Reflections on the Implementation of *New Frontiers in the Solar System* & *Vision and Voyages*

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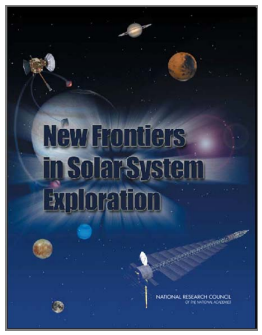
December 16, 2020

New Frontiers in Solar System Exploration (2003-2013)



- Content: New Frontiers, Discovery, Mars Exploration, R&A (NAI, Curation, PDS, and NEO)
- Challenges: Major budget reductions in R&A and Mars; Very small NEO program moving to Earth Science at one time; limit of Pu^{238}; Cost overruns on MSL & Juno threatened cancellation;
- New Initiatives: Lunar Program/NLSI, Redefined DoE-PSD partnership, Restructure R&A program; new opportunities with SALMON AO
- Community Input: AGs, CoEL, CAPS, town halls
- JLG Observations:
  - Limited PSD staff to perform all necessary functions
  - Very difficult and long procedure to obtain NAS input (no CAPS reports):
    - Opening New Frontiers in Space: Choices for next NF AO
    - Grading NASA's Solar System Exploration Program: A Midterm Review
    - Review of the Restructured R&A Program

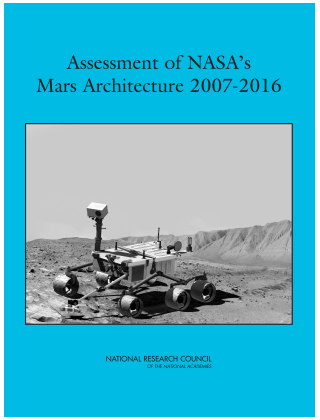
JLG Reflections (Complex 3/19/08)

- 19 months ago the PSD had these problems:
  - Research & Analysis was cut by 15%
    - Below life support! - Professors telling students don't go into PS
  - Astrobiology cut 50% (~$32M)
    - Putting in question if it would survive - NASA abandoning field?
  - New Frontiers mission Juno was being considered for cancellation (in Phase-A and over $1B)
    - Leading to the possible killing of NF program entirely
  - All NEO activities were moving to ESD
    - A very small program but a political football – Earth Science had National Needs w/Climate Change
  - VSE did not include science to/from/on the Moon – This is what happens when we ignore HEO
    - LSSO was SMD's only activity and it was a token at best – Lunar Sortie Science Opportunity (7 out of 70)
  - No Discovery selection (deja vu)
  - No Outer Planets Flagship
    - Community to be forced to survive within a dwindling R&A program
  - PSD was grossly understaffed with low morale – I brought in Detailees from the Centers to help
- Today these are no longer PSD problems but we do have a few different challenges

These were my decision – there were no decision rule in the NFSS Decadal

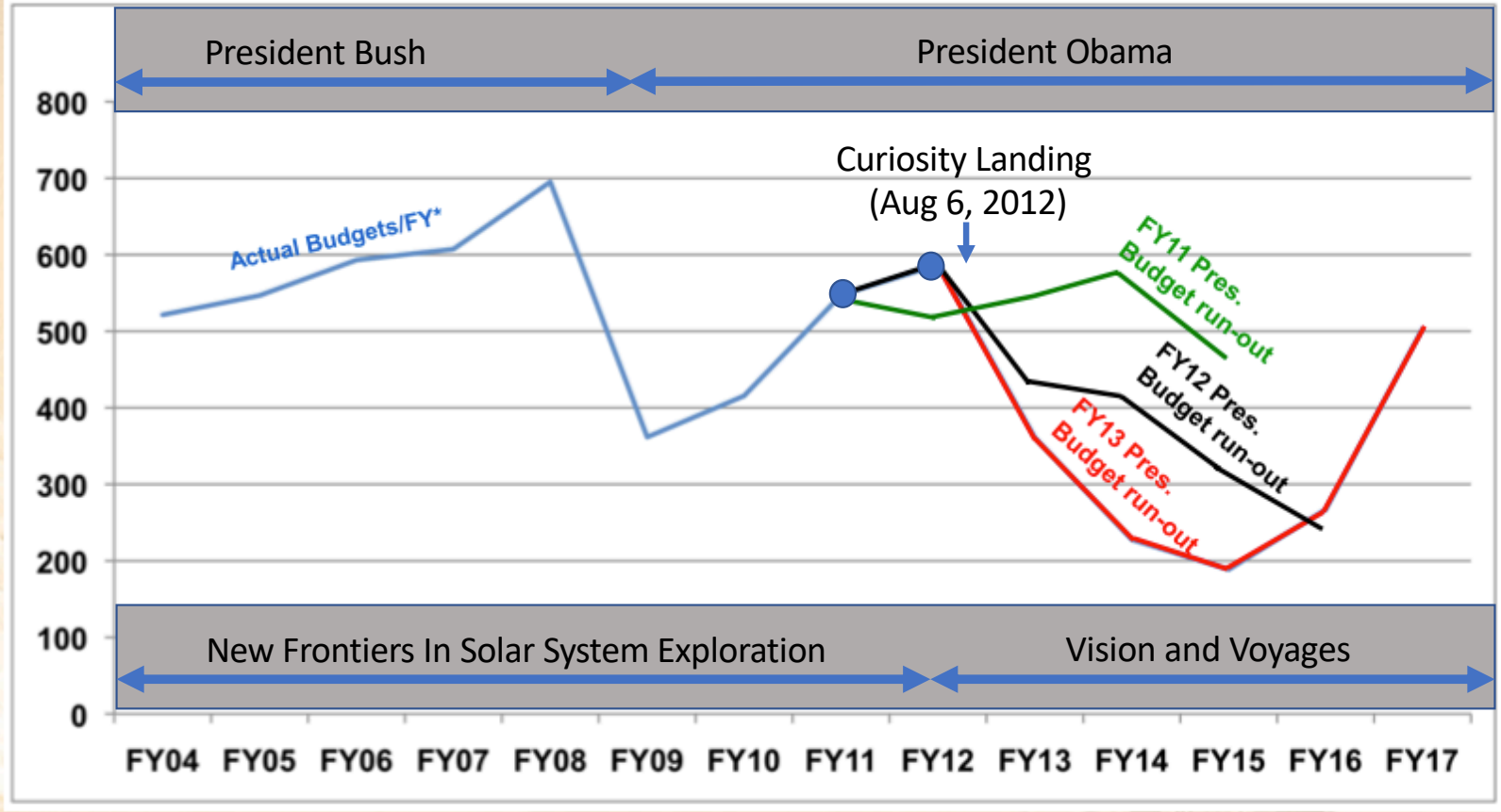
Mars Exploration Program History

- 1994 Mars Exploration Program (MEP) Begins
  - Missions: 96’ Mars Global Surveyor; [96’ Mars Pathfinder – Disco Prg]; 99’ Failure of both Mars Climate Orbiter and Mars Polar Lander
- April 2000-June 2001 S. Hubbard Dir. MEP defines new program
  - Missions: 01’ Odyssey; MER; MRO; Scout, MSR next decade
  - MEP reported directly to SMD AA budget separate from Solar Sys Exp Division (SSED)
- June 2001- Sept 2004 Orlando Figueroa, Dir. MEP
  - Missions: 03’ Spirit/Opportunity
  - Sept 2004 MEP joins Solar System Exploration Division; Orlando Dir
- Oct 2004 – Dec 2012 Doug McCuistion, Dir. MEP
  - Missions: 05’ MRO; 07’ Phoenix; 11’ MSL/Curiosity;
- Jan 2013 – Nov 2014 Jim Green, Acting Dir. MEP
  - Missions: 13’ MAVEN;
- Dec 2014 – Aug 2020 Jim Watson, Dir. MEP
  - Missions: [18’ InSight - Disco Prg]; 20’ Perseverance;



MEP Budget History
Including President's FY13 Request

Meyer/Green
CAPS March 2013 mtg
Budget Chart



(*) actual based on last Op Plan of each Fiscal Year

New Frontiers Program

1st NF mission
New Horizons:

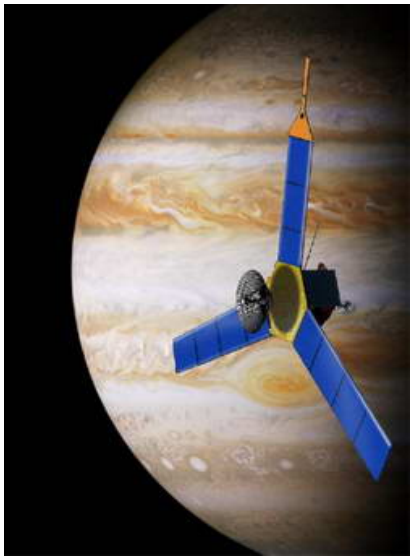
Pluto-Kuiper Belt Mission
(scheduled launch: Jan. 2006)

Launched January 2006
Arrives July 2015

Uses RPS

2nd NF mission
JUNO:

Jupiter Polar Orbiter Mission

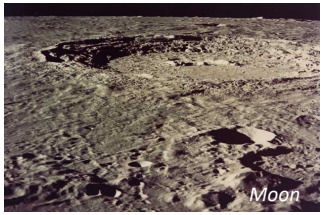


August 2011 launch

No RPS

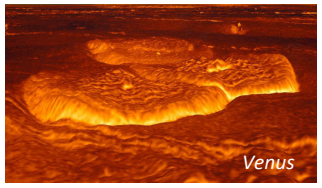
3rd NF mission opportunity

Lunar South Pole – Aitken Basin Sample Return

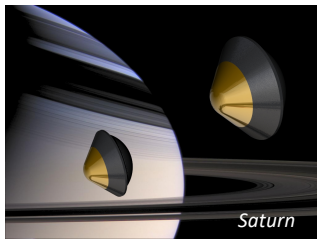


Comet Surface Sample Return (CSSR)

Venus In Situ Explorer (VISE)



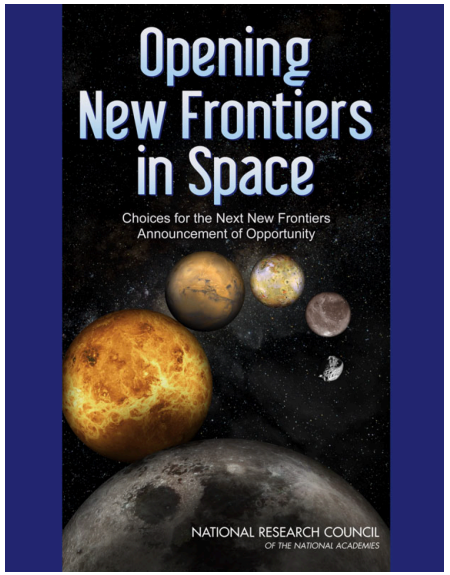
Saturn Flyby with Probes



No RPS available?

Just Released NRC NOSSE Report (2008)

- "*Opening New Frontiers in Space: Choices for the Next New Frontiers AO*" - NASA should:
  - R1: Emphasize science objectives
  - R2: Expand the list of candidate missions
  - R3: Limit to the list below unless compelling science
- Recommended target list in alphabetic order:
  - *Asteroid Rover/Sample Return**
  - Comet Surface Sample Return
  - *Ganymede Observer**
  - *Io Observer**
  - Lunar South Pole Aitken Basin Sample Return
  - *Mars Network Science**
  - *Trojan/Centaur Reconnaissance**
  - Venus In-Situ Explorer
- Report located at: http://www.nap.edu/catalog/12175.html



* Additions

New Frontiers Program

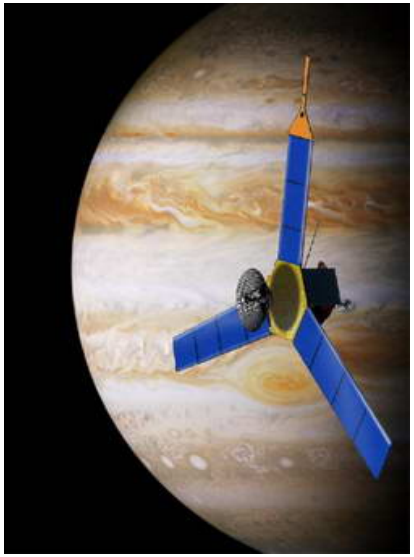
1st NF mission
New Horizons:

Pluto-Kuiper Belt

Launched January 2006
Arrives July 2015
PI: Alan Stern (SwRI-CO)

2nd NF mission
JUNO:

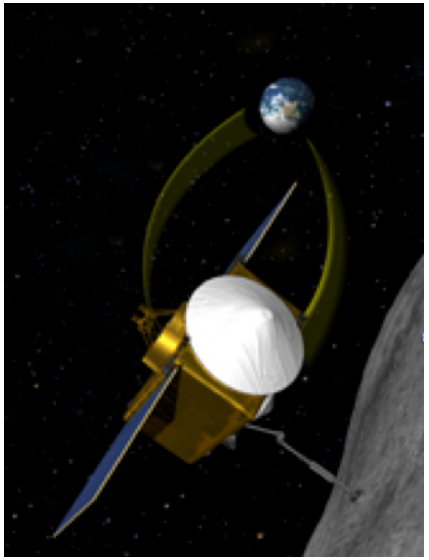
Jupiter Polar Orbiter



Launched August 2011
Arrives July 2016
PI: Scott Bolton (SwRI-TX)

3rd NF mission
OSIRIS-REx

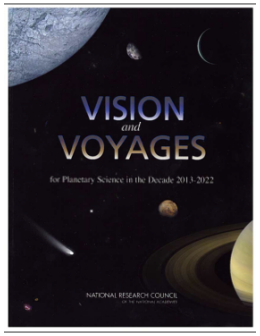
Asteroid Sample Return



Sept. 2016 LRD
PI: Dante Lauretta (UA)

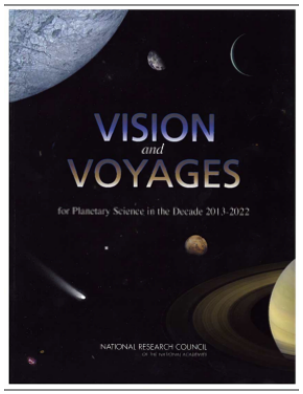
Selected
May 25, 2011

Vision and Voyages (2013-2022)



- Content: New Frontiers, Discovery, Mars Exploration, R&A (NAI, Curation, PDS, and NEO)
- New Features: CATE estimates; Decision rules for increasing or declining budgets;
- New Initiatives: SSERVI, NAI Transition to research networks, SIMPLEx
- New Starts: Perseverance, Europa Clipper, NEO Missions, Lunar, MSR
  - Must have AA, Administrator, OMB/OSTP, and Congressional Support
- Community Input: AGs, CAPS, town halls ...
- Observations: CAPS letter reports (starting 2017) are extremely important such as:
  - Getting Ready for the Next Planetary Science Decadal
  - Review of the Planetary Science Aspects of Lunar Sci & Exp Initiative
  - Review of the Commercial Aspects of Lunar Sci & Exp Initiative
  - Options for the Fifth New Frontiers AO

Planetary Program Architecture
Recommended by the Planetary Decadal Survey (2011-2022)



Large Missions ("Flagship"-scale)

"Recommended Program"
(budget increase for JEO new start)

1) Mars Astrobiology Explorer-Cacher – descoped
2) Jupiter Europa Orbiter (JEO) – descoped
3) Uranus Orbiter & Probe (UOP)
4/5) Enceladus Orbiter & Venus Climate Mission

"Cost Constrained Program"
(based on FY11 Request)

1) Mars Astrobiology Explorer-Cacher – descoped
2) Uranus Orbiter & Probe (UOP)

"Less favorable" budget picture than assumed
(e.g., outyears in FY12 request)

Descope or delay Flagship mission

Discovery
$500M (FY15) cap per mission (exclusive of launch vehicle) and 24 month cadence for selection

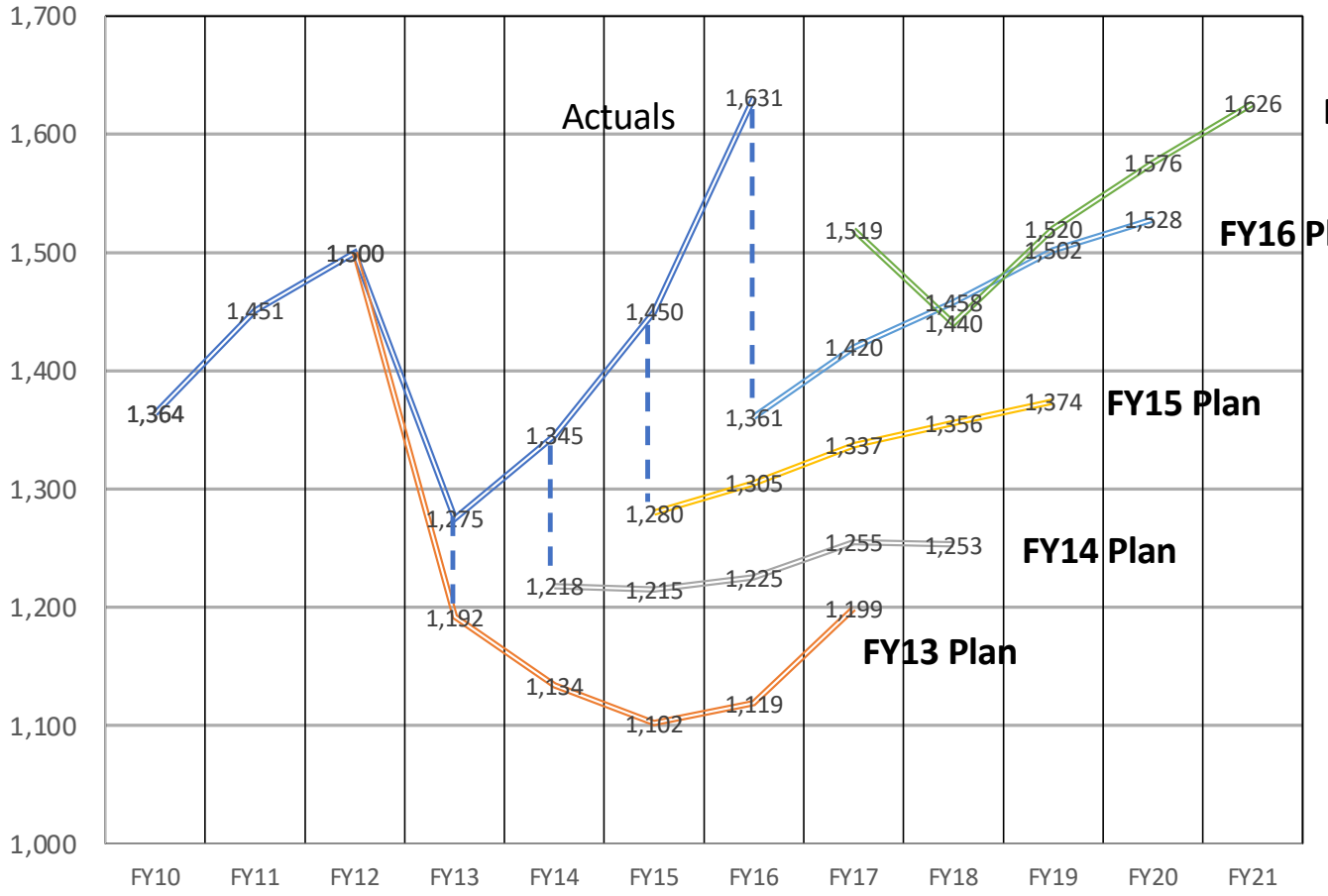
New Frontiers
$1B (FY15) cap per mission (exclusive of launch vehicle) with two selections during 2013-22

Research & Analysis (5% above final FY11 amount then ~1.5%/yr)

Technology Development (6-8%)

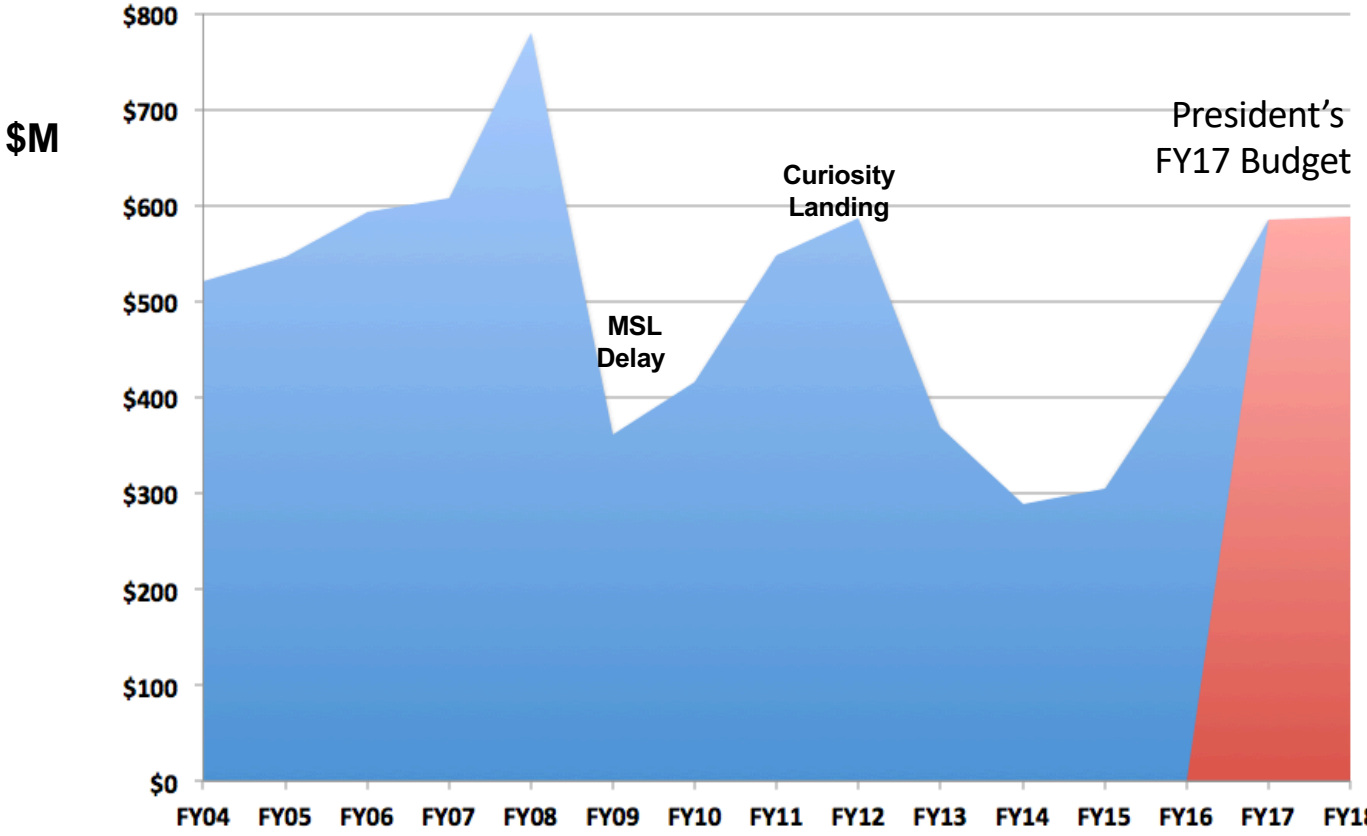
Current Commitments (ie: Operating Missions)

Planetary Program Budget Plans & Actuals



- Very Low 5 yr Pres Budget
- Congress provides MORE $ in 1 yr
- PSD can not select a mission without a mission “wedge”
- Results in delay of AOs

Mars Budget Analysis FY04 through FY18



Date: Feb 15, 2016	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18
Passed Budget	$521	$547	$593	$607	$780	$362	$416	$547	$587	$370	$288	$305	$434	$0	$0
President's FY17 proposed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$585	$589

Political and Programmatic Decisions that Occur

- Budget Reduction FY08-12
  - Selected MAVEN in Sept 2008 then moved it to the next opportunity (launched Nov 11, 2013)
  - Complete loss of the Mars Scout Program (*it will never come back)* in 2010
    - Mars Scout-like missions would be incorporated into the Discovery Program
  - InSight, a Mars seismology and geology mission, was chosen in Discovery
- Budget Reduction FY12-16 (total cut in PSD was ~$310M + $55M DoE costs)
  - Collapse of NASA's major ESA/TGO contributions (no instruments, no LV, Electra only)
  - Funding operating missions and MAVEN only was projected in (FY12 Presidents Mars Budget)
  - Mars 2020 study efforts by the Mars Program Planning Group (Feb 2012)
  - Loss of the Lunar Quest Program

Lunar Quest Program

- The change in Administration completely eliminated the LQ Program
  - FY09 - FY12 ($140M); FY13 ($65M) for close out
- LADEE launched September 7, 2013; EOM April 18, 2014
- With LQ close out moved LRO to Discovery; lunar science to R&A
  - LRO funding split from LQ to Disco then all Disco instead of declaring it EOM
- Renamed NLSI to SSERVI funded it out of R&A – trying to maintain our HEO connection

Evolution of the NEO Observation program

- Congressional Directives (Authorization Bills):
  - 1998 find 90% asteroids $\geq$1 km in size by 2008 (achieved in 2010)
  - 2005 find 90% asteroids $\geq$140 m in size by 2020 - (not possible)
- NFSSE - Find NEO's through the support of ground-bases telescopes
  - Budget: 2002-2009 (~$4M); FY11 (~$20M)
  - WISE – Pipeline augmented to find NEOs until WISE was put in hibernation
- V&V - Find NEO's through the support of ground-bases telescopes (LSST)
  - Budget: FY12-13 ($20.5M); FY14-15 ($40M); FY16-FY18 ($50M)
  - Turned WISE back on – NEOWISE (~$5M/yr)
  - 2012 Interagency roles defined and started table-top exercises with FEMA
  - Jan 2016 Established a Planetary Defense Coordination Office (PDCO)
  - New Missions: DART confirmed; NEO Survey not confirmed
  - An approved Agency "new start" enhanced NEO budget for FY19-22 ($150M) with its own budget line item (not book kept in R&A program)

Evolution of the NEO Observation program

- Building up a “National Needs” program with Congressional direction but no funding, and without Decadal support is VERY difficult
- Keeping the NEO Obs Program in PSD is the right thing to do!
- One thought: for a pandemic we are clearly unprepared, for a large NEO on its way to Earth – NASA is the only one standing in its way
- Therefore, we need to figure out a way to “right size” Planetary Defense as an element of the Federal Governments responsibility for national needs

New Frontiers Program

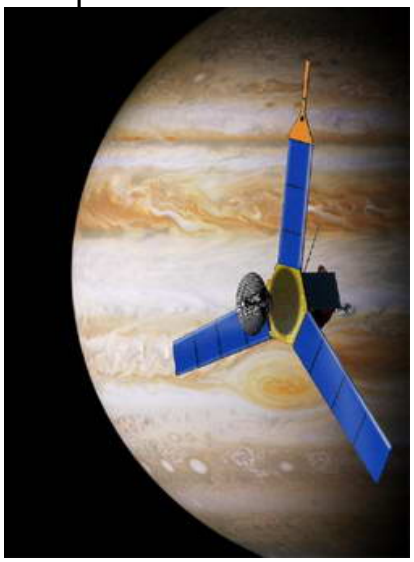
1st NF mission
New Horizons

Pluto-Kuiper Belt

Launched January 2006
Flyby July 14, 2015
PI: Alan Stern (SwRI-CO)

2nd NF mission
Juno

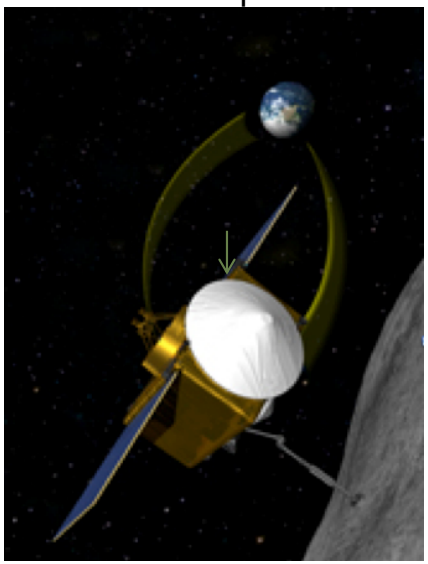
Jupiter Polar Orbiter



Launched August 2011
Arrived July 4, 2016
PI: Scott Bolton (SwRI-TX)

3rd NF mission
OSIRIS-REx

Asteroid Sample Return



Launched September 2016
Arrived December 2018
PI: Dante Lauretta (UA)

4th NF mission
Dragonfly

Titan Rotorcraft

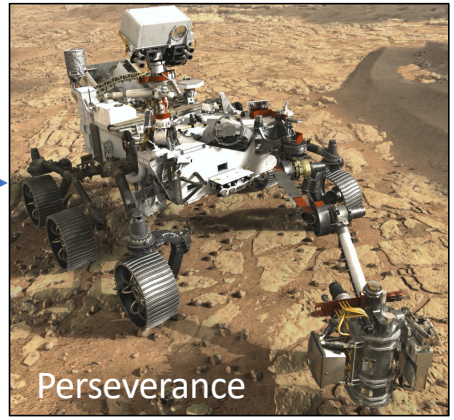
Launch 2026
Arrive 2032
PI: Elizabeth Turtle (APL)

Allow for the Evolution of Flagships

Decadal Missions - Concepts

Executed Missions

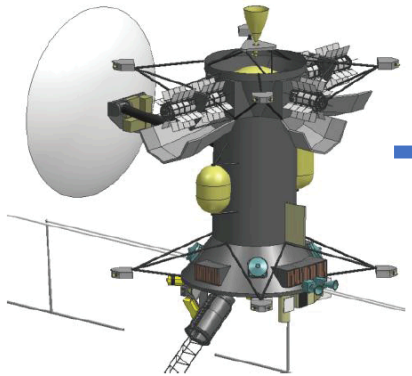
Caching Mars Rover

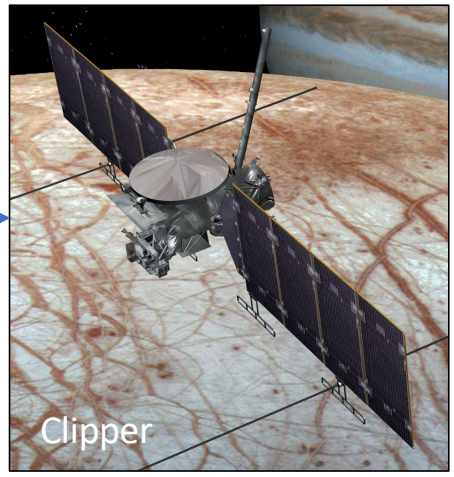


MAX-C Cashing Rover

- CATE at $3.5 billion as currently designed, MAX-C would take up a disproportionate share of NASA's planetary budget
- Fly MAX-C in the decade 2013-2022, but only if the mission can be conducted for no more than approximately $2.5 billion FY2015.

Flagship-Class Europa Orbiter





Jupiter Europa Orbiter (JEO)

- CATE at $4.7B unaffordable, and therefore it was the "second highest priority Flagship mission" based on "pragmatic reasons associated with the spending profiles"
- NASA should immediately undertake an effort to find major cost reduction for JEO

JLG - Allows us to trade on requirements. This is the only way to create these executable missions

Summary Comments

- NASA Planetary Science is not above changes in Administration
  - Here decision rules are extremely important part of progammatics
- Keep the established funding lines – creating new ones is enormously difficult requiring approved Agency “new starts”
  - Without focused well defined targets for NF - does it become a 2X Discovery? If it does then we don’t need a separate line
- Must be flexible allowing new approaches/technologies (ie: CubeSats) to mature and satisfy Decadal requirements
- Having more missions in the Decadal than can be executed is a good thing!
  - Allows for the Planetary Division to grow its budget
- Planetary Defense is important to preserve in PSD – guided by scientists
- We studied Europa & MSR from every conceivable angle – No flagship is ever selected as it starts out – *it has to travel the long and winding road*


QUESTIONS?
EXPLORE
with us