Charge to the Decadal Survey

Presentation to Planetary Science Decadal Panels

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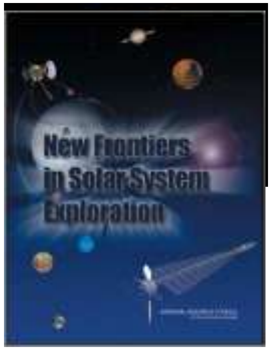
Outline

- Decadal Charge and Process
- FY10 Planetary Budget Overview
- Planetary Missions Overview
- New Frontiers & Discovery
- Outer Planets
- Supporting Research & Technologies
- Mission Enabling Technologies
- International agreements

PSD Decadal Perspective



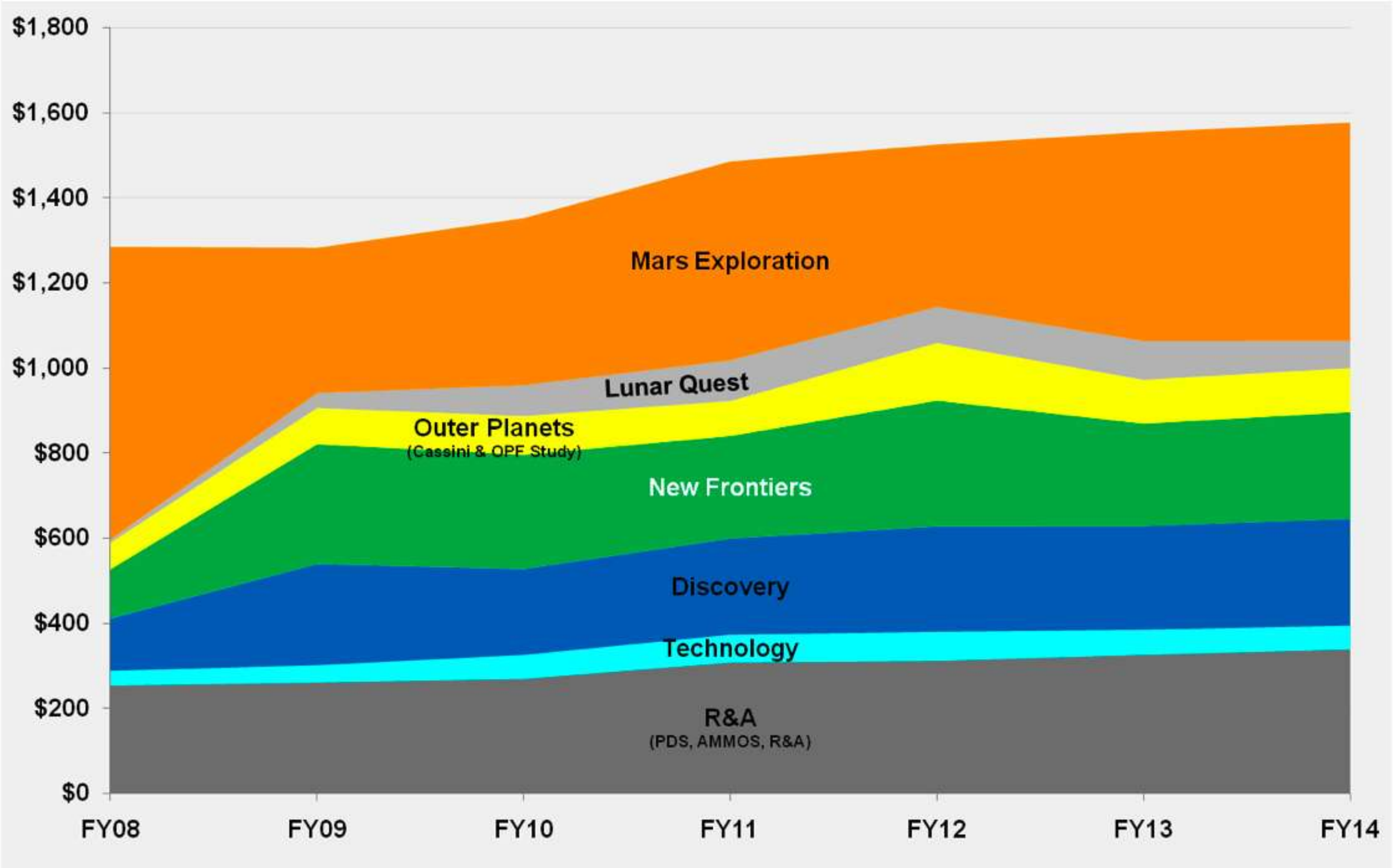
- Decadal results are shared between NASA & NSF with clear roles and responsibilities
  – NASA has space-based planetary science
  – NSF has ground-based planetary science

- Must be a *fully integrated view* of the entire solar system
  – Moon, Mars, and the rest of the solar system
  – Its is all about setting *priorities* not *expectations*

- Must also address planetary science within human exploration as it evolves (late in the next decade)
- Must address all aspects of the program
  – Sections on R&A and key technologies are important

- Budget and Technical reality
  - Program must fit within the known planetary budget
  - Use the FY11 Presidents budget after it is announced in February 2010

Planetary FY10 Budget



- Use the President's FY11 budget when issued in Feb '10
- 1st budget with goals from the new administration

POC & Main Duties

- PSD has assigned a HQ CS to be a point of contact for each panel
  - Steering Panel – Jim Green
  - Satellites Panel – Curt Niebur
  - Giant Planets Panel – Len Dudzinski
  - Inner Planets Panel – George Tahu
  - Mars Panel – Lisa May
  - Primitive Bodies Panel – Lindley Johnson
- Main Duties:
  - Be at every panel meeting
  - Responsible for satisfying panel requests for information
  - Facilitate the mission concept (MC) process that NASA has set up
  - Periodically report back to PSD management to ensure consistency and that the panels are getting what they need

Mission Concepts

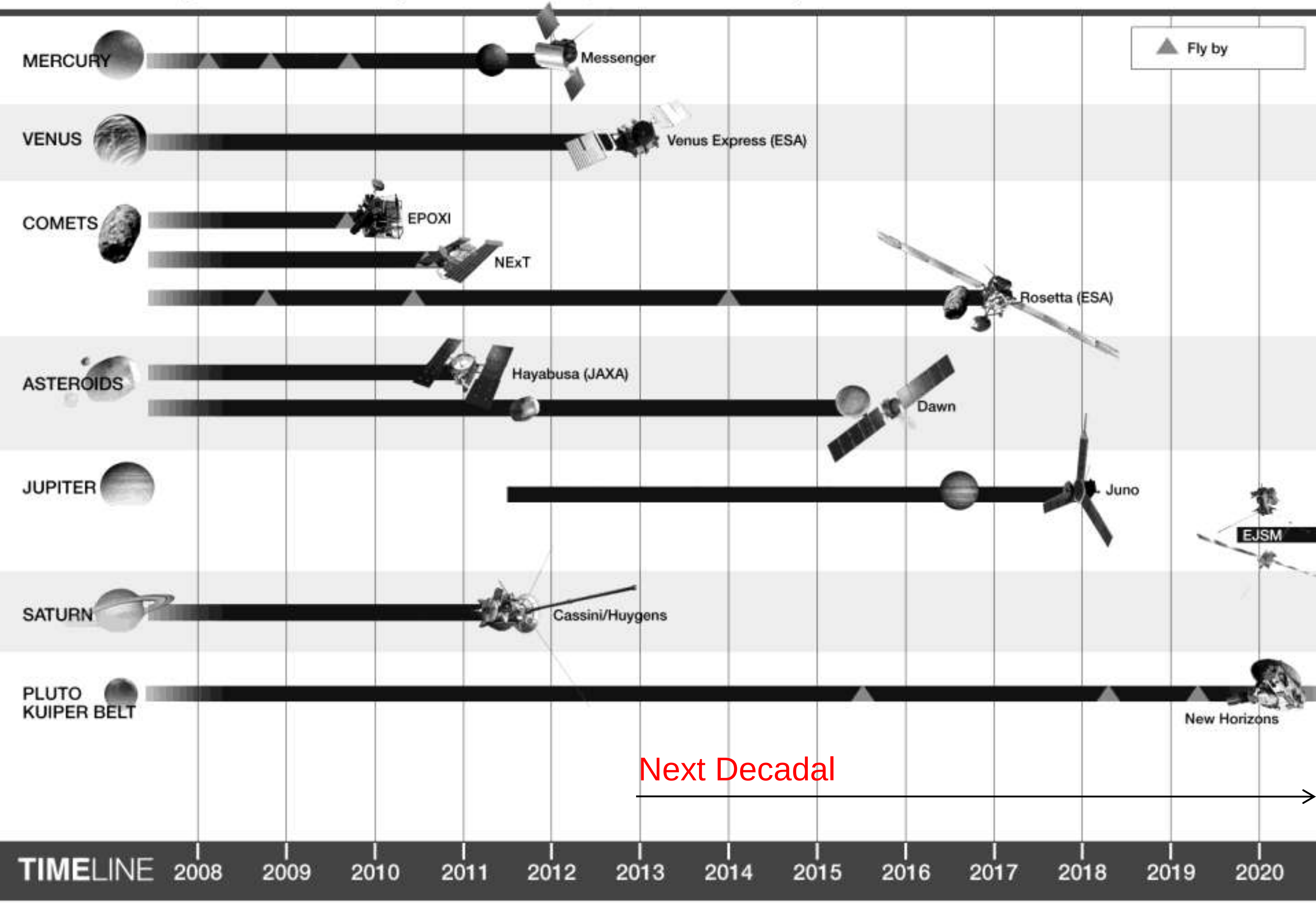
- Key Centers have been selected to participate in the analysis of decadal missions by using their capabilities to develop a mission architecture that “closes” and results in a “realistic” cost
  - Provide specific analysis & supporting documentation to the Decadal Steering panel and to the NRC contract cost reviewer

Next Steps:

- Study Guidelines (ie.: launch vehicles..)
- Input Standard:
  - Request for a Study should come from the Steering Group with a certain set of sufficient information to start the process
  - A "science champion" to keep the studies on course (this is not the HQ-POC)
- Output Standard:
  - MC addresses an agreed upon set of information necessary for the NRC cost review

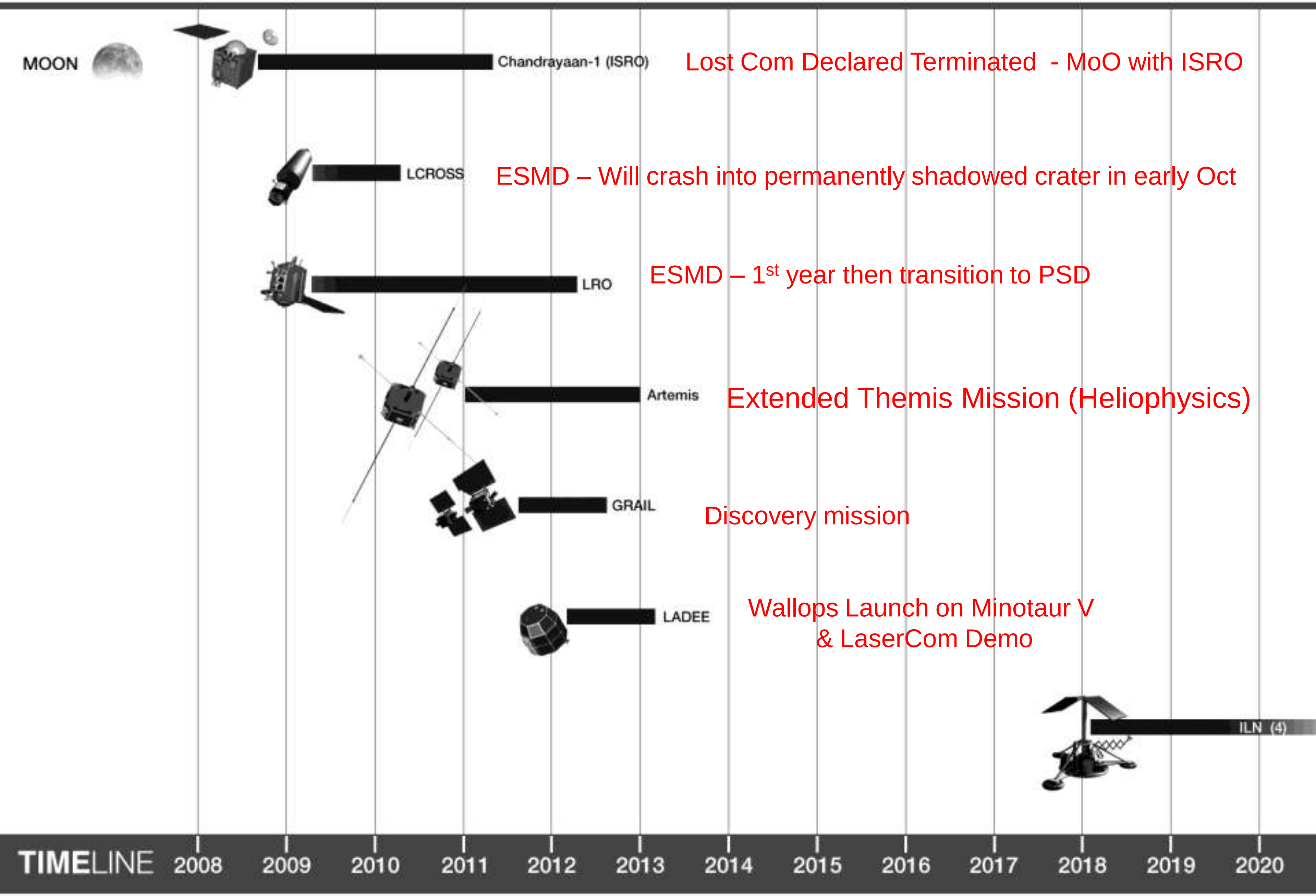
Planetary Missions Overview

Planetary Missions (Non-Mars, Non-Lunar) timeline



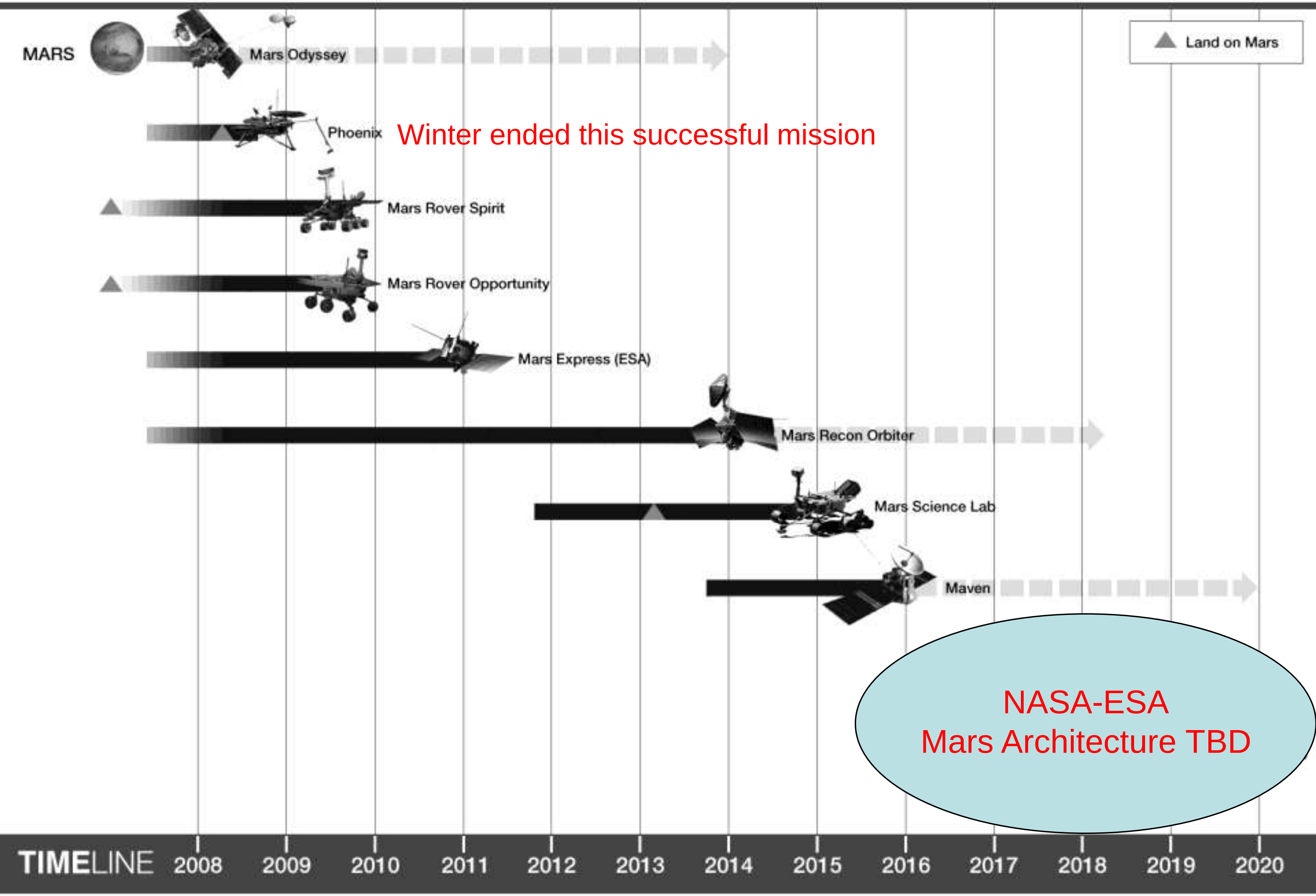
Lunar Mission timeline

Next Decadal



Mars Mission timeline

Next Decadal



New Frontiers & Discovery

PI Mission Opportunities

New Frontiers Program

1st NF mission
New Horizons:

Pluto-Kuiper Belt Mission

Launched January 2006
Arrives July 2015

2nd NF mission
JUNO:

Jupiter Polar Orbiter Mission

August 2011 launch

3rd NF mission AO

South Pole - Aitken Basin Sample Return

Comet Surface Sample Return

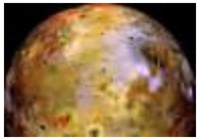
Venus In Situ Explorer

Network Science

Trojan/Centaur

Asteroid Sample Return

Io Observer



Ganymede Observer

New Frontier-3

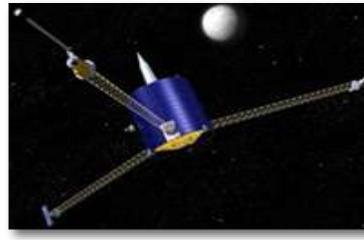
- Open competition for PI class missions of strategic importance to Planetary Science in the < $1B class
  – Select up to 3 for a 10 mo. Phase-A then a downselect to 1
  – Launch window beginning late CY 2016 ending NLT the end of CY 2018, according to target
  – Technology infusion:
    - NEXT ion propulsion system & Advanced Materials Bi-propellant rocket
- Proposals received and are in evaluation
  – Step-1 selection announcements on schedule (January 2010)

Discovery Program

Completed

Mars evolution:
Mars Pathfinder (1996-1997)

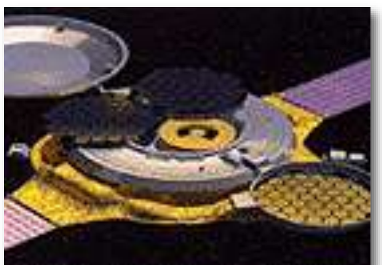
Lunar formation:
Lunar Prospector (1998-1999)



NEO characteristics:
NEAR (1996-1999)

Completed / In Flight

Solar wind sampling:
Genesis (2001-2004)



Comet diversity:
CONTOUR

Nature of dust/coma:
Stardust(1999-2006)

In Flight / In Development

Comet internal structure:
Deep Impact (2005-2006)

Mercury environment:
MESSENGER (2004-*2012*)

Main-belt asteroids:
Dawn (*2007-2015*)

Lunar Internal Structure
GRAIL (*2011-2012*)

Discovery-12

- Planetary Decadal science for PI missions
  - Across entire solar system (including Mars)
  - Cost Cap: $425M FY10 (without LV)
  - Selection: 2 to 3 missions for a 9 mo. Phase-A then downselect to 1
  - Launch date NLT December 31, 2016
- ASRG is provided GFE as an option
  - Funded 9 feasibility studies
- Schedule:
  - Draft AO out before end of FY09
  - Final AO ~ near the end of CY2009
  - Proposals due 90 days after AO release

Outer Planets Flagships

Cassini

Europa & Ganymede missions

Cassini Mission Overview
Four-Year Prime Tour, Equinox Mission, and Solstice Mission (Proposed), July 2004 - July 2017
Prime Mission
Equinox Mission
Solstice Mission
Year of Tour
1 '04-'05
2 '05-'06
3 '06-'07
4 '07-'08
5 '08-'09
6 '09-'10
7 '10-'11
8 '11-'12
9 '12-'13
10 '13-'14
11 '14-'15
12 '15-'16
13 '16-'17
Orbits
11 15 22 27 39 21 16 19 25 12 12 20 56
Titan
*Huygens
Proximal Orbits
Enceladus
Other Icy Satellites
(under 10,000 km)
Phoebe
Tethys
Hyperion
Dione
Telesto
Rhea
Rhea
Iapetus
Epimetheus
Rhea
Helene
Dione
G arc
Rhea
Helene
Dione
Dione
Tethys
Methone
Telesto
Rhea
Dione
Tethys
Dione
Epimetheus
G arc
EOM
Sep 15, 2017
Saturn
(seen from Sun)

Jupiter System Mission

- NASA's next planetary flagship mission will explore the Jupiter system and investigate the emergence of potentially habitable worlds around gas giants
- The mission benefits from a close partnership with ESA to send two independent spacecraft with complementary payloads to study the entire Jupiter system
  - Jupiter Europa Orbiter (JEO) provided by NASA
  - Jupiter Ganymede Orbiter (JGO) provided by ESA

- Responds to the strong and sustained recommendations in the current Planetary Decadal Survey for an Europa flagship mission (highest priority) and a Ganymede Observer mission (deferred priority)

Supporting Research & Technology Program

SR&T Program Elements

- Research & Analysis (ROSES)
- Astrobiology Institute
- Lunar Science Institute
- Near Earth Object Observations
- Planetary Data System (PDS)
- Astromaterials Curation Facility (JSC)

PSD R&A Program for ROSES 2009

- Cosmochemistry
- Laboratory Analysis of Returned Samples
- Planetary Geology And Geophysics
- Origins of Solar Systems (joint with Astrophysics)
- Planetary Astronomy
- Planetary Atmospheres
- Outer Planets Research
- Lunar Advanced Science and Exploration Research
- Near Earth Object Observations
- Cassini Data Analysis
- Planetary Missions Data Analysis
- Mars Data Analysis
- Mars Fundamental Research
- Mars Instrument Development
- Planetary Instrument Definition And Development
- Astrobiology: Exobiology And Evolutionary Biology
- Planetary Protection Research
- Astrobiology Science & Technology Instrument Development
- Astrobiology Science And Technology For Exploring Planets
- Dawn at Vesta Participating Scientists
- Early Career Fellowships
- Planetary Major Equipment
- Moon and Mars Analog Missions Activities

NEO Program

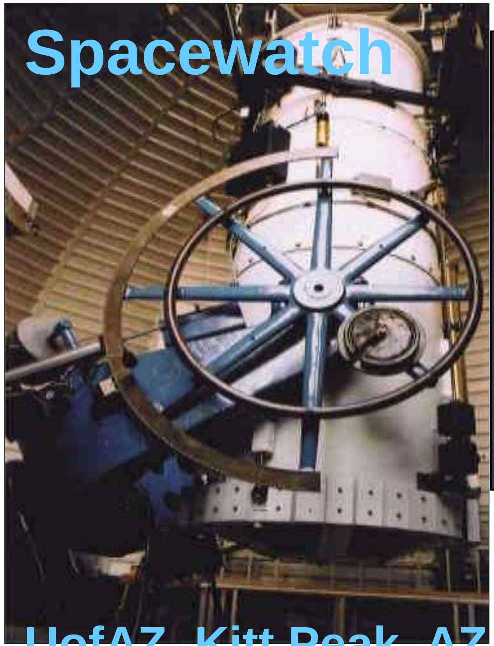
- Current program: Discover 90% NEOs >1 km in size within 10 years (1998 – 2008)
  - Using existing ground-based facilities
  - Arecibo used for characterization
- NASA Authorization Act of 2005 provided additional direction (but no additional funding)
  - "…plan, develop, and implement a Near-Earth Object Survey program to detect, track, catalogue, and characterize the physical characteristics of near-Earth objects equal to or greater than 140 meters in diameter in order to assess the threat of such near-Earth objects to the Earth. It shall be the goal of the Survey program to achieve 90 percent completion of its near-Earth object catalogue (based on statistically predicted populations of near-Earth objects) within 15 years after the date of enactment of this Act."
- NEO program has limited assets (~$4M/yr) and will continue to look for opportunities to partner and achieve Congressional goals

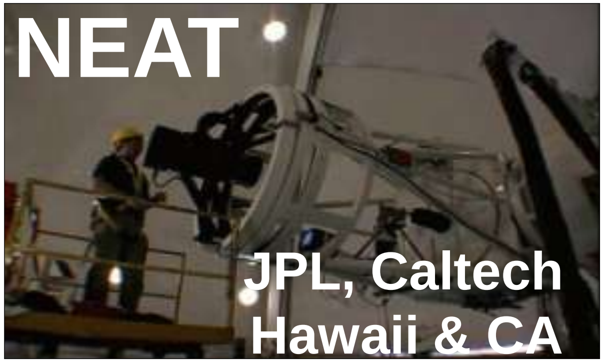
NASA's NEO Search Projects
(at peak in 2005)

NEO Program Office @ JPL
- Program coordination
- Automated SENTRY
  neo.jpl.nasa.gov

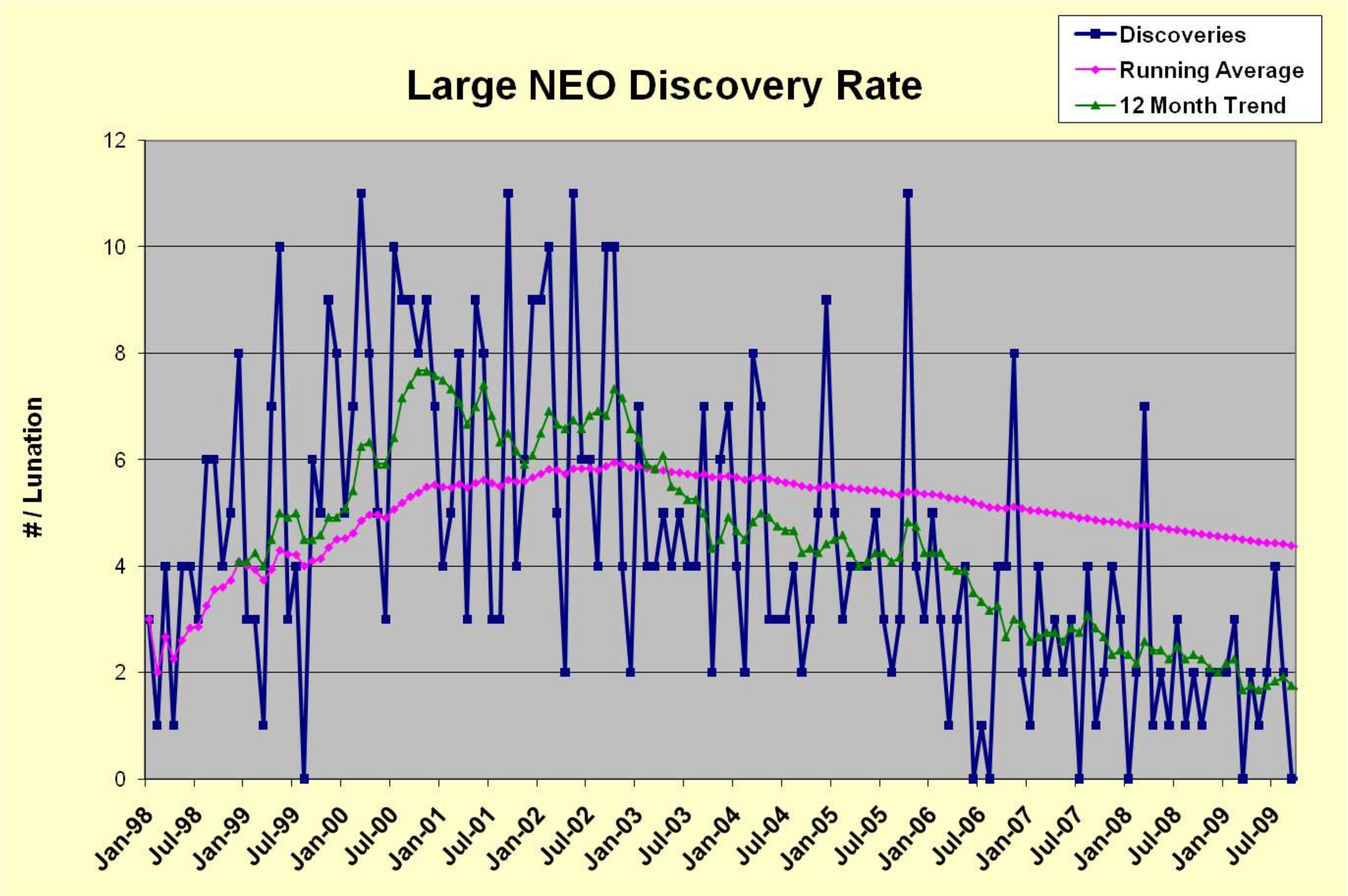
Minor Planet Center (MPC)
- IAU sanctioned
- Discovery Clearinghouse
- Initial Orbit Determination

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

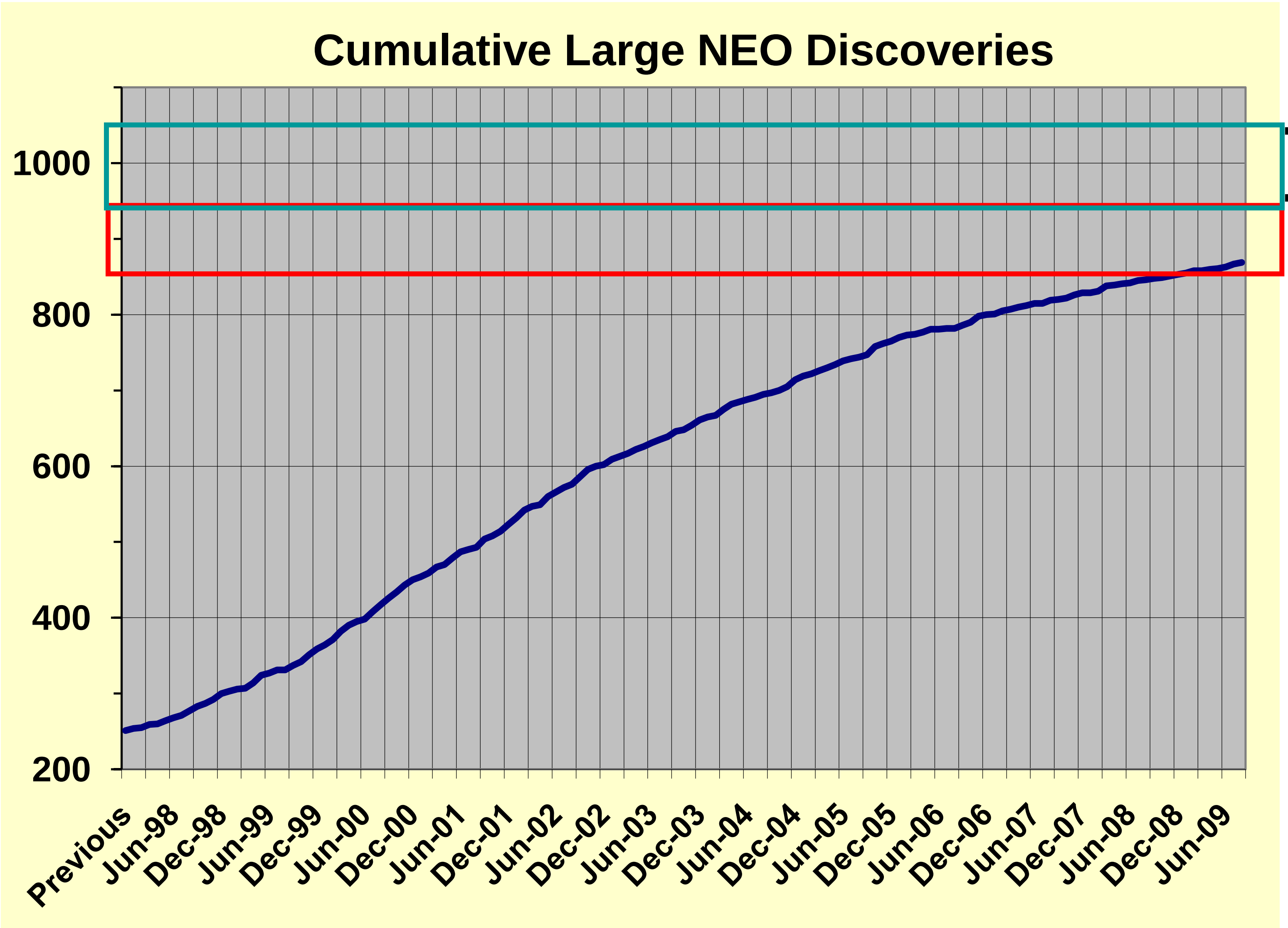




Discovery Metrics
Discovery Rate of >1km NEOs



Discovery Metrics



Estimated Population 940 to 1050

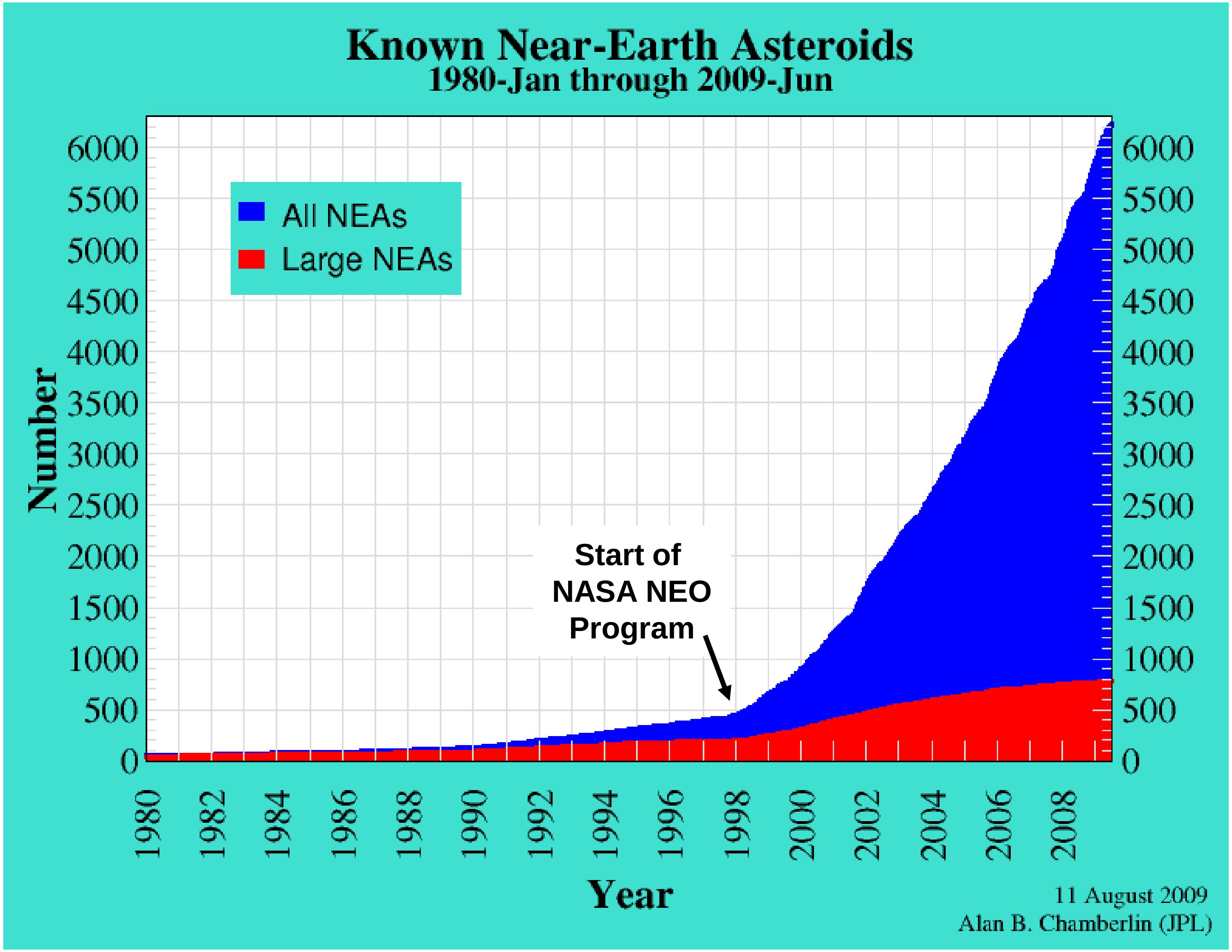
Goal 850 - 940

Achieved Minimum goal 869* (83-92%) as of 8/31/09

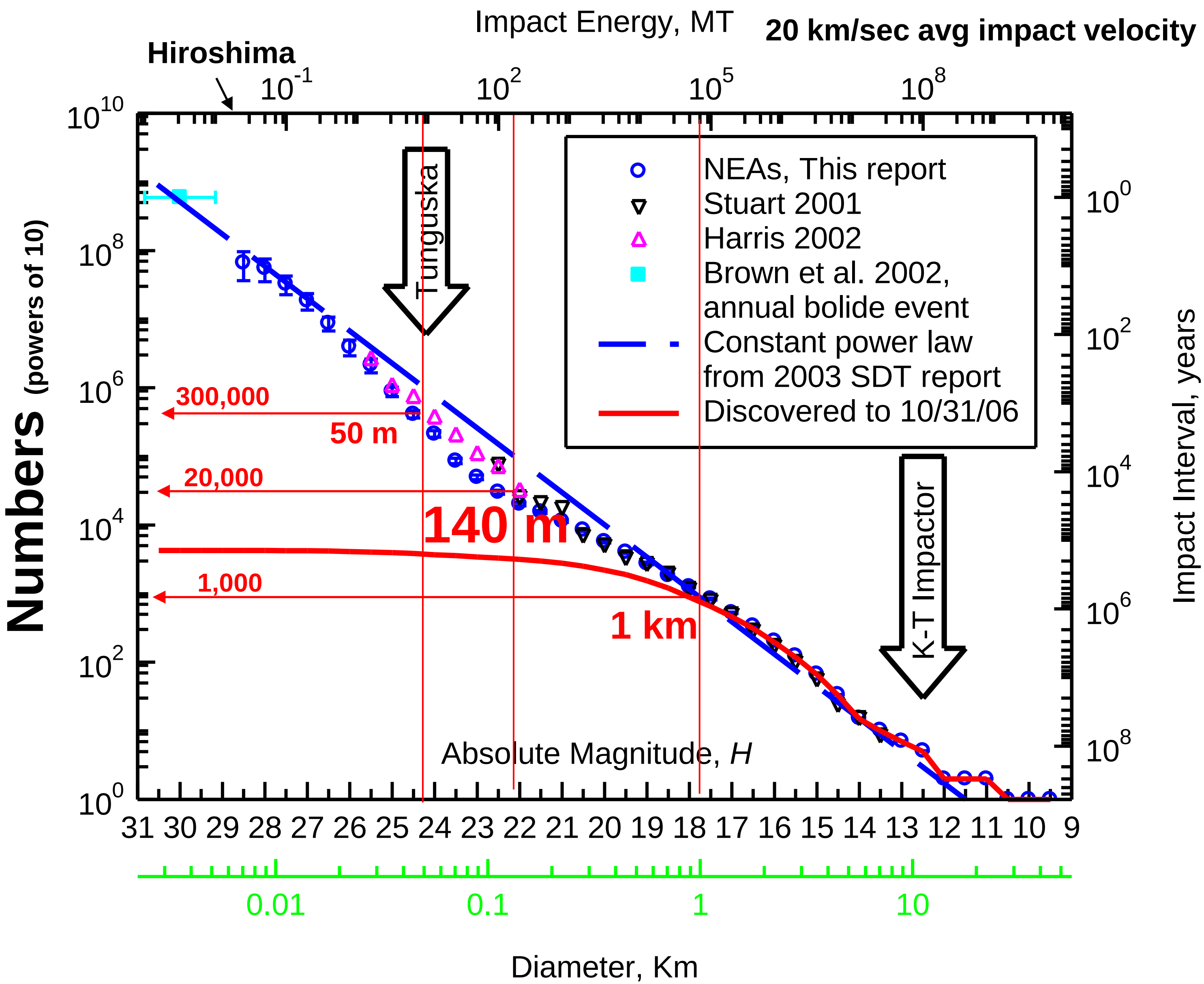
*Includes 84 NECs

5507 smaller objects also found

Known Near Earth Asteriod Population



Population of NEAs by Size, Brightness, Impact Energy & Frequency (Harris 2006)



Mission Enabling Technologies

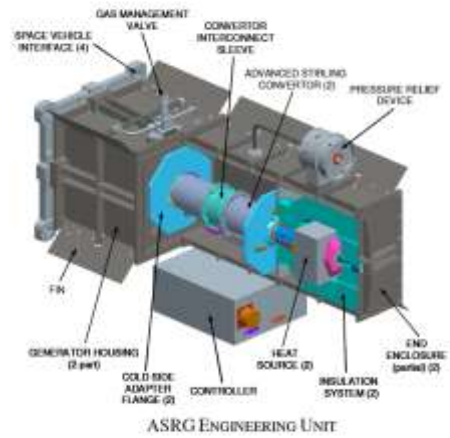
Technology Investment Overview

- Flight mission technologies
  - Radioisotope Power Systems
  - Laser Communications (with SOMD)
  - In-Space Propulsion Program
    - Propulsion: Electric & Advanced Chemical
    - Aerocapture
  - Advanced Multi-mission Operating Systems (AMMOS)
- Mars Technology Program
  - Mission specific technologies for strategic mission
  - Major cutbacks in this program due to MSL overruns
- Instrument Technologies from ROSES
  - Planetary Instrument Development & Definition Program (PIDDP)
  - Astrobiology Science & Tech. for Exploring Planets (ASTEP)
  - Astrobiology Science & Tech. Instrument Development (ASTID)
  - Mars Instrument Development Program (MIDP)

Advanced Stirling Radioisotope Generator Status

- Operation in space and surface of atmosphere-bearing planets & moons
- Characteristics:
  - ≥14 year lifetime
  - Nominal power : > 140 We
  - Mass: ~ 22 kg
  - Specific Power: > 6 W_e/kg
  - System efficiency: > 30 %
  - 2 GPHS (“Pu^{238} Bricks”) modules
  - Uses only 0.88 kg Pu^{238}
- ASRG Engineering Unit (EU) delivered by DOE/LM to NASA Glenn for extended (24/7) operation to provide long-life test
- ASRG EU has operated over 4000 hrs of operation to date (June 09) with no performance degradation identified.
- 2 Flight units to be delivered in 2014

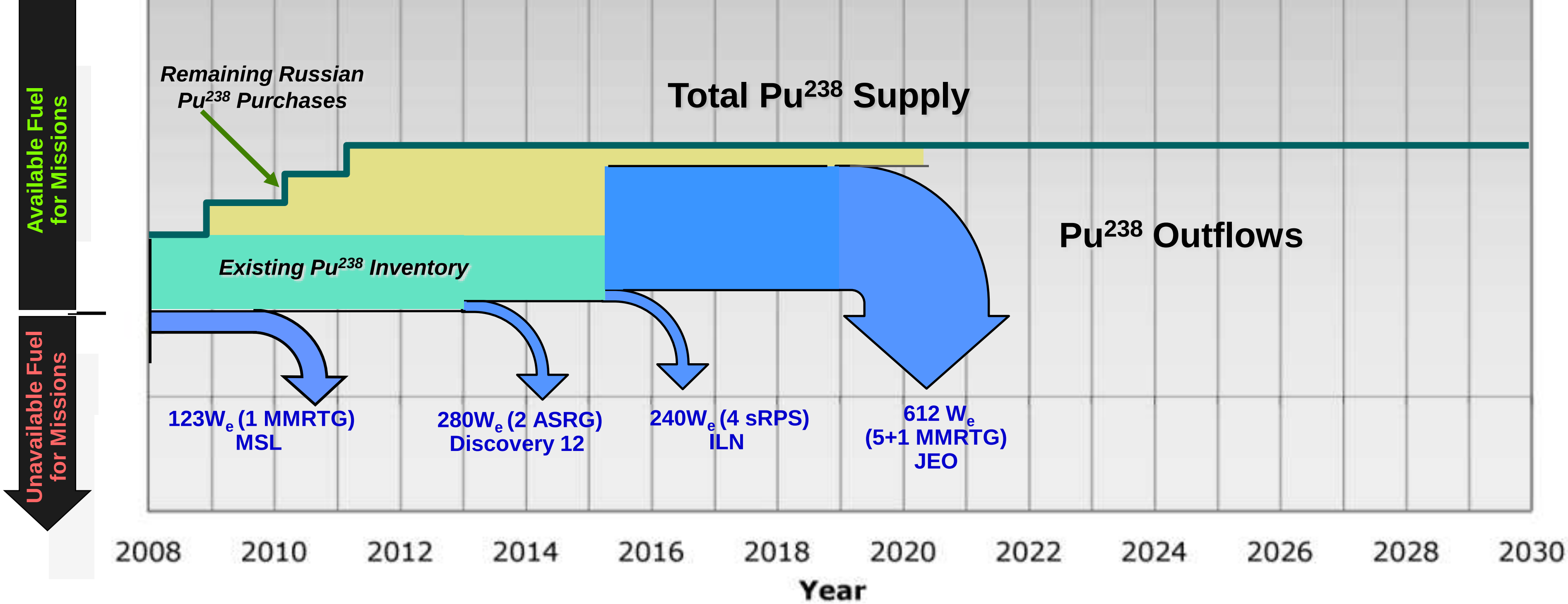
DOE/Lockheed Martin ASRG EU



ASRG EU on test at NASA Glenn

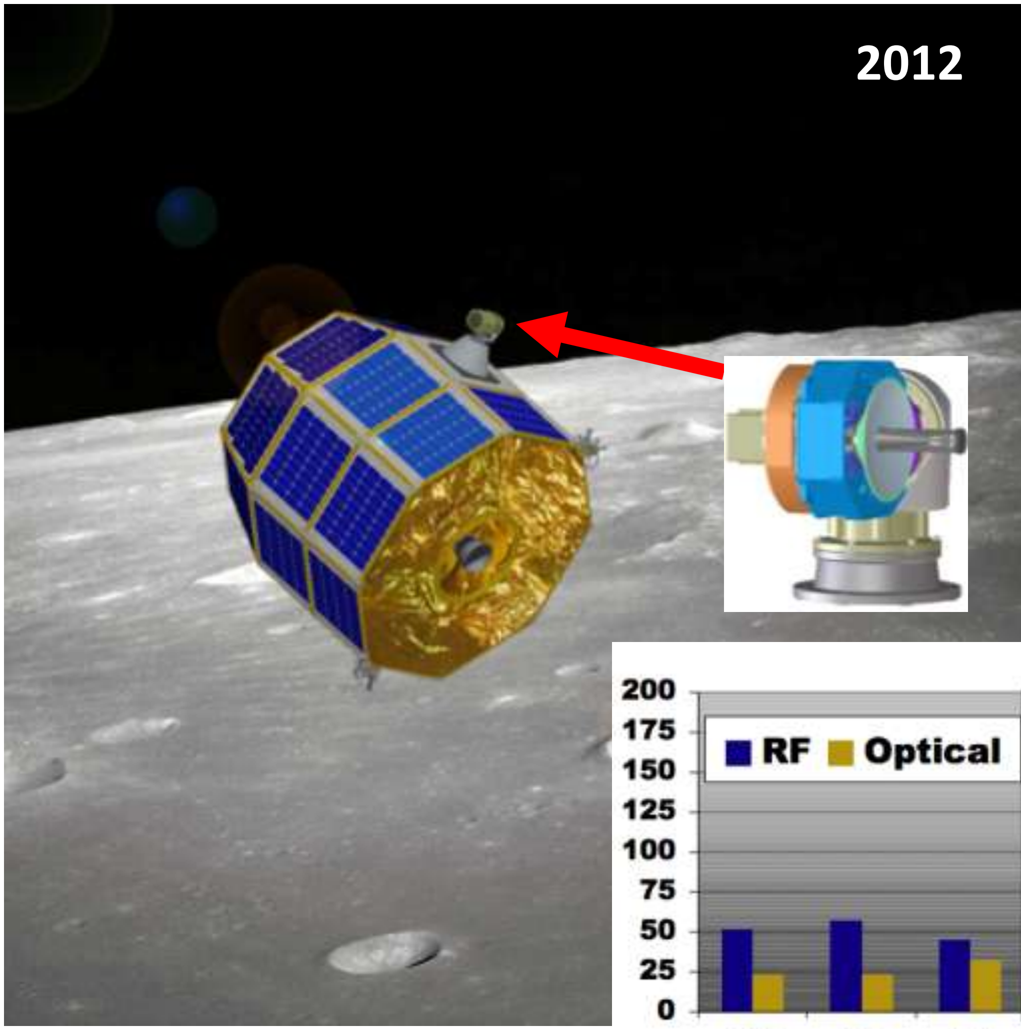
Plutonium Supply vs Potential NASA Demand
The era of special missions coming to an end

- JEO baselines 5 MMRTGs
- Requires purchasing all remaining Russian Pu^{238}
- Remaining fuel is contingency only
- Without DOE restarting Pu^{238} production, JEO will be NASA's last planetary mission that requires radioisotope power

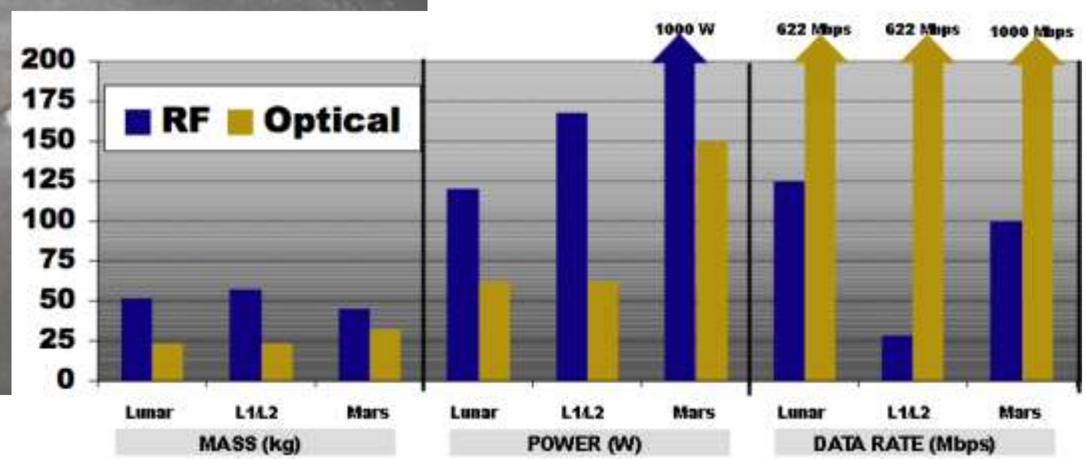


Deep Space Optical Comm Initiative

In Partnership with SOMD, LADEE will fly the 1st DS Optical Comm Demo



- Optical Terminal for LADEE on track
- Earth-based photon-counting technology
- Will provide 600 Mbps from moon
  - ✧ 10 cm terminal
  - ✧ Earth-based Beacon-aided acquisition & tracking
- LADEE will provide V&V flight time, and post science optical demonstration time
- Science NOT dependent on demo.



International Agreements

International Collaborations

- Many planetary PI missions have foreign instruments (ie: Dawn, Juno…)
- Agreements on foreign missions:
  - ESA: Venus Express, Mars Express, ExoMars, Rosetta
  - ASI: BepiColombo (recently selected instrument)
  - JAXA: Hayabusa
  - ISRO: Chandrayaan-1
  - Statement of Intent – 9 countries for ILN
- Developing Agreements:
  - ESA: OPF, Mars 16, 18, 20 …
  - JAXA: Venus Climate Orbiter

NASA’s

“Flyby, Orbit, Land, Rove, and Return Samples”

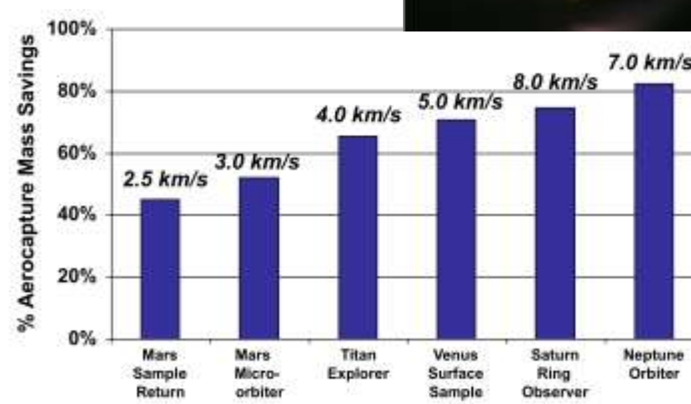
Planetary Science Division Budget History ($M)

	FY08	FY09	FY10	FY11	FY12	FY13	FY14
FY05 PFP (w/ DSN, O/H, & Lunar Robotics)	$2,955	$3,126					
FY06 PFP (w/DSN, O/H, & Lunar Robotics)	$2,832	$2,999	$3,066				
FY07 PFP (w/ DSN & O/H)	$1,599	$1,840	$1,900	$1,847			
FY08 PFP (include O/H)	$1,396	$1,677	$1,720	$1,738	$1,748		
FY09 PFP	$1,247	$1,334	$1,410	$1,537	$1,570	$1,609	
FY10 PFP	$1,313	$1,288	$1,346	$1,501	$1,578	$1,600	$1,633

In-Space Propulsion Development

- **Electric Propulsion** – Significantly reduced propulsion/payload mass ratio, reducing planetary trip times, and expanding launch windows
  - NSTAR flying on DAWN
  - NEXT (3x increase in power over NSTAR) undergoing life testing
  - HiVHAC prototype thruster demos completed
- **Aerocapture** - Shorter trip times to outer planets with less propellant; autonomous aerodynamic control technology also enables precision landing.
  - Mission design studies of Mars, Titan, Venus, and Neptune completed
  - Research on materials and sensors on-going, HEAT sensor used on MSL, Lightweight aeroshells
  - Crossover applicability to Orion development

NEXT Thruster



In-Space Propulsion (con't)

Advanced Chemical Propulsion –

Increased thruster performance to reduce propellant needs and increase payload fraction

- AMBR engine – improving performance from 327 sec to 335 sec Isp w/200 lbf thrust at <70% cost
- Active mixture ratio control and balanced flow meter technology to reduce system inert mass, minimize required residual propellant
- Tank Liquid Volume Instrument enables unique measurement of tank contents in any configuration or gravity environment; enables precise knowledge of state of tank contents during operations and long cruises
- Lightweight tank development

AMBR engine