Rosetta - An example for a modern planetary mission

M. Hilchenbach
Outline

- timeline, matter and comets
- schedule and management approach for new missions
- Rosetta mission and payload
- Rosetta mission highlights up to 2010
Cosmological Timeline

13,700 m.y.a. 13,500 m.y.a. 4600 m.y.a.

- The Big Bang
- Formation of the First Stars
- At least two generations of massive stars
- Origin of our Solar System

4600 m.y.a.

- Formation of the Earth
- Phanerozoic Eon

Geologic Time

All dates are in millions of years ago (m.y.a.).
Comets – greatest and tiniest cheaters in the solar system
Famous comet: Halley

Comet Halley (March 13, 1986)

„dirty snowbal“ ?

Edmond Halley, painted by Thomas Murray

nucleus, gas and dust 1986
Schwassmann-Wachmann 1, outburst beyond Jupiter’s orbit

Comet West, 1976
Cometary nucleus 19 P/Borelly

Deep space 1
2001
Cometary nucleus 81P/Wild-2

Stardust 2004

~ 5 km
Comet Tempel 1: Impact: July 4, 2005
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Timeline for new space missions

agencies: call for program visions →

mission proposal competition and selection →

years 1-2 →

science payload proposals →

years <1 →

payload selection and hardware →

mission →

years 3-6+ →

years 5-8+ →

science data phase →

years 0-10+ →

years 0-20+

agencies:

ESA, NASA, DLR, CNES etc.
Children's Books Online: the Rosetta Project, Inc.
www.childrensbooksonline.org

Space missions: General management approach

- **payload:** scientific institutes and/or industry
- **satellite:** agency contracted to industry
- **mission operation:** agency
- **mission science return:** scientific institutes
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Science goals of Rosetta mission

- a global characterization of the nucleus,
- the determination of its dynamic properties,
- the surface morphology and composition,
- the determination of chemical, mineralogical and isotopic compositions of volatiles and refractories in the cometary nucleus,
- the determination of the physical properties and interrelation of volatiles and refractories in the cometary nucleus,
- studies of the development of cometary activity and the processes in the surface layer of the nucleus and inner coma, that is dust/gas interaction,
- studies of the evolution of the interaction region of the solar wind and the outgassing comet during perihelion approach.
Mission Rosetta: orbiter and lander
Rosetta
Design Depends on Individual Who Defines Problem

As proposed by the project sponsor       As specified in the project request       As designed by the senior designer

As produced by manufacturing       As installed at the user's site       What the user wanted

FIGURE 1.4
Note how the design depends on the viewpoint of the individual who defines the problem.
update of landing gear
Oct 2003
<table>
<thead>
<tr>
<th><strong>Size:</strong> main structure</th>
<th>2.8 x 2.1 x 2.0 m³</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Span of solar arrays</strong></td>
<td>32 m</td>
</tr>
<tr>
<td><strong>Launch mass:</strong> total</td>
<td>2900 kg</td>
</tr>
<tr>
<td>- propellant</td>
<td>1720 kg</td>
</tr>
<tr>
<td>- science payload</td>
<td>165 kg</td>
</tr>
<tr>
<td>- lander PHILAE</td>
<td>100 kg</td>
</tr>
<tr>
<td><strong>Solar array output</strong></td>
<td>850 W at 3.40 AU</td>
</tr>
<tr>
<td></td>
<td>395 W at 5.25 AU</td>
</tr>
<tr>
<td><strong>Propulsion subsystem</strong></td>
<td>24 bipropellant</td>
</tr>
<tr>
<td></td>
<td>10 N thrusters</td>
</tr>
<tr>
<td><strong>Operational life time</strong></td>
<td>12 years</td>
</tr>
<tr>
<td><strong>Prime contractor</strong></td>
<td>Alenia Spazio, Italy</td>
</tr>
</tbody>
</table>
RPC: Plasma- and magnet field

ROSINA: abundance and velocity of gas and ions

Plasma- and neutral particle measurements onboard ROSETTA
Dust measurements onboard ROSETTA

MIDAS: Dustmicroscope

GIADA: Dust flux measurements

COSIMA: Element abundancies
CONSORT: radiowavetransmission („tomography“)

MIRO: microwavemeasurements

RSI: mass and density
OSIRIS: The ROSETTA cameras

VIRTIS: Infrared spectrometer

ALICE: UV spectrometer

Elektromagnetic waves onboard ROSETTA (II)
Rosetta COSIMA

COSIMA, a High Resolution Time-of-Flight Secondary Ion Mass Spectrometer for the Analysis of Cometary Dust Particles

COSIMA - functional diagram

- Target (Chemistry Station)
- Cometary Dust
- Target (Collect Position)
- Target Store
- Robotic Arm with Target (Spectrometer Pos.)
- Camera
- Tungsten Needle
- Primary Ion Beam
- Secondary Ion Beam
- Ion Optics
- Ion Source
- Ion Reflector
- Drift Tube
- Ion Detector
- Data from/to ROSETTA Spacecraft

Electronics
Selection of target comet for the Rosetta mission - I
Selection of target comet for the Rosetta mission - II

conditions:
periodic comet, „new“ in the inner solar system and target comet should not fall apart*, and rocket should be ready for launch in time....

*unpredictable...
Target comet for Rosetta in 2003:

67P/Churyumov-Gerasimenko

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>size</td>
<td>$3 \times 5 \text{ km}$</td>
</tr>
<tr>
<td>perihelion</td>
<td>1.292 AU</td>
</tr>
<tr>
<td>aphelion</td>
<td>5.730 AU</td>
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</table>

67P/Churyumov-Gerasimenko
February 1st 2003
Approaching comet 67P/Churyumov-Gerasimenko

Journey to comet (2004-2014)

Launch of Ariane V 2004

Science at comet (2014/2015: 12 month)
journey: ~ 10 years

1 Start von Erde
02.03.2004

2 Swing-by 1/Erde
04.03.2005

3 Swing-by 2/Mars
25.02.2007

4 Swing-by 3/Erde
13.11.2007

5 Fly-by Steins
05.09.2008

6 Swing-by 4/Erde
13.11.2009

7 Fly-by Lutetia
10.07.2010

8 Rendezvous Komet
22.05.2014

9 Landung auf Komet
10.11.2014

Today!
...and in Nov 2014...
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Mission operation

• **Mission Operations Centre**: European Space Operations Centre (ESOC), Darmstadt, Germany
• **Prime Ground Station**: New Norcia, near Perth, Australia
• **Science Operations Centre**: Space Astronomy Centre (ESAC), Madrid, Spain
• **Lander Control Centre**: DLR, Cologne, Germany
• **Lander Science Centre**: CNES, Toulouse, France
• Planned operational duration: 12 years
Outlook and milestones towards comet 67P/Churyumov-Gerasimenko

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<tr>
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<td>March 4, 2005</td>
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<td>Mars Gravity Assist</td>
<td>February 25, 2007</td>
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<tr>
<td>Second Earth Gravity Assist</td>
<td>November 13, 2007</td>
</tr>
<tr>
<td>2867 Steins Flyby</td>
<td>September 5, 2008</td>
</tr>
<tr>
<td>Third Earth Gravity Assist</td>
<td>November 13, 2009</td>
</tr>
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<td>21 Lutetia Flyby</td>
<td>July 10, 2010</td>
</tr>
<tr>
<td>Rendezvous Manoeuvre 1 and Start of Hibernation</td>
<td>January 23, 2011</td>
</tr>
<tr>
<td>Exit Hibernation</td>
<td>January, 2014</td>
</tr>
<tr>
<td>Comet Rendezvous Maneuver Between 4.5 and 4.0 AU</td>
<td>Spring, 2014</td>
</tr>
<tr>
<td>Start of Near-Nucleus Operations at 3.25 AU</td>
<td>August 22, 2014</td>
</tr>
<tr>
<td>PHILAE Deployment</td>
<td>November, 2015</td>
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<td>Perihelion Passage</td>
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<td>December 31, 2015</td>
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M42 Orion Nebula - Osiris NAC Color Composite
Outlook and milestones towards comet 67P/Churyumov-Gerasimenko

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