APOPHIS 2029

Preliminary results of a CNES feasibility study

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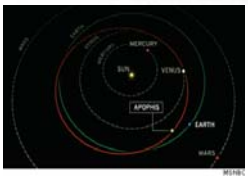
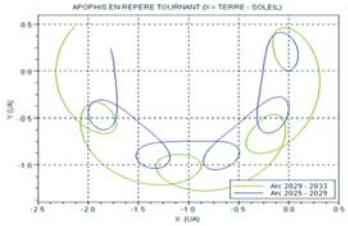
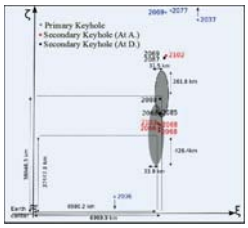
APOPHIS

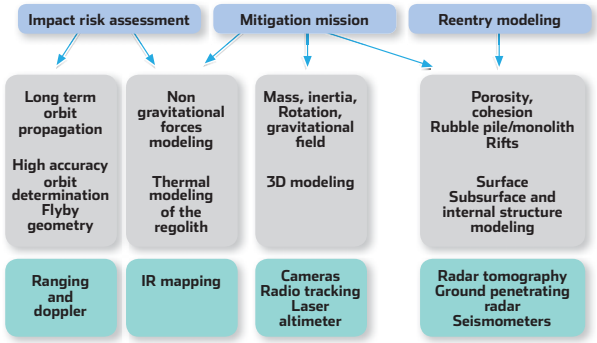
- Discovered in June 2004
- Close approach to the Earth on April 13, 2029
- Tumbling spin state with a period ~ 30 hours
- Diameter ~ 330 meters (from Herschell IR observations)
- Next observation window from the Earth in 2020-2021







Instrumentation / Objectives



Rationale of the CNES study

Is there a significative advantage to plan for a space mission where a probe would accompany Apophis during its 2029 pass?

Assumptions:
- first mission to Apophis
- priority to the mitigation preparation objectives
- scientific objectives not excluded but secondary

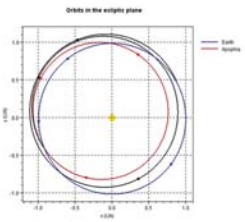
Main mission objective
Provide informations about Apophis that would be requested for designing a future mitigation mission, if needed:
=> Internal structure characterization
=> Observation of its possible changes induced by the close approach

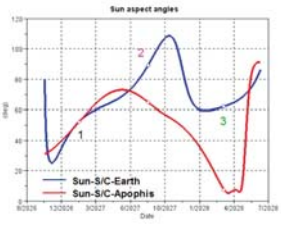
Mission analysis example

Departure : 22/10/2026
Arrival : 11/07/2028
ƒjt = 629 d
ƒjv = 2.14 km/s
ƒjm = 44.1 kg

Ion Thruster NSTAR
Isp = 3080 s
P = 1500 W
T = 53 mN

Thrust : 306 d
01/02/2027 – 08/05/2027
11/12/2027 – 08/07/2028





Strawman Payload

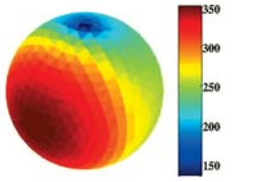
General features (shape, mass, rotation, gravity)
- Wide Angle and Narrow Angle cameras in VIS and near IR
- Radio science

Surface analysis
- Nac and Wac in VIS and Near IR
- Spectroscopie in VIS and IR large spectrum

Sub-surface analysis
- High Frequency Radar
- Options:
  - Sismometers
  - Artificial craterisation

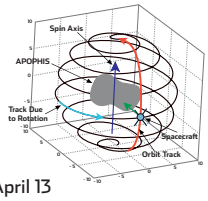
Sounding
- High Frequency Radar tomography
- Option: sismometers

Long term tracking:
- Radio and/or laser reflector to be assessed



Thermal map of Apophis from Herschel observations at 70, 100 and 160 microns.
@Esa, Herschel, Mach-11, T. Müller, MPE

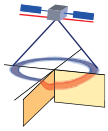
Operational scheme



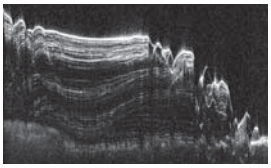
- Rendez-vous to a waiting position 200 km in the sun direction (mid July 2028)
- Approach to 20 km controled from the ground using NAC (1m@10km)
- VIS and IR science between 20 km and 3 km
- Radio science between 300 m and 3 km
- About 6 months for the programme before April 13
- Spacecraft ahead of Apophis for the flyby
- High accuracy geometry determination of the F/B from ranging/doppler between G/S and S/C (eg from KRU)
- Same observation programme after the flyby to identify possible changes

Radars

Low frequency radar for tomography
- Tomography in Reflection
  - RF wave propagation (~20 MHz)
  - Orbiter only (Marsis-like)
- Deep interior profiles : Interfaces, layers and voids
- Heritage Sharad, Marsis



High frequency radar for regolith characterisation
- 300 MHz-1GHz
- 10 cm resolution @10 m depth
- Can be used in an altimeter mode and contribute to the gravitational field determination
- Used in the range 500 m -2500 m
- Heritage Wisdom/EXOMARS



This image shows a cross-section of a portion of the north polar ice cap of Mars, derived from data acquired by the Mars Reconnaissance Orbiter's Shallow Radar (SHARAD).

Main outcomes

- Compatibility with a SOYOUZ launch from French Guyana Space Center
- Electric propulsion required
- Affordable fuel budget (~50 kg)
- Mitigation objectives can be achieved through VIS and IR cameras and 2 radars
- The mitigation objectives can be satisfied without landing any device
- The 2029 timeframe is a unique opportunity to study Apophis, its internal structure, the possible changes due to the gravitational effects from the Earth and determine the exact geometry of its flyby

Réalisation ACM 2014 - 305 - CNES Toulouse - Impression ACE CNES