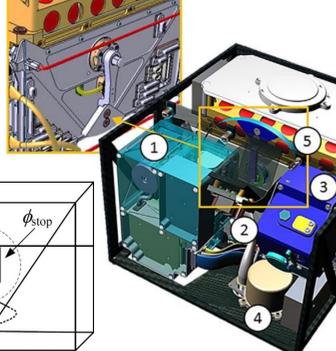
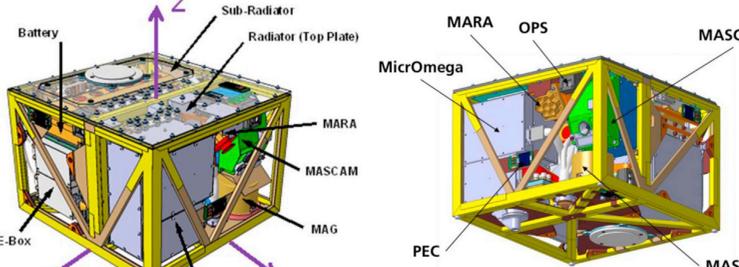




point of departure: MASCOT, the Mobile Asteroid Surface Scout nanolander carried by JAXA's sample-return probe HAYABUSA2 to NEA (162173) Ryugu for its landing on October 3<sup>rd</sup>, 2018. It successfully completed its scouting mission in 17 hours, jumping to 3 sites by command and self-righting autonomously.



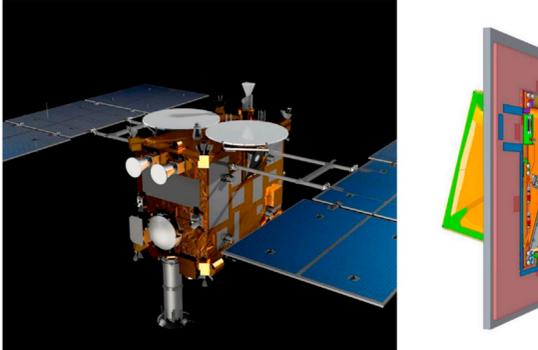
putting the 'M' in MASCOT: internal mobility mechanism integrated within the Common Electronics Box (E-Box)



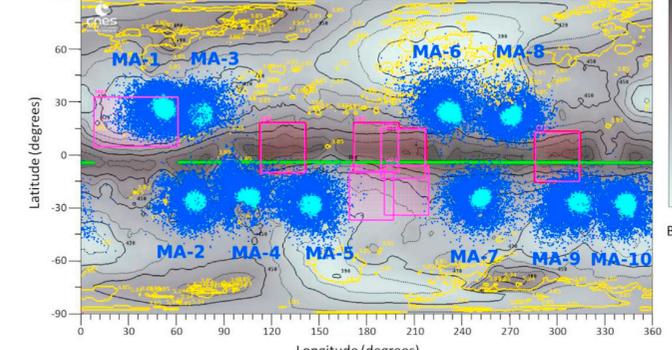
accommodation of the subsystems & payloads within the lander structure in two different perspectives  
↖ same perspective as photograph on the far left



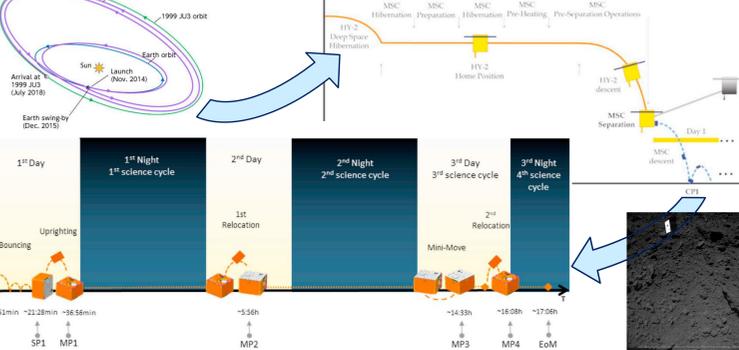
the MASCOT Flight Model  
↗ instruments & GNC sensors – MASCOT AIV team at ISAS, Sagamihara, in 2014 ↑ – ready for integration (10 cm scale on plate) ↖



under the wings of the Falcon: safely tucked away for 4 years in deep space CAD view of MASCOT in its Mechanical and Electrical Support System (MESS) on the –Y panel ↑



in search of a new home: the possible landing sites of MASCOT – new permanent address: MA-9  
light blue: possible 1<sup>st</sup> contact point clouds – dark blue: 1<sup>st</sup> settlement points – green: sub-Earth point – L: exclusion zone



not to scale: the very different timelines of MASCOT's journey beyond the horizon  
↑↑ interplanetary cruise with Earth flyby – approach and descent to separation ↗ ↘ ↑ science operations on Ryugu – just separated ↑



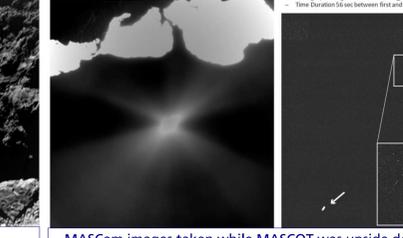
...if I had seen further, then by jumping from the wings of the Falcon MASCOT's shadow down among the boulders of Ryugu (to scale)



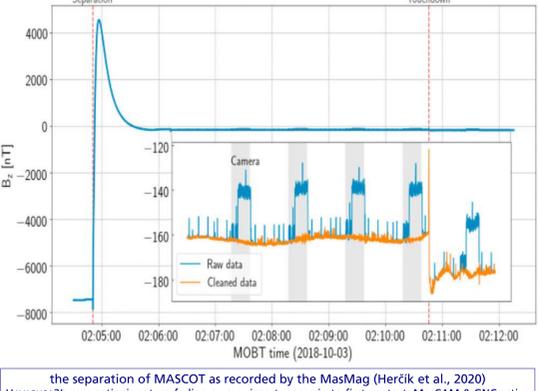
all boulders, no sands – close looks at a C-type rubble pile PHA dark fractured rocks, rubble and pebbles – with intriguing specks of light



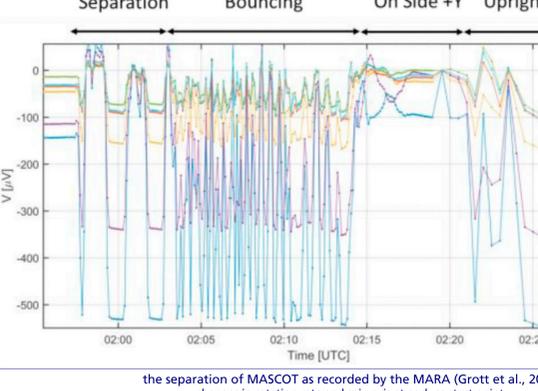
MASCAM images taken while MASCOT was upside down at MP1  
↖ the Sun & boulders – the sky at night: Jupiter, a Sagittari, Saturn ↗



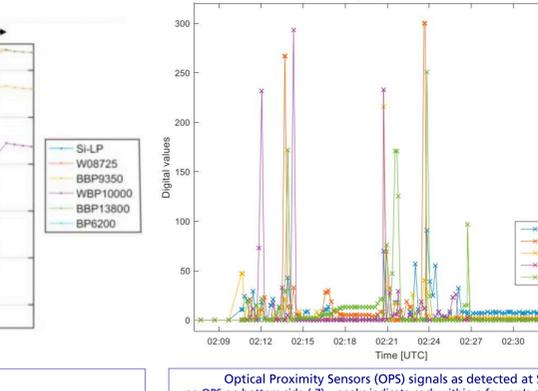
the sky at day reflections on Ryugu



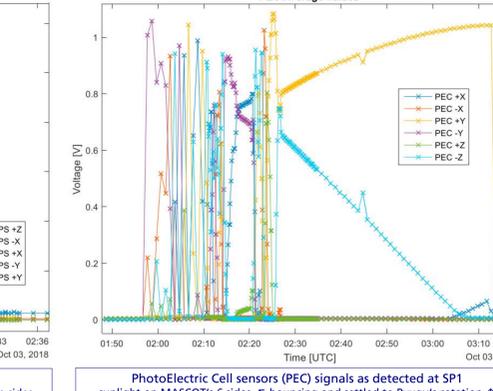
the separation of MASCOT as recorded by the MasMag (Herčík et al., 2020)  
HAYABUSA2's magnetic signature fading away – insert: zoom-in to first contact, MASCam & GNC active



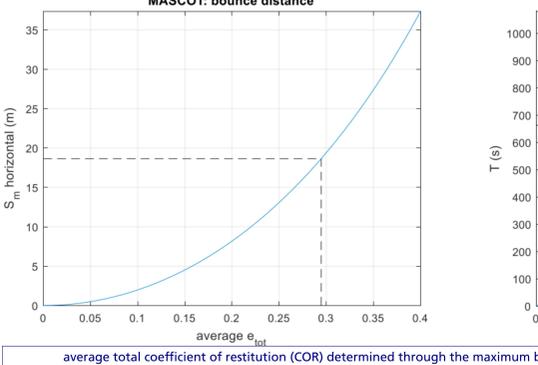
the separation of MASCOT as recorded by the MARA (Grott et al., 2019)  
changes in rotation rate and spin axis at each contact point



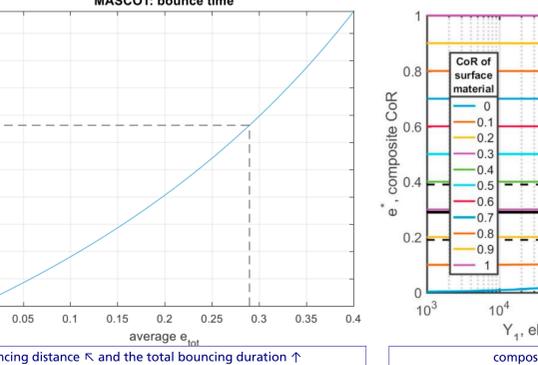
Optical Proximity Sensors (OPS) signals as detected at SP1  
no OPS on bottom side (-Z) – peaks indicate rock within a few cm's of the sides



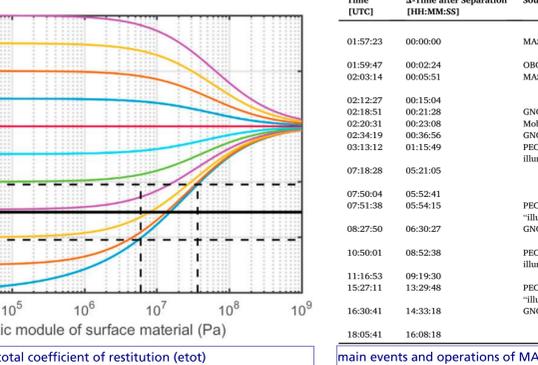
PhotoElectric Cell sensors (PEC) signals as detected at SP1  
sunlight on MASCOT's 6 sides, ↖ bouncing and settled to Ryugu's rotation ↑



MASCOT: bounce distance  
average total coefficient of restitution (COR) determined through the maximum bouncing distance  $\kappa$  and the total bouncing duration ↑  
from first touchdown until MASCOT came to rest



MASCOT: bounce time



composite total coefficient of restitution (etot)  
dependent on Young's module for COR  $0 < e < 1$  of Ryugu's surface material

Time [UTC]	Δ-Time after Separation [HH:MM:SS]	Source	Event	MASCOT Operation
01:57:23	00:00:00	MASMag	Before separation	MASMag and MARA are on
01:59:47	00:02:24	MASMag	MASCOT separation and descent towards the asteroid.	MASCOT separated with a velocity of -5.9 cm/s (Scholten et al., 2019)
02:03:14	00:05:51	OB	The first impact of MASCOT with Ryugu (CP1) detected by MASMag followed by a bouncing phase.	MASCAM started to acquire descent and bouncing images
02:12:27	00:15:04	GNC "at rest"	MASCOT reached its first settlement point (SP1)	MASCAM acquired last descent and bouncing images
02:18:51	00:21:28	Mobility	MASCOT started to upright	MASCOT started to upright
02:20:31	00:23:08	GNC "at rest"	MASCOT reached its first measurement point (MP1)	Start of the 1st science cycle.
02:34:19	00:36:56	PEC "not-illuminated"	End of 1st day and start of 1st night on Ryugu.	
07:18:28	05:21:05	PEC "illuminated"	End of 1st night and start of 2nd day on Ryugu.	A ground command has been sent to MASCOT to interrupt its science measurement and force the lander to relocate MASCOT performed its 1st relocation
07:50:04	05:52:41	GNC "at rest"	MASCOT reached its second measurement point (MP2)	The GNC sensors confirmed the correct orientation of the lander and the 2nd science cycle was started.
07:51:38	05:54:15	PEC "not-illuminated"	End of 2nd day and start of 2nd night on Ryugu.	
08:27:50	06:30:27	PEC "illuminated"	End of 2nd night and start of 3rd day on Ryugu.	MASMag has been turned off.
11:16:53	09:19:30	PEC "illuminated"	MASCOT at its third measurement point (MP3)	MASCOT made a "Mini-Move" and initiated its 3rd science cycle once on MP3
15:27:11	13:29:48	GNC "at rest"	MASCOT reached its 4th measurement point (MP4)	MASCOT performed a 2nd relocation once at MP4 executed
18:05:41	16:08:18			

	MicrOmega	NIRS3	MARA	TIR	MASCAM	ONC-T
Spectral range	0.99–3.65 μm	1.8–3.2 μm	5.5–7, 8–9.5, 9.5–11.5, and 13.5–15.5 μm	8–12 μm	54.8° (72.5° diagonal)	6.27° × 6.27°
FOV	3.2 mm × 3.2 mm	0.11 × 0.11	18°	16.7° × 12.7°	1024 × 1024 pixel (CMOS)	1024 pixel × 1024 pixel (CCD)
Spectral Sampling	20 cm-1 (2 nm at 1.0 μm, 25 nm at 3.6 μm)	18 nm	123–373 K	233–423 K	209.05 arcsec/px	22.14 arcsec/px
Spatial Sampling	On asteroid surface: 25 μm	At 20 km altitude: 40 m At 1 km: 2 m	extending the eyes of the Falcon ↖ main characteristics of MicrOmega (MASCOT) and NIRS3 (HAYABUSA2) ↗ main characteristics of MARA (MASCOT) and TIR (HAYABUSA2) ↑ performance of MASCam (MASCOT) and the ONC-T (HAYABUSA2) ↓		400 nm–1000 nm	390 nm–950 nm
Ground/area coverage At 150 mm distance: 156.3 mm × 156.3 mm At HP (=20 km): 2 km × 2 km At 100 m altitude: 10 m × 10 m						

The MASCOT team says thank you! ☺ to the entire HAYABUSA2 team at ISAS and JAXA for the invitation, the challenge, the trust, the cooperation, the generosity, the exciting time on-site, the launch, the ride, the long cruise, the views of Ryugu, the drop into Wonderland, and the adventure "down among 'em" rocks & boulders. The best of good luck for the extended mission!

With a unique view, MASCOT scouted for HAYABUSA2 the terrain, topography, and texture of the surface materials of a large potentially hazardous near-Earth asteroid with rubble-pile structure and carbonaceous composition.

