarVa region were coordinated by the WFF/GSFC team since January 2013. Docents and mobile launch countdown devices deployed.
  - Conservative Estimate: 13,808
- Chincoteague locations:
  - Beach Road
    - 1500 at Beach Road
    - 1100 Assateague Channel Bridge
  - Robert Reed Park:
    - 700-800 people
  - Main Street-hotels- (3)
    - 520. All Island hotels reported no-vacancies for evening of launch
  - Campgrounds
    - Estimated 1000 across four campgrounds

Over 50 Official Launch Viewing Events Held

- WFF Visitor Center – 1088
- WFF UB-40 - 350
- Captain's Cove – Estimated 550
- Assateague- State Park-MD
  - Assateague Welcome Center-50
  - Assateague Campgrounds-600
  - Assateague Youth area-150
  - Assateague Bridge-600-700
- Ocean City-Estimated 3500
- Ocean Pines-Estimated 2000
- Crisfield/Tangiers Island – ~200
- NASA EDGE- Ustream.tv/nasaedge: 20,20 views
  - Facebook: 116,000 views

Ames Research Center – September 6

- Over 7000 guests attended Ames Science Night, featuring the LADEE mission. LADEE was the first

Times Square NYC – September 6

- Mason Peck/SME
- Estimated 2000 in Times Square
- Not as focused as MSL, but Toshiba (LADEE partner) was pleased with event

Photo: Bernd Opoop

Social Media

REACH:

- 7,093,511 total # of people directly following the official launch accounts

TWITTER:

- 231,730,609 potential impressions of @NASA, @NASALADEE & @NASA_Wallops on launch day, Sept. 6. (@NASALADEE alone was 2.4 million of these -- the vast majority were for @NASA).
- 6,319 retweets of official launch accounts on launch day, Sept. 6.
- Gained 11,300 new followers over normal baseline of ~8,000 new followers on @NASA.
- *#1 Trending Topic in the United States at the time of launch on Twitter*

INSTAGRAM:

- 7 images posted about LADEE & the Moon on NASA's New Instagram, with 53,480 likes across the images.
- 70,000 new followers in 24 hours on the new NASA Instagram account.

FLICKR:

- 270 photos posted on the Flickr Group for LADEE images from 197 members

FACEBOOK:

- 1,201,549 potential impressions of NASA's Facebook posts on launch day, Sept. 6.
- Gained 4,419 new likes on NASA's Facebook page over normal rate (~1,700/day)
- Timeline deliveries was 87% of traffic, visits to the NASA page was 8% of traffic, visits to individual photos posted was 4% of traffic, and visits to the UStream player on Facebook was 1% of traffic.
- On photos, interestingly, uploaded image from LADEE launch was seen by 8,800 people with 319 likes; meanwhile, Instagram uploaded photo reshared onto Facebook has 179,100 people with 8,300 likes.

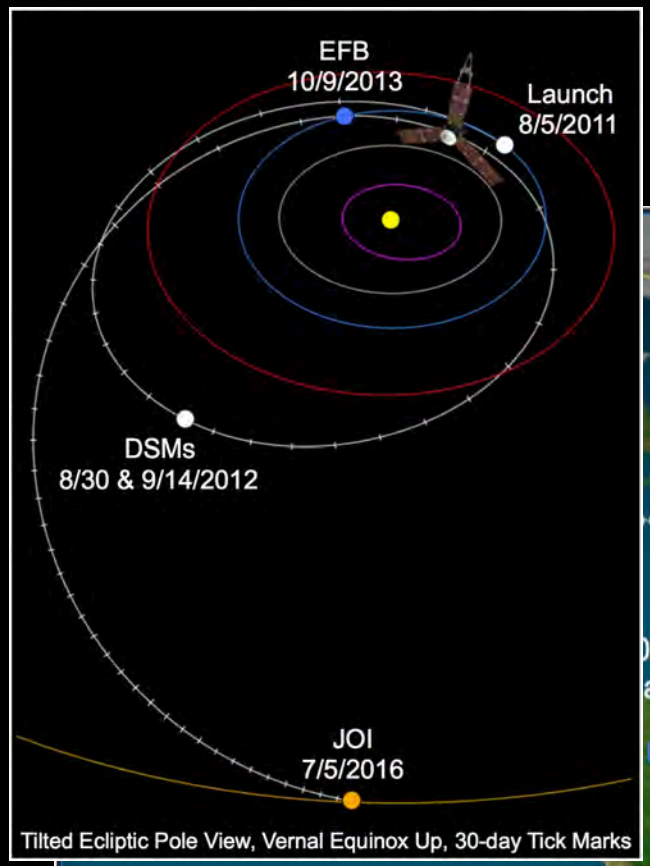
GOOGLE+:

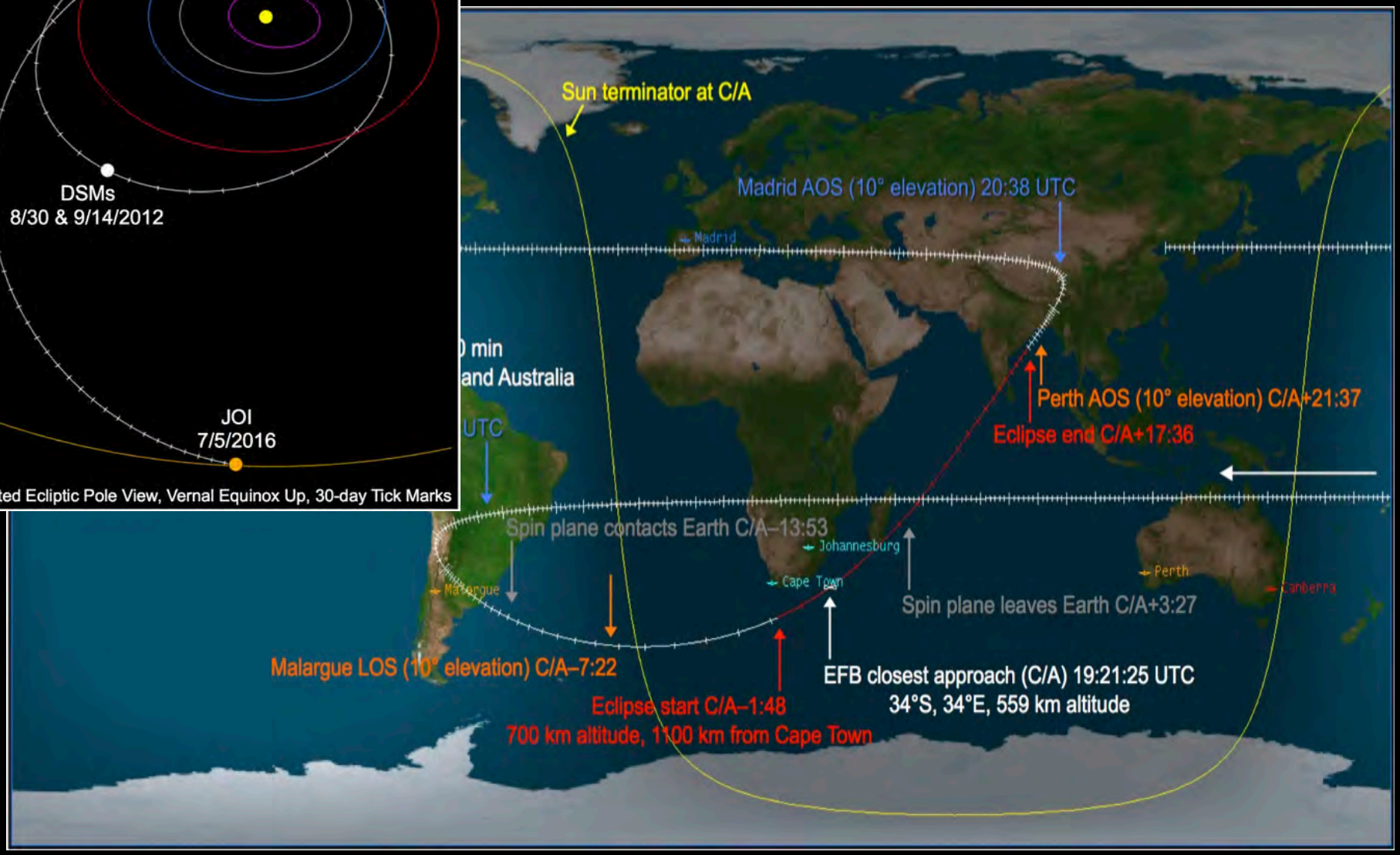
- 1,349,297 people +1 our NASA page on Google+ as of launch day.
- 3,731 total +1's on LADEE related posts on Google+.

NASA SOCIAL:

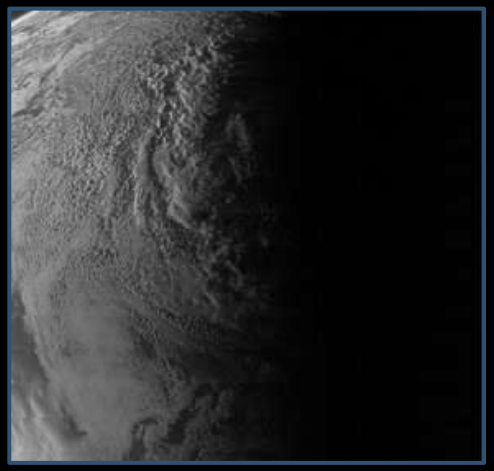
- 3,531 tweets containing the #NASASocial hashtag during the two day event.
- 42 NASA Social participants showed out of 50 invited.
- 62,784 Twitter followers combined across the 50 individuals invited to take part in the NASA Social.

Juno Earth Flyby

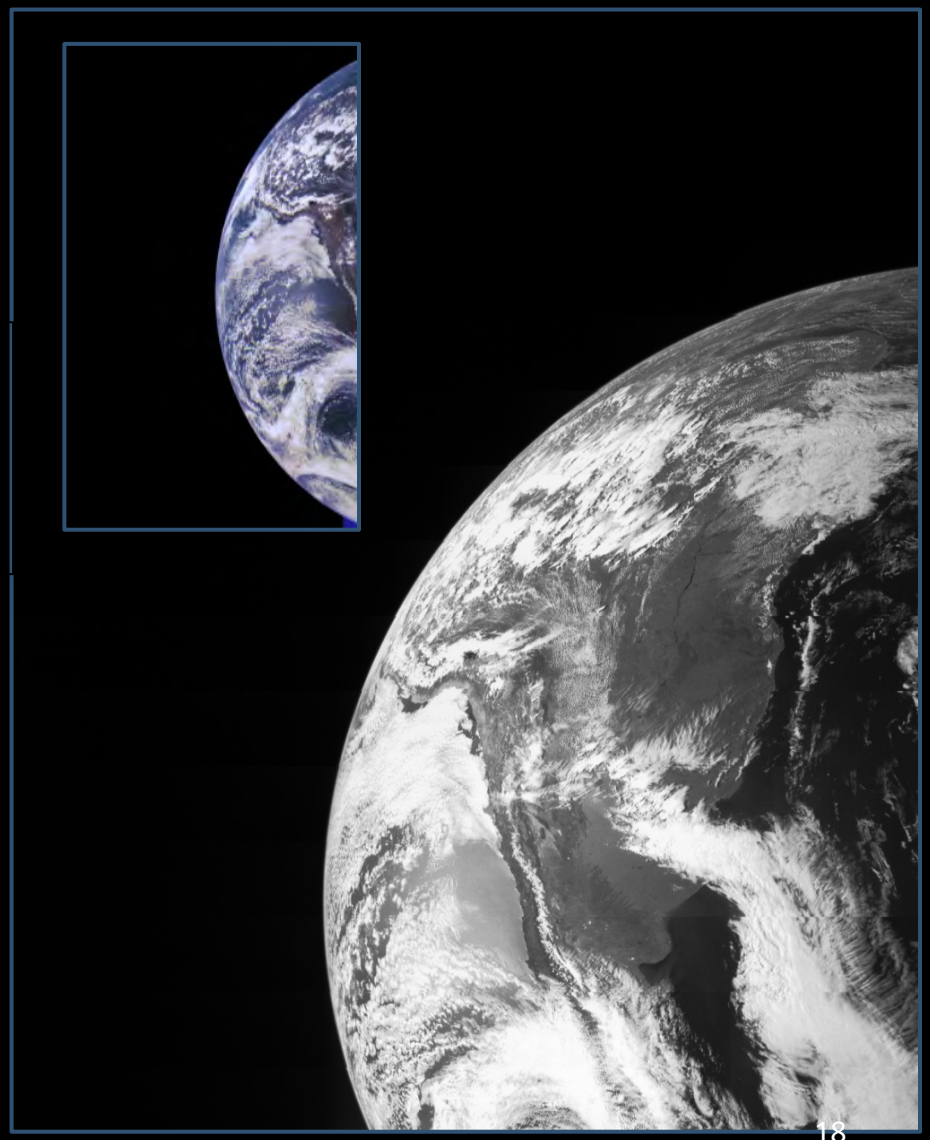




NASA *Juno* Spacecraft's Earth Flyby Images



Juno, launched on August 5, 2011, passed by Earth on its way to Jupiter in a gravity-assist maneuver on October 9, 2013. Images taken by JunoCam instrument.



Right: Earth as seen by JunoCam during Juno's Earth flyby. This monochrome view shows exquisite detail in the clouds and coastlines of South America.

Inset, top left: The west coast of South America is visible in this image, taken when the Juno spacecraft was 15,091 km from the Earth. Processed by "Gerald" at unmannedspaceflight.com

Top: Methane band image of the terminator region taken at 12:15:30 PDT on Oct. 9.

MAVEN

CU/LASP • GSFC • UCB/SSL • LMA • JPL

Launched November 18, 2013, from Cape Canaveral on an Atlas V – on schedule

Mars orbit insertion in Sept. 2014

Science:

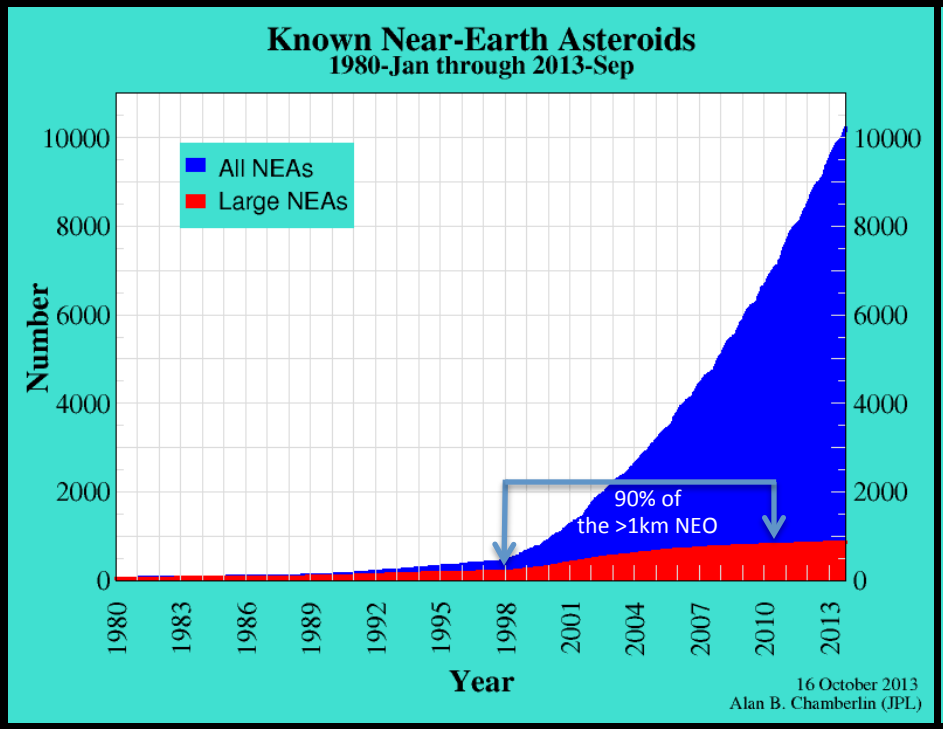
- Determine the structure and composition of the Martian upper atmosphere today
- Determine rates of loss of gas to space today
- Measure properties and processes that will allow us to determine the integrated loss to space through time

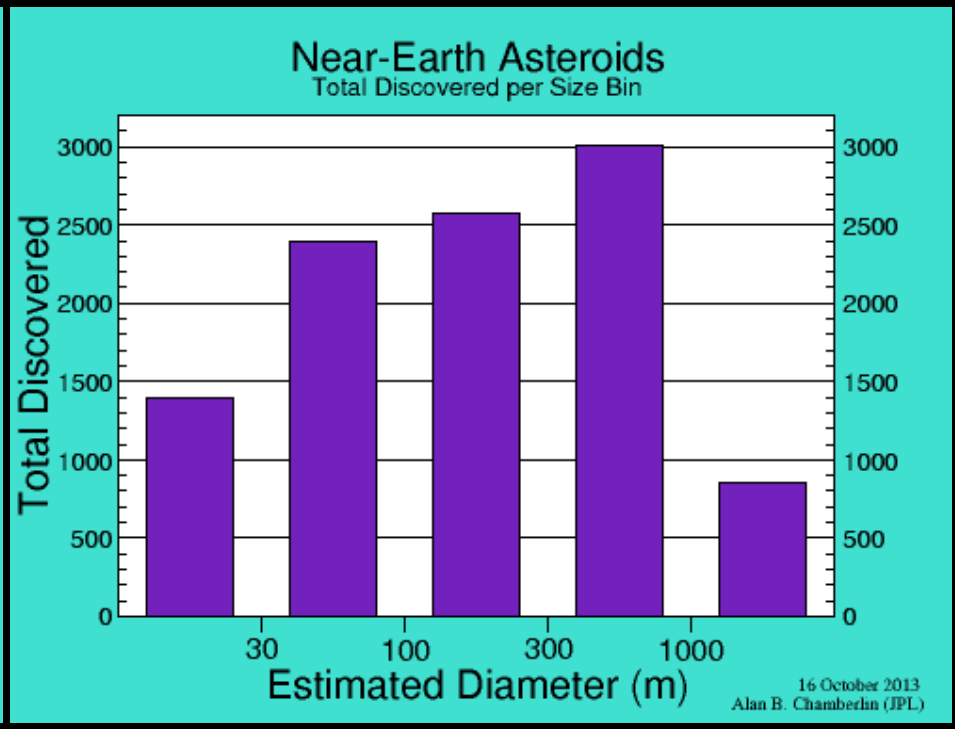
Seeking Signs of Past Life

- **FBO released August 12, 2013**
- **AO released September 24, 2013**
- **NOIs due November 4, 2013**
- **Proposals due January 15, 2014**

Near Earth Objects Program

Quick Status of the NEO Survey Program





- Congressional Bill 1998 – Find 90% of the >1km NEO within 10 yrs
- Congressional Bill 2005 – Find 90% of the >140m NEO within 15 yrs

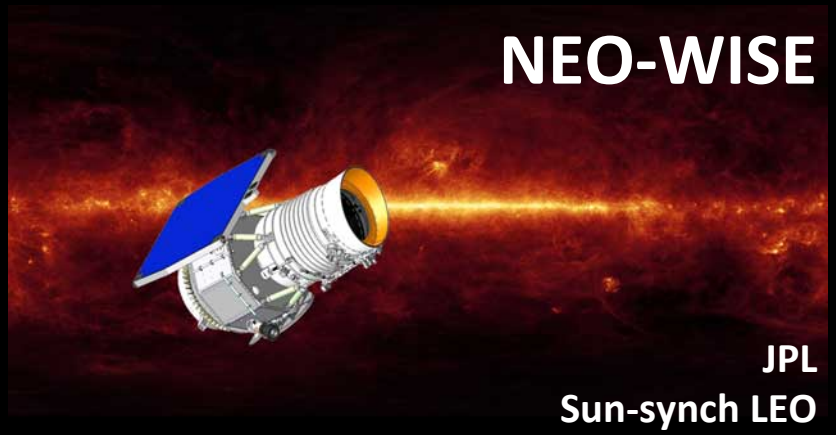
NASA's NEO Observation Program

Minor Planet Center (MPC)
- IAU sanctioned
- Int'l observation database
- Initial orbit determination

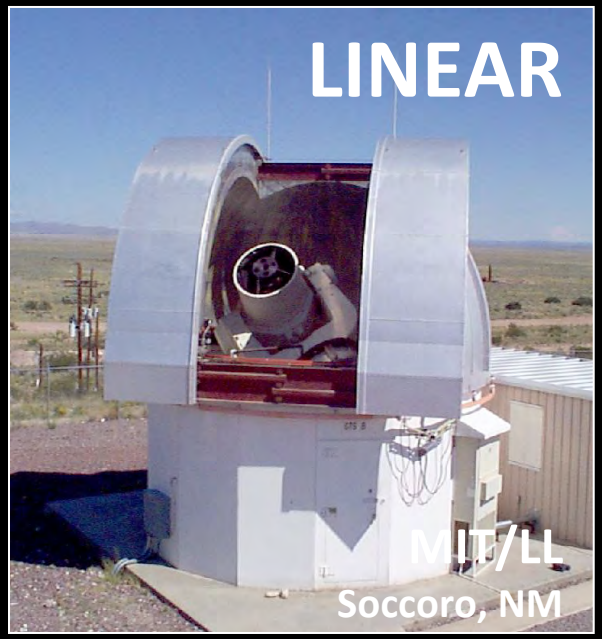
www.cfa.harvard.edu/iau/mpc.html

NEO Program Office @ JPL
- Program coordination
- Precision orbit determination
- Automated SENTRY

http://neo.jpl.nasa.gov/

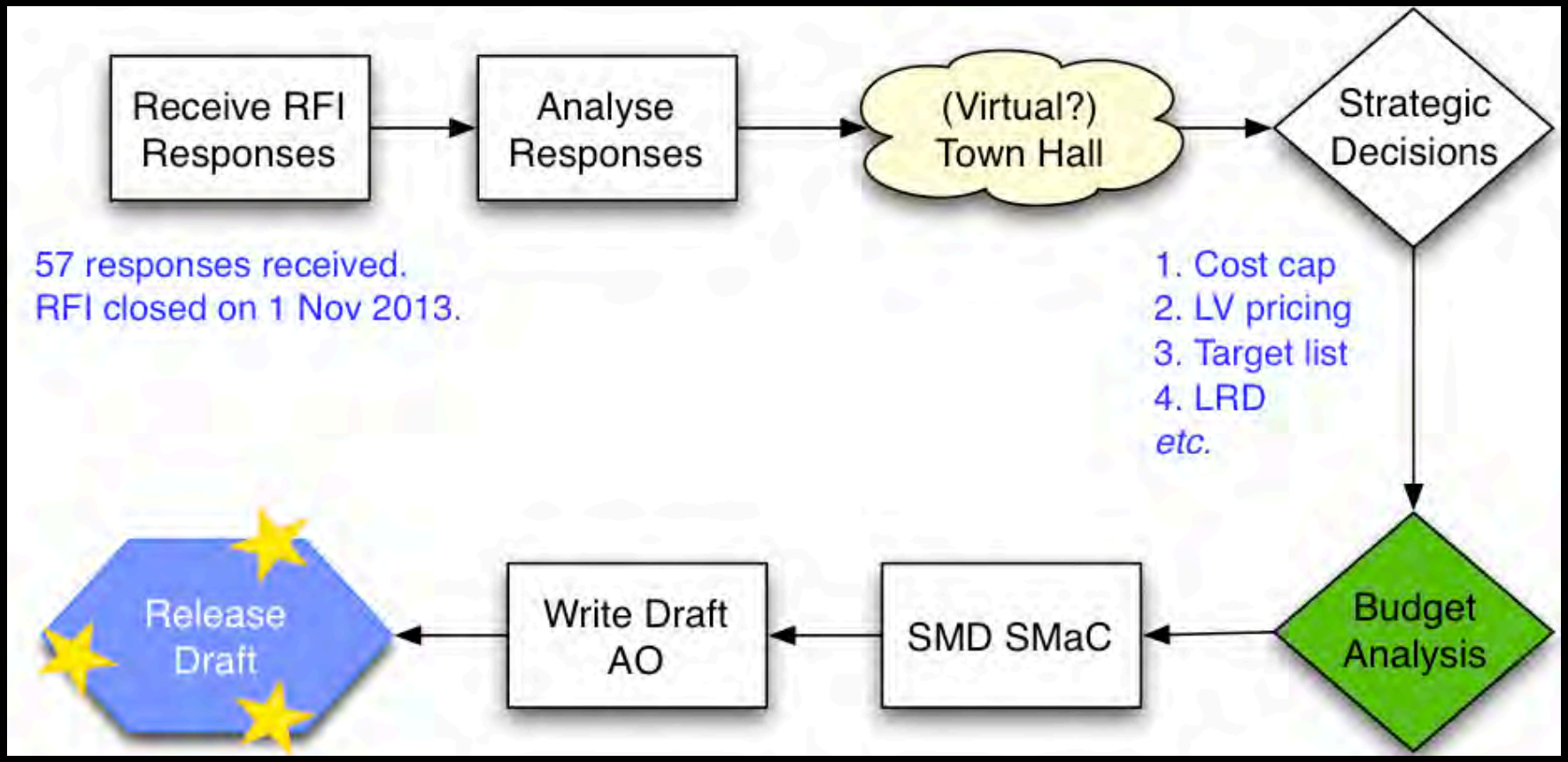


Reactivated WISE on Aug.19



Next Discovery AO

Process for Next Discovery AO



Michael H. New, Lead Discovery Program Scientist

Upcoming Senior Review

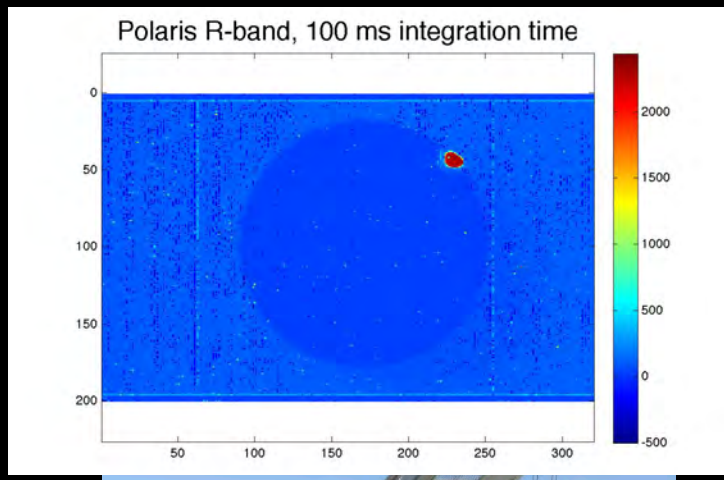
Senior Reviews

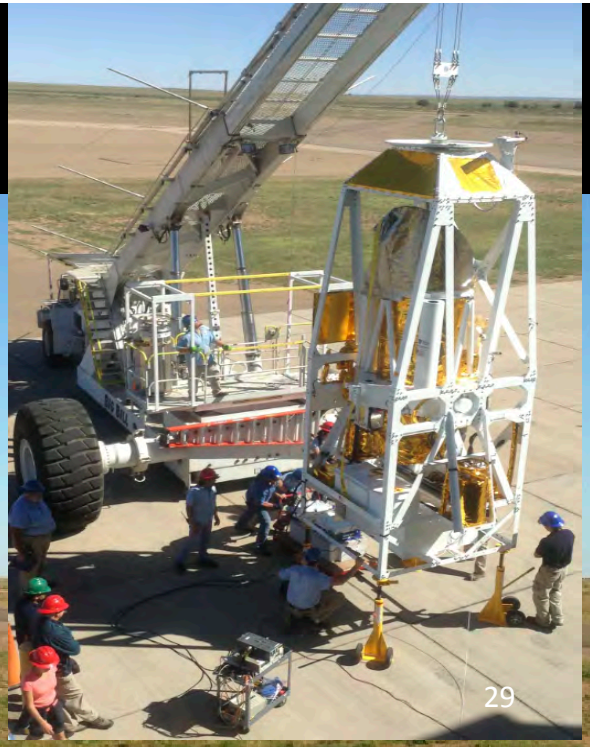
- Last Senior Review was completed in July 2012 for fiscal years FY13 and FY14
- Guidelines for the next senior review to be issued early 2014
  - Total funding available for extended missions is approximately constant at FY14 levels
  - Missions in the review: Cassini, LRO, Mars Express, MRO, Opportunity, Mars Odyssey, and Curiosity
- Due to a constrained budgets what should be critical features/discriminators of the next call for proposals?

Suborbital Flights

BRRISON Anomaly Summary

- During ascent the telescope deployed and commissioning began; included capture of star image shown
- At ~90,000 feet the telescope unexpectedly returned to the stowed upright position with high torque
- The telescope's angular rate was too fast and its stow bar became trapped behind the stow latch
- Numerous commands were issued to release the telescope during the overnight flight but were all unsuccessful
- Payload recovered in excellent shape
- Probable cause under investigation
- Telescope will be repaired and available for future flights (for example: Comet Siding Spring)





Comet ISON observations with FORTIS

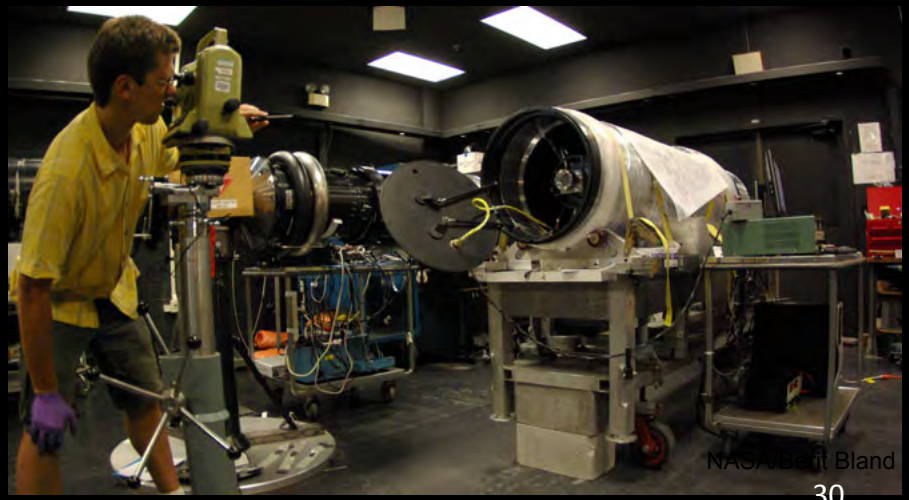
(Far-uv Off Rowland-circle Telescope for Imaging and Spectroscopy)

Launch: November 19, 2013
White Sands Missile Range

- Far-UV (800-1950 Å) spectra and imagery of comet ISON.
- Measure volatile production rates of CO, H, C, C+, O and S
- Search for previously undetected atomic and molecular species (*e.g.,* Ar, N, N+, N2, O+ and O5+)

Stephan McCandliss, PI, JHU
Paul Feldman, Co-I/Science PI, JHU

Jointly funded by Planetary and Astrophysics Divisions



The Venus Spectral Rocket Experiment (VeSpR)

NASA's next Venus flight mission

Scheduled Launch:	**November 25, 2013**
Launch Site:	White Sands Missile Range, New Mexico
Mission Number:	36.261
Principle Investigator:	John Clarke (Boston University) jclarke@bu.edu 617-353-0247

Purpose: To study the present day escape of water from the atmosphere of Venus and relate it to the past abundance of water on Venus

Mariner 10 Image of Venus

DoE RPS Infrastructure Review Status

Review Committee Membership

- NASA Membership
  - **Jim Adams** Chair, NASA Deputy Chief Technologist
  - **David Schurr** NASA PSD Deputy Division Director
  - **Hal Bell** NASA Deputy Chief Engineer
  - **Frank Bellinger** NASA Facilities Engineering & Real Property Director(former); NASA WFF Technical Director
  - **Kevin Gilligan** Committee Executive Secretary; NASA OCFO Program Analyst

- Non-NASA Consultants
  - **Ralph McNutt** APL, NRC RPS Study Chair
  - **Mark Rokey** The Aerospace Corporation
  - **Tim Frazier** DOE Radioisotope Program Director (former)

- Ex-Officio Observers
  - **Len Dudzinski** NASA PSD Liaison
  - **Alice Caponiti** DOE NE-75 Liaison

DOE RPS Infrastructure Capabilities

DOE manages RPS assembly, delivery and analysis capabilities and RPS development and system integration contracts

- Physical infrastructure at INL, ORNL, LANL
  - Material handling
  - Material storage
  - Safeguards and security
  - Safety
  - Waste management
- Personnel skills
  - Professionals and technicians
  - Corporate knowledge
  - Succession
- Assemble, test and deliver power systems
- Analyze safety and risk of RPS deployment and operations
- Knowledge Bases
  - Safety: in design, production and use for worker safety in production and public safety in application
  - Quality assurance: in production, assembly and testing to assure product quality
  - Program knowledge: the integration of all processes and participant organizations
- Provide launch support and emergency response
- Manage plutonium-238 supply
- Provide international leadership on safe use of space NPS
- Manage customer funded RPS System Integration Contracts

Select Observations

Pu-238 is an exceptionally difficult material with which to work.
Disposal of waste products is a significant factor in the process.
The processes observed at the sites did not show excess.
The role of DOE in the process is essential.
RPS's are a critical resource to execute most missions from the National Research Council's National Academy of Science Decadal Survey of Planetary Science for the period 2013-2022.
If the need for plutonium-238 grows beyond the 1.5kg annual production rate currently planned, significant changes will be necessary.
Fine-weave pierced fabric is a critical resource in the production of general-purpose heat source modules.

Select Recommendations

Together, NASA and DOE should derive production rates that maintain proficiency across the DOE sites, as well as meet NASA's future mission needs.
Ensure the availability of fine-weave pierced fabric in order to enable general-purpose heat source module production.
Communications between NASA and DOE need to be free and open, while authority needs to be formalized.
Regularly scheduled meetings should be held between the leadership of NASA and DOE at all levels.

Continued on next slide…

Select Recommendations (cont.)

Though NASA is providing infrastructure funding, the responsibility, accountability, and ownership of these assets should remain with DOE.
NASA should ensure sufficient funding is available to DOE so as to not impact ongoing operations
The investigation of new processes should be considered routinely, coupled with a long-term continuous improvement program.

ASRG Status

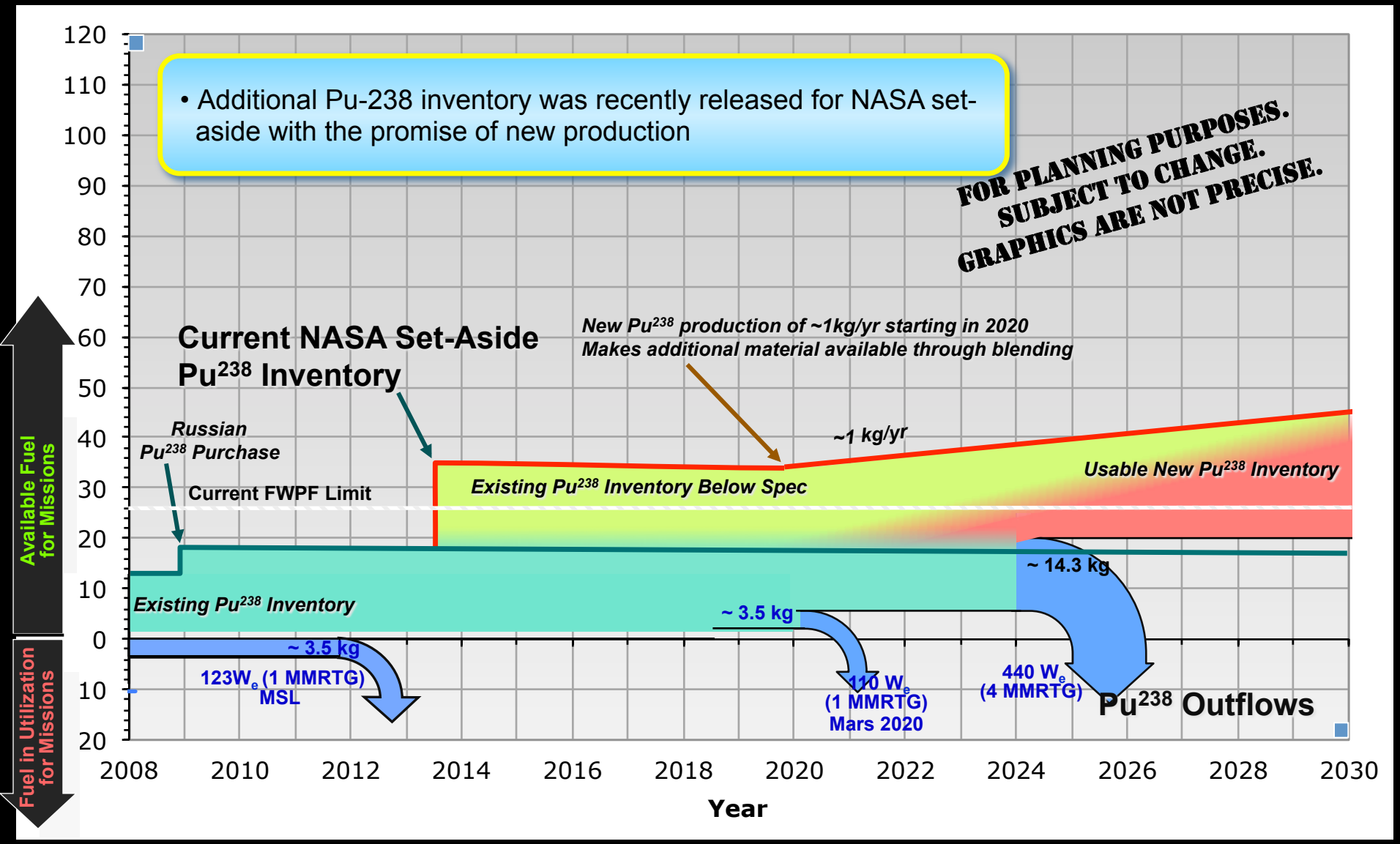
Background

- The Science Mission Directorate (SMD) and Planetary Science Division (PSD) are under *tighter* fiscal constraints for FY13 and beyond than when the ASRG project was established.
  - No Flagship missions were identified in the President's FY14 budget request that would require ASRGs.
  - The Discovery and New Frontiers Announcements of Opportunity (AOs) will have a slower than historical cadence under the FY14 budget levels, reducing the concerns about Plutonium limitations.
- Pu-238 availability, incorporating new production, will be sufficient to support the cadence that PSD can support using MMRTG technology

Go Forward Plan

- PSD has been directed to maintain the infrastructure, technology, expertise, and production capabilities for the Nation's RPS capabilities.
  - This has to be our highest RPS priority
- PSD's technology program, and the RPS Program, is re-scoped to optimize production and sustaining of existing capabilities, to support the expected missions and mission cadence of the Planetary programs
- PSD has directed DOE to terminate the existing ASRG flight project, and the RPS Program Office to develop options to continue Stirling research as a technology development project

Plutonium Availability



Research & Analysis Status & Plans

Jim Green – SSERVI
Jon Rall – ROSES

NASA's Intent for SSERVI

SSERVI was created to further the goals of science and exploration by addressing fundamental and applied science questions and human spaceflight concerns, i.e., to bring science to bear on issues related to potential targets for human exploration.

- Science which enables human exploration
- Science enabled by human exploration

SSERVI is funded jointly by SMD/PSD and HEOMD/AES through the Joint Robotic Precursor Activity (JRPA)

- Important opportunity to advance joint goals

The NASA virtual institute structure is uniquely suited to create and foster inter-team, as well as interdisciplinary, collaborations (e.g. heliophysics and geology) that previously would not have existed. Therefore, expansion of the NASA Lunar Science Institute's scope to include all potential near-term human destinations (Moon, NEAs, Phobos/Deimos) is the most effective method of integrating science (SMD) and exploration (HEOMD) research goals.

SSERVI Selected Teams

- **Bill Bottke**, Southwest Research Institute. "*Institute for the Science of Exploration Targets: Origin, Evolution and Discovery*"
- **Dan Britt**, University of Central Florida. *"Center for Lunar and Asteroid Surface Science"*
- **Ben Bussey**, Applied Physics Lab, Johns Hopkins University. *"Volatiles, Regolith and Thermal Investigations Consortium For Exploration and Science (VORTICES)"*
- **Bill Farrell**, Goddard Space Flight Center. *"Dynamic Response of Environments at Asteroids, the Moon, and moons of Mars (DREAM2)"*
- **Tim Glotch**, Stony Brook University. *"Remote, In Situ and Synchrotron Studies for Science and Exploration"*
- **Jennifer Heldmann**, Ames Research Center, *"Field Investigations to Enable Solar System Science & Exploration"*
- **Mihaly Horanyi**, University of Colorado. *"Institute for Modeling Plasma, Atmospheres and Cosmic Dust (IMPACT)"*
- **David Kring**, Lunar and Planetary Institute. *"Inner Solar System Impact Processes"*
- **Carle Pieters**, Brown University. *"Evolution and Environment of Exploration Destinations: Science and Engineering Synergism (SEEED)"*

Recommended Institute - Programmatic Balance

					Britt		Heldmann						
	Heldmann				Farrell	Heldmann	Britt						
	Britt		Heldmann		Pieters	Britt	Farrell						
	Pieters		Pieters		Bussey	Pieters	Pieters		Heldmann				
Pieters	Bussey		Bussey		Bottke	Bussey	Bussey		Farrell				
Bottke	Bottke		Bottke	Britt	Kring	Kring	Kring	Farrell	Pieters	Heldmann		Heldmann	
Kring	Kring	Farrell	Kring	Farrell	Horanyi	Horanyi	Horanyi	Horanyi	Bussey	Bussey		Kring	
Horanyi	Glotch	Horanyi	Glotch	Horanyi	Glotch	Glotch	Glotch	Glotch	Glotch	Glotch	Britt	Glotch	Glotch
Role of Target Body(s) in revealing the origin and evolution of the inner Solar System	Target Body structure and composition	Innovative observations that will advance our understanding of the fundamental physical laws, composition, and origins of the Universe	Moon, NEA, and Martian moon investigations as windows into planetary differentiation processes	Dust and plasma interactions on Target Body(s)	Near-Earth asteroid characterization (including NEAs that are potential human destinations)	Geotechnical properties (Moon, NEAs, Mars)	Regolith of Target Bodies	Radiation	Volatiles (in its broad sense) and other potential resources on Target Body(s)	In-Situ Resource Utilization (ISRU)/ Prospecting (Moon, NEAs, Mars)	Propulsion-induced ejecta (Moon, NEAs, Mars)	Operations/Operability (all destinations, including transit)	Human health and performance (all destinations, including transit)

Science emphasis

Exploration emphasis (SKGs)

Planetary Research & Analysis

Program Consolidation & Restructuring

- Why are we consolidating & restructuring R&A?
- What are the goals of consolidation?
- What are the pros and cons of consolidation?
- What are modestly healthy and sustainable funding levels for a restructured R&A program?

Approach: Program Evolution not Revolution

Why are we consolidating & restructuring R&A?

- Planetary R&A originally started with a few "Core" programs decades ago based on disciplines (Planetary Atmospheres, Planetary Astronomy, Cosmochemistry, Exobiology
- To grow the R&A budget, new program elements were created and added on
- Special targeted and focused program elements that should have retired have stayed in the portfolio so that we have a mix of program elements
  - Some covering science disciplines and some covering single planetary targets.
- With limited budgets and growing numbers of planetary scientists, proposal pressure is increasing and selection rates plummeting

Restructuring Goals

Management Goals

- To make the structure of the R&A program explainable to those outside of NASA.
- To make it easy for those outside of NASA to compute the amount of money spent on grants.
- To reduce the time between proposal submission and award announcement.

Program Officers' Goals

- To encourage interdisciplinary research.
- To enable PSD strategic decision making.
- To be more flexible in responding to changing research priorities.
- To reduce overlaps between program elements.

Planetary Science Objective:
Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.

Establish 5 new core programs aligned with the five basic science themes (which are also our annual performance goals).

- **How did the Sun's family of planets, satellites, and minor bodies form and evolve? (Building New Worlds)**
- **How do the chemical and physical processes active in our solar system operate, interact and evolve? (How Planetary Systems Work)**
- **What are the characteristics of the solar system that lead to habitable environments? (Habitable Worlds)**
- **How did life originate and evolve here on Earth and can that guide our search for life elsewhere? (Exobiology & Evolutionary Biology)**
- **What are characteristics of planetary objects and environments that pose threats to, or offer potential resources for, humans as we expand our presence into the solar system? (NEOO & PAST)**

Continuing Program Elements

- Institutes (NAI and SSERVI) are already cross cutting
- PSD has already begun the restructuring process:
  - From: PDDIP, ASTID, MDIP
  - To: PICASSO and MatISSE
- Programs not included in the reorganization are:
  - Data Analysis Programs
  - Planetary Protection
  - Laboratory Analysis of Returned Samples

Planetary Science R&A – path forward

- All ROSES 2013 calls are closed (except: LASER & OPR) with some reviews are yet to be completed – paid with FY14 funding
- Implement some or all of restructuring in ROSES 2014 solicitation – budget dependent
  - ROSES 2014 is paid out of FY15 dollars
- Planning a virtual roll-out for first week of December (week before AGU Fall meeting)
  - WebEx, Adobe Connect, Google Hangout etc. but widely advertised and open to everyone
  - Accepting comments/recommendations through the AGs

Backup Charts

"Flyby, Orbit, Land, Rove, and Return Samples"

NASA's Planetary Science

Advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as humans explore space