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

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

Objective - Instrument table

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
Fly by			X	X	X				X
RV orbiter	X	X	X	X	X	X			X
RV orbiter + cubesat	X ++	X	X	X	X	X	X		X
RV orbiter + lander(s)	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

Screenshot of instrument table (49 entries as of October 2022)

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1	Instrument Ty	Count	Organisati	Instrument Nan	Instrument Princi	Mission (flown or planne	TRL	Performances	Mass	Volume	Electrical Pow
2	Radio Science (DTE or ISL)	Belgium	ROB	LARA	Doppler Shift	ExoMars 2020	8	10^-14 Allan Deviation	2.2 kg	(23 x 10 x 10) cm3	40 W
3	**Radio Science (DTE or ISL)**	**Italy**	**La Sapienza**	**MORE (on MPO)**	**Doppler and range measurents, Ka-band transponder**	**BepiColombo**	**8**	**Allan Deviation of 10^-15 at 1000 s int time, tested at ground @ 4*10^-16, Accuracy of ~15 cm, Doppler RMS @60s int time ~0.01-0.04 mm/s**	3.5 kg	2.1 L	Avg: 32.6 W
4	**Radio Science (DTE or ISL)**	**Luxembourg**	**GomSpace Luxembourg**	**ISL (Inter-Satellite Link)**	**Doppler inter-satellite link, precise range-rate measurements**	**Based on Proba-3 / HERA, launch 2024**	**>4**	**Gravity coefficient J2 determinatin with uncertainty of 10-11%, higher degree grav coefficient to degree 2 and 3**			
5	Accelerometer	Belgium	ROB	GRASS (on Juventas)	Spring-based	Hera, launch 2024	5	First design <5mg resolution on Earth, scalable: <50 um/s^2 accuracy (Phobos)	< 0.4 kg	(9.5 x 4.4 x 1.5) cm3 (per axis, 2-axis, 6DOF)	< 1W
6	Accelerometer	Belgium	KUL	NA	Capacitive MEMS	NA	3	0.2 mg/Sqrt(Hz) sensor noise, bandwidth of more than 5 kHz. The resulting noise performance is far below 1µg/√Hz which makes the accelerometer well suited for high precision applications such as seismic measurements.	< 10g (depends on package)	(0.7 x 0.9 x 0.06) cm3 (sensor)	< 200 mW (TBC)
7	**Accelerometer**	**Italy**	**INAF**	**Italian Spring Accelerometer**	**Tri-axial electromechanical accelerometer**	**BepiColombo**	**8**	**Sensing axes with an accuracy within 20-30 arcseconds at 2σ per single axis, Measurement accuracy 1e-8 ms-2, Intrinsic noise 1e-9 ms-2Hz-1/2**	**5.8 kg**	**IDA (detector assembly): (30 x 17 x 18) cm3 ICE (control electronics): (17 x 13 x**	**Peak: 12.1 W, Average: 10.1 W**
8	**LIDAR Altimeter**	**Japan**	**JAXA**	**Hayabusa2 LIDAR**	**Time-of-flight measurement of reflected pulse + dust count mode + albedo measurement**	**Hayabusa2**	**9**	**Range: 30 m ~ 25 km Resolution: 0.5 Range accuracy (1σ): +- 1 m @ 30 m alt +- 2 m @ 25 km alt Pulse repetition rate: 1Hz**	**3.52 kg**	**(24.1 x 22.8 x 28.9) cm3**	**18 W**
9	**LIDAR Altimeter**	**Germany**	**Jenoptik**	**DLEM 20**	**Compact diode 1550 nm laser rangefinder**	**M-ARGO, launch 2024/2025**	**3-4?**	**Measuring time 100 ms Measuring distance up to 1500 m Accuracy +- 0.5 m up to 1000 m**	**< 33 g**	**(5 x 2.2 x 3.4) cm3**	**< 1.8 W**
10	LIDAR Altimeter	Germany	DLR / Uni Bern / MPS / Instituto de Astrofisica de Andalucia	BELA - Bepi-Colombo Laser Altimeter	Target: Mercury, single shot range measurement, return pulse shape and albedo analysis, digital samples	BepiColombo	~8-9	Range accuracy: < 1 m, Max. distance: 1000 - 1800 km depending on surface roughness and albedo	14.2 kg	Transmitter+ Receiver: (72 x 48 x 50) cm3, Electronics boxes: ELU: (25 x 16 x 16) cm3, LEU: (24 x 13 x 15) cm3	< 30 W in nominal operation (10 Hz shot frequency)

Survey greatly enhanced by Andy Schmit at ESA in Spring 2022

Instrument table, next step

At this stage, 12 Countries are represented in the table: Belgium, France, Finland, Germany, Italy, Japan, Korea, Luxembourg, Netherlands, Portugal, UK, USA

Distribution of instrument Excel file to SMPAG members for:

- Verification
- Additions
- Introduction of cost estimates

Gaps, orbiters versus fly-bies

At SMPAG meeting in Feb. 2022, we showed that **fly-by missions are much more accessible than orbiters.**

DART has illustrated the **importance of density measurement & internal structure** characterization for impact (or nuclear blast) deviation methods.

Density & internal structure cannot be characterized through fly-bies

=> On going and future orbiter missions should build up gradually a typology associating :

Shape / spin / surface properties / topography / morphology

to

Density / internal structure

In case of a real threat, if a reconnaissance mission is limited to a fly-by because of lack of time or DV capability, it could still provide indirect estimation of density & internal structure.

Back-up slides

Physical parameters needed for various mitigation methods

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Tractor, slow push

Nuclear or impactor deflection

Civil Defence

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	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

Needs a RV