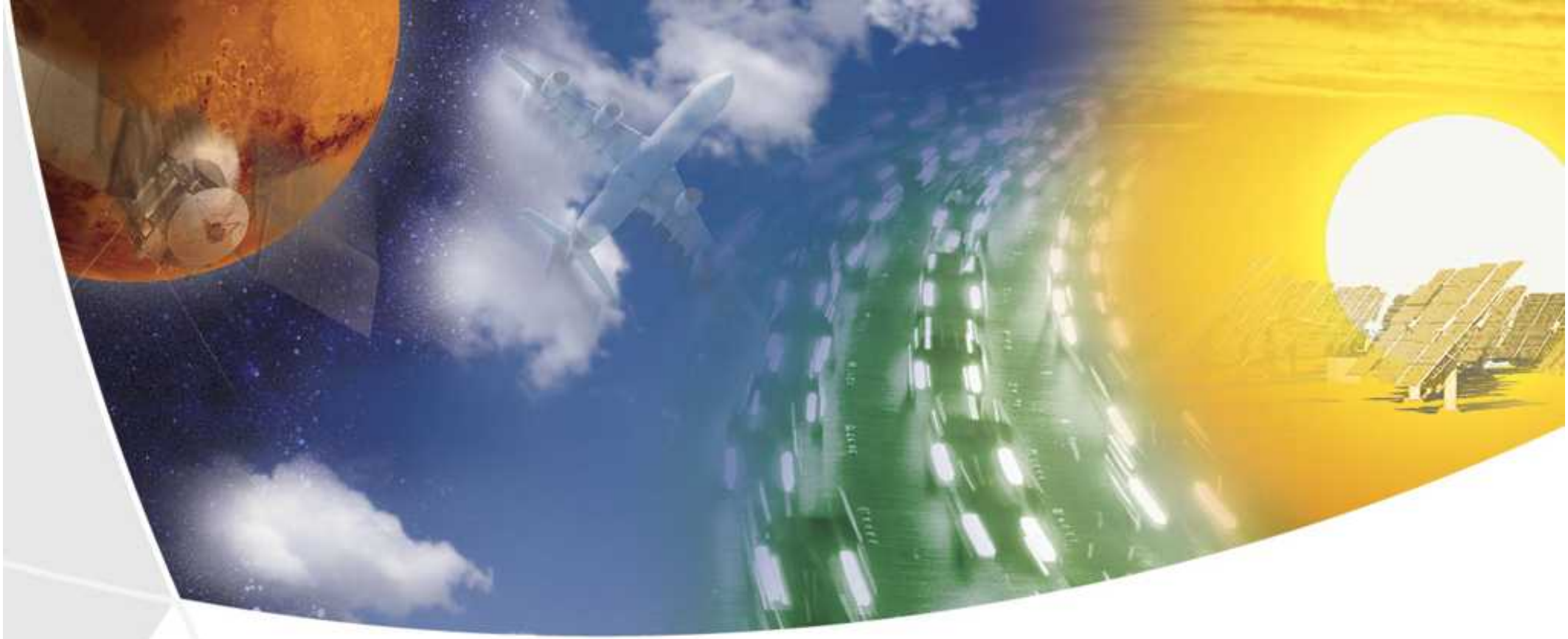


Landen auf einem Kometen - Umgang mit Risiken in der Raumfahrt

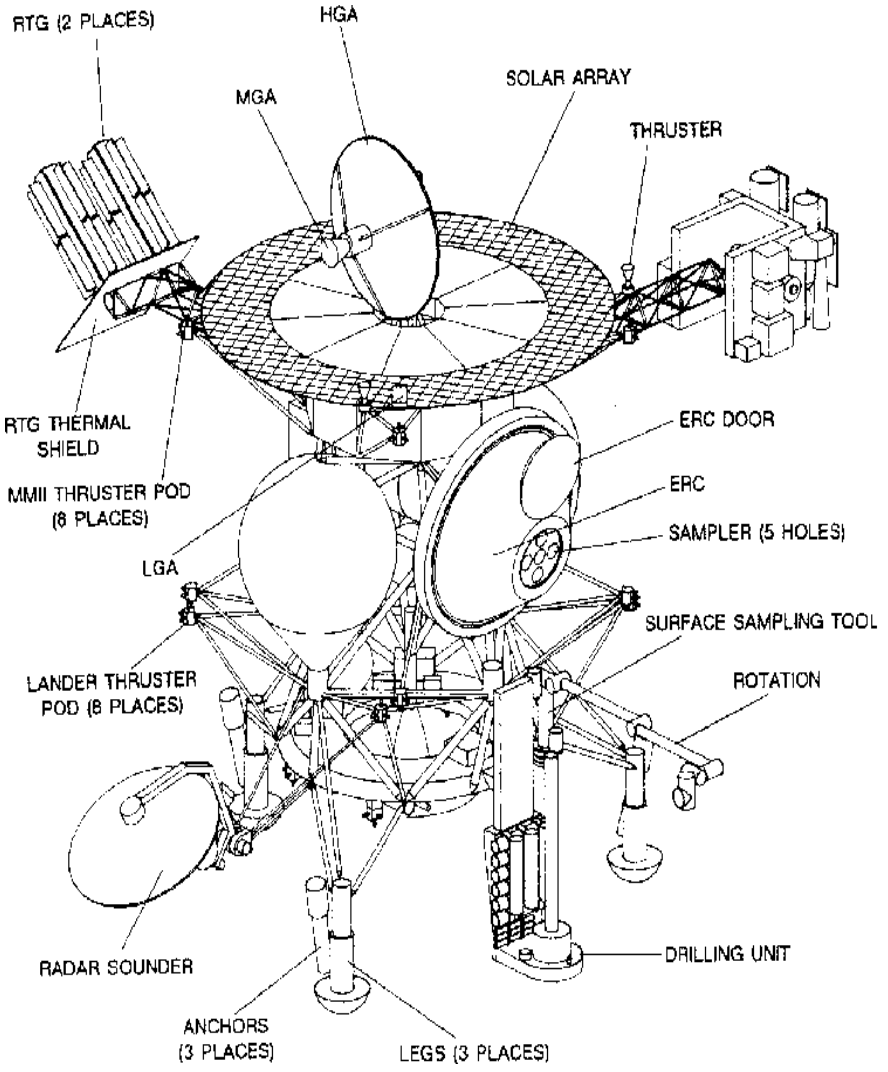
J.Biele

Eltville, 31.08.2015

Deutsches Zentrum
DLR für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Die Untersuchung eines Kometenkerns- ein wenig Geschichte

- Rosetta entstand, nach der Giotto Mission zum Kometen Halley, aus der Idee einer Probenrücknahmemission CNSR
- Das „Objekt der Begierde“ ist das pristine Kometenmaterial
- Messungen vom Orbiter legen Modelle zum Ausgasen zugrunde
- Messungen an der Oberfläche geben „Ground Truth“



Rosetta

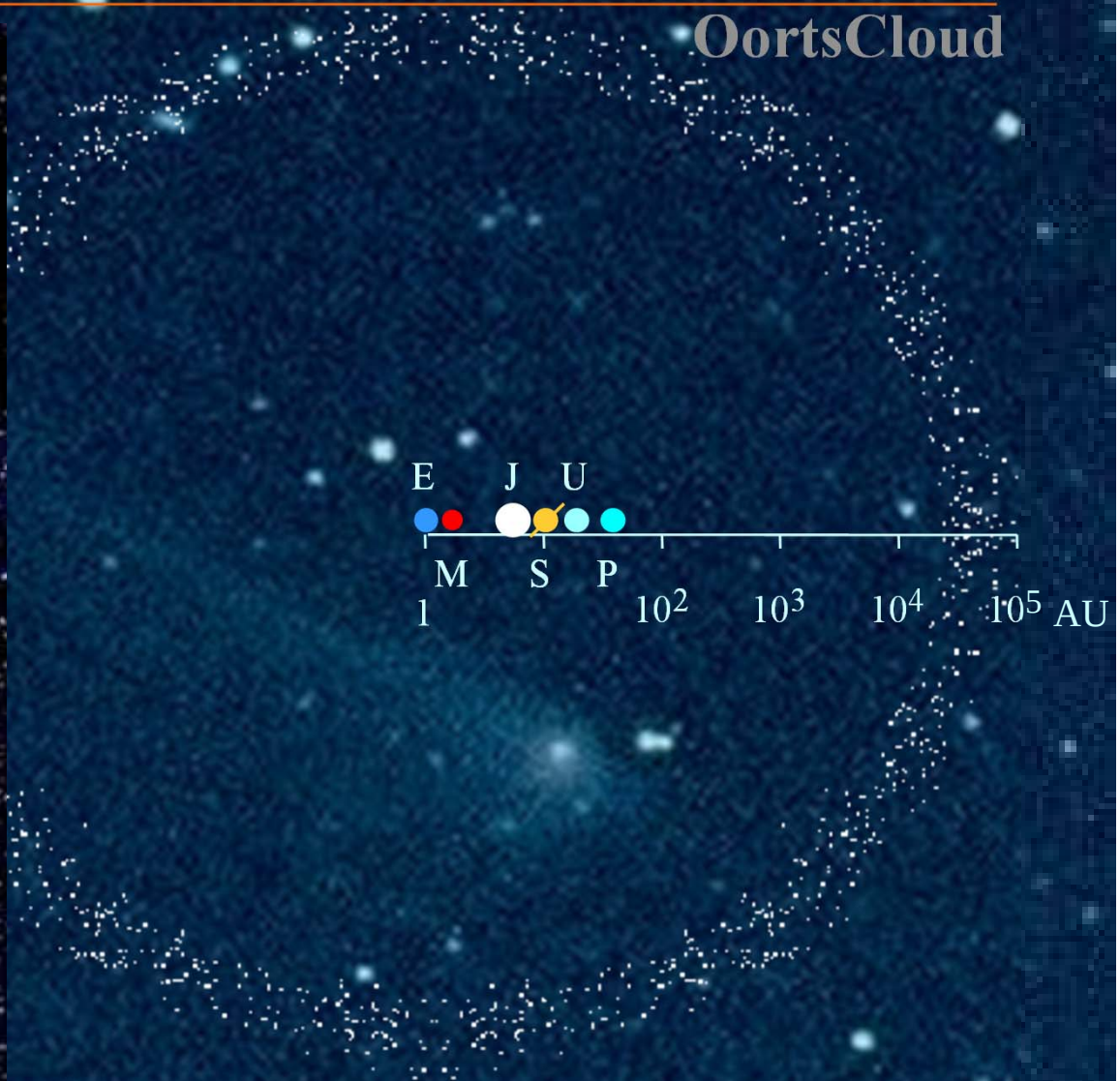
- An ESA Cornerstone Mission to comet
- 67P/Churyumov Gerasimenko
- 11 Orbiter Instrumentes as well as a Lander
- Launch: March, 2004
- Exit Hibernation January 20th, 2014
- Arrival at Comet August 6th
- Landing of Philae: November 12th 2014

Kosten und Risiken

- Rosetta: ~ 1 Mrd€ (ESA)
- Lander: ~100 Mio€ (Konsortium)
- Zeitraum: 1994-2016
- Fast alle Einheiten „Unikate“
- Obligatorisch: QS bei Design, Bau, Tests, Betrieb
- Aber: (fast) unbekanntes Ziel, nur 1 Versuch → System muss robust sein, redundante Subsysteme

➔ Was tue ich beispielsweise bei hochkomplexen Projekten in der (robotischen!) Raumfahrt, wenn mal etwas schief geht?

Ursprung der Kometen

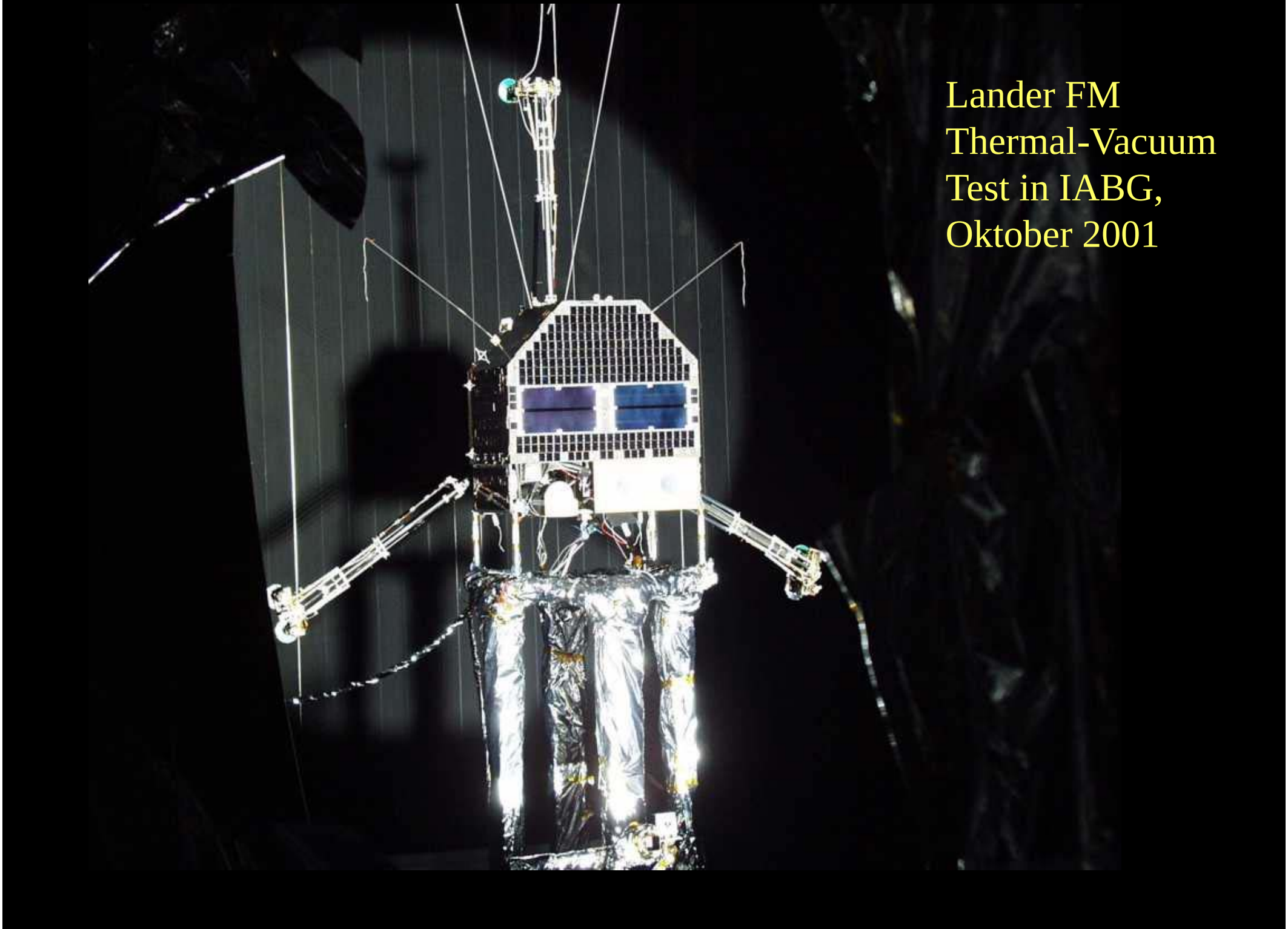


Comets are probably the most
pristine Objects in the Solar System

Background Image: Comet P/Churyumov-Gerasimenko; 22.3.2003 by *Herman Mikuz / Crni Vrh Observatory*

Management Challenge

- Duration of Project
  - Rosetta considered: 1986
  - Rosetta approved 1993
  - Lander proposed 1994
  - Development:1995-2002
  - Launch 2004
  - Hibernation 2011-2014
  - Arrival (August), Landing (Nov) 2014
- Lander: No industry, but International Team with contributions
  - Best Effort Basis / No exchange of Funds /
  - Steering Committee
- 10 Instrument Teams (with evolving technical requirements)



Lander FM
Thermal-Vacuum
Test in IABG,
Oktober 2001

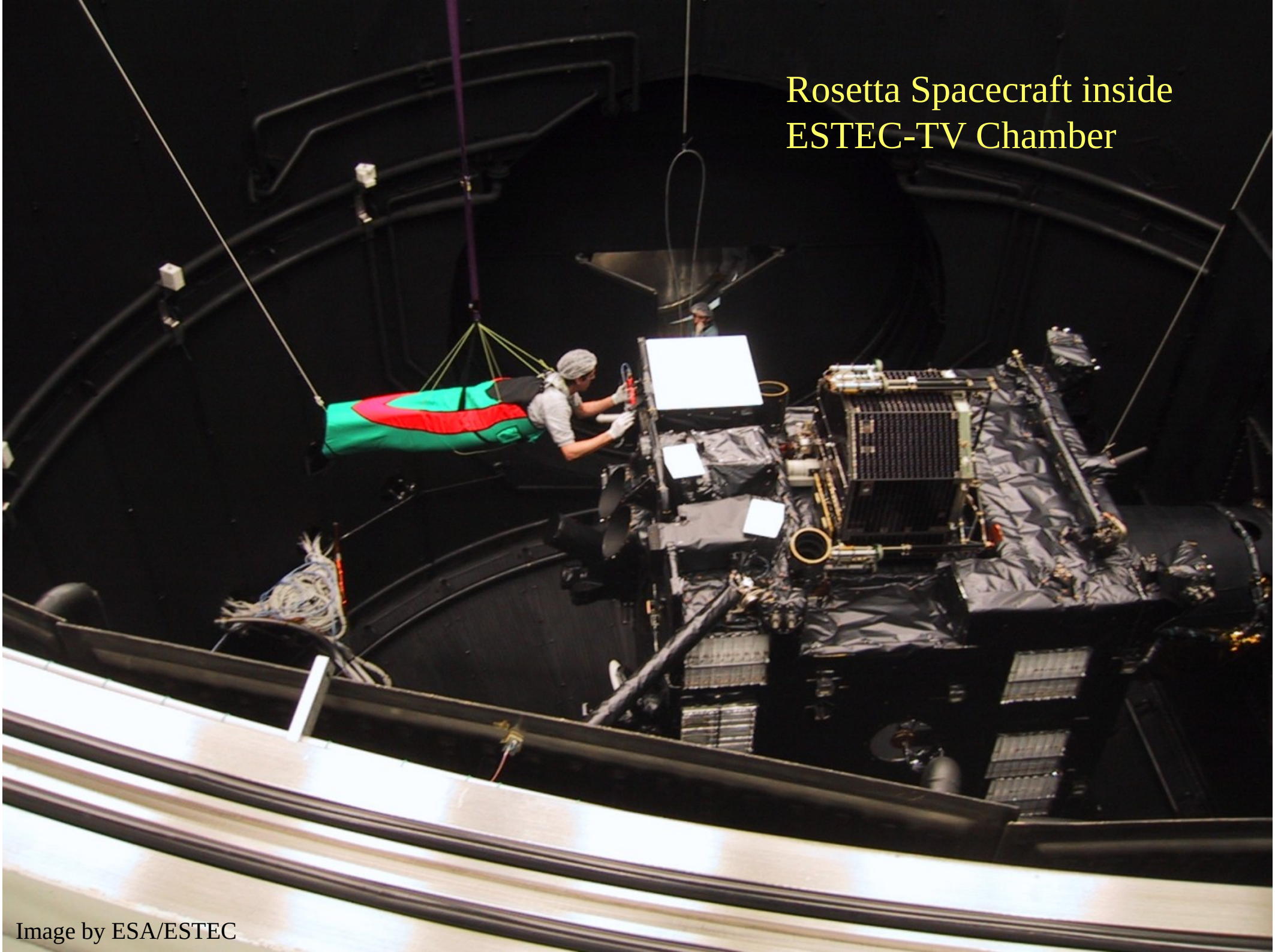


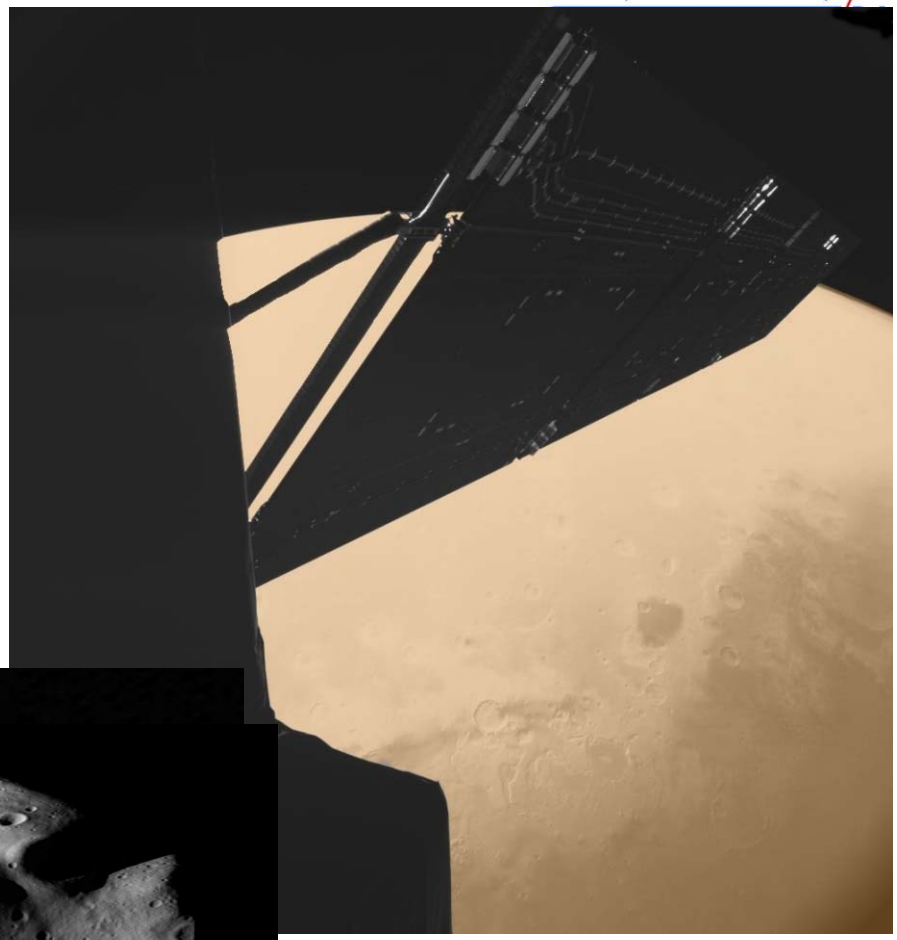
Image by ESA/ESTEC

Rosetta Launch 02-03-04

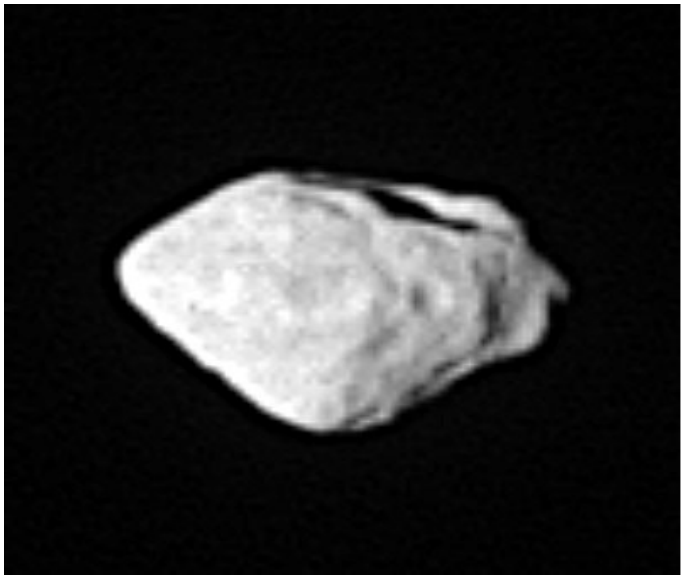
Images by OSIRIS

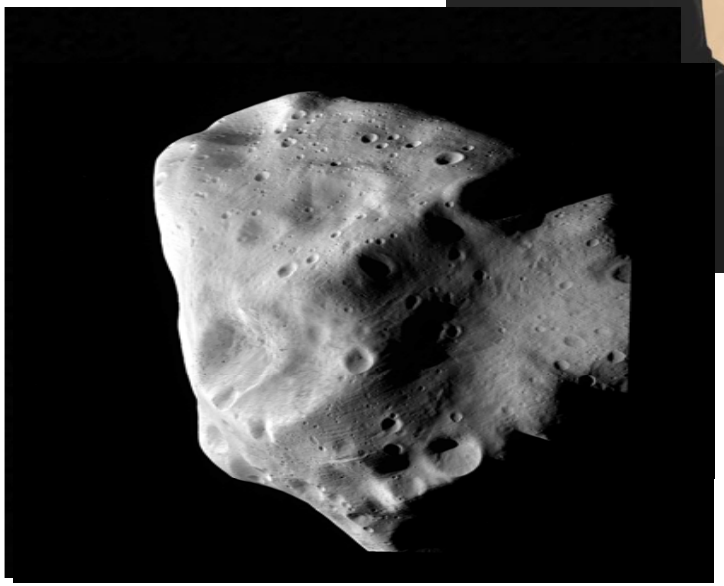
10 years of Cruise

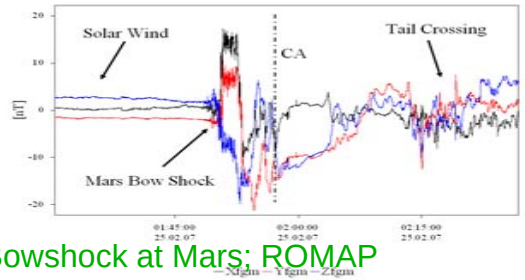
- Mars swingby, February23rd 2007; CA: 250.6 km
- Šteins : September 5th 2008
- Lutetia: July 10th 2010
- Hibernation: Dec 2010 - Mar 2014



Mars as seen by CIVA



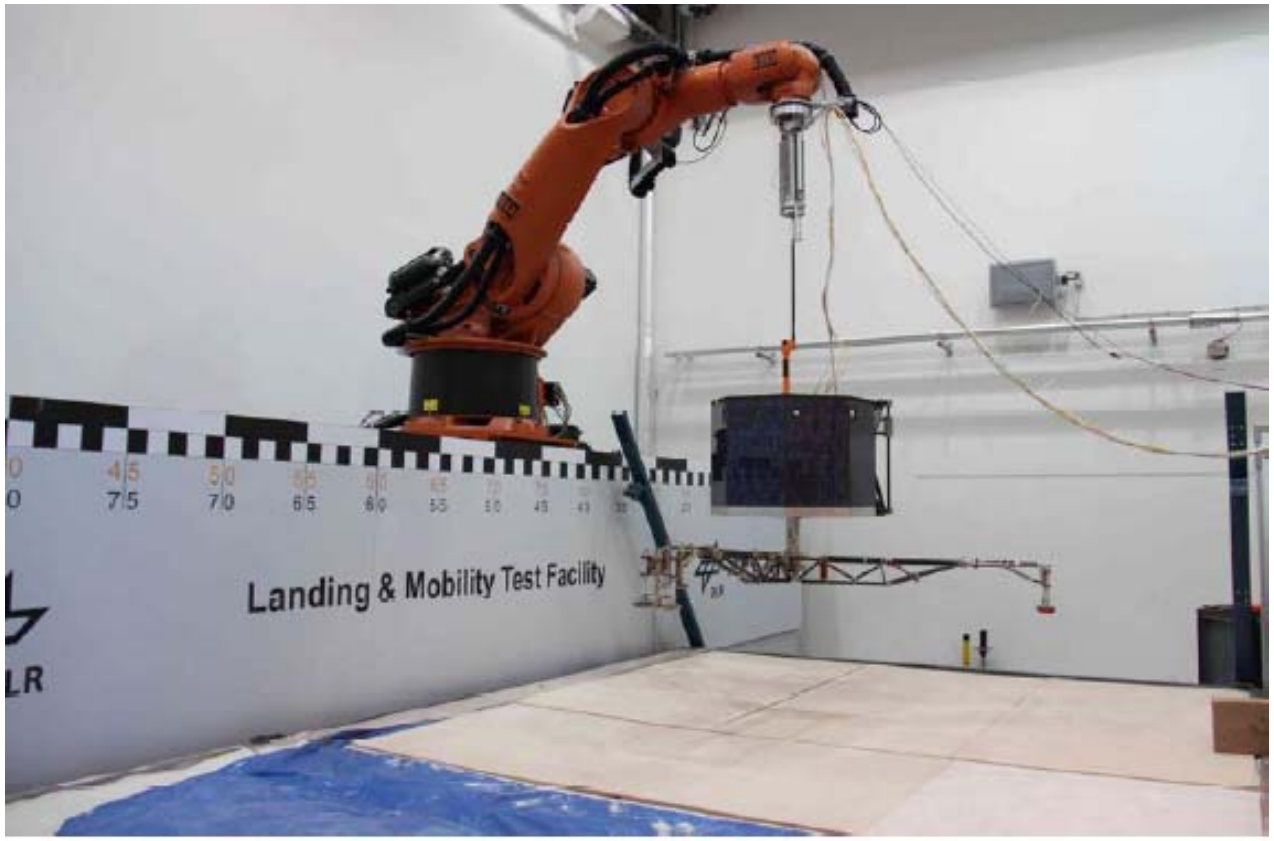




Bowshock at Mars: ROMAP

Images by OSIRIS

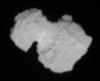
Landing simulations



LAMA Anlage im DLR-Bremen

Pendeltests im MPS, Lindau

Surprise image: OSIRIS (early July 2014)



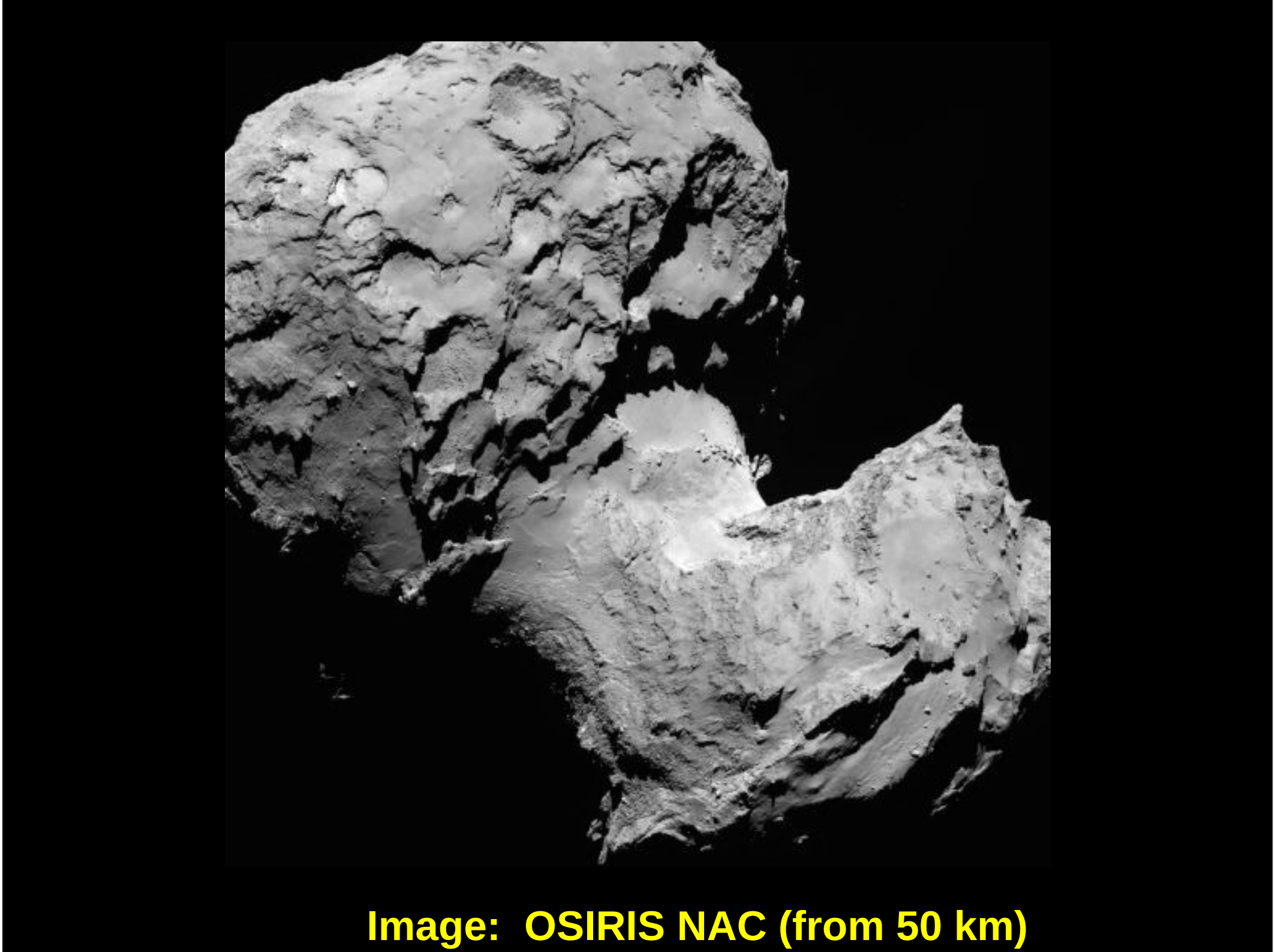
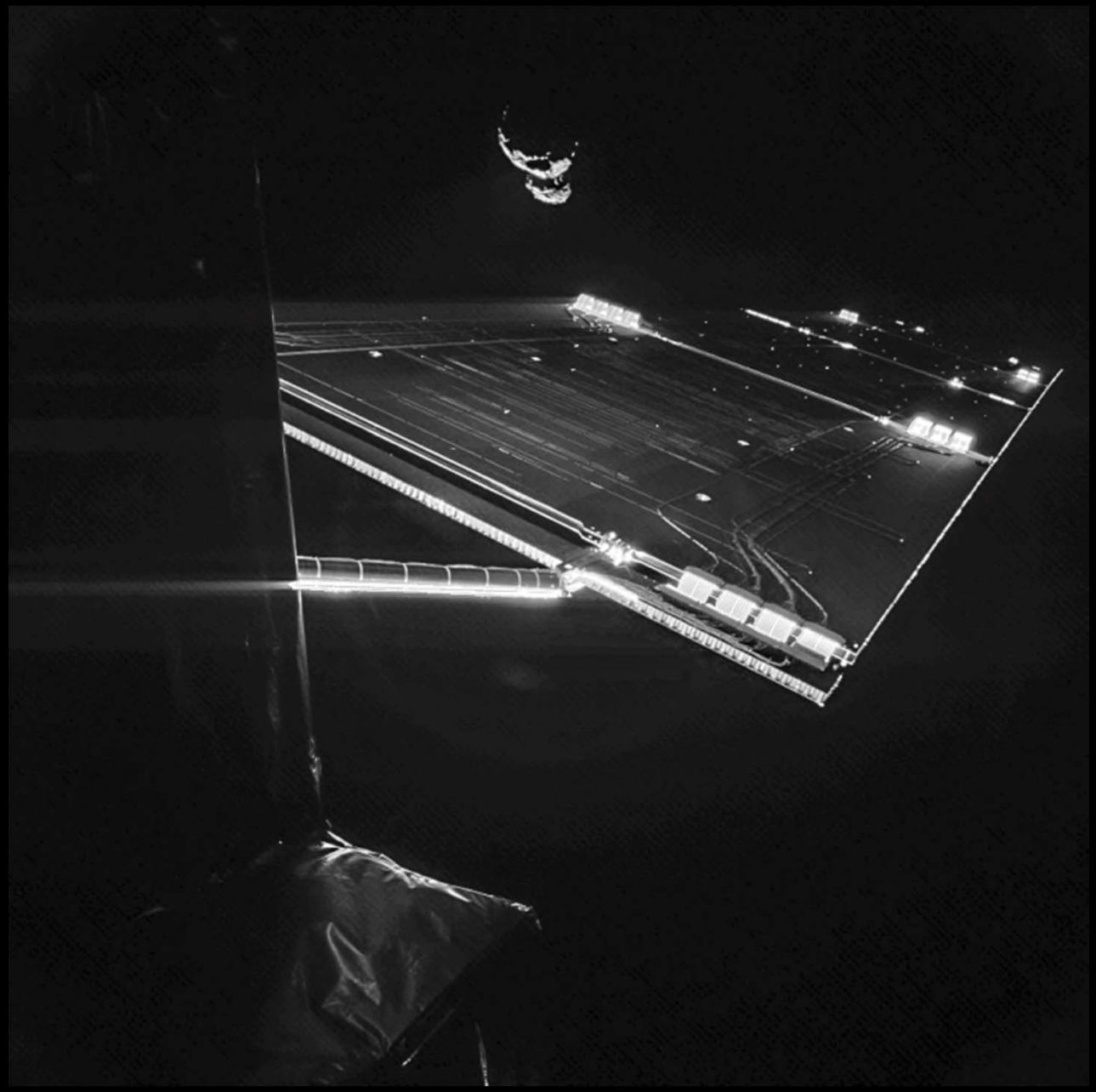


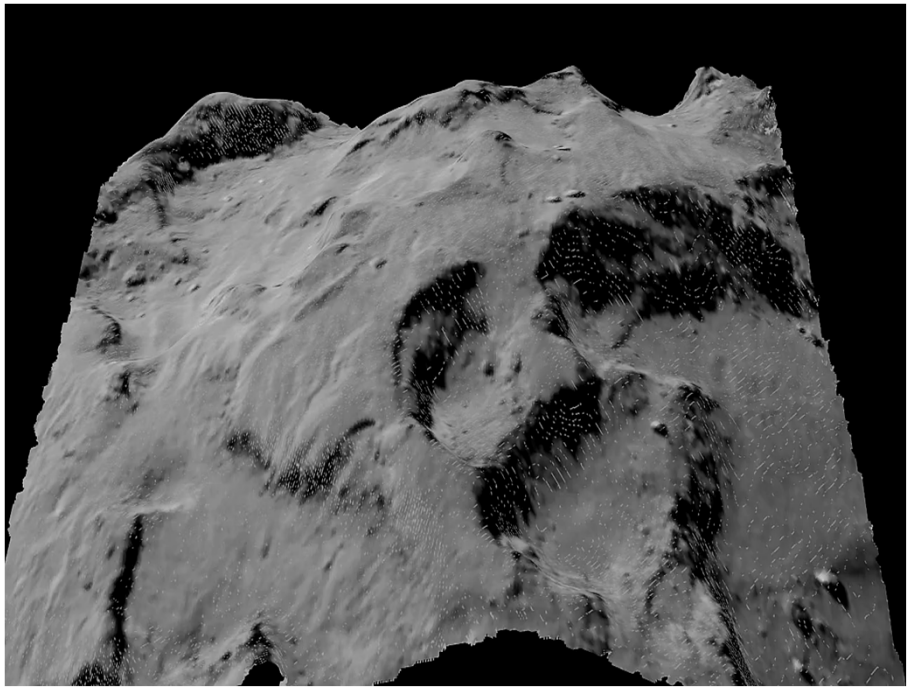
Image: OSIRIS NAC (from 50 km)

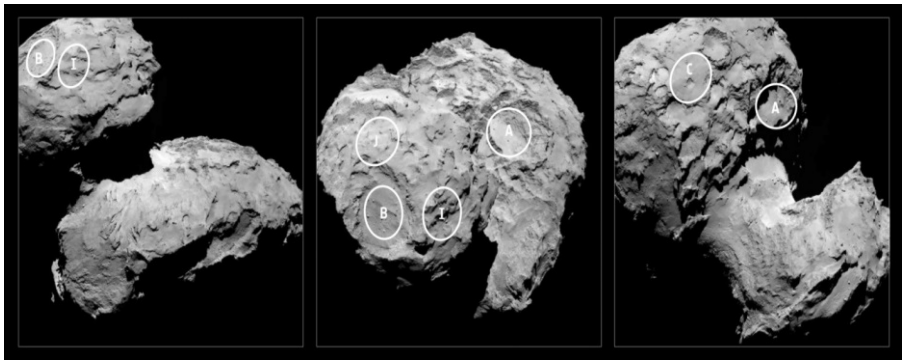
Image: CIVA from 50 km

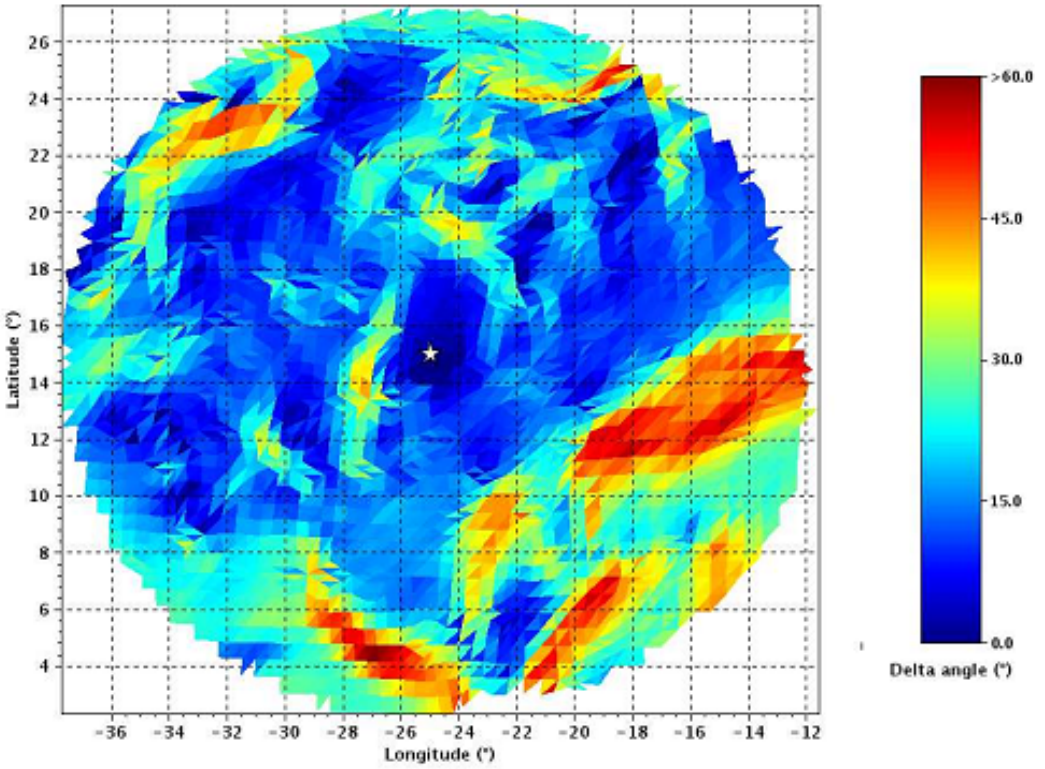


Selected Candidates for Landing Sites

Reminder: our site J, (Agilkia)







OSIRIS DTM

The drama before separation

- Monday night (10.11., 18:05), Lander switch-on: booting failed, wrong DPU on, not talking to us.. Needed to power-cycle ad-hoc. Then worked nominally. Then heating.
- Tuesday (11.11.) Carnival season begins.
  - From 18:37: ADS tank opening – failed 1st time
  - From 18:57: Pbat conditioning, failed
  - 21 UTC: MRB meeting. Close to NOGO and delaying the landing by at least 2 weeks.


esa
esoc

PDOR – Nem Pump (PDOR)

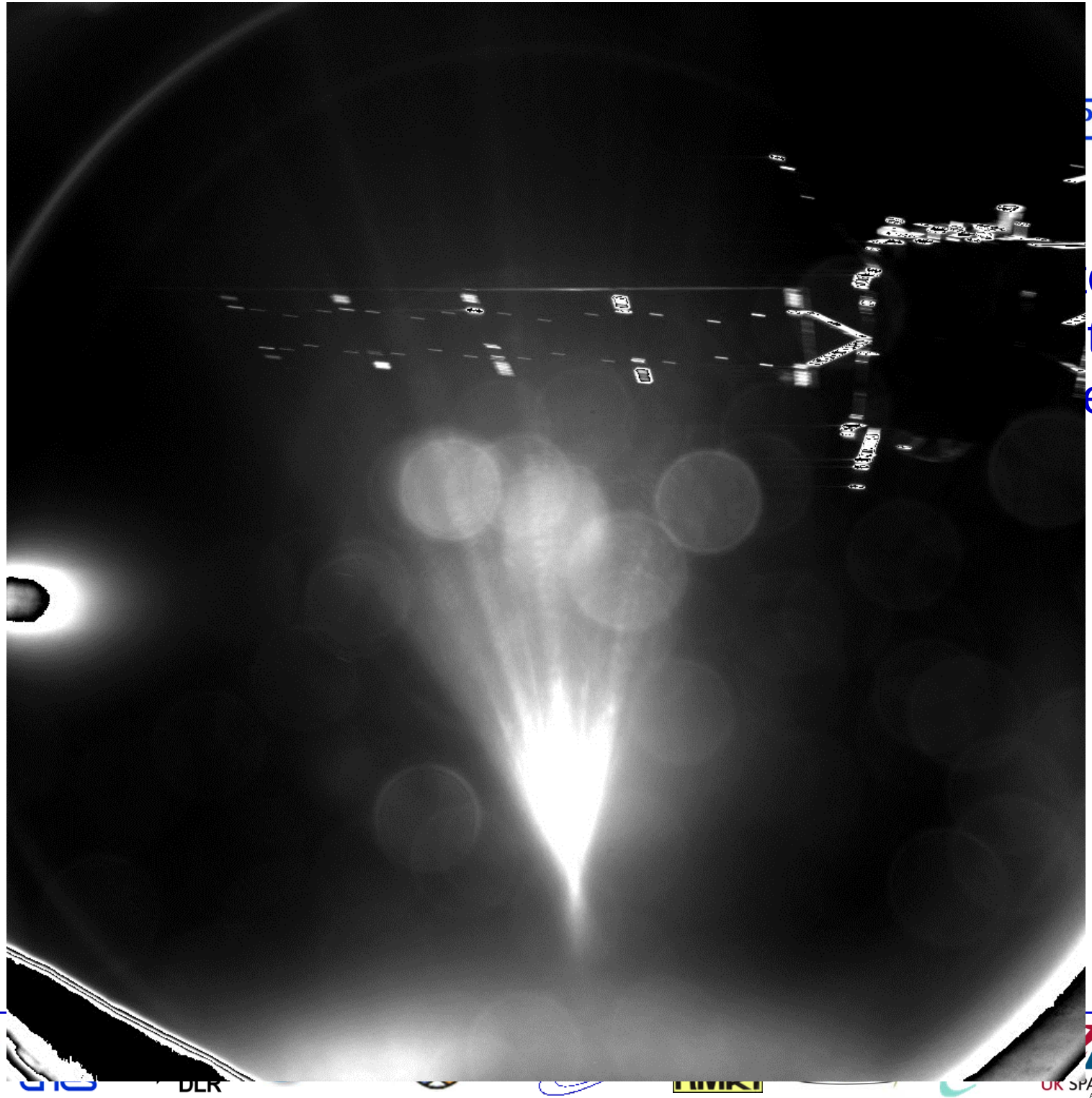
VOR
- BAT Cond Patch
- BAT Cond.
- SAME LOR as before (PWR cycle + SAT/PAT upload) + RAM Pump

GO only if all OK

ADS retry only if OK & time OK

AI FCTLCC < K interference with OBCP

BTR Heating skipped



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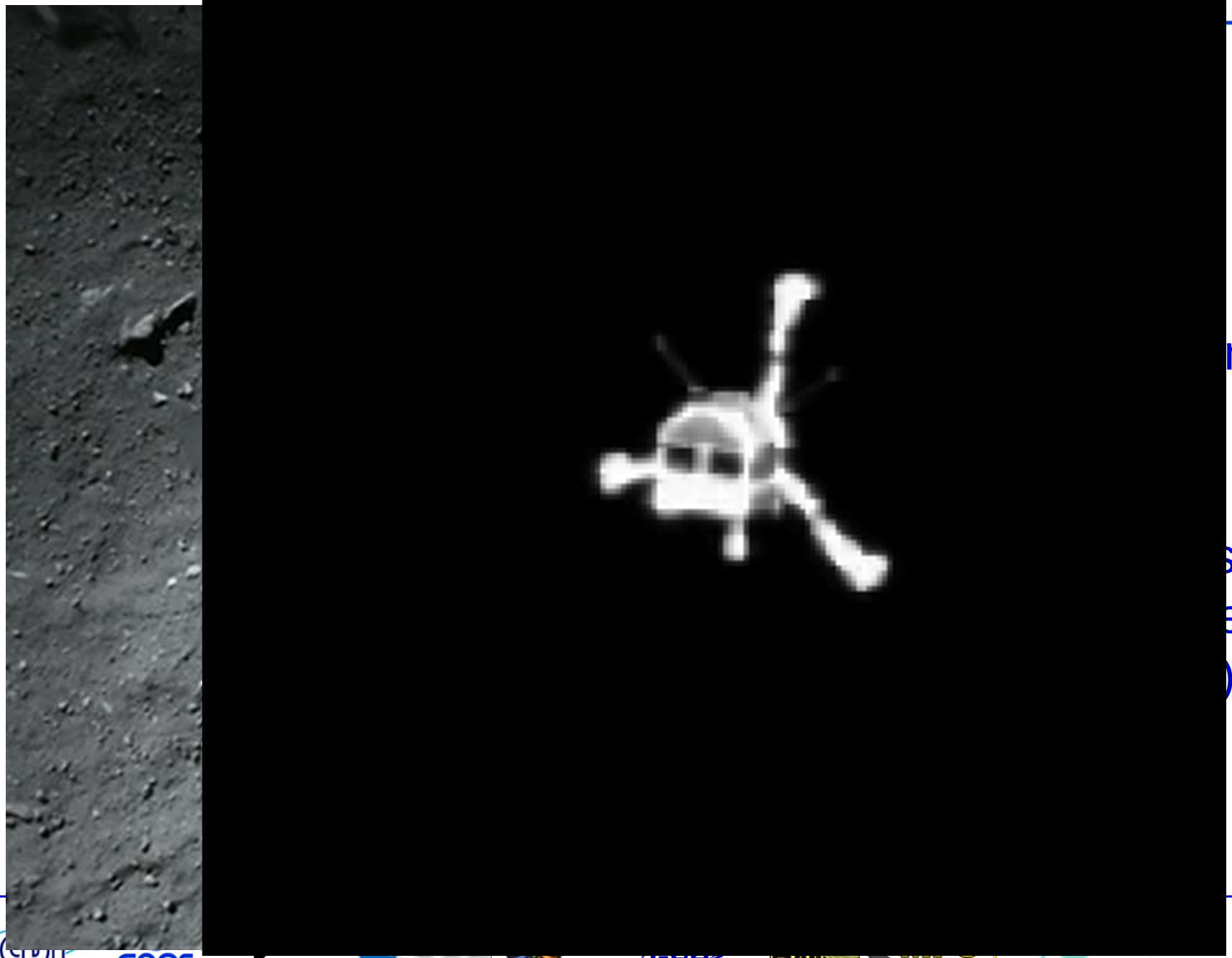

min

sion

ed)

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Later on 12 Nov

- RF link nearly always on, but frequent (every 40 s to 3 min) link breaks, very brief; SG HK shows strange fluctuations, as does ROMAP magnetic field, MUPUS-TM telemetry..
- ➔ we must be flying!
- After 17.32, until LOS, no more fluctuations: we must have landed finally (at least the 2nd time)
- LOS 17:59, but Consert sounding until next AOS confirms that Lander is alive!!

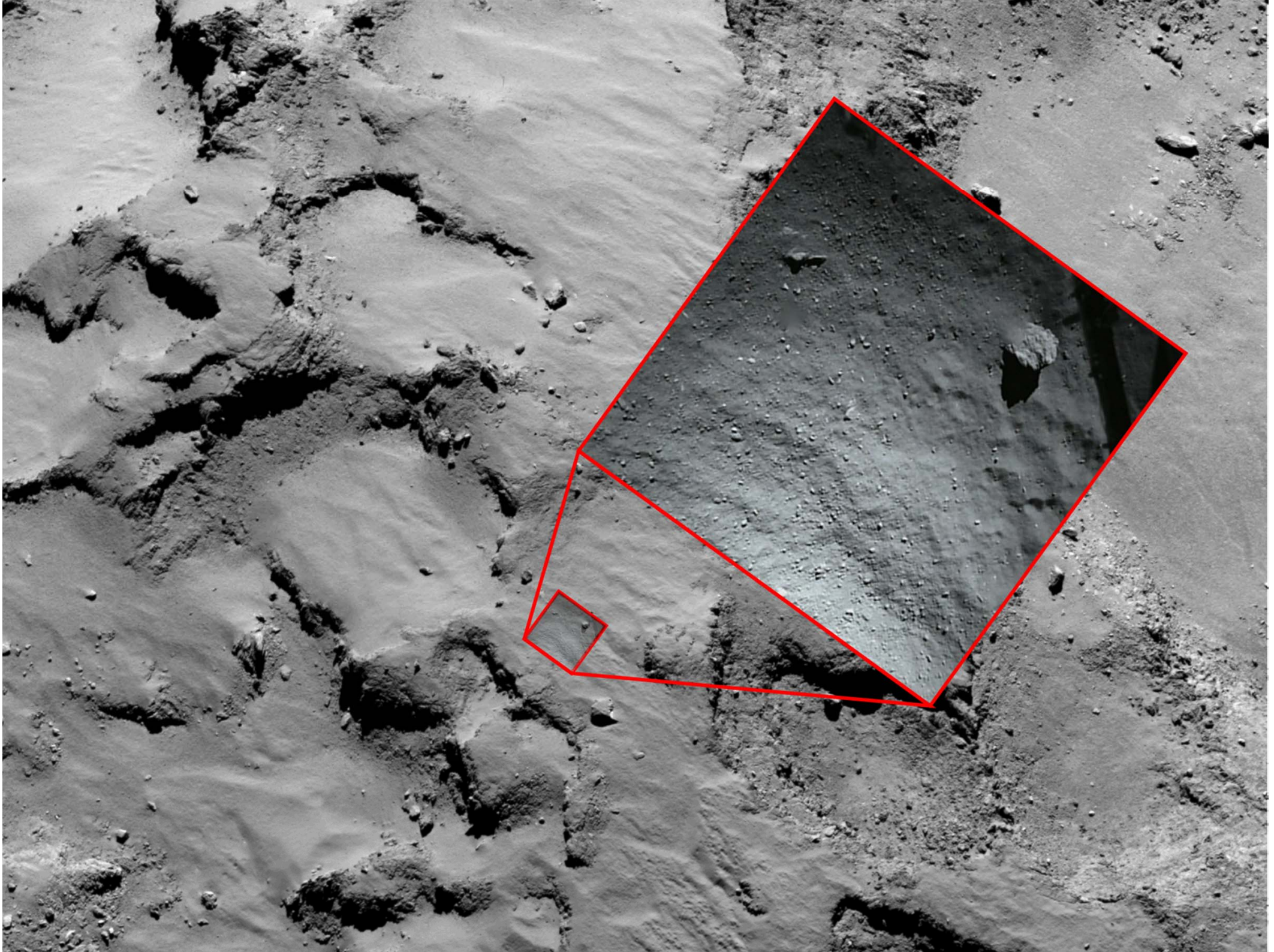
The days after landing

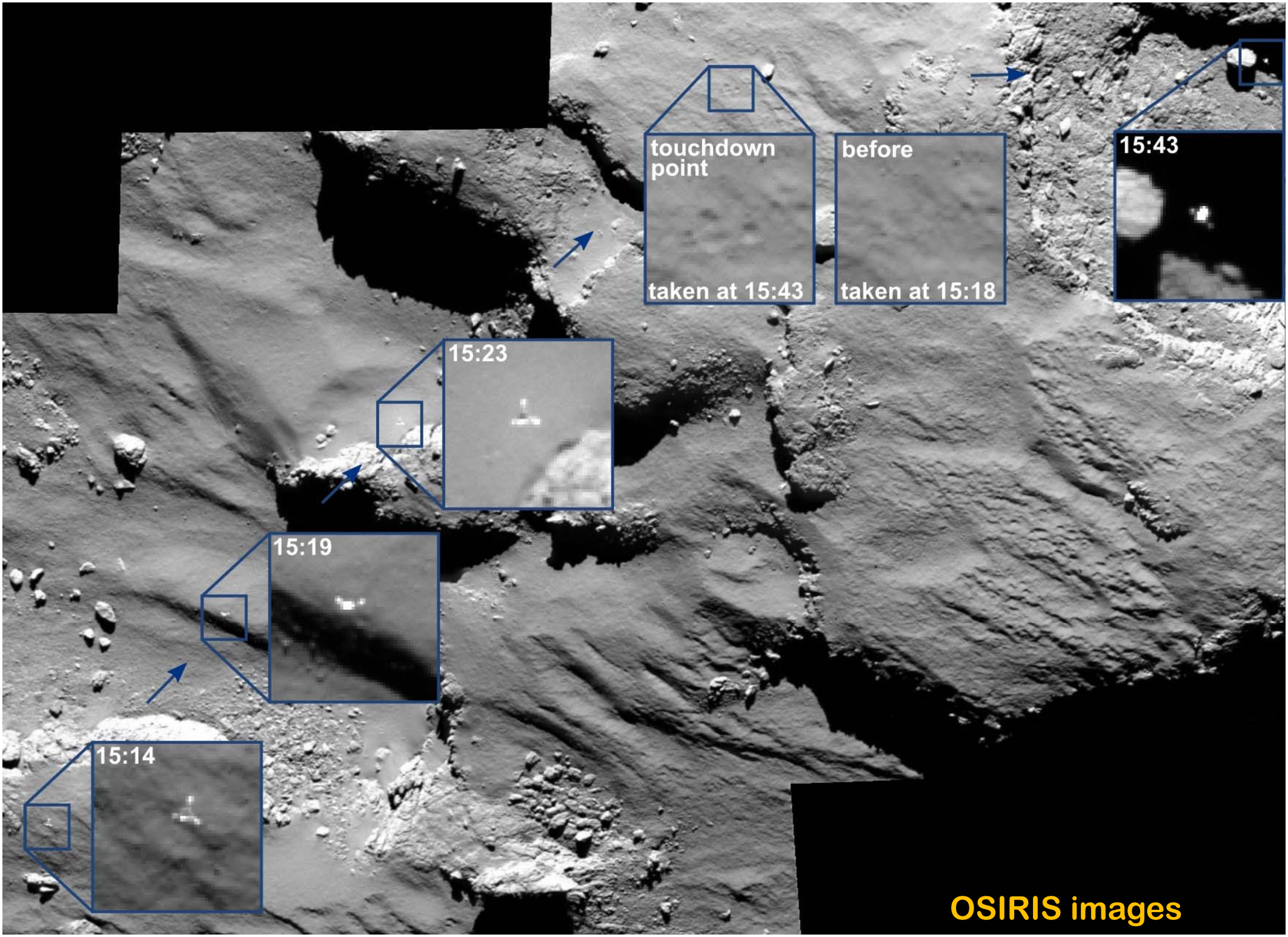
- A blur…
- Just plannig from one AOS to the next (about every 12.4 hours) – downlinkning TM and uplinking commands for next block


Hey, du bist nicht zum Spielen da!
Das sind nur Freudensprünge!
Juhuuuuuuu!
WWW.FUCHSKIND.DE

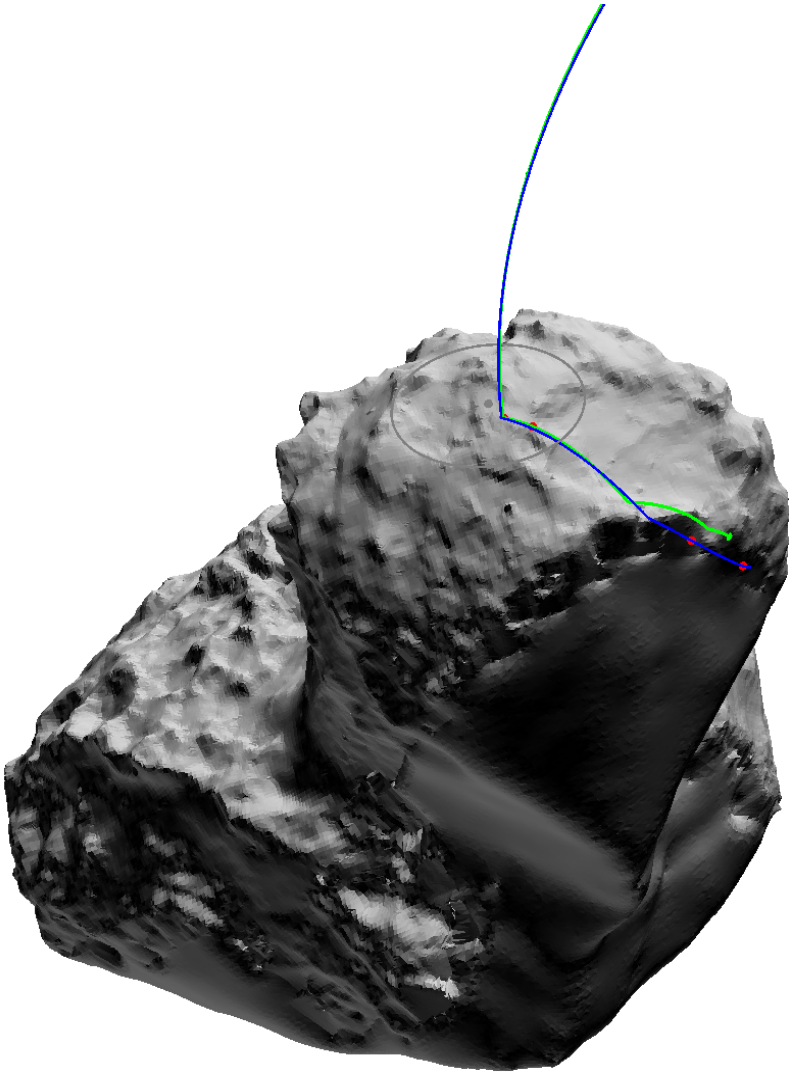
An improvised FSS

- All experiments ran.. Some „without measuring very much“ (APXS, COSAC sample, MUPUS-ANC)
- The ops team at LCC did real miracles -reprogramming in a very short time, no mistakes! PDOPs or LORs sent to RMOC (via SGS and direct ftp), loaded to manual stack, signed by LA, uplinked (MTL/ESS queue) and executed either time-tagged or directly after start of AOS.

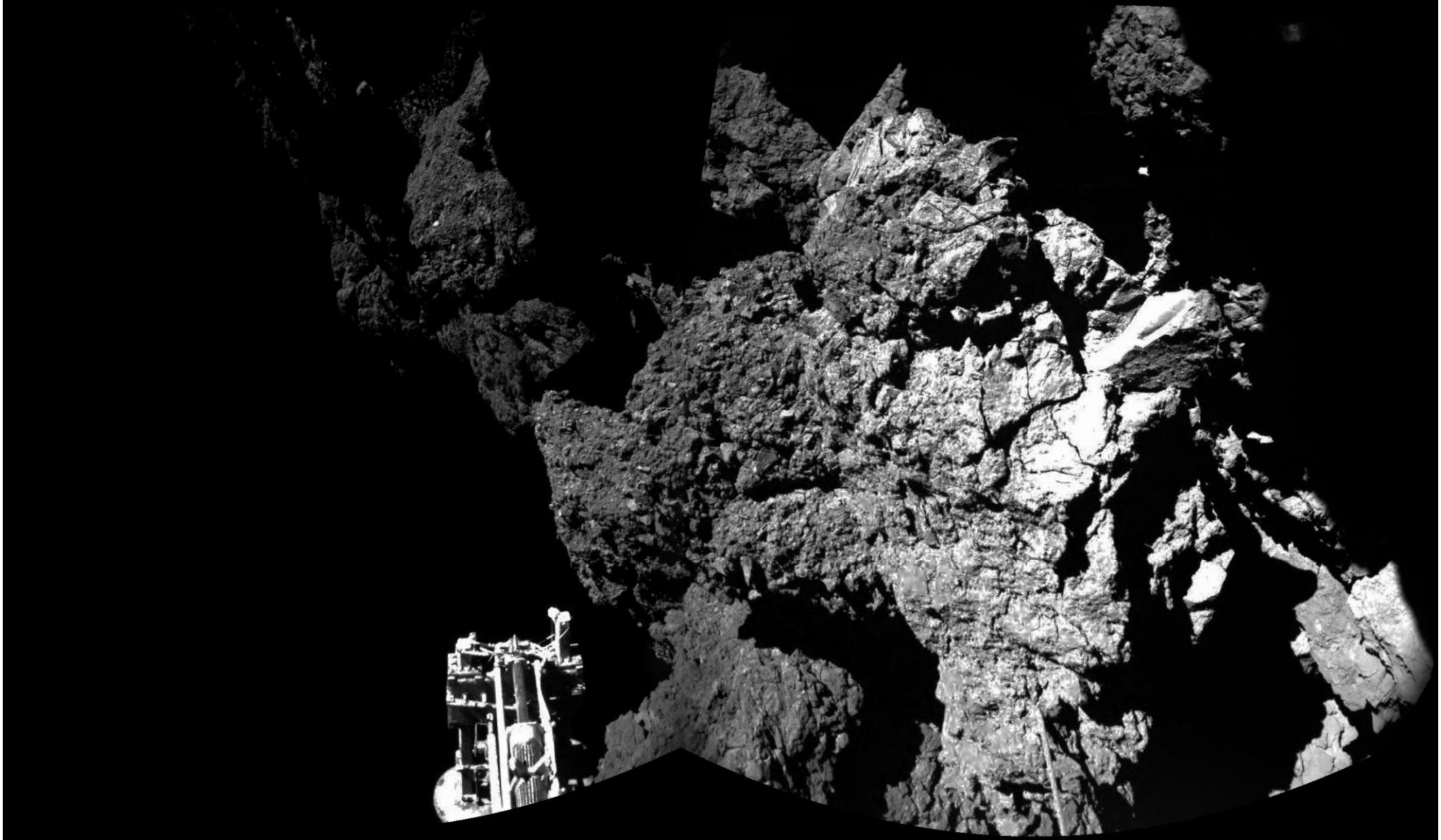



touchdown point
taken at 15:43
before
taken at 15:18
15:43
15:23
15:19
15:14
OSIRIS images

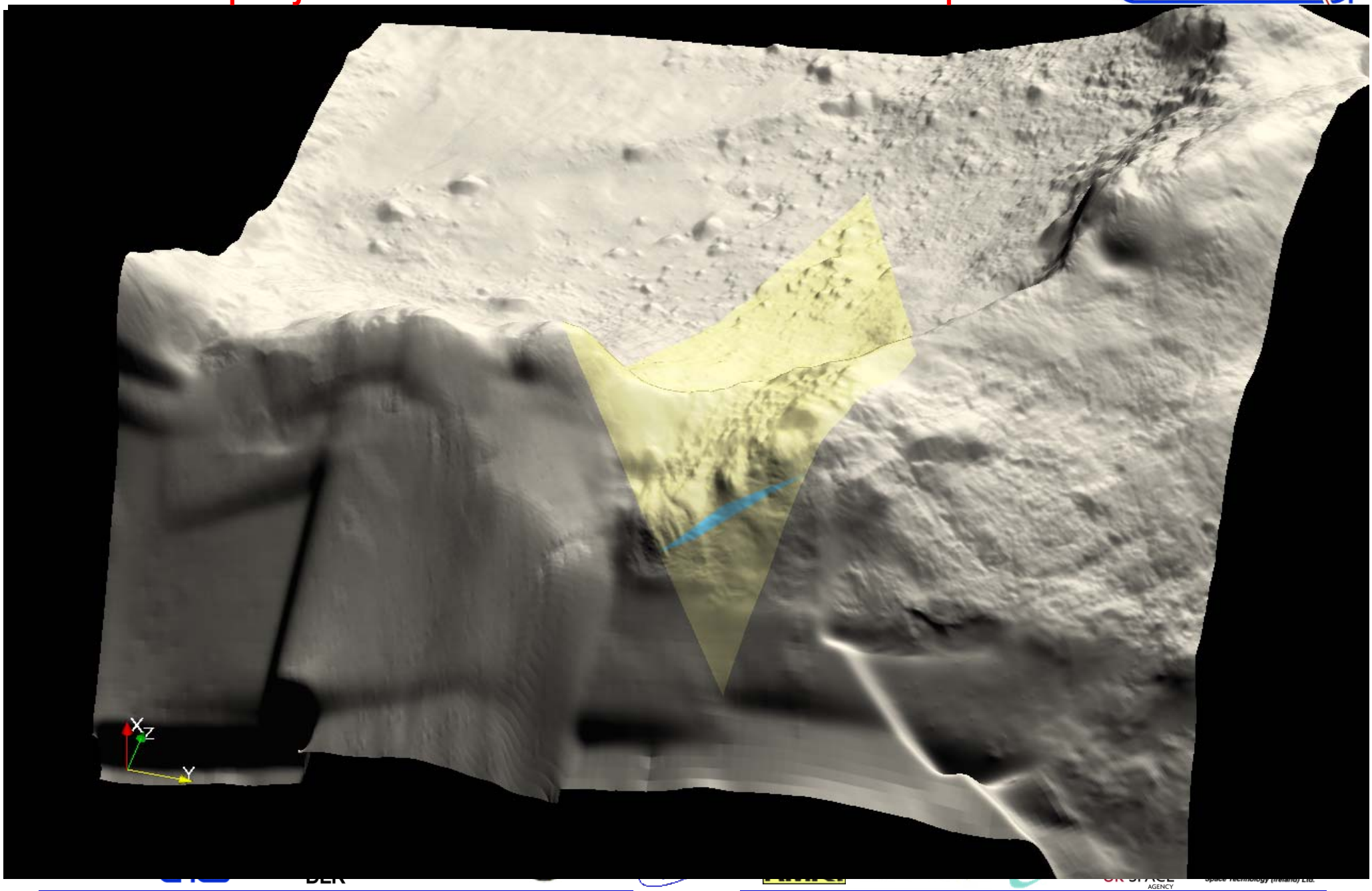
Reconstructed Trajectory after first touch-down



CIVA panoramic at final TD site



CONSERT's determination of the final landing area, detailed projection on OSIRIS DTM6V7 shape model



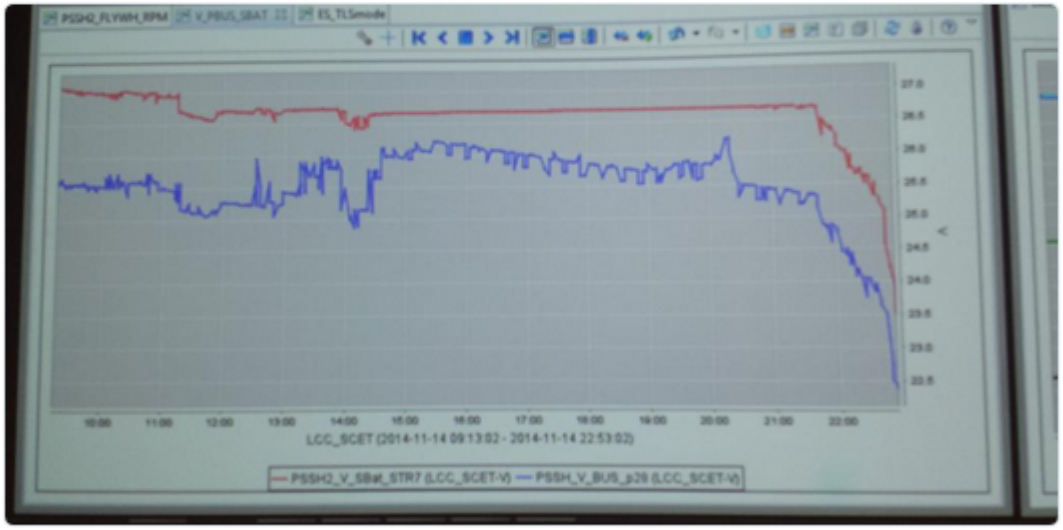
Philae Lander @Philae2014 · 15. Nov.

.@ESA_Rosetta I'm feeling a bit tired, did you get all my data? I might take a nap… #CometLanding

4,1 Tsd 3,2 Tsd

Philae Lander @Philae2014 · 14. Nov.

So much hard work.. getting tired... my battery voltage is approaching the limit soon now



3,6 Tsd 1,8 Tsd Mehr Fotos und Videos anzeigen

PHILAE

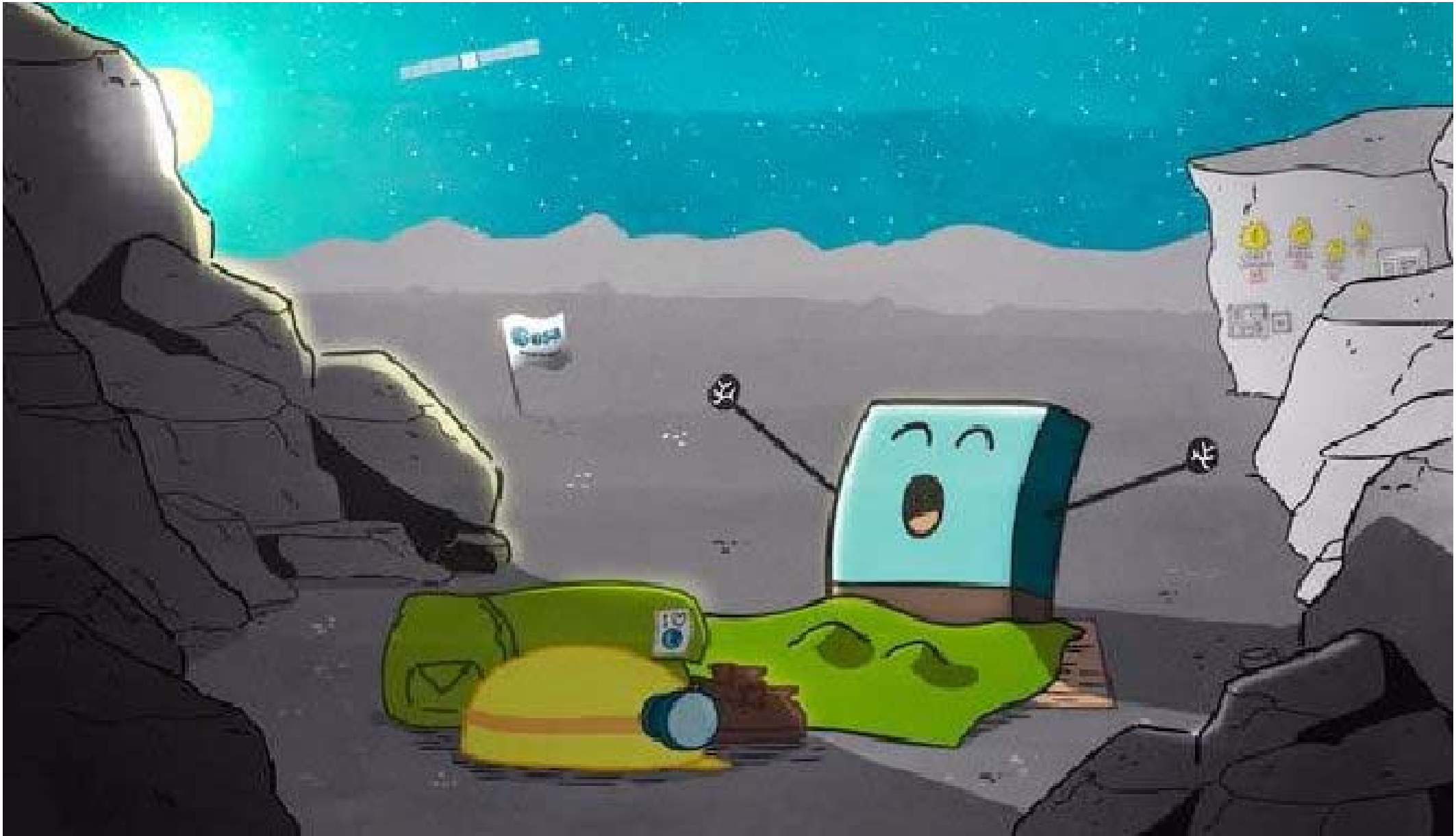
Valentinstag

Close flyby
8 km

UK SPACE AGENCY

Space Technology (Ireland) Ltd.

Juni 2015: We are back !!!



Wir waren immer optimistisch…

manuel_senfft_-_a_singing_comet.mp3