Status on action 5.11 – NEOtoolkit, TOOLBOX FOR A CHARACTERISATION PAYLOAD

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Aim of action 5.11

To reach a consensus among SMPAG members regarding the objectives of a space mission designed for a NEO characterization, and then the instruments that can be made available for achieving it.

This consensual definition of a ‘straw man payload’ would be available on a reasonably short notice for a characterization mission targeted to NEOs that present a potential threat.

Lead : CNES

Support from Belgium, DLR, UKSA, ASI, ESA

Documentation in support to action 5.11

- Synthesis of CNES Apophis study,
- FP7 project Neoshield – 1 deliverable 2.2, Requirements for mitigation precursor reconnaissance,
- FP7 project Neoshield – 1 deliverable 2.3, Instrumentation design for mitigation precursor & demo mission,
- “Science case for the Asteroid Impact Mission (AIM): A component of the Asteroid Impact & Deflection Assessment (AIDA) mission”, published in Advances in Space research (paper based on the initial AIM configuration),
- “HERA mission to the binary asteroid Didymos characterization and interpretation of the impact of the DART mission”, under revision, submited to Advances in Space research,
- Payload and Instrumentation Design for an Orbit Knowledge Improvement via Flyby Missions at Asteroids, Stephan Schuster - TUM term thesis
- Asteroid Orbit Knowledge Improvements via Spacecraft Flybys, Philipp Kollo – TUM term thesis

Plan for action 5.11

Planned sequence :

- Summarize the outcomes of a study dedicated to Apophis (done)
- Identify some short notice mission scenarios and specify the objectives of the associated characterization mission
- Specify the instruments and mission requirements for achieving these objectives
- Review available existing instruments and, in case of gaps, assess the need for the development of new instruments
- Provide with cost estimates of such instruments, if available

Main physical parameters needed for each mitigation method

Mitigation method→ / Parameter ↓	Gravitational tractor	Solar sail, harpoon… techniques based on tracting and requiring anchoring the asteroid	Methods based on thermal properties modification	Impactor, Explosion to deflect	Explosion to destroy, atmospheric entry
Accurate orbit determination	X	X	X	X	X
Mass	X	X	X	X	X
Shape	X	X	X	X	X
Spin	X	X	X	X	X
Sub surface		X	X	X	X
Thermal properties			X	X	X
Chemical properties				X	X
Internal structure				X	X

Table to be discussed, amended and complemented, in particular through the completion of actions 5.2, 5.3 & 5.4.

Potential mission scenarii

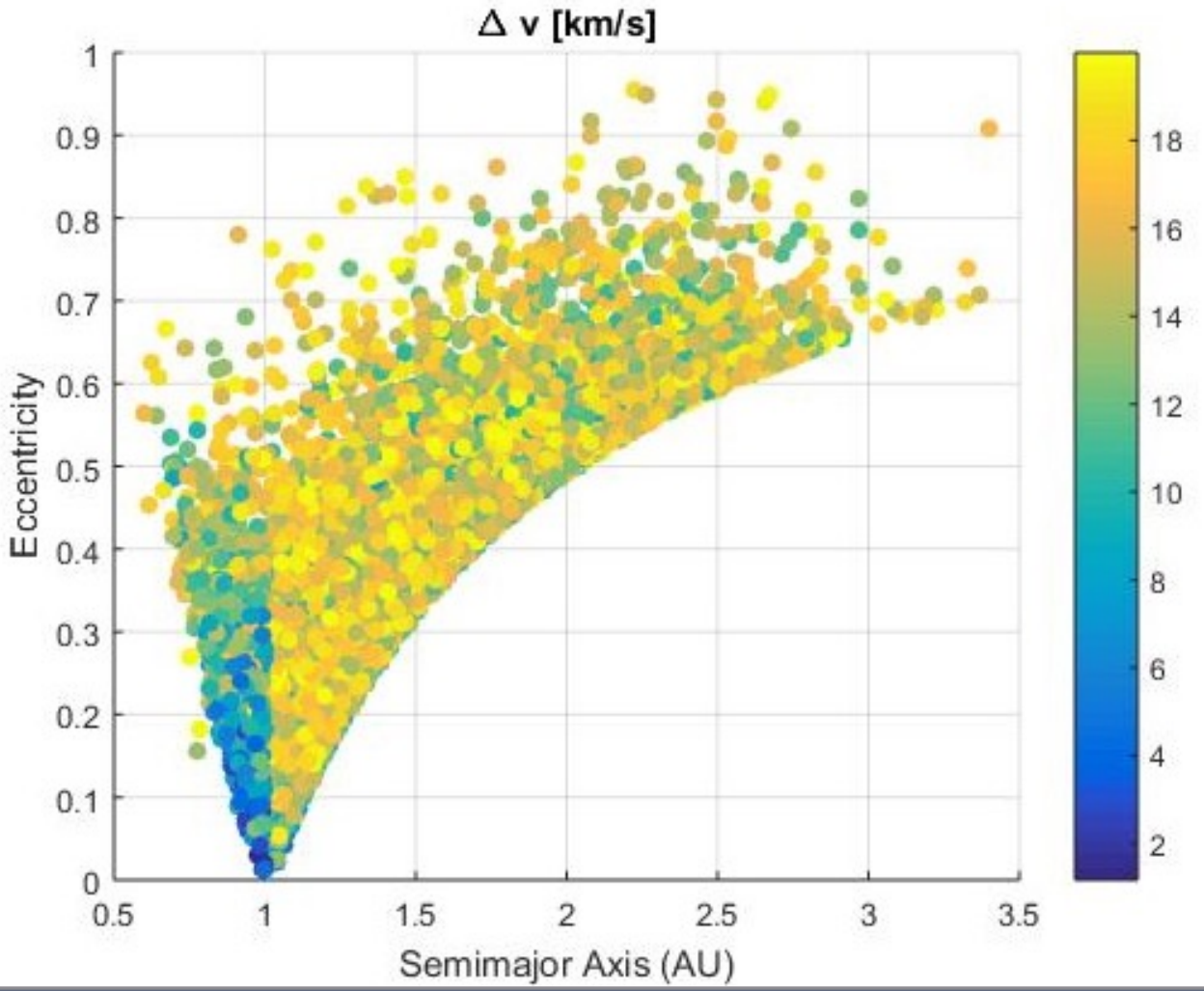
- 1 - Minimum characterization : **fly-by** of NEO target.

- 2 - Enhanced remote sensing : **RV** with NEO target.

- 3 – Same as 2 + **companion cubesat**
  => potential access to inner structure.

- 4 – Same as 2 + **one or several landers**
  => inner structure characterization.

Impulsive DV to RV with NEOs



Work from Massimiliano Vasile Strathclyde Space Institute

=> Very few targets accessible

Low thrust strategies under process

Action 5.11 splinter meeting from 2:00 PM to 2:55PM

Room C 0431 – 4th floor of building C

Discussion on :

- Limitations of fly-bies in comparison to RV orbiters
- Added value of companion cubesat(s) or lander(s)
- Way forward

Instruments associated to mission scenarii

Mission scenario	Radio Science	Accelerometer	WAC & NAC Camera	Lidar	Thermal IR imager	Monostatic HF radar	Bi-static LF radar	Seismometer (+ excitation ?)	Vis& near IR spectro-imager	X-ray / gamma ray spectrometer
Fly by			X		X				X	
RV orbiter	X	X	X	X	X	X			X	X
RV orbiter + cubesat	X ++	X	X	X	X	X	X		X	X
RV orbiter + lander(s)	X	X	X	X	X	X	X	X	X	X
	Orbit improvement	Enhanced orbit improvement								
	Mass/Density	Mass/Size/ Density	Mass/Size/Density	CoG			CoG	CoG		
			Shape	Shape						
			Dynamical state							
			Surface & photometric properties	Topography & morphology	Surface roughness	Shallow sub-surface structure	Deep internal strcture	Deep internal structure		
			Chemical & mineral composition (?)		Thermal properties				Mineralogy	Elemental composition

Fly by mission discussion

Radio-science is unpractical with single fly-by. => Orbital parameter determination limited to the knowledge of the position of the asteroid at the moment of fly-by, without velocity estimation.

Only a few objectives can be met :

- **size,**
- **shape**
- **possibly thermal & chemical properties**

=> limited subset of instruments compatible with a small probe, possibly a multi U cubesat.

The possibility of sending several – small – fly by probes could be advantageous:

- For obvious reliability reasons
- To improve shape characterization through several angles of view (in particular for slow spinning asteroids)
- To enable some **mass characterization and orbital parameters** evaluation (=> Q2)

RV orbiter mission discussion

Need of large DV capacity for DV, electrical propulsion likely.

Several major improvements in comparison to fly-bies :

- **Full orbital parameter estimation, & mass/density** with radio science and accelerometer
- **Enhanced CoG, shape & topography** with lidar
- Access to **sub-surface properties** using a high frequency radar
- **Higher accuracy on thermal and chemical properties** with thermal IR imager, and/or some visible/near IR or neutron spectrometer

Companion cubesat(s) or lander(s)

Companion cubesat(s), such as envisioned on HERA, shall be discussed : **surface characterization ++**, access to **deep internal structure** with bi-static radar ? (=> Q3)

Orbiter + lander(s)

Best way to investigate the **deep internal structure** trough Concert type tomography radars and seismology.

The lander could also **enhance subsurface characterization**, if only by having the associated orbiter analyze the impact / bounces of the lander after its deployment.

A few questions to tackle

Q1: Can we **quantify the limitations of fly by missions** in comparison to orbiters for :

- Size determination?
- Mass determination?
- Shape determination?
- Surface thermal properties?
- Surface chemical properties?

Q2: Could **mass characterization and orbital parameters** evaluation be enabled by **simultaneous flybies of the target by several probes** ?

Q3: Elaborate on the **added value of a companion cubesat** to a main orbiter, enhanced surface characterization, possibility of a bi-static radar,… ?

Q4: keep the 4 mission scenarios or only show 2 missions scenarios with the option of a companion cubesat or a lander attached to the orbiter case?