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FLARE

FLYBY ASTEROID RECONNAISSANCE MISSION

A mission concept to Apophis before its Earth encounter to demonstrate flyby reconnaissance for planetary defense

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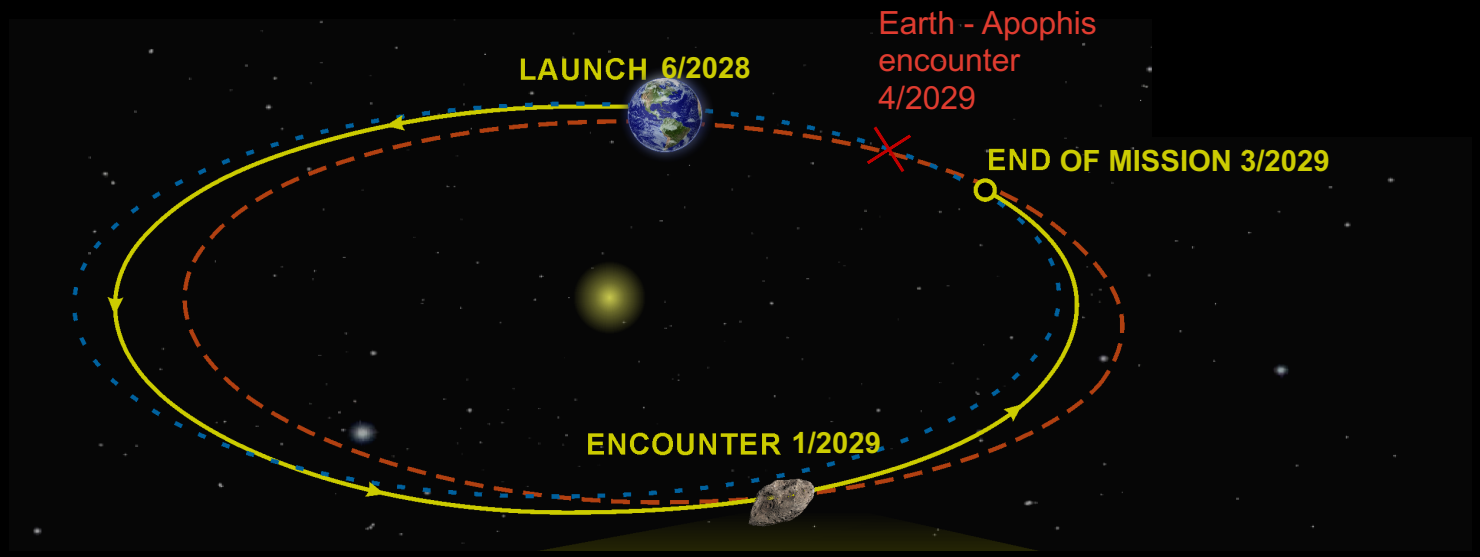
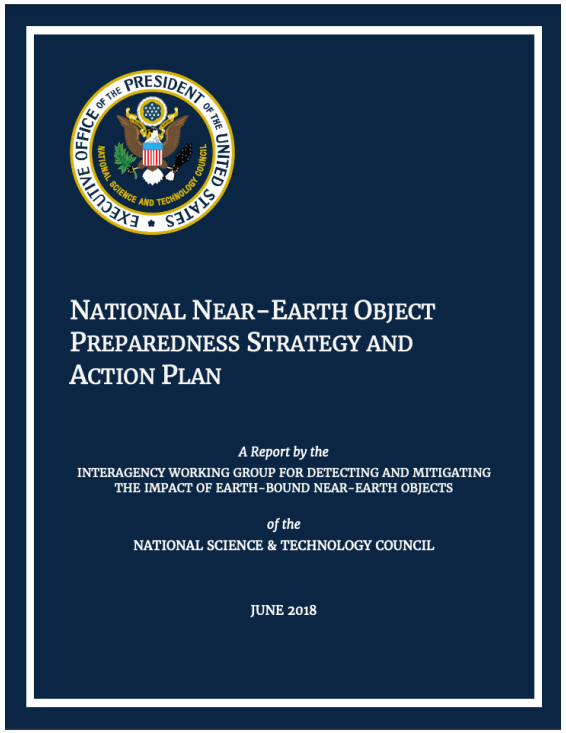
***FLARE** uses the close approach of Apophis to demonstrate rapid flyby reconnaissance for planetary defense*



FLARE uses a unique opportunity to establish the utility of flyby data by:

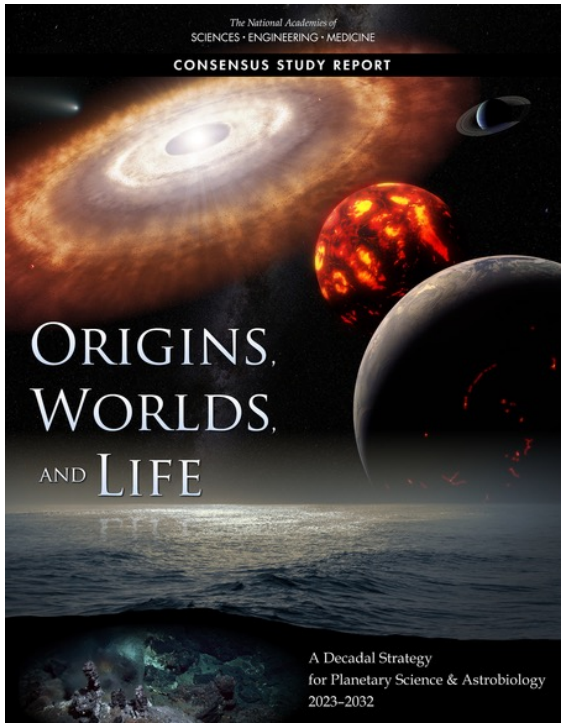
1. Characterizing the key physical properties of Apophis that are important for planetary defense
2. Comparing to higher quality “truth data” by OSIRIS-APEx rendezvous mission & ground observations
3. Establishing the surface conditions of Apophis before its close approach

Why PD Flyby?



"[Assessment of] technologies and concepts for rapid-response NEO reconnaissance missions [is needed]"

Key gap identified in TTX4 in rapid response, recon, and characterization

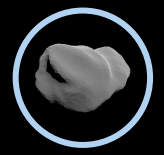


"… assess the capabilities and limitations of flyby[s] … to better prepare for a short-warning-time NEO threat"

Why Apophis?

Validating flyby characterization: Apophis will be the smallest NEA visited by a NASA rendezvous mission, which makes Apophis ideal for this test.

NEA: Eros
Size: 33 x 13 x 13 km
Mission: NEAR



NEA: Apophis
Size: 370 m across
Mission: OSIRIS- APEx

NEA: Bennu
Size: 525 m across
Mission: OSIRIS-REx

Why Now?

A date with destiny

- Apophis 2029 provides a simulated operational PD scenario. In both cases, the asteroid has chosen the date.

Mission design in the face of uncertainty

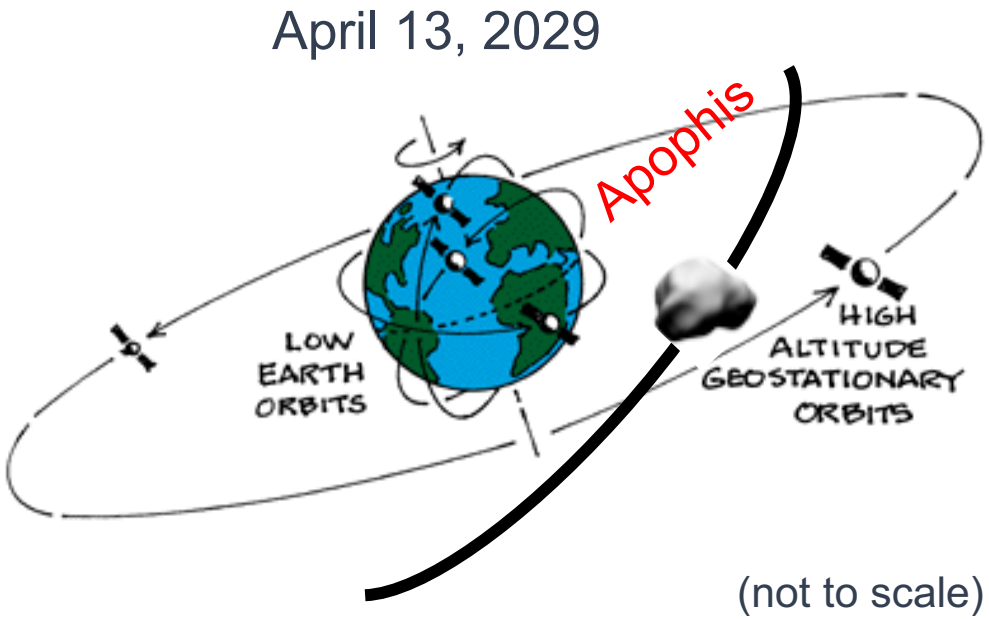
- Ensure mission planning is *not* informed by the high-fidelity in-situ information obtained by OSIRIS-APEX.

Schedule pressure

- Timeliness is of the essence for PD. The sooner we get recon info, the sooner we can plan an effective response.
- Obtaining a before-picture of Apophis enables characterization of its surface geotechnical properties.

A stepping stone to 100-m objects

- Apophis is large enough for mass determination with space-ready technology.



(not to scale)

FLARE Goals:

- **Goal 1:** FLARE tests flyby recon technologies and measures asteroid properties relevant to planetary defense

- **Goal 2:** FLARE assesses capabilities of a flyby PD mission by comparing flyby-derived quantities to OSIRIS-APEx and ground-based observations

- **Goal 3:** FLARE provides high-resolution mapping and color imaging of Apophis ***before*** the asteroid's Earth encounter

FLARE Mission Overview

Launch 6/1/2028
VSFB or KSC
Falcon 9

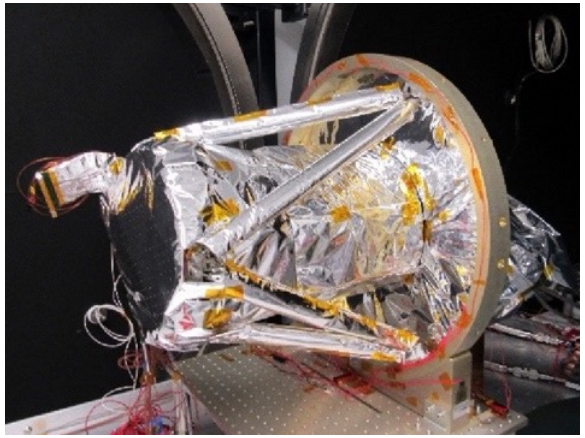
Flyby 1/21/2029
Speed 2 km/s
Closest Approach Distance 40 km

- Image Apophis (FLI)
- *Measure its mass (FLAME)*
- Playback data

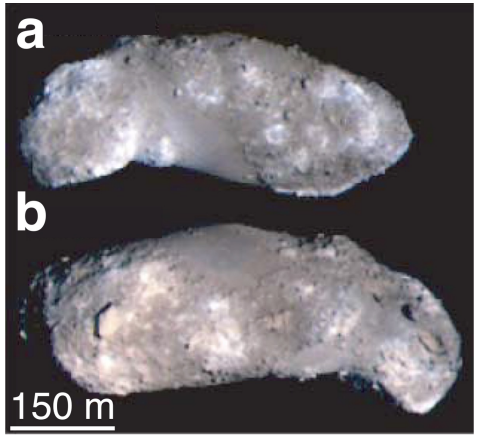
FLare Imager (FLI) is a rebuild of a high-performing, high-heritage, narrow-angle imager

- Rebuild or re-use of flight spare of DART's DRACO
  - Successfully employed to direct DART to Dimorphos
  - Will update FLI to include RGB color detector from the DRACO detector manufacturer (same form factor)
- Satisfies all optical navigation and shape, surface, and color properties imaging requirements.
- Pixel scale ≤ 20 cm at the CA distance of 40 km.

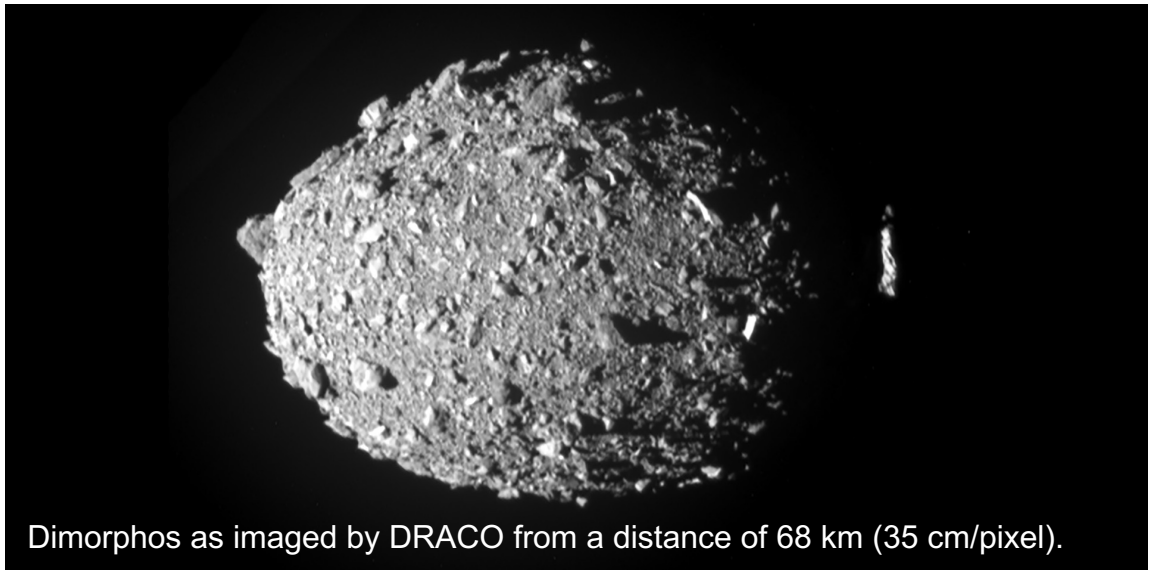
Parameter	Requirement	Performance
Spatial Sampling (IFOV)	<5.0 urad (0.5 m at 100 km)	2.5 urad
System MTF	>0.1@Nyquist	>0.15@Nyquist
FOV	>0.21 deg	0.29 deg
FOR	±90	±90
Spectral range	0.4 – 0.95 μm	3 filters, 450,550 and 600 nm



DRACO during calibration.



Surface color variegation on Itokawa as captured by Hayabusa's AMICA at 70 cm/px [Saito+ 2006]



Dimorphos as imaged by DRACO from a distance of 68 km (35 cm/pixel).

FLyby Asteroid Mass Experiment (FLAME)

Objective: Through Doppler Gravimetry (DopGrav), FLAME measures the mass of Apophis by tracking a CubeSat with FLARE and DSN during the close flyby of the CubeSat to Apophis

6U CubeSat similar to LICIACube

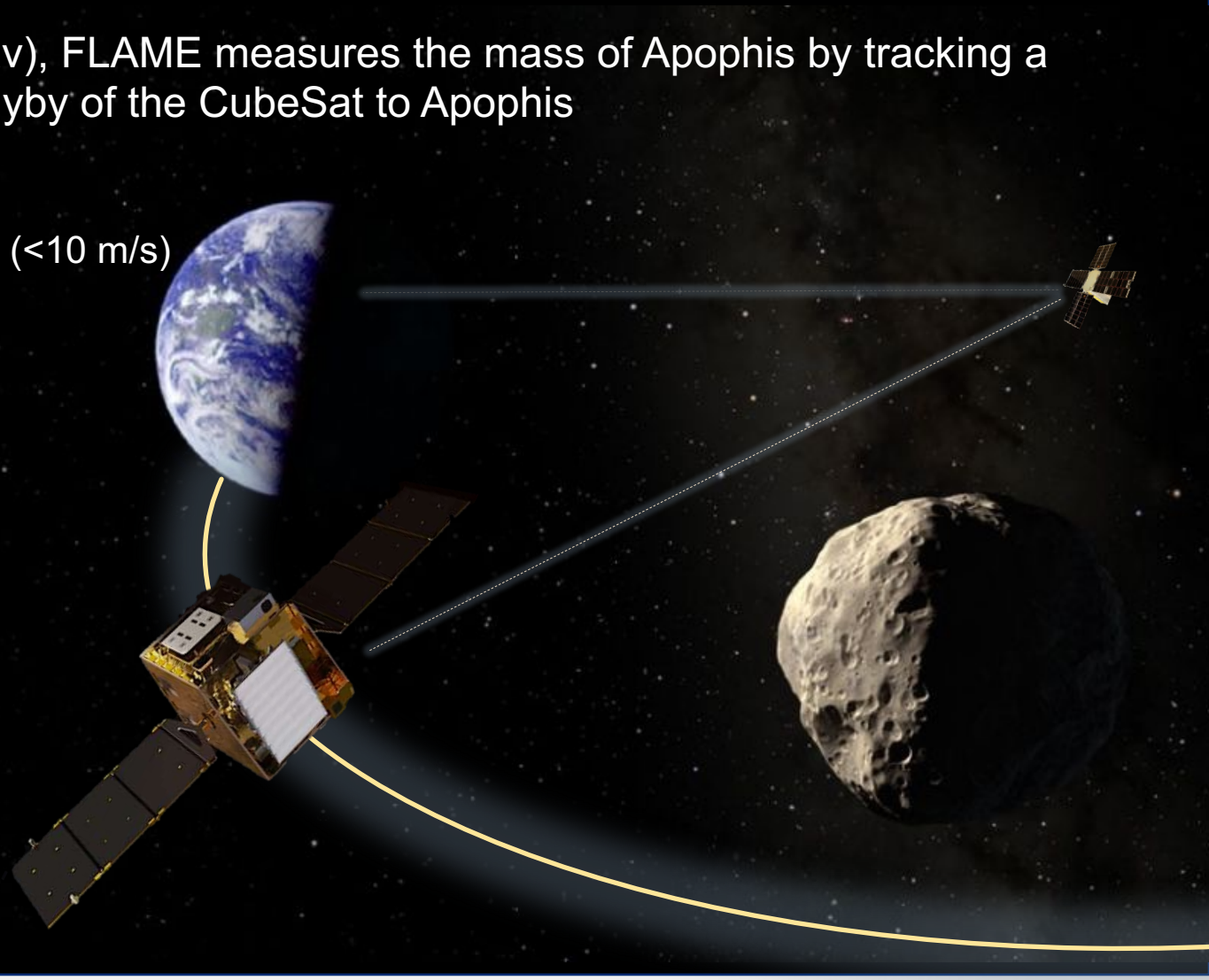
- Reaction Wheels, Cold Gas Propulsion System (<10 m/s)
- No Payload
- Frontier Lite Radio/Transponder
- Total mass < 12 kg

FLAME Concept of Operations:

1. Deploy CubeSat with an X-Band transponder to pass very close to Apophis's surface during a flyby.

2. Track CubeSat with the host spacecraft and an Earth ground-station to reconstruct its trajectory and solve-for the small Δv imparted by the asteroid.

This technique gives over *3 orders-of-magnitude* improvement in mass-measurement sensitivity.



Baseline ConOps & Schedule

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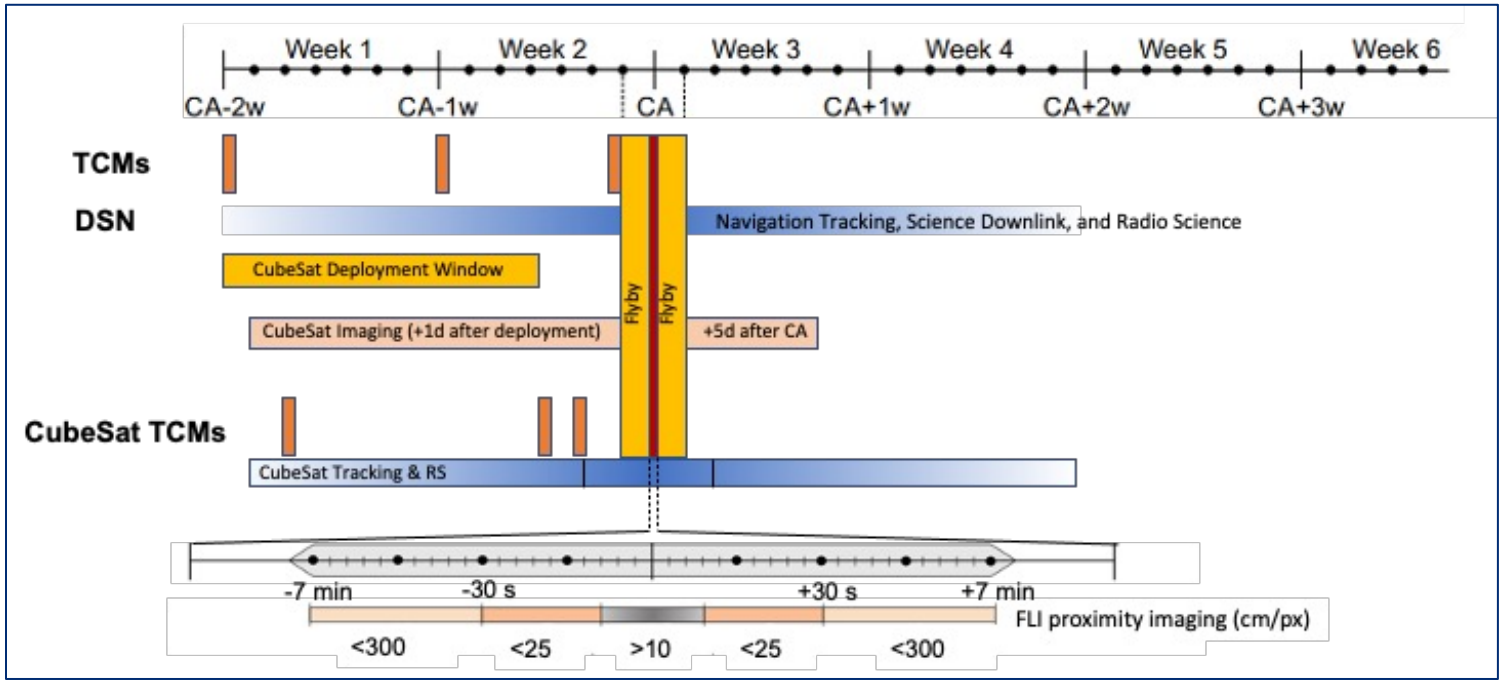

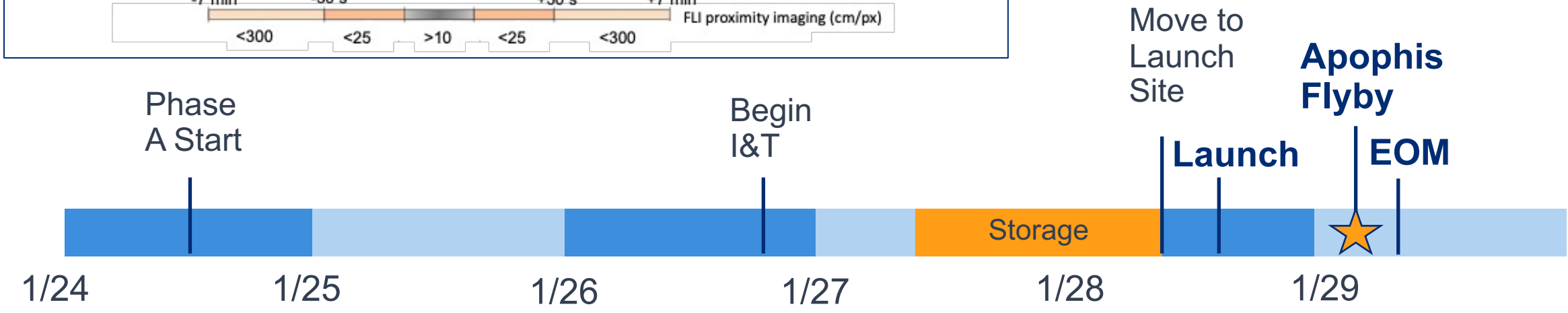

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