Credits ESA/ROSETTA/NAVCAM

De l'Espace pour la Terre

Flight Dynamics Analyses for Landing Site Selection and post-landing studies

12th IPPW – Köln, June2015

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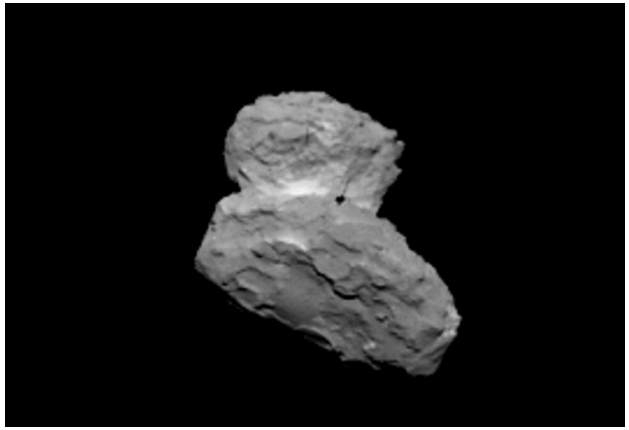
Landing Site Selection Process deadlines

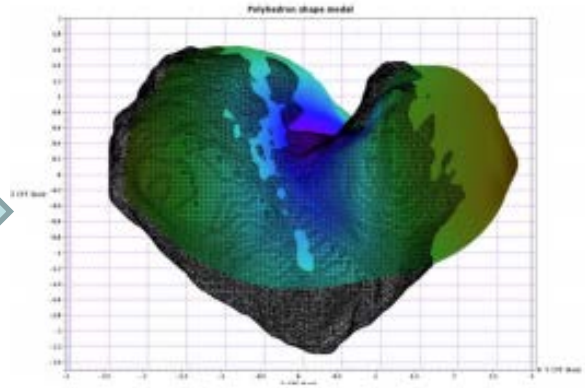
- Landing Site Selection Process (LSSP): driven by the Orbiter observations and generation of models to characterize the comet.
- 3 loops have been done with increasing knowledge of the comet characteristics.

Days to Landing	Date/min distance to comet	Deadline
L-79	24/08/2014 50 km	RLGS proposed 5 candidate landing sites RMOC checked feasibility of the proposed landing sites.
L-58	14/09/2014 30 km	RLGS proposed the nominal and backup landing sites to RMOC, who computed the operational trajectory.
L-30	12/10/2014 10 km	RLGS confirmed the choice of the nominal landing site. RMOC updated the operational trajectory. Beginning of operational preparation

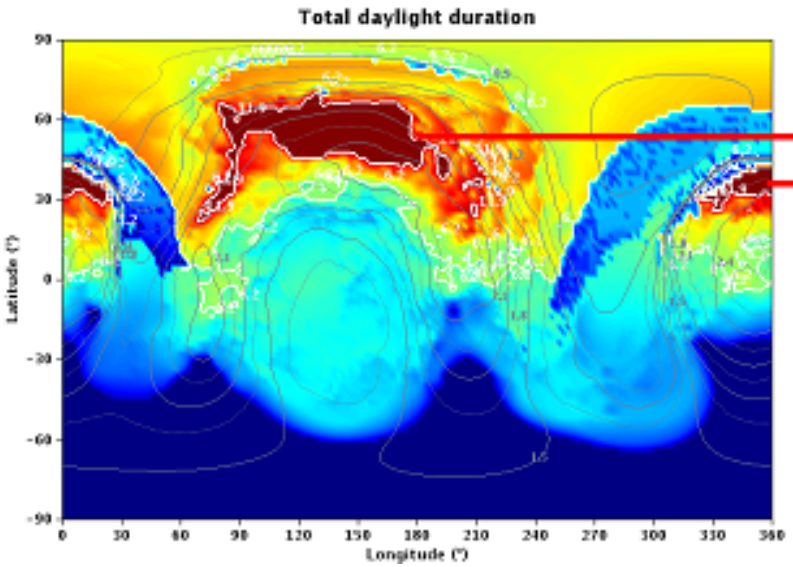
Topography and illumination conditions

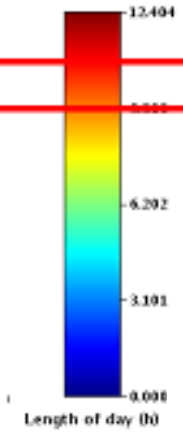


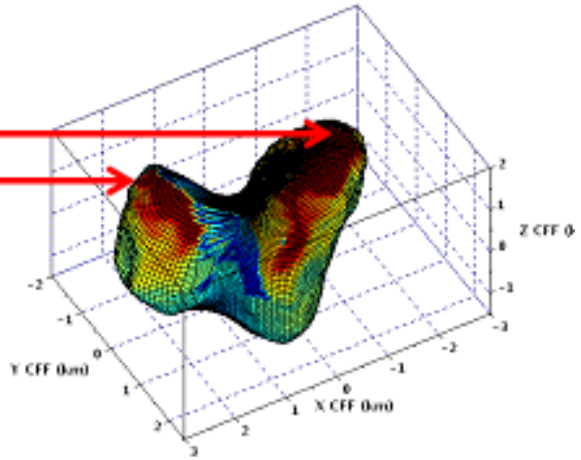
Credit : ESA/ROSETTA/OSIRIS



Models provided by RMOC and OSIRIS teams



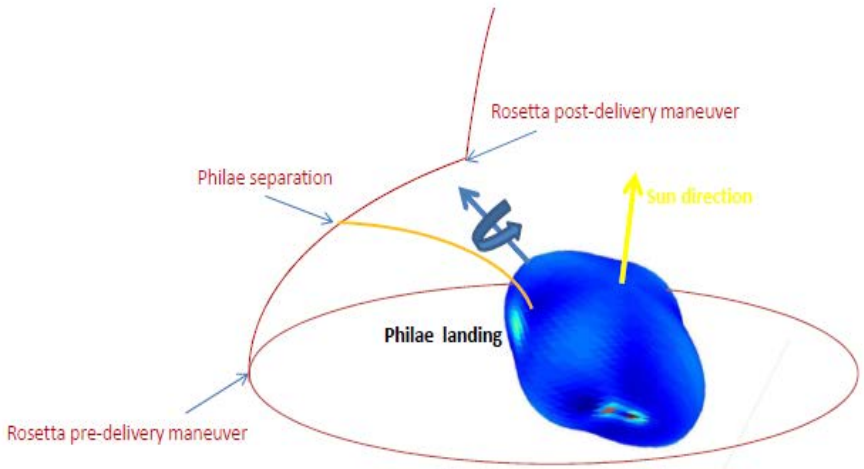


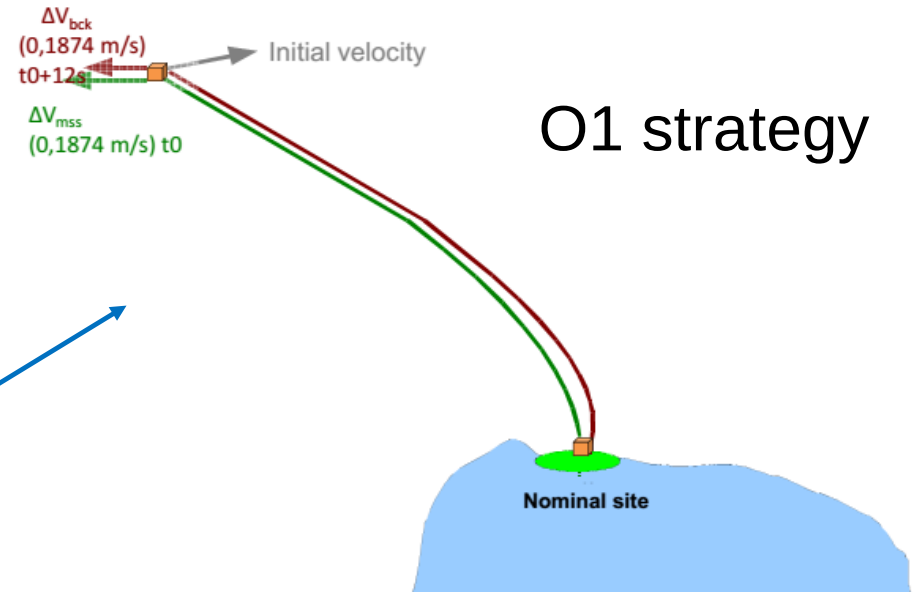


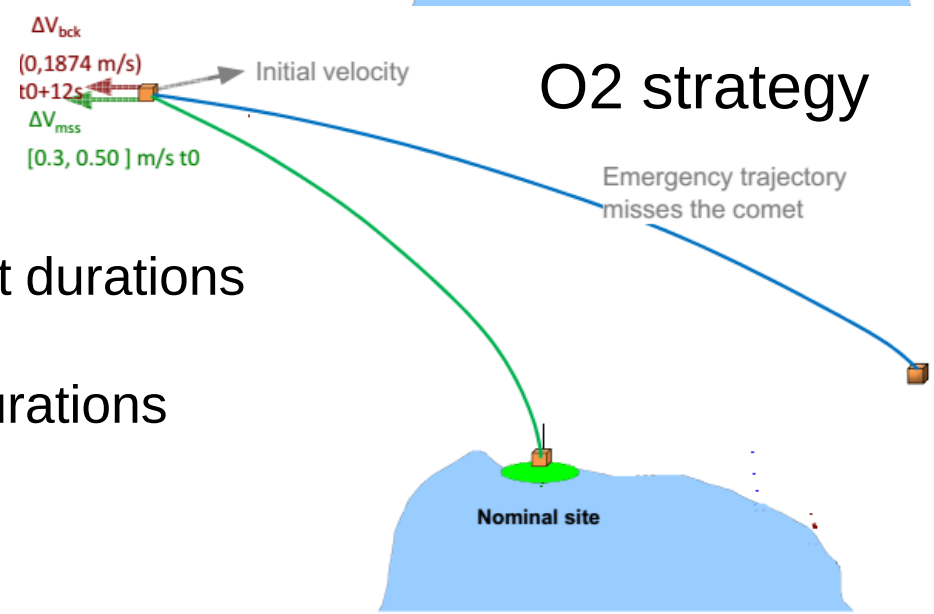
Minimum daylight duration 6.2 hours.
Minimum of 30 minutes night

Philae Delivery scenario

Orbiter trajectory design by ESOC-FD





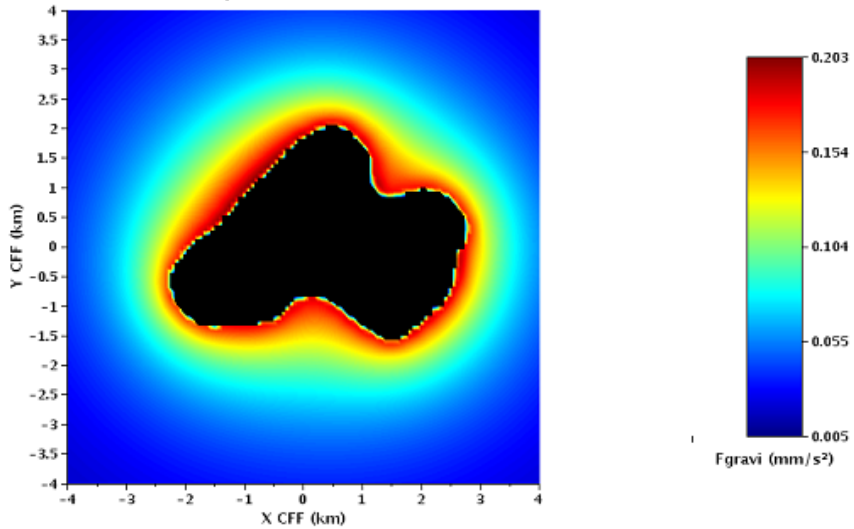


O1 strategy is the safer, but high descent durations

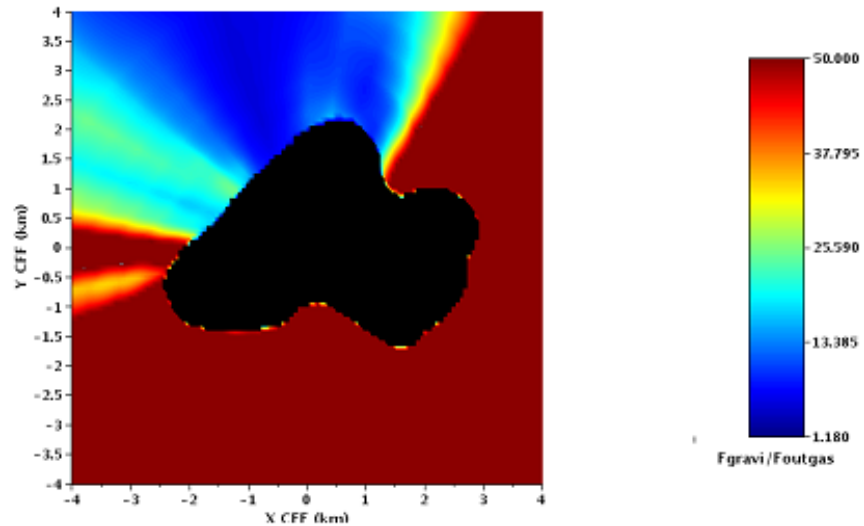
O2 strategy more risky, lower descent durations

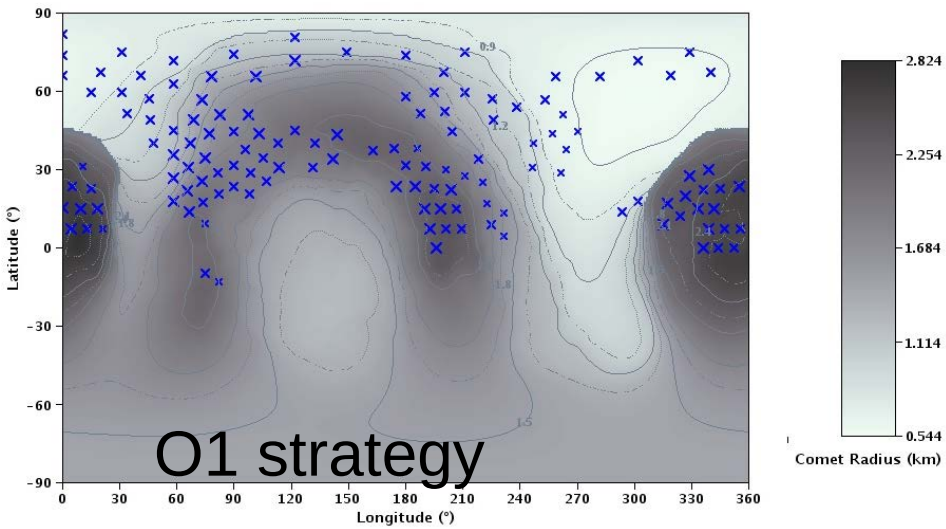
Trajectory analysis

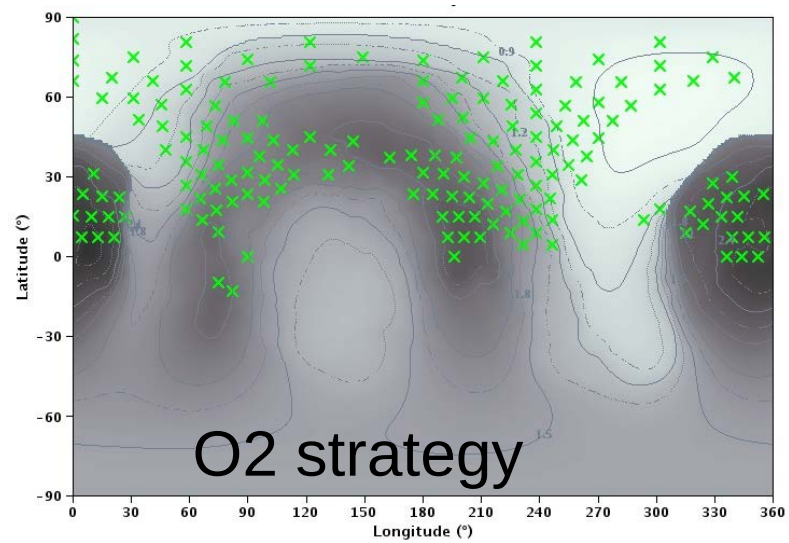
Gravity field models



Outgassing models

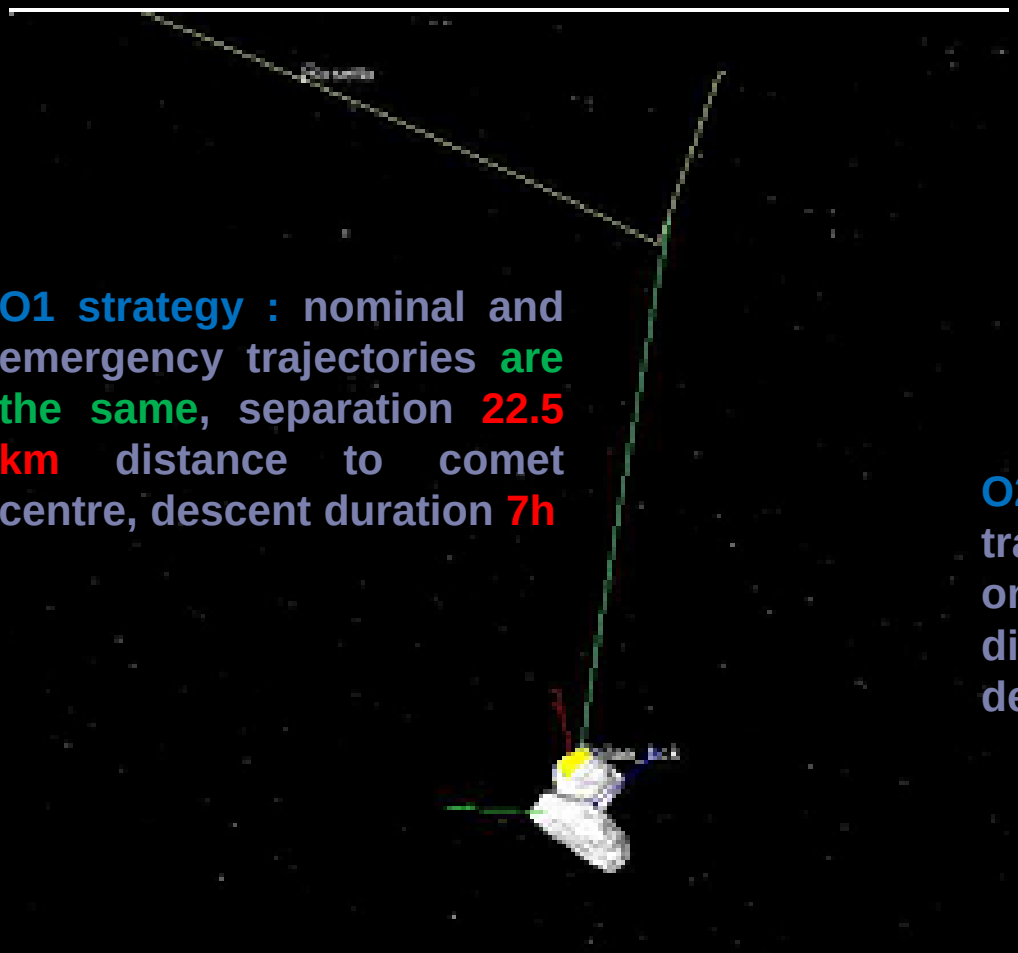






✓ Reachable area on comet was computed

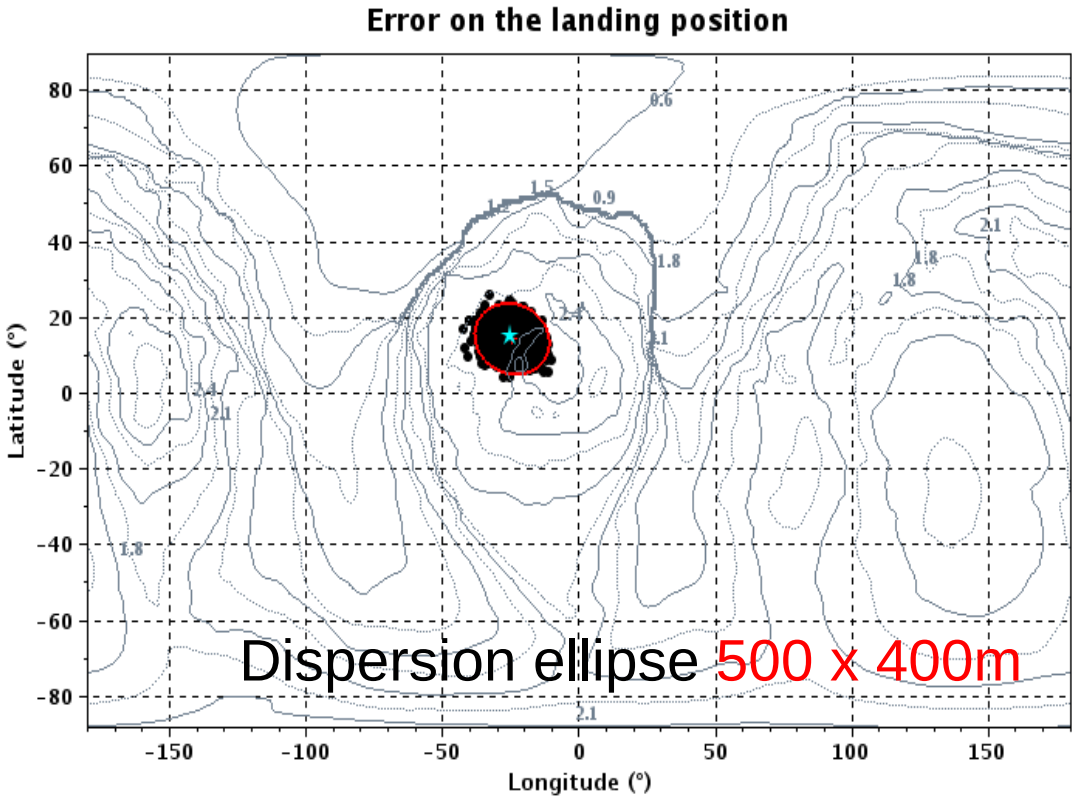
Design of SDL strategy (Example for final site “Agilkia”)

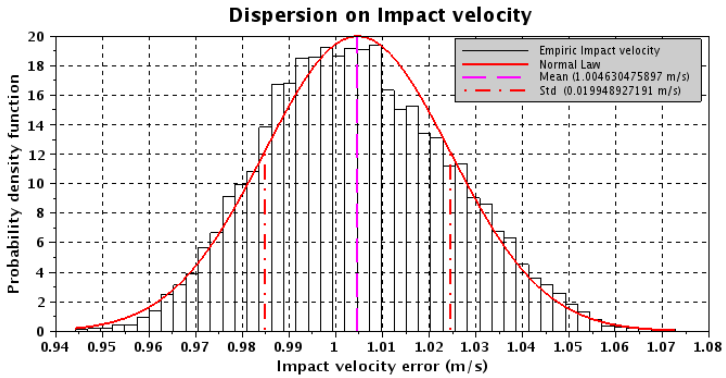


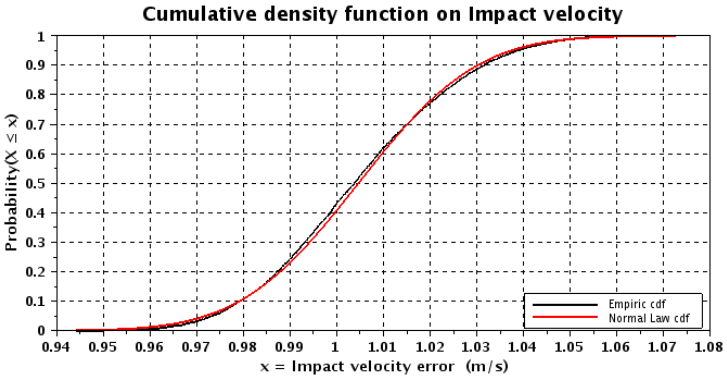
O1 strategy : nominal and emergency trajectories **are the same**, separation **22.5 km** distance to comet centre, descent duration **7h**

O2 strategy : emergency trajectory **far from nominal** one, separation **8.5 km** distance to comet centre, descent duration **3h**

Analysis of trajectory dispersions

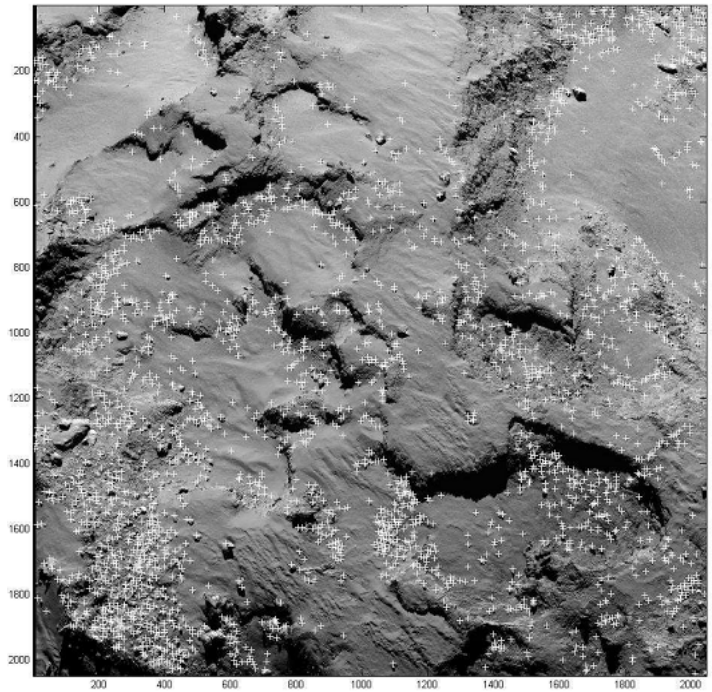


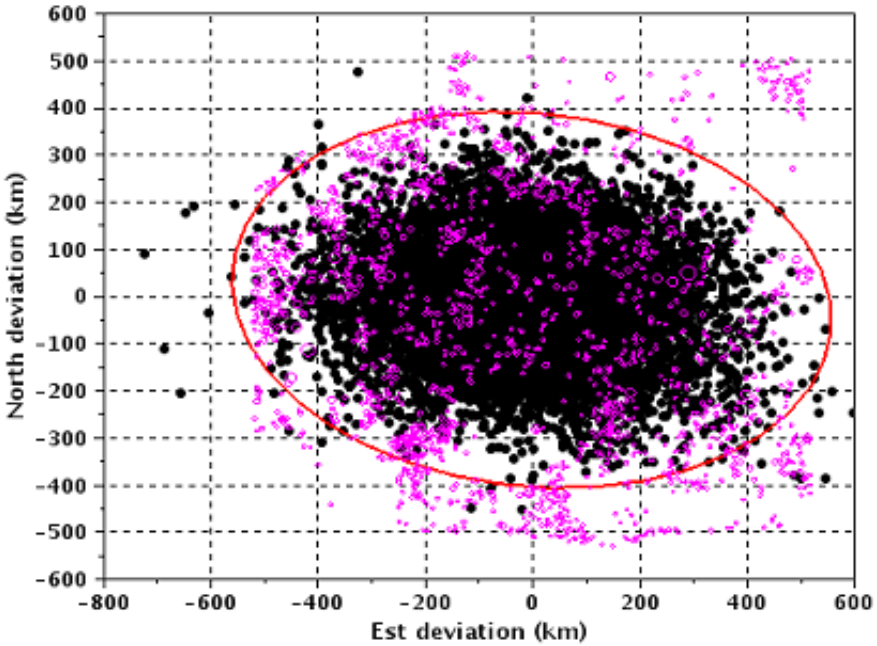


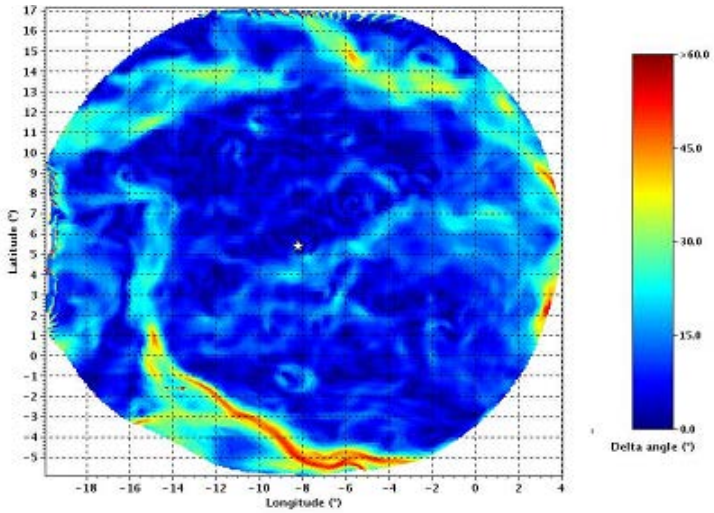


- ✓ Main contributor to the dispersion was the uncertainty on Orbiter state vector at separation

Risk at landing





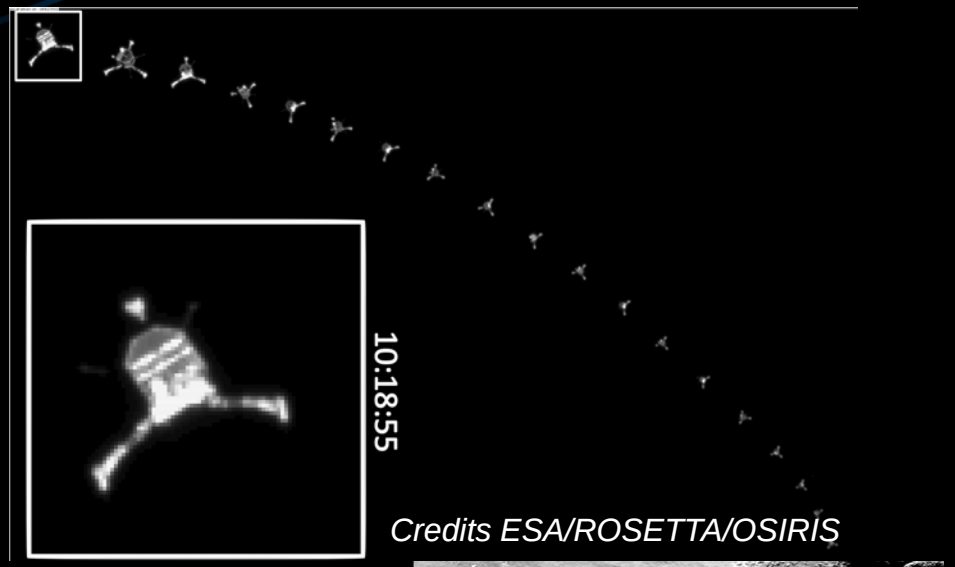


Risk at landing (statistical analysis) :

- ✓ Slopes and illumination conditions inside landing ellipse
- ✓ Probability to land on a boulder (from OSIRIS observation)

Landing on site J “Agilkia”

12-11-2014 Nominal descent (O1 sep ΔV=18.76 cm/s)



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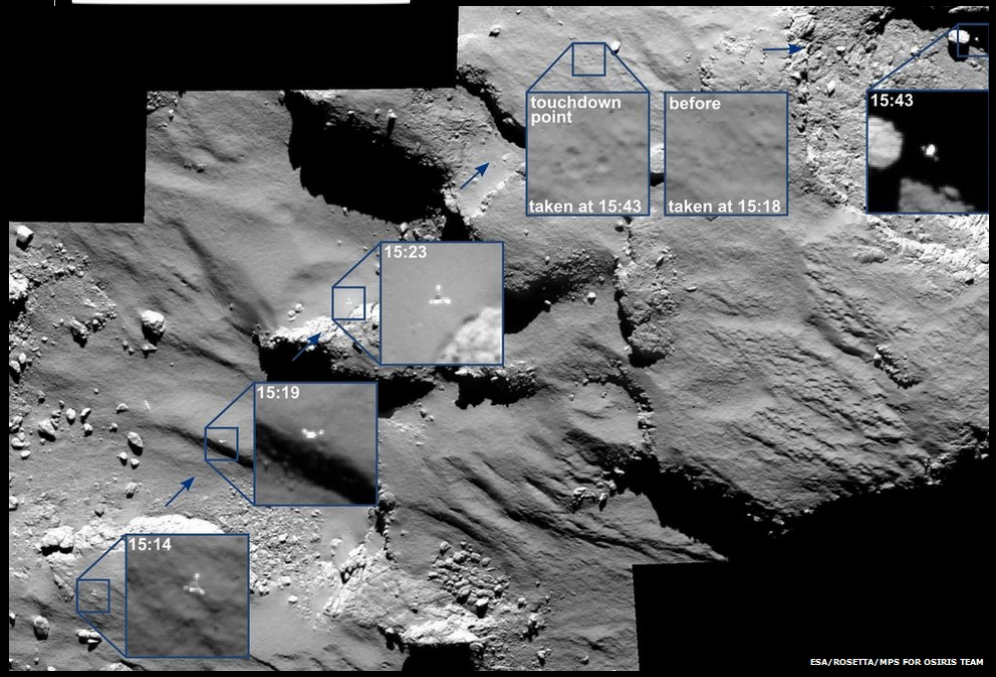
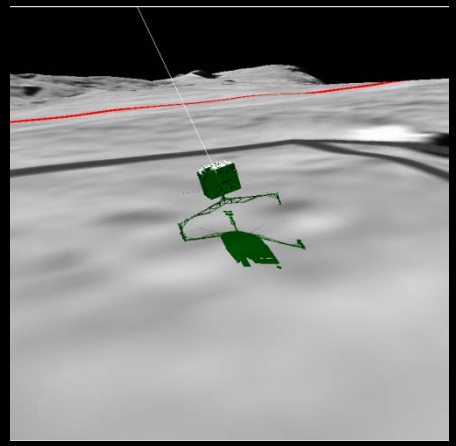
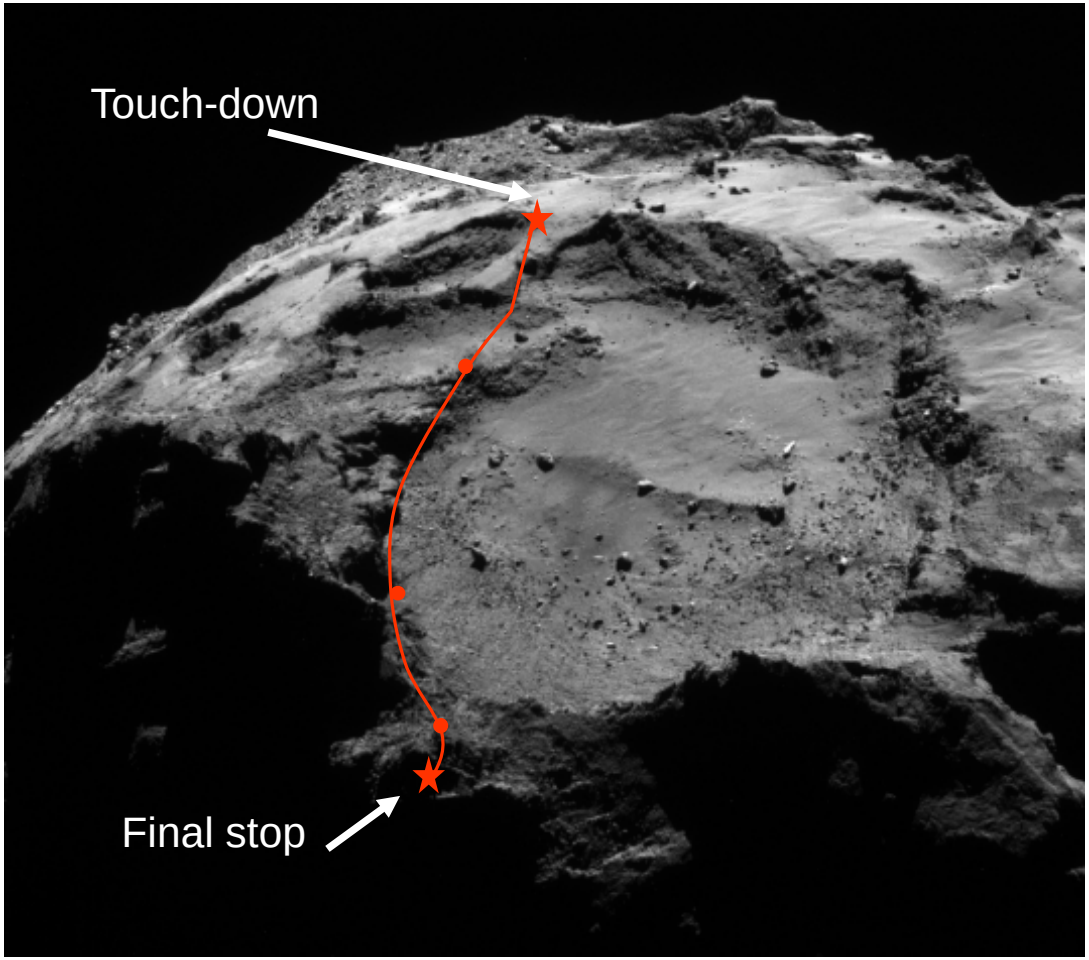


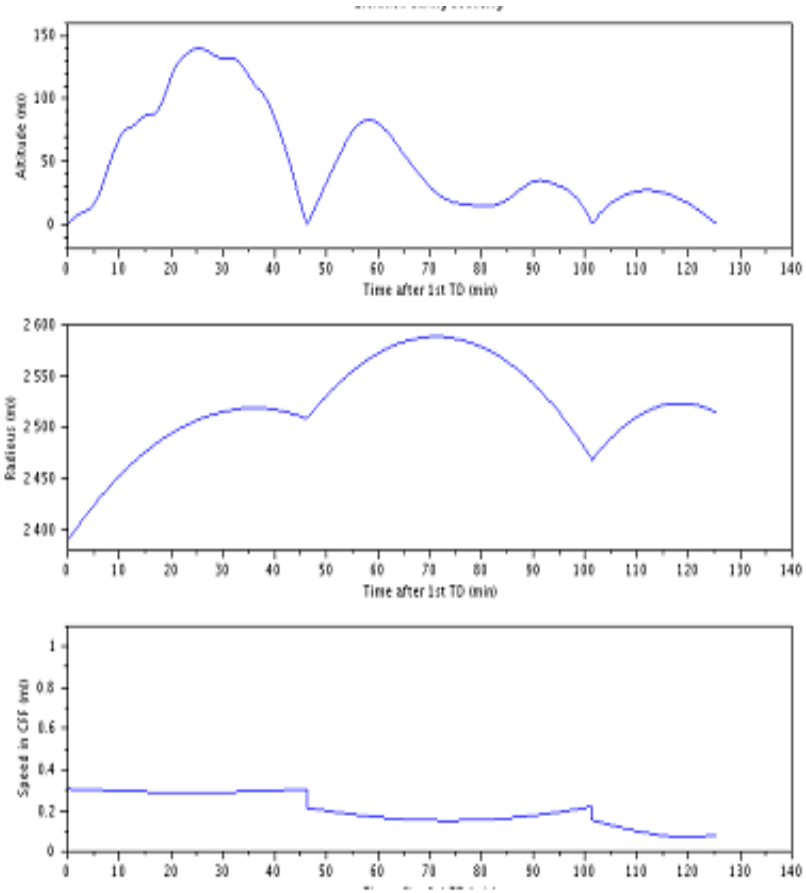
TD 120m from target position and 50s before expected time



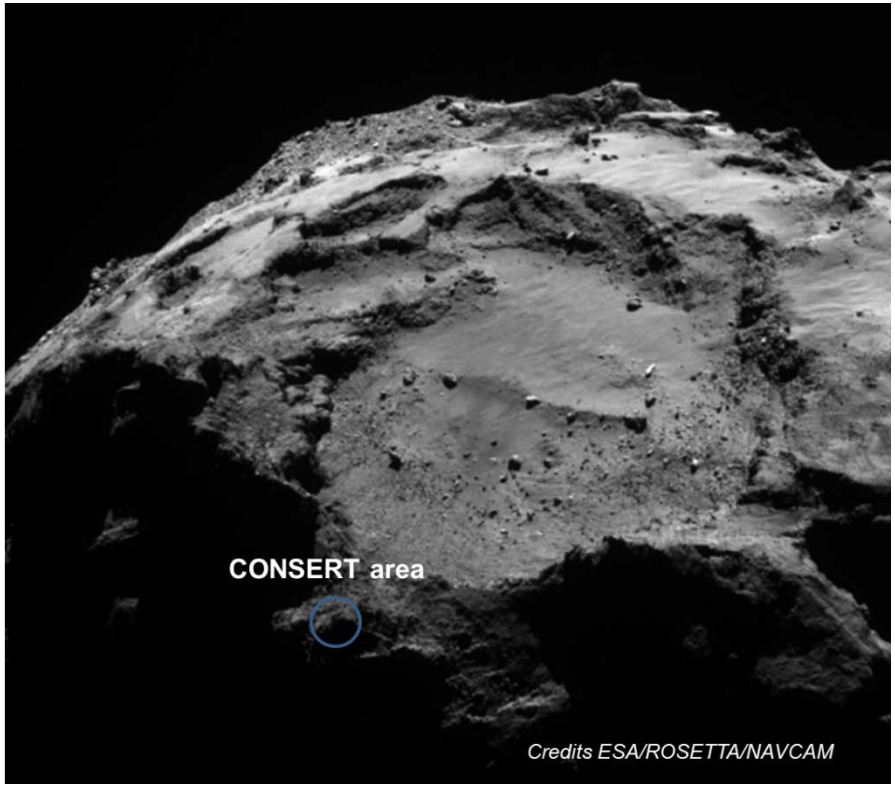
Bouncing trajectory

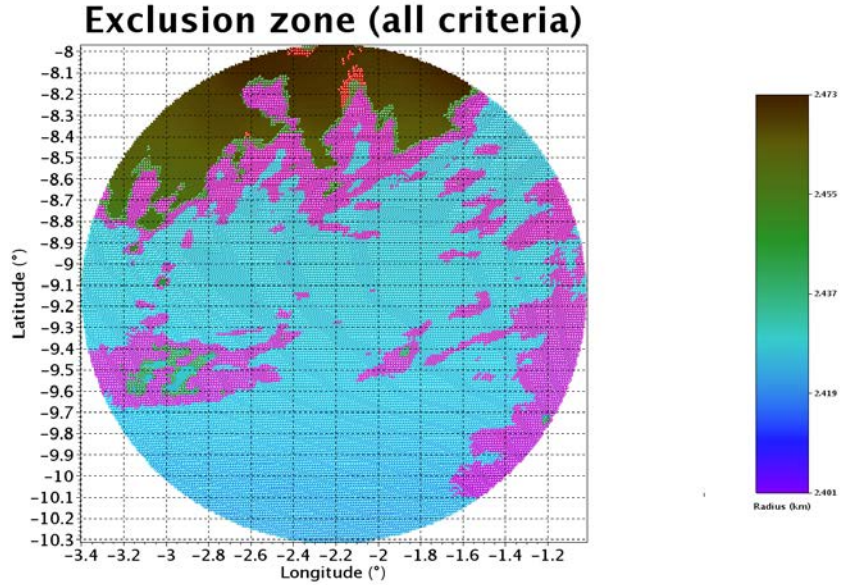
Preliminary reconstruction of bouncing trajectory, from images and ROMAP data

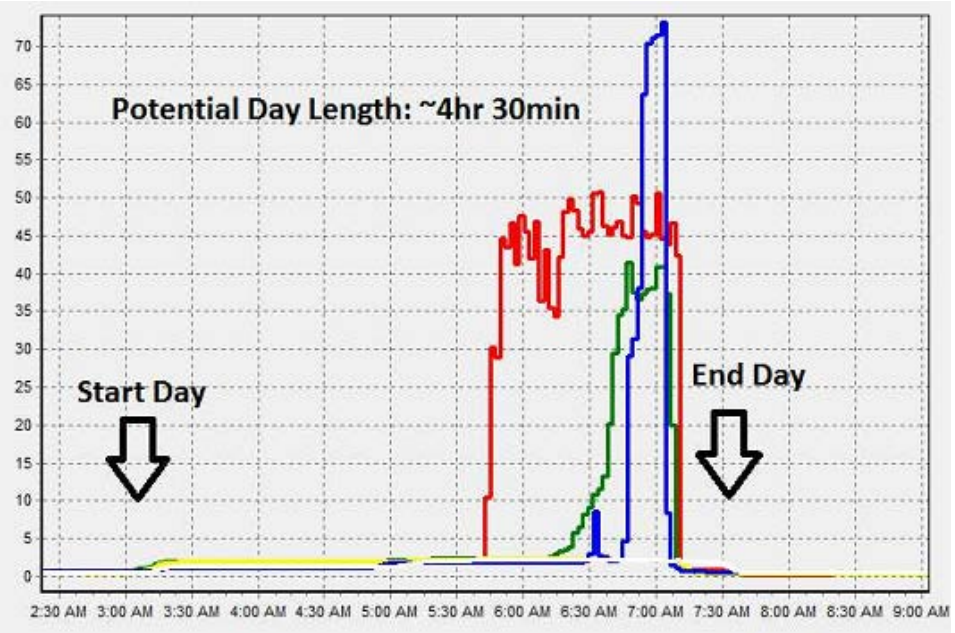




Estimation of the current position

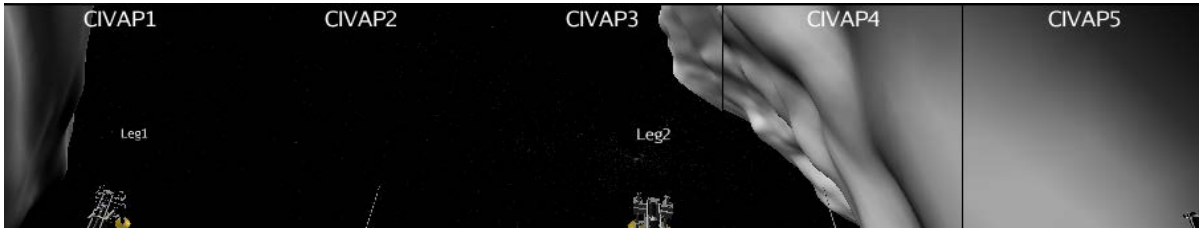


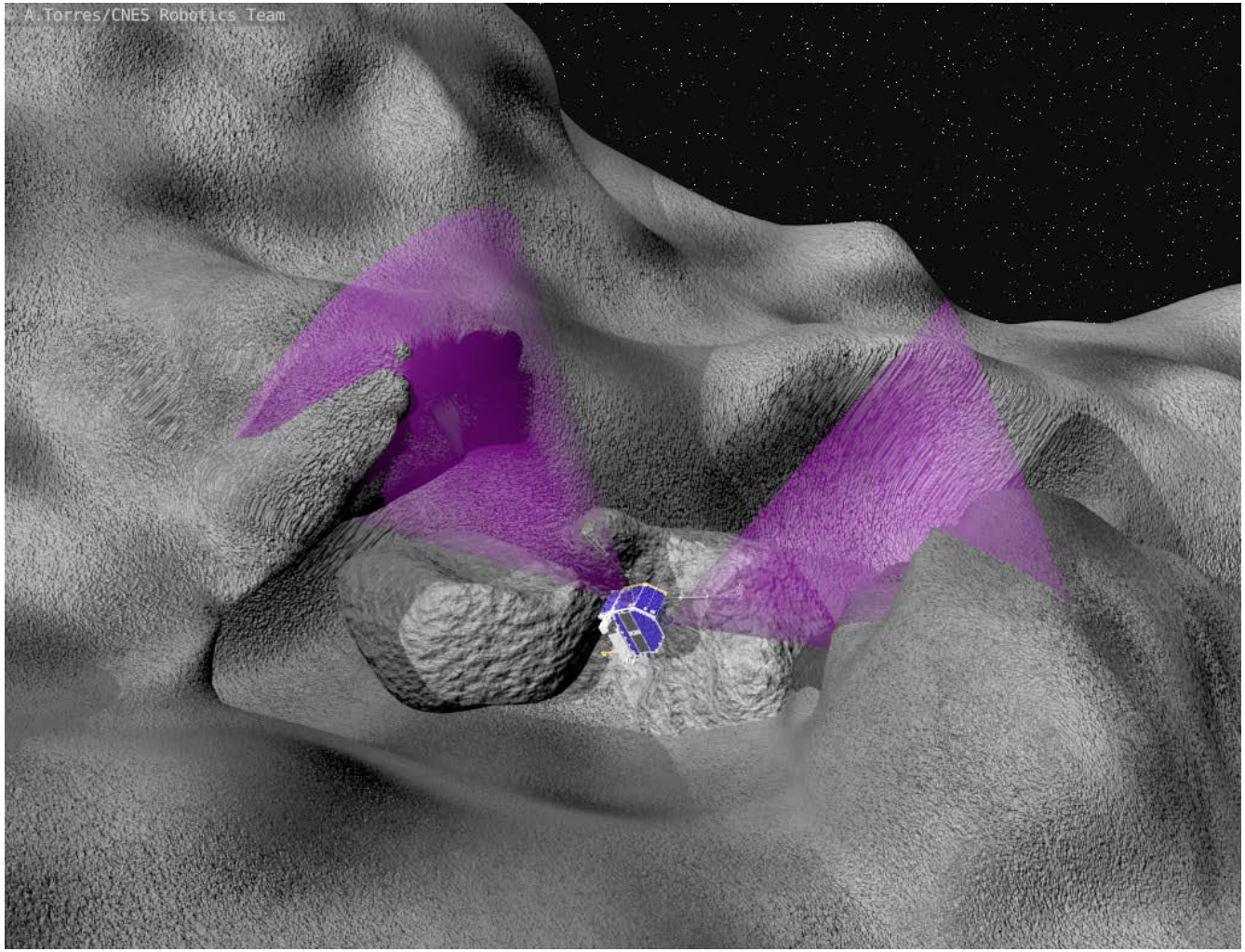




- ✓ Inside CONSERT area, zones where daylight durations and illuminations conditions at time of CIVA images or RF links do not match are excluded

Estimation of the orientation





- Solar panels
- ROMAP
- Internal tools
- Images

Orientation of
3 axis at ±10 deg

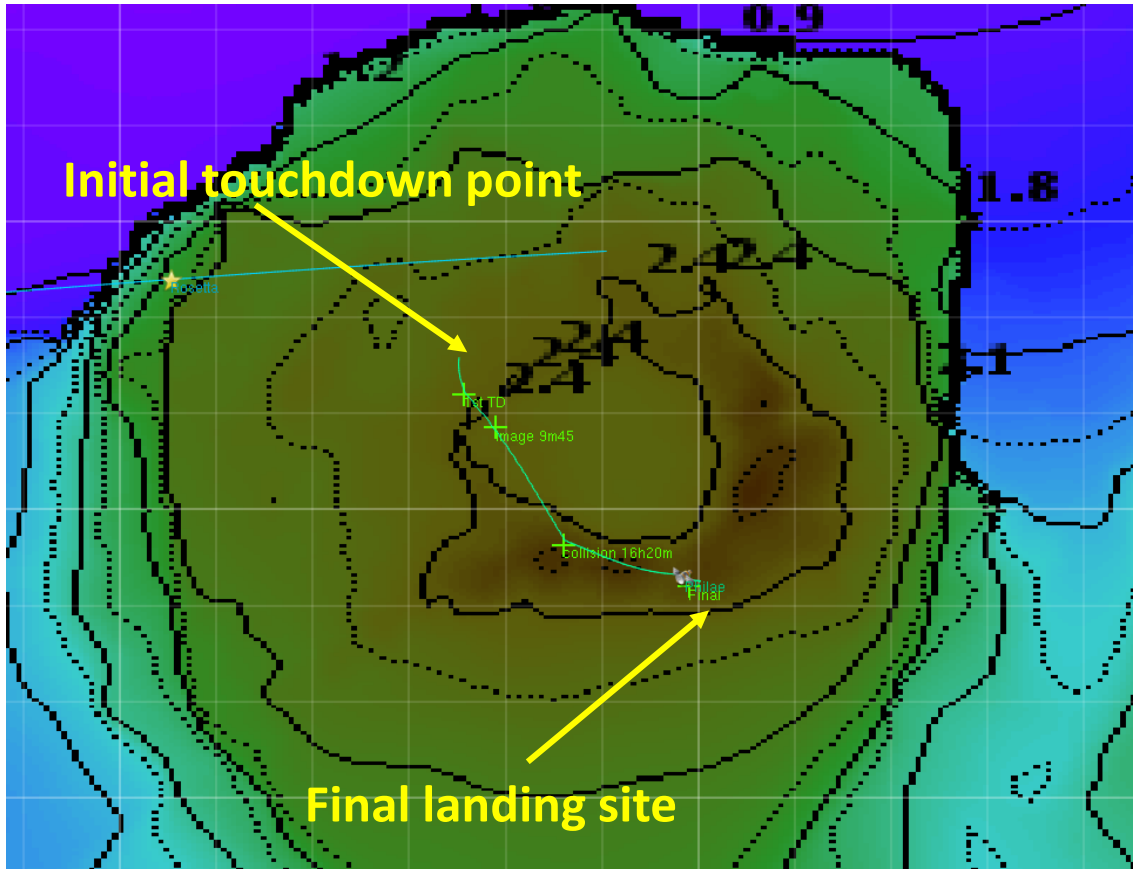
Thank you for your attention !

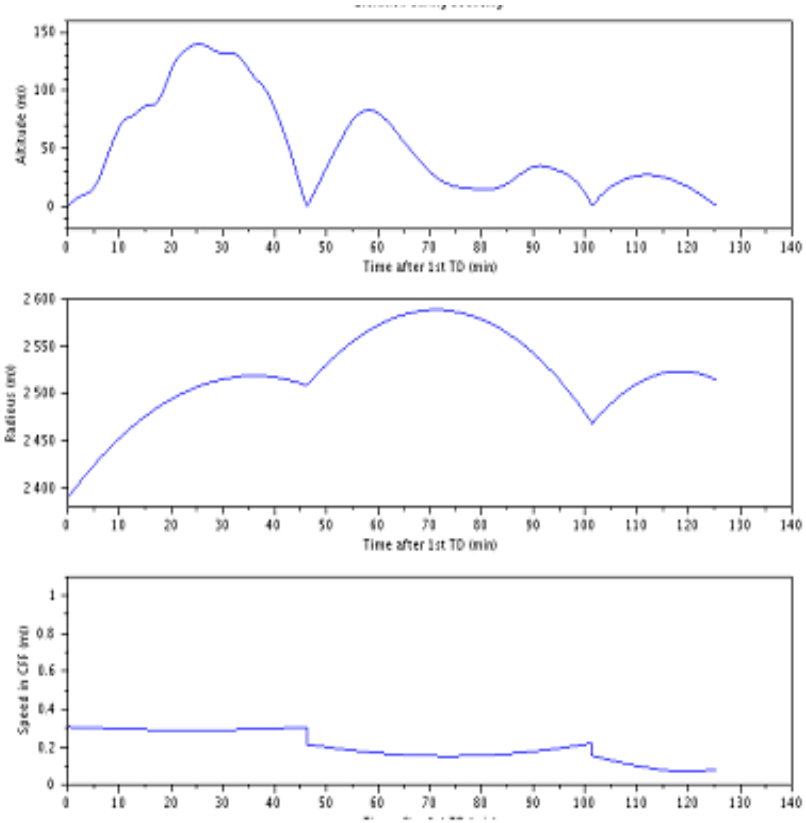
Credits ESA/ROSETTA/Philae/CIVA

Additional slides

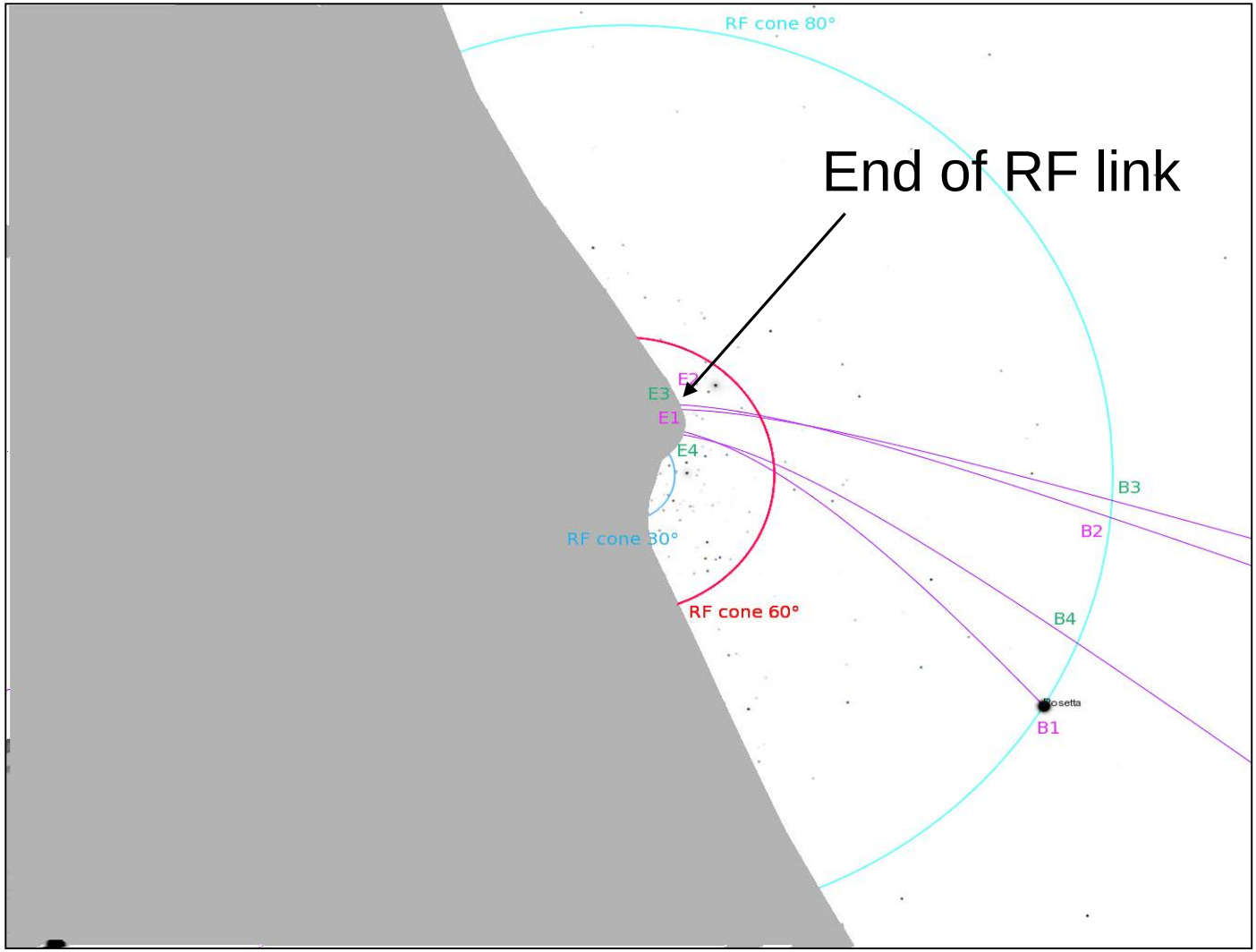
Bouncing trajectory

Preliminary reconstruction of bouncing trajectory, from images and ROMAP data





RF link during FSS



Landing Site Selection Process deadlines

Landing Site Selection Process (LSSP) was mainly driven by the Orbiter observations necessary to characterize the comet in the various mission phases. 3 loops have been done with increasing knowledge of the comet characteristics

Days to Landing	Date/min distance to comet	Deadline	Input data	Technical products used for selection
L-79	24/08/2014 50 km	RLGS proposed 5 candidate landing sites to RMOC that checked feasibility of the proposed landing sites.	global Digital Terrain Models (max. accuracy 20 m), gravity field update, outgassing model update	Global topographic analysis, global illumination maps, reachable areas computed on the whole comet surface
L-58	14/09/2014 30 km	RLGS proposed the nominal and backup landing sites to RMOC, who computed the operational trajectory.	Local DTMs (on the 5 pre-selected landing sites), gravity field update, outgassing model update	Local slopes analyses around the landing sites, local illumination conditions analyses, expected dispersions for landing trajectories, RF links opportunities
L-30	12/10/2014 10 km	RLGS confirmed the choice of the nominal landing site. RMOC updated the operational trajectory. Beginning of operational preparation	boulder statistics (risk analysis), last updates on gravity field and outgassing models	Risk at landing (landing on a boulder), refined local slopes and illumination conditions analyses, refined dispersion analyses for landing trajectories