SMART-1
Reserve slides

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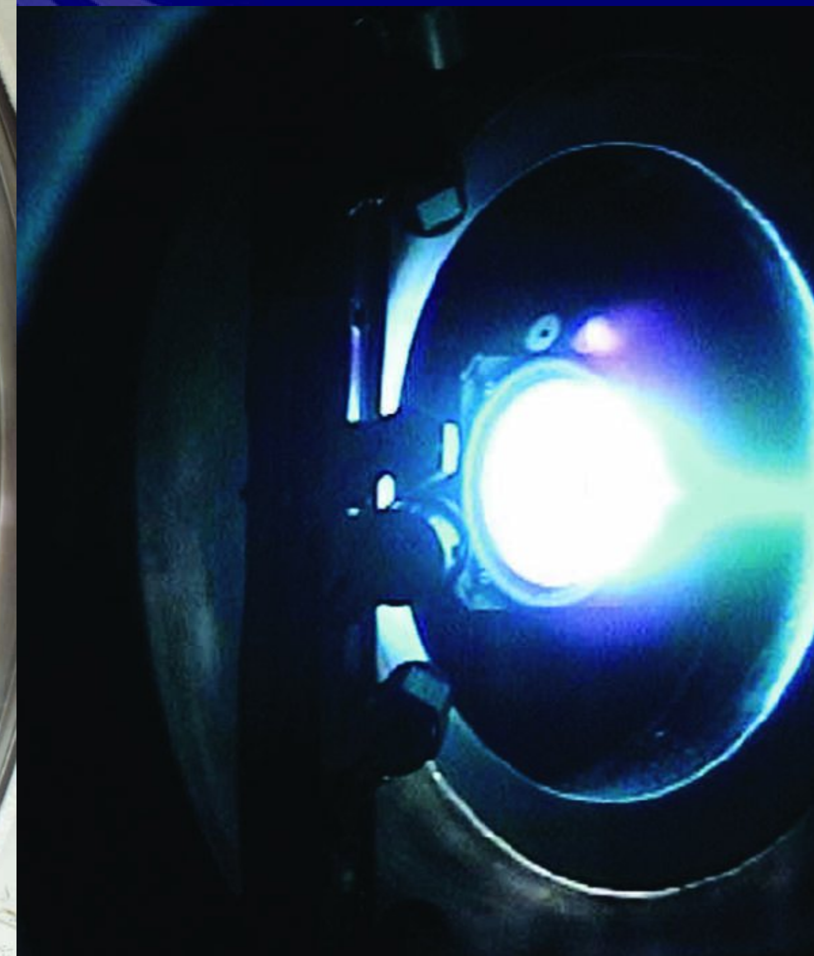
Electric Primary Propulsion: 7 g thrust, 60 liters Xenon fuel to the Moon



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esa

Europe to the Moon

The Launch

• V162 lift-off on 27 September 2003 at 23:14:39 UTC – The launch was perfect

• SMART-1 separated at 23:56:03 into a GTO (656 x 35,881 km): perfect injection

• 100 s later telemetry was received by Perth GS

•Automatic activation sequence worked flawlessly

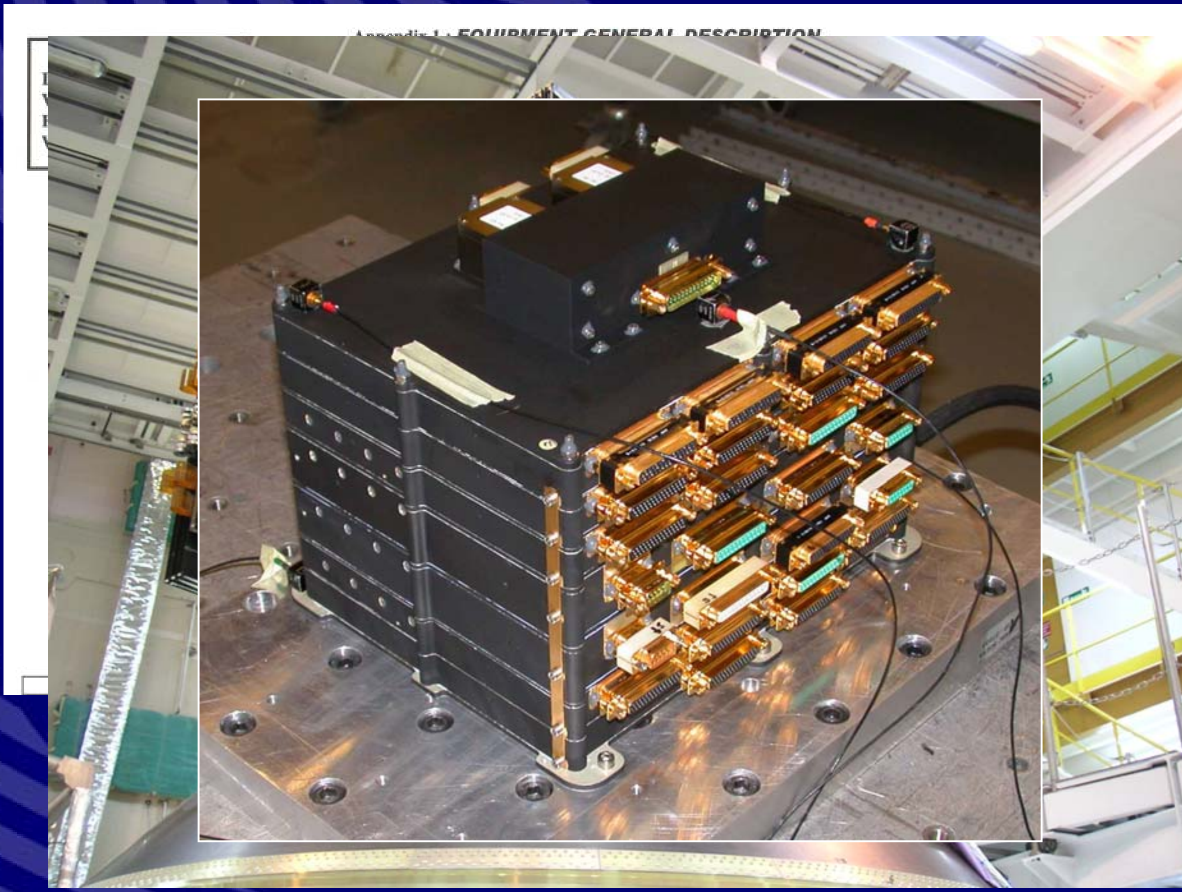
Technology Achievements

Technology objectives fully achieved, through:

- Flight Earth-Moon powered by Solar Electric Primary Propulsion and making use of the lunar gravity assists and weak stability boundaries;
- Technology demonstration
  - advanced communications (Ka-band, Laser Link),
  - autonomy, novel navigation,
  - miniaturisation of instruments
  - spacecraft technologies (batteries, solar cells, computer, software)

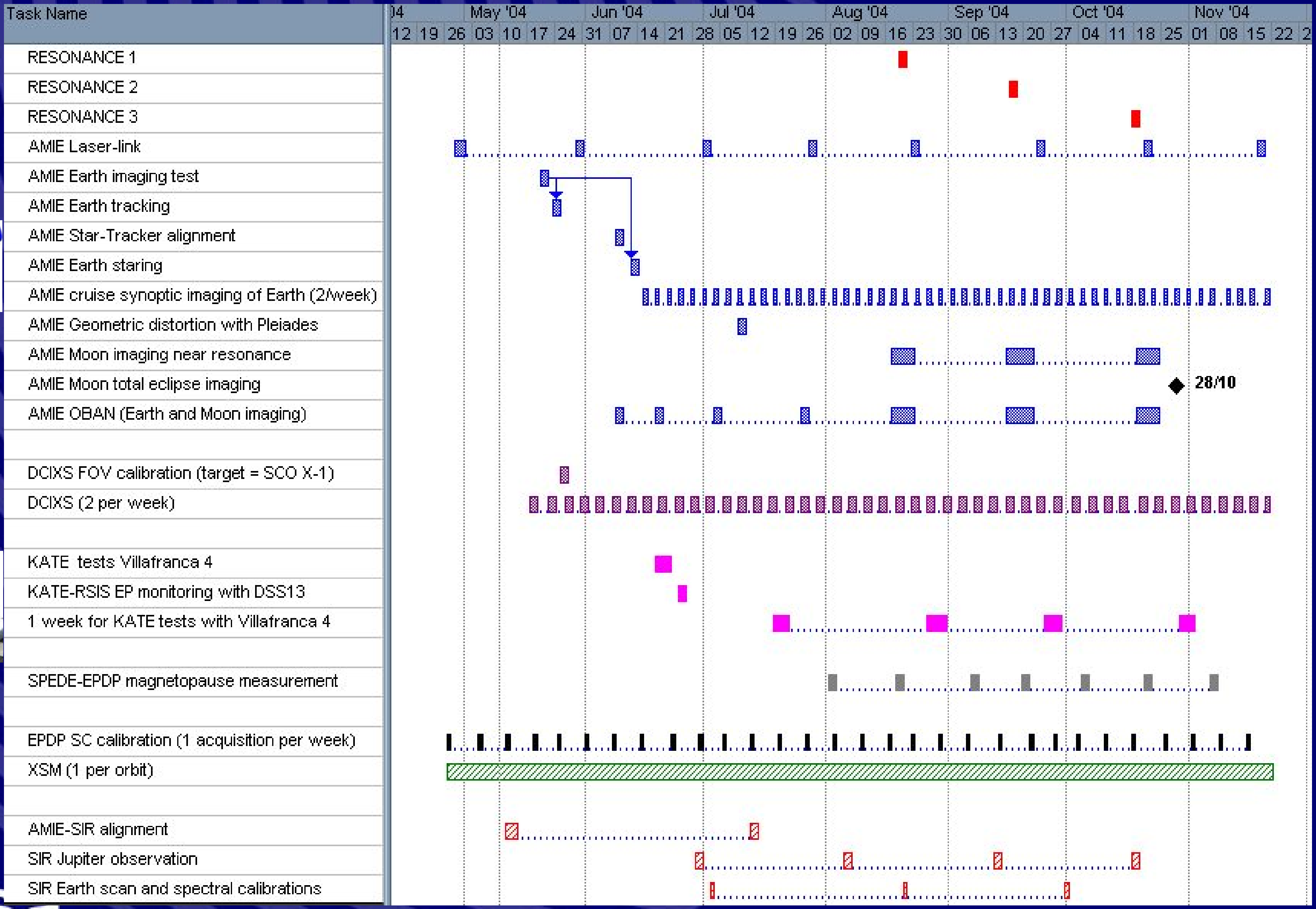
Spacecraft Technology

- New type of batteries, which allowed the spacecraft to withstand eclipses longer than expected,

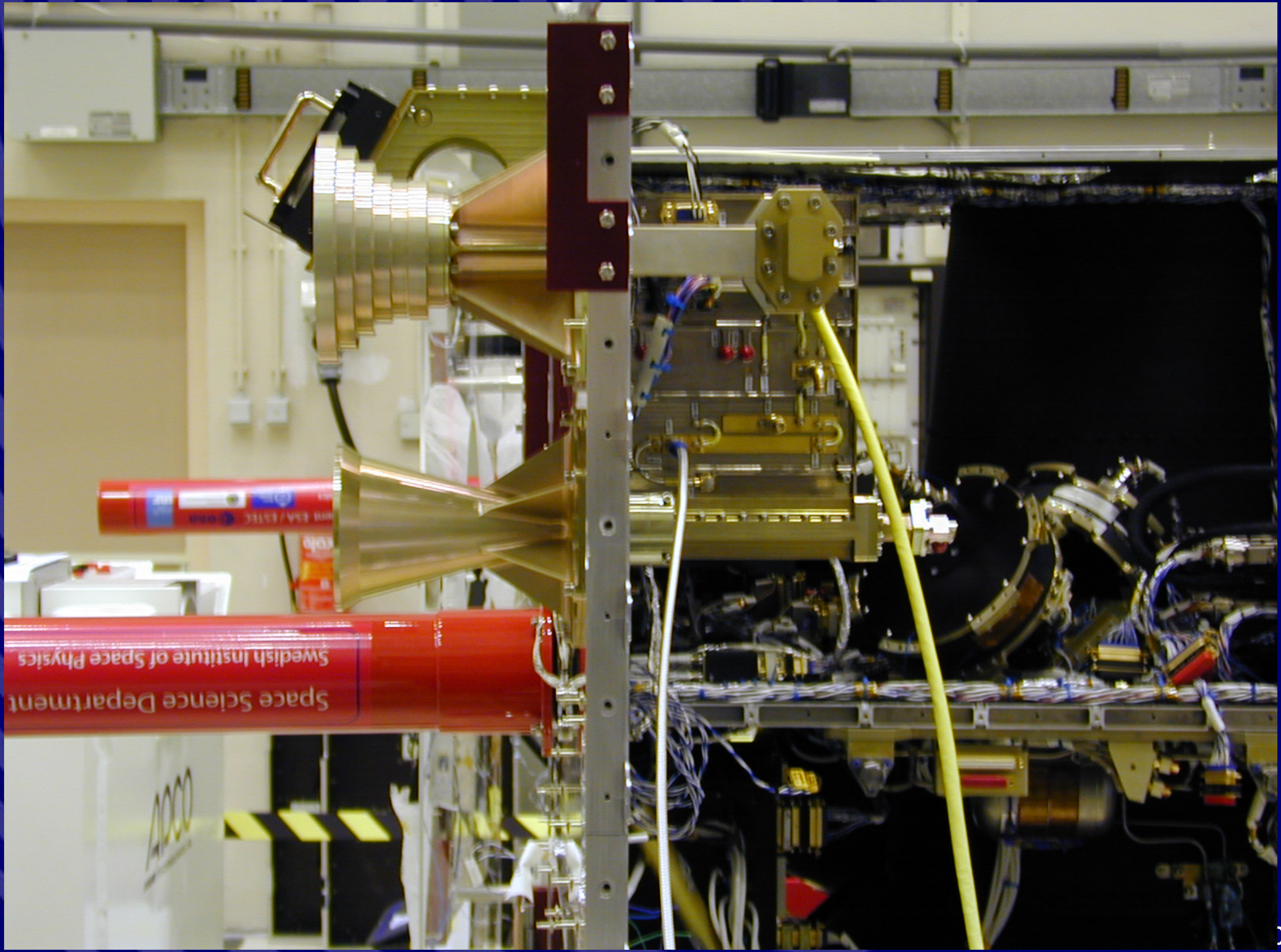


- New types of solar cells, which resisted very well to the heavy bombardment in the radiation belts
- Compact onboard computer,
- Sophisticated SW which allowed to solve problems

Cruise April-Nov 04 planning: a Smart musical score

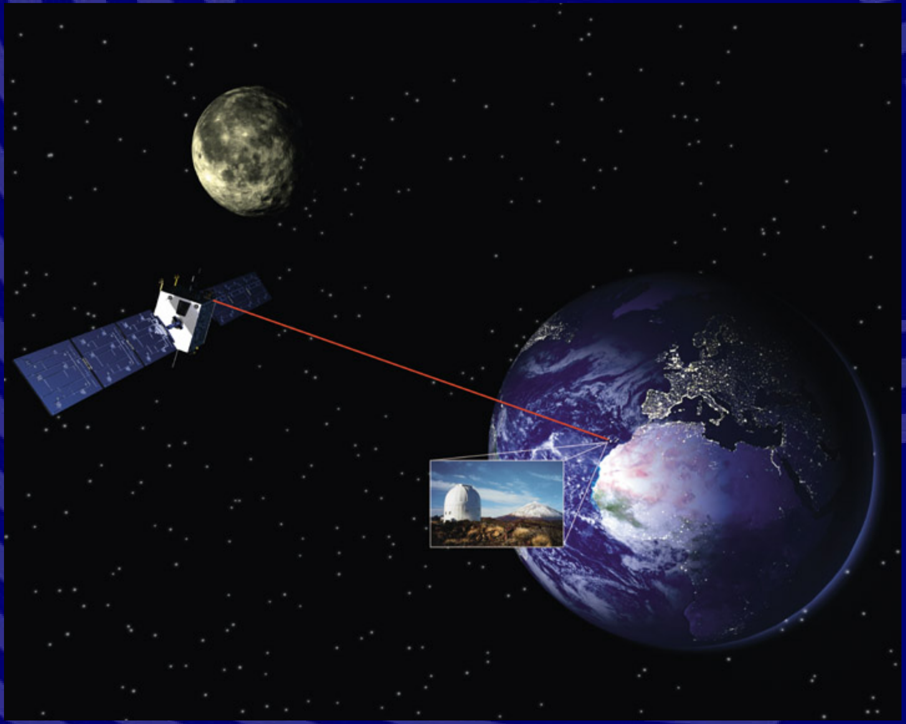


Communication Technology: Ka-band



KaTE ground station

Laser Link experiment



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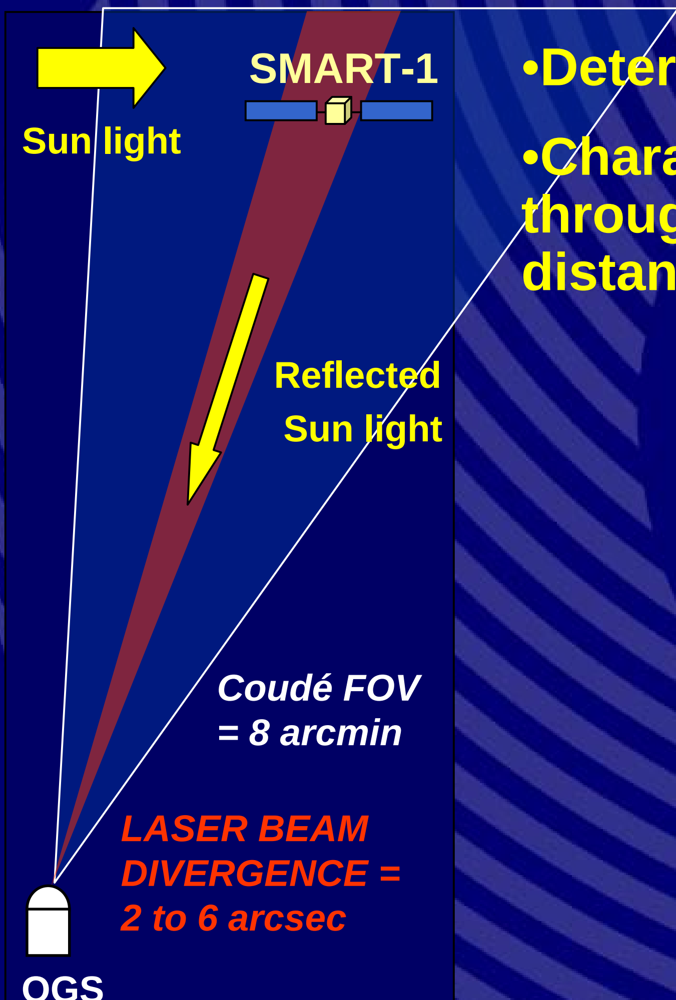
Laser Link

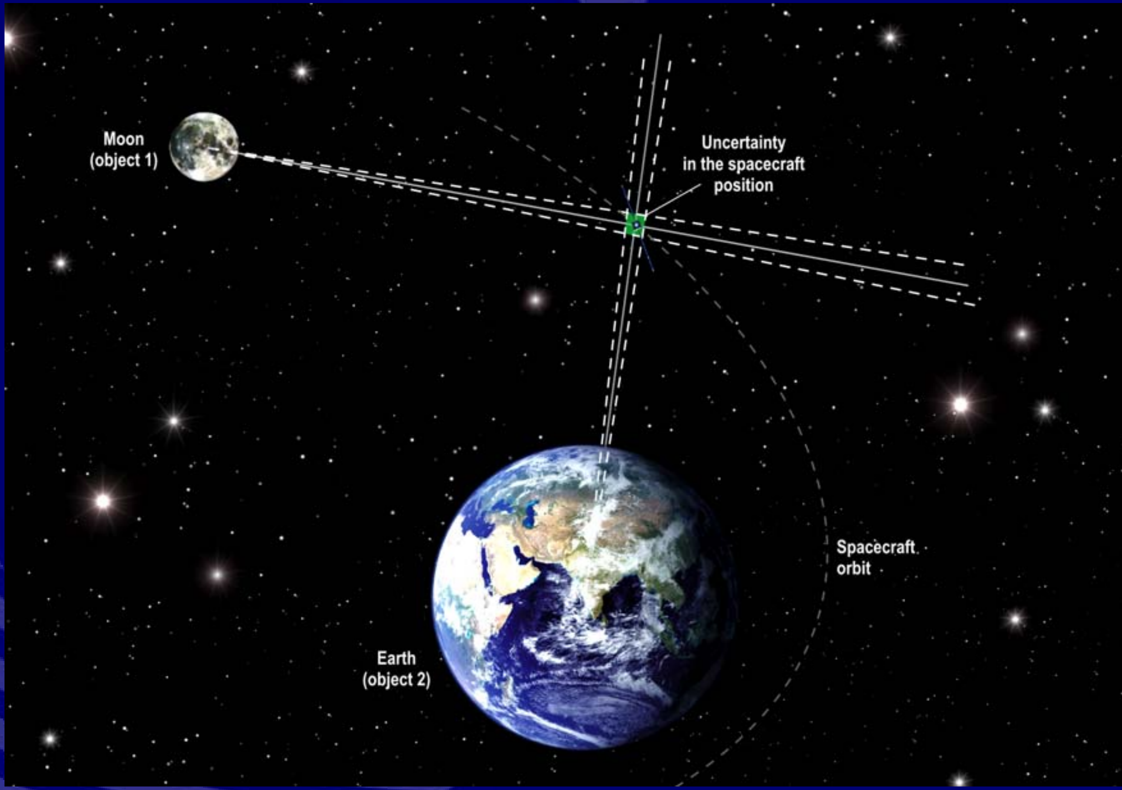
Demonstration for future deep space optical communication



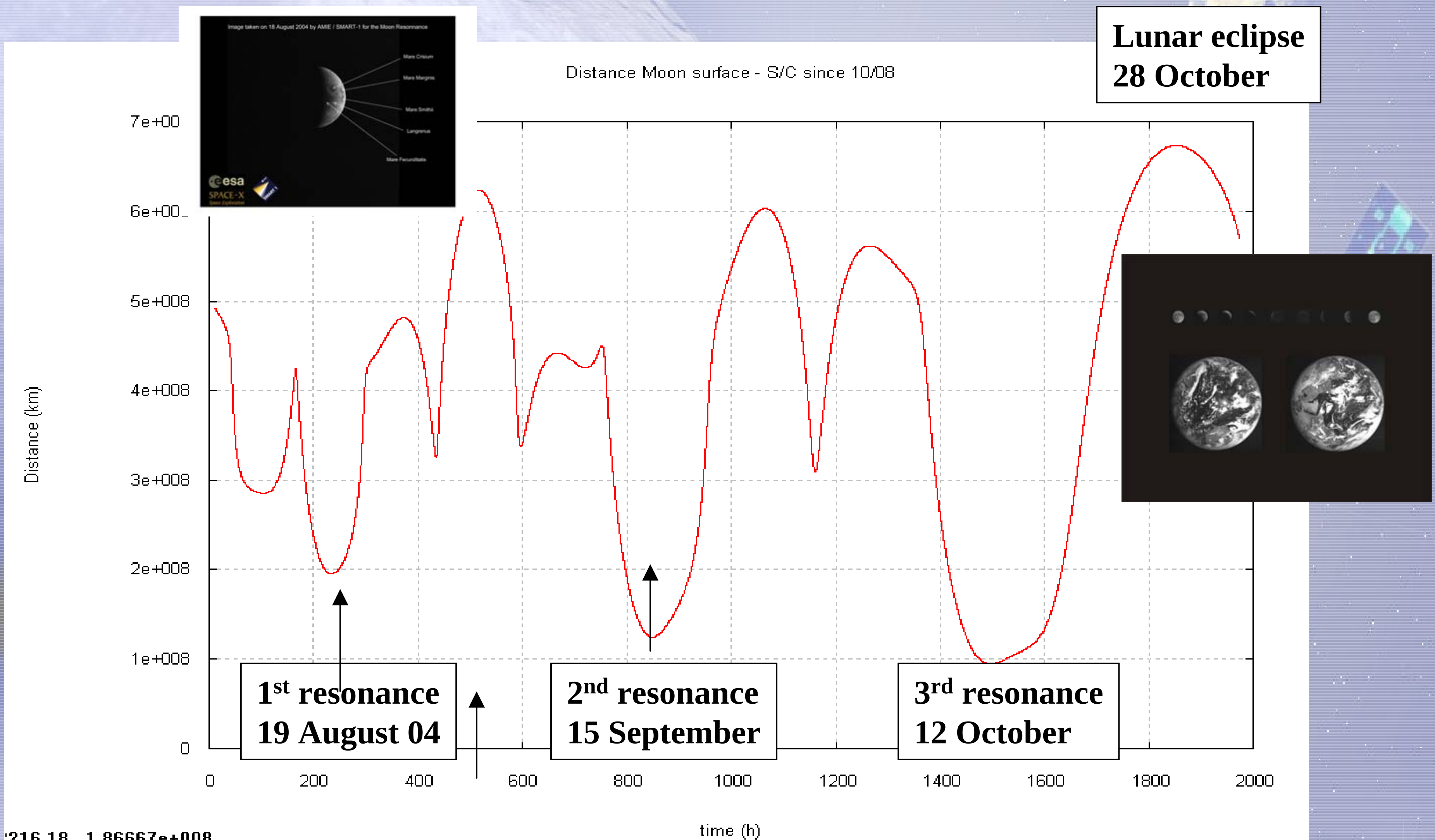
- Determination of an accurate alignment procedure
- Characterization of laser beam propagation through atmosphere & space for various link distances and elevations

OBAN

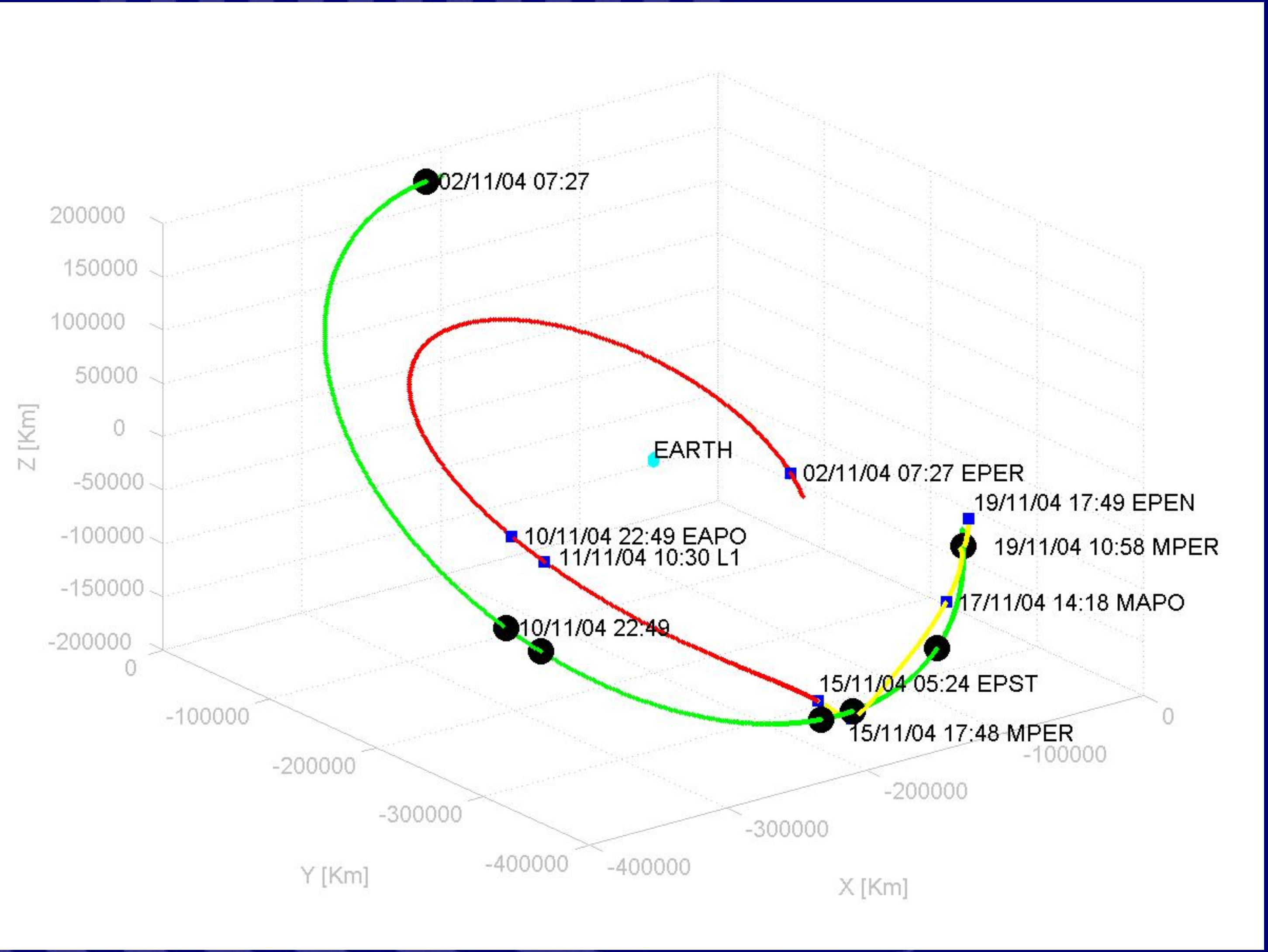
- AMIE camera and the Star Tracker are used to make images of solar system objects
- By triangulation determine the position and the velocity of the spacecraft



From resonances to eclipse: SMART-1 Distance to the Moon



Final approach to first lunar orbit to the Moon



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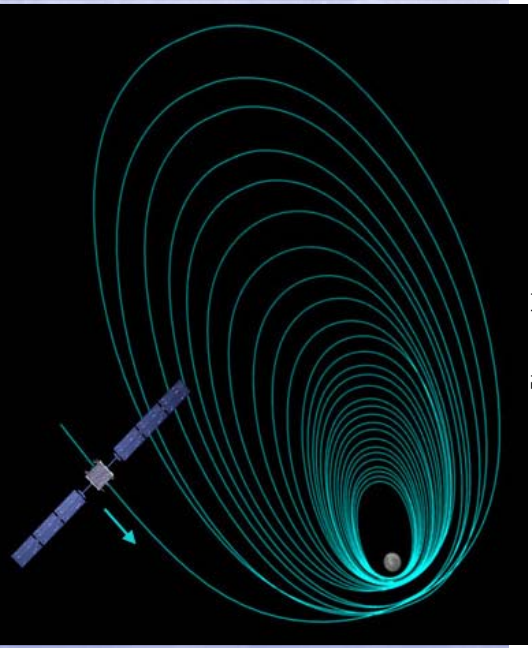
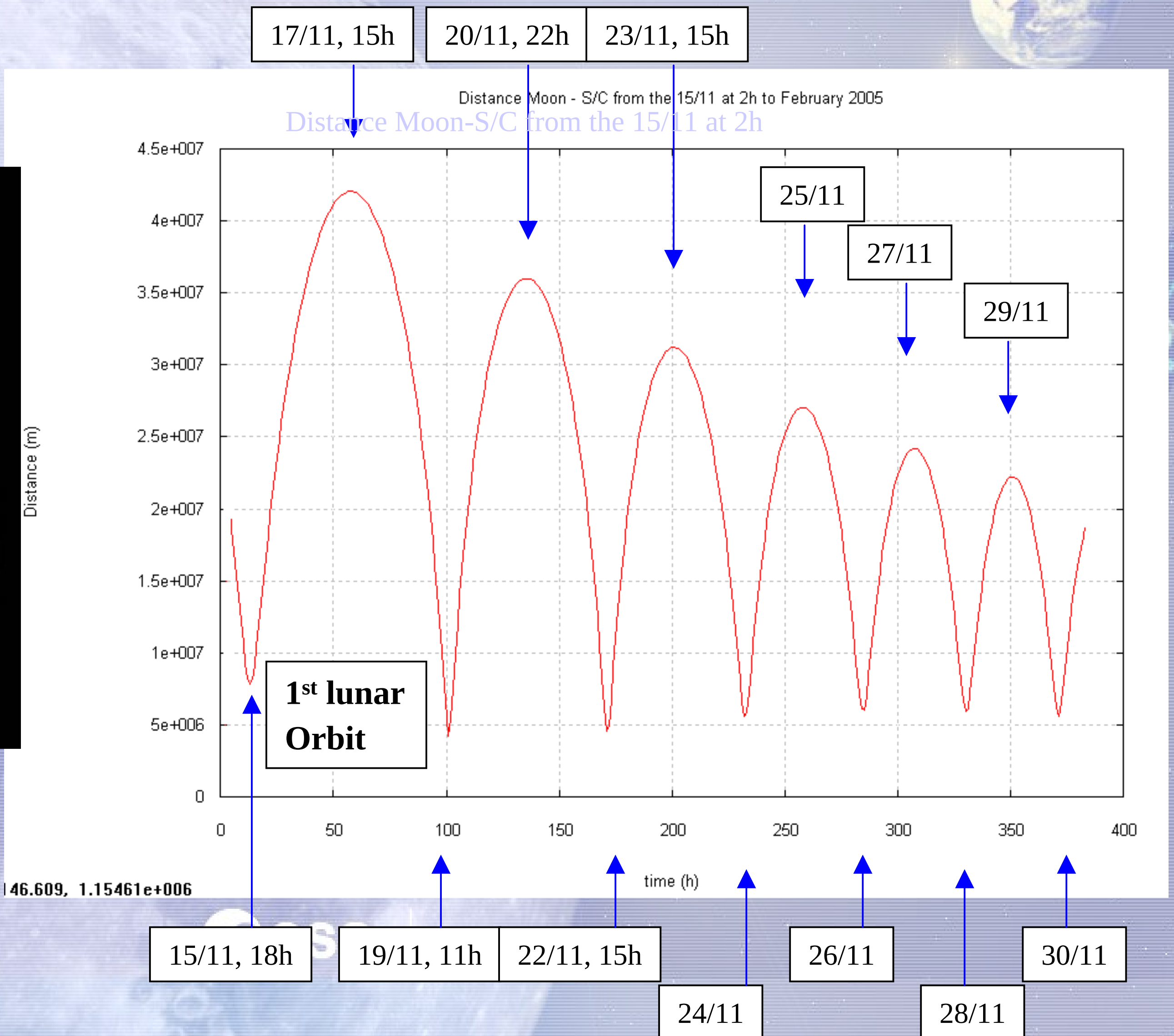
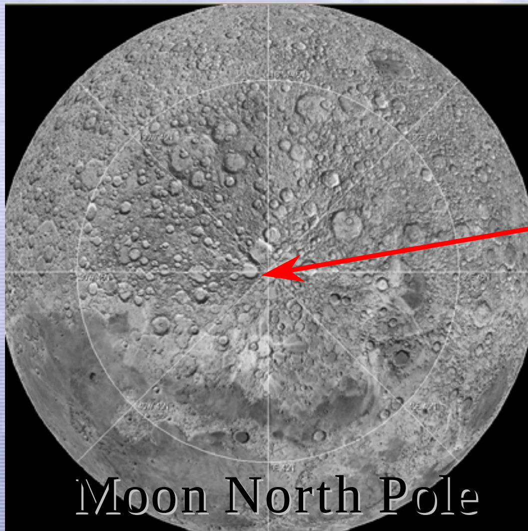
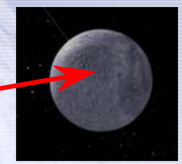
Spiralling down closer to the Moon, towards science orbit 300-3000 km after 15 January 05



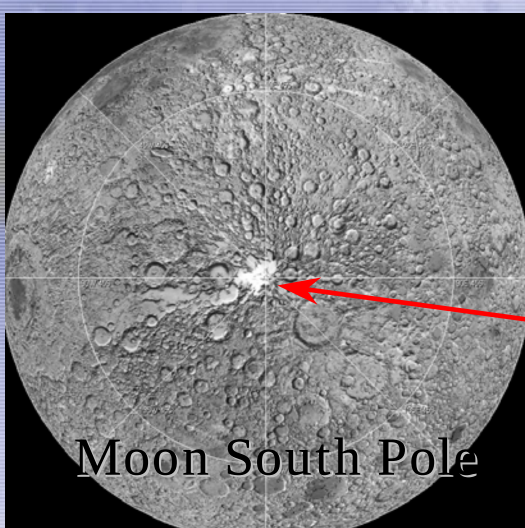


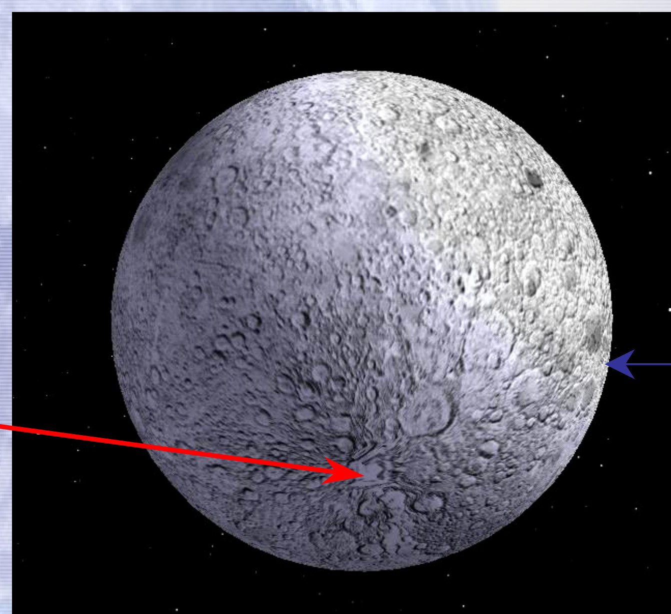
1st Perilune-Apolune around the Moon





Face of the Moon
at the 1st apolune
From 40000 km





Face of the Moon
at the 1st perilune
From 5000 km

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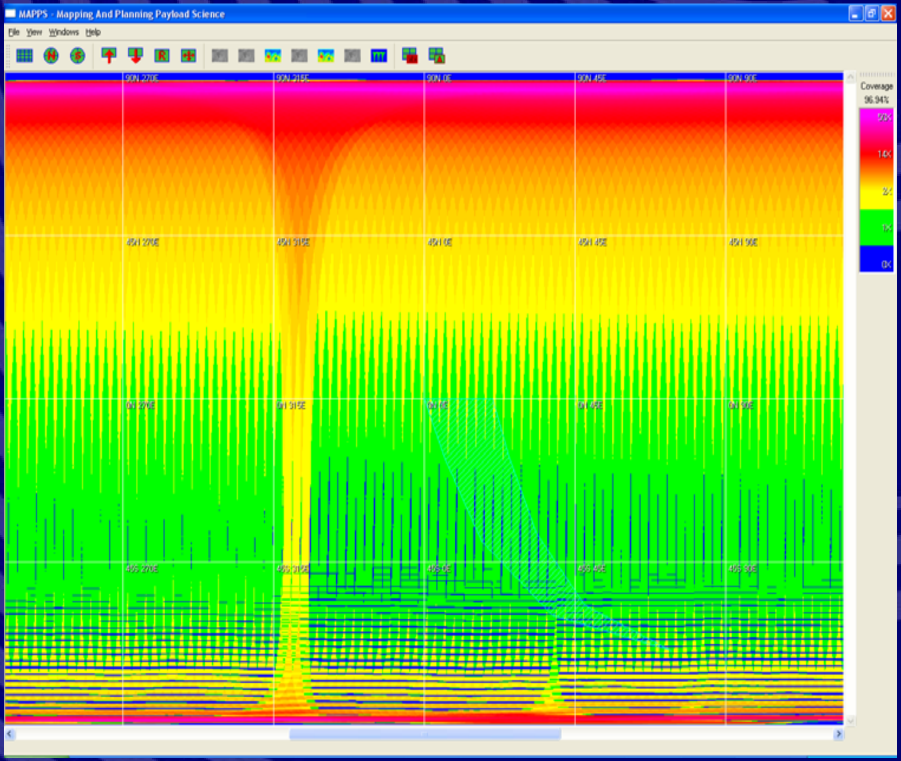
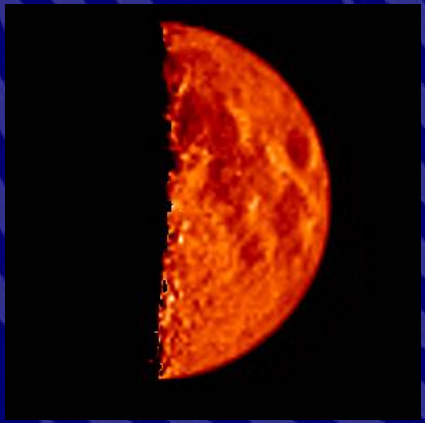
Full-frame global mapping, 50% overlap low res survey from 1000- 4500 km

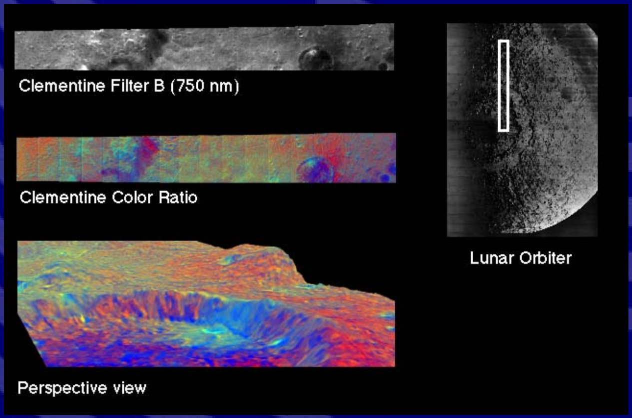


- "Simple and systematic" mode of operation – default nadir pointing and repetitive commanding

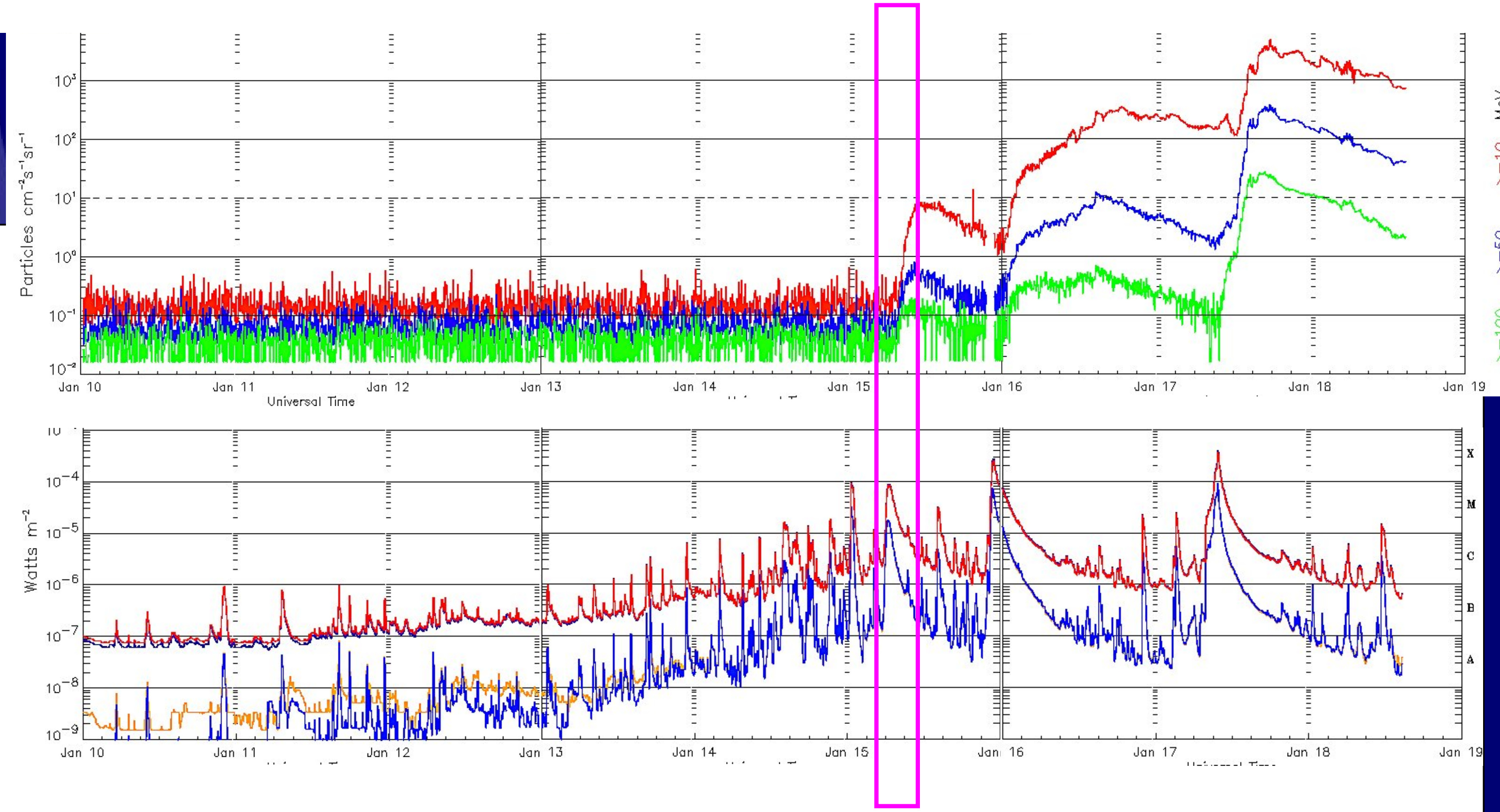
SMART-1 Science/Exploration Opportunity

- INSTRUMENTS READY FOR LUNAR TASKS
- 1st X-ray global mapping for Mg, Al, Si at 50 km resolution
- 1st infrared spectral mineralogy mapping 0.9- 2.5 microns
- Local multi-band mapping at resolution 40 m from 300 km
- Polar areas illumination and resource mapping
- Stereo mapping for Digital Elevation Models





Community support: operation, PDS archive, data analysis and science exploitation
Extension to 2006, and joint international investigations



This is proton (top) and X-ray (bottom) data from the GOES space weather monitor. Early on January 15th there is an M9 X-ray flare…

Assumption for science payload operations:

- Standard mode: payload operations conducted over illuminated side of the Moon pole-to-pole:
- priority 1 from south pole to 2000 km distance (with nadir or near nadir pointing)
- priority 2 for part 2000-3000 km
- priority 3 operations on dark side (pending spacecraft platform operations and data download)
- Off nadir pointing and targeted observations during extension phase
- STWT & Project scientist overall responsibility for science operations
  - long term science planning (with STWT and RSSD support staff)
  - mid-term and short term operations (with PIs, STOC and ESOC staff)
  - data archiving (with PIs and RSSD Planetary science archive staff)

SMART-1 Science Management Plan SPC nov 99

- The ESA Project Scientist will act as the Chairman of the SMART-1 Payload Working Team (SPWT), and as such coordinate its activities.
- The ESA Project Scientist will assume responsibility for management of the SMART-1 Project at a suitable time after launch.
- The SMART-1 data rights will follow the established ESA rules (ESA/C(89)93). Therefore all scientific data obtained during the full mission duration will remain proprietary of the Investigator teams for a period of up to 6 months after they have been received from ESA.

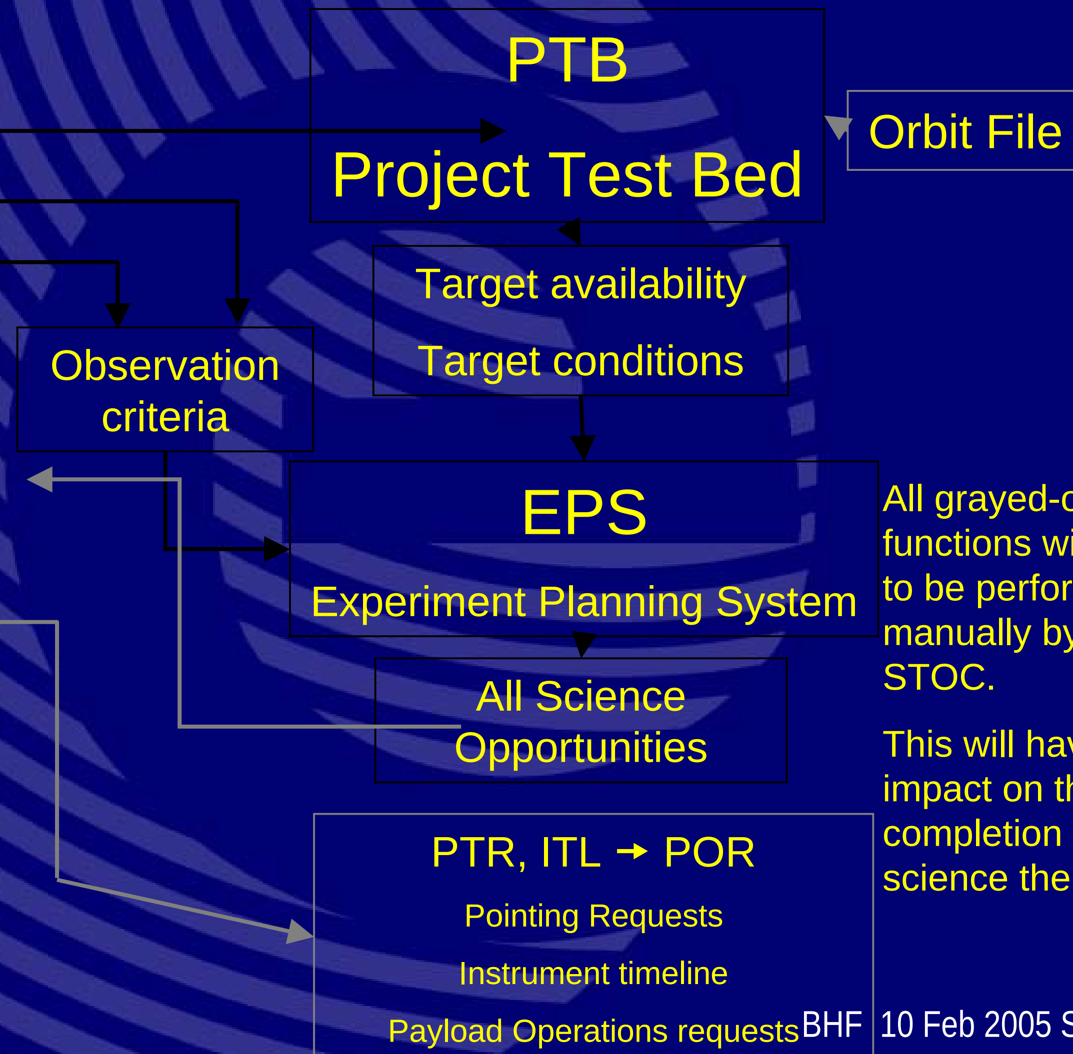
Science Planning Software – Present status

•SPS Functions

•Linked knowledge base:
- Target Lists
- Science constraints
- Observation Requests
- Science Themes

•Analysis:
- Matches science opportunities to observations
- MTP observation selection

•Record:
- Selected observations
- Contribution to the science themes



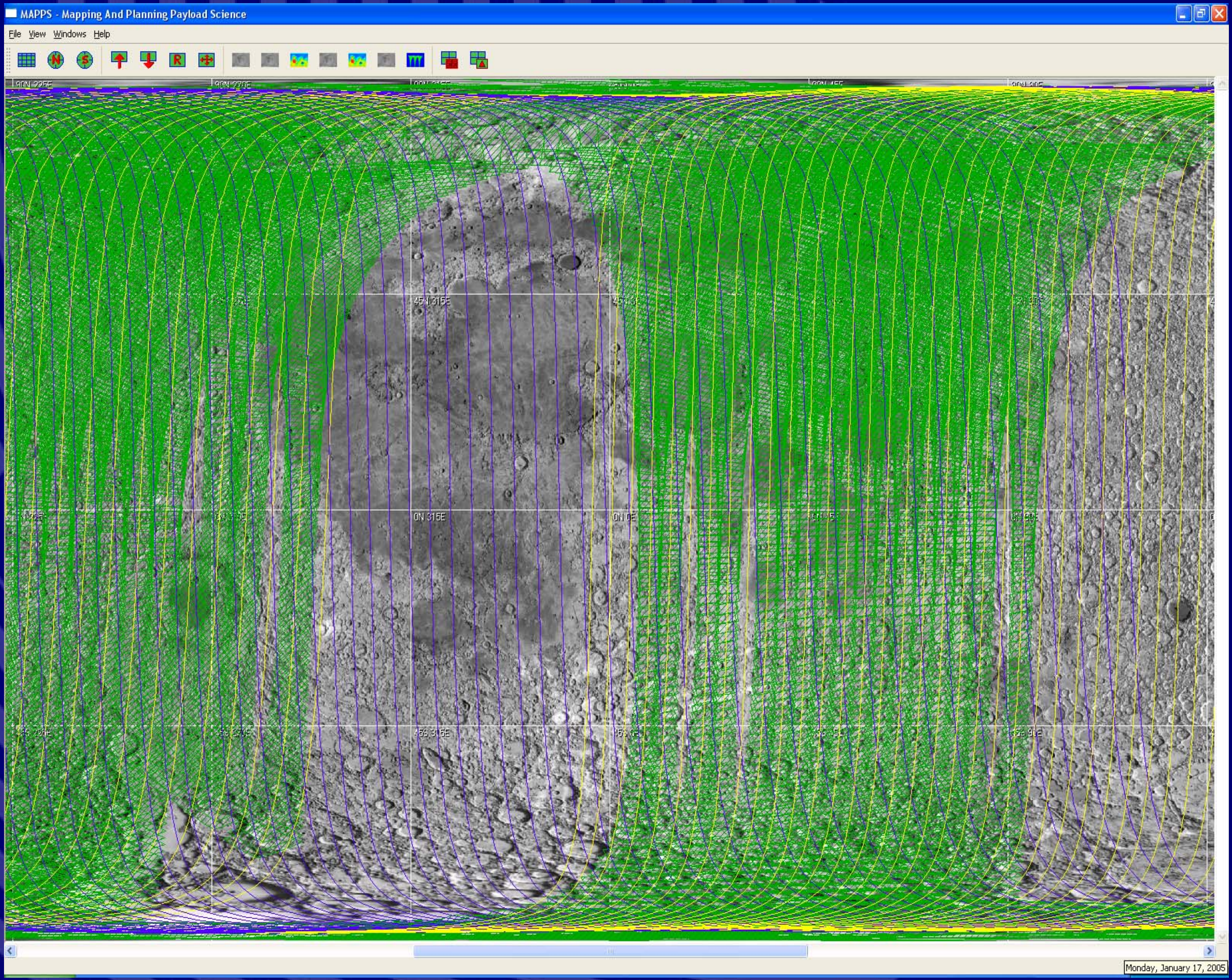
All grayed-out functions will need to be performed manually by the STOC.

This will have an impact on the completion of science themes

AMIE commanding levels

- Constraints: nominal uplink every 4 days = 8000
  - Max commands/APID = 4096. , POR Payload Operation Request= 9999
- Executed Operations: New Year: colour with 50% overlap at 1000-5000 km orbit
  - 137 images*9 commands*3 orbits ~ 4000/day
    - solution 1, use 4 APIDs
    - solution 2, uplink every day
    - solution 3, reduce # of commands/image (proposal to reduce to 5 tbc by AMIE)
    - solution 4, reduce number of images to 35!
- Consolidated operations: Jan 2005: colour imaging
  - 122 images*5 commands*3 orbits = ~2000/day
    - solution 1, use 2 APIDs
    - solution 2, uplink every 2 days
    - solution 3, reduce # of commands/image
    - solution 4, reduce number of images!
- Future Operations: Science phase: 20% overlap to avoid gaps due to s/c rotation
  - 150 images*5 commands*5 orbits ~ 2750/day
    - solution 1, use 3 APIDs!
    - solution 2, uplink every day
    - solution 3, reduce # of commands/image to 1 macro-command
    - solution 4, compromise: reduce # of commands/image to 2, uplink every 2 days
    - solution 5, reduce number of images to < 40

January Low resolution Coverage



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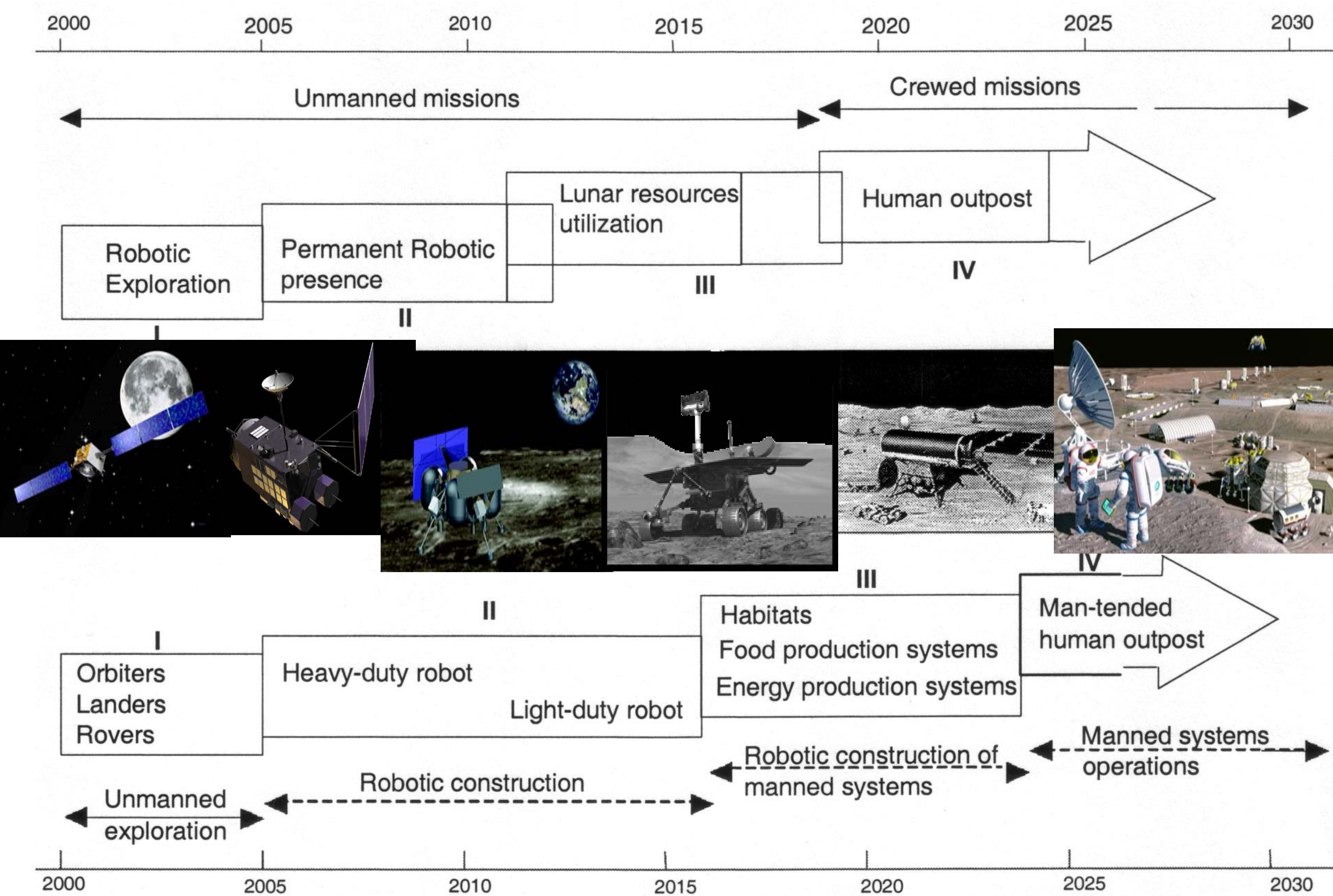
Case for 1 year extension

- to extend the global coverage for AMIE, SIR, DCIXS
- due to 1 mrad FOV and telemetry limitations, it is expected that only a few percents of the surface will be covered by the SIR spectrometer after 6 months
- due to telemetry limitations the extension permits to augment coverage by the AMIE camera at high res colour mode
- Only 2 over 6 months give good illumination conditions for IR spectrometry, X-ray sensitivity and quantitative colour radiometry
- increases the probability of solar flares events (in rising solar activity) for very sensitive D-CIXS scans providing high res maps Fe
- to perform dedicated programmes to prepare future international lunar missions
  - mapping potential landing sites for future missions (including South pole Aitken sample return)
  - Measurements in coordination and preparation for observations with Lunar A cameras and Selene, Chandrayaan-1, Chang’E and LRO, seasonal illumination maps at high resolution)

ILEWG phased approach for lunar exploration

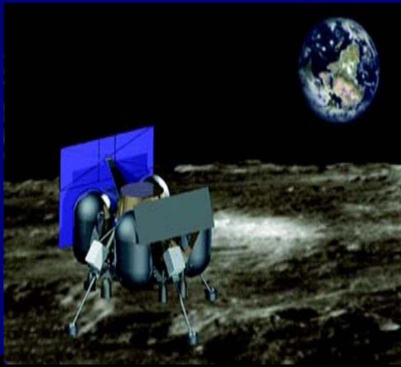


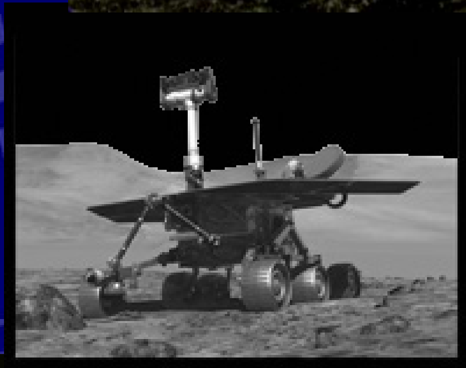
Roadmap for international lunar exploration

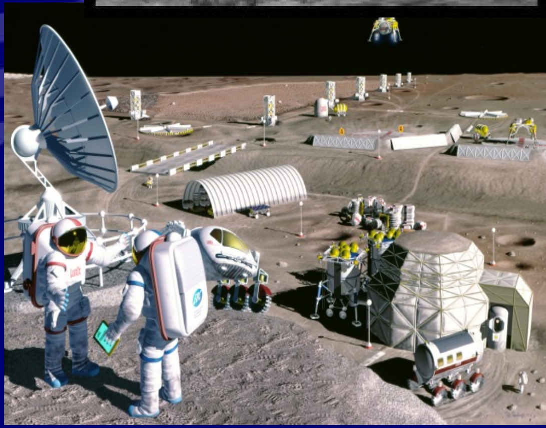
- 2014 International Robotic village
  - Robotic outposts: geology, water ice, life sciences,
  - Advanced landers/rovers from international partners
  - In Situ Resource Utilisation (power, minerals, H, O, He3)
  - Life support systems, deploying larger infrastructures
  - Autonomous & intelligent robots prepare for humans
- 2017 Man tended missions
- 2024 Permanent Lunar base
  - Living off the land on another planet

- Moon as SMART testbed for technologies
  - human/robot optimised operations,
  - step to Mars and solar system exploration

- Science, technology, exploration, societal synergies
  - Aurora/exploration, Cosmic Vision 2015-2025
  - Develop Europe as strong international space partner
  - Inspiring an innovative and competitive Europe







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