# Argo

## Voyage Through the Outer Solar System

## White Paper Status

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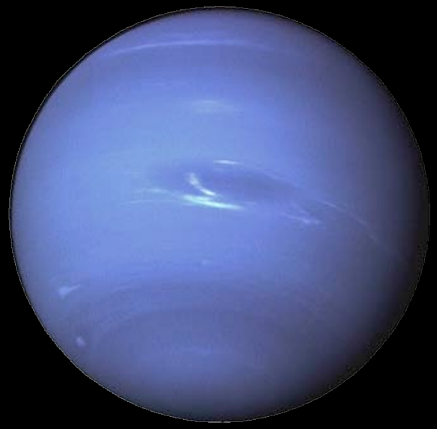
Candice Hansen (JPL) & the Argo Science Team

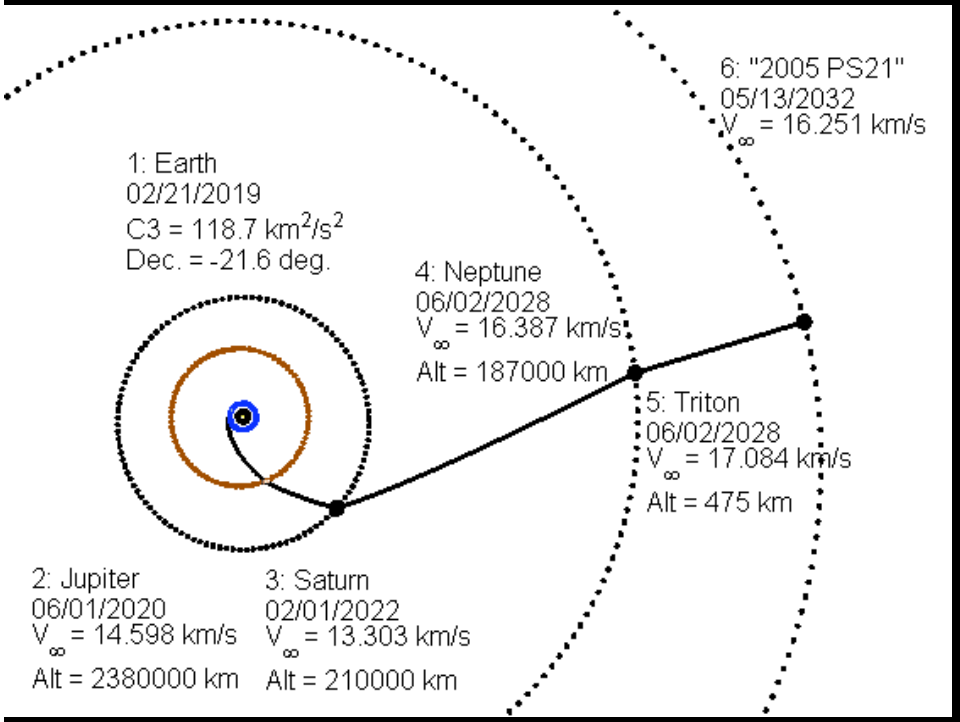
# Argo Concept: Flyby of Neptune, Triton and a *Scientifically-selected* KBO

- A **KBO encounter** explores another primitive outer solar system body
  - Triton / KBO comparison
  - Pluto / KBO comparison
  - Numerous potential targets
- **Triton and Neptune are compelling flyby targets**
  - Dynamic worlds, rich opportunities for new science discoveries
  - Trajectories identified with reasonable trip times and approach velocities
- The **Argo Mission** is **feasible for New Frontiers**
  - Key science addressed by instrument package based on New Horizons heritage
  - Avenues available for additional cost savings in development, operations, and launch vehicle
  - Mission is scoped to be accomplished within New Frontiers cost cap

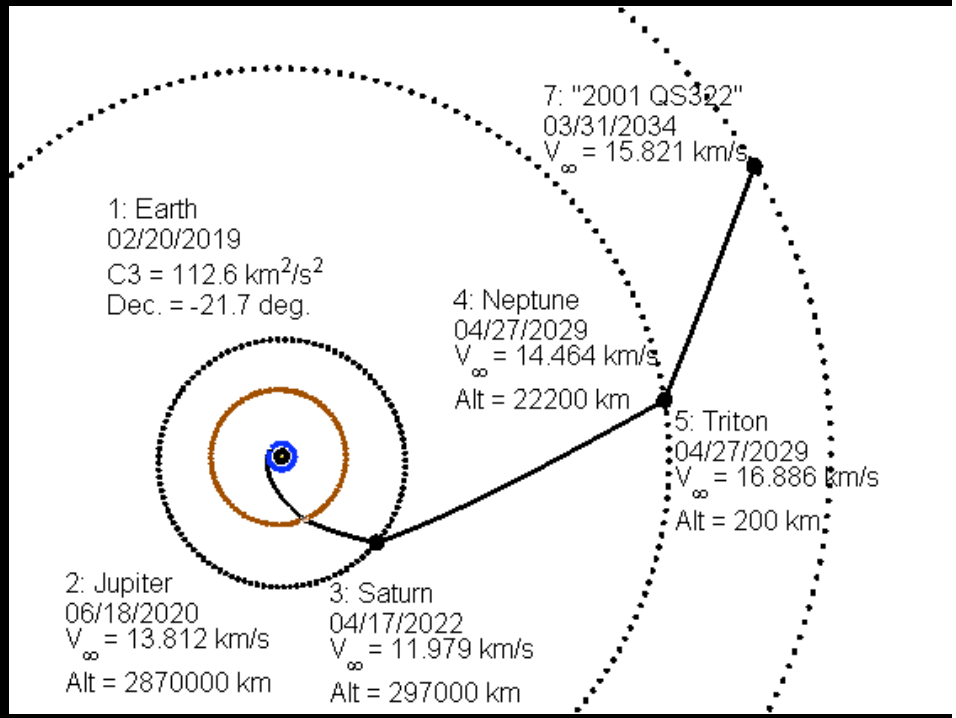


# Example 2019 Launch Options

## Voyager-like flight times to Jupiter and Saturn; even faster to Neptune



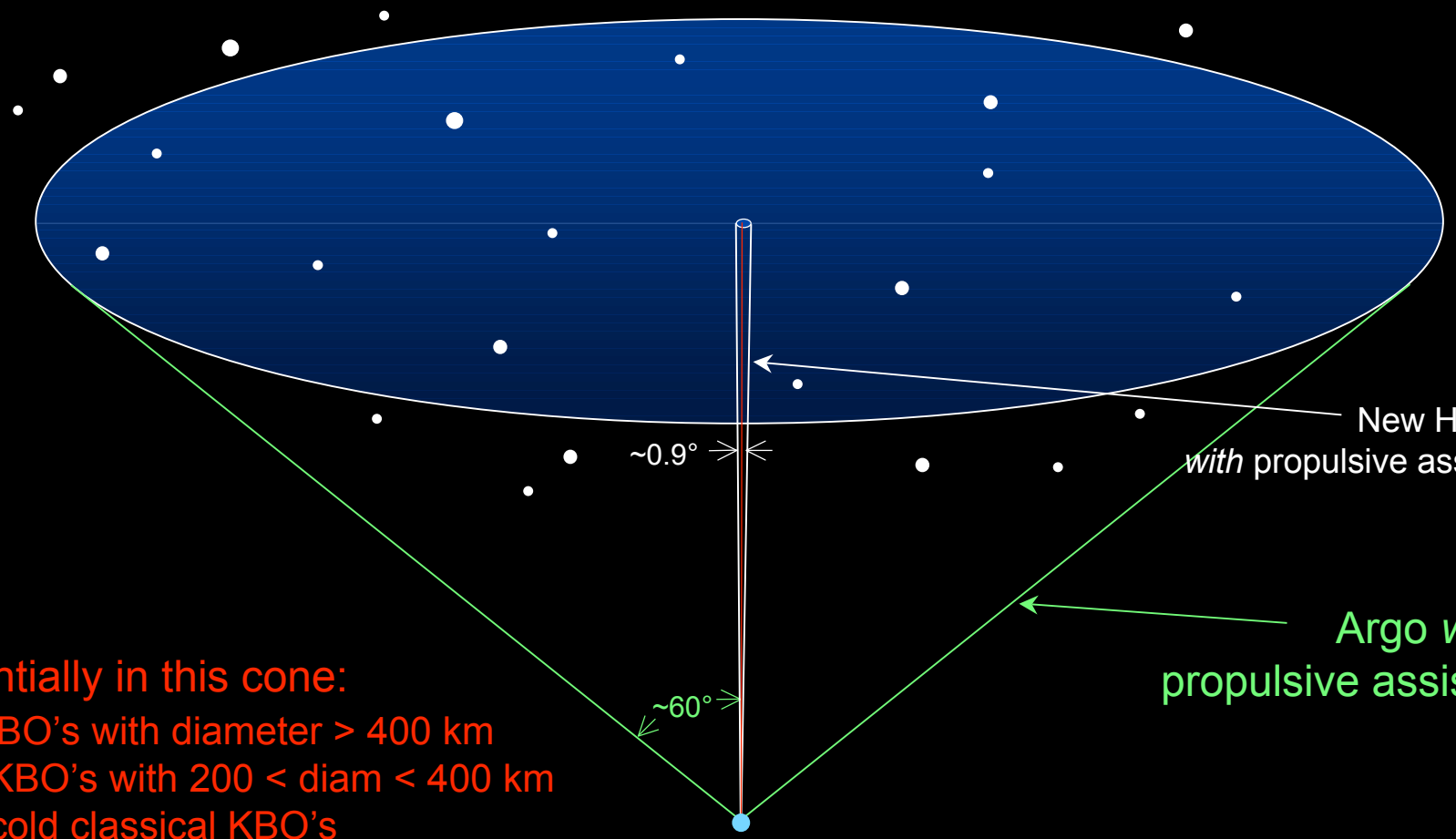

Time of Flight = 9.3 yr
Neptune flyby 2028
38S Neptune periapsis
KBO: 2005 PS21




Time of Flight = 10.2 yr
Neptune flyby 2029
21N Neptune periapsis
KBO: 2001 QS 322

# Access to Kuiper Belt Objects

Argo's accessible volume is ~4000x that of New Horizons
Flight time to KBO is just ~1.5 - 3 years (KBO at 35-39 AU)




Potentially in this cone:

- 9 KBO's with diameter > 400 km
- 40 KBO's with 200 < diam < 400 km
- 18 cold classical KBO's

# Argo is a Multi-Disciplinary, Multi-Target Concept

## Argo Mission Statement

Argo is the next step for outer solar system exploration, illuminating the genesis and evolution of the solar system by

- characterizing Kuiper Belt objects with diverse evolutionary paths ranging from captured KBO Triton to an *in situ* KBO, and
- accomplishing ground-breaking science at Neptune by opening a window on the dynamical nature of the atmosphere, rings, and magnetic field, and laying the groundwork for future ice-giant missions.

# White Paper(s) Status

- Argo white paper is finished
  - But it is currently 28 pages long
- Next steps
  - Send current version to OPAG, SBAG
    - solicit endorsements
  - Break into smaller target-oriented white papers
- New small (7-page) white papers:
  - Neptune, Neptune's rings, Neptune's magnetosphere ➔ Outer planet panel
  - Triton ➔ Outer planet satellites panel
  - KBOs ➔ Primitive bodies panel
- Content of each:
  - Overview (solar system evolution, mission concept) - same
  - Specific target body science - individualized
  - Summary table of science objectives and proposed payload - same

# Backup Slides

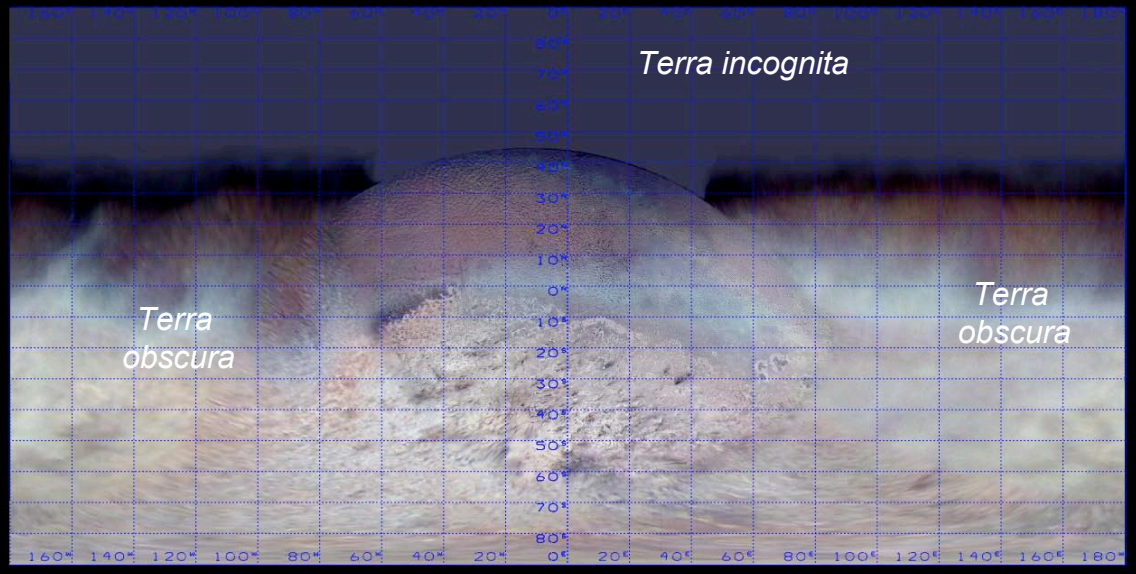
# Argo Science Objectives - Triton

*Triton Science Objective 1: Triton has a youthful surface, substantially modified when Triton was captured by Neptune. Argo will map the side of Triton seen only at a distance by Voyager ("terra obscura") and more of the northern hemisphere. Near-global surface coverage will extend the post-capture cratering history and other modification of Triton's surface.*

- More of Triton's northern hemisphere will be sunlit
  - Most of it was in seasonal darkness for Voyager

Terminator in 2027: 60°

Terminator in 1989 for VGR flyby: 45°

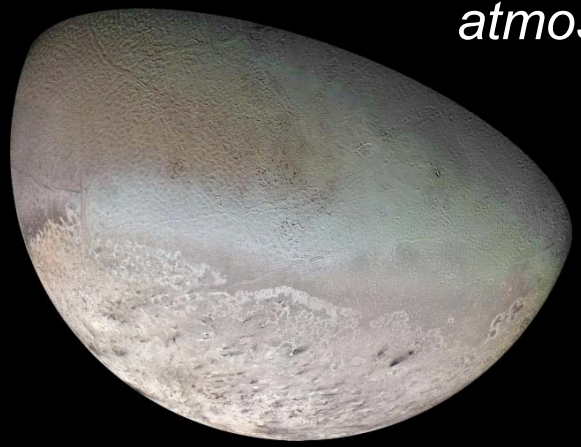


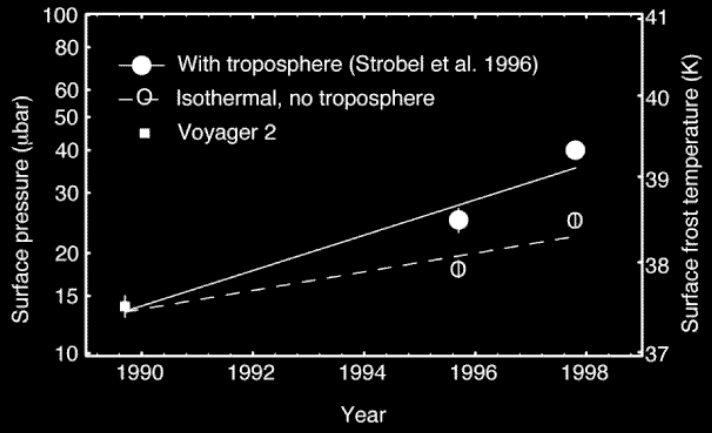

Will Triton's enigmatic plumes still be active?

# Argo Science Objectives - Triton

*Triton Science Objective 2: Triton's climate is controlled by its nitrogen atmosphere in vapor equilibrium with surface frost. Argo will map the distribution of ices on Triton's surface and measure the atmospheric pressure to capture another point in time for modelling climate change on an icy body*

- Triton's atmosphere has changed significantly since the Voyager flyby in 1989
  - *Nitrogen and methane ices move seasonally from hemisphere to hemisphere and the pressure of the atmosphere increases and decreases seasonally*

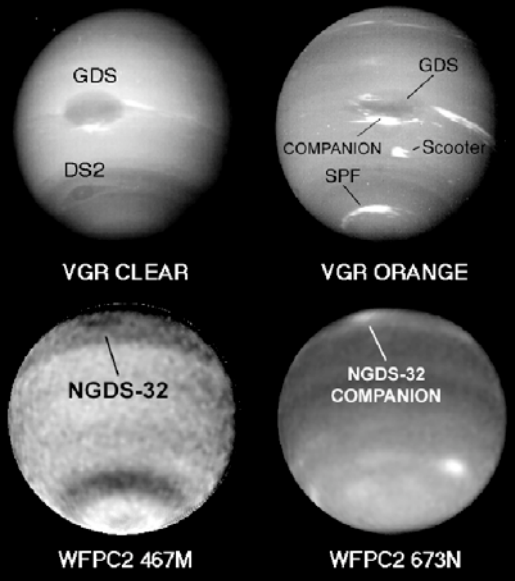




# Argo Science Objectives - Neptune

*Nearly all aspects of the Neptune system detectable from Earth have changed significantly since Voyager fly-by in 1989*

- Neptune's atmosphere shows fundamental differences in large-scale structure
  - No Vgr GDS, significant atmospheric evolution on <5-yr timescale; evidence for stratospheric heating since Voyager

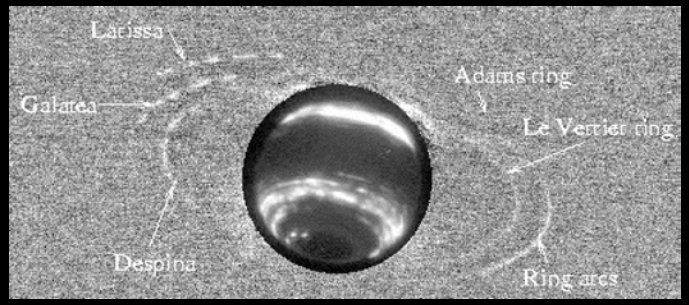



Neptune Measurement Goals

- Small-scale cloud distribution
- Atmospheric lightning
- Magnetic field measurements in completely different orientation
- First detailed compositional/spectral map
- First detailed infrared map
- Gravitational moments refined for interior models

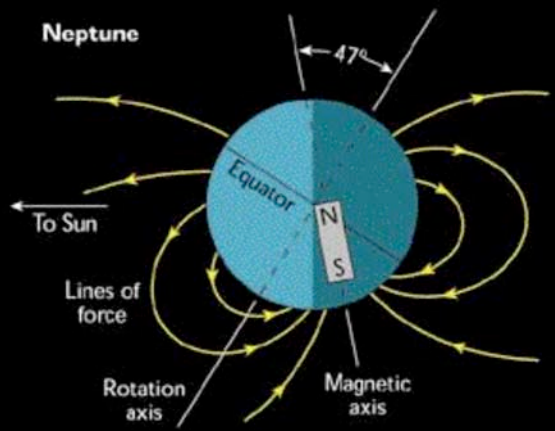
# Argo Science Objectives – Neptune system

*Nearly all aspects of the Neptune system detectable from Earth have changed significantly since Voyager fly-by in 1989*




- The ring system has changed
  - Arcs evolved within <8 yrs

- Neptune's Magnetosphere
  - Very complex and undetectable from Earth



# Notional Argo Payload

## Preliminary suite based on science traceability matrix

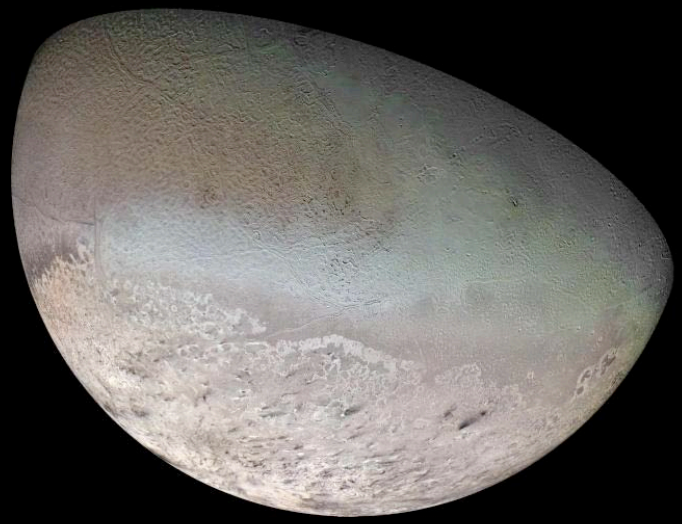
- High resolution visible camera - New Horizons (NH) or reduced Cassini heritage - Alfred McEwen
- Near-Infrared spectrometer - NH heritage - Don Banfield
- UV solar & stellar occ. spectrometer - reduced Cassini heritage - Amanda Hendrix
- Far-infrared linear radiometer - Diviner heritage - David Paige
- Magnetometer - Krishan Khurana
- Charged particle spectrometer – Messenger heritage
- Gimballed high-gain antenna - heritage radio science instrument

Beyond this: explore trade space for other instrumentation in terms of science, cost, power, and mass

# Argo: New Frontiers 4 Mission Concept

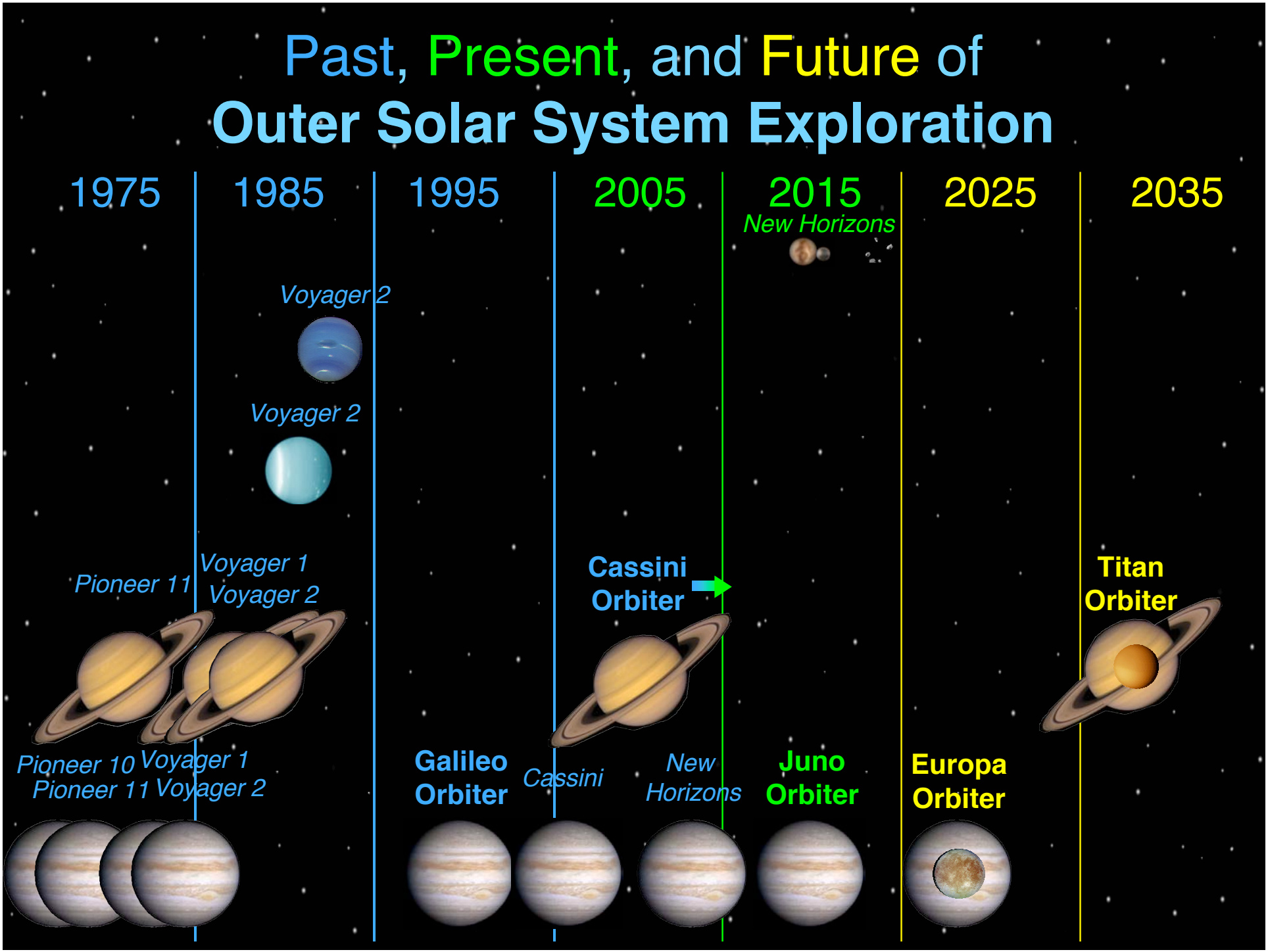
A *small body explorer* doing *exceptional ice giant science*

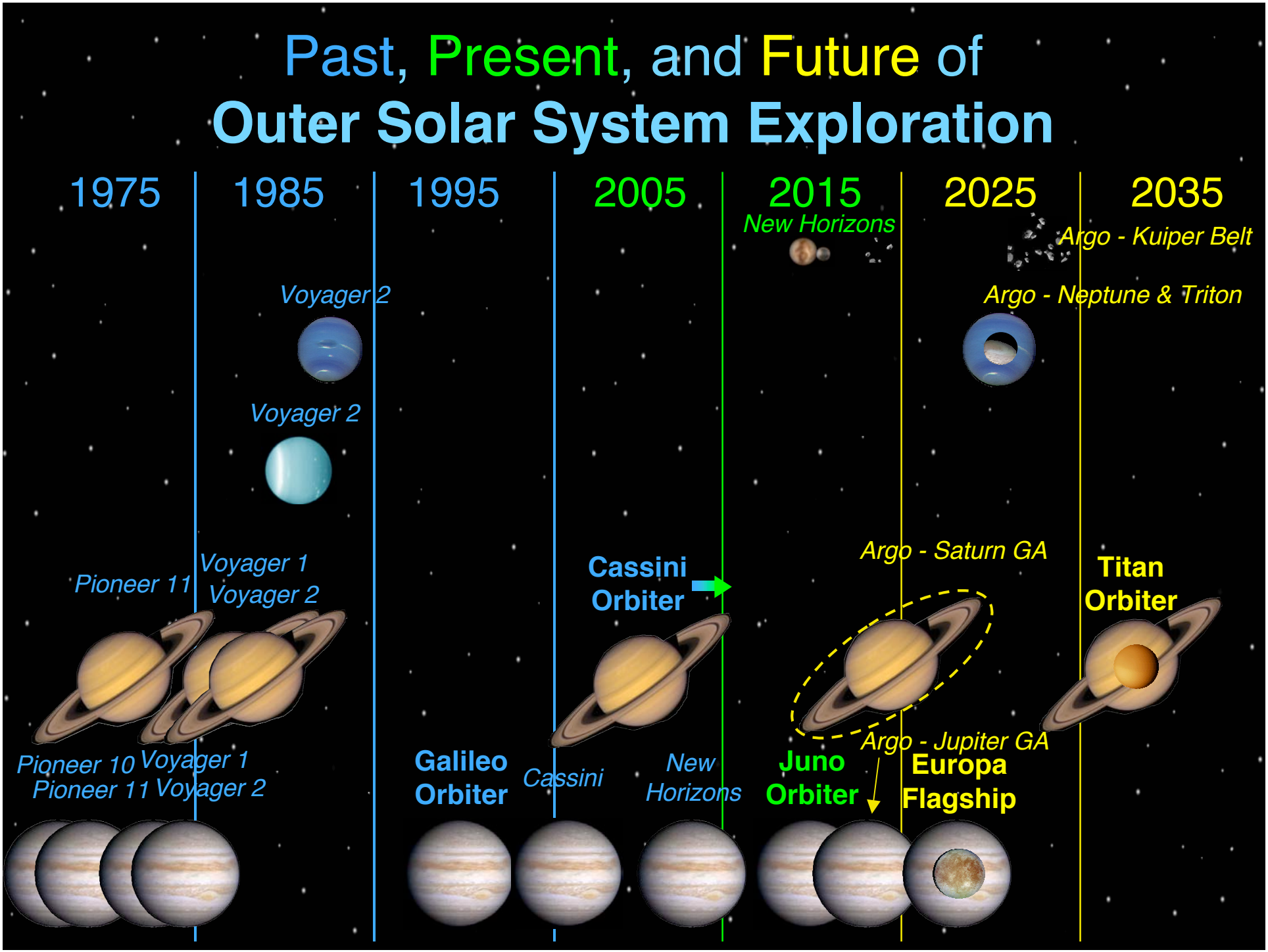
- Fly by a Kuiper Belt Object; close flyby of Triton
- Fly by Neptune
- Gravity assist from Jupiter and Saturn



## Key Characteristics:

Focused science mission
Simple mission profile
Current instrument technology
Current spacecraft technology
Capable payload
Nuclear power


Past, Present, and Future of
Outer Solar System Exploration
1975
1985
1995
2005
2015
2025
2035
New Horizons
Voyager 2
Voyager 2
Pioneer 11
Voyager 1
Voyager 2
Cassini
Orbiter
Titan
Orbiter
Pioneer 10
Pioneer 11
Voyager 1
Voyager 2
Galileo
Orbiter
Cassini
New
Horizons
Juno
Orbiter
Europa
Orbiter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Voyager 1
Voyager 2
Pioneer 11
Cassini
Orbiter
Argo - Saturn GA
Titan
Orbiter
Pioneer 10
Pioneer 11
Voyager 1
Voyager 2
Galileo
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Cassini
New
Horizons
Juno
Orbiter
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Europa
Flagship