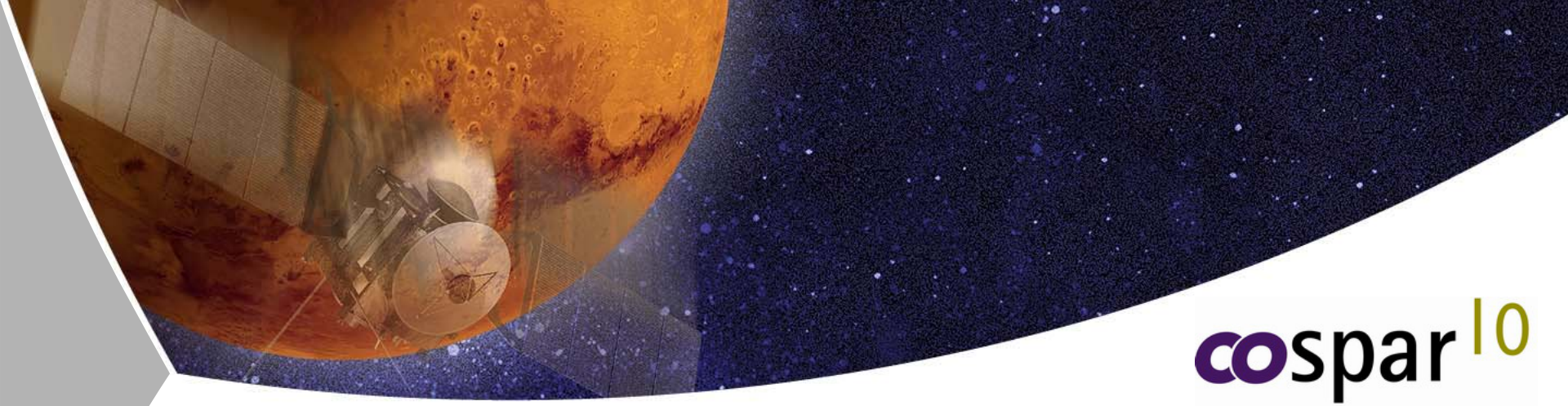


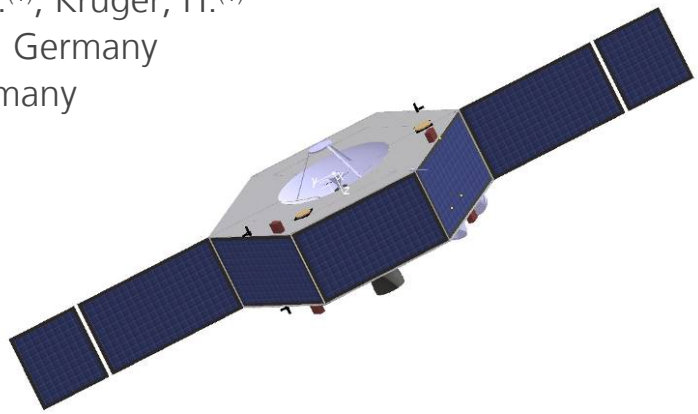
cospar 10
38th scientific assembly
18 – 25 july 2010 | bremen . germany

Germany's Option for a Moon Satellite

38th COSPAR B01-0016-10

Quantius, D.(1), Päsler, H.(2),
Gülzow, P.(2), Braukhane, A.(1), Vollhardt, A.(2), Bauer, W.(1), Romberg, O.(1),
Scheibe, K.(1), Hoffmann, H.(1), Börner, A.(1), Krüger, H.(1)
(1) DLR German Aerospace Center, Germany
(2) AMSAT-DL, Marburg, Germany

Bremen, 23 July 2010



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

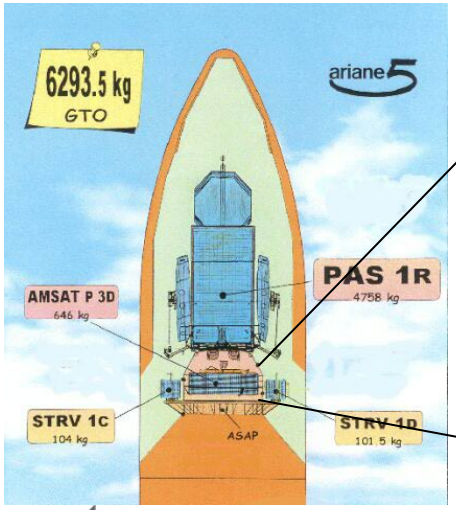
AMSAT-DL

Content

- Background
- Concept
- Transfer to the Moon
- Instruments
- Conclusion

Background

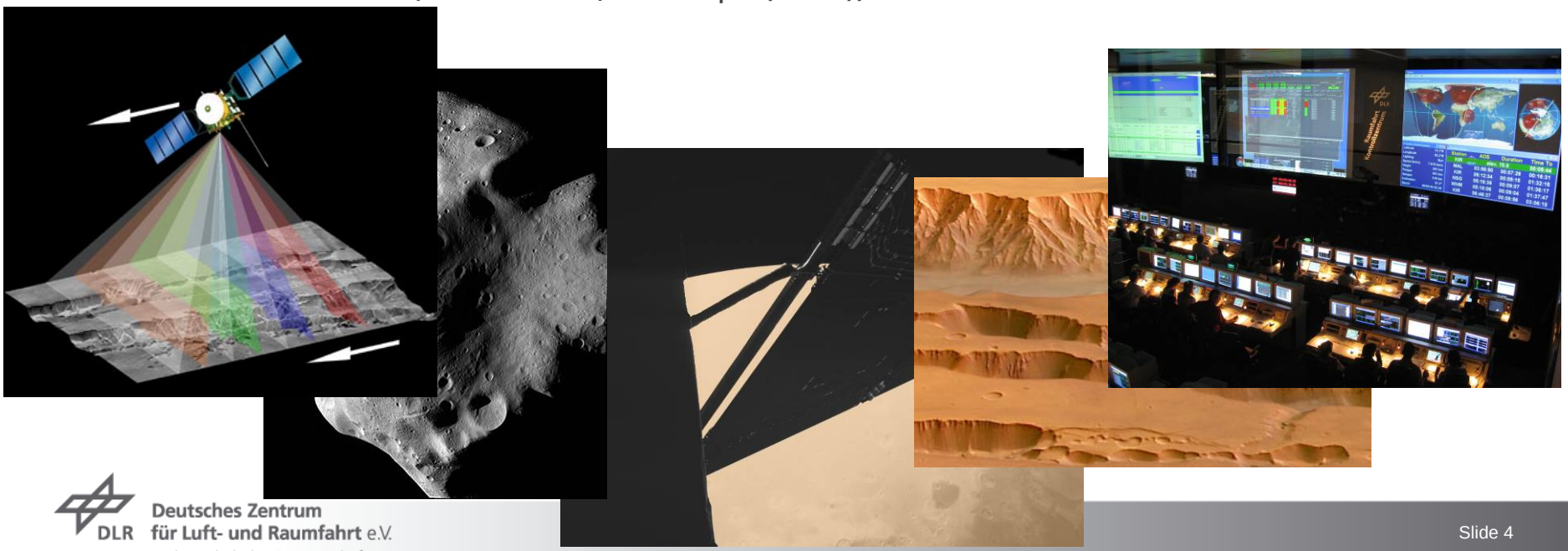
- AMSAT-DL:
  - German non-profit amateur satellite organisation (~1200 members)
  - >30 years experience in planning, building + operating satellites
  - Low-cost missions in Earth orbit (LEO (800 km) and HEO (60000 km Apogee))
  - Usage of commercial off-the-shelf (COTS) components whenever possible
  - Focus on telecommunication (amateur radio)
  - P3-D (AO-40) launched in 2000 into GTO using the main payload launch adapter: 650 kg launch mass, high amount of radio transponders and digital signal processing, propulsion system for inclination changes



Background

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

- DLR
  - Germany's national research center for aeronautics and space (transportation and energy)
  - ~6500 employees at 29 institutes and facilities at 13 locations in Germany
  - Scientific participation in e.g. Cassini-Huygens, Mars Express, Venus Express, Rosetta-Philae, SCIAMACHY, TerraSAR-X, TanDEM-X
  - >35 experience in operations (e.g. AZUR, AEROS, HELIOS, GALILEO, CHAMP, BIRD, GRACE, TerraSAR-X, SAR-Lupe (LEOP))



Background

AMSAT-DL

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

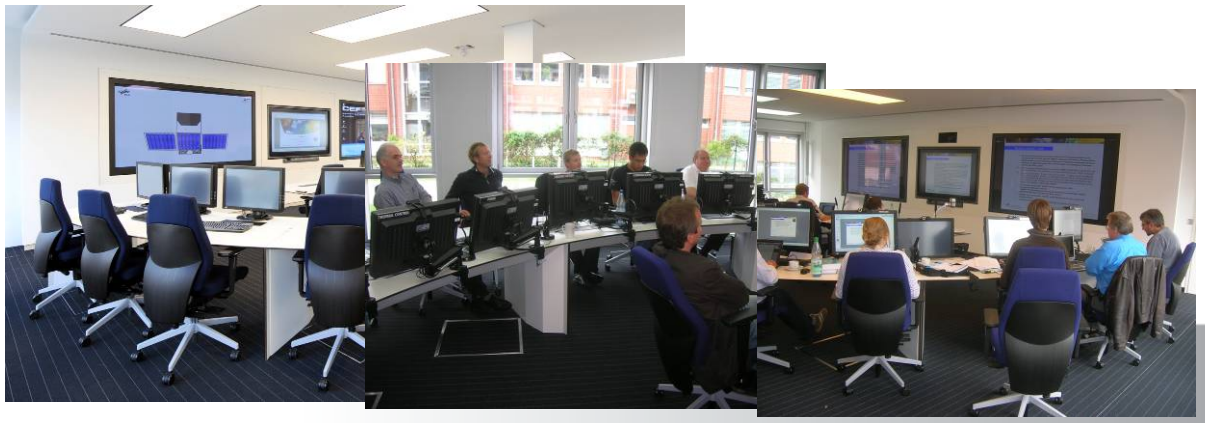
Goal:

go Mars with AMSAT-DL's P5A-mission!

Interest:

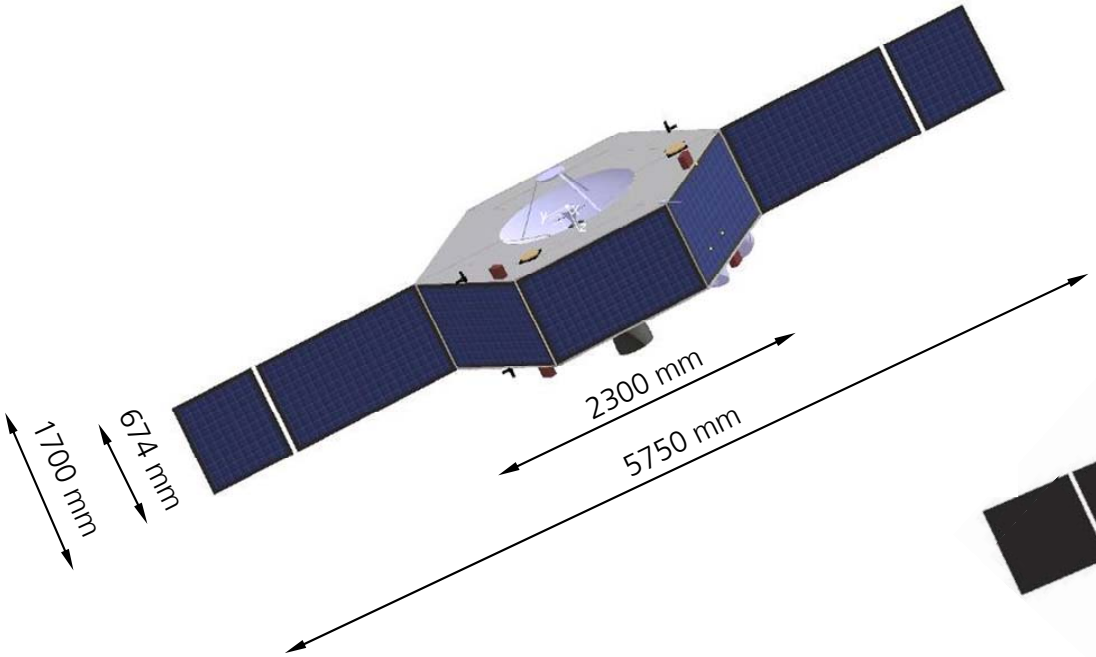
perform cost effective scientific missions

concept for a joint mission
to Mars and/or Moon
using the Concurrent Engineering Facility (CEF)
at DLR Bremen



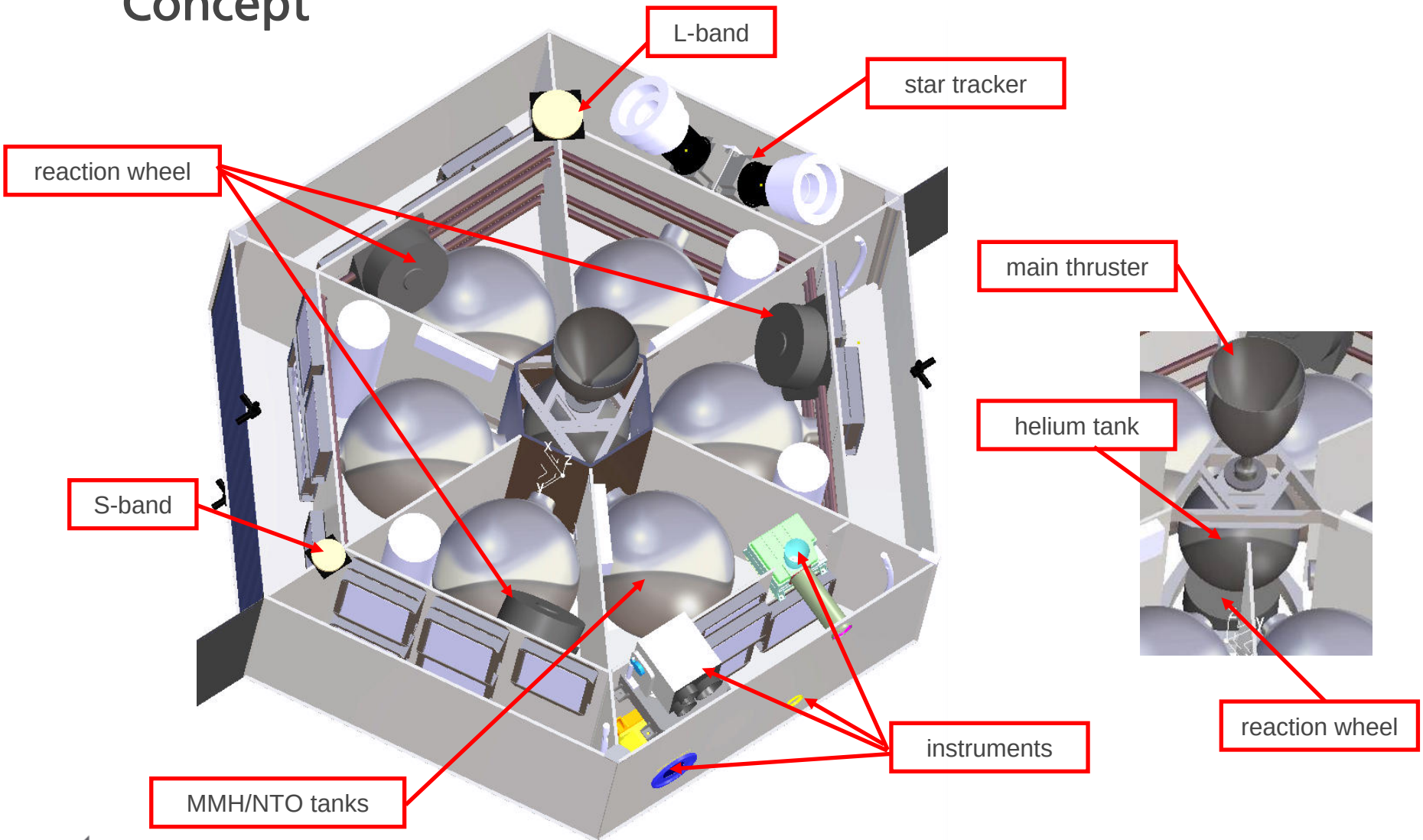
Concept

- Design strongly based on the flight proven P3-D

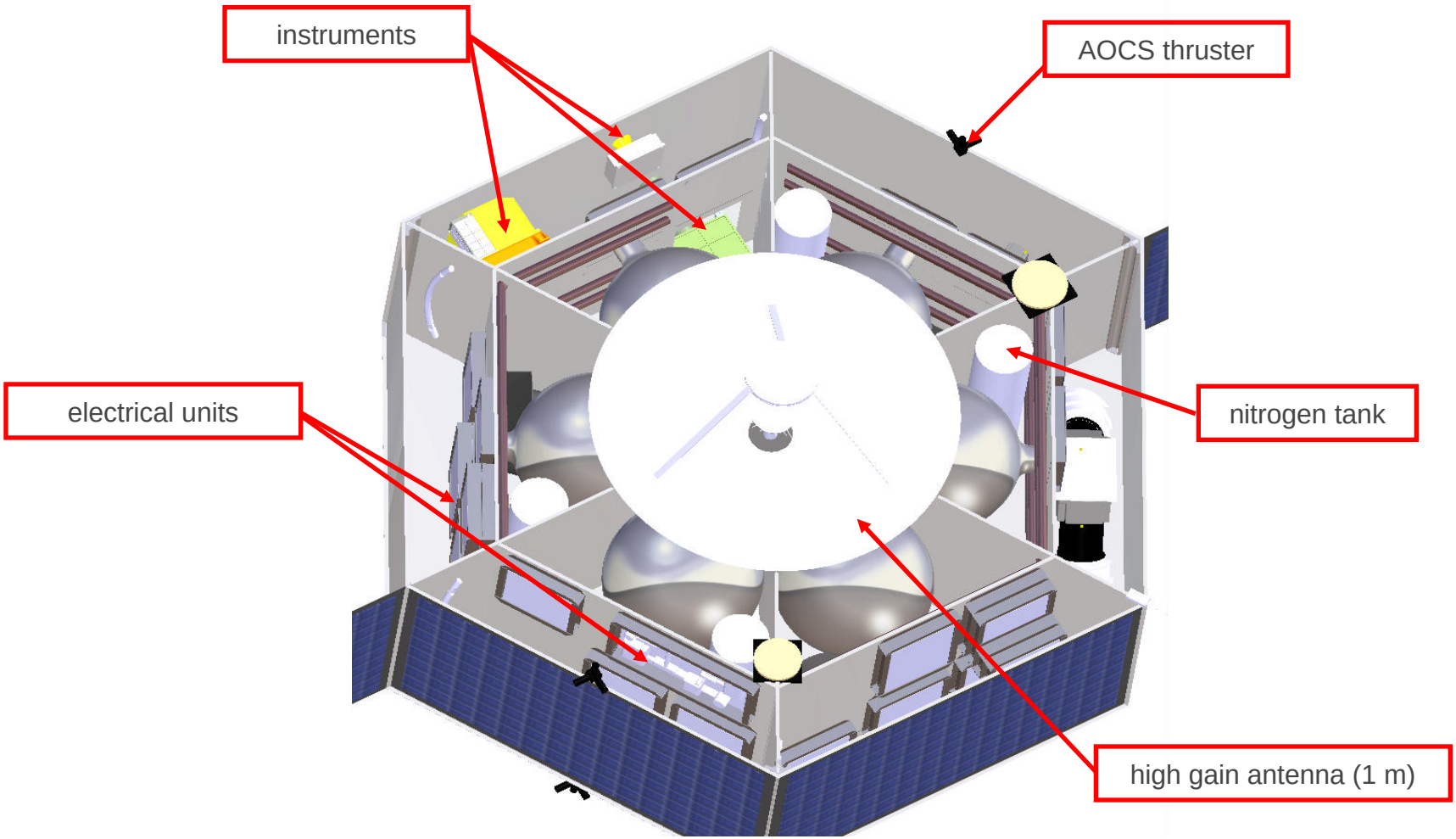


Launch mass: ~670 kg into GTO
Propulsion: 400 N, 1625 m/s delta-v
Power: ~ 380 W (45° solar angle)
Data Rate: 30 Mbit/s using TV dish
Comm.: X-, S-, L-Band and UHF

Concept


L-band
star tracker
reaction wheel
main thruster
helium tank
S-band
reaction wheel
instruments
MMH/NTO tanks

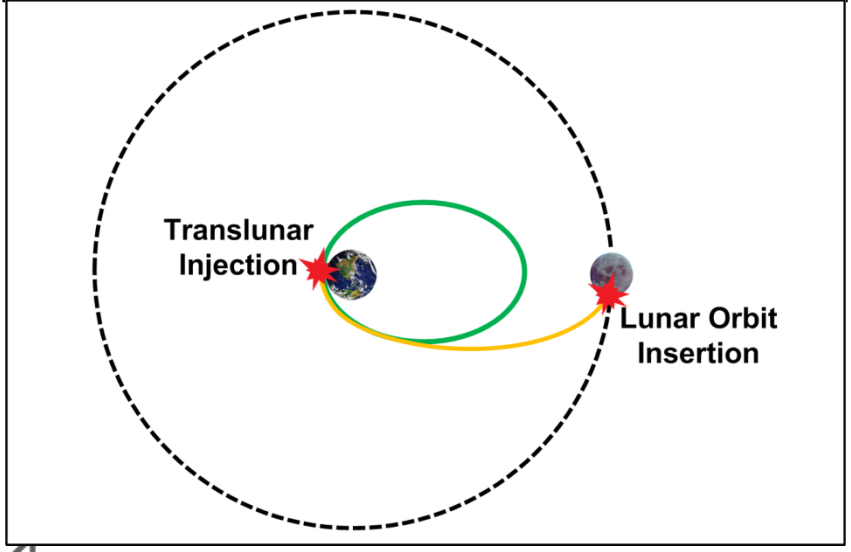
Concept


instruments
AOCS thruster
electrical units
nitrogen tank
high gain antenna (1 m)

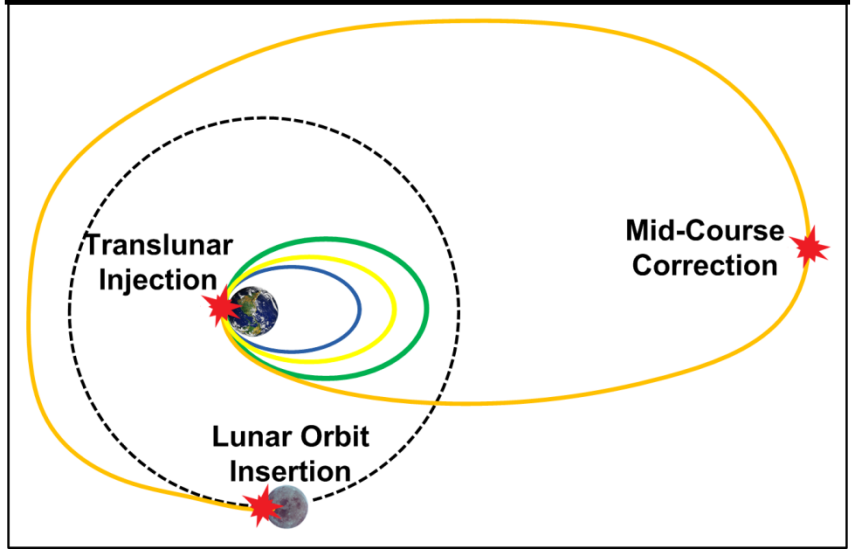
Transfer to the Moon

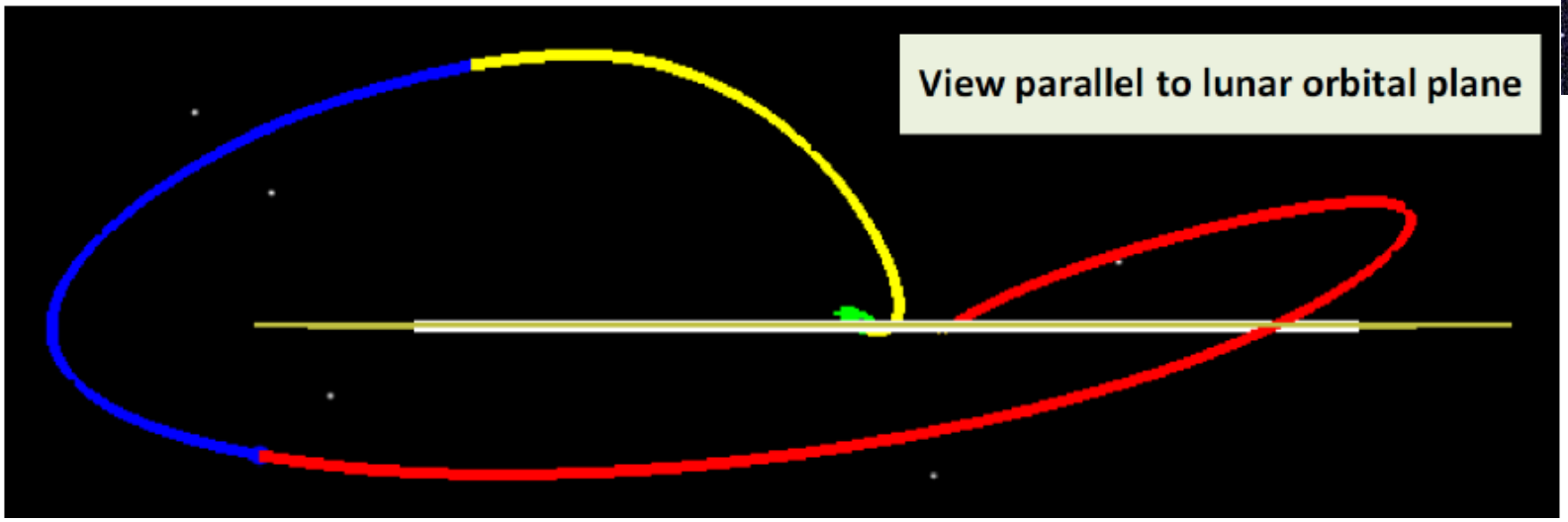
Transfer trajectory options		
	Hohmann	WSB
ΔV (for worst-case launch date)	~2200 m/s	~1600 m/s
Duration	~5 days	80 to 120 days
Largest distance from Earth	0.4 million km	1.5 million km

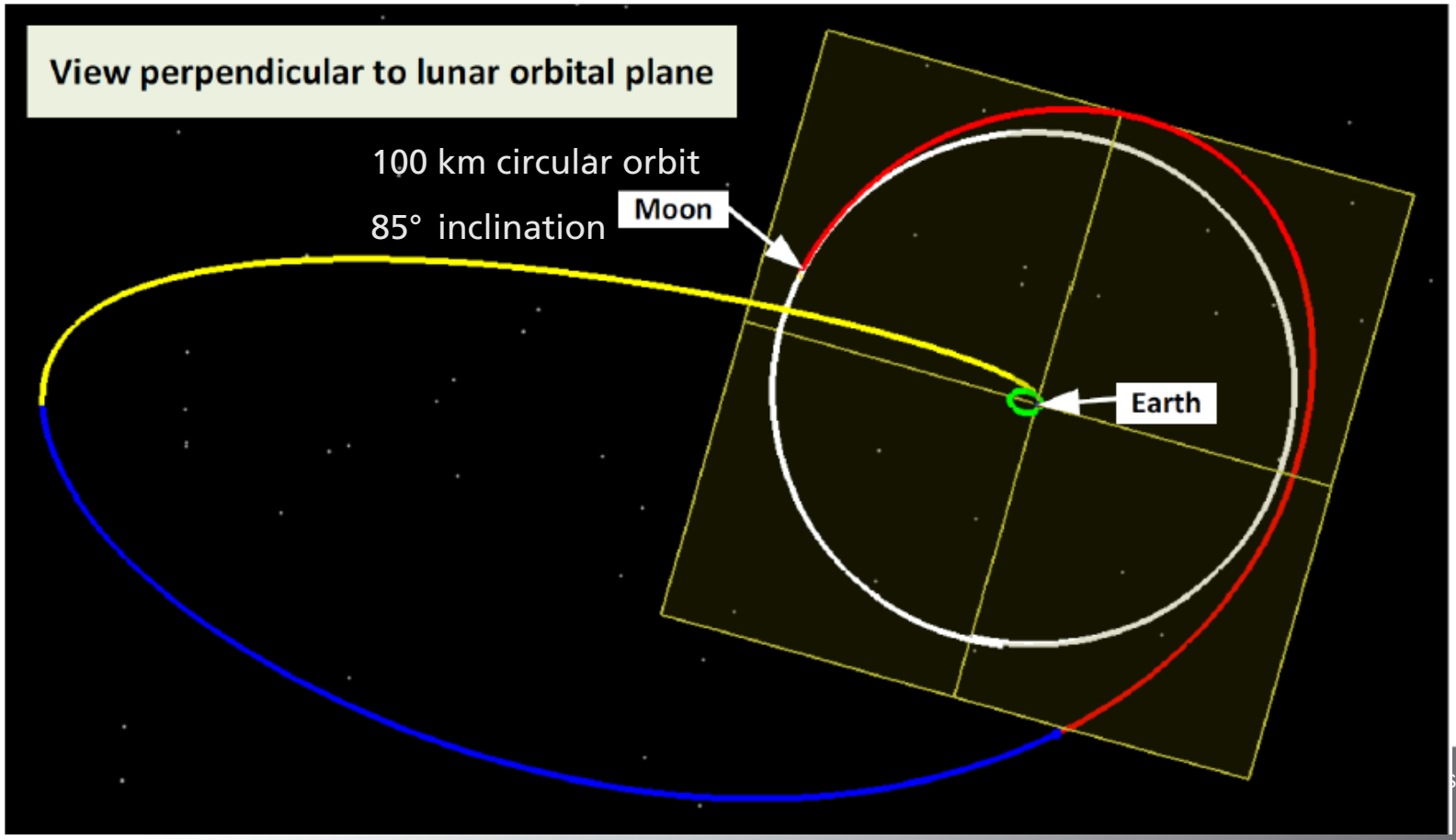
Hohmann



Weak-stability-boundary (WSB)




View parallel to lunar orbital plane


View perpendicular to lunar orbital plane
100 km circular orbit
85° inclination
Moon
Earth

Instruments

- Criteria for instrument selection:
  - Unique feature
  - Scientific value
  - Cost
  - National interest
  - (public visibility, technology readiness, demand on mass/power/volume)

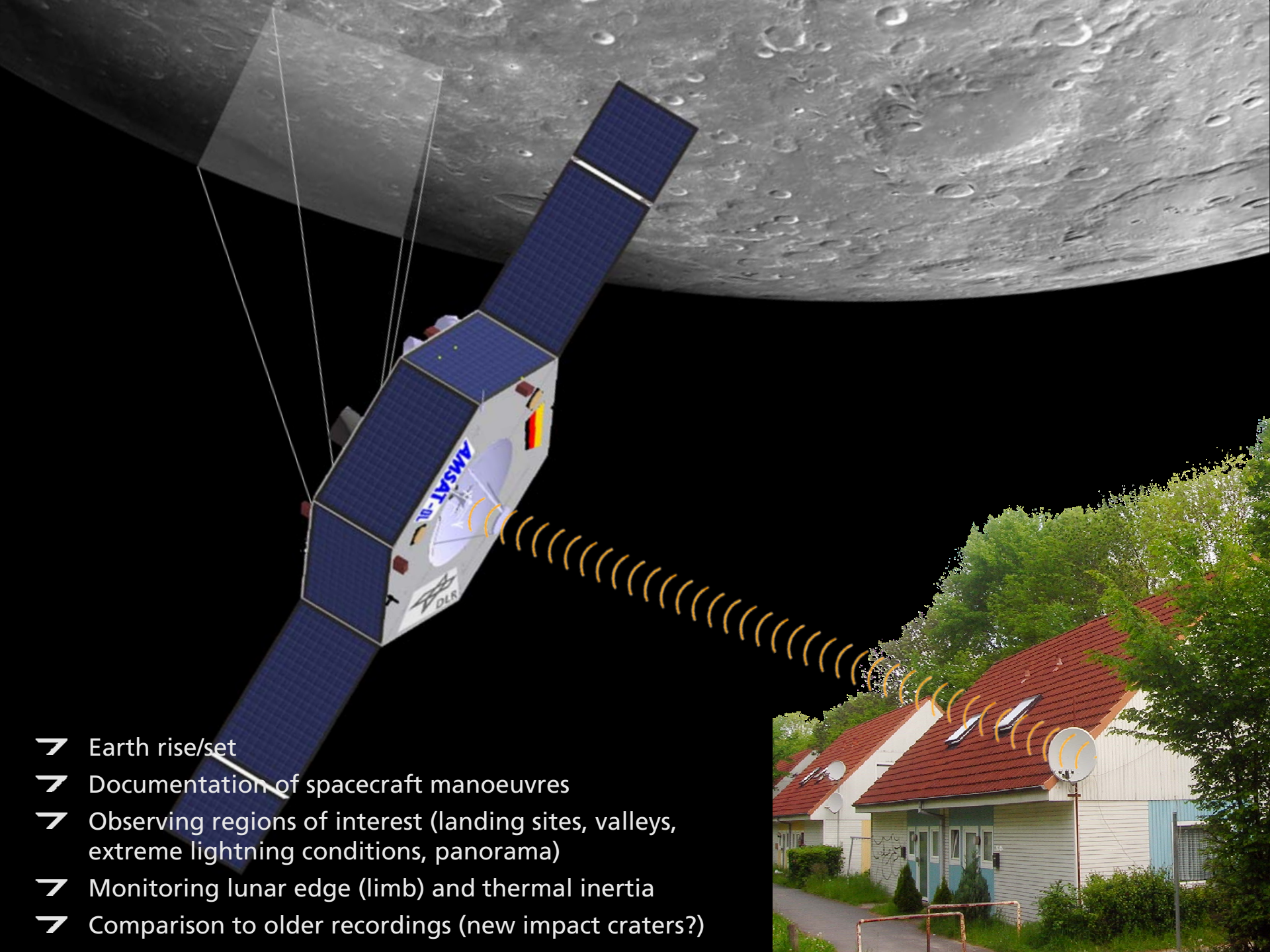
- No outperforming of Kaguya/Chandrayaan/LRO

→ 4 instruments: Video Imager System, MORTIS, SPOSH, ATON

Instruments – Video Imager System

- Video Imager System:
  - HDTV video system
  - RGB CMOS APS detector
  - 3 camera heads with fix focal distance
  - Slewable in 2 axis
  - Based on LEVIS/LEO
  - Designed by IDA TU Braunschweig
- Combined with high gain antenna

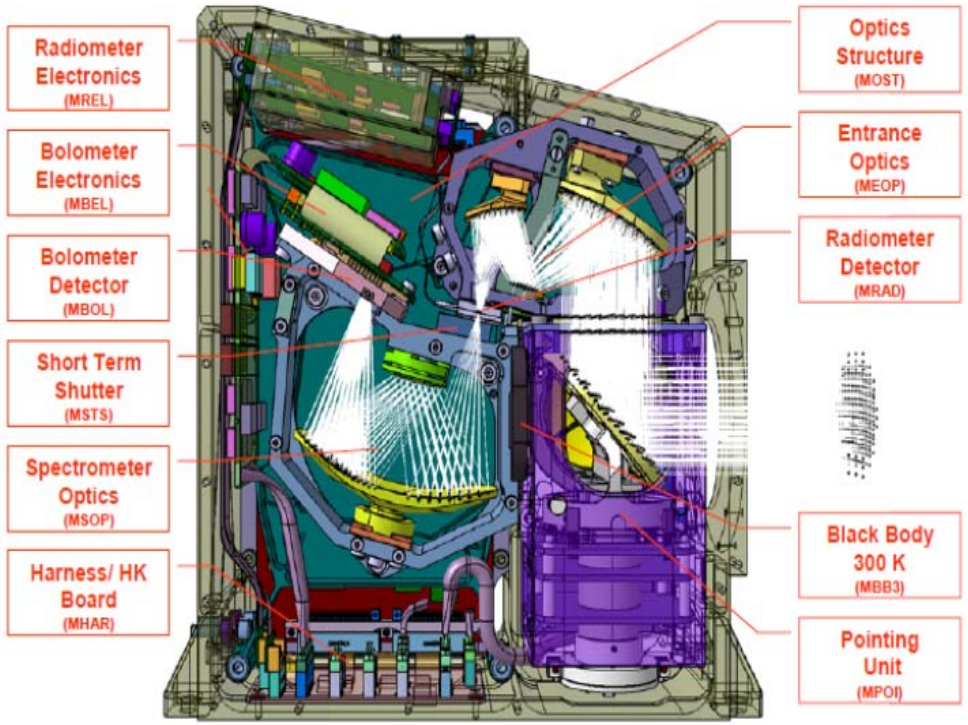
→ allows direct TV from Moon on Earth



- Earth rise/set
- Documentation of spacecraft manoeuvres
- Observing regions of interest (landing sites, valleys, extreme lightning conditions, panorama)
- Monitoring lunar edge (limb) and thermal inertia
- Comparison to older recordings (new impact craters?)

Instruments – MORTIS

- MORTIS
  (MOon Radiometer and Thermal infrared Imaging Spectrometer):
  - Spectrometer (7-14 µm)
  - Thermal radiometer (7-14 µm)
  - Push broom imager principle
  - Monitoring of lunar surface and 3 calibration targets
  - Based on MERTIS (Bepi Colombo)/SERTIS (LEO)



Instruments – MORTIS

- Goals of MORTIS:
  - Identification of rock forming siliceous minerals
  - Investigation of the lunar surface composition
  - Mapping of lunar surface mineralogy
  - Evolution of lunar volcanism and magma composition
  - Measurement of surface temperatures
  - Mapping of thermal inertia
  - Modelling of thermo physical properties of regolith

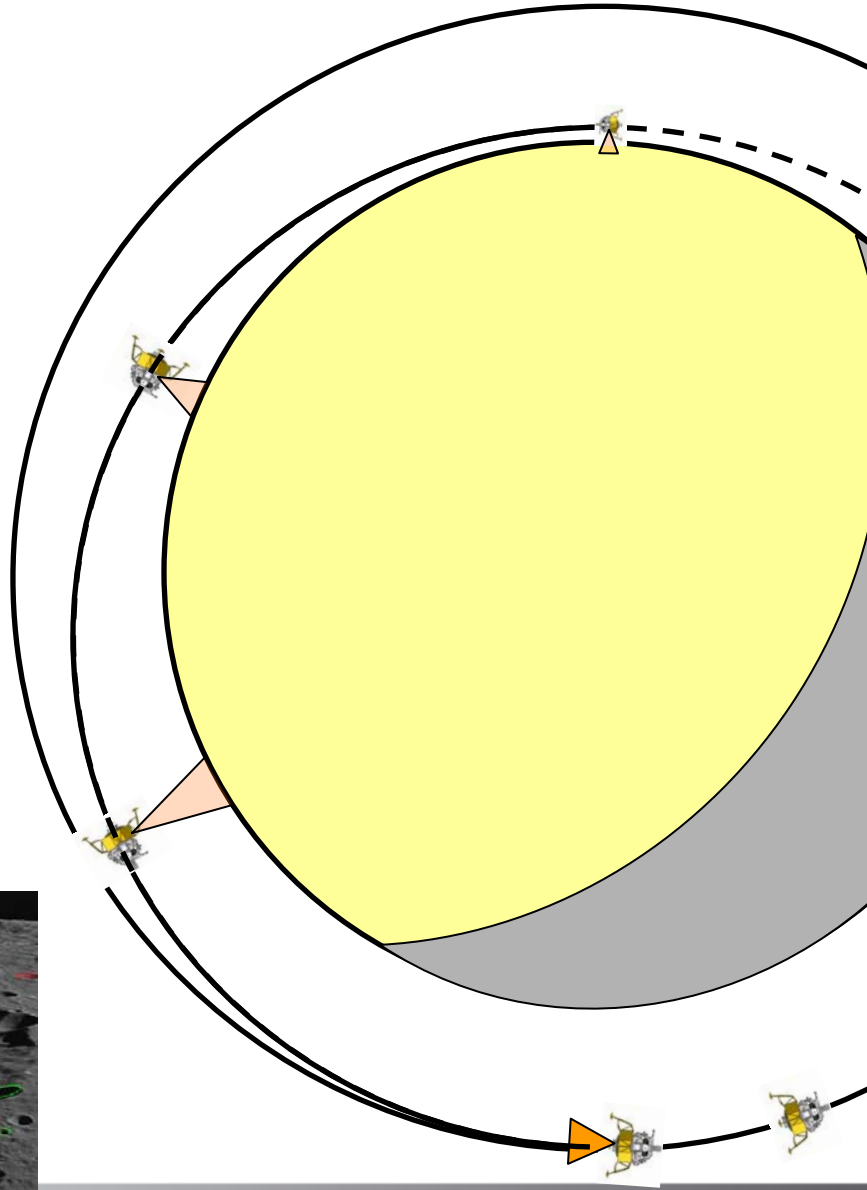
Instruments – SPOSH-VIS

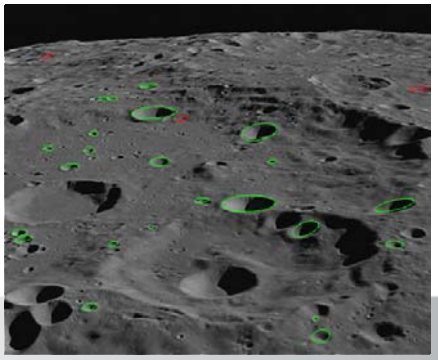
- SPOSH (Smart Panoramic Optical Sensor Head):
  - Wide angle camera (120° x 120° FOV)
  - Autonomous data processing on board
  - Based on SPOSH study for LEO (DLR-PF/TUB/DJO)
  - 4 bread boards in routinely operation on Earth

- Goals of SPOSH:
  - Monitoring of impact flashes on lunar night side caused by meteoroid impact events
  - Impact rate per time unit and area
  - Magnitudes distribution of detected flashes
  - Daytime and seasonable variation and showers
  - Interpretation of data concerning orbital parameters of meteoroids
  - Verification of scaling law
  - Detection of dust in exosphere at Moon limb by forward dispersion

Instruments – ATON

- ATON
  (Autonomous Terrain based Optical Navigation):
  - Sensor for autonomous navigation in lunar orbit and during landing (in this case impacting)
  - Precise determination of position during parking orbit and descent orbit (Hohmann from 100 - 10 km)
  - Principle: detection and identification of craters
  - Developed by DLR-RY





Instruments – ATON

- Goals of ATON:
  - Technology demonstration →qualification to TRL 7
  - Autonomous determination of the position of the DLR-AMSAT P5 Moon satellite in orbit in order a few 100 m
  - Preparation for exploration missions to Mars, asteroids, other moons

Conclusion

- Non-industrial Moon satellite concept that could be launched as piggyback load on Ariane 5 into GTO
- Due to the fact, that the satellite would be built by space enthusiasts the mission costs would remain low (comparable to an Earth satellite mission)
- Otherwise the scientific and public output would be high using that satellite bus for the promising instrument ensemble contributed by DLR

→ DLR-AMSAT P5 Moon satellite is a feasible option for a German Moon mission