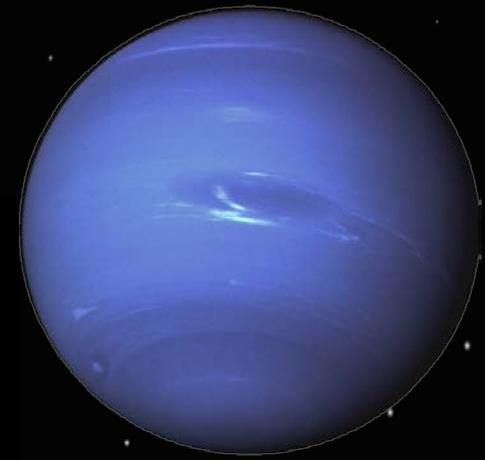
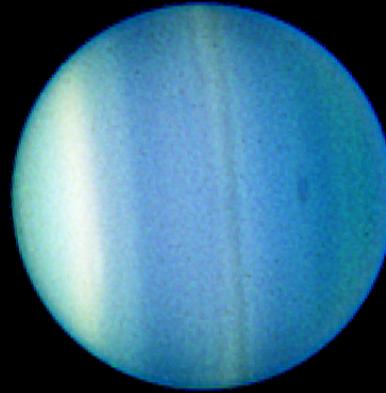
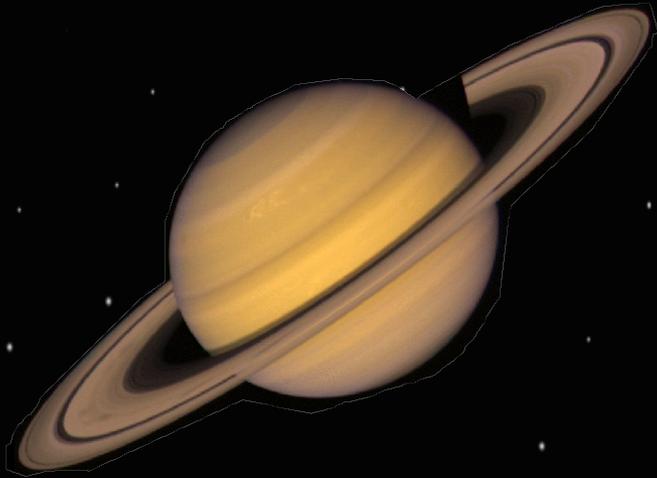


Outer Solar System Exploration



Looming Gap from
2017 to 2030

Decline in NASA Planetary Launches

- 2003-2012:

- MESSENGER – Mercury
- GRAIL -- Moon
- Lunar Reconnaissance Orbiter
- MER-Opportunity
- MER-Spirit
- Mars Reconnaissance Orbiter
- Phoenix – Mars lander
- Mars Science Laboratory
- Dawn – Vesta and Ceres
- Juno – Jupiter
- Deep Impact – comets
- New Horizons – Pluto

- **Total: 12 missions, from Mercury to Pluto, all successful**

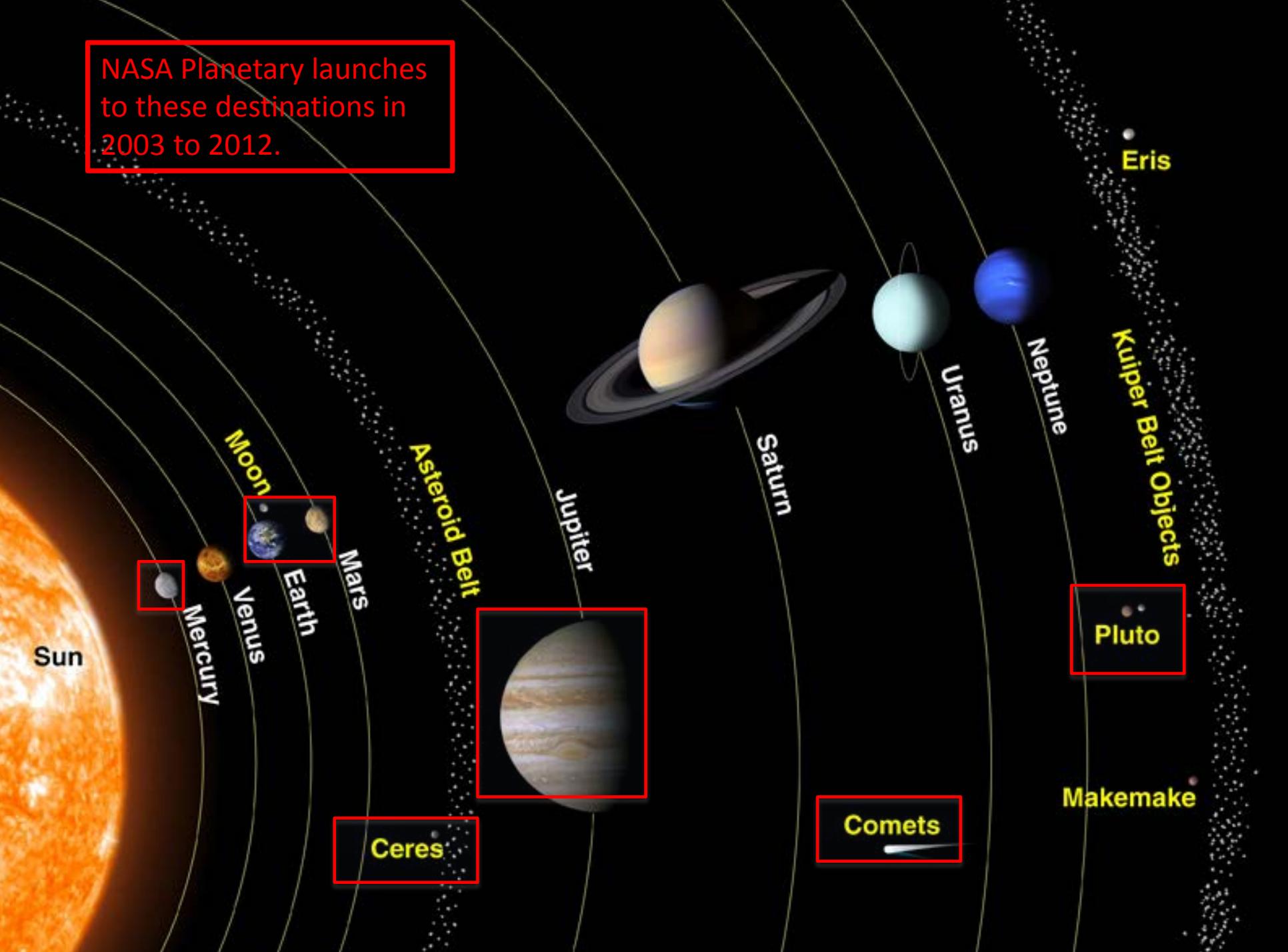
- 2013-2022:

- LADEE – Moon
- MAVEN – Mars orbiter
- InSight – Mars Lander
- OSIRIS-Rex – near-Earth asteroid sample return
- 2020 Mars rover
- New Discovery mission?

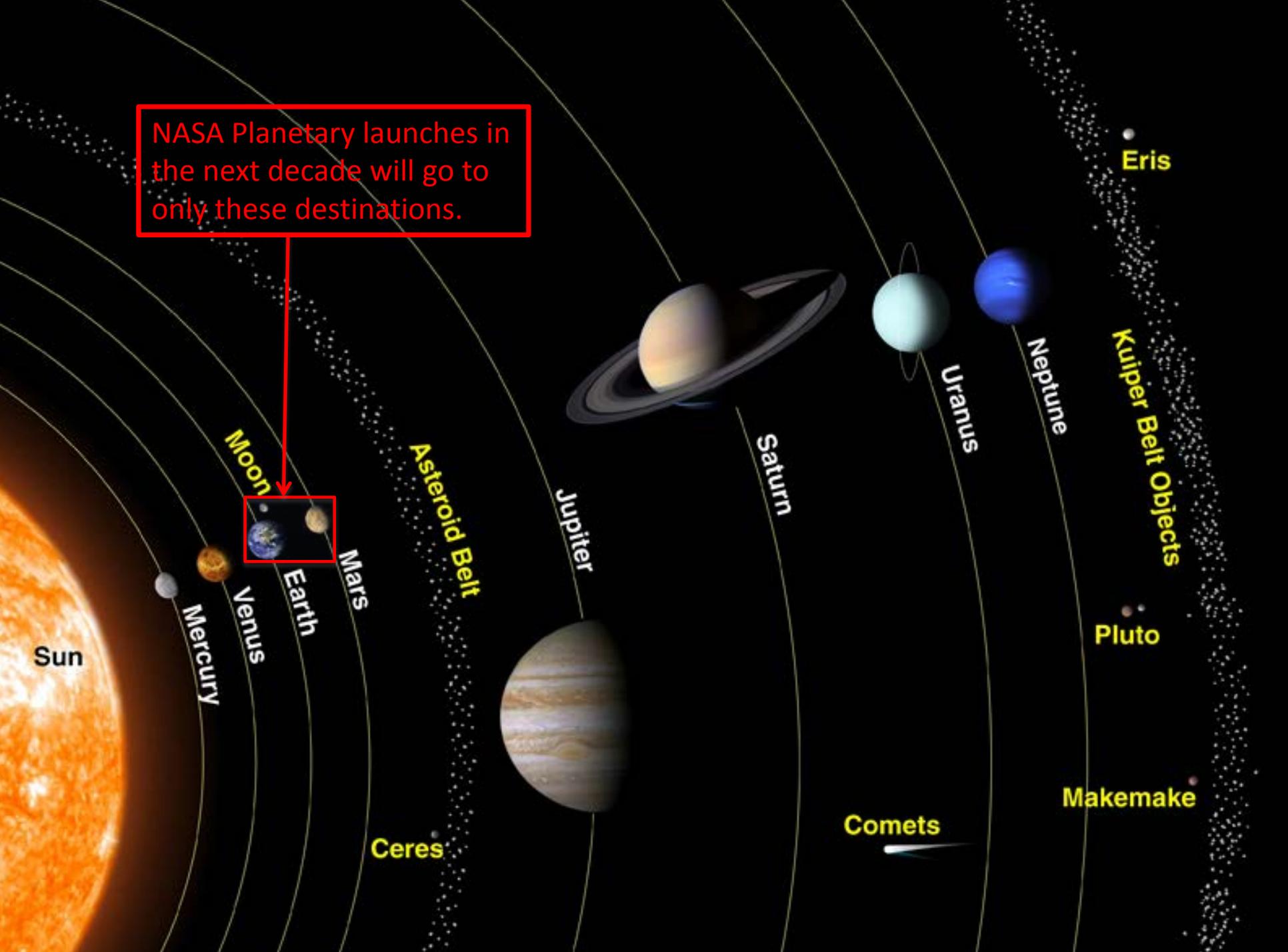
- **Total: 5 or 6 missions**

- **It is already too late to increase the number of launches over the next decade, except for one Discovery mission if the planetary budget is restored soon.**

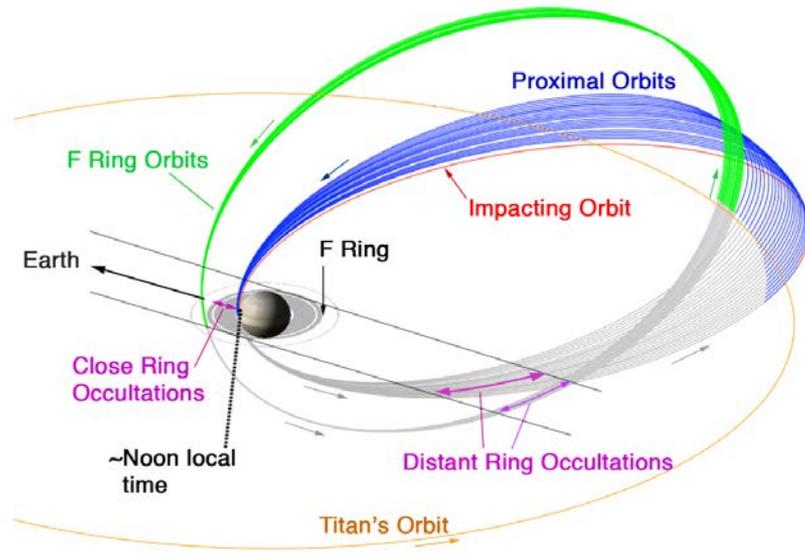
NASA Planetary launches
to these destinations in
2003 to 2012.



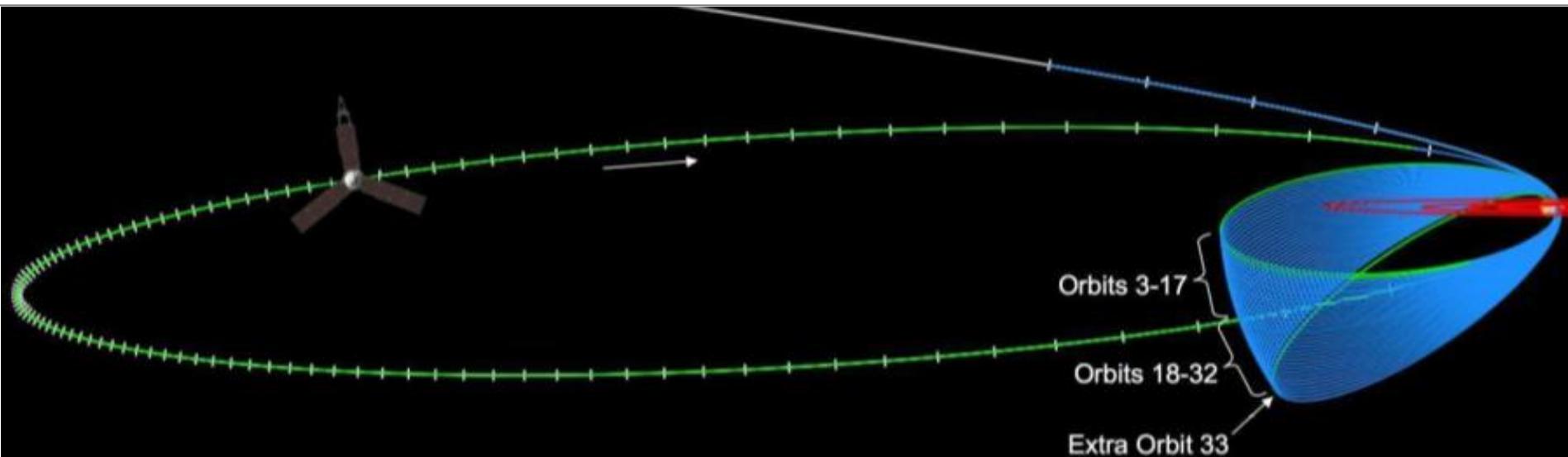
NASA Planetary launches in the next decade will go to only these destinations.



The final stages of the Juno and Cassini missions



- After a long successful mission at Saturn the Cassini End-of-Mission is planned for September 2017 when the spacecraft runs out of fuel
- Juno End-of-Mission at Jupiter is predicted as October 2017 with expected radiation damage
- In both cases the spacecraft are deliberately plunged into atmosphere to burn up



Why should we explore the Outer Solar System?

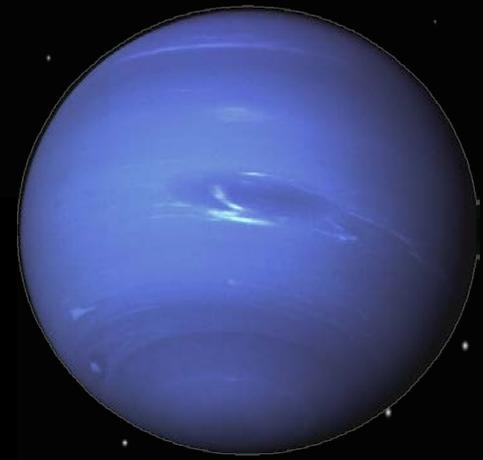
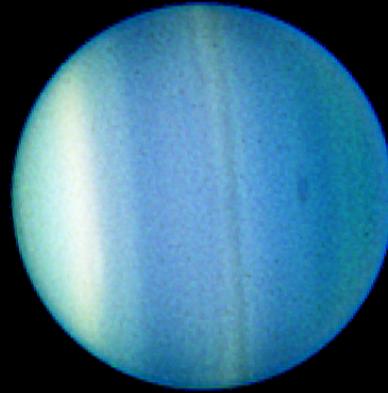
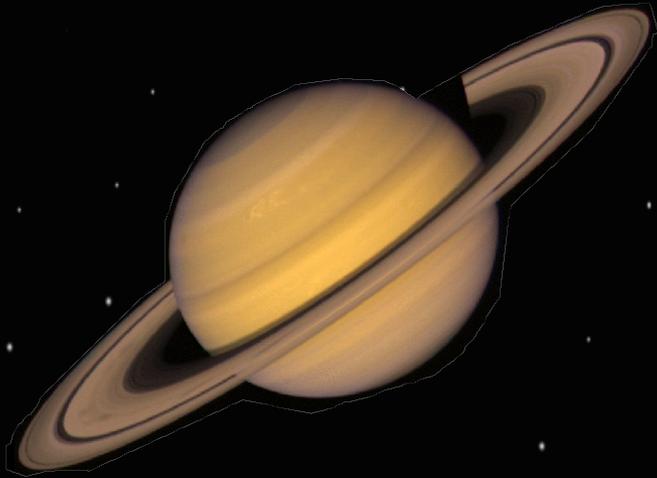
Why not just focus on Mars? (Mars is *a fascinating* planet, certainly worthy of exploration, but...)

- Understanding *atmospheric circulation* – the giant outer planets have entirely different atmospheres than the terrestrial planets – understanding them means developing advanced fluid dynamics models (that have been applied for example to ocean currents)
- *Weather* more akin to earth: Earth is at the mercy of processes today that are taken to extremes on Saturn's moon Titan: a thick greenhouse atmosphere with violent rainstorms, desertification, and seas with coastline erosion and climate impact.
- *Atmospheric chemistry and astrobiology* - The reducing atmospheres in the outer solar system are home to a vigorous organic chemistry that does not occur in the inner solar system in the present day, providing an opportunity to study natural production of biological building blocks.
- *Magnetospheres* – the variety of the outer solar system tests our models and understanding of how our own magnetosphere is structured
- *Materials' behavior* in extreme pressures and temperatures not natural on earth – for example ice behaves like rock at outer solar system temperatures, but interior to many moons may be liquid
- *Exoplanets* – most of the new planets discovered around other stars are similar to Uranus and Neptune

Oh the Places we'll Go

- *The outer solar system is target-rich.* We'd like to learn more about volcanoes on Io, storms on Titan, the rings around Uranus and whether Ariel is a frozen version of Enceladus. We'd like to study geysers on Triton, the plumes of Enceladus, and the magnetosphere of Neptune. And of course the highest priority of all is to learn more about Europa, a moon that could conceivably have life today in a subsurface ocean.
- We send our robotic emissaries to places too dangerous for humans – that doesn't make those places less worthy of exploration
- Destinations recommended in the Decadal Survey “Visions and Voyages” for the upcoming decade:
 - [Europa](#), to learn more about the subsurface ocean and how to access it in the future
 - [Uranus](#) orbiter, to study an ice giant in our own solar system analogous to many exoplanets being discovered
 - [Saturn](#) probe, to study the layers under the cloudtops
 - [Io](#) volcano observer, to learn the secrets of the most volcanically active place in the solar system

Outer Solar System Exploration



Worth the journey