Planetary Science Division Activities with Small Bodies

Jim Green and Lindley Johnson

August 25, 2011

NASA's Year of the Solar System
Planetary Science Mission Events

2010

- September 16 – Lunar Reconnaissance Orbiter in PSD
- November 4 - EPOXI encounters Comet Hartley 2
- November 19 - Launch of O/OREOS

• Completed

- ***2011***
- February 14 - Stardust NExT encounters comet Tempel 1
- March 7 – Planetary Science Decadal Survey released
- March 17 - MESSENGER orbit insertion at Mercury
- May 5 - Selection of 3 Discovery-class missions for study
- May - Selection of the next New Frontier mission for flight, OSIRIS-Rex
- July 16 - Dawn orbit insertion at asteroid Vesta
- August 5 - Juno launched to Jupiter
- August 9 - Mars Opportunity Rover gets to Endeavour Crater
- September 8 - GRAIL launch to the Moon
- November 25 - Mars Science Laboratory launch to Mars
- December 31 - GRAIL-A orbit insertion at Moon

2012

- January 1 - GRAIL-B orbit insertion at Moon
- Mid-year - Dawn leaves Vesta starts on its journey to Ceres
- August - MSL lands on Mars

http://solarsystem.nasa.gov

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Planetary Program Architecture
Recommended by the Planetary Decadal Survey

Large Missions ("Flagship"-scale)

"Recommended Program" (budget increase for JEO new start)	*"Cost Constrained Program"* (based on FY11 Request)	*"Less favorable" budget picture than assumed* (e.g., outyears in FY12 request)
1) Mars Astrobiology Explorer-Cacher – descoped	1) Mars Astrobiology Explorer-Cacher – descoped	Descope or delay Flagship mission
2) Jupiter Europa Orbiter (JEO) – descoped	2) Uranus Orbiter & Probe (UOP)	
3) Uranus Orbiter & Probe (UOP)		
4/5) Enceladus Orbiter & Venus Climate 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)

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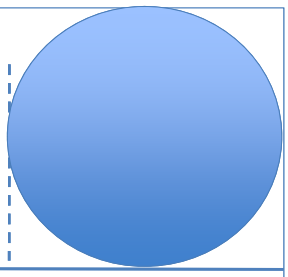

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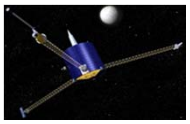
Discovery Program

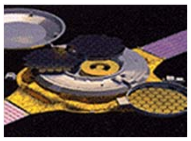
Mars evolution:
Mars Pathfinder (1996-1997)

Lunar formation:
Lunar Prospector (1998-1999)

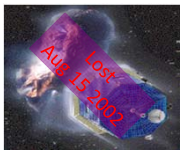


NEO characteristics:
NEAR (1996-1999)

Solar wind sampling:
Genesis (2001-2004)

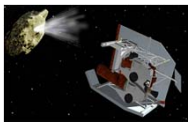


Comet diversity:
CONTOUR

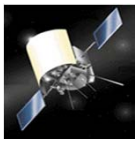


Nature of dust/coma:
Stardust(1999-2006)

Comet internal structure:
Deep Impact (2005-2006)

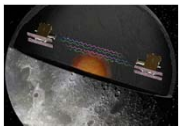


Mercury environment:
MESSENGER (2004-*2012*)



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

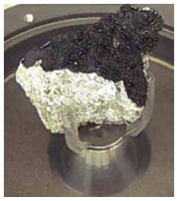
Lunar Internal Structure
GRAIL (*2011-2012*)



Exo-planets:
Kepler

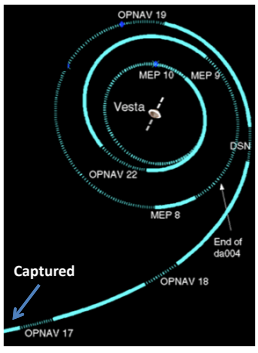
To Astrophysics

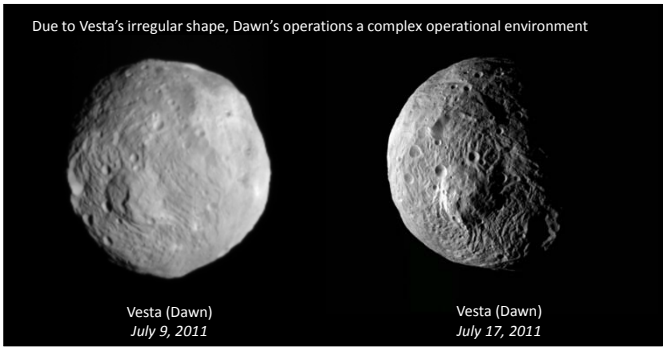
Dawn Enters Into Orbit Around Vesta



Dawn is a mission of planetary exploration firsts:

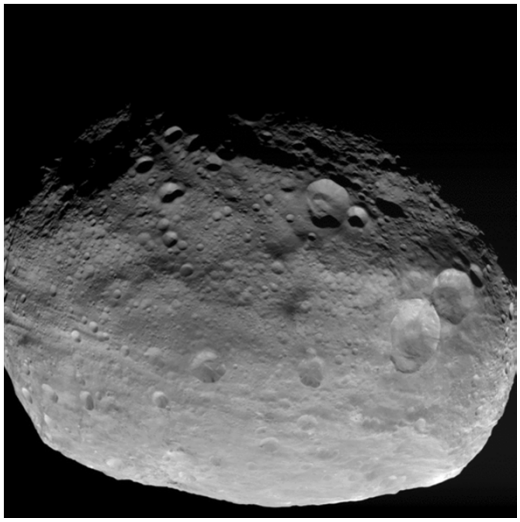
- First time an ion engine has been used on a NASA planetary mission
- First time a spacecraft has entered into orbit around an asteroid belt object
- First time a spacecraft has visited an asteroid thought to be the source of many meteorites



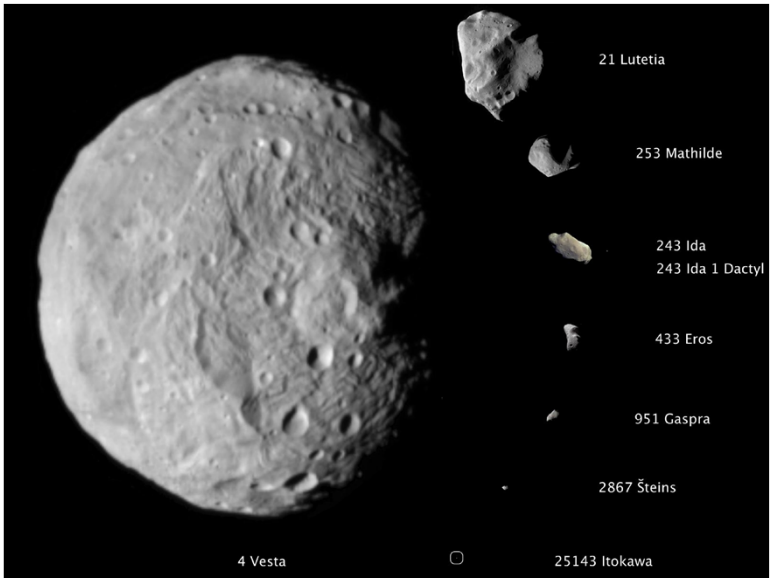


Dawn, after a 1.7 billion mile journey, was captured into orbit around Vesta on July 15 (PDT), starting a yearlong science campaign to map one of the solar system's largest main asteroid belt protoplanets. Mission engineers estimate the orbit capture took place at approximately 10 p.m. PDT Friday, July 15 (1 a.m. EDT Saturday, July 16).

Dawn's First Rotation Study of Vesta

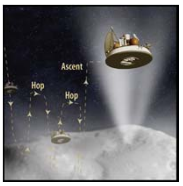


Asteroid Rogues Gallery



DISCOVERY 12 PHASE A STUDY

CHopper: Comet Hopper
PI: Jessica M. Sunshine



Mission & Science Team:
PI: Jessica Sunshine, UMD
Deputy PI: M. A'Hearn, UMD
Project Management: GSFC
S/C: LM
Mission Ops: LM
Science Ops: UMD

Mission:
Comet Wirtanen rendezvous and landing mission using LM S/C. 4 sorties between 4.5 and 1.5 AU from Sun.

Goals:
- Map spatial heterogeneity of gas & dust emissions and surface solids
- Determine nucleus structure, geologic processes, coma mechanisms
- Document changes w/ increasing isolation

Instruments:
- CHIRS- CHopper Infrared Spectrometer
- CHIMS- CHopper Ion/Neutral Mass Spectrometer
- CHI- CHopper Imager
- CHEX- CHopper Heating Experiment
- PanCams- Panoramic Cameras

Mission Details:
- Flight: 2016 launch with Standard 4m LV, 34-day launch period
- Mission: 7.3-yr mission, 2022 rendezvous / science ops
- Science Phase: Remote survey and multiple *in situ* surface measurements
- Cruise/Parked Ops: Quiescent ops during cruise and between sorties, science data downlink
- Spacecraft: high-heritage spacecraft design, flight-proven components for reliability and long life, large systems margins, dust covers for robustness in cometary environment , two ASRGs supply continuous power during all mission phases

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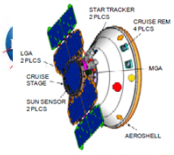
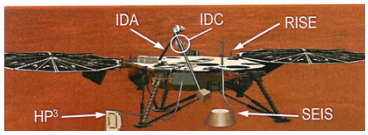
GEMS: GEophysical Monitoring Station
PI: Bruce Banerdt





Mission & Science Team:
PI: Bruce Banerdt, JPL
PM: Tom Hoffman, JPL
Deputy PI: Sue Smrekar, JPL
Spacecraft: Lockheed-Martin (LM)
Operations: JPL/LM
Payload: JPL, IPGP (France), DLR (Germany)

Mission:
- Geophysical (seismology, heat flow, planetary rotation) lander mission on Mars using Phoenix heritage spacecraft

Goals:
- Understand formation/evolution of terrestrial planets via interior structure/processes of Mars
- Determine present tectonic activity and meteorite impact rate

Payload:
- Seismic Experiment for Interior Structure (SEIS)
- Rotation & Interior Structure Experiment (RISE)
- Heat Flow & Physical Properties Probe (HP^3)
- Instrument Deployment Arm (IDA)
- Instrument Deployment Camera (IDC)

Mission Details:
- Flight: 3/2016 launch w/ELV, 4m fairing; 9/2016 landing; ~6.5 mo cruise, 1 Mars yr surface ops
- Selected Systems Features (Phoenix-based design): Cruise: 3-axis stabilized, 3.2 m^2 UTJ solar array, X-band telecom; EDL: Landing radar, UHF telecom; Surface: 4.3 m^2 UTJ solar array, 2 Li-ion batteries, UHF telecom, Rad 750-based avionics
- Mass: 597.6kg dry launch, margin ≥31% (depending on ELV)
- Surface Ops Energy: 881Wh/sol, margin 180%
- Schedule: 39 mo B/C/D, 98 days sched reserve
- Threshold Mission: Descope: HP^3, SEIS SP sensors

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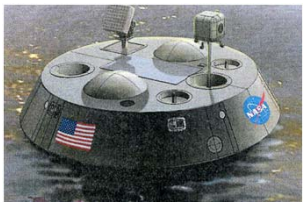
TiME: Titan Mare Explorer
PI: Ellen Stofan



Mission & Science Team:
PI: Ellen Stofan, Proxemy
Project Mgmt: APL
S/C: LM
Ops: LM, JPL (nav)
Payload: APL, GSFC, MSSS
Deputy PI: J. Lunine, UA
Project Scientist: R. Lorenz, APL

Mission:
Lander msn to Titan's *Ligeia Mare* methane-ethane polar sea, 96 days on surface

Goals:
- Understand Titan's methane cycle through study of a Titan sea.
- Investigate Titan's history & explore the limits of life

Instruments:
- Meteorology & physical properties (MP3)
- Mass Spec for Lake Chemistry (NMS),
- Descent and Surface Imaging Cameras

Efficient Trajectory:
- Launch 2016
- Cruise 7.5 years (EGA, JGA)
- Entry 2023

Mission Features:
- Focused science objectives
- High-heritage instruments
- Simple cruise, no flyby science
- Simple surface operations
- ASRGs, launch vehicle are GFE

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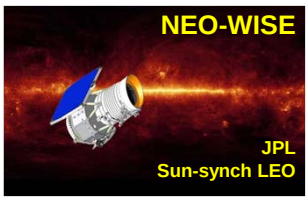
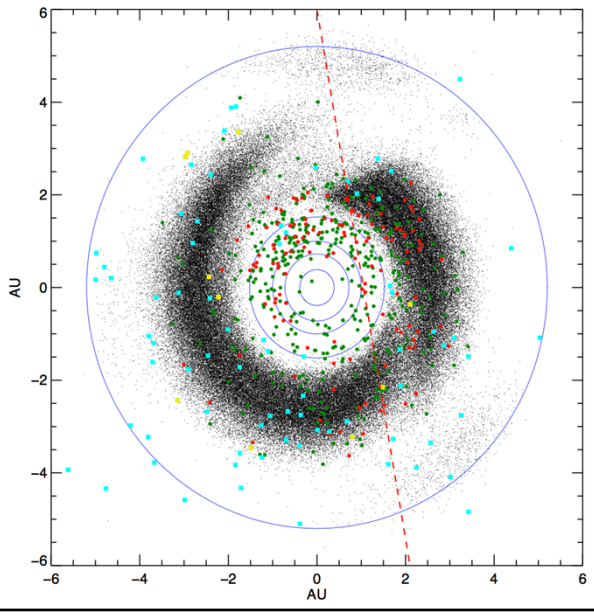
Discovery-12 Tech Development

- *Primitive Material Explorer (PriME):*
  Cometary Mass Spectrometer
- *Whipple:*
  Outer Solar System Object Blind Occultation Technique
- *NEOCam:*
  Near Earth Object Telescope and IR Sensor Technology

Discovery of Small Bodies



This figure shows a top-down view of the objects detected by NEOWISE as of February 2011 (distances are given in AU). The outermost circle represents Jupiter's orbit; the interior circles represent the terrestrial planet orbits. Previously known NEOs are shown as green dots; new NEOs discovered by NEOWISE are shown as red dots; previously known comets observed by WISE are shown as cyan squares, and comets discovered by NEOWISE are shown as yellow squares. All other objects, mostly main belt asteroids, are shown as black points.



New Frontiers Program

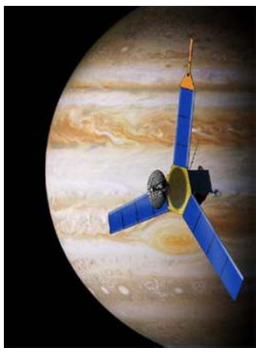
1st NF mission
New Horizons:

Pluto-Kuiper Belt

Launched January 2006
Arrives July 2015

2nd NF mission
JUNO:

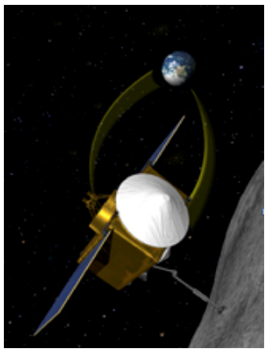
Jupiter Polar Orbiter



Launched August 2011
Arrives July 2016

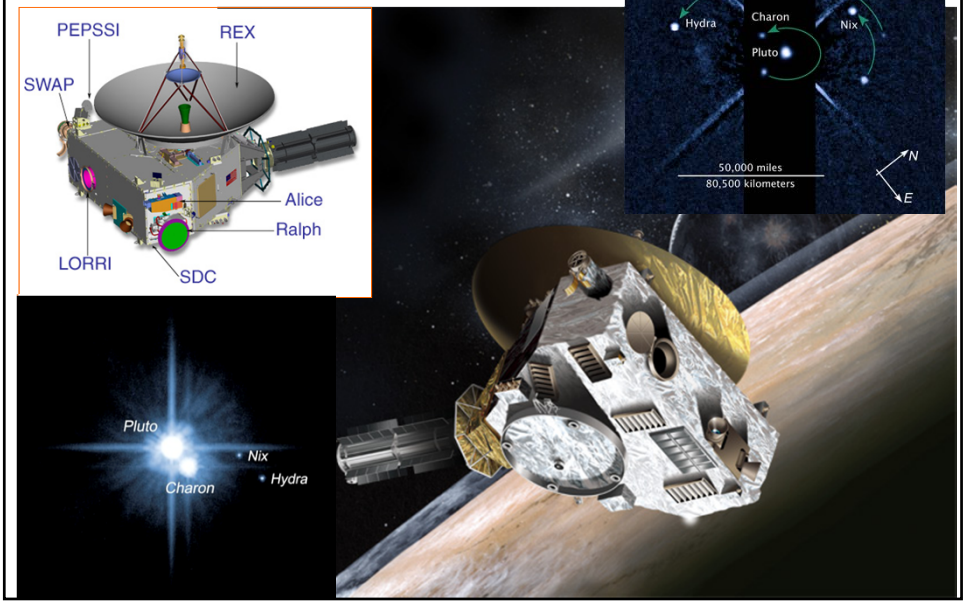
3rd NF mission
OSIRIS-REx

Asteroid Sample Return



Sept. 2016 Launch

New Horizons



OSIRIS-REx Asteroid Sample Return Mission

PI: Michael Drake (UA), PM: Robert Jenkens (GSFC)

- Science Objectives:
  - Return and analyze a sample of pristine carbonaceous asteroid
  - Map the global properties, chemistry, and mineralogy
  - Document in situ the properties of the regolith at the sampling site
  - Measure the Yarkovsky effect and constrain the asteroid properties that contribute to this effect.
  - Characterize the integrated global properties to allow comparison with ground-based telescopic data of entire asteroid population
- Mission Overview:
  - Launch in September 2016
  - Encounter asteroid (101955) 1999 RQ36 in October 2019
  - Study RQ36 for up to 505 days, globally mapping the surface
  - Obtain at least 60 grams of pristine regolith/surface material
  - Return sample to Earth in September 2023 in a Stardust-heritage capsule
  - Deliver samples to JSC curation facility for world-wide distribution
- Instruments:
  - OSIRIS-REx Camera Suite (OCAMS) - UA
  - OSIRIS-REx Laser Altimeter (OLA) - CSA
  - OSIRIS-REx Visible and IR Spectrometer (OVIRS) - GSFC
  - OSIRIS-REx Thermal Emission Spectrometer (OTES) - USA
  - Spacecraft Telecom/Radio Science
  - Touch-And-Go Sample Acquisition Mechanism (TAGSAM) – LM
  - Regolith X-ray Imaging Spectrometer (REXIS) MIT (Student Collaboration Experiment)