

# *The ANIME CubeSat Mission: Science & Planetary Protection*

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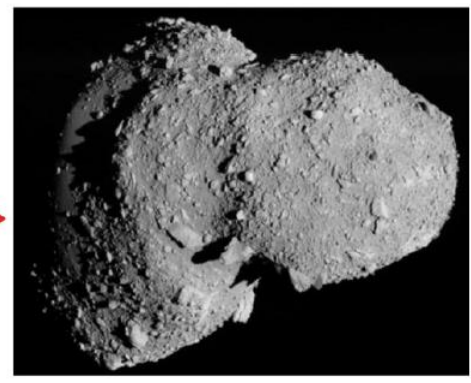
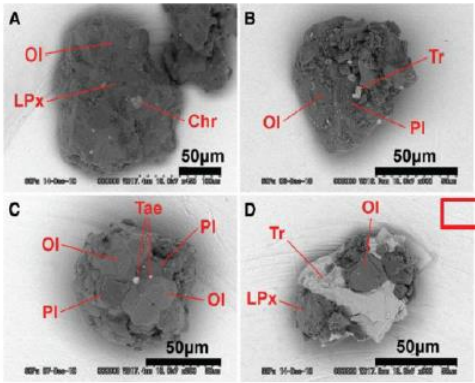
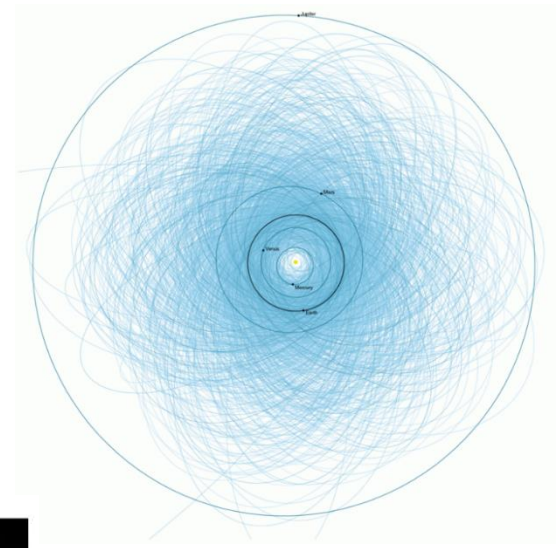
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**7<sup>th</sup> Planetary Defense Conference, 26 – 30 April 2021, Online Event**

# The NEA proximity: a risk...

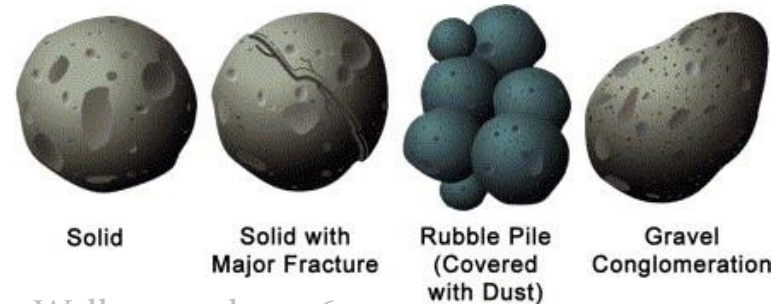
## ... & an opportunity

- Multi-target space missions
  - ✓ To constrain physical diversity
- Accessibility of ultra-small asteroids
  - ✓ Unexplored!
  - ✓ To constrain aggregation structure (monolithic vs. cohesive vs. rubble pile)



## In a nutshell

- Concept developed for the 2020 ASI call for “future CubeSat missions”
  - ✓ ESA GSTP framework
  - ✓ 50-month (phases A-to-D) development plan
  - ✓ 24-month post-launch operations
- Rendezvous with “high-risk, decametre-size” NEA + 2 PHA fly-bys
  - ✓ Unexplored physical regimes
  - ✓ Science + Planetary protection
- COTS, flight-proven components
  - ✓ Low-cost
  - ✓ Low-risk
  - ✓ High-return!



Walkers et al. 2006

## Targets & mission profile

|                  | Earth   | 2006 HZ51 | 2004 QD14 | 2000 SG344 |
|------------------|---------|-----------|-----------|------------|
| Date             | 11/2026 | 6/2027    | 12/2027   | 8/2028     |
| $V_{rel}$ (km/s) | 0       | 9.72      | 10.31     | 0          |

- 2000 SG344

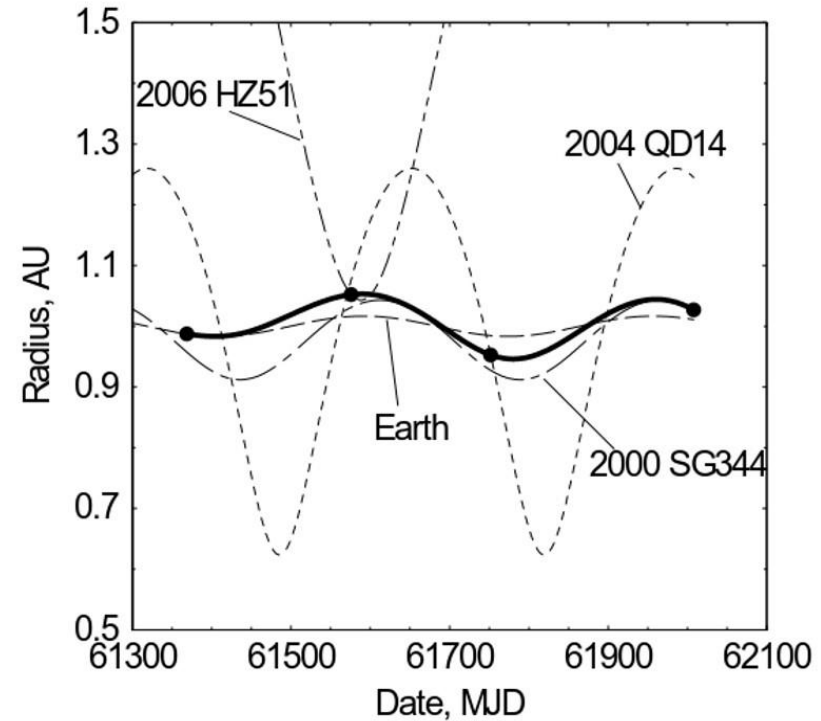
- ✓  $\varnothing \sim 40$  m (H=24.7)
- ✓ ESA/NASA: Risky & Accessible

- 2004 QD14 (PHA)

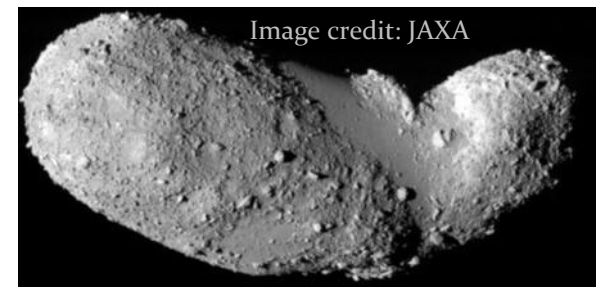
- ✓  $\varnothing = 143$  (-24/+49) m
- ✓  $p_V = 0.37$  (-0.18/+0.20) [Trilling+2016]

- 2006 HZ51 (PHA)

- ✓  $\varnothing = 410 \pm 90$  m
- ✓  $p_V = 0.42 \pm 0.23$  [Nugent+2015]



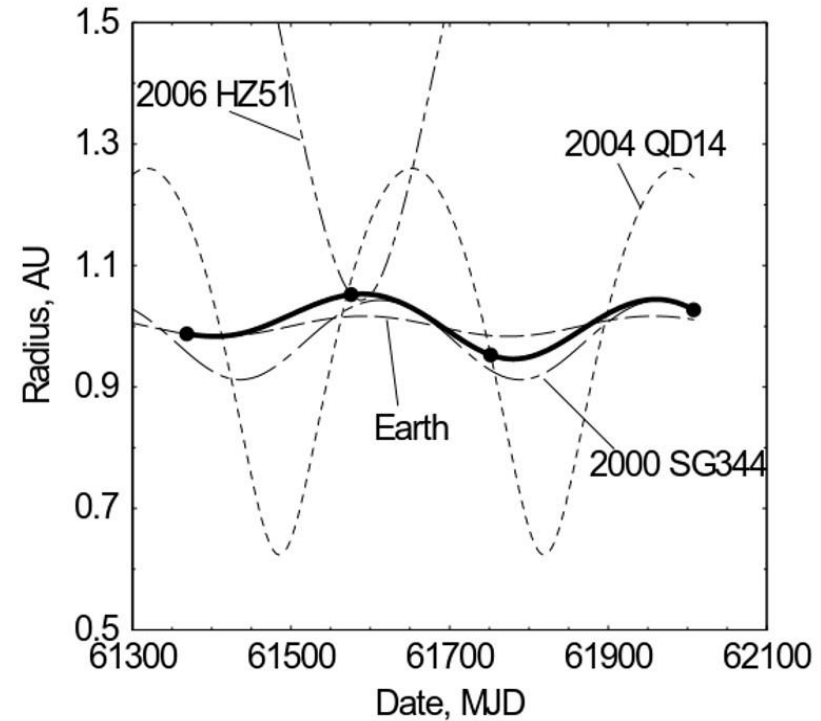
Smallest asteroid visited to date:  
Itokawa (~350 m)



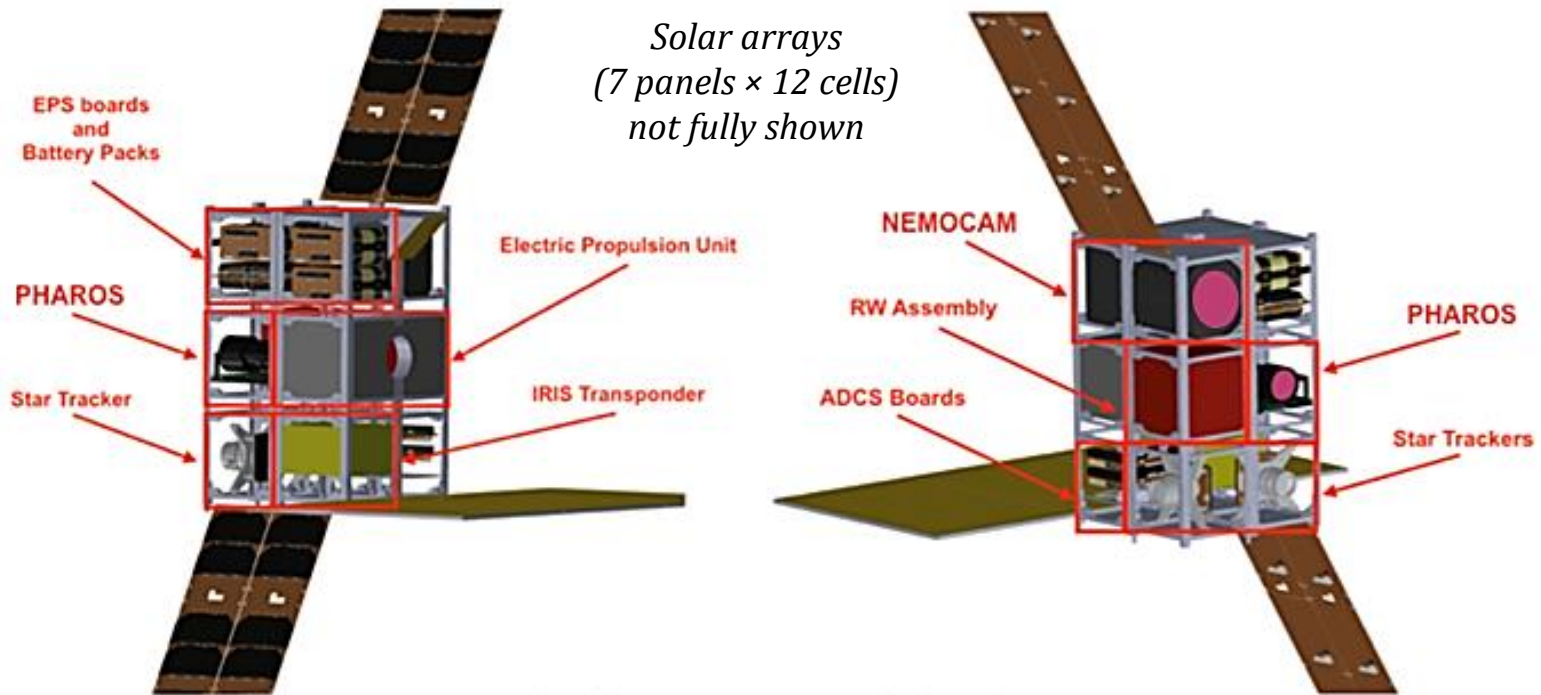
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- Baseline scenario
  - ✓ Launch window ~ Sep.-Dec. 2026
  - ✓ Total  $\Delta V \sim 1.0$  km/s
  - ✓ Ample propellant margin (~30%)
  
- Huge flexibility
  - ✓ Launch dates to 2000 SG344 (late 2025 – early 2028)
  - ✓ Alternative fly-by (PHA) and rendezvous (“small-size”) targets
  - ✓ ...



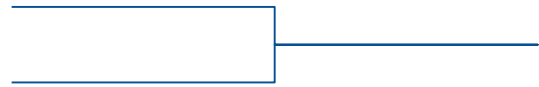
## Spacecraft design



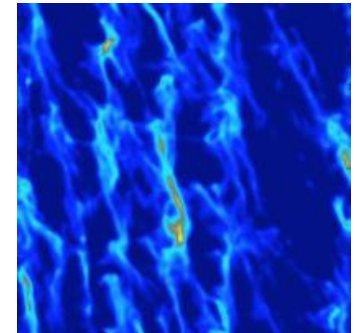
- *12U CubeSat*
- *COTS components, mostly with TRL 9 acquired in LEO*
- *RF ion thruster (thrust ~1 mN, Isp ~2100 s)*
- *Two RGB off-the-shelf cameras (renamed NEMOCAM & PHAROS)*
- *Margined wet mass ~20 kg*

|         | FoV<br>(across track) | Spatial Resolution<br>(@ 100 km) | Focus   |
|---------|-----------------------|----------------------------------|---------|
| NEMOCAM | 2.22°                 | 0.95 m                           | > 10 km |
| PHAROS  | 5.0°                  | 7.8 m                            | > 400 m |

- Both fly-bys
  - ✓  $V_{\text{rel}} \sim 10$  km/s @  $\sim 50$  km distance
  - ✓ Decimetre-scale images
  
- Rendezvous with 2000 SG344
  - ✓ 2-month nominal campaign
  - ✓ Cm-scale images
  - ✓ Radio science
  - ✓ Constraints to orbit/Yarkovsky/YORP



input for  
streaming  
instability  
+ N-body  
numerical  
simulations



- *ASI call for “future CubeSat missions”*
  - ✓ Among proposals that successfully passed the technical and scientific screening (April 2021)
  - ✓ Financial evaluation currently ongoing
- *Flexible, low-risk, high-return mission concept for both planetary science & planetary protection*
- *Opportunity for technological solutions (deep space validation)*
- *For more information:*
  - ✓ See “full manuscript”
  - ✓ [davide.perna@inaf.it](mailto:davide.perna@inaf.it)