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

pierre.bousquet@cnes.fr

**Remote meeting, October 19th 2022** 



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

**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**

lission 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
ly by			х	Х	х				Х
RV orbiter	х	Х	х	Х	х	Х			Х
RV orbiter + cubesat	X ++	х	х	Х	х	Х	Х		х
RV orbiter + lander(s)	x	х	x	х	х	х	х	Х	х
	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

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

Instrument iv Badio Science         Oppointal *         Instrument hind *         Mission (flown or plant) *         THL         Performances         *         Mass version         Value *         Value * <th colspan="10"></th>												
Belgium         ROB         LARA         Doppler Shift         ExoMars 2020         8         10^-14 Allan Deviation         2.2 kg         (23 ± 10)         (20 ± 10)           Badio Science         ID         ID         Doppler and range measurements, kar- band transponder         Beglium         NORE (on MPO)         Beglium (KUL         La Sepienza         MORE (on MPO)         Beglium (KUL         Arg 52.6 W           4         ID         Trimal         Beglium (KUL         Sepienza         MORE (on MPO)         Beglium (KUL         Arg 52.6 W           5         Accelerometer         Belgium         GRASS (on processes)         Spring-based         Hera, launch 2024         >4         Coloridation (Seconder Liber of the seconder seconder Liber of the seconder	1	Instrument Ty 🔻	Count 🔻	Organisati 🔻	Instrument Nan 🔻	Instrument Princi 🔻	Mission (flown or planne 🔻	TRL 🔻	Performances 🔻	Mass 🔻	Volume 🔻	Electrical Pow
2         UCE or ISU, Balido Science (DTE or ISU, Balido Science (DTE or ISU, Balido Science (DTE or ISU, Depeter Marken (DTE or ISU, DEPETER (DTE or ISU, DEPETER (DT		Radio Science									(23 x 10 x	
Autor         Doppler and range measurements, ko- band transporter         Begic Johnson         Allen Deviation of 10-15 at 1000 init time, tested at ground # 110-15, Accursey of 15 cm, Doppler RMS @606.init time "0.01-0.04 mm/s         S.5 kg         2.1 L         Aug. 22.6 W.           4         IDE or ISL IDE OR	2	(DTE or ISL)	Belgium	ROB	LARA	Doppler Shift	ExoMars 2020	8	10^-14 Allan Deviation	2.2 kg	10) cm3	40 W
Ballo Science         measurents, for- UDE or ISU.         tested at ground @ 4*100-16, Accuracy of ~15 cm, Doppler inter- statilite link precise range-rate         tested at ground @ 4*100-16, Accuracy of ~15 cm, Doppler inter- statilite link precise range-rate         tested at ground @ 4*100-16, Accuracy of ~15 cm, Doppler inter- statilite link precise range-rate         tested at ground @ 4*100-16, Accuracy of ~15 cm, Doppler inter- statilite link precise range-rate         tested at ground @ 4*100-16, Accuracy of ~15 cm, Doppler inter- statilite link precise range-rate         tested at ground @ 4*100-16, Accuracy of ~15 cm, Doppler inter- statilite link precise range-rate         tested at ground @ 4*100-16, Accuracy of ~15 cm, Doppler inter- statilite link precise range-rate         tested at ground @ 4*100-16, Accuracy of ~15 cm, Doppler inter- statilite link precise range-rate         tested at ground @ 4*100-16, Accuracy of ~15 cm, Doppler inter- statilite link precise range-rate         tested at ground @ 4*100-16, Accuracy (Photos)         tested at ground @ 4*100-16, Accuracy (Photos)           5         Accelerometer         Belgium         NOB         Juventas)         Spring-based         Hera, launch 2024         First design <5m grass or noise, landwidth of more than \$ \$KLT. The resulting noise performance is a color on on on o						Doppler and range			Allan Deviation of 10^-15 at 1000 s int time,			
3         UE or KL, below in the construction of the constructin of the constructin of the construction of the con		Radio Science				measurents, Ka-			tested at ground @ 4*10^-16, Accuracy of ~15 cm,			
A Badio Science (DTE or ISL)         Luxembourg urg (DTE or ISL)         Linker-satellite urg ucembourg         Doppler inter- set ange-rate based on Proba-3 / HEA, bunch 2024         Gravity coefficient 12 determinatin with uncertainty of 10-113%, higher degree grav coefficient to degree 2 and 3         (9.5 x.4.4.x 1.5) cm 3 (per axis, 5-axis, 5-2 cm 4/2)           5         Accelerometer         Belgium         ROB         Juventasi         Spring-based         Here, launch 2024         5         (	3	(DTE or ISL)	Italy	La Sapienza	MORE (on MPO)	band transponder	BepiColombo	8	Doppler RMS @60s int time ~0.01-0.04 mm/s	3.5 kg	2.1 L	Avg: 32.6 W
A         Badio Science (DTE or ISL)         Luxembo urg         Gendspace (Link)         Ist (Inter-stellite ink)         mage rate measurements         Badio Science (DTE or ISL)         Gendspace (Link)         Ist (Inter-stellite ink)         Ist (Inter-stellite measurements         Gendspace (BSAS (on Link)         Ist (Inter-stellite measurements         Ist (Inter-stellite measurement         Ist (Inter-stellite measurement         Ist (Inter-stellite measurement         Ist (Inter-stellite measurement         Ist (Inter-stellite measurement         Ist (Inter-stellite measurement         Ist (Int						Doppler inter-						
Reading Science         Luxembourg         Based on Probe-3 / HERA, (DT or ISL)         uncertainty of 10-115, higher degree grav           6         UT         urg         Lixembourg         inhigh         measurements (BASS (on GRASS (on GRASS (on GRASS (on First design -Smg resolution on Earth, scalable (BASS (on First design -Smg resolution on Earth, scalable (BASS (on GRASS (on First design -Smg resolution on Earth, scalable (BASS (on GRASS (on First design -Smg resolution on Earth, scalable (BASS (on First design -Smg resolution on Earth, scalable (Baged on First design -Smg resolution on Earth) (Baged - Baged -						satellite link, precise			Gravity coefficient J2 determinatin with			
4         (DTE or ISL)         urg         Link)         measurements         launch 2024         >4         coefficient to degree 2 and 3         (5 × 4.4 × 1.5) cm3 (per attribute)           5         Accelerometer         Belgium         ROB         Juventas)         Spring-based         Hera, launch 2024         5         So Um/c/2 accuracy (Phobos)         C0 4 gg         600F)         <1W		Radio Science	Luxembo	GomSpace	ISL (Inter-Satellite	range-rate	Based on Proba-3 / HERA,		uncertainty of 10-11%, higher degree grav			
5       Accelerometer       Belgium       ROB       GRASS (on GRASS (on Sering-based       Spring-based       Hera, launch 2024       5       First design <5mg resolution on Earth, scalable:	4	(DTE or ISL)	urg	Luxembourg	Link)	measurements	launch 2024	>4	coefficient to degree 2 and 3			
S         Accelerometer         Belgium         ROB         Juventas)         Spring-based         Hera, launch 2024         S <so (phobos)<="" accuracy="" long="" sr2="" th=""> <col ark<="" th=""/>         60070         &lt;1W           6         Accelerometer         Belgium         KUL         NA         Capacitive MEMS         NA         3         as selsmic measurements.         package)         (depends)           6         Accelerometer         Belgium         KUL         NA         Capacitive MEMS         NA         3         as selsmic measurements.         package)         (depends)         &lt;200 mW (TE</so>											(9.5 x 4.4 x	
Accelerometer         Belgium         ROB         Juventas)         Spring-based         Hera, launch 2024         5         CS         COUM/SV2 accuracy (Phobos)         <0.4 k d         600F         <1W           6         Accelerometer         Belgium         KUL         NA         Capacitive MEMS         NA         3         as seismic measurements.         (0.2 mg/Str1{k12) sensor noise, band/with of more than 5 kkr. The resulting noise performance is performance is on on on 0.006 cm3         (0.06) cm3         (200 mW (TE design - Str1 knew)           6         Accelerometer         Belgium         KUL         NA         Capacitive MEMS         NA         3         as seismic measurements.         package)         (ansor)         <200 mW (TE design - Str1 knew)											1.5) cm3 (per	
S         Accelerometer         Belgium         ROB         Juventas)         Spring-based         Hera, launch 2024         5         <50 um/sv2 accuracy (Phobos)         <0.4 kg         60.0 Fr         <1000           6         Accelerometer         Belgium         KUL         NA         Cames/sv1(tl) sensor noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise, bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more than 5 kHz. The resulting noise bandwidth of more th					GRASS (on			_	First design <5mg resolution on Earth, scalable:		axis, 2-axis,	
6         Accelerometer         Belgium         KUL         NA         Capacitive MEMS         NA         3         assessmit conse, bandwidth of more, the solutions such on lose performance is far which makes the accelerometer well suited for high precision applications such on 0.06 (or X 0.9 x 0.06) (or X 0.9	5	Accelerometer	Belgium	ROB	Juventas)	Spring-based	Hera, launch 2024	5	<50 um/s^2 accuracy (Phobos)	< 0.4 kg	6DOF)	< 1W
6       Accelerometer       Belgium       KUL       NA       Capacitive MEMS       NA       3       as seismic measurements.       package       (genods)       (0.7 x 0.9 x)       0.06) cm3         6       Accelerometer       Belgium       KUL       NA       Capacitive MEMS       NA       3       as seismic measurements.       package       (genods)       (0.7 x 0.9 x)       0.06) cm3         7       Accelerometer       Belgium       KUL       NA       Capacitive MEMS       NA       3       as seismic measurements.       package       (genods)       (detector assembly):       (detector as									0.2 mg/sqrt(Hz) sensor noise, bandwidth of more			
6       Accelerometer       Belgium       KUL       NA       Capacitive MEMS       NA       3       as seismic measurements.       package       (sensor)       < 200 mV (TE									than 5 KHz. The resulting noise performance is far	<10g	(07.06	
Accelerometer         Beigum         KUL         NA         Capacitive MEMS         NA         3         assessmic measurements.         package         (sensor)         C200 mW (TE           6         Accelerometer         Beigum         KUL         NA         Capacitive MEMS         NA         3         assessmic measurements.         package         (sensor)         Capacitive MEMS         NA         3         assessmic measurements.         package         (sensor)         Capacitive MEMS         NA         3         assessmic measurements.         package         (sensor)         Capacitive MEMS         NA         3         assesswith an accuracy within 20-30         IB (m3)         IB (m3)         IB (m3)         IB (m3)         IB (m3)         IEC (control         electronics)         Package (it and it an									below 1µg/VHz which makes the accelerometer	(depends	(0.7 x 0.9 x	
• Accelerometer       beigrum       KuL       NA       3       ass seismic measurements.       package)       (sensor)       < 200 mW (TE         7       Accelerometer       Italian Spring       Tri-axial       Tri-axial       Sensing axes with an accuracy within 20-30       18) cm3       180 cm3         7       Accelerometer       Italian Spring       electromechanical       accelerometer       BepiColombo       8       intrinsic noise 1=9 ms-21k:1/2       5.8 kg       (17 x 13 x       Average: 10.1         7       Accelerometer       Italy       INAF       Accelerometer       BepiColombo       8       intrinsic noise 1=9 ms-21k:1/2       5.8 kg       (17 x 13 x       Average: 10.1         8       UDAR Altimeter       Japan       JAXA       Hayabusa2       9       Pulser repetition rate: 1kt       3.52 kg       28.9 cm3       18 w         9       LIDAR Altimeter       Japan       JAXA       Hayabusa2       9       Pulser repetition rate: 1kt       3.52 kg       cm3       18 w         9       LIDAR Altimeter       Germany       LIDAR Microsoft       Compact diode 1550       Measuring distance up to 1500 m       (24.1 x 22.8 x         1       DIR / Uni       maser       M-ARGO, launch       Measuring distance up to 1000 m       <33g	~								well suited for high precision applications such	on	0.06) cm3	
7         Accelerometer         Italy         INAF         Italian Spring electromechanical accelerometer         Tri-axial Bepi Colombo         Sensing axes with an accuracy within 20-30 arcseconds at 20 per single axis, Measurement accuracy 1e-8 ms-2, electronics):         Deal: 12.1 V (30 x 17 x 13 x           7         Accelerometer         Italian Spring electromechanical accelerometer         Tri-axial electronechanical accelerometer         Bepi Colombo         8         Intrinsic noise 1e-9 ms-2it-10 (30 x 17 x 13 x         Average: 10.3 (17 x 13 x           7         Accelerometer         Italy         INAF         Accelerometer         Bepi Colombo         8         Intrinsic noise 1e-9 ms-2it-10 (30 x 17 x 13 x         Average: 10.3 (17 x 13 x         Average: 10.3 (17 x 13 x           8         LIDAR Altimeter         Japan         JAXA         Hayabusa2 LIDAR         Range accuracy [10]; (40 st count mode + dust count mode + dus	6	Accelerometer	Belgium	KUL	NA	Capacitive MEMS	NA	3	as seismic measurements.	package)	(sensor)	< 200 mW (TBC)
7         Accelerometer         Italian Spring         Tri-axial electromechanical electromechanical electromechanical         Tri-axial electromechanical electromechanical         Sensing axes with an accuracy within 20-30 arcseconds at 20 per single axis, Measurement accuracy te 8 ms-2, electronics):         Italian Spring electromechanical electromechanical         Tri-axial electromechanical         Tri-axial electromechanical         Sensing axes with an accuracy within 20-30 arcseconds at 20 per single axis, Measurement accuracy te 8 ms-2, electronics):         Peak: 12.1 V electronics):           7         Accelerometer         talian Spring Accelerometer         Time-of-flight measurement of reflected pulse + dust count mode + albedo         Range: 30 m <sup>-2</sup> 5 km Resolution: 0.5 Range accuracy (10):         I/1 x 13 x         Average: 10.1 A verage: 10.1 Resolution: 0.5           8         LIDAR Altimeter         Japan         JAXA         Hayabusa2 LIDAR         Pulse repetition rate: 11tz         3.52 kg         28.9) cm3         18 W           9         LIDAR Altimeter         Germany         Jenptik         DLEM 20         Compact diode 150 mm laser         M-ARGO, launch         Measuring distance up to 1500 m         (5 x 2.2 x 3.4) (5 x 2.2 x 3.4)           9         LIDAR Altimeter         Germany         Jenptik         DLEM 20         Target: Mercury, single shot range measurement, emeasurement, germasurement, instituto de         Set 2.2 x 3.4) (25 x 16 x         Target: Mercury, single shot range measurement, emeasurement,											(detector	
7       Accelerometer       Italian Spring       Tri-axial electromechanical accelerometer       Tri-axial electromechanical accelerometer       Tri-axial electromechanical accelerometer       Sensing axes with an accuracy within 20-30 arcseconds at 20 per sigle axis, Measurement accuracy 1e-8 ms-2, electronicsi:       IRE (ontrol electronics):       Peak: 12.1 V Peak: 12.1 V         7       Accelerometer       Italian Spring accelerometer       BepiColombo       8       Intrinsic noise 1=9 ms-2ite-1/2       5.8 kg       [17 x 13 x       Average: 10.1 Average: 10.1         7       Accelerometer       Italian Spring       Time-of-flight measurement of reflected pulse + dust count mode + albedo       Range: 30 m <sup>-</sup> 25 km       Italian Spring       Average: 10.1 (24 x 22.8 x         8       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       P       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         9       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       M-ARGO, launch       Measuring time 100 ms       (5 x 2.2 x 3.4)         9       LIDAR Altimeter       Jeonptik       DLEM 20       rangefinder       2024/2025       3-42       Accuracy + 0.5 m up to 1000 m       (5 x 2.2 x 3.4)         9       LIDAR Altimeter       Germany       Jeonptik       DLEM 20       rangefinder       2024/2025       3-42											quetector	
7       Accelerometer       Italian Spring       Tri-axial electrometenical accelerometer       BepiColombo       8       Sensing axes with an accuracy within 20-30 arcseconds at 20 per single axis, Measurement accuracy 1e-8 ms-2, IEE (control electronics):       Peak: 12.1 V electronics):       Average: 10.3 Verage: 10.3         7       Accelerometer       Italy       INAF       Accelerometer       BepiColombo       8       Intrinsionise 1e-9 ms-2tx-1/2       5.8 kg       (17 x 13 x)       Average: 10.3         7       Accelerometer       Italy       INAF       Accelerometer       BepiColombo       8       Intrinsionise 1e-9 ms-2tx-1/2       5.8 kg       (17 x 13 x)       Average: 10.3         8       IDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       Range accuracy (10): dust count mode + albedo											assembly):	
7       Accelerometer       Italian Spring       Tri-axial electromechanical accelerometer       BepiColombo       8       Intrinsionise 1e-9 ms-2h; 21/2       5.8 kg       (17 x 13 x       Average: 10.1 electronics):         7       Accelerometer       Italian Spring       accelerometer       BepiColombo       8       Intrinsionise 1e-9 ms-2h; 21/2       5.8 kg       (17 x 13 x       Average: 10.1 electronics):         8       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       8       Intrinsing time 100 ms       (24.1 x 22.8 x         9       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       9       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         9       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       9       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         9       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       9       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         9       LIDAR Altimeter       Germany       Jenoptik       DLE // Compact diode 1550       MARGO, Jaunch       Measuring distance up to 1500 m       (5 x 2.2 x 3.4)									Consistent with an environmentable 20,20		(50 x 17 x	
Thradial       Intradial       Intradial <thintradial< th=""> <thintradial< th=""></thintradial<></thintradial<>						Tel avial			Sensing axes with an accuracy within 20-30		18) cm5	
7       Accelerometer       Italian spring       electronmeter measurement       BepiColombo       8       Intrinsionise 1-9 me3/2, interval       electronmes/2, interval       electronmes					Hallon Casina	ITI-dXidi			arcseconds at 20 per single axis,		ICE (control	Deels 42.4 M
Acceleronnecter       Interver       Acceleronnecter       Deprodution       s       Interver       Jake       (17 A 13 A       Average: 10:4         8       Interver       Tempofflight measurement of reflected pulse + dust count mode + albedo       Timeofflight measurement of reflected pulse + dust count mode + albedo       Range: 300 m 325 km Range accuracy (10): + 1 m @ 30 m alt       (24.1 x 22.8 x         8       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       9       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         9       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       M-ARGO, launch       Measuring time 100 ms       (5 x 2.2 x 3.4)         9       LIDAR Altimeter       Germany       Jenoptik       DLEM 20       rangefinder       2024/2025       3-4?       Accuracy + 0.5 m up to 1000 m       <33 g	7	Accelerometer	Italy	INIAE	Accelerometer	accelerometer	BaniColombo	•	Intrinsic poise 1e-9 ms-2Hz-1/2	5 9 4 7	(17 × 12 ×	Peak: 12.1 W,
8       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       measurement of reflected pulse + dust count mode + albedo       Hayabusa2       9       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         8       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       measurement       Hayabusa2       9       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         9       LIDAR Altimeter       Germany       Jenoptik       DLEM 20       rangefinder       2024/2025       3-47       Accuracy + 0.5 m up to 1000 m       <(5 x 2.2 x 3.4)	-	Attelefonieter	Italy	INAF	Acceleronneter	Time-of-flight	Depicolombo	•	Bange: 30 m ~ 25 km	<b>3.0 K</b>	(1/ × 13 ×	Average: 10.1 v
8       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       measurement       Hayabusa2       9       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         9       LIDAR Altimeter       Germany       Jenoptik       DLEM 20       rangefinder       2024/2025       3-4?       Accuracy + 0.5 m up to 1000 m       <33 g						measurement of			Resolution: 0.5			
8       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       measurement       Hayabusa2       9       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         9       LIDAR Altimeter       Germany       Jenoptik       DLEM 20       rangefinder       2024/2025       3-4?       Accuracy + 0.5 m up to 1000 m       <33 g						reflected pulse +			Range accuracy (1g):			
8       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       measurement       Hayabusa2       9       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         9       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       Measurement       Hayabusa2       9       Measuring time 100 ms       (5 x 2.2 x 3.4)       (5 x 2.2 x 3.4						dust count mode +			+ 1 m @ 30 m alt			
8       LIDAR Altimeter       Japan       JAXA       Hayabusa2 LIDAR       measurement       Hayabusa2       9       Pulse repetition rate: 1Hz       3.52 kg       28.9) cm3       18 W         9       LIDAR Altimeter       Germany       Jenoptik       DLEM 20       rangefinder       2024/2025       3-4?       Measuring time 100 ms       (5 x 2.2 x 3.4) <td< td=""><td></td><td></td><td></td><td></td><td></td><td>albedo</td><td></td><td></td><td>+ 2 m @ 25 km alt</td><td></td><td>(24.1 x 22.8 x</td><td></td></td<>						albedo			+ 2 m @ 25 km alt		(24.1 x 22.8 x	
9       LIDAR Altimeter       Germany       Jenoptik       DLEM 20       Compact diode 1550 nm laser       M-ARGO, launch 2024/2025       M-ARGO, launch 3-4?       Measuring time 100 ms Measuring distance up to 1500 m       (5 x 2.2 x 3.4) (5 x 2.2 x 3.4)         9       LIDAR Altimeter       Germany       Jenoptik       DLEM 20       rangefinder       2024/2025       3-4?       Accuracy + 0.5 m up to 1000 m       < 33 g	8	LIDAR Altimeter	Japan	JAXA	Havabusa2 LIDAR	measurement	Havabusa2	9	Pulse repetition rate: 1Hz	3.52 kg	28.9) cm3	18 W
9       LIDAR Altimeter       Germany       Jenoptik       DLEM 20       nm laser       M-ARGO, launch       Measuring distance up to 1500 m       < (5 x 2.2 x 3.4)						Compact diode 1550	,	-	Measuring time 100 ms			
9       LIDAR Altimeter       Germany       Jenoptik       DLEM 20       rangefinder       2024/2025       3-4?       Accuracy + 0.5 m up to 1000 m       < 33 g       cm3       < 1.8 W         V       Interview       Image: State of the state of t						nm laser	M-ARGO, launch		Measuring distance up to 1500 m		(5 x 2.2 x 3.4)	
DLR / Uni     Target: Mercury, single shot range     Target: Mercury, single shot range     Electronics       DLR / Uni     measurement, return pulse shape     (25 x 16 x)     < 30 W in	9	LIDAR Altimeter	Germany	Jenoptik	DLEM 20	rangefinder	2024/2025	3-4?	Accuracy + 0.5 m up to 1000 m	< 33 g	cm3	< 1.8 W
Bern / MPS /     return pulse shape     Receiver: (72       Instituto de     BELA - Bepi-     and albedo						_					Transmitter+	
DLR / Uni     measurement,     x48 x 50)       Bern / MPS /     return pulse shape     cm3,       Instituto de     BELA - Bepi-     and albedo											Receiver: (72	
DLR / Uni     Target: Mercury, single shot range     cm3, Electronics       DLR / Uni     measurement, return pulse shape     boxes: ELU:       Bern / MPS / Instituto de     return pulse shape     (25 x 16 x       BELA - Bepi-     and albedo     16) cm3, LEU:											x 48 x 50)	
DLR / Uni     single shot range     Electronics       DLR / Uni     measurement,     boxes: ELU:       Bern / MPS /     return pulse shape     (25 x 16 x       Instituto de     BELA - Bepi-     and albedo						Target: Mercury,					cm3,	
DLR / Uni     measurement, return pulse shape     boxes: ELU:       Bern / MPS / Instituto de     return pulse shape     25 x 16 x       Instituto de     BELA - Bepi- and albedo     and albedo						single shot range					Electronics	
Bern / MPS /         return pulse shape         (25 x 16 x         < 30 W in           Instituto de         BELA - Bepi-         and albedo         16) cm3, LEU:         nominal				DLR / Uni		measurement,					boxes: ELU:	
Instituto de BELA - Bepi- and albedo 16) cm3, LEU: nominal				Bern / MPS /		return pulse shape					(25 x 16 x	< 30 W in
				Instituto de	BELA - Bepi-	and albedo					16) cm3, LEU:	nominal
Astrofisica Colombo Laser analysis, digital Range accuracy: < 1 m, Max. distance: 1000 - 1800 (24 x 13 x operation (10				Astrofisica	Colombo Laser	analysis, digital			Range accuracy: < 1 m, Max. distance: 1000 - 1800		(24 x 13 x	operation (10 H
10 LIDAR Altimeter Germany de Andalucia Altimeter samples BepiColombo ~8-9 km depending on surface roughness and albedo 14.2 kg 15) cm3 shot frequence	10	LIDAR Altimeter	Germany	de Andalucia	Altimeter	samples	BepiColombo	~8-9	km depending on surface roughness and albedo	14.2 kg	15) cm3	shot frequency

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



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

		Tractor, slow pus	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	Х	X
Mass	Х	Х	Х	Х	Х
Shape	Х	Х	Х	Х	Х
Spin	Х	Х	Х	Х	Х
Sub surface		Х	Х	Х	X
Thermal properties			X	X	X
Chemical properties		Needs	a RV	X	x
Internal structure				X	X

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