Near-Earth small body nodal encounter mission opportunities

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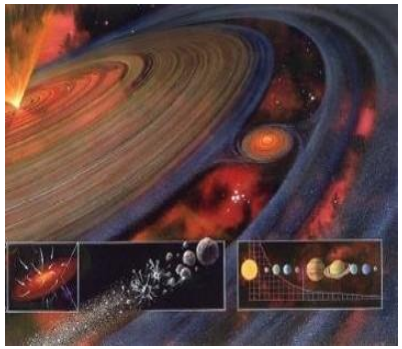
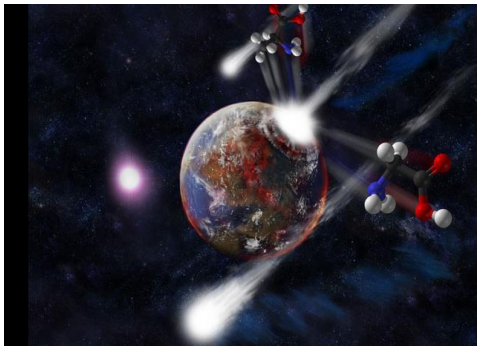
Why near-Earth asteroids do matter

- The closest building blocks of the solar system
  - ✓ Relevant for the origin of prebiotic material on the early Earth
  - ✓ Study of small-sized asteroids (m-sized NEAs observable from Earth)

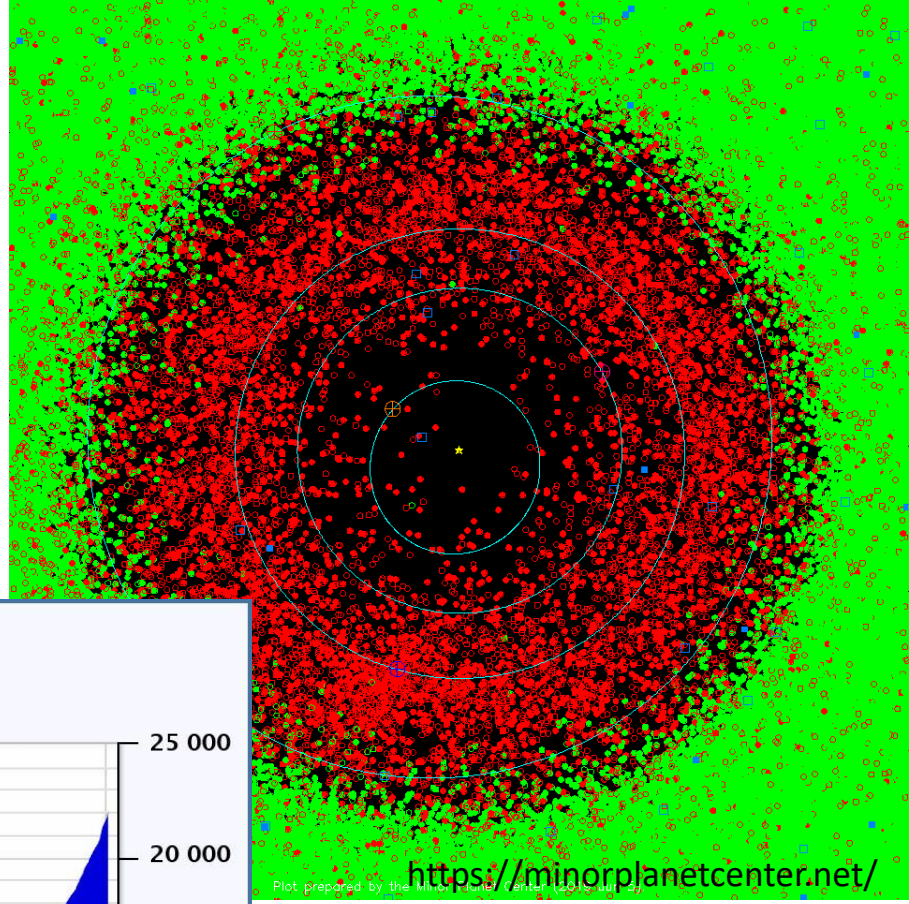
- Accessible targets for space missions
  - ✓ Science
  - ✓ Water/mineral resources
  - ✓ Planetary defense

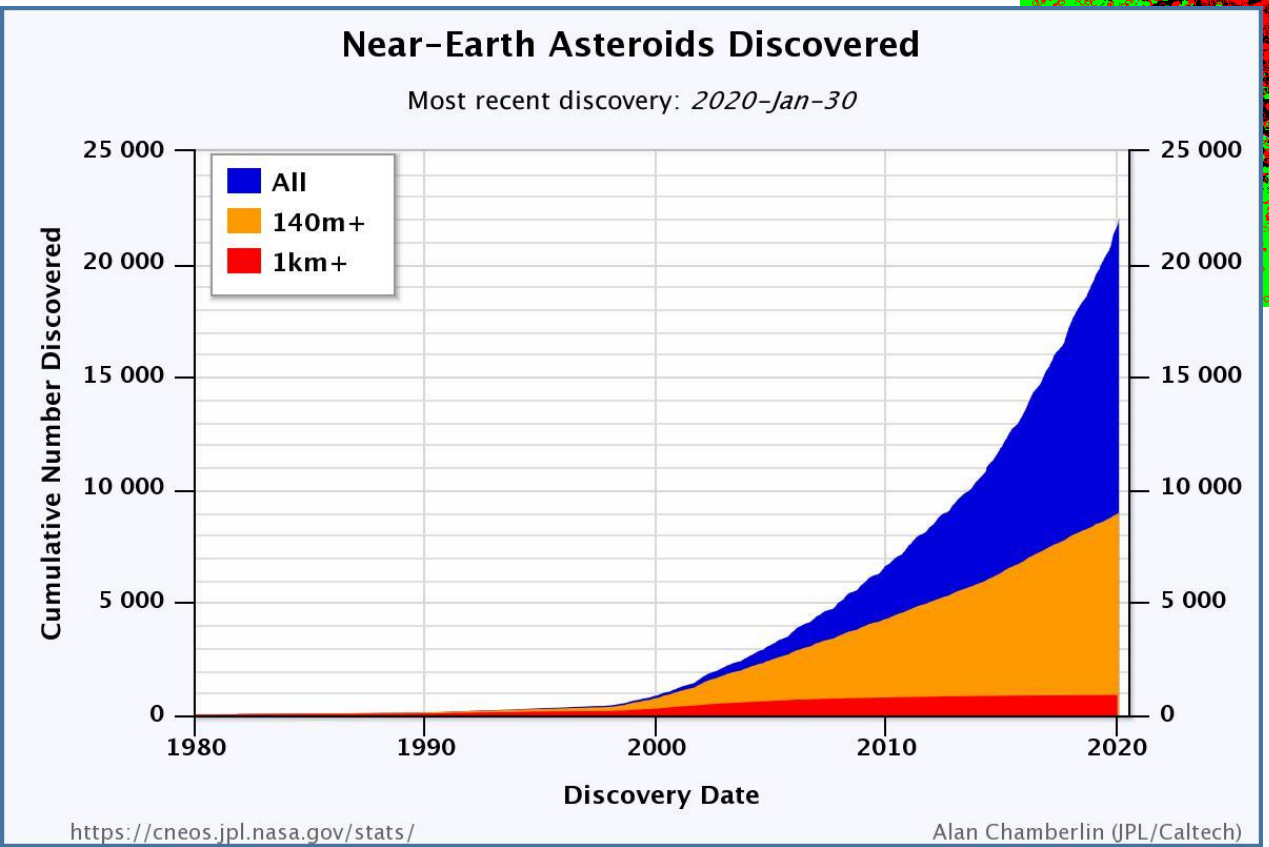


NEA population

- Current discovery rate:
  - ✓ >6 objects/night
  - ✓ Mostly “small” asteroids





NEA population

A Ride With The Earth

An animation centered on Earth showing the known objects that have approached to within 20 million km between July 2007 and June 2008. See the Animations Page on the MPC website for a description of the symbols used in this animation.

Population discovered was >5 times smaller than today

https://minorplanetcenter.net/

A bunch of NEAs (size range ≈ 350 m – 17 km) have been explored in situ with ad hoc space missions, each time revealing exciting new insights…

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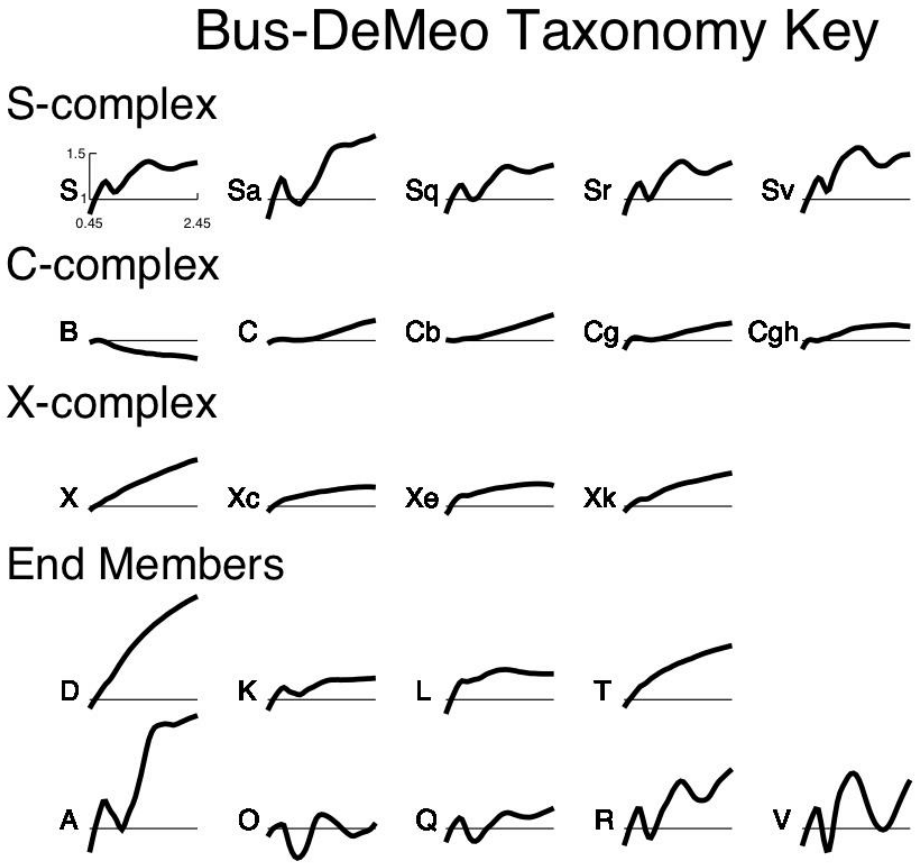
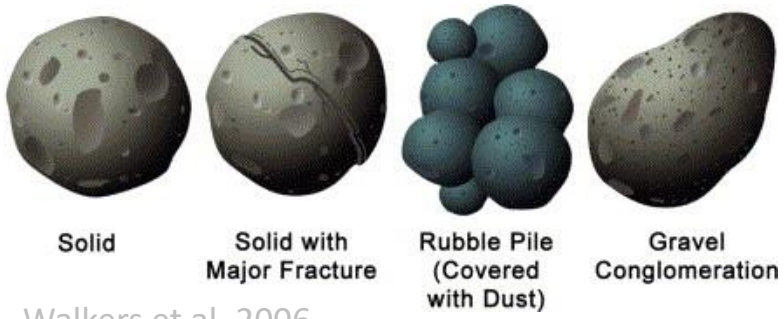
A **huge diversity** (in terms of composition, size, internal density distribution, material strength, …) is still to be explored!



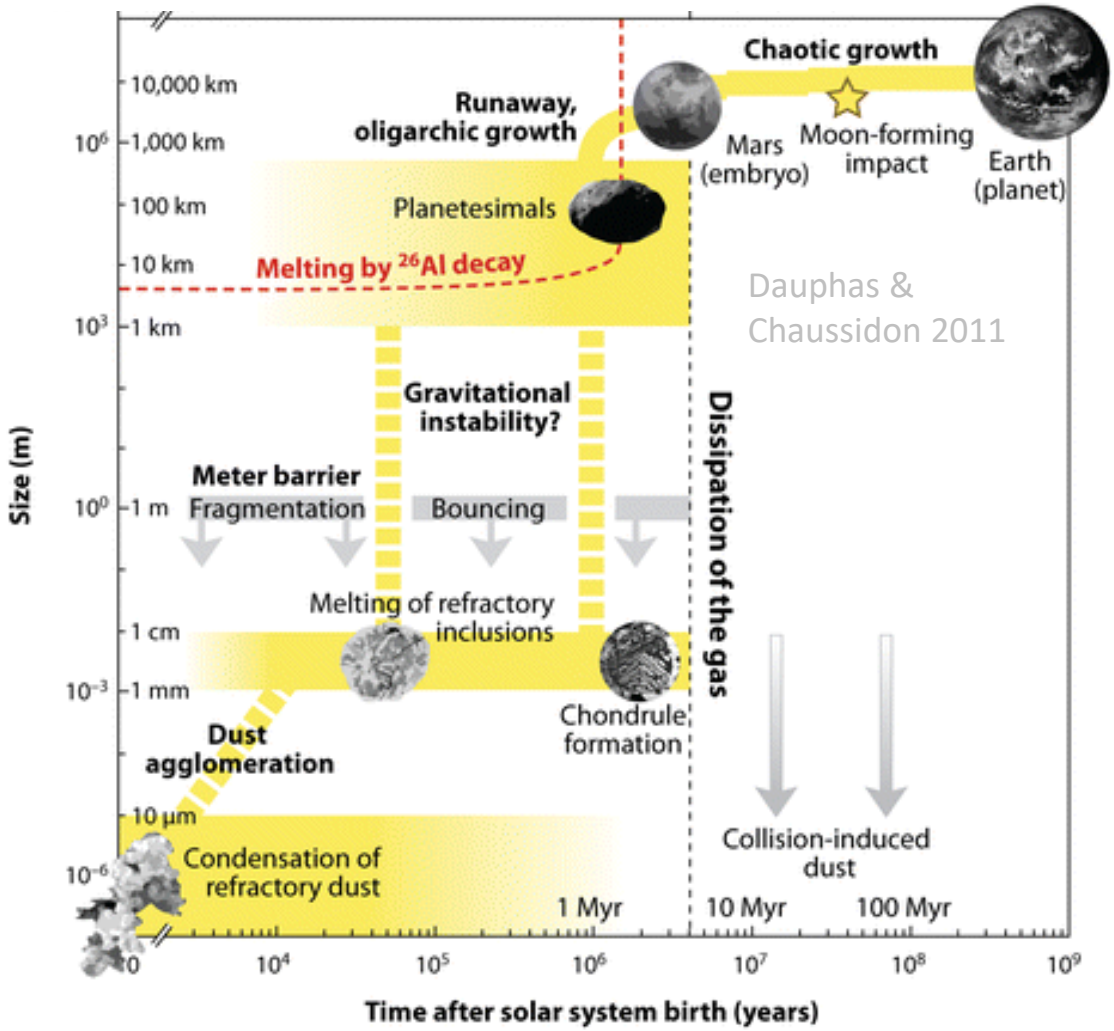


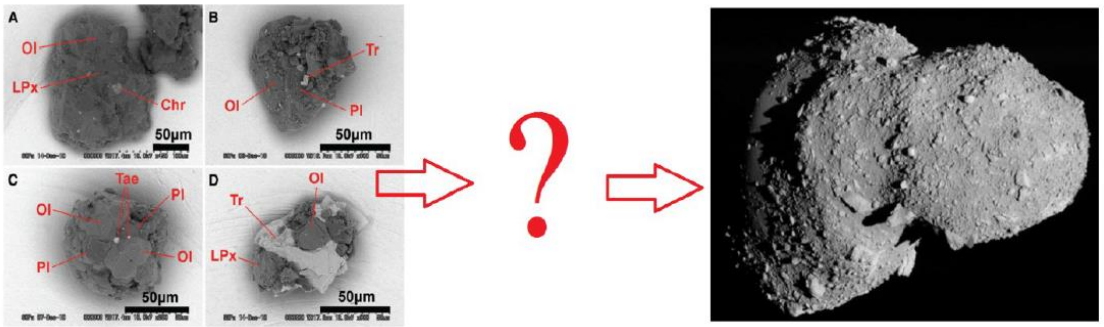
Walkers et al. 2006

Investigating:

- **asteroids' interiors**
- **very small bodies**

gives key information about formation and evolution, from the condensation in the solar nebula at different heliocentric distances, to the collisional accretion, enhancing our understanding of the mechanisms underlying planetary formation.





NEST

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2018 ESA "Fast" mission call

"Near-Earth Space Trekker"
selected (6 out of 23 Phase-1 proposals)
for Phase-2 after the technical and
scientific screening by ESA

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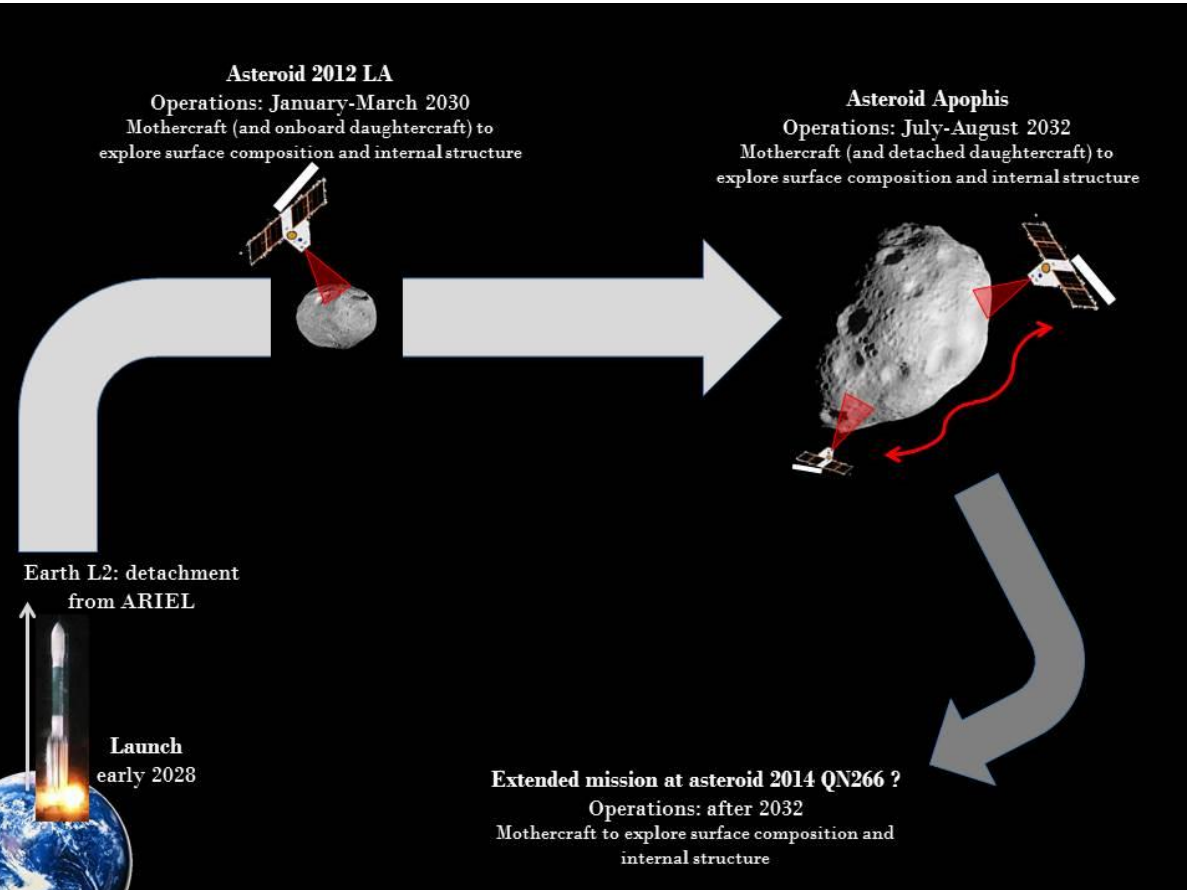
Observatoire de la CÔTE d'AZUR

SPACE - X Space Exploration Institute

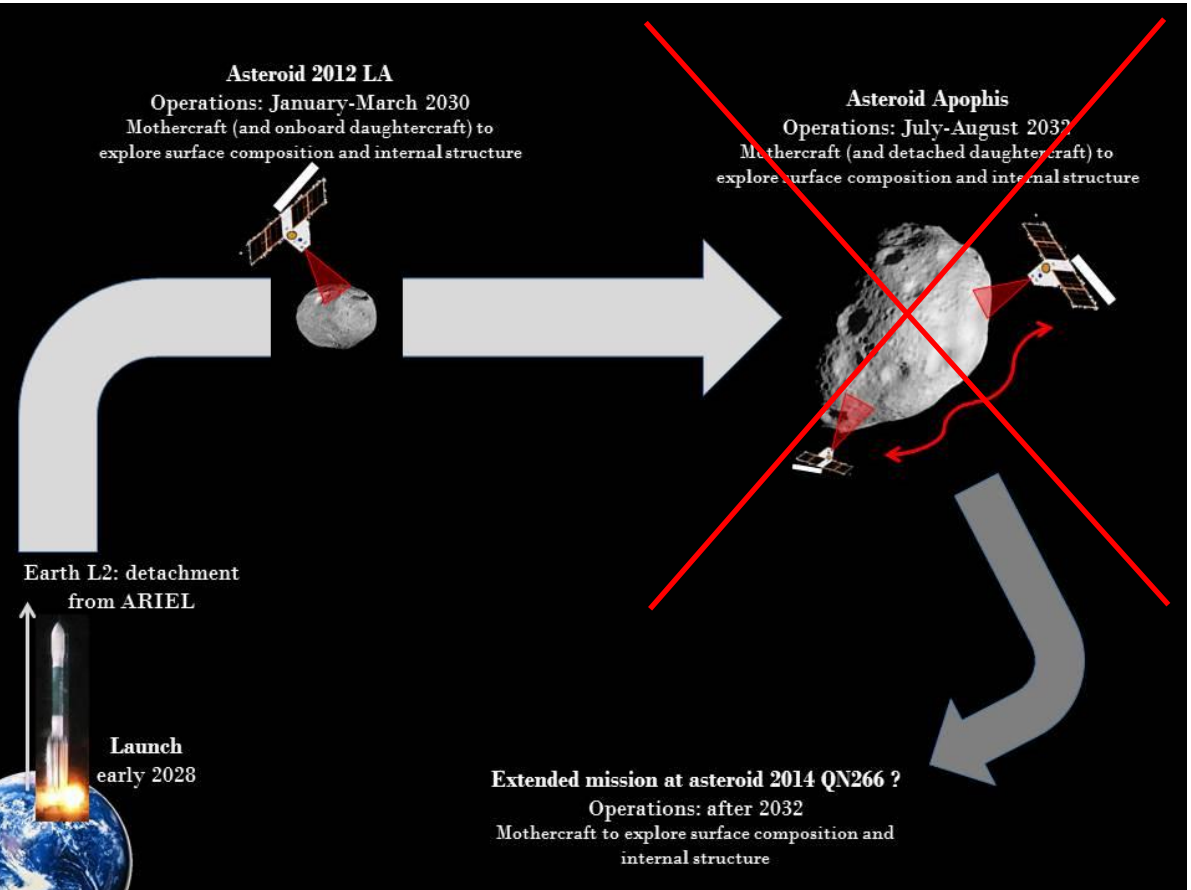
INSTITUTE FOR ASTRONOMY UNIVERSITY OF HAWAI'I

- **Rendez-vous with multiple NEAs** *(few months at each target)*
  - Baseline targets: **2012 LA** (10-m) and **Apophis** (350-m)
  - Extended mission target: **2014 QN266** (20-m)
- **Science goals** *(to constrain latest theories about planetary formation)*
  - Smallest asteroids ever visited
  - First radar investigation of asteroid interiors



- Electric propulsion (e.g., Arianegroup RIT 2X or Qinetiq T6)
- Daughtercraft to be released at Apophis (close-up investigation and bistatic radar measurements)
- Total ΔV
  - ✓ ~4.8 km/s (baseline)
  - ✓ ~8 km/s (extended)

- NEST proposal didn't pass Phase-2 technical screening:
  "incompatible with the boundary conditions of the call"
  - Radar technology (TRL 4)
  - ΔV to reach Apophis



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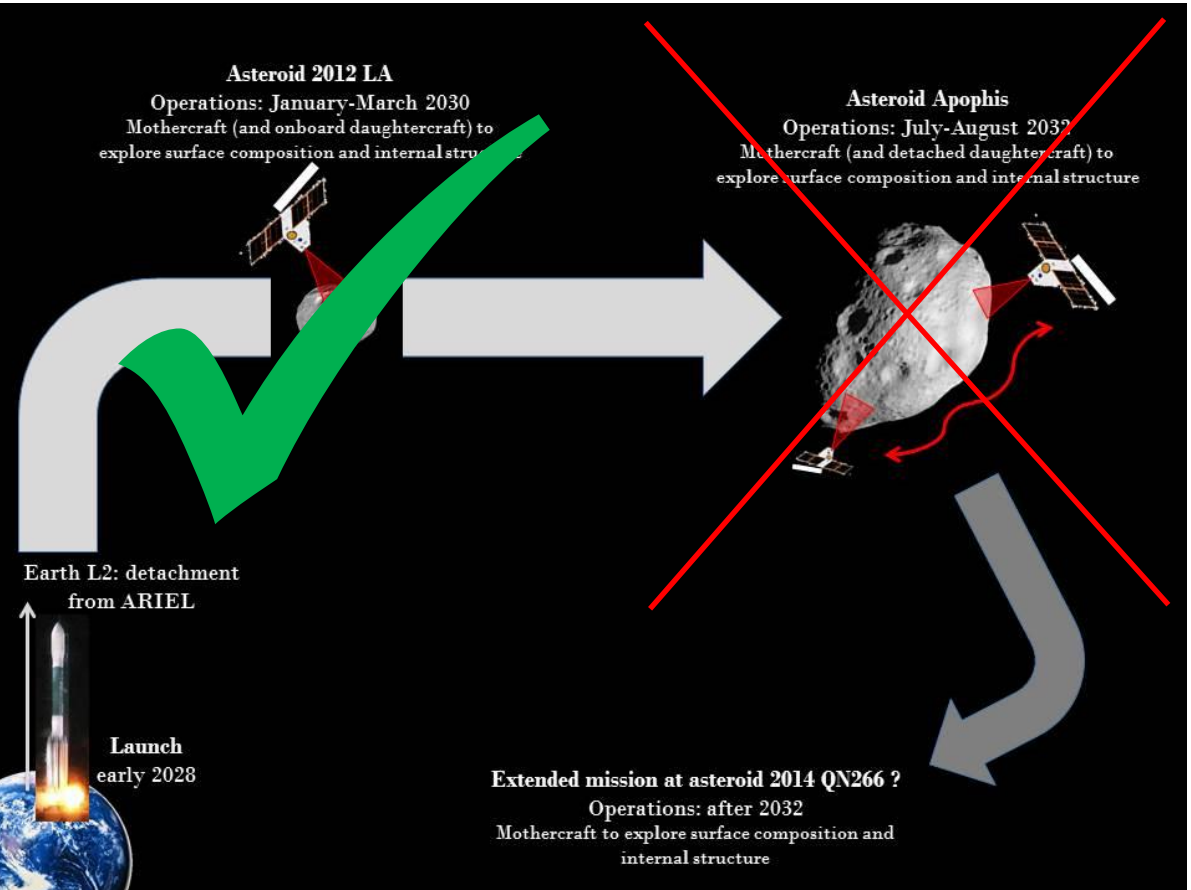
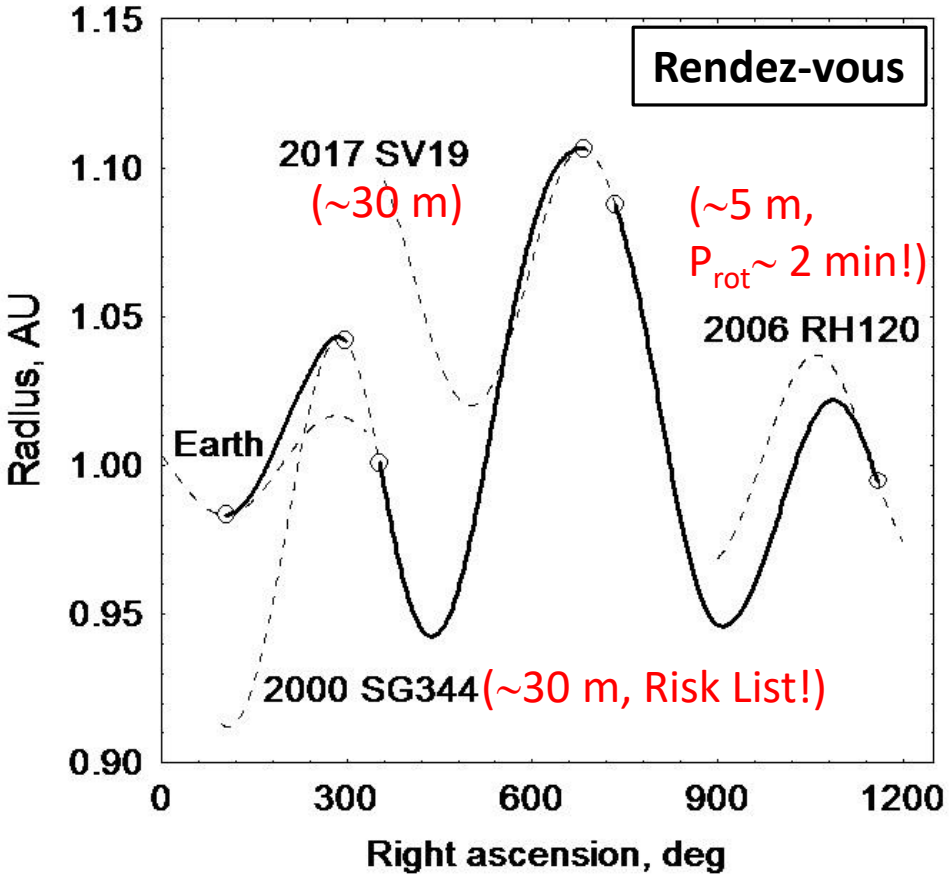


- *Extremely positive Phase-1 scientific assessment!*

→ **Explore next mission opportunities!**

✓ Larger mission class
✓ Small/cheap missions (no radar)

“Low-cost” missions: nodal encounters!

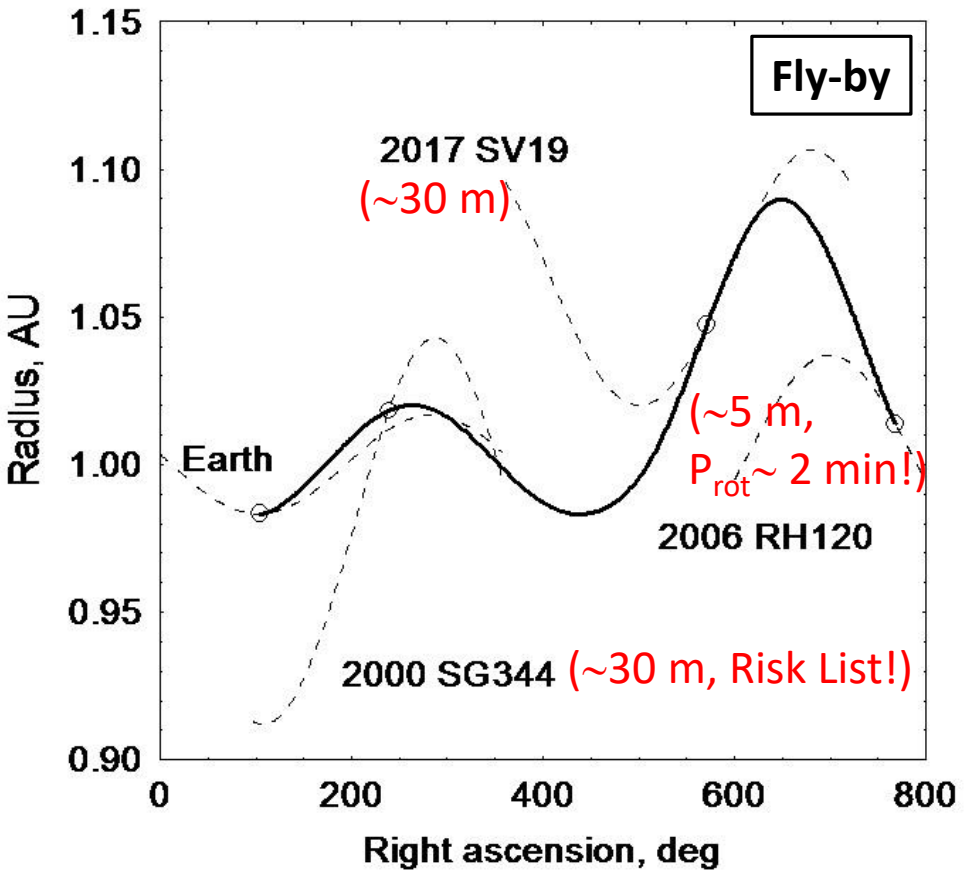


Assuming:

- Spacecraft mass at launch: 850 kg
- Launch date: 5 Jan 2028

	Date	Leg ΔV (km/s)	V_{rel} (km/s)
Earth	5/1/2028		0
2000 SG344	24/7/2028 22/9/2028	0.945	0
2017 SV19	1/9/2029 31/10/2029	2.000	0
2006 RH120	5/1/2031	1.557	0

“Low-cost” missions: nodal encounters!



Assuming:

- Spacecraft mass at launch: 850 kg
- Launch date: 5 Jan 2028

	Date	Leg ΔV (km/s)	V_{rel} (km/s)
Earth	5/1/2028		0
2000 SG344	20/5/2028	0.203	1.335
2017 SV19	24/4/2029	0.816	0.550
2006 RH120	2/12/2029	0.000	0.629

“Low-cost” missions: nodal encounters!

- Several further rendez-vous and fly-by solutions exist with similar ΔV
  - More and more (and cheaper) solutions with increasing NEA discovery rate

- Will allow to investigate:
  - Small body diversity
  - Asteroids’ internal structure
  - Ultra-small asteroids’ properties
  - …