
Argo
Voyage Through
the Outer Solar System
Presentation to SBAG
12 January 2009
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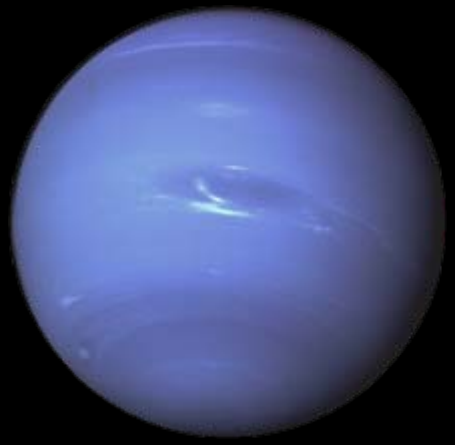
Argo: New Frontiers 4 Mission Concept

"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



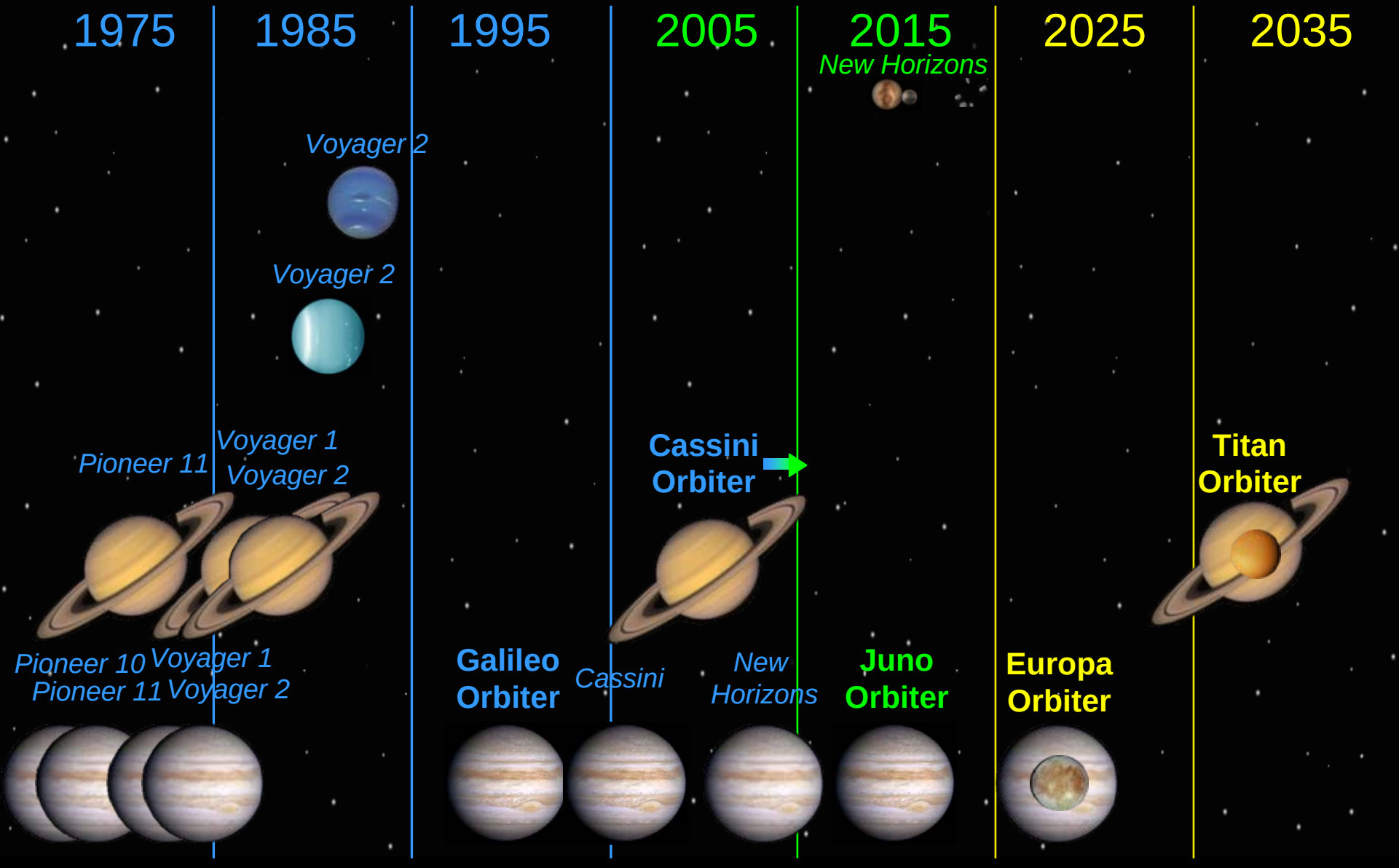
Key Characteristics:

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

Outline

- Short review of concept
  - New Frontiers 4
  - New trajectory options
- Recent developments
  - Spacecraft partner
  - Payload definition
- Decadal Survey
- Requests to SBAG

Past, Present, and Future of **Outer Solar System Exploration**



Past, Present, and Future of
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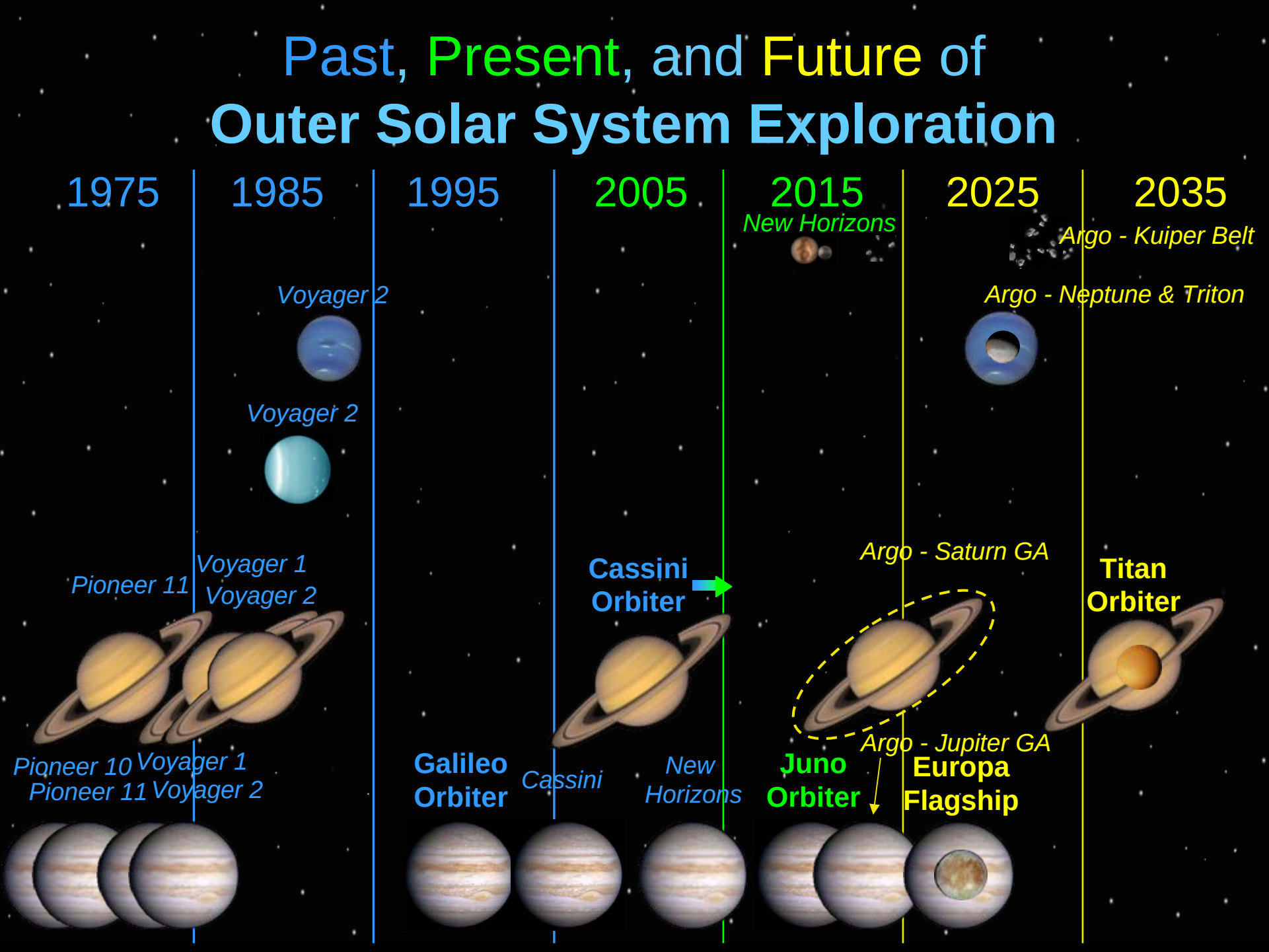


Neptune flyby enables KBO science

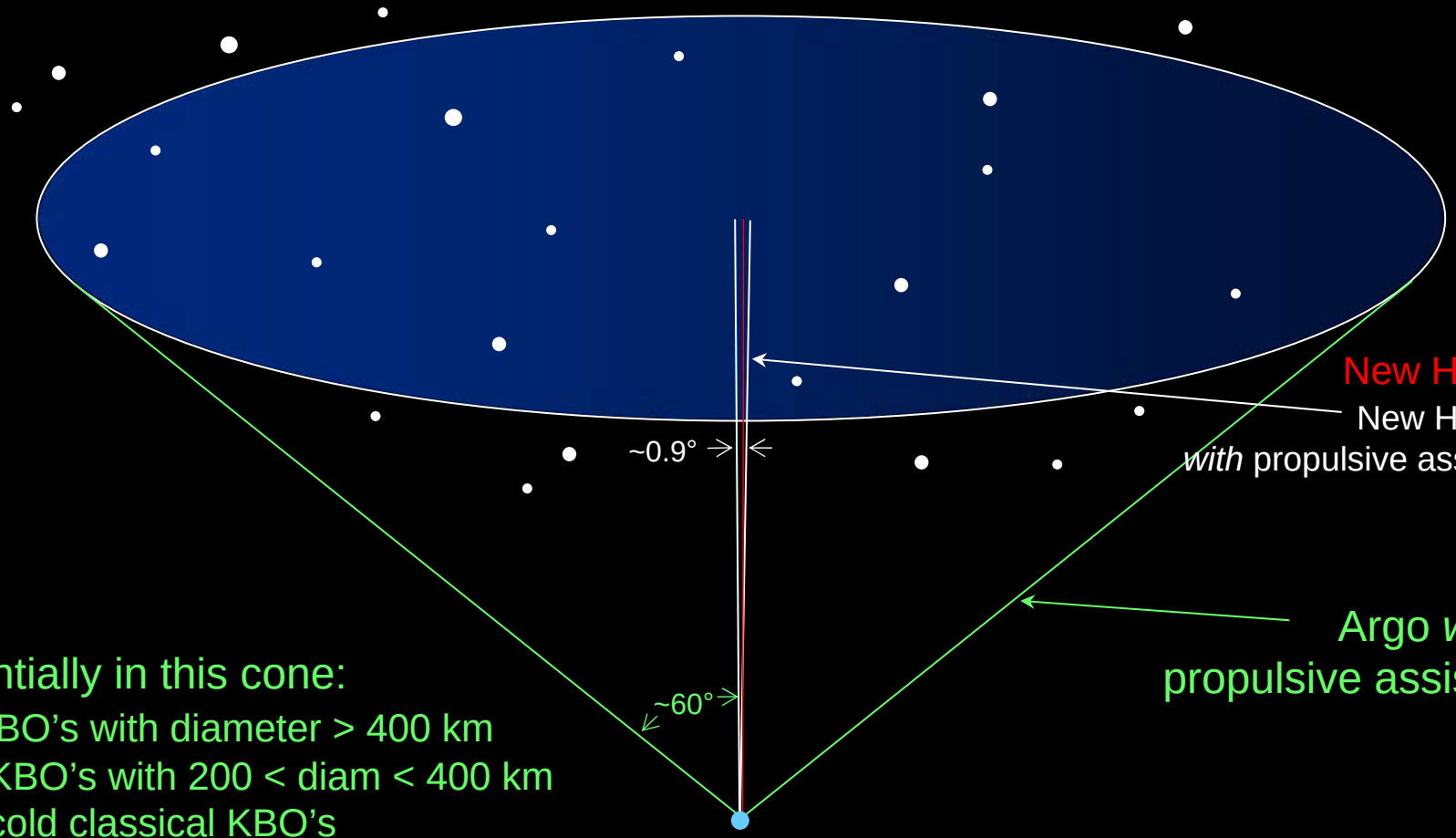
- Opportunity to continue on to a KBO□!
- Potential KBO Targets
  - Our cone of accessibility includes ~40 of the largest KBOs
  - Several binary KBOs
  - Many objects in the cold classical disk

- Neptune flyby permits selection of KBO with highest scientific interest

Address evolution of the solar system…

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)



New Horizons

New Horizons, *with* propulsive assistance

Argo *without* propulsive assistance

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 Science Objectives - KBO

- Reconnaissance of primitive solar system body that is member of a much larger population
- Determine comparative properties of the captured KBO Triton and a KBO *in situ*
- Expand the diversity of volatile-rich small bodies explored in the outer solar system
  - Between Argo and New Horizons (shown here) we will double the number of explored KBOs
    - Pluto
    - New Horizons *in situ* KBO
    - Triton
    - Argo *in situ* KBO

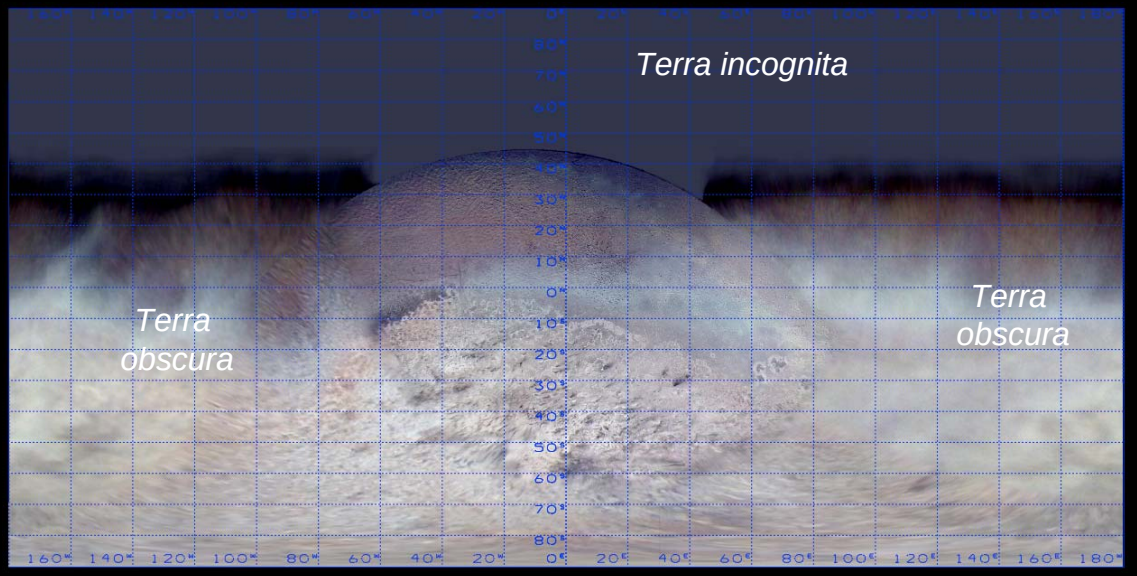
Argo Science Objectives - Triton

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°

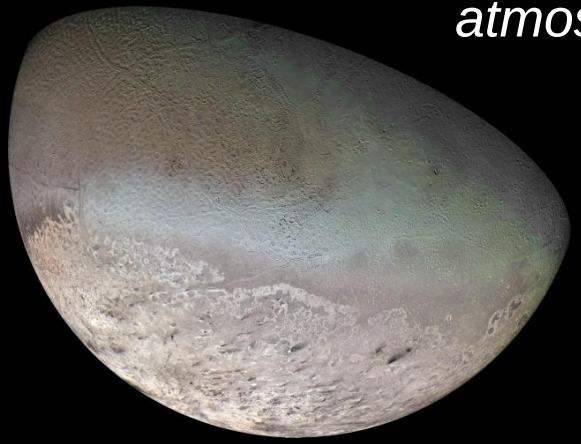


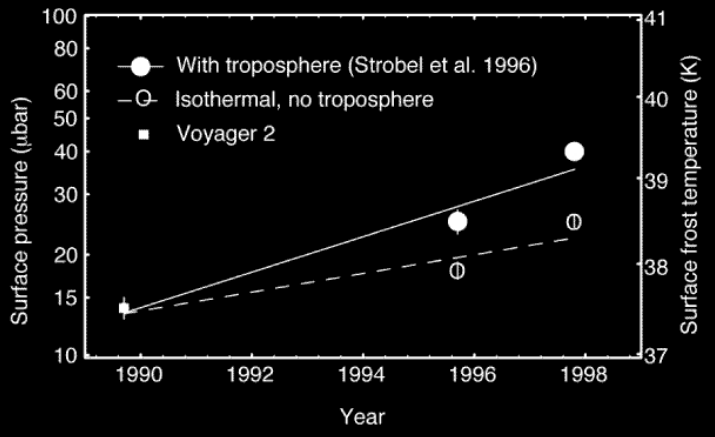
Will Triton's enigmatic plumes still be active?

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

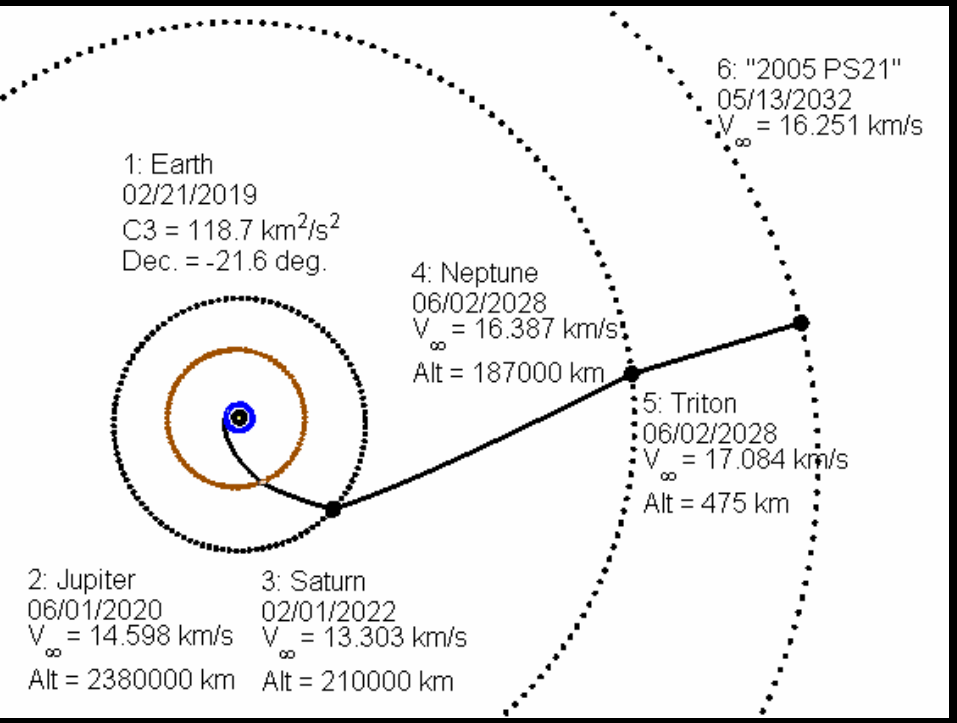
- Triton's atmosphere has changed significantly since the Voyager flyby in 1989
  - *Nitrogen and methane ices move seasonally from hemisphere to hemisphere and the pressure of the atmosphere increases and decreases seasonally*



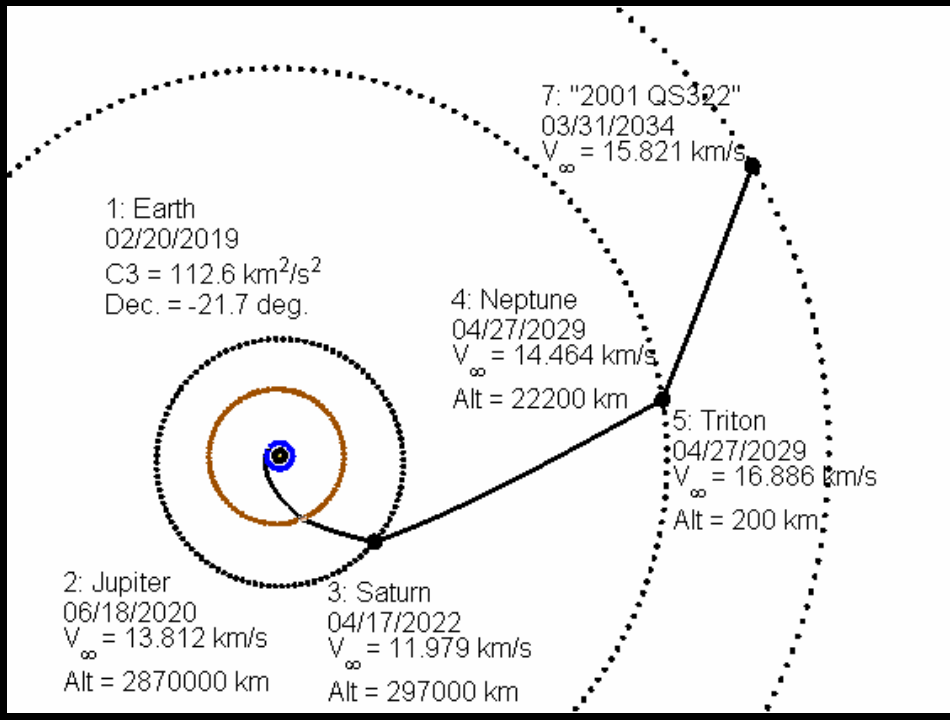


Example 2019 Launch Options

Voyager-like flight times to Jupiter and Saturn



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

Why NF4?

- Launch opportunity window from 2017 - 2019
  - Such windows occur every 12 years due to Jupiter gravity assist
- Waiting for flagship, or next window, will result in ~50-year gap in observations of a Triton dynamic system
- Neptune / Triton Flyby is complementary to eventual Neptune system orbiter
  - Outstanding ice giant science can also be obtained on the way to the KBO
- Need time to resolve nuclear power issues

NRC Midterm Report

- The Committee on Assessing the Solar System Exploration (CASSE) Program gave NASA a "C" in its 2008 Report, on Science Question #2*, and made the specific recommendation:

  "The next solar system exploration decadal survey should address the objectives and merit of a Neptune/Triton mission"

- NF4 can address this recommendation and raise this grade *without a flagship mission!*

* How long did it take the gas giant Jupiter to form, and how was the formation of the ice giants (Uranus and Neptune) different from that of Jupiter and its gas giant sibling, Saturn?

NF3 vs. NF4

New Frontiers 3		New Frontiers 4
AO comes out	2008	
Proposal writing, down-select	2009	
Step 2 = Phase A	2010	
Phase B	2011	
Phase C/D	2012	
Phase C/D	2013	AO comes out 54 months after NF3, write proposal
Phase C/D	2014	Down-select, Step 2 = Phase A
Launch window opens	2015	Phase B
Launch	2016	Phase C/D
Launch backup	2017	Phase C/D
Launch backup	2018	Phase C/D
	2019	Launch in February
	2020	Launch backup

The schedule for NF4 is tight but not out of the question

Spacecraft Update

- Envisioned spacecraft is similar to New Horizons spacecraft
  - Similar total mass and mass distributions (~400 kg dry mass)
  - Similar power needs (200 W)
- Must use nuclear power
- Spacecraft partner: Lockheed Martin Aerospace (LMA)

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 - Ralph McNutt
- Gimballed high-gain antenna - heritage radio science instrument

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

Payload mass

8.6 kg	Lorri
10.5	Ralph
5.0	UV
12.0	Diviner
10.0	Magnetometer w/ boom
3.5	Charged particle spectrometer
1.5	USO
51.1 kg	Total

Figure 1. The MCS flight instrument photographed during calibration at JPL. Major elements of the instrument are identified.

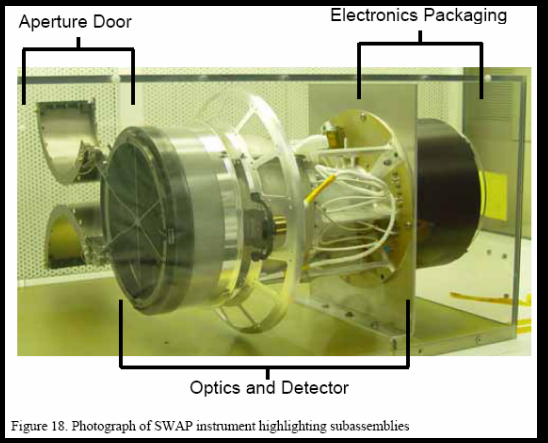


Figure 18. Photograph of SWAP instrument highlighting subassemblies

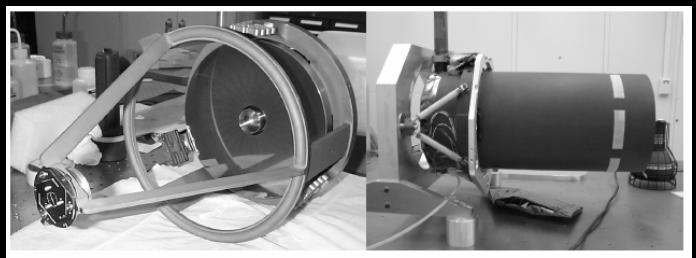


Figure 1 (left) LORRI telescope assembly, showing SiC mirrors and metering structure; (right) LORRI composite baffle and flexure mount on test stand

Argo science team

		KBO	Triton	Neptune	Neptune Rings	Neptune Magneto-sphere
		J. Stansberry	C. Hansen	H. Hammel	L. Spilker	K. Khurana
High res imager	A. McEwen	M. Brown			M. Showalter	
Near IR imager	D. Banfield					
UV spectrograph	A. Hendrix				J. Colwell	
Far IR linear radiometer	D. Paige			A. Simon-Miller		
Magnetometer	K. Khurana					M. Dougherty
Charged particle spectrometer	R. McNutt					

your name here?

Lead scientists recruited plus other key members
Most slots will stay open until we are ready to write the proposal

Argo 2008 - 2011

- *Most important near-term goal is to be highly ranked in the new decadal survey*
  - Panels to be formed in 2009
  - Report due to HQ 2010
  - Release window is Jan-March 2011

  (our launch window is 2016-2020)

- Argo science team activities for 2008, 2009
  - White paper (nearly done)
  - Address SBAC, OPAC, PSS, Complex


- Timing is urgent: when Argo is selected we need to hit the ground running because NF4 puts us at the end of the good launch opportunity

Motivation for Argo Decadal Survey Activities

- Previous Decadal Survey drove the selections for New Frontiers 1, 2, and 3
  - NF1: New Horizons
  - NF2: Juno
  - NF3: No-nuclear mission constraint excludes all targets beyond Saturn

- Previous NASA studies (e.g., two vision mission concepts) were required to focus on orbiter science, not on science advantages enabled by a flyby
  - *Scientific selection* of a KBO can only happen with flyby

Argo and New Frontiers

- Argo *must* fit within a New Frontiers budget
- Our most important challenge is to get a *good cost estimate* as quickly as possible
- Early partnership with LMA is key advantage to scoping the mission
- We need to do our study now to support the Decadal Survey

Of $1B Boxes and Bricks

"I heard that a joint NASA study by JPL and APL said NASA couldn't send any mission to the outer Solar System for less than $1B." **This is wrong.**

The "Titan and Enceladus $1B Mission Feasibility Study" *actually* said:

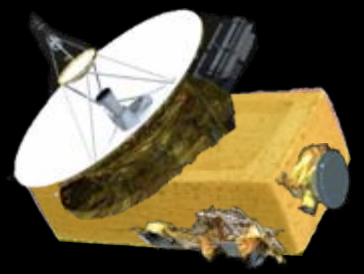
Pg 1-1: "no missions to Titan or Enceladus that achieve at least a moderate understanding beyond Cassini-Huygens were found to fit within the cost cap of 1 billion dollars (FY'06)."

Relevance to Neptune: None

"But I also heard that the study said NASA couldn't even send a BRICK (spacecraft with no instruments) to the outer Solar System for less than $800M." **This is only partially correct.**

CORRECT Pg 1-11: "Even the lowest cost mission studied [Enceladus flyby], without the cost of science payload, has a minimum expected cost of ~$800M."

HOWEVER Pg 2-4: "[The Enceladus flyby's] design (and therefore cost) was uniquely derived using actual cost data from the NH mission."



Neptune cost mitigators: Can use an Atlas 541 instead of a 551.
Do not require Star-48 upper stage. Other savings under study.

Result: $$ available for Argo science payload within $800M cap

Cost-Saving Options

- Use simple spacecraft with current (New Horizons) heritage
  - Experience base and corporate knowledge available
  - No miracle developments required
- Identify many trajectories, some of which offer mass relief
  - NH's Star 48 upper stage may not be needed
- Use smaller Atlas V launch vehicle
  - 541 instead of 551 -- promising for some trajectories
- Scale instrument requirements to available $
- Use the market-based approach that Cassini followed for payload development (power, mass, dollars were trade-able)
    - No instruments over-ran or were descoped from payload
- Science ops at Jupiter or Saturn will be a mission of opportunity
  - Under SALMON umbrella

Proposed Short-term Activities

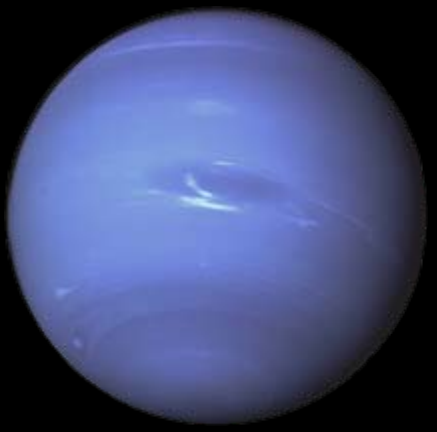
A. Top Priority
   1. Trajectory analyses
      - Launch vehicle trades
      - Triton and Neptune science vs. KBO accessibility
   2. Power trades and plutonium availability
      - MMRTG vs. ASRG
   3. Mission Cost
      - How to accomplish this mission with a New Frontiers budget
      - Team X session

B. Additional work on mission design
   1. Assessment of spacecraft mass, power (from analogs)
   2. Evaluation of DSN requirements and onboard data storage
   3. Trade study on how KBO selection affects spacecraft lifetime requirements

We will only get one shot at this proposal because the window will close

Argo Summary

- A **KBO encounter** explores another primitive outer solar system body
  - Triton / KBO comparison
  - Pluto / KBO comparison
  - Numerous potential KBO 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



Requests for SBAG Findings

- We request SBAG's endorsement for New Frontiers missions (e.g., Argo) — and particularly mission study money during lead-up to Decadal Survey

- We request that SBAG keep on the pressure for the nuclear power situation to be solved

- We request that SBAG stress the importance to HQ of keeping the communications infrastructure intact for outer solar system missions (DSN 70 m stations)