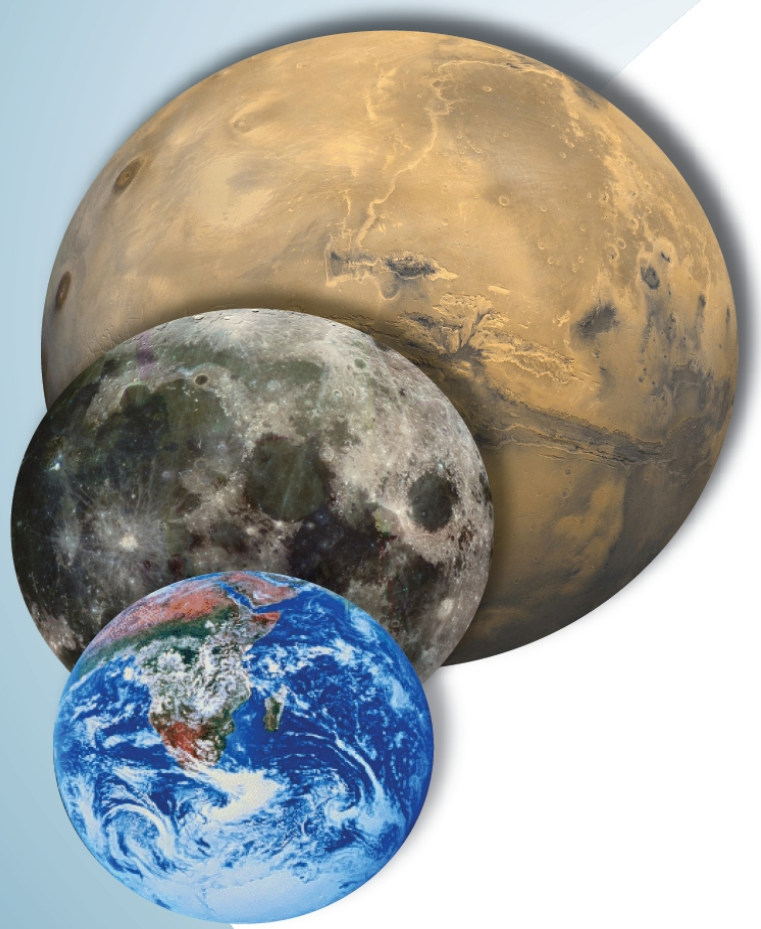

International Reference Architecture Integration

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International scenarios

- **International Permanent Base on the Lunar Surface (“ISS-on-the-Moon”)**
  - In line with US objectives
  - European role :
    - Supply modules and surface elements (rovers, ISRU units, science instruments…) – Columbus type approach
    - Supply cargo transport to the Lunar surface (Ariane 5 cargo lander) – ATV type approach
    - Long term : assured crew return, then crew transport
  - Other space powers
    - Japan, in same situation as Europe
    - For Russia, same situation as Europe (to be compared with its major partner position in the case of ISS)
    - China, India ?

International scenarios

- **Multiple visits to the lunar surface, without permanent infrastructure (repeat of Apollo)**
  - Not in line with US objectives
    - Could be a form of descoping of the Lunar Base scenario
  - European role :
    - Could be limited to bilateral or trilateral activity
    - Participation in these Apollo like missions, supplying support by launch capability, modules, vehicles, stages
    - Probably longer term than International outpost
  - Other space powers
    - Japan, in same situation as Europe
    - For Russia, could be in line with their objectives (CSTS approach)
    - China, India ?

International scenarios

- **Permanent outpost, visited by crew for short duration stays**
  - Not in line with US objectives
    - Could be a form of descoping of the Lunar Base scenario
  - European role :
    - Supply modules and surface elements (rovers, ISRU units, science instruments…) – Columbus type approach
    - Supply cargo transport to the Lunar surface to support the visits (Ariane 5 cargo lander) – ATV type approach
  - Other space powers
    - Japan, in same situation as Europe
    - For Russia, same situation as Europe (to be compared with its major partner position in the case of ISS)
    - China, India ?

International scenarios

- **International robotic facility (robotic village, far-side telescope…) visited by crew**
  - Not in line with US objectives
  - European role :
    - Participation in these missions, supplying elements of the surface facility, launch capability, modules, vehicles, stages
    - Probably the robotic form could allow an earlier start than a human infrastructure
  - Other powers
    - Japan, in same situation as Europe
    - For Russia, could be in line with their objectives (CSTS approach)
    - China, India ?

International scenarios

- **International orbiting outpost in LLO (or L1)**
  - Not in line with US objectives, it could provide
    - Safe haven for US crew
    - Docking location for Orion during surface stays
    - International laboratory/platform for microgravity science and Lunar science
  - European role :
    - Participation in these missions, supplying elements of the orbital facility, launch capability, modules, vehicles, stages
    - Probably start earlier in a human-tended form
  - Other powers
    - Japan, in same situation as Europe
    - For Russia, could be in line with their objectives (CSTS approach)
    - China, India ?

International scenarios

- **Multiple robotic missions, including sample return**
  - European role :
    - Participation in these missions, on a purely European, loosely coordinated way
    - Bilateral cooperation on most costly missions

Integrated architectures

- **Europe as provider of cargo to lunar surface**
  - Ariane 5 class cargo lander
    - Elements to develop
      - Ariane 5 class lander
    - Cooperation scheme
      - Europe delivers payload to an International Base/Outpost with barter against :
        - » Access for European experiments to the Base/Outpost
        - » Landing of items out of Europe capabilities on the Lunar surface
        - » European crew on the lunar surface
    - Evolution potential
      - Increase of capabilities with increase of Ariane 5 performance
      - Payload return capability (with a launcher with increased performance)
      - Hopper (delivery in multiple points)

Integrated architectures

- **Europe as provider of a crew return system space-based in LLO**
  - Ariane 5 class (2 launches of Ariane 5 ME)
    - Hardware to be developed
      - CRV
      - Braking stage for Lunar insertion of the CRV
      - EDS for CRV TLI
      - Assembly in orbit
    - Cooperation scheme
      - Europe delivers a CRV in LLO to be bartered against :
        - » Access for European experiments to the Outpost
        - » Landing of items out of Europe capabilities on the Lunar surface
        - » European crew on the lunar surface
    - Evolution potential
      - Increase of capabilities with increase of Ariane 5 performance
      - CTV
      - CRV capability from Lunar surface (ascent system)

Integrated architectures

- **Europe as partner in a Crew Transport System to LLO**
  - Development needed
    - CTV
    - Earth Departure Stage
    - 50-ton class launcher (Ariane X)
  - Cooperation scheme
    - Europe provides elements (CTV modules, EDS) and Ariane X launch services for the assembly in LEO of a Crew Transport System to LLO (CSTS-type scheme)
    - Sustainability of Lunar exploration by providing a path parallel to US/Orion
  - Evolution potential
    - Increase of capabilities with increase of Ariane 5 performance
    - Crew transport to Lunar Surface in combination with a lander (need a specific way to bring the lander in LLO)
    - CRV capability

Transportation worksharing

- **Architectures on the Moon surface**
  - US will have capability to provide transportation to surface with Orion/Altair (cargo and crew)
  - Europe has capability to provide
    - In the short term, cargo transportation to the Lunar surface with an Ariane 5 class lander
    - In the longer term, a redundant crew transportation capability
- **Architectures in LLO**
  - US will have capability to provide transportation to LLO with Orion
  - Europe has capability to provide
    - In the short term, cargo transportation to LLO
    - In the longer term, a crew transportation capability to LLO
- **Other space powers, such as Russia, Japan, or China can develop similar cargo transportation, and later crew transportation, capabilities.**

Need for coordination

- **Definition of cooperation scheme**
- **Coordination of standards**
  - System of references, units, etc.
- **Coordination in terms of interoperability of crewed and robotic systems**
  - Common crew interfaces, operating pressure, etc.
- **Common interfaces with Payloads (pressurized and unpressurized)**
  - Mechanical
  - Power/data
  - Etc
- **Common docking systems**
  - Large type (inter-propulsion stages / EDS)
  - Small size (IBDM, LIDS)

Coordination examples

- **Cooperation scenario involving the Lunar cargo lander**
  - Flight corridors for lander
  - Geometrical interface with payload
  - Mechanical interface with payload
  - Communication standards
  - Power and data interface with payload
- **Redundant crew transport**
  - Pressurized docking interface
  - Atmosphere and crew environment
  - Power
  - Communication protocol

How to foster coordination

- **International pilot project of Lunar exploration**
  - Would showcase exploration and cooperation in human spaceflight activities beyond ISS
  - Would use existing hardware to reduce costs
  - Would ultimately lead to operational system
- **Establishment of a joint concept of Automated Lunar Cargo Lander**
  - Compatible with international launchers
  - Service available to partner agencies