Lunar Lander

ESA Thematic information day

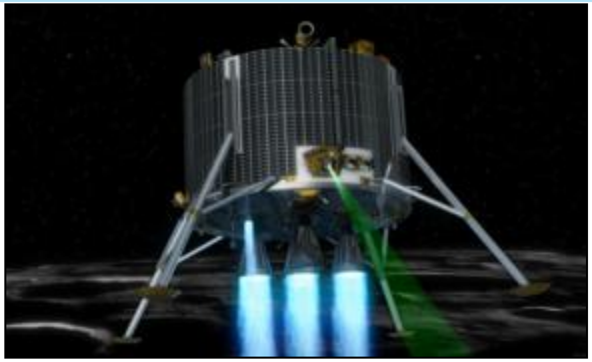
BELSPO, 3 July 2012

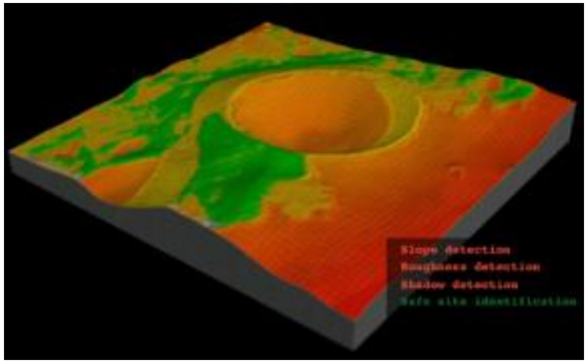
Lunar Lander Mission Objectives

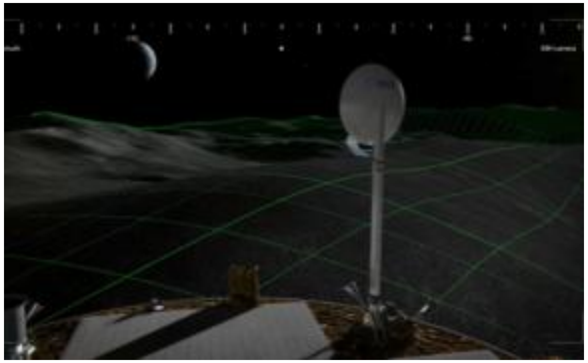
TECHNOLOGICAL OBJECTIVE, preparing for future robotic and human exploration missions:

- **PRECISION LANDING** with surface hazard avoidance, based on Visual Navigation and advanced Guidance Navigation and Control
- **AUTONOMOUS** on board decision during crucial landing phase
- **Energy efficient** design, based on solar energy for surface operation

SCIENTIFIC investigations of the Moon surface environment, its effects and potential resources.







International Context

esa
human spaceflight and operations

Apollo/Luna Era

1990 - 2006

- HITEN
- CLEMENTINE
- LUNAR PROSPECTOR
- SMART-1

2007 - 2012

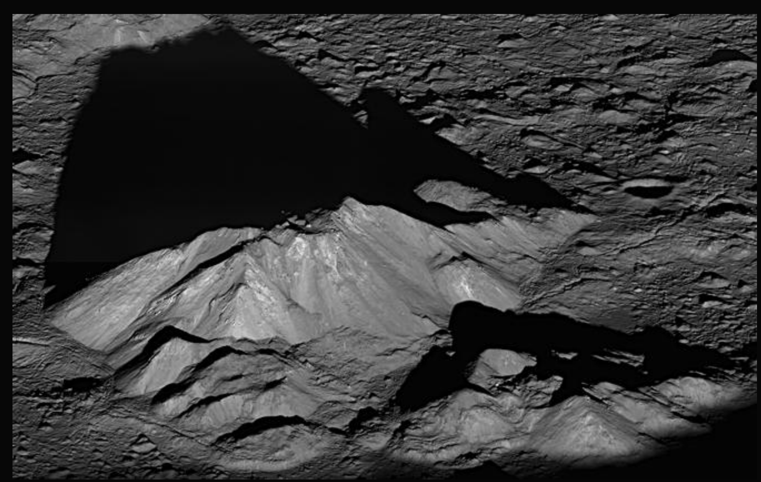
- KAGUYA
- L-CROSS
- LRO
- GRAIL
- ARTEMIS
- CHANG'E-1
- CHANG'E-2
- CHANDRAYAAN-1

2013 - 2020

- SELENE-2
- LADEE
- GOOGLE-X
- LUNAR LANDER
- CHANG'E-3
- CHANG'E-4
- CHANDRAYAAN-2/ LUNAR-RESOURCE
- CHANDRAYAAN-3
- LUNA-GLOB

Next Decade

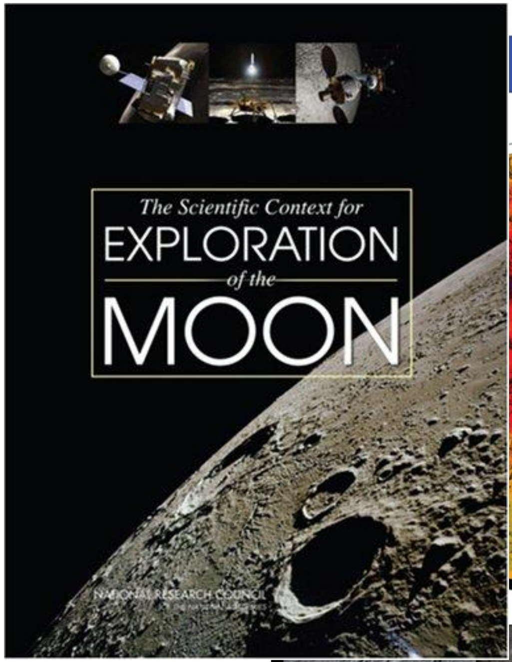
- HUMAN LUNAR EXPLORATION MISSIONS
- LUNAR POLAR SAMPLE RETURN
- LUNAR GEOPHYSICAL NETWORK

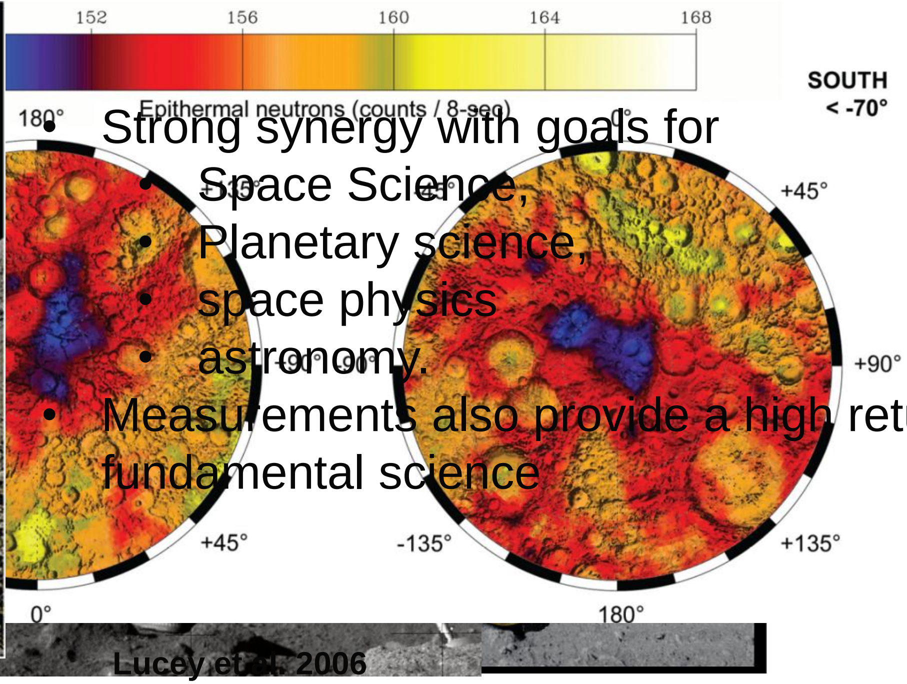


ORBITER
IMPACTOR
LANDER
SAMPLE RETURN

Science Objectives

Research Area	Investigation Topic
Human health	Toxicity of lunar dust associated risks to humans
	Radiation environment and likely hazards to humans
Environment and effects	Landing site characterization
	Dust properties and effects on systems
	Dust - Plasma environment and effects
Resources	water, other volatiles and mineralogical species
	Physical properties of potential resources
Preparations for future activities	Characterize the exosphere
	Radio astronomy precursor measurements





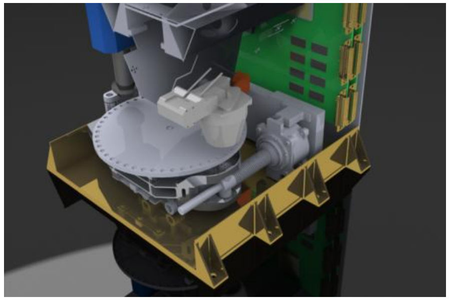
- Strong synergy with goals for
  - Space Science,
  - Planetary science,
  - space physics
  - astronomy.
- Measurements also provide a high return for fundamental science

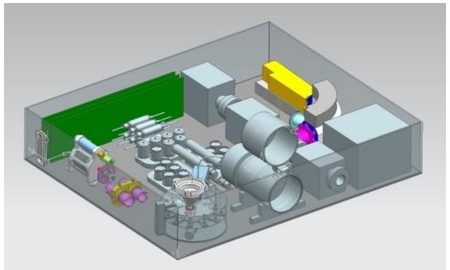
Lucey et al. 2006

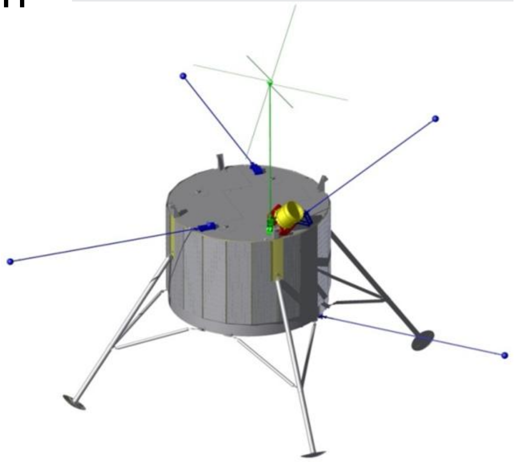
Payload Definition Studies

human spaceflight and operations

- 6 x GSP Payload definition studies ongoing
  - **L-DAP:** dust analysis package investigating size distribution, structure and morphology of lunar dust, plus its chemistry, mineralogy and elemental composition
  - **L-VRAP:** volatiles analysis package identifying volatiles and other potential resources in Lunar regolith, plus analysis of Lunar exosphere
  - **3 x L-DEPP:** dust environment and plasma package investigating dust motion, charge, size distribution, E-fields, plasma properties, radio environment
  - **AMERE** radiation biology experiment investigating effects on human cells
- Studies incorporate industry and scientists from outset
- Provide an important input for definition of interfaces between Lunar Lander and model payload
- Completion by mid 2012

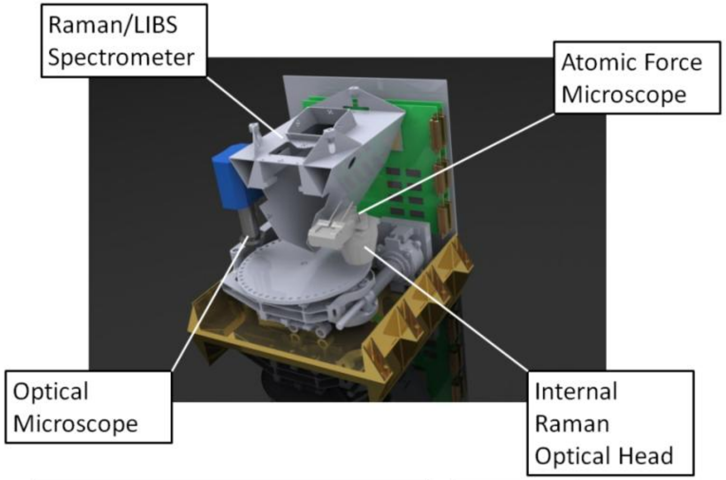


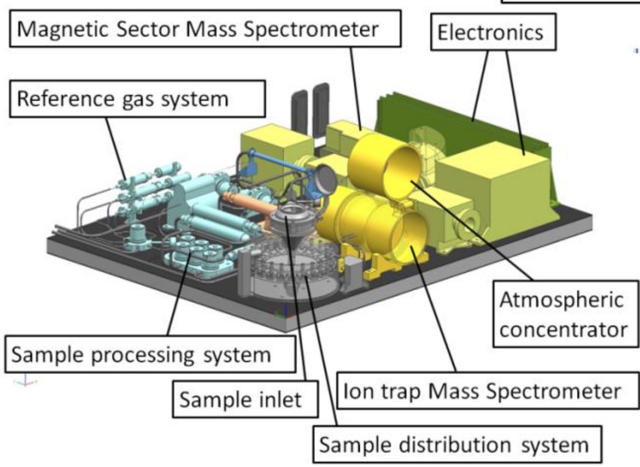


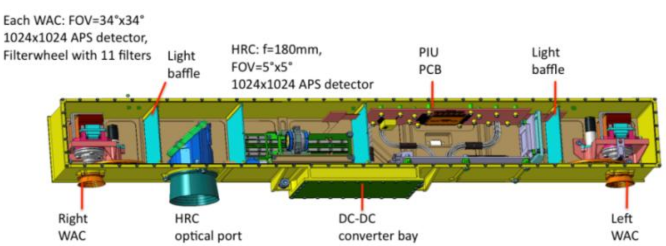


Separate study on a Mobile Payload Element (MPE) initiated by DLR and led by Kayser Threde ongoing
DLR contribution in-kind to Lunar Lander

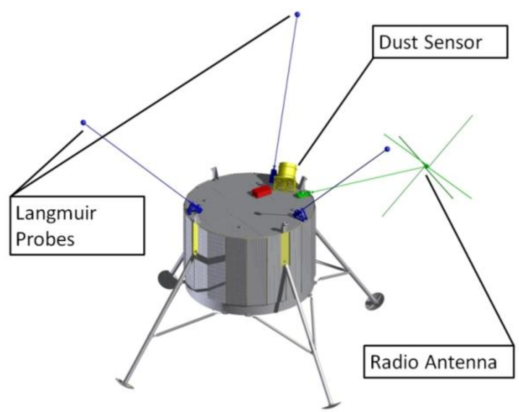
Lunar Lander: Model Payload

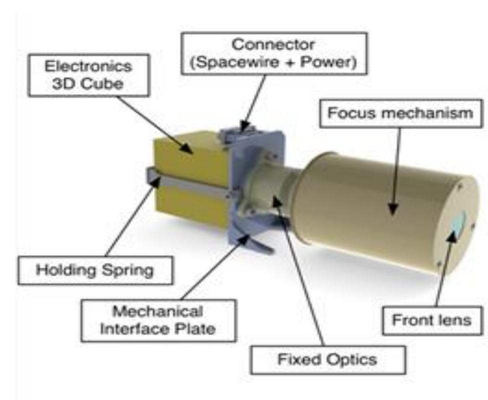






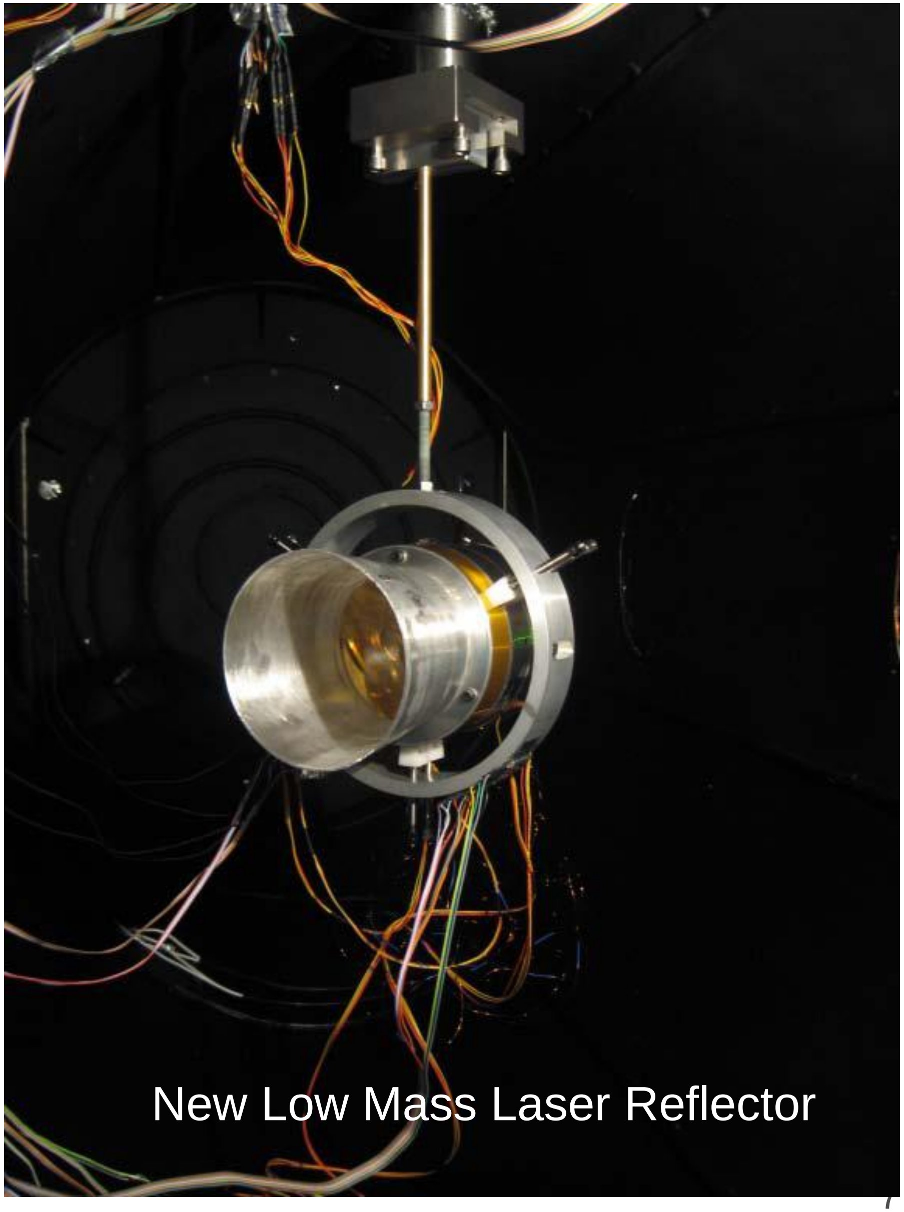
Package	Instrument
Lunar Camera Package (L-CAM)	Stereo Panoramic Camera
	High Resolution Camera
	Robotic Arm Camera
Lunar Dust Analysis Package (L-DAP)	AFM
	Micro Raman-LIBS
	Microscope
	External Raman-LIBS
Lunar Dust Environment and Plasma Package (L-DEPP)	Dust Sensor
	Langmuir Probes
	Radio Antenna
	Ion/Electron Spectrometer
	Magnetometer
Lunar Volatile Resource Analysis Package (L-VRAP)	Mass Sector Mass Spectrometer
	Ion trap mass spectrometer
Radiation and effects experiments	Radiation monitor



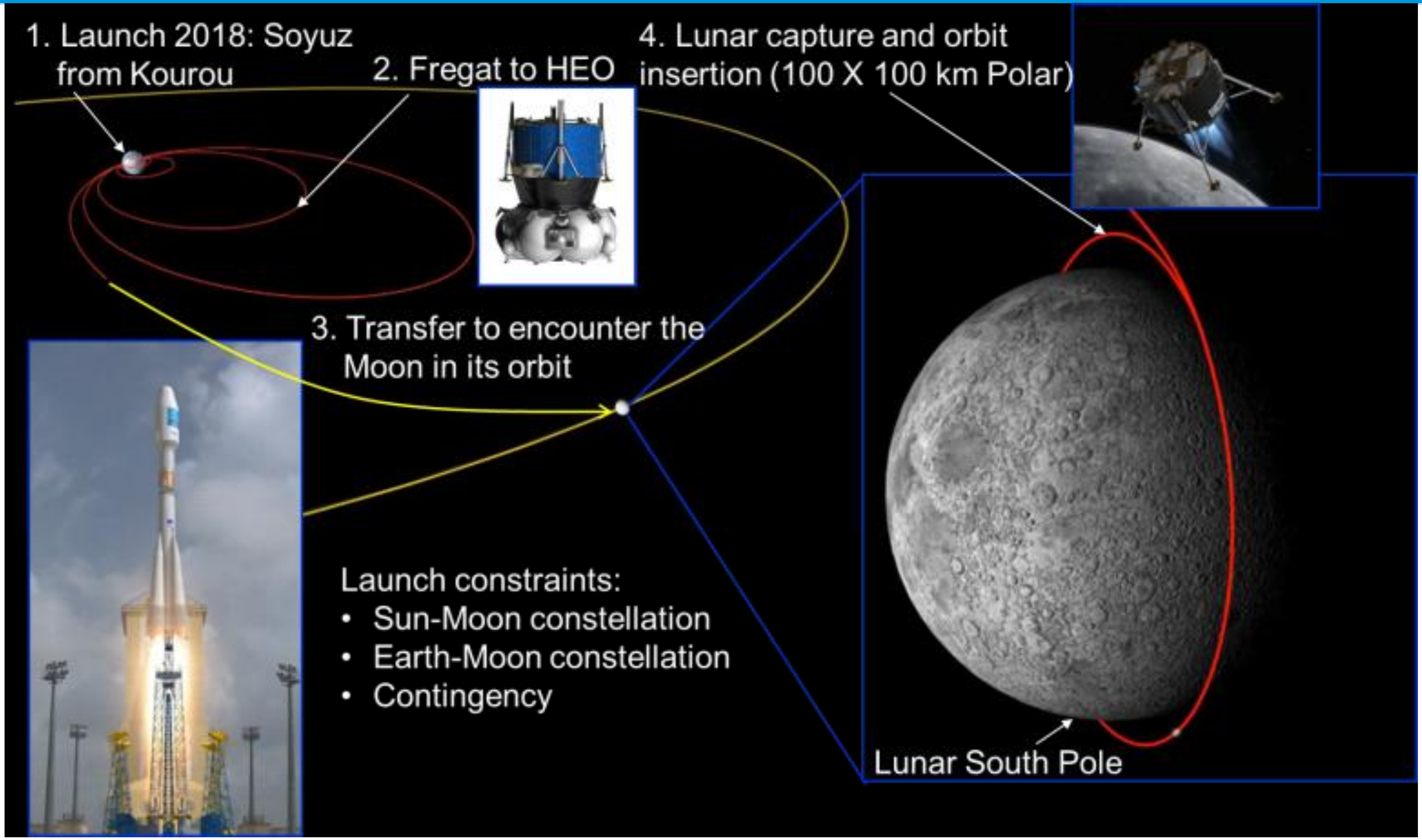


Alternative Experiments

- ESA led Model Payload is not a selected payload
- Alternative experiments can be considered
  - Address exploration relevant questions
  - Provide fundamental scientific return
- E.g. Laser reflector
  - Verify landing precision
  - Provide absolute reference for lunar coordinate systems
  - lunar geodesy/geophysics
  - fundamental physics
- Supports exploration and science goals
- Strong Belgian science competence


New Low Mass Laser Reflector

Mission Description: Launch to Lunar Orbit



Further to the initial trade offs in early Phase B1, the mission design has been stable for more than one year.

Industrial Contracts

esa human spaceflight and operations

- **Phase B1 contract with EADS Astrium - Bremen started September 2010**
- **Current participating countries: Germany, Portugal, Canada, Spain, Belgium and Czech Republic.**
- **Payload accommodation studies in European Industries and Research Institutes (D, UK, NL, CH, S, B, PL, F, E, FN, CZ).**

Lunar Lander Phase B1

human spaceflight and operations

ASTRIUM **Mission Prime**

Strong Belgian participation

- Software (SPACEBEL)
- Communication (antwerpspace, QinetiQ Space)
- Optical/electrical stimulator (navigation bread boarding) (spaceapplications services)

- Lunar Lander Phase A mission studied since 2008; Technology development since 2005.
- Mission architecture frozen, design stable since more than one year
- Project is ready to enter hardware development phase.

Soyuz Launcher

arianespace service & solutions

Technologies Activities

Landsafe (SPACEBEL, ULg)

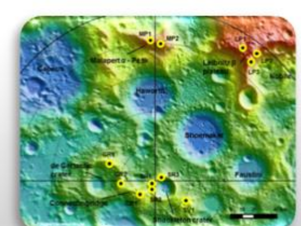
Landing System Development (QinetiQ Space)

Landing Site Characterisation

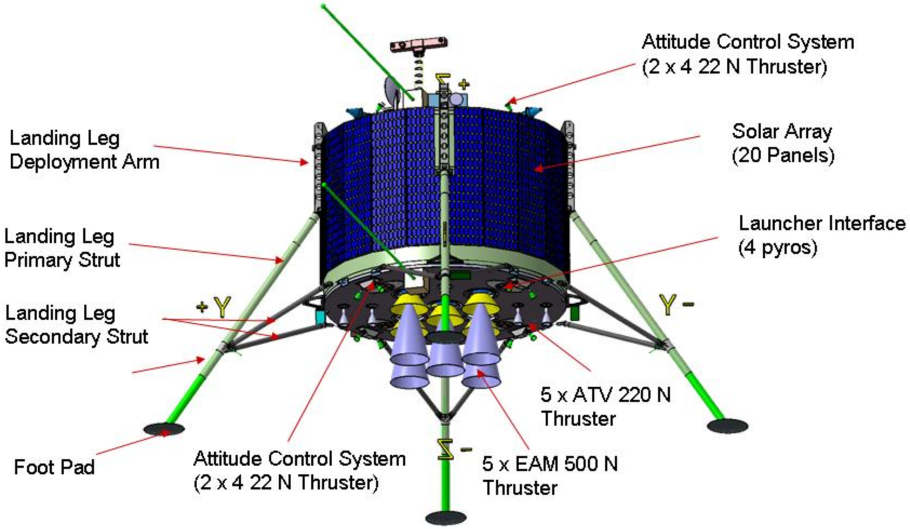
Birkbeck University of London

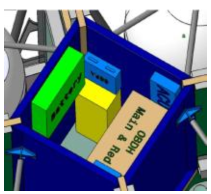
Freie Universität Berlin

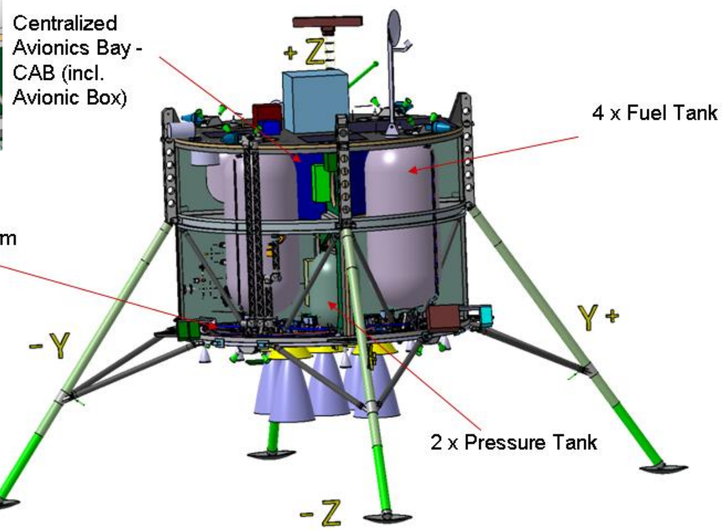
APL The Johns Hopkins University Applied Physics Laboratory

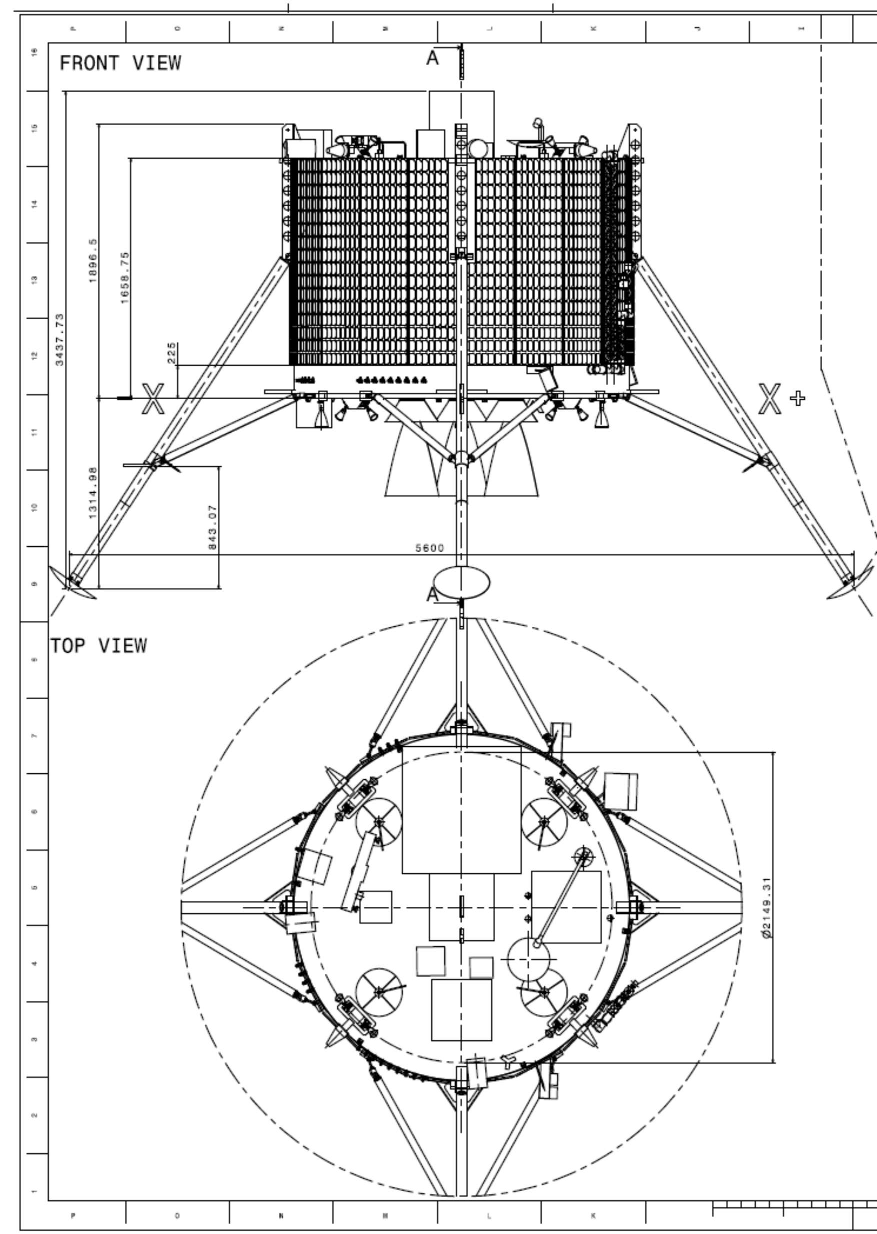


Spacecraft Configuration









Subsystem / Equipment List

Structure
- Main structure (top/bottom plates, struts, shear web)
- Secondary structure
- Payload servicing (manipulator arm, camera mast)
- Landing legs (primary/secondary strut, footpad)

Propulsion
- Propellant tanks
- Pressurant tanks
- 500N EAM engines
- 220N ATV engines
- 22 ACS engines
- Propulsion equipment (valves, pressure regulators, piping)

Mechanisms
- Antenna deployment
- Antenna pointing
- Landing leg deployment and latching
- Camera mast deployment
- Camera mast pointing
- Manipulator arm joints

Thermal Control
- MLI
- Heaters
- Sensors
- Thruster platform heat shield
- Radiators
- Loop heat pipes
- Heat switches

Power
- Solar generator (solar cells, panels)
- Power harness
- CAB (PCDU, battery, harness)

Avionic

Guidance Navigation and Control
- IMU
- Distance-to-ground sensor
- Lidar
- Navigation camera
- Sun sensors
- Star trackers
- Propulsion drive unit
- GNC Software

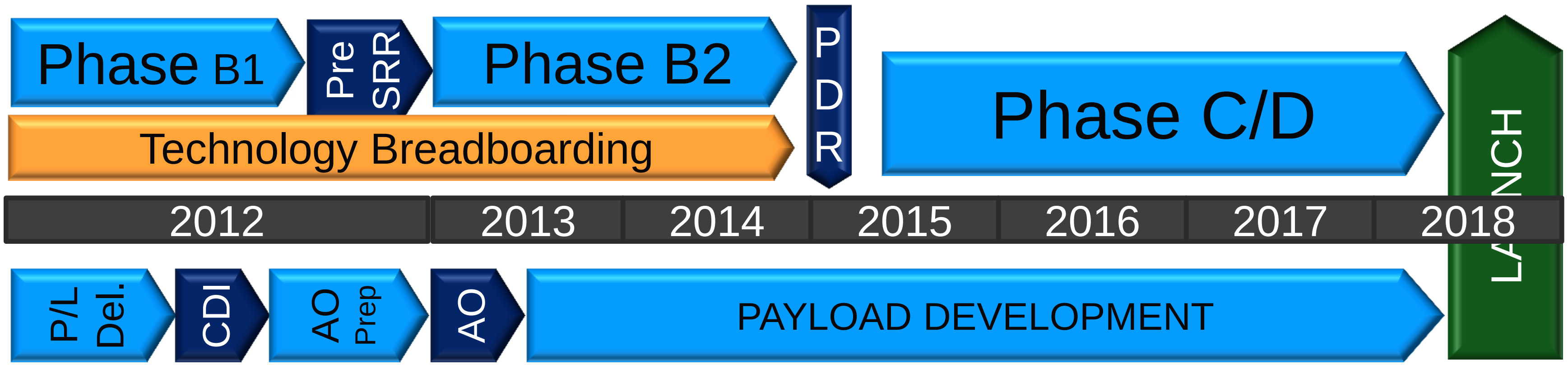
On board Computer and Data Management
- Data Management System
- Data harnes

TM/TC
- Transponder
- RF network
- High gain antenna
- Low gain antenna

Schedule and Next Steps

esa
human spaceflight and operations

- Pre-SRR in October 2012
- Ministerial Council in November 2012 (MC2012)
- S-PDR planned early 2015
- Bread boarding activities running continuously up to PDR (TRL 5



- Call for Declarations of Interest (CDI) in May 2012, due 9 July 2012
- Announcement of Opportunity expected early 2013

Lunar Lander Phase B2 /C/D/ E

- European Lunar Lander: frame to develop/apply Belgian industrial, research and scientific know-how with significant added-value
  - challenging, mass-critical mission (like any landing)
  - state-of-the-art technology and expertise required

- After Phase B1, pending approval at MC'12 , the industrial consortium will evolve, building on the existing consortium, but also adapting to new partners:
  - to broaden the industrial base and reflect the support across Europe
  - to further incorporate expertise necessary for B2/C/D/E

- Lunar Lander B2/C/D/E offers opportunities for design, manufacturing, verification, test, integration, operations and post-processing

- Phase B2 until PDR will be crucial: HW & SW breadboarding effort to be pursued in various areas (including at equipment level) to achieve TRL 5

Areas of Possible Belgian Contributions

human spaceflight and operations

- Software
- Software verification facility
- Communications
- Tools for landing site certification
- Landing leg deployment/latching mechanism
- Thermal control assembly/component (e.g. loop heat pipe)
- PCDU
- MGSE, EGSE
- Trajectory reconstruction

- Scientific instrumentation
- Electrical ground support equipment for payload simulation / testing

- Others?

Conclusions

- **The Lunar Lander is the culmination of several years of investment in design and technology development started with the Aurora Core.**

- **As an exploration mission gives the opportunity to develop advanced technology while providing new opportunities for Moon surface science.**

- **The spacecraft design is stable for more than one year. An intensive programme of bread boarding activities is coming to conclusion with very positive results.**

- **The Lunar Lander is a Project ready to go into a hardware development phase,**

BACK-UP

Scientific Objectives

- Wide consultation to identify objectives and requirements

Lunar Exploration Definition Team
Topical Teams and workshops: Dust Toxicity (T3LD) Resources (TTELPM) Radiation Biology (TT-IBER) Dusty Plasma Environments (TT-DPESS)
Payload Definition Studies
Landing site characterisation studies

- Workshop “Scientific Preparations for Lunar Exploration” at capacity with 180 participants
- Forthcoming special issue of Planetary and Space Science

Breadboarding

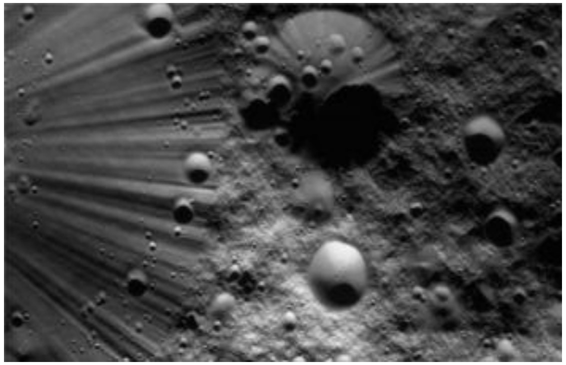
- Propulsion:
  - Hot firing tests have established adequate behaviour and performance of 220N in pulse mode
  - Successful testing on a full breadboard of the propulsion feed system

220N engine hot-firing at various pulse frequencies

Propulsion feed system hydraulic mock-up used to investigate water-hammer effects, thruster cross-talk etc.

- GNC:
  - TRON facility at DLR Bremen shall be used to validate absolute visual navigation solutions, with HW in-the-loop testing

TRON facility at DLR-RY



Artificially generated terrain mock-up

+ avionics, Lidar, alternative Guidance & Control, landing legs (DLR/Astrium) etc.

Industrial Team Phase B1

Ongoing Support Activities

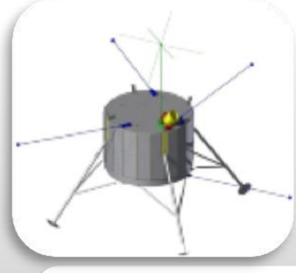
esa
human spaceflight and operations

Payload Definition Studies

L-DAP

sea
a Cohort plc company

L-DEPP

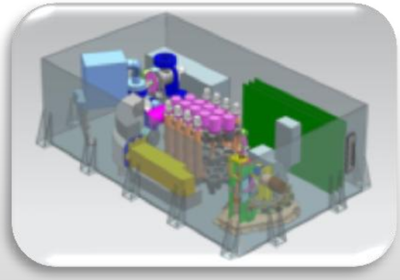


FINNISH METEOROLOGICAL INSTITUTE

KAYSER-THREDE
An OHB Technology Company

CSRC

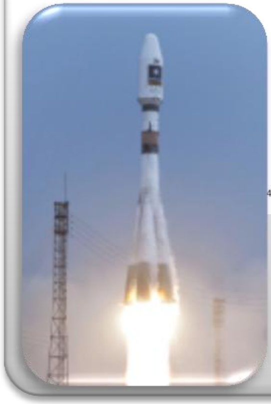
L-VRAP

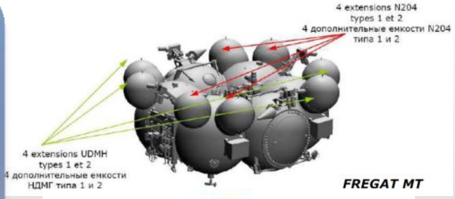


The Open University

Phase B1

Soyuz Launcher Feasibility Assessment





arianespace
service & solutions

Landing Site Characterisation

Birkbeck
UNIVERSITY OF LONDON

Freie Universität Berlin

APL The Johns Hopkins University Applied Physics Laboratory