Asteroid Framing Cameras for RAMSES

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RAMSES SOWG

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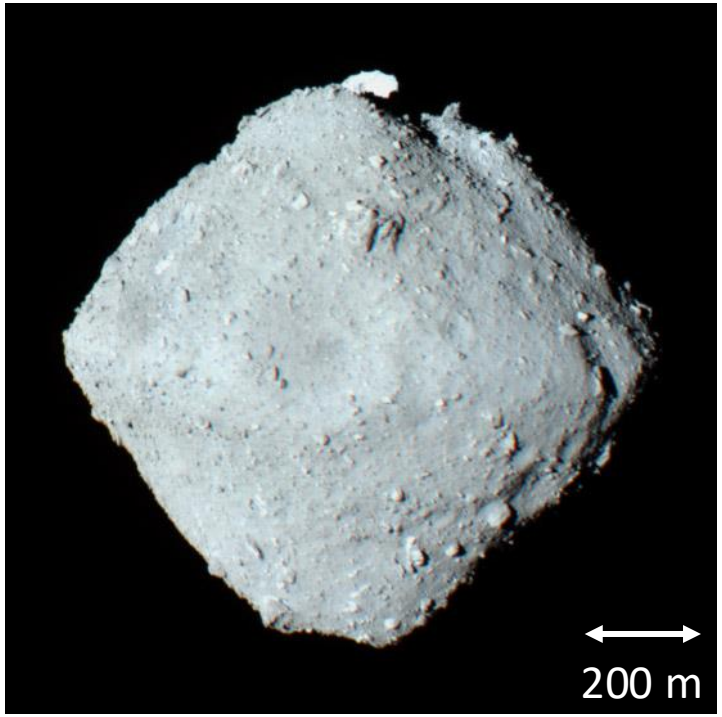
Framing Cameras

Core payload of Hera and RAMSES

Dual use for Navigation & Science

	NAC	WAC
Field of View	5.5 x 5.5 deg	19.5 x 19.5 deg
Image size	1020 x 1020 pixel	
Focal length	105.57 mm	30.5 mm
Angular resolution	94.1 µrad/px	333.6 µrad/px
Spectral range	400-900 nm	
A/D resolution	12 bits (4096 DN values)	
Integration time	224 µs to 5 s	146 µs to 0.5 s
Readout frequency	Up to 4 Hz	
Data/image	1.5 MByte	

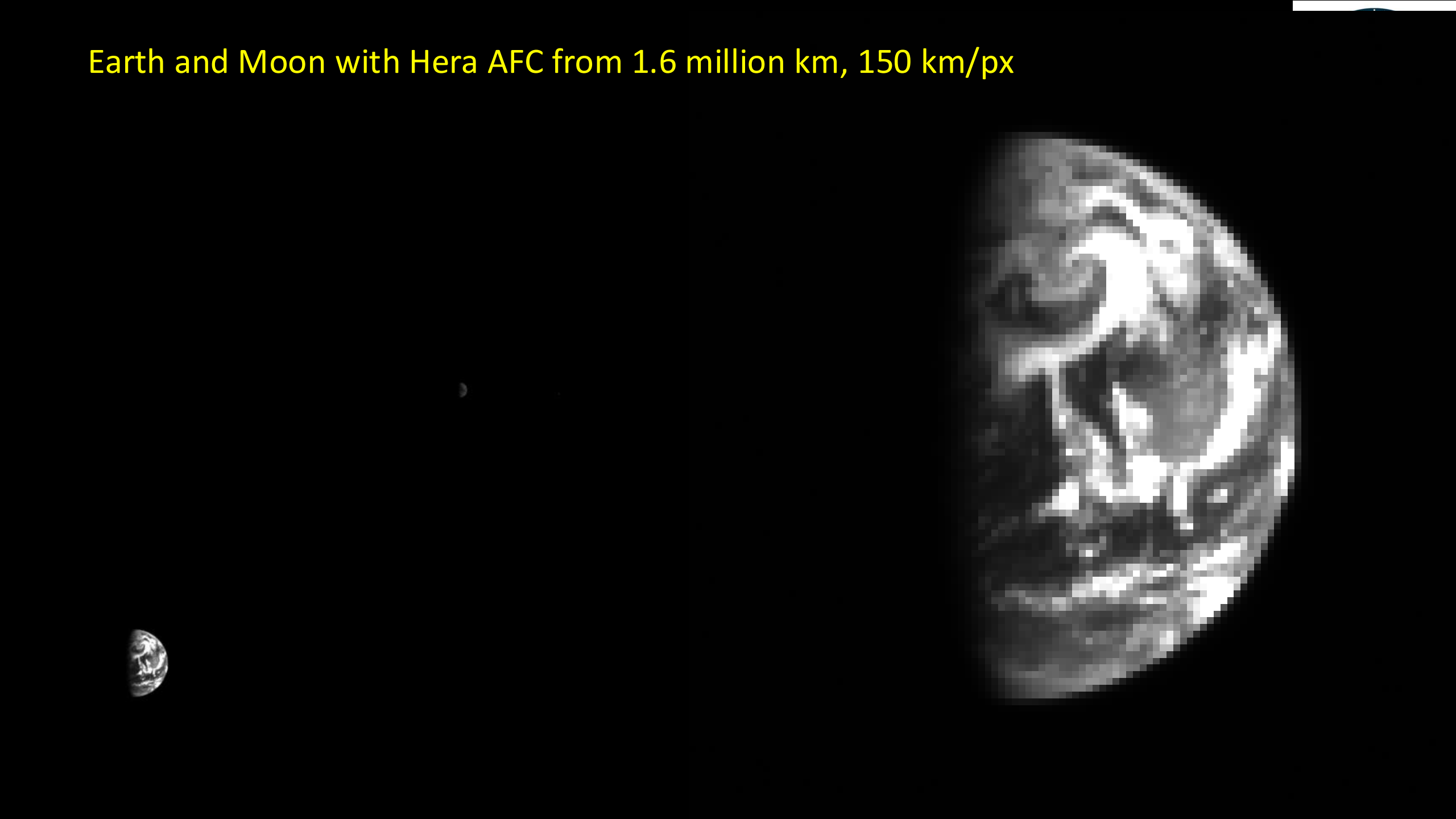
- Panchromatic cameras used for GNC and Science
- based on FaintStar 2 CMOS detector, ASTROhead design
- Built by Jena-Optronik (Germany)



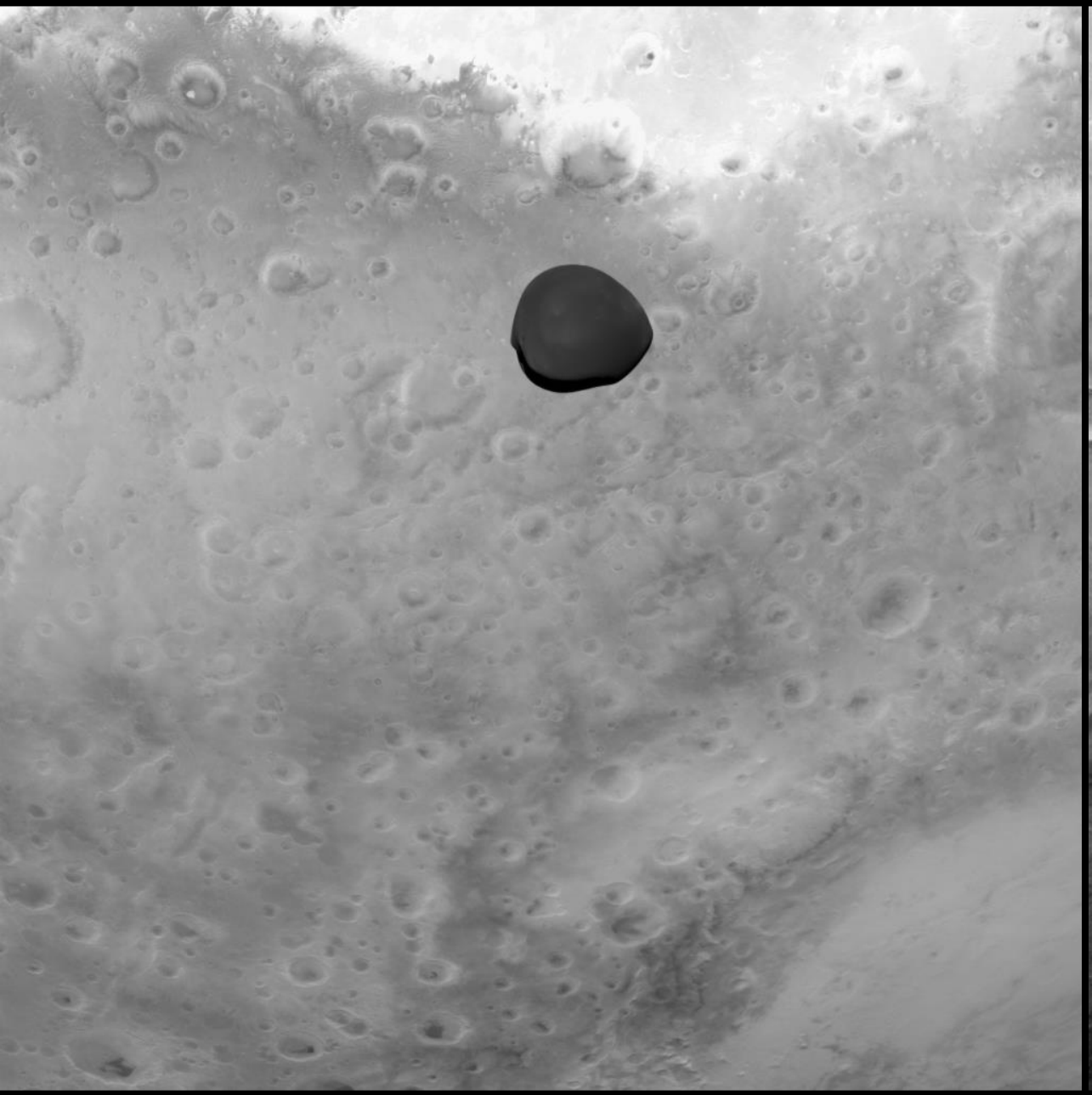
Ryugu from 10km (Hayabusa 2 ONC-T, comparable resolution to AFC)

1 m/px from 10 km

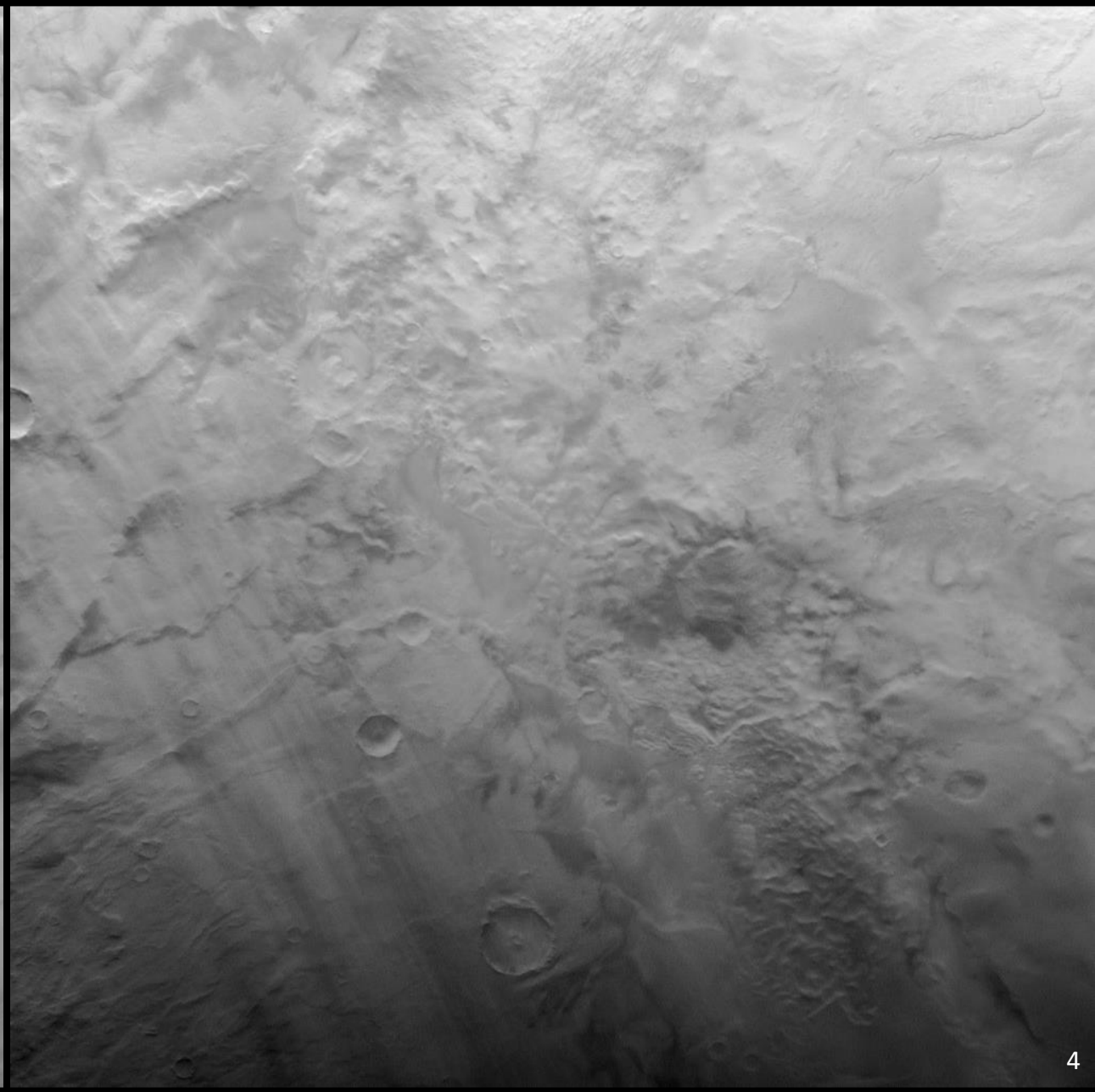
Earth and Moon with Hera AFC from 1.6 million km, 150 km/px



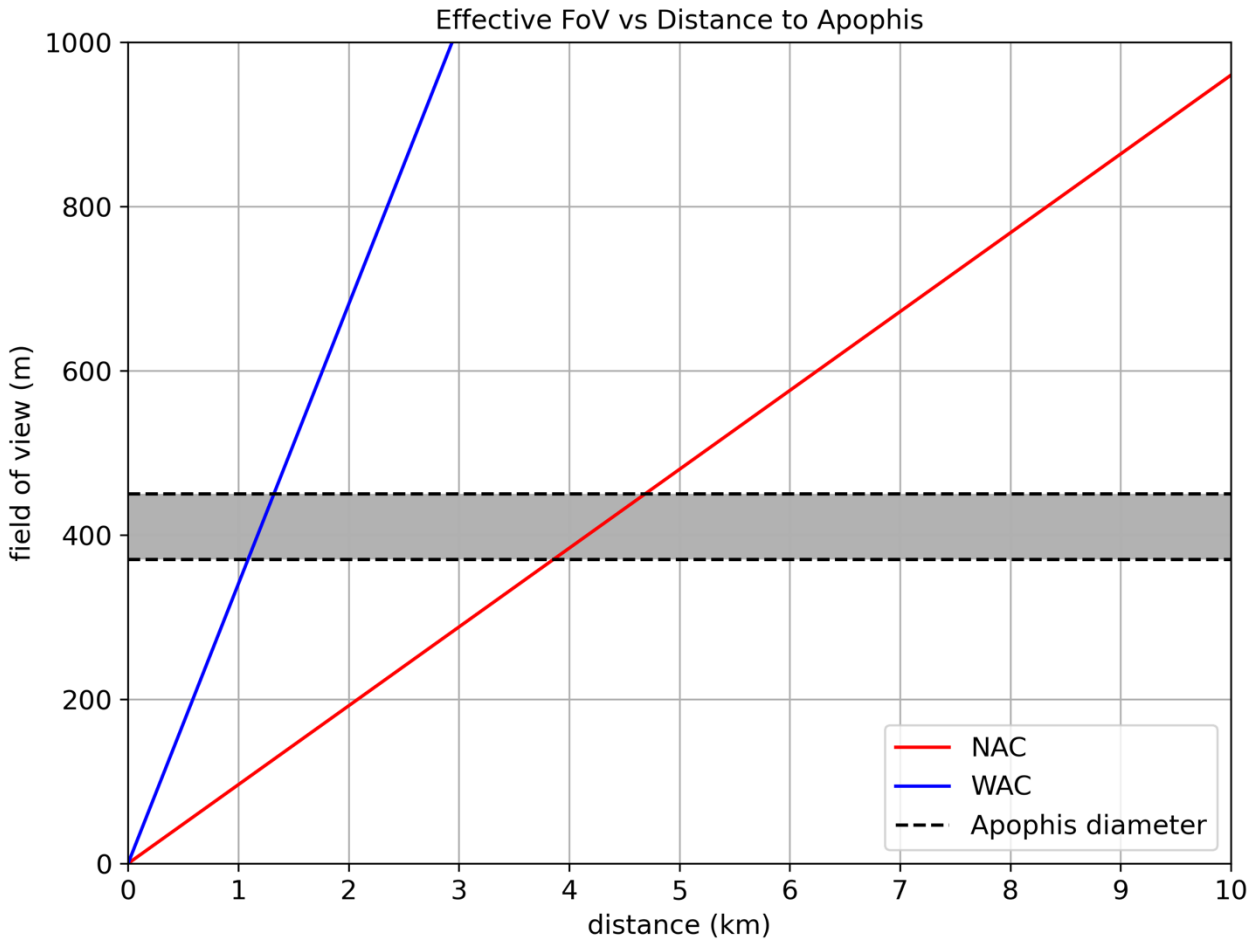
Deimos in front of Mars as seen by AFC



Mars from ~6000 km with AFC



AFC for RAMSES



- **Hera:** both cameras are identical, for redundancy

- **RAMSES:**, we need to optimize the FoV for close operations, and guarantee that the full asteroid is always visible
- This requires a wide angle camera (same detector as NAC, different optics)

Mission phases (CREMA v2.0)

Start Date	End Date	Duration [days]	Event
24/04/2028	-	-	Launch
24/04/2028	26/04/2028	3	Launch and Early Orbit Phase (LEOP)
27/04/2028	01/07/2028	66	Near Earth Commissioning Phase (NECP)
12/05/2028	-		Deep Space Manoeuvre #1 (DSM1)
02/07/2028	10/02/2029	224	Interplanetary Transfer Phase (ITP)
18/09/2028	22/09/2028	5	Payload checkout #1
26/10/2028	-		Deep Space Manoeuvre #2 (DSM2)
11/12/2028	15/12/2028	5	Payload checkout #2
10/02/2029	04/03/2029	23	Apophis Rendezvous (RDV)
05/03/2029	12/04/2029	39	Pre-Encounter Phase (PREP)*
13/04/2029	14/04/2029	2	Close Encounter Phase (CEP)
13/04/2029 21:45	-		Apophis Closest Approach (CA)
15/04/2029	31/05/2029	47	Post-Encounter Phase (POSP) *
01/06/2029	21/08/2029	82	Experimental Phase (EXP)
22/08/2029	31/08/2029	10	Extended Operations Phase (EOP) / End-of-Life Phase (ELP)

Close Operations Phase

- Hovering at 20-10-5-1 km
- Phase angle ~20°

Requirements

- Mission requirements (RAMSES MRD v1.1)
  1. Determination of the orbit of Apophis
  2. Determination of the spin state and orientation of Apophis
  3. Apophis shape and surface changes
  4. Interior Structure of Apophis
  5. Presence of Submillimeter dust particles (not relevant for AFC)

- System requirements (RAMSES SRD v2.0)

  AFC Science Data Volume: The RAMSES Spacecraft shall support a minimum scientific data return volume of 72 Gbits over the mission for AFC.
  - This does not include AFC data for GNC purposes.
  - This includes the high-frequency imaging during the Close Encounter Phase

Data Volume (1/2)

- 72 Gbits = 9 Gbytes ~= 6000 images
- Most images will be acquired during 6 months of proximity operations => 1000 images/month
- Assuming ~12 hours of imaging per day, this amounts to 1 image every 20 min

- Apophis is a slow tumbler: precession 27.4 h, rotation 263 h (Pravec+2014)
- A cadence of 45 min gives one image every 10 degree of precession. Can be relaxed to one image per hour without loss of science.
- Imaging with one camera most of the time (NAC > 5km, NAC+WAC < 5km)

- **Baseline: 1 image/hour over the 6 months of close proximity operations, when pointing at Apophis**
- **Room for increased cadence at close distances: high-res spatial coverage and detection of surface changes during Earth fly-by, cubesat landing and landing site characterization, ...**

Data Volume (2/2)

Mission Phase	Duration (days)	Activity	Camera	# images	Data Volume (Mbytes)	Data Volume (Gbits)
LEOP	3					
NECP	66	Calibration: dark, star fields, Earth/Moon	NAC+WAC	200	300	2
ITP	224	2x payload checkout: dark, star fields	NAC+WAC	100	150	1
RDV	23	Early shape model and rotation state, search for debris	NAC	300	450	4
PREP	39	Surface characterization and high-res shape model from multiple distances	NAC	500	750	6
CEP/CA	2	Fast cadence imaging (5min) at highest resolution	NAC+WAC	300	450	4
POSP	47	Surface characterization and high-res shape model from multiple distances	NAC	600	900	7
EXP	82	Additional data as needed, joint operations with OSIRIS-APEX ?	NAC	1000	1500	12
			SUM=	**3000**	**4500**	**36**

Notes:

- Based on what we defined for Hera
- Very conservative approach with 1h baseline cadence
- Not yet iterated with Science Team and WG4

Summary

- Using a conservative approach that still fulfill the mission requirements, AFCs use only 50% of the nominal data volume allocated for AFC science.
- Many of our images are also relevant for navigation and we will likely merge some of the operations (science + GNC) like we do for Hera.
- There is room to optimize the data acquisition, and add redundancy.

- This is only the minimal baseline, to be iterated with the science team.