European Architecture for Lunar Exploration

LEAG – ICEUM - SRR

29 October 2008

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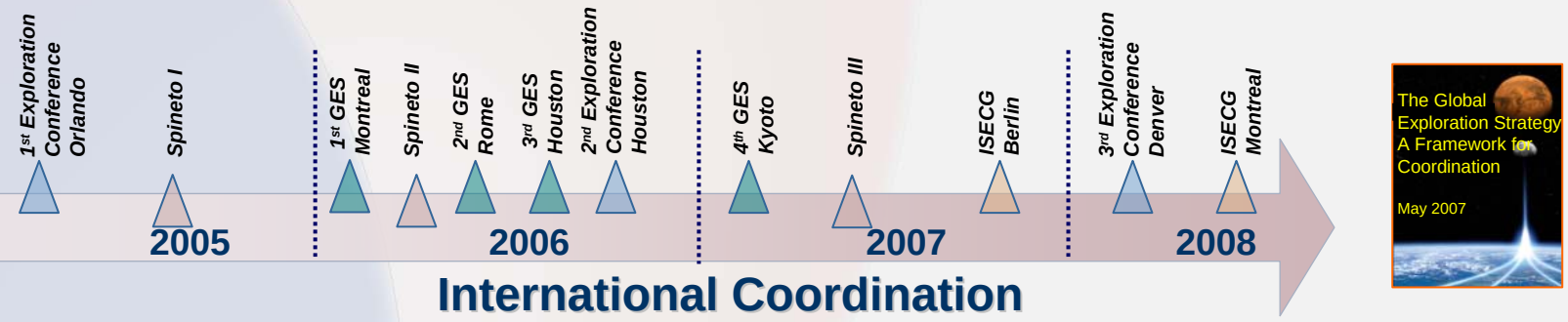
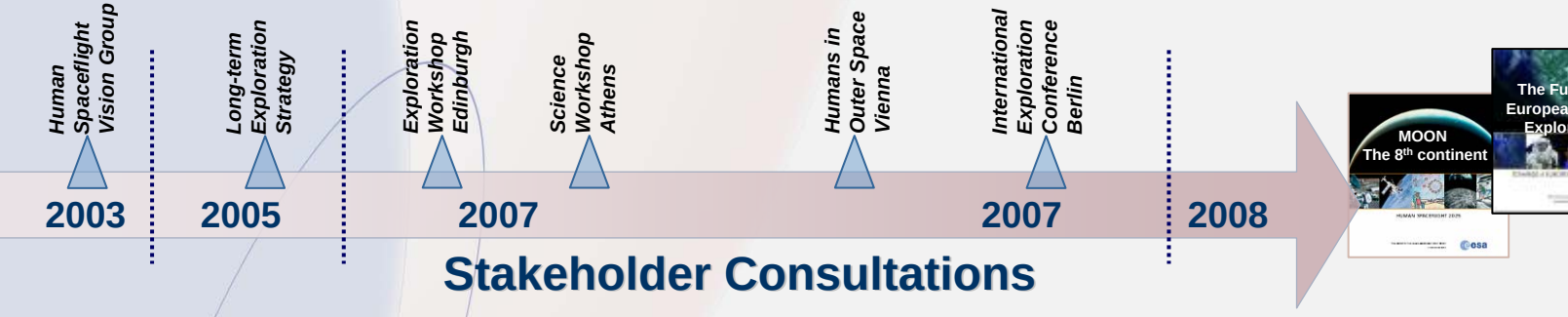
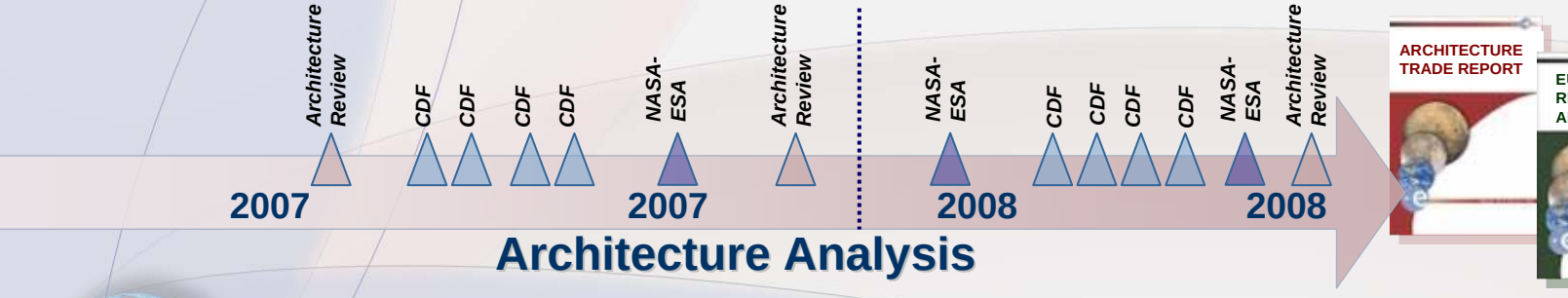
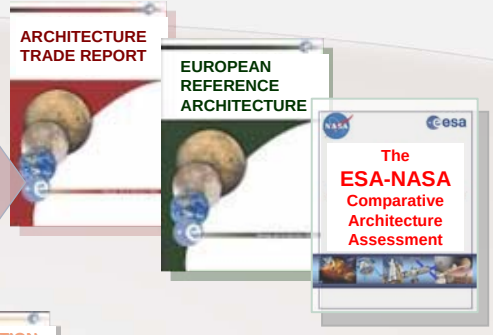
website: http://www.esa.int/explorationstrategy

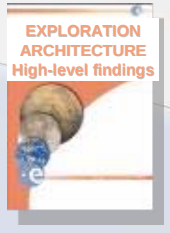
Analysis Process and Products











Scenario Studies and Stakeholder Consultations

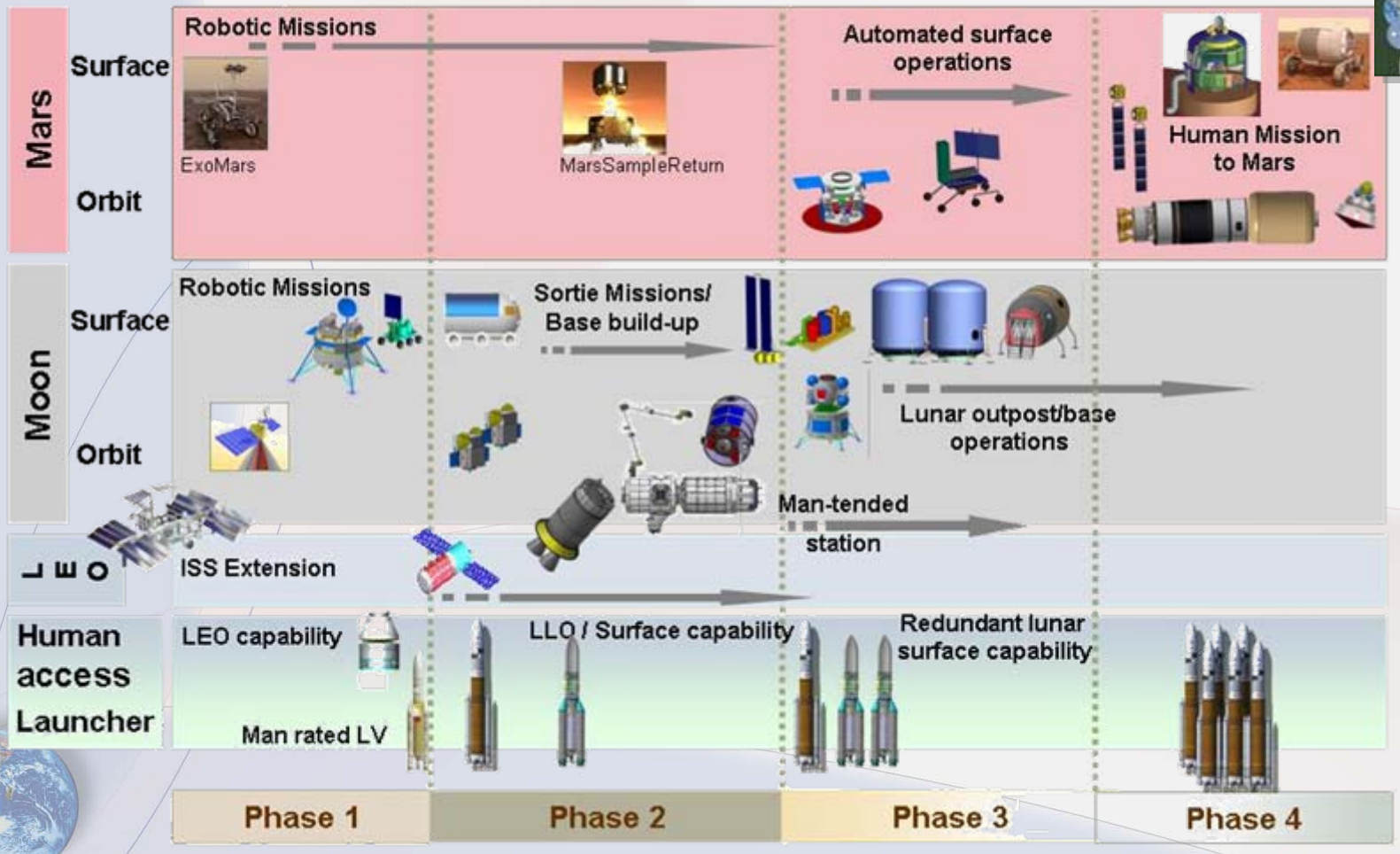
Science	Economy	Policy
Co-evolution of Life with its Planetary Environment	Applied Research in Space	European Ambition
Lunar Observatories	Space Services	Lisbon Agenda
Life Sciences	Entrepreneurial Activities	Global Partnership

Exploration Phases

	PHASE 1	PHASE 2	PHASE 3	PHASE 4
LEO	**ISS Operations** • On-orbit Research • Risk mitigation for exploration	**Sustained Human Operations – Research** • On-orbit research • Risk mitigation for exploration	**Sustained Human Operations – Exploration** • On-orbit research • Risk mitigation for exploration • Services for human Moon missions • Commercial initiatives (tourism)	**Sustained Human Operations – Exploitation** • On-orbit research • Risk mitigation for exploration • Services for human Moon/Mars missions • Commercial initiatives • Power plants
MOON	**Robotic Missions** • Mapping • Landing site preparation • ISRU demonstration • Lunar science	**Initial Human Surface Operations (Short Visits)** • Limited Life/Physical sciences research • Capability demonstrations for sustained presence • Base construction • Limited geological fieldwork • Sortie support tasks • Limited laboratory analysis	**Sustained Human Surface Operations (Base)-Exploration** • Life/Physical sciences research • Mars forward capability demonstration • Geological fieldwork • ISRU processing • Base support tasks • Laboratory analysis	**Sustained Human Surface Operations (Base)-Exploitation** • Tourism • Large observations • Resources
MARS	**Robotic Missions** • Science	**Mars Sample Return** • Science	**Extended Robotic Surface Operations** • Science	**Human Mars Mission**

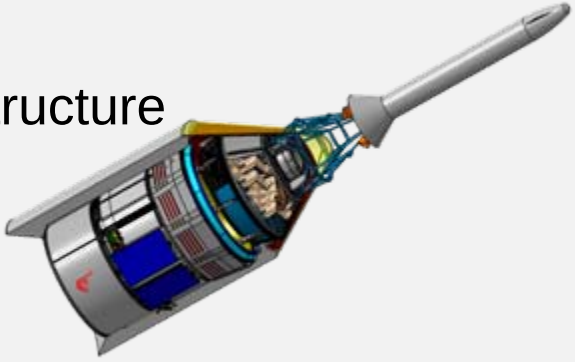
Phased Approach to Architecture Development

EUROPEAN REFERENCE ARCHITECTURE

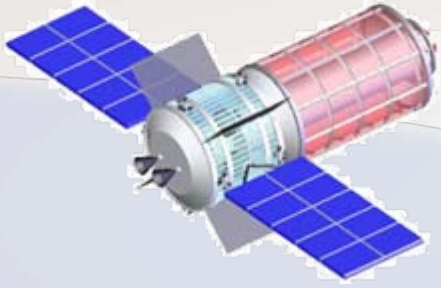


Operations in Low Earth Orbit

- Development of crew transportation capability
  - Secure access to existing and future research infrastructure in LEO
  - Enable participation to human exploration



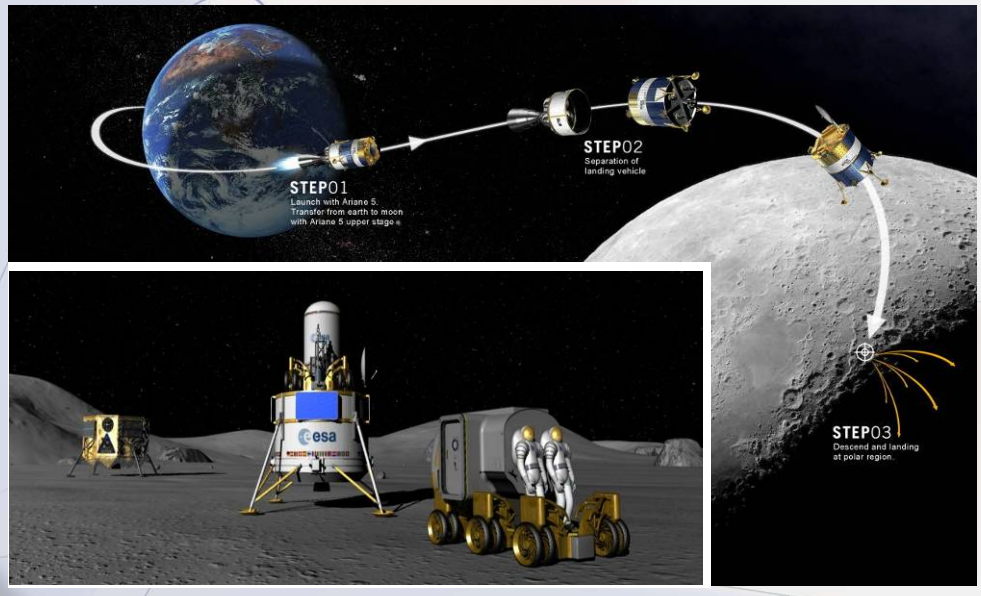
- ISS lifetime extension up to 2020 assumed for research continuation and exploration preparation
- Minimum configuration for research continuation post-ISS is a Man-Tended Free Flyer



Total mass 20540 kg
Support crew 2-3 for 15 days
Lifetime 10 years

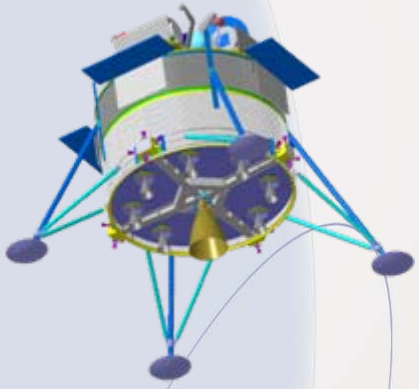
Lunar Cargo Lander

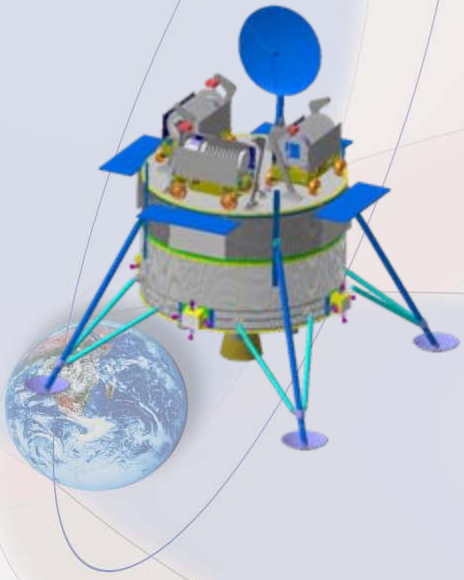
- Use the full Ariane 5 performance capability
- Deliver payloads to any location on the lunar surface
- Perform soft precision landing (500m)
- Deploy payloads on lunar surface
- Provide resources to the P/L (power, comm's etc)



- Gross payload performance (A5 ECA) ~1.2 ton

Lunar Cargo Lander Mission Scenarios

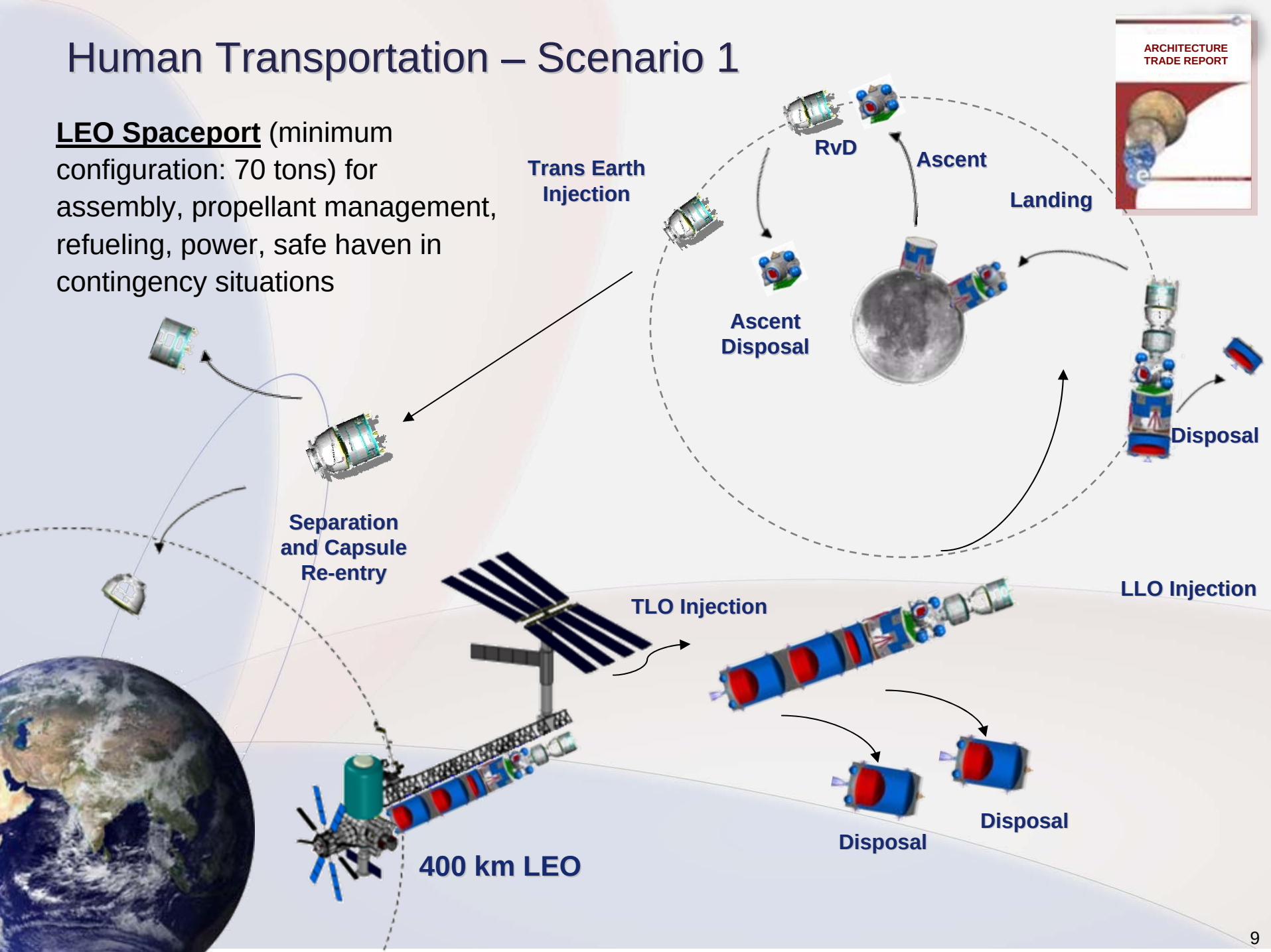




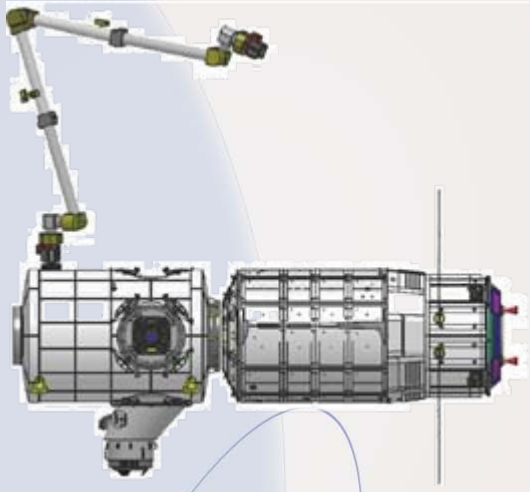
- Technology demonstration and potential human landing preparation;
- Delivery of surface assets, be they stationary or with mobility, in order to support and accelerate the international lunar outpost build-up or for science and technology demonstration in sustained human operations.
- Provision of consumables for extended human surface exploration range and duration;
- Delivery of regular logistics to an international lunar base;
- (Automated lunar surface operations (e.g. ISRU) and exploration

Human Transportation – Scenario 1

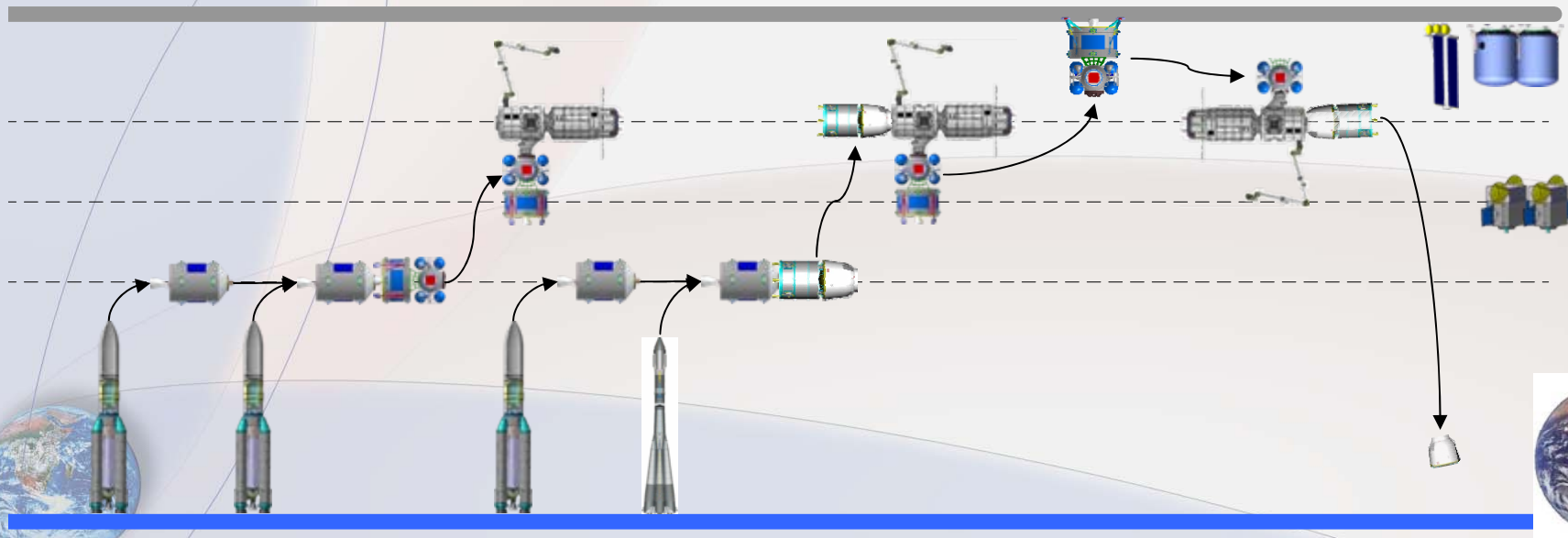
<u>LEO Spaceport</u> (minimum configuration: 70 tons) for assembly, propellant management, refueling, power, safe haven in contingency situations



Human Transportation – Scenario 2



<u>LLO Staging Post</u> in polar quasi-circular frozen orbit (minimum configurations 28 tons) providing also crew rescue (anytime return, safe haven) and provision of power, attitude control, communications, refuelling to crew vehicle in LLO.

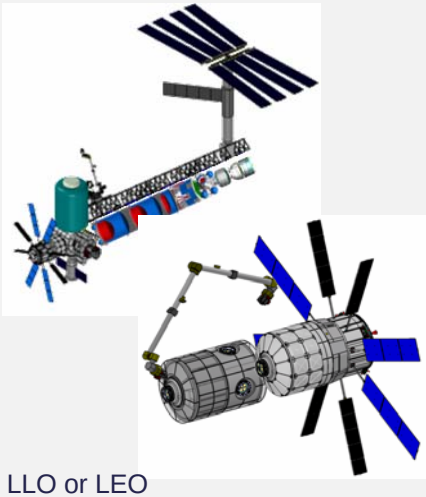


Transportation Infrastructure

EUROPEAN REFERENCE ARCHITECTURE

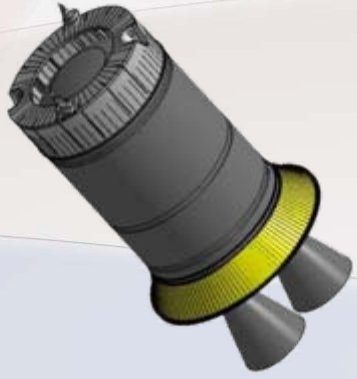
Human-rated launcher
> 13 tons payload

Crew Vehicle
13 tons



LLO or LEO
Staging Post

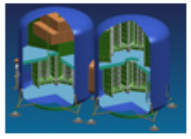
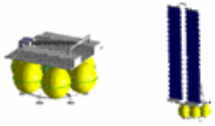
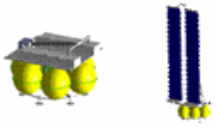
Heavy Lift Launcher
50 tons payload



Cryo-Transfer Stage
24 and 50 tons

Human-rated Lander
26 tons

Lunar Surface Exploration Scenarios

Scenario	Sortie (short)	Sortie (long)	Outpost	Lunar Base
Crew Number	4	4	2	4+
Duration	7-14 days	14-42 days	14-42 days	180 days
Characteristics	Apollo-like. One visit to a particular landing site.	Longer duration Apollo-like. Multiple visits to a region requiring high mobility.	Multiple visits to a region of high interest (e.g. science, telescope maintenance).	Permanent human presence at a lunar base.
Surface Infrastructure: Habitat				
Surface Infrastructure: Mobility				
Surface Infrastructure: Power plant				
Surface Infrastructure: ISRU plant				

Lunar Surface Infrastructure

EUROPEAN REFERENCE ARCHITECTURE

Pressurized rover

7600 kg

Provide long-range mobility for human surface exploration

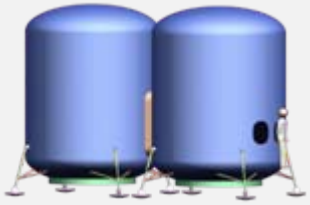
Mini-habitation module

6960 kg

Support crew of two for short duration missions (14 days)

Lunar Base Modules

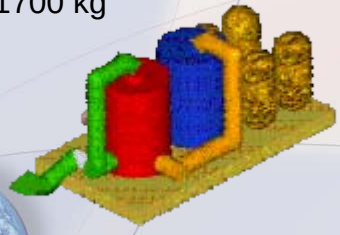
13 t each



Support up to 4 astronauts to survive on Lunar Surface for extended stays (several months)

ISRU plant

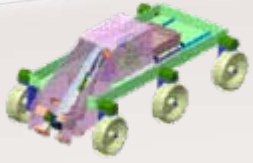
1700 kg



Provide O_2 from regolith

Utility vehicles

350 kg



Terrain management vehicle

350 kg

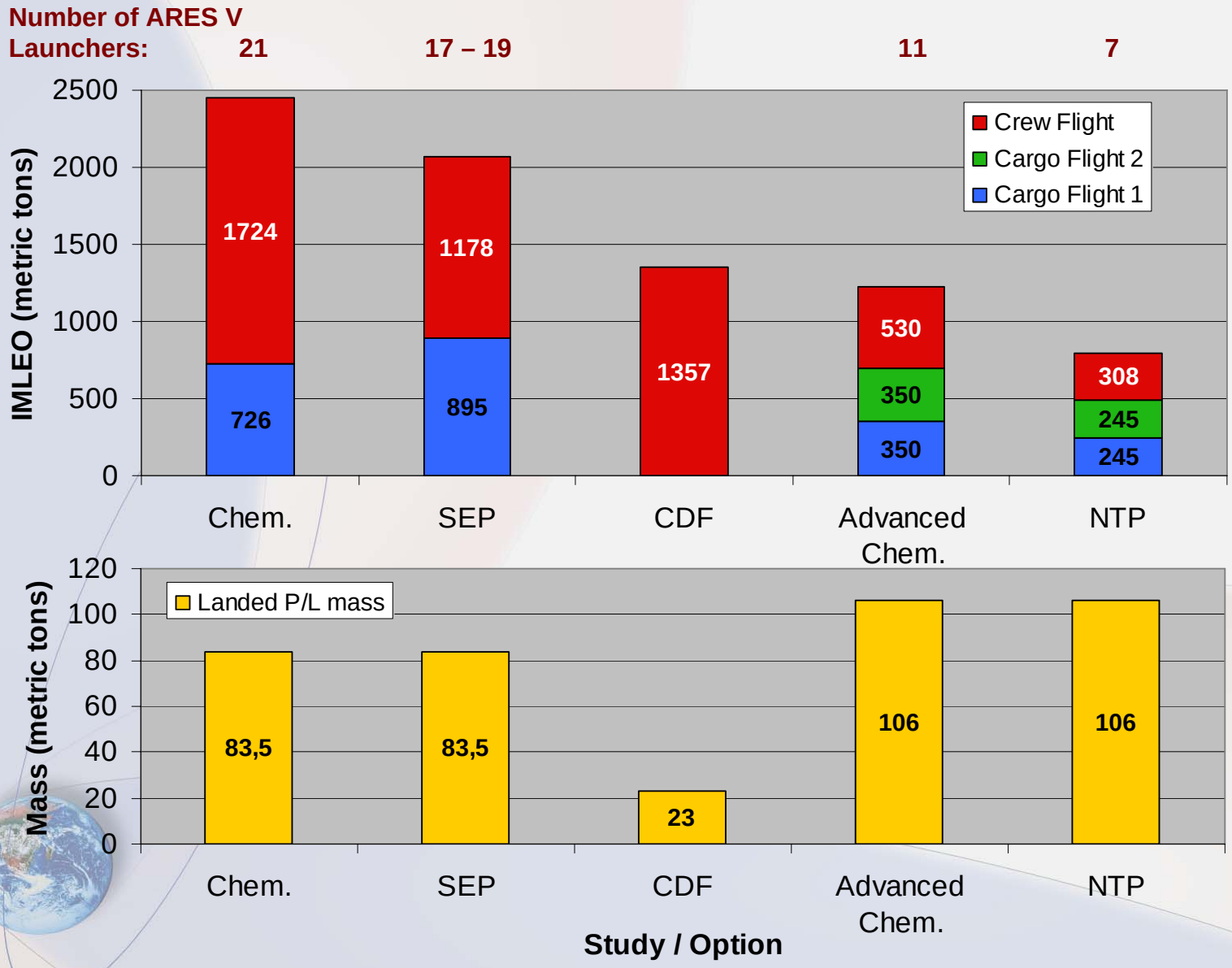
Tanker and services vehicle

Large solar power plant

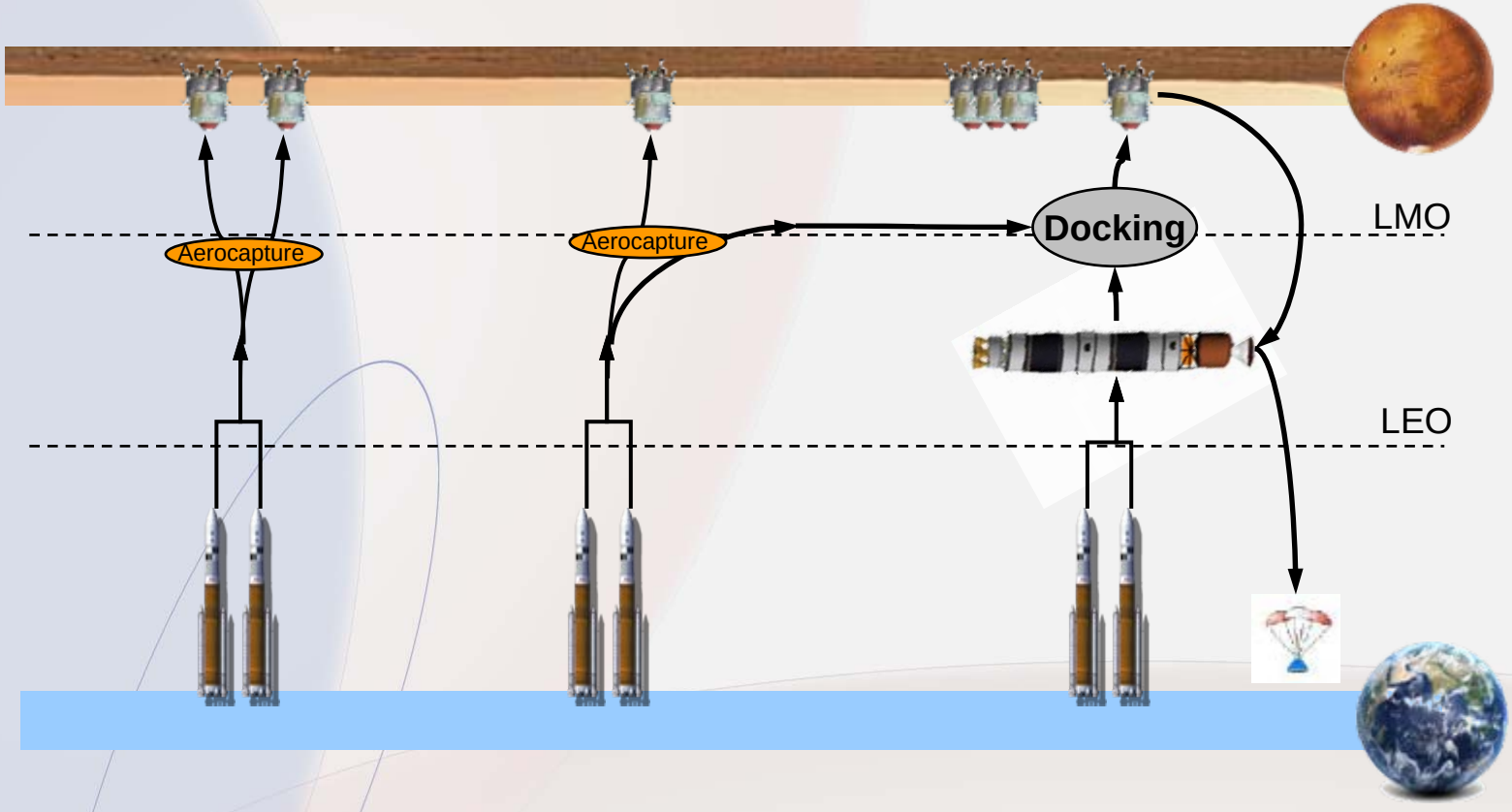
1500 kg

Provide power to outpost/base

Human Mars Mission Trade-Off



Human Mars Mission Reference Architecture



Pressurised Rover 8 tons

Transit Hab 38 – 50 tons

Surface Hab 32 tons

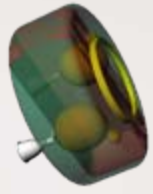
Nuclear Power Plant 12 tons

Ascent Vehicle 30 tons

Descent Vehicle 24 tons

Nuclear Transfer stage 120 tons

LEO Tug 22 tons



Payload Tug 5,8 tons

High-level Findings

- Heavy-lift launcher with 50 tons payload capability enable human mission beyond LEO
- Human operations in Low Earth orbit of continued strategic interest beyond ISS programme
- Orbital infrastructure (a) enhance robustness of human exploration transportation architecture providing safe haven in contingency situation and services to the transportation system (assembly, maintenance, inspection, cryo-management, re-fueling, power) and (b) open opportunities for innovations in the transportation architecture
- Lunar surface architecture strongly depends on exploration scenario
- Interest in utilisation of Lunar ISRU for consumables (break-even in 2nd year of operations
- Advanced propulsion required for Human mission to Mars
- Moon-Mars synergies for advanced robotics, long-range exploration, long-term surface habitation, soft precision landing, surface operations, in-space operations, communications and navigations