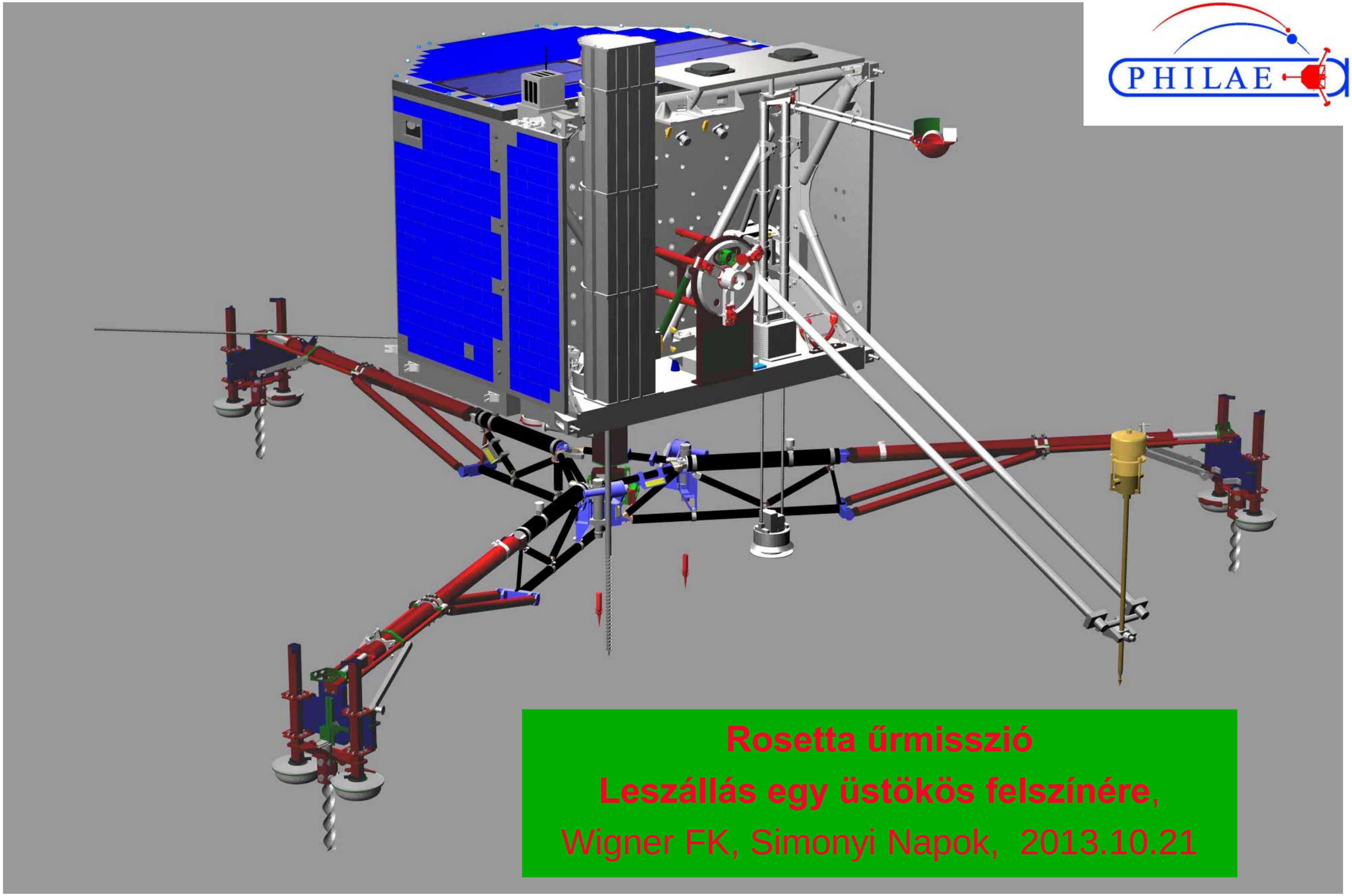
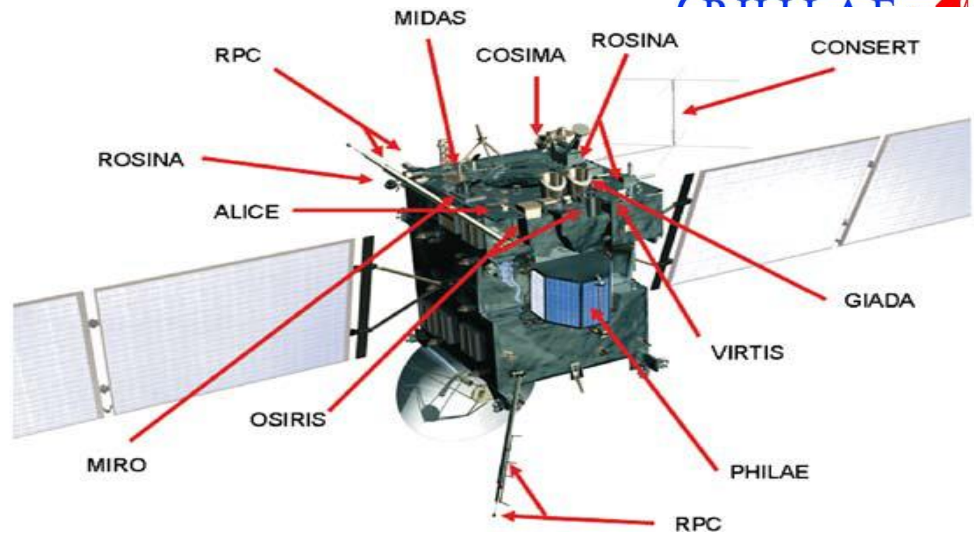


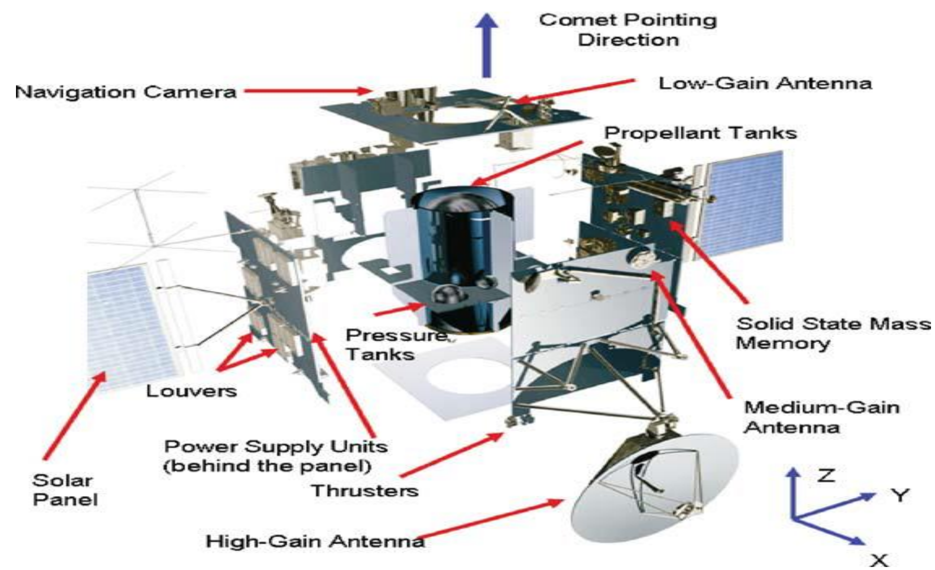
Rosetta űrmisszió

Leszállás egy üstökös felszínére,

Wigner FK, Simonyi Napok, 2013.10.21

ROSETTA   Spacecraft & Lander(Philae)



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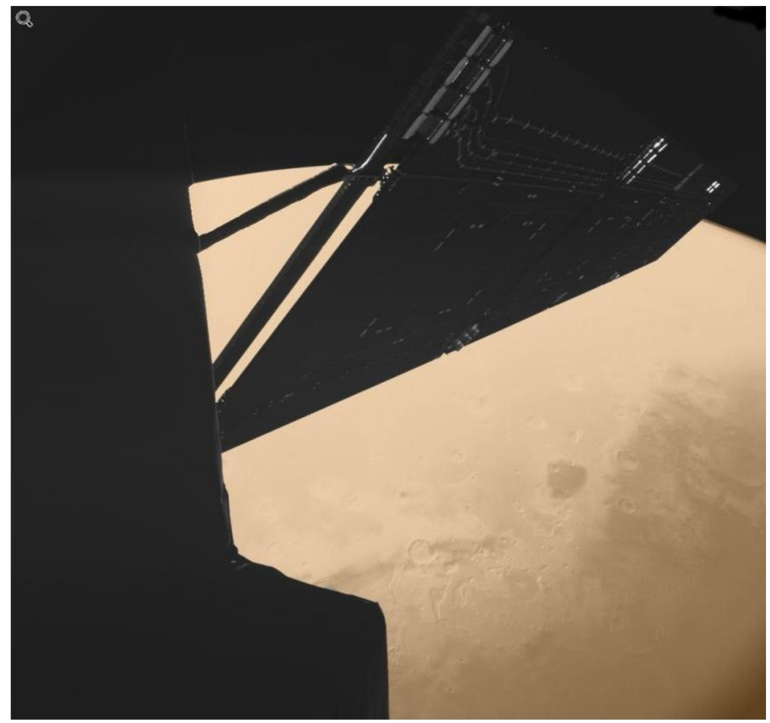
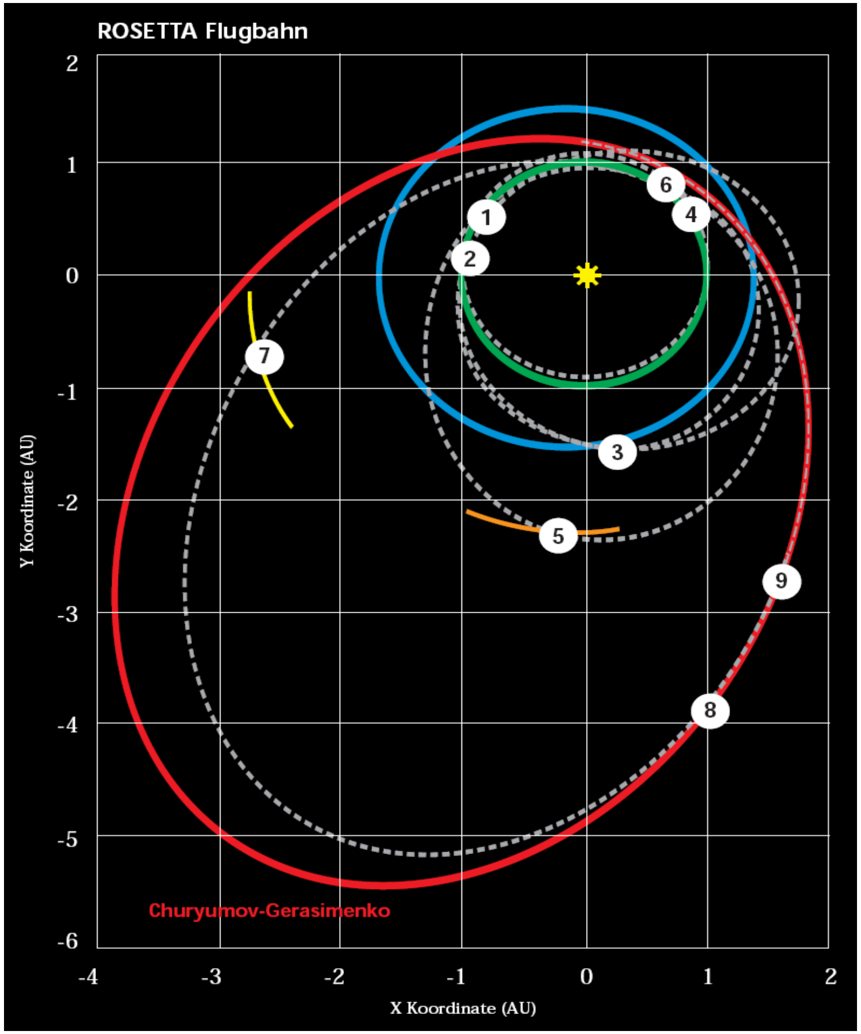


Rosetta's 10 years flight in solar system

Mission event	Nominal date
(1) Launch	March 2, 2004
(2) First Earth Gravity Assist	March 4, 2005
(3) Mars Gravity Assist	February 25, 2007
(4) Second Earth Gravity Assist	November 13, 2007
(5) Steins Flyby	September 5, 2008
(6) Third Earth Gravity Assist	November 13, 2009
(7) Lutetia Flyby	July 10, 2010
Rendezvous Manoeuvre	1 January 23, 2011
Start of Hibernation	July, 2011
Hibernation Wake Up	January, 2014
(8) Rendezvous Manoeuvre Between 4.5 and 4.0 AU	2 May 22, 2014
Start of Near-Nucleus Operations at 3.25 AU	August 22, 2014
(9) PHILAE Delivery	November 10, 2014
Start of Comet Escort	November 16, 2014
Perihelion Passage	August, 2015
End of Nominal Mission	December 31, 2015



Rosetta Spacecraft Instruments

Instrument Name	Scientific Objectives	Principal Investigator
OSIRIS	Multi-Colour Imaging with a Narrow and a Wide Angle Camera	Horst-Uwe Keller MPS, Lindau Germany
ALICE	UV-Spectroscopy (70 nm - 205 nm)	Alan Stern SRI, Boulder, USA
VIRTIS	VIS and IR Mapping Spectroscopy (0.25 - 5 *µm)*	Angioletta Coradini IAS-CNR, Rome, Italy
MIRO	Microwave Spectroscopy (1.3 mm and 0.5 mm)	Sam Gulkis JPL, Pasadena, USA
ROSINA	Neutral Gas and Ion Mass Spectroscopy DFMS: 12-200 AMU M/M ≈ 3000 RTOF: 12-350 AMU M/M > *1000* incl. Gas Pressure Sensor	Hans Balsiger Uni Bern, Switzerland
COSIMA	Dust Mass Spectrometer (SIMS, m/*µm ≈ 2000)*	Martin Hilchenbach (form. Jochen Kissel) *MPS, Lindau,* Germany
MIDAS	Grain Morphology with an Atomic Force Microscope at nm Resolution	Willi Riedler IWF, Graz, Austria
CONSERT	Radio Sounding and Nucleus Tomography	Wlodek Kofman LPG, CNRS/UJF, Grenoble, France

Rosetta Spacecraft Instruments (cont.)

Instrument Name	Scientific Objectives	Principal Investigator
GIADA	Dust Velocity and Impact Momentum Measurement, Contamination Monitor	Luigi Colangelo INAF, Naples, Italy
RPC	Langmuir Probe (LAP)	Anders Eriksson (formerly Rolf Boström) IRF Uppsala, Sweden
	Ion and Electron Sensor (IES)	Jim Burch SRI, San Antonio, USA
	Flux Gate Magnetometer (MAG)	Karl-Heinz Glassmeier Germany IGEP, Braunschweig, D
	Ion Composition Analyser (ICA)	Rickard Lundin IRF, Kiruna, Sweden
	Mutual Impedance Probe (MIP)	Jean-Gabriele Trotignon LPCE/CNRS, Orleans, France
	Plasma Interface Unit (PIU)	Chris Carr Imperial College, London, England
RSI	Radio Science Experiment	Martin Paetzold Uni Köln, Germany
SREM	Standard Radiation Environment Monitor	

Lander(Philae) Instruments

Instrument Name	Scientific Objectives	Principal Investigator
APXS	α-p-X-Ray Spectrometer	Göstar Klingelhöfer, (Rudi Rieder), Uni Mainz, Germany
COSAC	Evolved Gas Analyser: elemental and molecular composition	Fred Goesmann, (formerly Helmut Rosenbauer) MPS, Lindau, Germany
PTOLEMY	Evolved Gas Analyser: isotopic composition	Ian P. Wright Open University, Milton Keynes, UK
CIVA	Panoramic Camera IR microscope	Jean-Pierre Bibring IAS, Orsay, France
ROLIS	Descent Camera	Stefano Mottola, DLR Berlin, Germany
SESAME	Comet Acoustic Surface Sounding Experiment (CASSE)	Klaus J. Seidensticker, (formerly Dirk Möhlmann) DLR Cologne, Germany
	Dust Impact Monitor (DIM)	**Istvan Apathy, KFKI, Budapest, Hungary**
	Permittivity Probe (PP)	Walter Schmidt, (Harri Laakso), FMI, Helsinki, Finland
MUPUS	Multi-Purpose Sensor For Surface and Sub-Surface Science	Tilman Spohn DLR Berlin, Germany
ROMAP	RoLand Magnetometer (ROMAG)	Hans-Ulrich Auster, IGEP, TU Braunschweig, Germany
	Plasma Monitor (SPM)	**Istvan Apathy, KFKI, Budapest, Hungary**
CONSERT	Comet Nucleus Sounding	Wlodek Kofman, LPG, CNRS/UJF, Grenoble, France
SD-2	Drill, Sample, and Distribution System	Amalia Ercoli-Finzi Politechnico di Milano, Milano, Italy

Magyar hozzájárulás…

Műszer/szolgálati-rendszer	Hol?	Készítette
SESAME / Dust Impact Monitor (DIM)	Lander	KFKI-AEKI
ROMAP / Plasma Monitor (SPM)	Lander	KFKI_AEKI
RPC / EGSE	Spacecraft	KFKI-RMKI
ESS (Separation/Telecom Subsystem) HW	Spacecraft	STIL(?)
PSS (Power Subsystem) HW	Lander	BME
CDMS (Command&Data Management System) HW&SW	Lander	KFKI-RMKI

Lander On-board Computer (CDMS)

Fault tolerant HW structure: Hot and cold redundant HW functional sub-units

Major tasks of On-board SW:

- Autonomous failure recognition, isolation and recovery procedures
- Telecommunication units and link establishment and control
- Telecommand distribution and Telemetry data collection and management
- Science operation control and autonomous sequencing
- Touch-down and Anchoring control
- Battery & Power flow control (Primary battery/1300Wh, Secondary batt/140Wh, Solar panels/10-20W)

Comet science operation phases:

- Separation-Descent-Landing (~3-6 hours), power src: batteries and solar power
- First Comet Science Sequence (~50 hours), power src: batteries and solar power
- Long Term Science Operations (max. 8-10 months), power src: rechargeable secondary & solar power

Major Mission phases at the comet

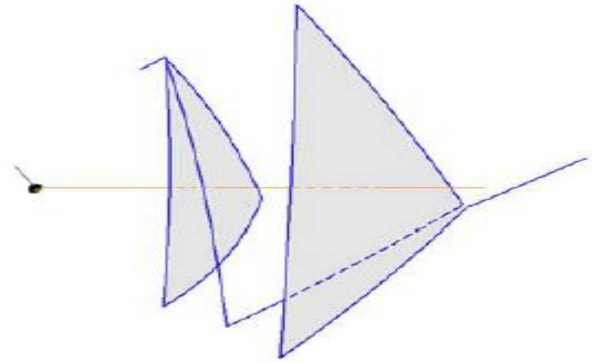
- **Near Comet Drift** (NCD):
  Relative distance reduced from ca. 1e6km to **1e5 km**, relative **velocity reduced from ca. 780 m/s to ca. 100 m/s**
- **Far Approach Trajectory** (FAT):
  Relative distance reduced to ca. 1000 radii (ca. **2000 km**), **relative speed reduced to ca. 3 m/s**
- **Close Approach Trajectory** (CAT):
  To enter in the sphere of influence of the comet and perform its **characterisation (typically 50 to 100 km distance)**

SEE NEXT PAGES

- **Transition to Global Mapping** (TGM):
  Intermediate phase used to set spacecraft in proper comet orbit
- **Global Mapping Phase** (GMP):
  Orbital phase to perform a global mapping of comet surface and **identify potential landing sites (typ. 20 km radius)**
  Global mapping will be from circular ~20 km polar orbits.
  Global mapping orbit plane is inclined 30 deg from Sun direction
  Orbit plane changes are performed at poles to stay on day side. 3-day side arcs are flown followed by one night side arc.
  For navigation and mapping an array of 4 NAVCAM images is taken every 4 hours
- **Close Observations Phase** (COP):
  Circular/elliptic orbital phase used to perform **detailed observations of selected potential landing sites (typically 10 km radius)**
  Orbit plane inclined < 20 deg from terminator plane
  Periodic manoeuvres are implemented to maintain the above conditions
  Orbital period is synchronised with comet rotation period, allowing for repeated overflights of the target landing site
- **Landing**:
  Once the target trajectory is achieved the S/C is maintained in the delivery trajectory, **free of manoeuvres for several revolutions, allowing accurate navigation**
  For a landing attempt, data images are collected up to typically ~8 hr prior to landing. Upon confirmation that the navigation is sufficiently accurate, the separation sequence is triggered. Time and attitude of the separation may be updated in the short term
- **Escort and Monitoring Phase** (EMP):
  Post landing phase fully dedicated to comet monitoring

Comet approach (NCD/FAT/CAT)

Manoeuvre	Time	Size [m/s]	Sun dist [AU]	Earth dist [AU]	Comet dist [km]
NCD#1	2014/05/21	321.8	4.00	3.33	934000
NCD#2	2014/06/04	263.9	3.93	3.10	389000
NCD#3	2014/06/18	88.9	3.86	2.92	163000
FAT#1	2014/07/02	66.1	3.79	2.79	44000
FAT#2	2014/07/09	24.6	3.75	2.74	19000
FAT#3	2014/07/16	10.5	3.72	2.71	8043
FAT#4	2014/07/23	5.0	3.68	2.70	3459
CAT-preinsertion	2014/08/04	2.0	3.61	2.70	400
CAT-insertion	2014/08/07	1.0	3.59	2.71	100



Comet Initial Characterisation Phase:

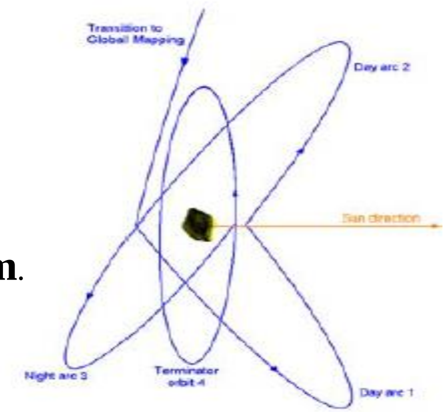
Identify **landmarks** on the comet surface and estimate their positions

Determine the **shape** and **rotation state** of the comet, first estimation of **mass**

10 days at **90-120 km** for operations with CAM, then distance to the nucleus reduced to **50-70 km**.

Operations with science payloads.

Fly hyperbolic trajectories (3-4 days arcs) : lower sensitivity to navigation and maneuver execution



Comet Mapping Phase:

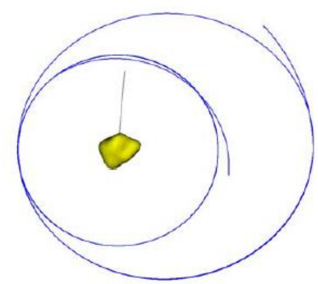
Mapping of at least 80% of the comet surface

Fly circular orbit from **20 to 30 km** radius. Orbital period 7 to 14 days.

Comet Close Observation :

Observation of the **2 candidate landing sites** identified by Lander Community

Observation from ~3 radius (**10 km**). Orbit plane inclined <20 deg from terminator.



Comet parameters & models update by ESOC

- 3D comet shape model :
  - Delivered at L-85 (data from first pyramid orbit), resolution ~100 m
  - Later on gradually improve resolution down to 2-3 m

- Comet rotational kinematics (axes and periods):
  (No significant precessional and nutational motion counted with…???)
  - L-92 with accuracy better than 1 deg
  - Improvement of the prediction of comet orientation axis at time of touchdown :
    - L-92 error 1 deg
    - L-60 error 0.1 deg

- Comet mass:
  - L-85 error 10% (15% in case of high activity)
  - L-60 error 5%
  - L-30 error 2%
  - L < 1%

- Cometary outgassing: see later…

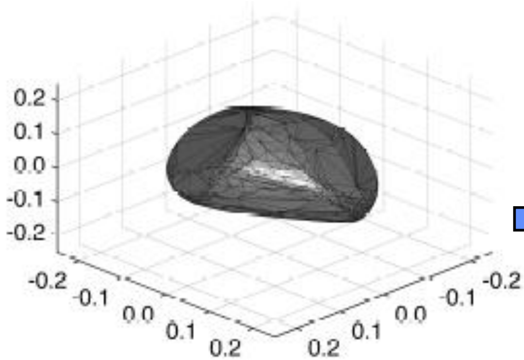
Landing site selection process

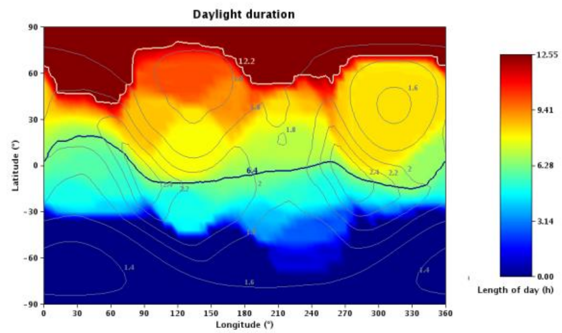
3D comet shape model

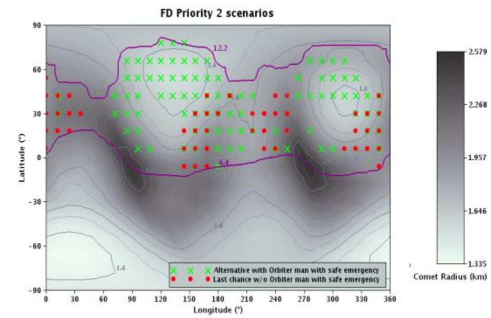
5 sites of scientific interest to be selected and prioritized by Lander team

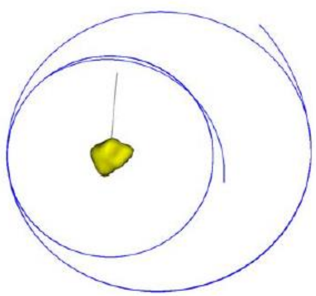
+ Technical requirement -> „Sufficient” solar power, optimize through Lander rotation

2 flight dynamically feasible sites to be selected and detailed orbit calculations prepared by ESOC









Spacecraft & Lander flight track/orbit calculations, deltaV maneuvers

PHILAE

Initializations:

$n = 0$

Time = -dtEject

$\mathbf{r}^{lander}[0] = \mathbf{r}^{spacecraft}$ // at 'tSep - dtEject'

$\mathbf{v}^{lander}[0] = \mathbf{Vspc}$ // at 'tSep - dtEject'

The loop:

$R^{lander}[n] = |\mathbf{r}^{lander}[n]|$ // cometocentric distance of the lander in the n-th step

$a^{ldrgrav}[n] = G * m^{comet} / R^{lander}[n]^2$ // magnitude of gravitational acceleration in the n-th step

$\mathbf{a}^{ldrgrav}[n] = ||-\mathbf{r}^{lander}[n]|| * a^{ldrgrav}[n]$ // gravitational acceleration vector, $||-\mathbf{r}^{lander}[n]||$ unit vector to comet centre

$\mathbf{a}^{lander}[n] = \mathbf{a}^{ldrgrav}[n] + \mathbf{a}^{drag}[n]$ // $\mathbf{a}^{drag}[n] = \mathbf{F}^{drag}[n] / m^{lander}$; accleration by drag force, at $\mathbf{r}^{lander}[n]$

if (Time = tSep)/ // once, at the moment of lander separation, tSep = 0

$\mathbf{v}^{lander}[n] = \mathbf{v}^{lander}[n] + \mathbf{Veject}$ // lander and spacecraft are separated…

if (Time = dtAds) // once, at the moment of ADS maneuver

$\mathbf{v}^{lander}[n] = \mathbf{v}^{lander}[n] + \mathbf{Vads}$

$\mathbf{r}^{lander}[n+1] = \mathbf{r}^{lander}[n] + \mathbf{v}^{lander}[n] * dt$

$\mathbf{v}^{lander}[n+1] = \mathbf{v}^{lander}[n] + \mathbf{a}^{lander}[n] * dt$ // further deltaV maneuvers - as single shot events - can be introduced here

Time = Time + dt

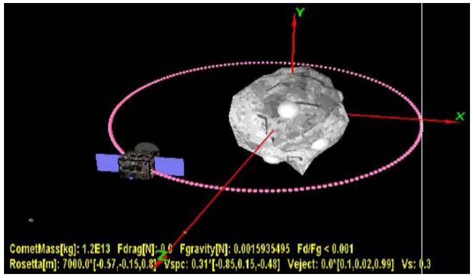
$n = n + 1$

Inverse calculation is also possible:

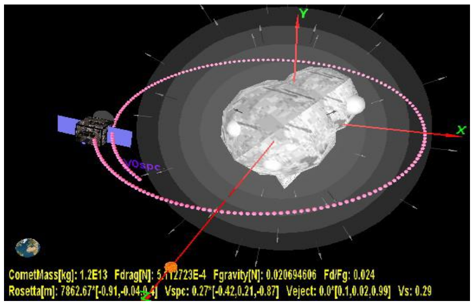
Starting from landing site vector and lander touch-down velocity vector,
lander and spacecraft orbits calculations can also be performed „backwards"…

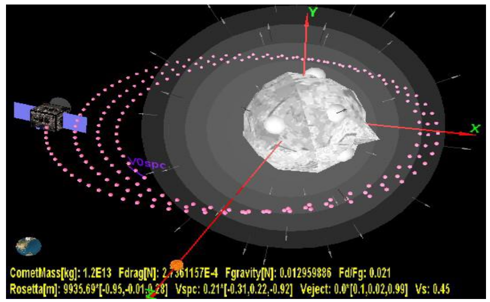
cnes DLR esa FMI IWF GRAZ KFKI RMKI MPS MPE STFC Space Technology (Ireland) Ltd.

Impact of cometary outgassing

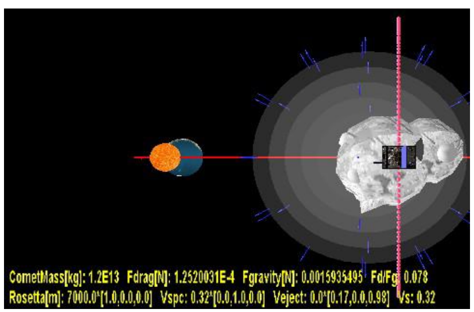


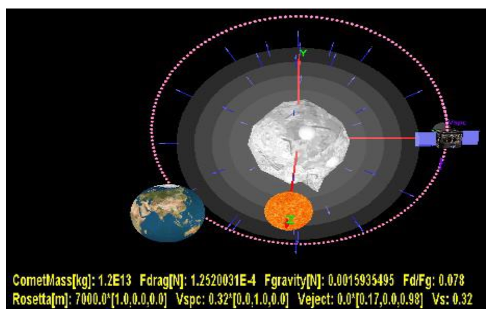
If there were no cometary outgassing,
a stable elliptical spacecraft orbit could be maintained easily



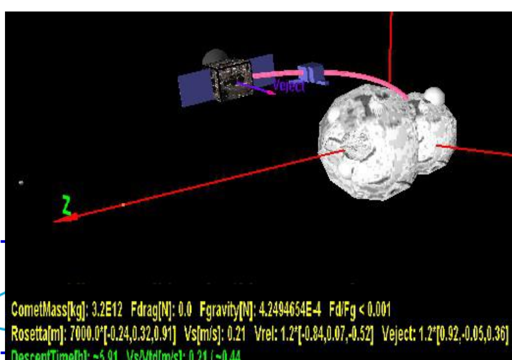


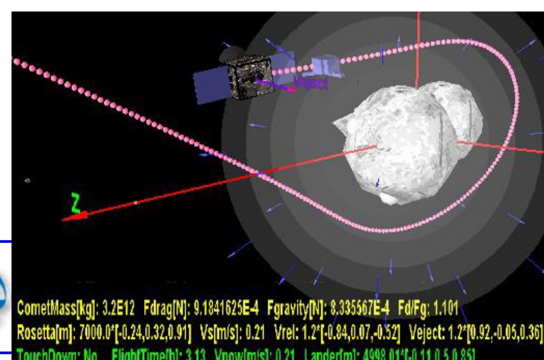
In case of cometary outgassing and a "horizontally" aligned spacecraft orbit, the spacecraft is dragged/lifted away from the comet more-and-more on the left side, and more-and-more closer to the comet on the right side.





The reason for drifting away process of the spacecraft (or, of its orbit) is - in general - not simply the fact and magnitude of the cometary outgassing, rather its spatial asymmetry and inhomogenity. Terminator orbit in a plain, in which the cometary outgassing is „more or less" symmetric → stable, calculable orbit on long term





A "lumpish" shot of the lander…
Left: if no outgassing,
right: if strong outgassing

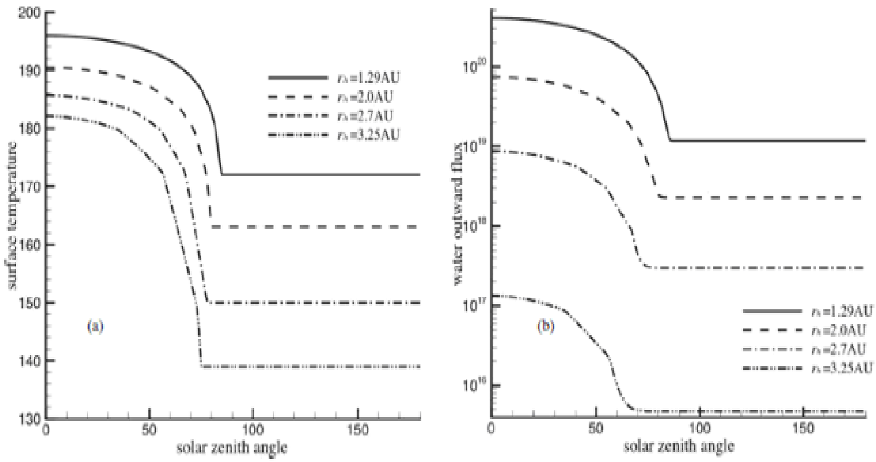
Simplified outgassing model

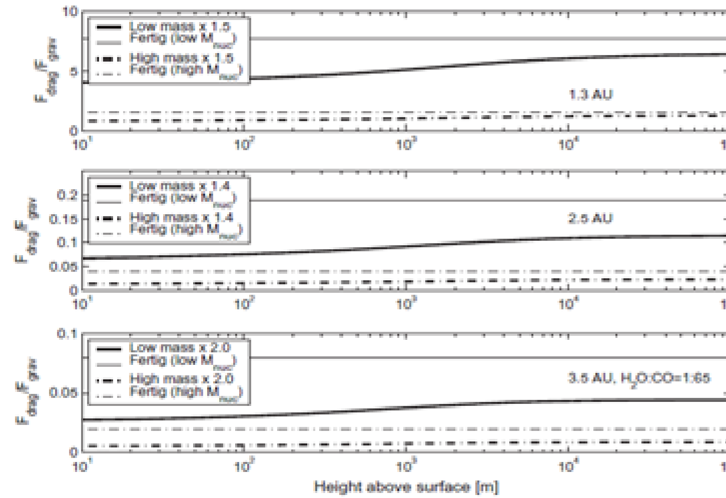
$$F^{drag}[n] = -\tfrac{1}{2} * C^{d} * A^{eff} * \rho[n] * |\mathbf{v}^{spacecraft}[n] - \mathbf{v}^{flux}[n]|^{2} * ((\|\mathbf{v}^{spacecraft}[n] - \mathbf{v}^{flux}[n]\|) / \mathbf{v}^{unit})$$

$$A^{eff} = A^{spacecraft\text{-}frame} + A^{solarpanels\text{-}frontal} * \mathrm{abs}\,(\,\|\mathbf{r}^{spacecraft}[n]\| * \|\mathbf{Veject}\|\,)$$

$$\rho[n] = \rho^{surface} / (\,|\mathbf{r}^{spacecraft}[n]| / R^{comet}\,)^{2}$$

$$\mathbf{a}^{drag}[n] = \mathbf{F}^{drag}[n] / m^{spacecraftORlander}$$





$\rho^{darksidesurface} = \rho^{zenithsurface} * qN/D$; DecayWrtZenith = 1 - exp($-(\pi/2 - \delta) / \pi/8$)

$\rho^{surface} = \rho^{darksidesurface} + (\rho^{zenithsurface} - \rho^{darksidesurface}) *$ DecayWrtZenith

$\Phi^{surface} \sim 1.1e10^{17}$ [mol/m^{2}s] @~3.25[AU]

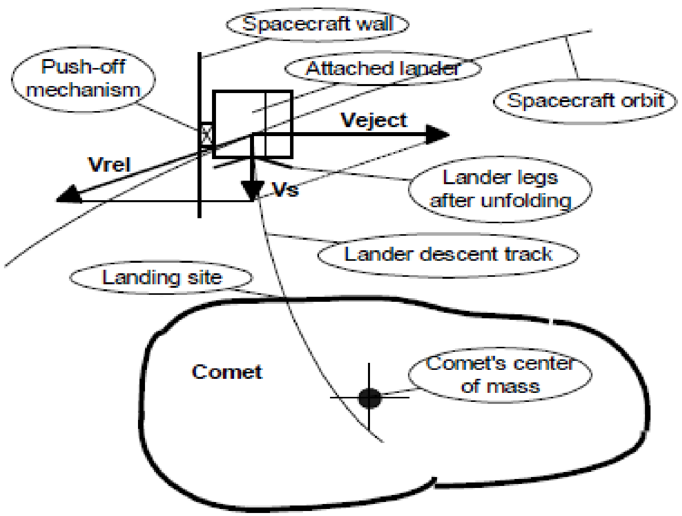
$v^{flux} = (k * T / m^{H2O})^{1/2} = (2 * 1.38e10^{-23}$[Nm/K] * 180[K] / $3e10^{-26}$[kg] $)^{1/2}$ ~ 410[m/s]

$\eta^{surface} = \Phi^{surface} / v^{flux} \sim 1.1e10^{17}$ [mol/m^{2}s] / 410[m/s] ~ $0.45e10^{14}$ [mol/m^3]

$\rho^{surface} = \eta^{surface} * m^{H2O} \sim 0.45e10^{14}$ [mol/m^3] * $3e10^{-26}$[kg] ~ $1.35e10^{-12}$[kg/m^3]

Pure Gas: Fdrag/Fgravity ~10^{-4} Gas&Dust : Fdrag/Fgravity ~ 0.08   @~3AU

Possible Lander delivery strategies



A/ „Direct" lander delivery, from a near-comet terminal orbit, without spacecraft maneuver

B/ Lander delivery, initiated from a far-comet terminal orbit, with a fly-by track in the terminal plain, spacecraft maneuver for lander separation

Complicated set/tree/chain of dependencies:

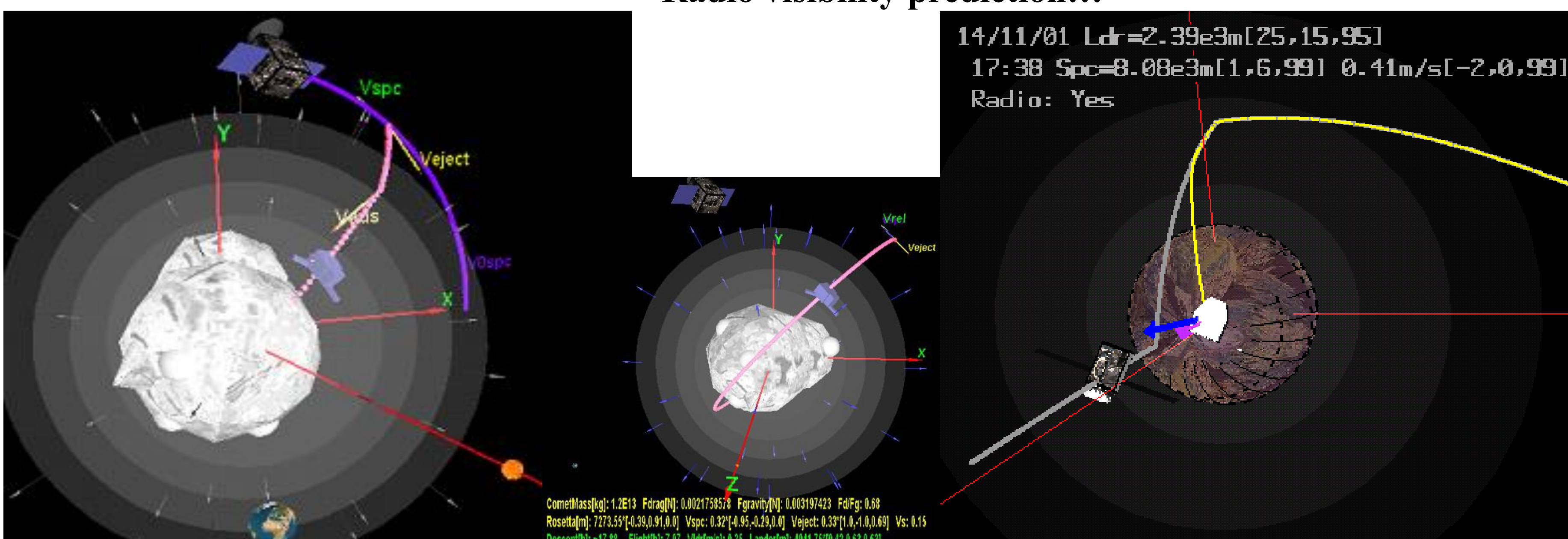
Strict geometrical constraints (spacecraft attitude)…

Large number of parameters to know, calculate and set to achieve the selected landing site…

Risk assessment and minimisation…

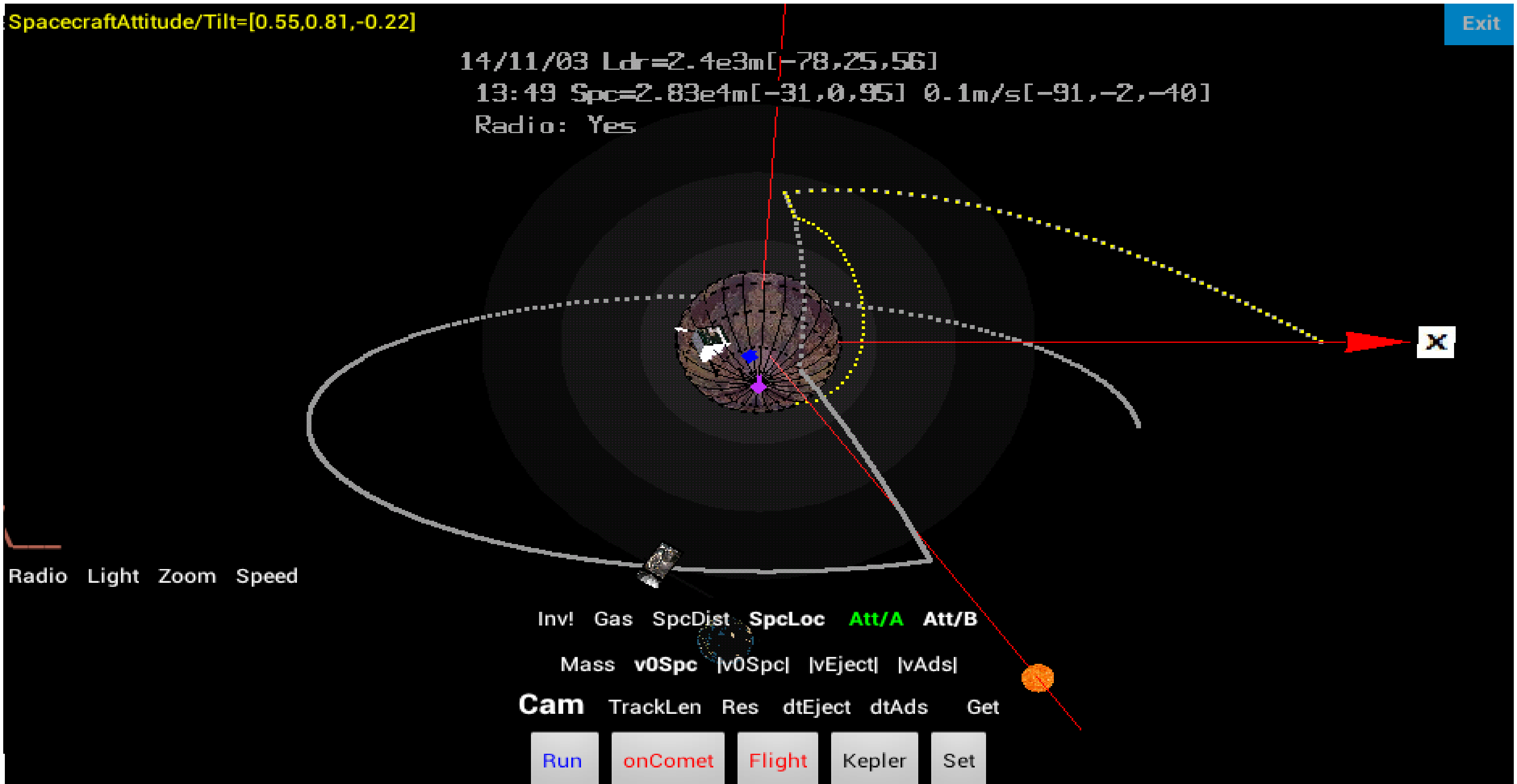
Achievable lander descent duration (~3-6h) critical…

Radio visibility prediction…

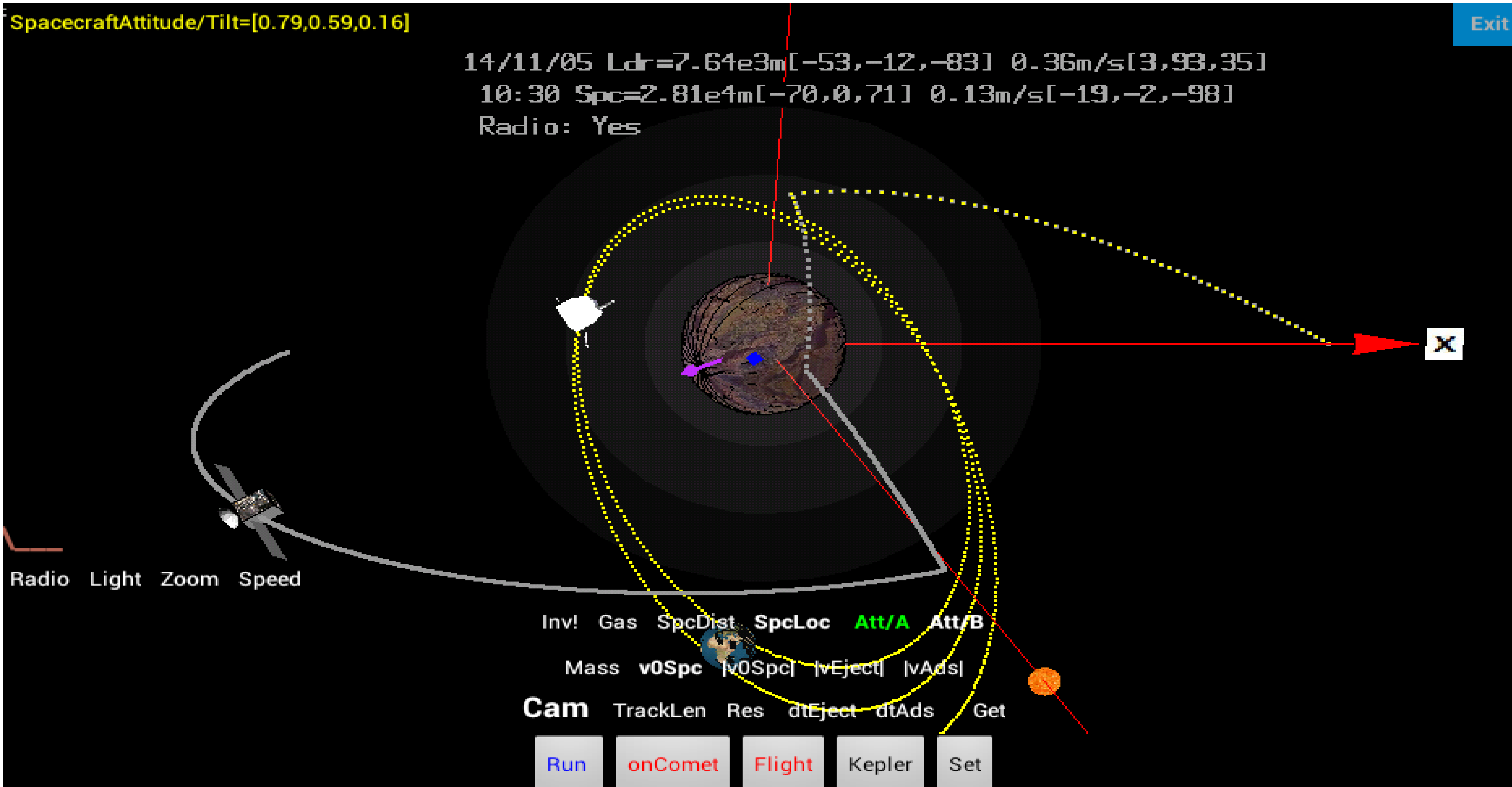


Fail of spacecraft attitude/orientation control

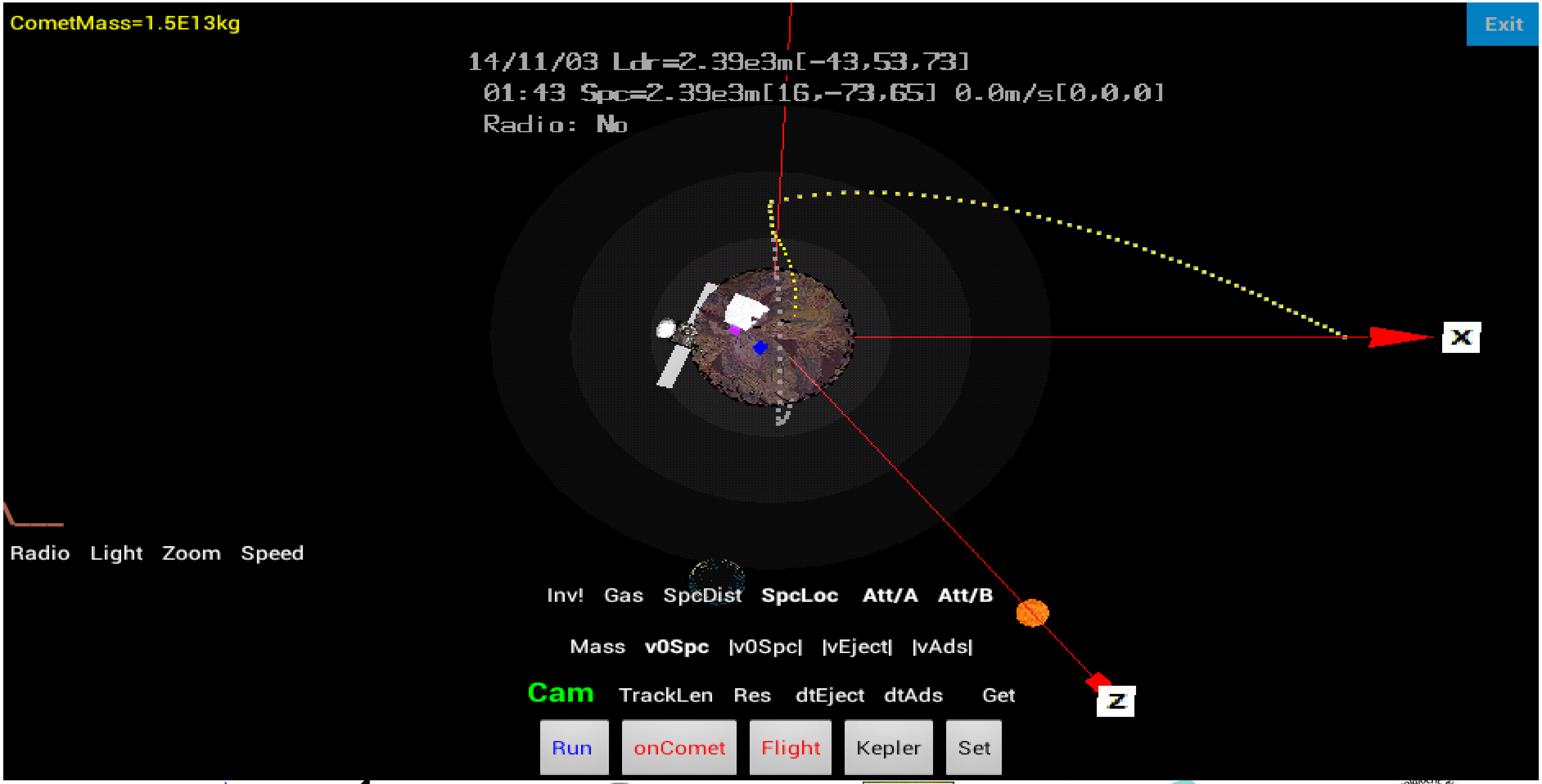
- **landing site quite different**
- **lander „upside-down”**



Fail of spacecraft attitude/orientation control
- lander might not hit the comet at all….

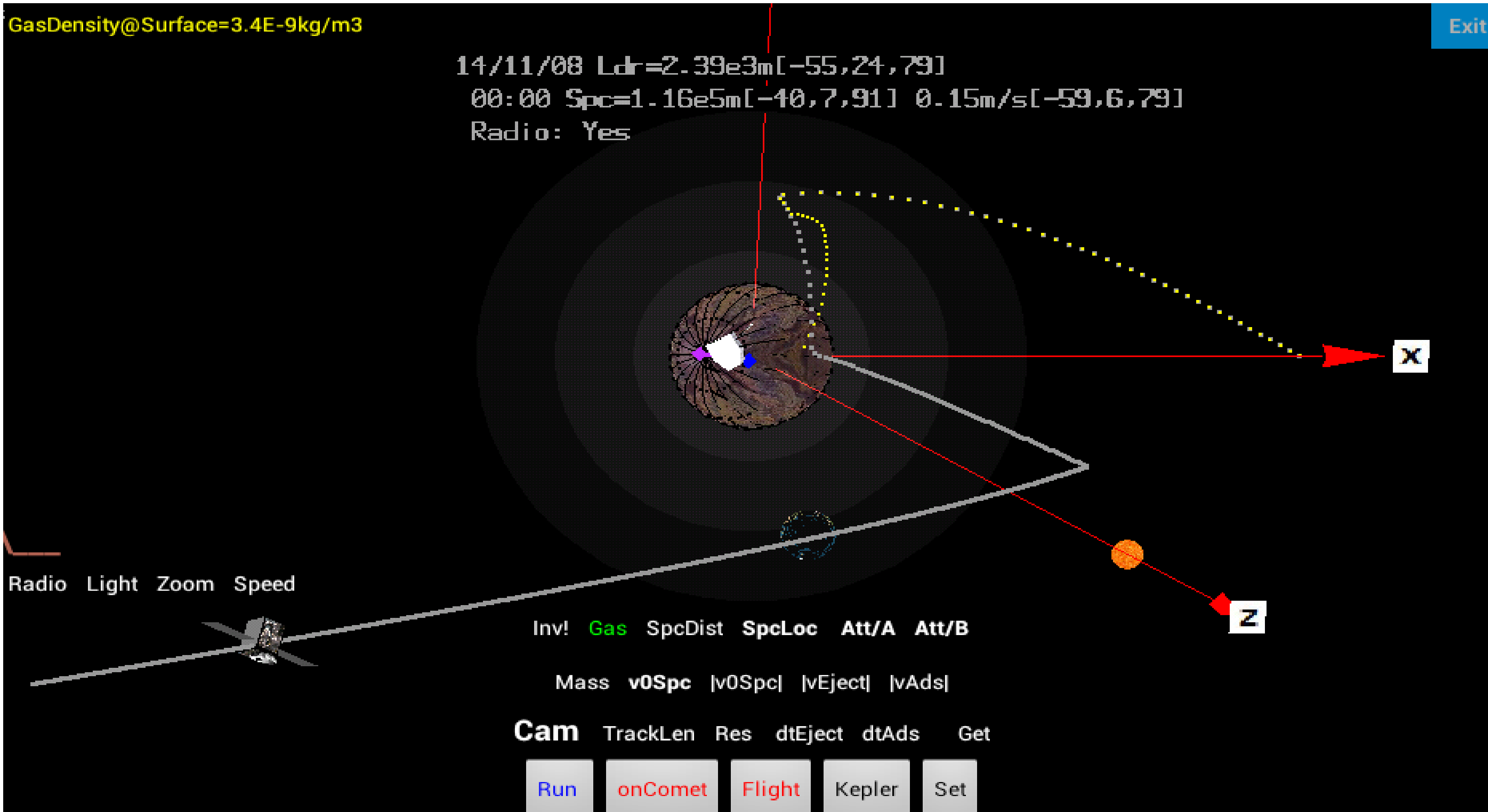


Wrong assessment (~2% error) of the comet mass
- Spacecraft might land on the comet….



Wrong assessment assessment of the cometary outgassing…
- Spacecraft might leave the vicinity of the comet….

PHILAE



Mission success vs. risks

Large number of critical elements
(HW/SW, mechanics, models/predictions, decision taking procedures, „human components" in the loop…)
in the „system" for the nominal case(s) anyway…

In addition…

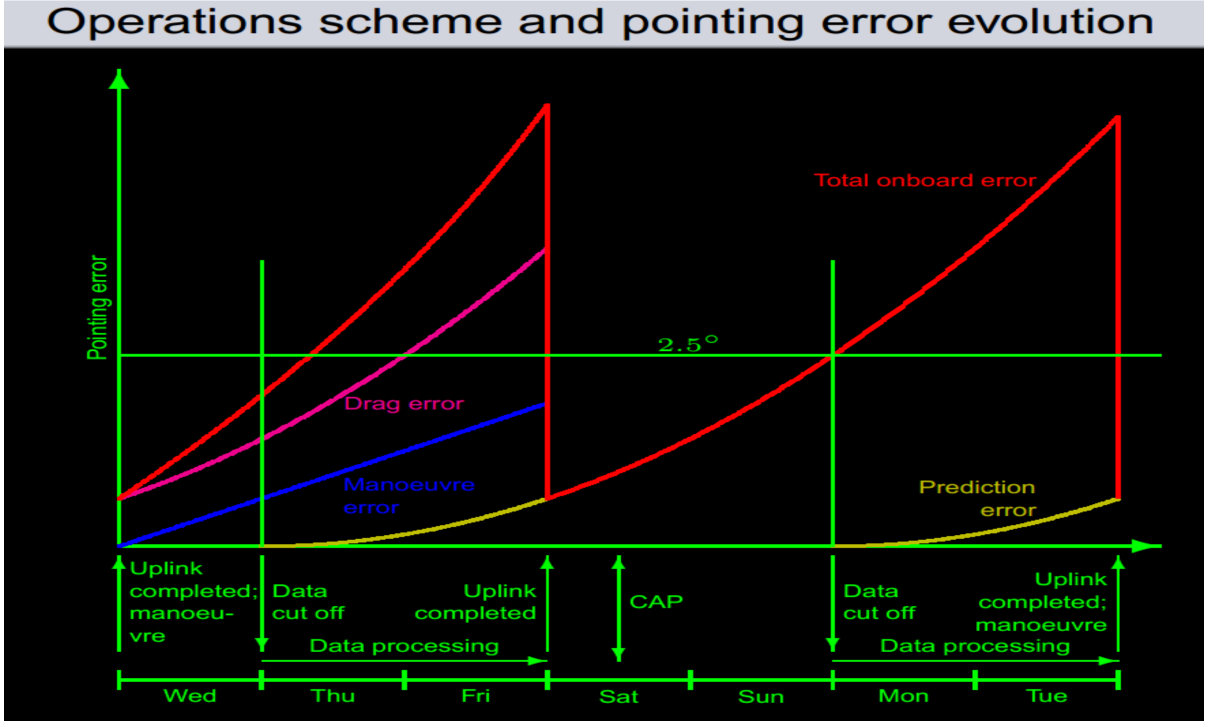
Spacecraft

- Slight leakage in main gas tank (number/magnitude of spacecraft maneuvers to be reduced)
- 1 reaction-wheel in the spacecraft attitude stabilisation system significantly degraded
- another one slightly degraded

Lander

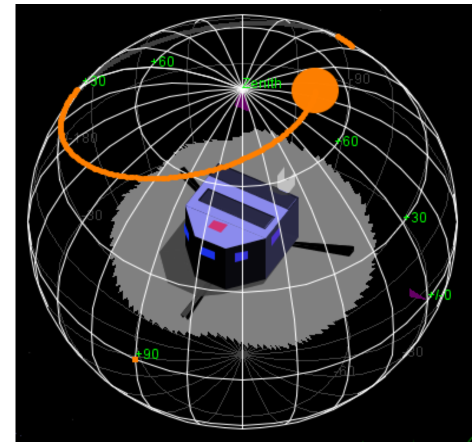
- Anhoring system gas tank leakage
- Harpoon ignition system design failure, work-around is about to be worked on
- Some motors for lander rotation/tilt might get stuck because of aging…

Spacecraft maneuvers on weekly plannig basis



One camera image every 8 hours during icosahedral arcs, one image every 6 hours during close flybys
Data cut-off for manoeuvre optimisation: 24 hours before each manoeuvre
Data cut-off for attitude commanding: 24 hours before closest approach /
shortly before targeting manoeuvre for close Flybys
Data cut-off for flyby reconstruction: 24 hours before next manoeuvre /
shortly before targeting manoeuvre for close Flybys

Methods and tool for determining the in-situ Sun orbit and long term solar power profile for the ROSETTA lander



- To set up a generalized formula for the Sun location vector - in a lander-centric coord. system - as function of time
- **SunLoc(t)** = f (**RotAxis**, RotPeriod, **PrecAxis**, PrecPeriod, NutAmpl, NutPeriod, NutPhase, **LdrSite**, **LdrTilt**, LdrOrient, **CometLoc**)
- **SunLoc(t)** through series of elementary rotation operations

PrecAxis(t) = **Rotate** (**PrecAxis(t0)**, -CometOrbitDelta, **OrbitPlainInclination**)
NutAxis(t) = **Rotate** (**NutAxis(t0)**, -CometOrbitDelta, **OrbitPlainInclination**)
RotAxis(t) = **Rotate** (**RotAxis(t0)**, -CometOrbitDelta, **OrbitPlainInclination**)
LdrSite(t) = **Rotate** (**LdrSite(t0)**, -CometOrbitDelta, **OrbitPlainInclination**)
tmpVec = **Rotate** (**SunLoc(t0)**, +PrecAngle, **PrecAxis(t)**) ; PrecAngle = 2*PI*(t/PrecPeriod)
tmpVec = **Rotate** (**tmpVec**, +NutDelta, **NutAxis(t)**); NutAngle = 2*PI*(t/NutPeriod); NutDelta = Ampl * sin(Phase(t0)+NutAngle)
tmpVec = **Rotate** (**tmpVec**, +RotAngle, **RotAxis(t)**); RotAngle = 2*PI*(t/RotPeriod)
tmpVec = **Rotate** (**tmpVec**, -DeltaRotToLdrSite(t), **AxisToLdrSite(t)**)
tmpVec = **Rotate** (**tmpVec**, -DeltaRotToLdrTilt, **AxisToLdrTilt**)
SunLoc(t) = **Rotate** (**tmpVec**, -LdrOrient, **yAxis**)

Expressed in a concise matrix form:

$$\mathbf{SunLoc(t)} = \mathbf{M}_{\mathbf{LdrOrient}} * \mathbf{M}_{\mathbf{LdrTilt}} * \mathbf{M}_{\mathbf{LdrSite}} * \mathbf{M}_{\mathbf{CometRot}} * \mathbf{M}_{\mathbf{CometNut}} * \mathbf{M}_{\mathbf{CometPrec}} * \mathbf{SunLoc(t0)}$$

Source data to calibrate the generalized formula of the SunLoc(t) vector function

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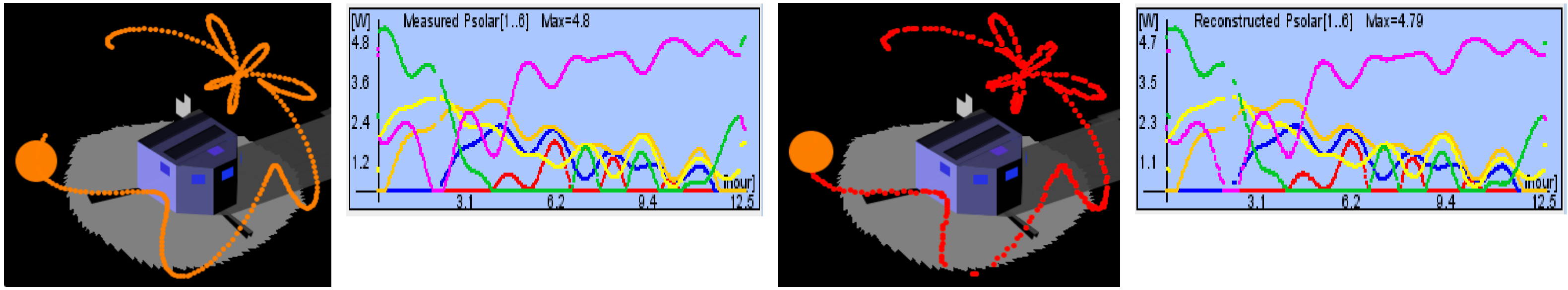
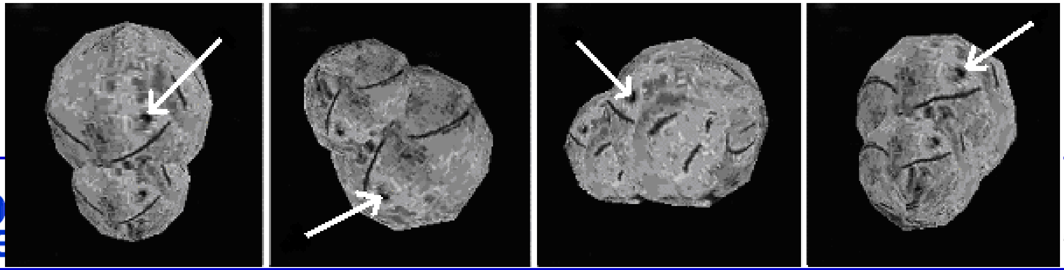
- To determine/approximate the in-situ values of: **RotAxis**, RotPeriod, **PrecAxis**, PrecPeriod, NutAmpl, NutPeriod, NutPhase, **LdrSite**, **LdrTilt**, LdrOrient, **CometLoc**
- **Source-A**, as measured lander telemetry data are at disposal:
  The Sun orbit for short term – as series of SunLoc vectors – can be posteriorly reconstructed from the changing distribution of solar panels HK data collected e.g. either during the first revolutions of the comet after landing, or later on



- **Source-B**, snapshot images of the comet maybe (not necessarily, probably not) at disposal:
  To determine the rotational kinematics parameters (rotational, precessional, nutational axes, periods) of the comet, and possibly to identify the lander site.
  Questionmarks: accuracy, spacecraft location and pointing, intellectual property rights…



Methods to calibrate the generalized formula

$$SunLoc(t) = M_{LdrOrient} * M_{LdrTilt} * M_{LdrSite} * M_{CometRot} * M_{CometNut} * M_{CometPrec} * SunLoc(t0)$$

- **Method-1**, uses Source-A(landerTM) & B(images)
  - determine $\mathbf{M}_{CometRot}$, $\mathbf{M}_{CometNut}$, $\mathbf{M}_{CometPrec}$, and $\mathbf{M}_{LdrSite}$ from Source-B
  - look for $\mathbf{M}_{LdrOrient}$ and $\mathbf{M}_{LdrTilt}$ (trial-and-error, or least-squares basis), so that the formula fits the measured data - series of SunLoc vectors - acquired by Source-A

- **Method-2**, uses Source-A(landerTM) & B(images)
  - determine $\mathbf{M}_{CometRot}$, $\mathbf{M}_{CometNut}$, $\mathbf{M}_{CometPrec}$ from Source-B
  - introduce the matrix $\mathbf{M}_{LdrTiltSite} = \mathbf{M}_{LdrTilt} * \mathbf{M}_{LdrSite}$ → one less unkonwn rotation Matrix
  - Note that the lander/site does not need to be explicitly recognised/identified in the snapshot images!
  - look for $\mathbf{M}_{LdrOrient}$ and $\mathbf{M}_{LdrTiltSite}$ (trial-and-error, or least-squares), so that the formula fits the measured data - series of SunLoc vectors - acquired by Source-A

- **Method-3**, uses **Source-A, lander telemetry only**
  - fix $\mathbf{M}_{LdrTilt}$ at a constant no tilt
  - pick-up a measured SunLoc vector from Source-A, and determine (trial-and-error, least-squares), at what $\mathbf{M}_{LdrSite}$ and $\mathbf{M}_{LdrOrient}$ matrices the calculated SunLoc vector fits the measured one
  - look for $\mathbf{M}_{CometRot}$, $\mathbf{M}_{CometNut}$, $\mathbf{M}_{CometPrec}$ (trial-and-error, or least-squares), so that the formula fits the measured data - series of SunLoc vectors - acquired by Source-A

Account and benefits, some technical aspects

- Prediction of how the Sun orbit and the solar power profile will develop on short, medium and long term (aid for LTS operations scheduling and control)

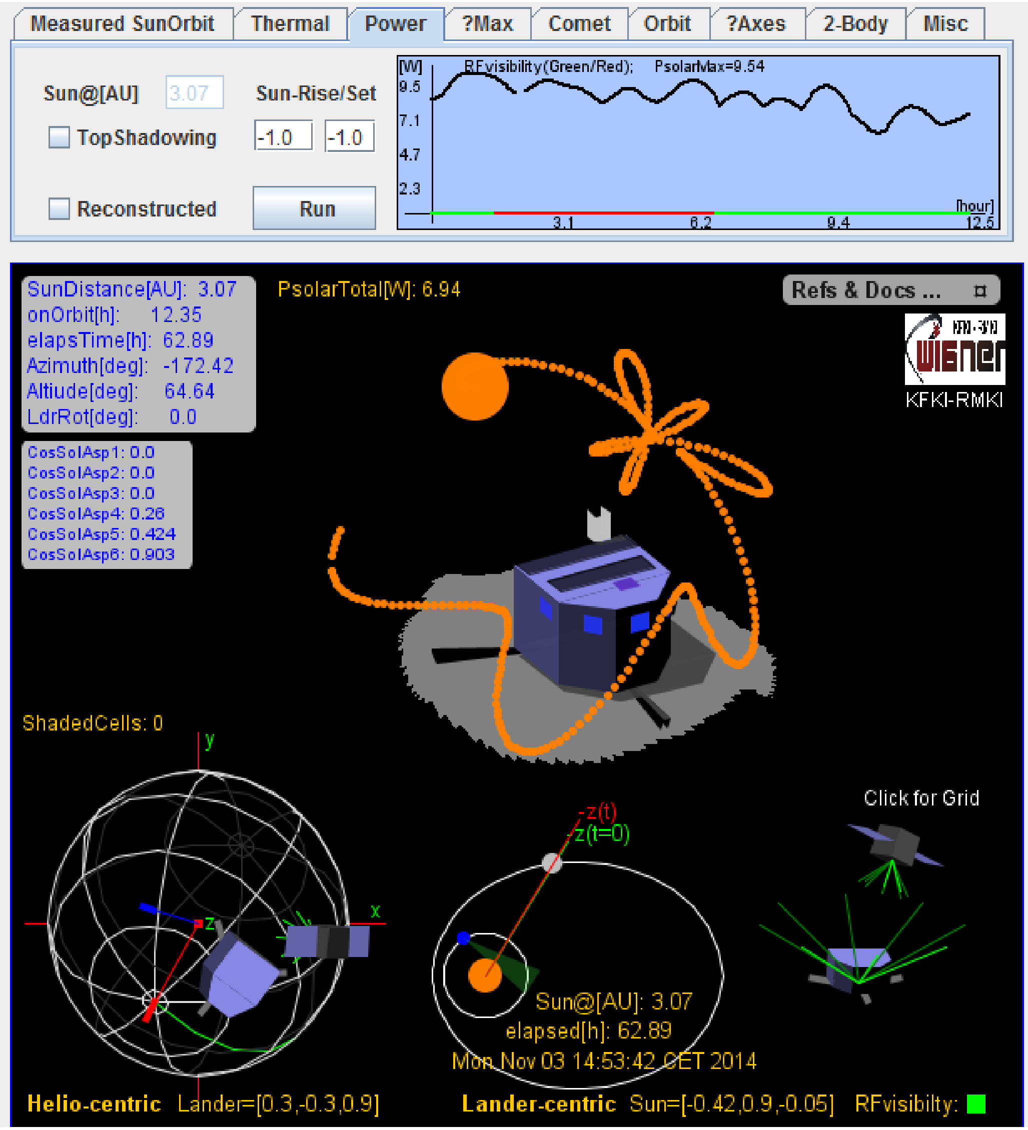
- Reconstructed rotational kinematics of the comet → RF communication scheduling

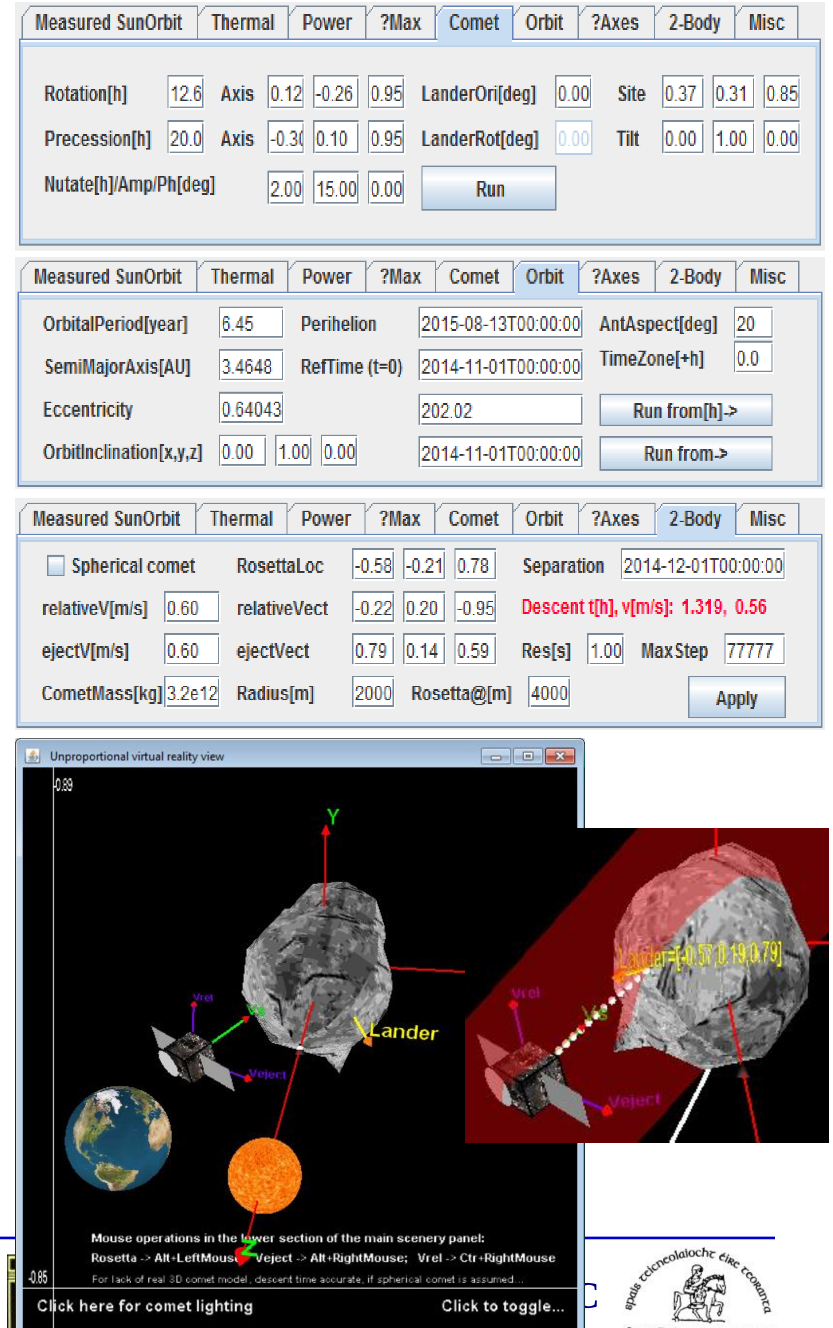
- The full SunLoc(t) vector function for long term can answer, **if it has sense at all** to rotate the lander to an orientation for collecting the maximal solar energy….
  - The answer depends on several factors (rotational axes and periods, changing illumination and thermal conditions, etc..).
  - May even be that – instead of maximum – rather the minimum should be preferred, so that the lander is not over-heated when flying close to the Sun.

Accounts and benefits
Some scientific aspects

- Reconstructed Sun orbit → Illumination-shadowing conditions
  at/around lander on a daily basis
- Cross point of rotational, precessional, nutational axes
  identifies the comet's mass centre
- „Regular" reconstruction of the rotational kinematics of the comet
  from Source-A (lander telemetry) can answer,
  - if the rotational kinematics, the axes and periods of the comet prove to be stable
  - if not stable, this knowledge may be correlated with other cometary events and/or activities, slow drifts and/or fast processes (outgassing, etc…)
- Either the eventual degradation or just eventual non-degradation of the solar panels may – as measured data – be input for making „some sort of science", e.g. dust building upon/after touching-down and/or later on, and/or ice buliding, etc… either yes or no, and why yes or no…
- Reconstruction of the rotational kinematics of the lander during/after descent
  from Source-A (lander telemetry) can answer the question,
  what the lander roughly did during descent
  Magyarán: utólag választ kaphatunk arra, hogy a lander miért fejjel lefelé landolt... ☹

http://tfo.rmki.kfki.hu/SunTracker





asi cnes DLR esa FMI IWF GRAZ Space Technology (Ireland) Ltd.