Planetary Science Decadal Reports

NASA’s Planetary Science Division follows the broad strategy laid out in the National Academy Decadal Reports.

1st Planetary decadal: 2002-2012

2nd Planetary decadal: 2013-2022

3rd Planetary Decadal: 2023-2032

underway with report to NASA
due 1st quarter 2022
Planetary Program Architecture
Recommended by the Planetary Decadal Survey

<table>
<thead>
<tr>
<th>Large Missions (“Flagship”-scale) - Strategic Missions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Recommended Program”</strong> (budget increase for JEO new start)</td>
</tr>
<tr>
<td>1) Mars Astrobiology Explorer-Cacher - descoped</td>
</tr>
<tr>
<td>2) Jupiter Europa Orbiter (JEO) - descoped</td>
</tr>
<tr>
<td>3) Uranus Orbiter &amp; Probe (UOP)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discovery (PI Class)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$500M (FY15) cap per mission (exclusive of launch vehicle) and 24 month cadence for selection</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New Frontiers (PI Class)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1B (FY15) cap per mission (exclusive of launch vehicle) with two selections during 2013-22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Research &amp; Analysis (5% above final FY11 amount then ~1.5%/yr)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Technology Development (6-8%)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Current Commitments (ie: Operating Missions)</th>
</tr>
</thead>
</table>

The cost information contained in this presentation is of a budgetary and planning nature and is intended for informational purposes only. It does not constitute a commitment on the part of JPL and/or Caltech.
How does NASA Cooperate Internationally?

- Foreign policy objectives, public diplomacy and international cooperation have been part of NASA since its inception
  - Directed by the 1958 National Aeronautics and Space Act:
    - NASA will cooperate with other nations
    - Disseminate information as broadly as practicable
  - Goal of the 2010 National Space Policy: *Expand international cooperation on mutually beneficial space activities to: broaden and extend the benefits of space; further the peaceful use of space; and enhance collection and partnership in sharing of space-derived information*

- Current NASA international cooperation:
  - Over 700 active international agreements
  - 8 partners account for 50% of the agreements:
    - France, Germany, ESA, Japan, UK, Italy, Canada, Russia
  - By mission area: 2/3 are in science missions
  - By region: 1/2 are with partners in Europe
Guidelines for International Cooperation

• Consistent with U.S. law and foreign policy objectives
• International partners are *generally* government agencies
• Projects/Partnerships:
  – Must have scientific and technical merit
  – Must benefit NASA
  – No exchange of funds
  – Have clear managerial and technical interfaces
    – “Meet at the interface” (i.e.- no joint development, limit tech transfer)
  – Documented in written, binding agreements, closely coordinated with the U.S. Department of State and other U.S. Government agencies
• Decision meetings can be Bilaterals or Multilateral
• Types of collaborations:
  o NASA accepts foreign instruments on NASA missions
  o NASA provides instruments to foreign missions
  o Exchange of extra-terrestrial samples
Non-U.S. instruments on NASA missions (Examples)
Discovery Program: PI Competitive

- NEO characteristics
  - NEAR (1996-1999)
- Mars evolution
  - Mars Pathfinder (1996-1997)
- Lunar formation
- Nature of dust/coma
  - Stardust (1999-2011)
- Solar wind sampling
  - Genesis (2001-2004)

- Comet Diversity
  - CONTOUR (2002)
- Mercury Environment
- Comet Internal Structure
- Lunar Internal Structure
  - GRAIL (2011-2012)
- Main-belt Asteroids
- Exoplanets
  - Kepler (2009-TBD)

- Lunar Surface
  - LRO (2009-TBD)
- Mars Interior
  - InSight (2018)
- Trojan Asteroids
  - Lucy (2021)
- Metal Asteroid
  - Psyche (2022)
- Martian Moons
  - MMX/MEGANE (2024)

- Lost
  - Aug 15 2002

Currently Operating

- Nature of dust/coma
  - Stardust (1999-2011)
- Solar wind sampling
  - Genesis (2001-2004)
- Comet Diversity
  - CONTOUR (2002)
- Mercury Environment
- Comet Internal Structure
- Lunar Internal Structure
  - GRAIL (2011-2012)
- Main-belt Asteroids
- Exoplanets
  - Kepler (2009-TBD)
- Lunar Surface
  - LRO (2009-TBD)
- Mars Interior
  - InSight (2018)
- Trojan Asteroids
  - Lucy (2021)
- Metal Asteroid
  - Psyche (2022)
- Martian Moons
  - MMX/MEGANE (2024)
Discovery Program: International Participation

Mars evolution
Mars Pathfinder (1996-1997)

Nature of dust/coma
Stardust (1999-2011)

Main-belt Asteroids

Lunar Surface
LRO (2009-TBD)

ESA/Mercury Surface
Strofio (2017-TBD)

Mars Interior
InSight (2018)

Martian Moons
MMX/MEGANE (2024)

Currently Operating
Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight)
Seeking Signs of Life: Mars 2020 Rover

- Jezero Crater
- Mars Helicopter
- RETROREFLECTOR
- SUPERCAM
- MASTCAM-Z
- MEDA
- ROBOTIC ARM
- SHERLOC
- RIMFAX
- MOXIE
- CACHING SYSTEM
- PIXL
- MMRTG

RGB/Context: 500 μm
NASA provided instruments to non-U.S. missions (Examples)
JAXA: Martian Moons eXploration (MMX) Mission

- Sample Return mission to Phobos or Demos
- COSPAR Decision: Category V - Unrestricted Earth return
- NASA role: GammaRay-Neutron spectrometer & surface sampler
Exchange of Samples

Bennu
Diameter = ~490 m

JAXA's Hayabusa II

Ryugu
Diameter = ~865 m

~2 kg

5.4 g
Future Collaborative Missions
In Situ Exploration of Saturn's Moon Titan, an Organic-Rich Ocean World

Science and Engineering Instruments

- DraMS: Mass Spectrometer (GSFC, CNES)
- DrACO: Drill for Acquisition of Complex Organics (Honeybee Robotics)
- DraGMet: Geophysics & Meteorology Package (APL, JAXA Lunar-A seismometer)
- DragonCam: Camera Suite (MSSS)
- DraGNS: Gamma-ray Neutron Spectrometer (APL, LLNL, GSFC, Schlumberger)
- DrEAM: Atmospheric entry measurements (ARC, DLR)

https://dragonfly.jhuapl.edu
Venus Missions On-going Studies

• NASA/RSA created a Venera-D Joint Science Definition Team
  • Completed an initial study report Jan 31, 2017
  • Defines all the top decadal science that can be accomplished versus a series of *notional* platforms

• Baseline missions:
  – Orbiter: Polar 24-hour orbit with a lifetime greater than 3 years- Can trade orbiter period for communication with other elements of mission for more than 24h
  – Lander: (updated VEGA) 2+ hours on the surface

• Other components discussed as potential augmentations:
  – Free flying aerial platform and balloons
  – Sub-satellite
  – Small long-lived stations

• Next steps:
  • Focus shifts to realistic mission designs & architectures
Status of NASA’s Current Plan

All contents represent notional planning and are for discussion purposes only.

MSR Architecture Overview

Mars

Mars 2020
Tube Collection & Depot
Tube Delivery
Tube Retrieval
Sample Fetch Rover
SRL
Mars Ascent Vehicle
Orbiting Sample
Retrieval OS
Break-the-Chain
Avoid Earth
Earth Entry Vehicle

Earth

Mars2020
Earth Return Orbiter
Sample Retrieval Lander
Sample Return and Science
Partnerships under Discussion
Lunar Science & Exploration Missions
Artemis Accords: International Guidelines

- Peaceful Purposes
- Transparency
- Interoperability
- Emergency Assistance
- Registration of Space Objects
- Release of Scientific Data
- Protecting Heritage
- Space Resources
- Deconfliction of Activities
- Orbital Debris and Spacecraft Disposal

Signers: US, Australia, Canada, Japan, Luxembourg, Italy, UK, UAE, Ukraine

Artemis Astronauts

Joseph Acaba
Kayla Barron
Raja Chari
Jonny Kim
Christina H. Koch
Kjell Lindgren
Matthew Dominick
Victor Glover
Walter Hosbury
Nicole A. Mann
Anne McClain
Jessica Meir
Jasmin Moghbel
Kate Rubins
Frank Rubio
Scott Tingle
Jessica Watkins
Stephanie Wilson
Commercial Lunar Payload Services (CLPS)

Working with industry to deliver science and technology payloads to the lunar surface
LUNAR SOUTH POLE TARGET SITE
ARTEMIS: Living, Learning and Working on the Moon

SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

MATERIAL SCIENCE AND CARGO PAYLOADS | U.S. GOVERNMENT, INDUSTRY, AND INTERNATIONAL PARTNERSHIP OPPORTUNITIES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS

All contents represent notional planning and are for discussion purposes only.
Questions?
In Situ Exploration of Saturn’s Moon Titan, an Organic-Rich Ocean World

**Science Objectives**
- Analyze chemical components and processes that produce biologically relevant compounds
- Measure atmospheric and surface conditions
- Constrain processes that mix organics with water
- Search for chemical evidence of biological processes

**Mission Plan**
- Launch in 2027; Titan arrival mid-2030s
- ~3.3 years of exploration, traversing over 100 miles to more than 24 unique landing sites
- Current activities: Preliminary design and hardware testing in the Titan environment

Titan’s dense atmosphere and low gravity make it easier to fly there than on Earth. By flying, Dragonfly can explore and sample materials in different areas, including organic sand dunes and impact crater deposits where organics may have mixed with water.

**Science and Engineering Instruments**
- DraMS: Mass Spectrometer (GSFC, CNES)
- DrACO: Drill for Acquisition of Complex Organics (Honeybee Robotics)
- DraGMet: Geophysics & Meteorology Package (APL, JAXA Lunar-A seismometer)
- DragonCam: Camera Suite (MSSS)
- DraGNS: Gamma-ray Neutron Spectrometer (APL, LLNL, GSFC, Schlumberger)
- DrEAM: Atmospheric entry measurements (ARC, DLR)

https://dragonfly.jhuapl.edu
Title: Current and Future Prospects for International Cooperation in Planetary Sciences: A NASA Perspective

Authors: Steven D. Vance, James Green

Abstract:
Planetary exploration investigates objects and physical processes throughout the solar system, and beyond. The scope of possible scientific investigations can easily outpace available resources. International partnerships can lead to new innovations. NASA has engaged in many such partnerships. We will describe some examples of such international partnerships, and successes and lessons learned. We will also describe mechanisms for international contributions to NASA missions and science. Over 500 white papers have been received by the National Academy of Sciences as input to the Planetary Science Decadal Survey that will serve as its guide for prioritizing missions in the 2023-2033 timeframe, many will require international participation.