Lunar Cargo Lander for Exploration

LEAG/ILEWG/SRR
28-31 October 2008

ESA
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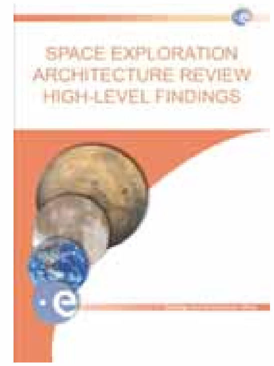
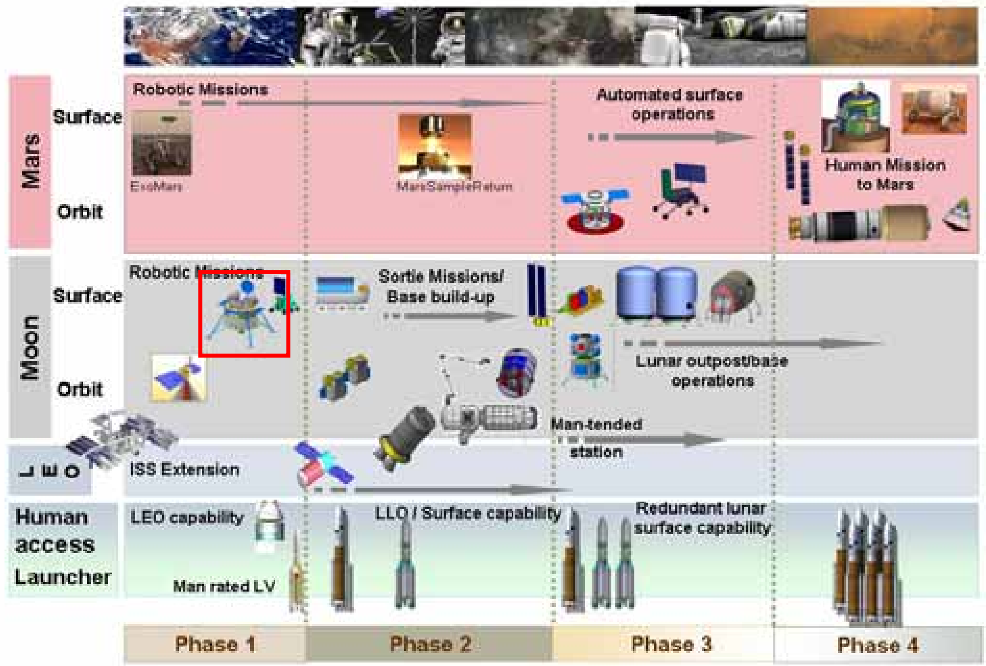
Architecture Studies

- Studies on future space exploration architectures
- Define missions and capabilities for human and robotic exploration of Moon and Mars
- Respond to the objectives and requirements of European stakeholders
- Integrated within the international context



"An Ariane 5-based lunar landing system has been identified as an important lunar architecture element, since it addresses all of the lunar exploration objectives, makes it possible to demonstrate capabilities for human missions and adds an important and versatile cargo and logistic capability for human missions."



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NASA-ESA CAA

A Cooperative Study

Determine if specific exploration capabilities currently under study for future independent development by ESA and NASA can complement, augment, or enhance the exploration plans of the other

Phase 1: January to May, 2008

A joint review of each agency's lunar architecture studies with the intent of identifying potential synergies between ESA and NASA concepts

Elements included in Phase 1 :

- •Cis-lunar Transportation
- •Lunar Surface Systems and Technologies
- •Potential Orbiting Platforms
- •Communication Systems

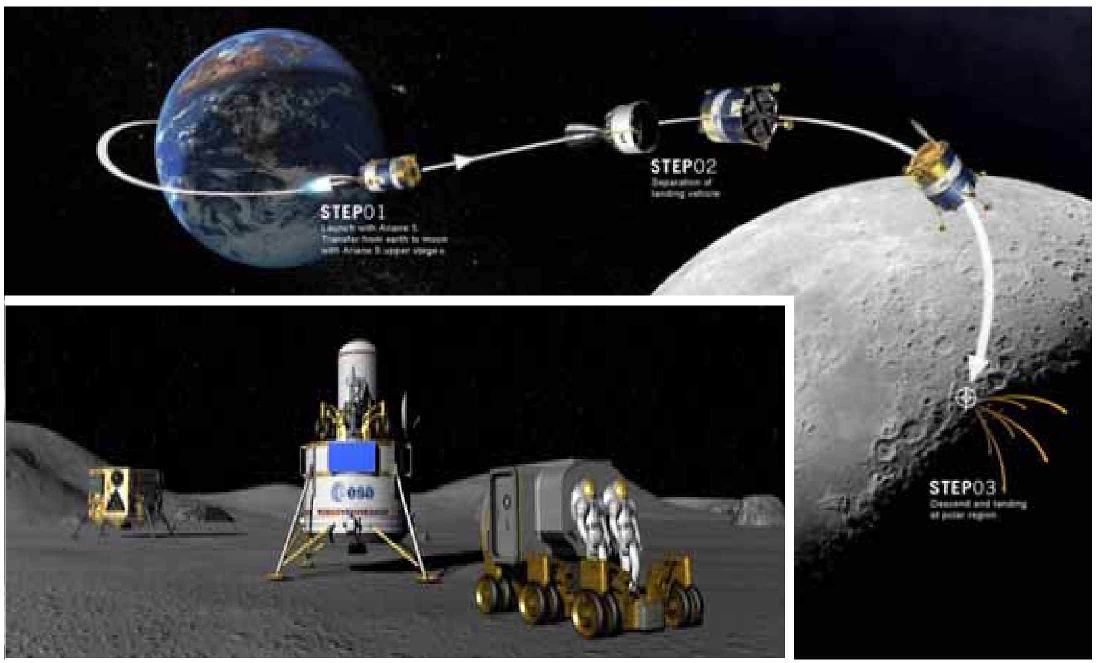
"The ESA lunar logistics lander would significantly extend surface exploration opportunities by enabling enhanced mobility, extended habitation, and new science opportunities."

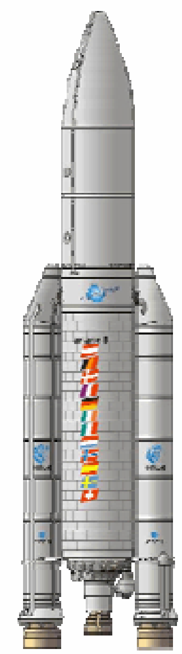
Full-A5 Lunar Lander
High Level Requirements

- **Use the full Ariane 5 performance capability**
- **Deliver payloads to the lunar surface (global access)**
- **Perform soft precision landing with hazard avoidance capability**
- **Deploy payload on lunar surface**
- **Provide resources to the P/L (power, comm's etc) during flight and on the surface**
- **Ensure communications either directly with Earth or through Lunar Relay spacecraft**

Mission Sequence

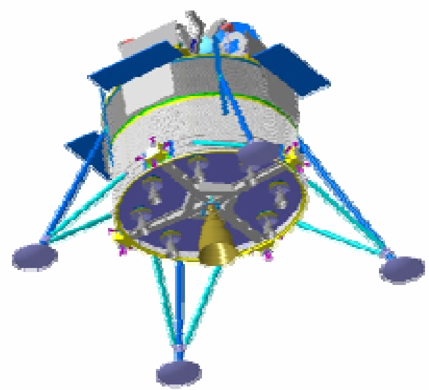
- Launch with Ariane 5 from Kourou
- Direct injection into Lunar Transfer Orbit by launcher
- Earth-to-Moon transfer
- Insertion in low lunar circular orbit (possible loitering of a few days to ensure global access)
- Braking, final descent and soft precision landing with hazard avoidance





Main Design Features

- **Total landed mass ~2.8 t**
- **Payload mass of ~ 1.2 t using existing A5-ECA launcher**
- **Main mass drivers: propulsion and structure subsystems**
- **Complex propulsion subsystem with multiple thrust levels**
  - In order to maximise European heritage: storable bi-propellant design
  - Example of envisaged propulsion concept without throttability:
    - Medium thrust engine for high impulse manoeuvres
    - Combination of 500 N (continuous) and 220 N engines (in pulse mode) to provide modulated thrust for landing



- **Thermal control:** depends on mission scenarios; radioisotope element might be required
- **LIDAR and optical camera for landing navigation sensors**
- **Touchdown: 4 deployable legs with crushable**

Mission Types

3 top-level scenarios identified with associated timeframes:

1. **Human preparation (before 2020):**
   - Location of first human mission (to increase base capability)
   - Any representative polar location (to increase mission capability)

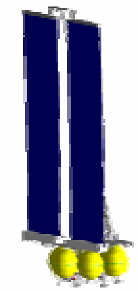
2. **Human support (2020-2025):**
   - Provision of base logistics and/or equipment
   - Provision of sortie logistics and/or equipment

3. Autonomous lunar exploration missions (2020-2025):
   - Utilising a hopper (to access permanently-shaded craters)
   - Utilising a deep-driller (to access lunar sub-surface)
   - Search for territes (amongst the regolith top layer)
   - Special case: LOFAR (far-side location)

Human Preparation

Any representative polar location

- Lunar Environment characterisation:
  Gather data about local terrain, soil interaction with mechanical systems, dust conditions, materials exposure effects, radiation etc.
- In-Situ Resource Utilization (ISRU) demonstration
  Test efficiency of tools and processes for generating useful products from real lunar materials
- Other technology demonstration (soft landing, fuel cells etc.)



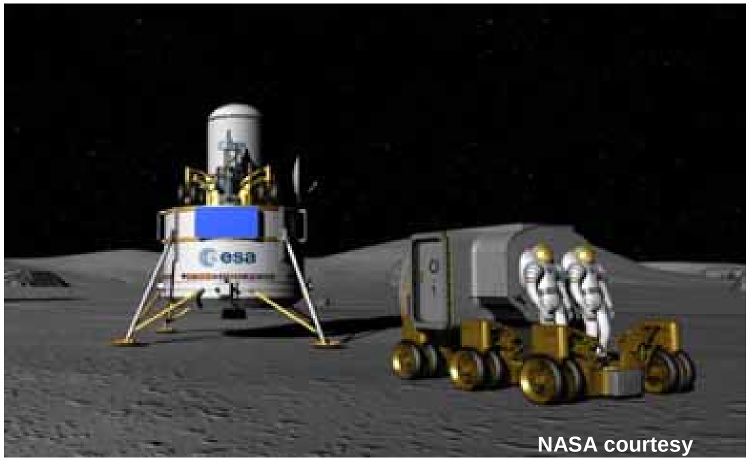
Human outpost location

- Site preparation: prepare landing area for further missions
- Pre-deploy safety enhancement capabilities (safe-haven shelters for SPE…)
- Deploy lunar surface communication terminal
- Deploy navigation beacons
- Pre-deploy crew mobility chassis
- Pre-deploy power plants
- Deploy oxygen production plant (ISRU) and tools

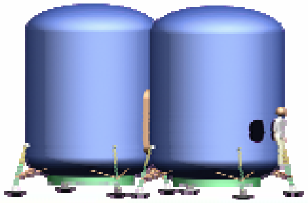
Human Support (1/2)

- **Possible human support scenarios**

1. Delivery of non-pressurized logistics
2. Delivery of elements
   + non-pressurized logistics
3. **Delivery of pressurized logistics**



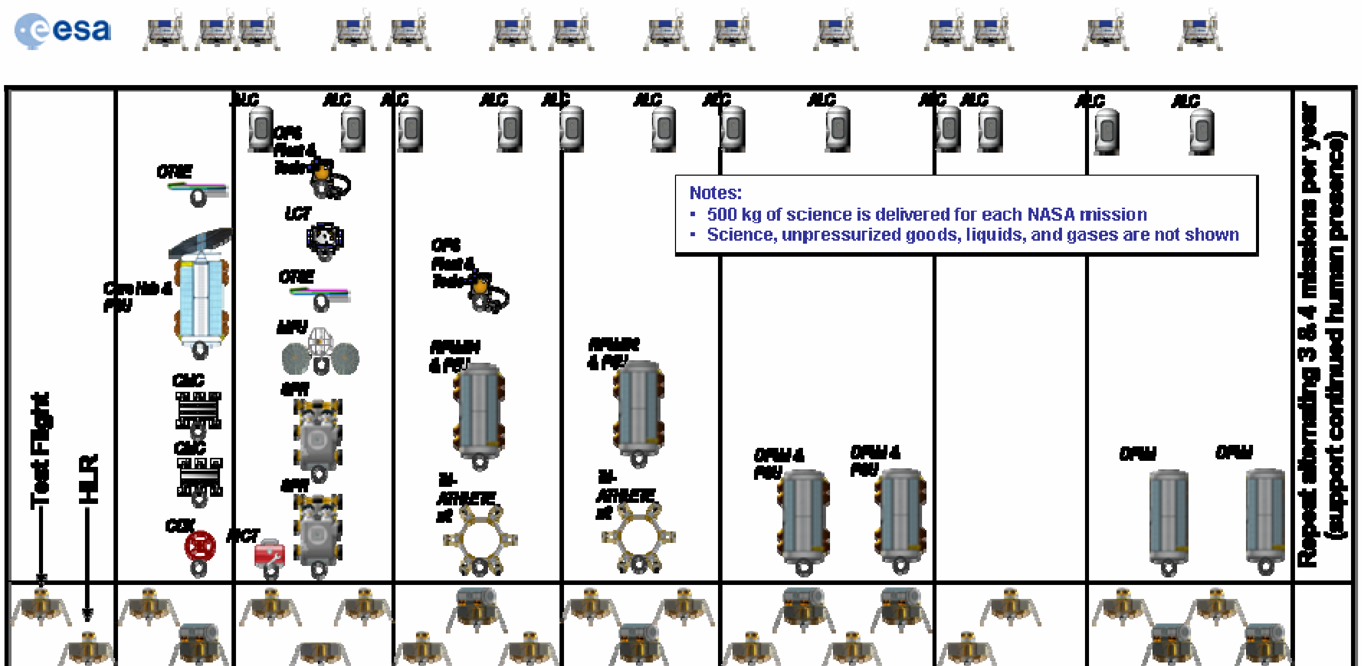
- **Lunar outpost logistics needs for crew of 4 per year**
  - Life support supplies,
  - Maintenance needs (includes spare parts, hand tools,..)
  - Crew systems supplies (clothing, stowage, medical kit…)



Type of Supply	Mass	Unit	Volume	Unit
Life Support	**8960**	**kg**	**9,6**	**m^3**
Maintenance	**2400**	**kg**	**5,9**	**m^3**
Crew Systems	**2600**	**kg**	**16,4**	**m^3**
Total	13960	kg	31,9	m^3

Human Support (2/2)

"Delivery of pressurized logistics significantly improve crewed surface stays over first 9 crewed flights and could delete ALTAIR launch from manifest". NASA estimation



FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	...
0 4	4 0	4 0 4	4 0 4	4 0 4	4 0 4 0	4 4	4 0 4 0	
0 7	7 0	30 0 60	60 0 90	120 0 180	180 0 180 0	180 180	180 0 180 0	

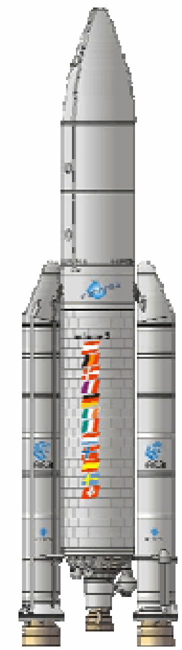
NASA courtesy

Early availability at beginning of base construction (2020) is critical to get maximum benefit

Conclusion

Full-A5 lunar landing system is a key element of a lunar exploration architecture:

- Asset for international cooperation on the basis of autonomous European capability
- Main application scenario is to support human lunar surface operations
- Utilisation of European heritage / competences



Questions ?

http://www.esa.int/SPECIALS/Space_Exploration_Strategy/