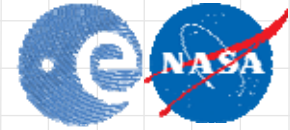


The NASA-ESA Comparative Architecture Assessment (CAA)

Richard B. Leshner, PhD
NASA Exploration Systems Mission Directorate

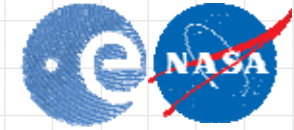
Bernhard Hufenbach
ESA Directorate of Human Spaceflight

October 29, 2008



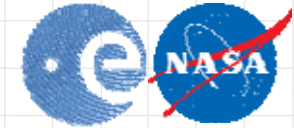
- ESA and NASA Context
- The NASA-ESA Comparative Architecture Assessment
 - Purpose, process, and findings

ESA Context for Exploraiton



- **The European Space Policy identifies space exploration as a new priority and an area for international cooperation and political dialogue with other space power ("Space Exploration as a political and political endeavour")**
- **“Global Space Exploration - A Framework for International Coordination” forms strategic framework for ESA activities - document has been taken note of at the 5th European Space Council meeting in September.**
- **ESA Council Meeting at Ministerial-level in November 2008 forms an important milestone for providing further guidance by ESA Member States on ESA preparatory activities**
- **High-level political conference on a long-term global vision for space exploration will be initiated in 2009 opening a public debate on the European role in this global space exploration**

ESA Exploration Themes



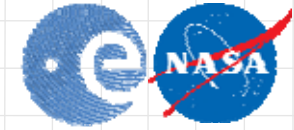
Science	Economy	Policy
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Co-evolution of Life with its Planetary Environment	Applied Research in Space	European Ambition
Lunar Observatories	Space Services	Lisbon Agenda
Life Sciences	Entrepreneurial Activities	Global Partnership



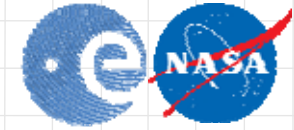
**Space Exploration needs to be political relevant and attractive
(Role of Europe in the World, European Autonomy)**

NASA Context for the CAA – Why the Moon?



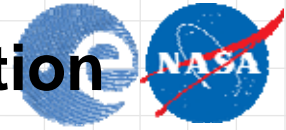
- **National Policy – clear and explicit direction**
 - Architecture studies and Lunar Architecture Teams
- **Earliest opportunities for engaging commercial and international partners**
 - Resonant with the Global Exploration Strategy
- **Testing of technologies, systems, flight operations and exploration techniques**
 - Learn how to survive and operate effectively on another planet
 - Learn how to best support astronaut crews living far from home
- **Infrastructure development for sustained human exploration beyond LEO**
 - Also part of the Global Exploration Strategy
 - Mars preparation

Opportunity for Comparative Assessment



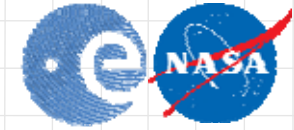
- **A Cooperative Study**
 - Determine if specific exploration capabilities currently under study for future independent development by ESA and NASA can complement, augment, or enhance the exploration plans of the other
- **Phase 1: January to May, 2008**
 - A joint review of each agency's lunar architecture studies with the intent of identifying potential synergies between ESA and NASA concepts
 - Several face-to-face meetings via video conference and in person
 - Information exchange, table-top review of technology and system concepts
 - Scenario development and qualitative assessment against figures of merit
- **Elements included in Phase 1 included:**
 - Cis-lunar transportation
 - Lunar Surface Systems and Technologies
 - Potential Orbiting Platforms
 - Communication Systems

Some NASA Thinking About Surface Exploration



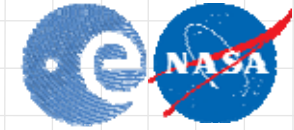
1. **Conduct as much risk reduction and technology demonstration as possible in advance of (and during) human missions**
2. **Assure access to the lunar surface and return to Earth for a crew of 4**
3. **Enable the build-up of an outpost on the lunar surface as soon as is feasible**
 - a. leading to long duration missions
4. **Enable the greatest possible mobility for astronauts on the surface as soon as is feasible**
 - a. leading to the greatest possible science and exploration opportunities
5. **Enable access to multiple locations on the surface as soon as is feasible**
 - a. leading to the greatest possible science and exploration opportunities
6. **Engage with partners and facilitate international participation in all aspects of lunar surface exploration**

Findings: European Cargo Lander



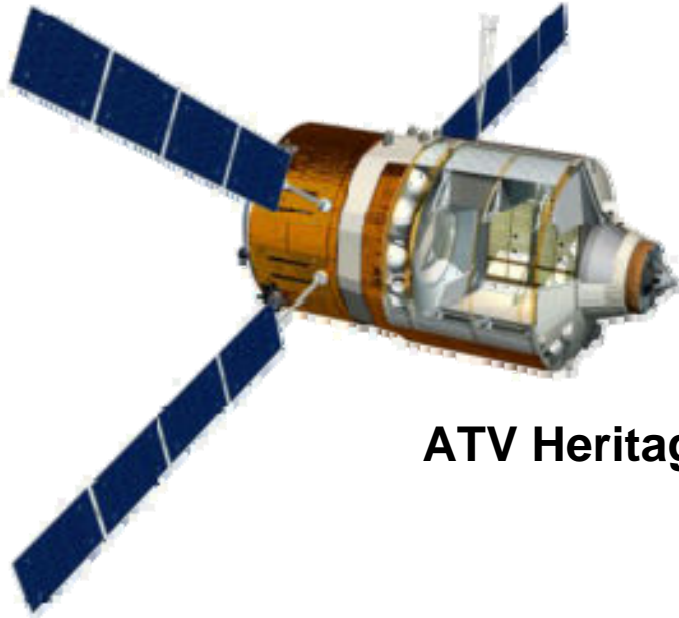
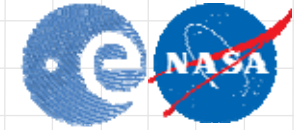
- **Ariane 5 based lunar landing system**
 - Science utilization, technology demonstration, surface characterization
 - Potential human landing preparation – both sortie and outpost missions
 - Delivery of regular logistics and consumables to a lunar base
 - Delivery of surface assets for accelerated lunar outpost build up

Findings: European Cargo Lander

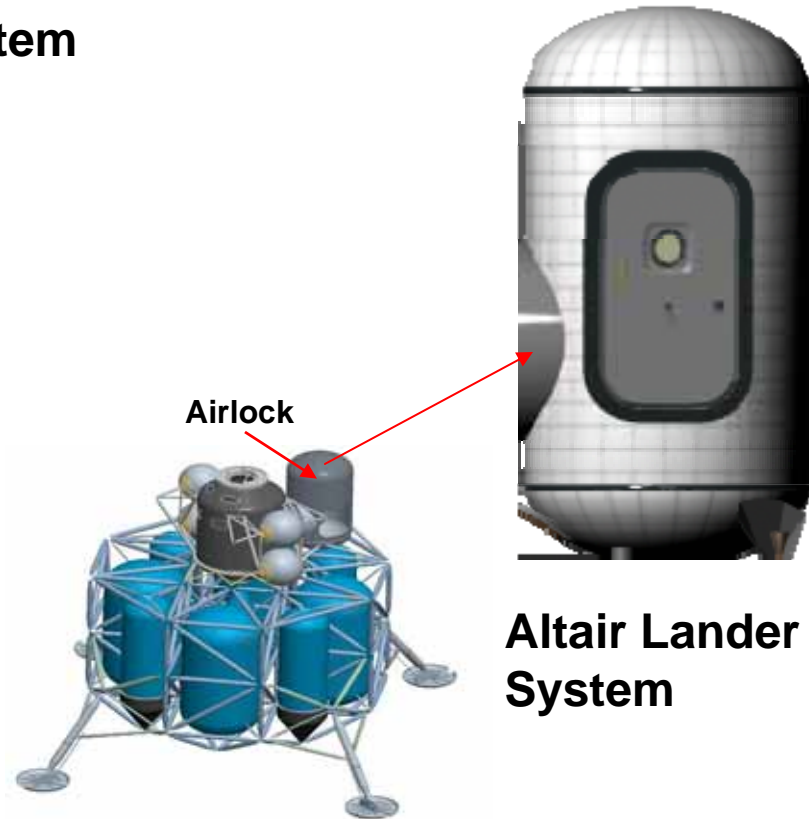


- **Ariane 5 based lunar landing system**
 - Science utilization, technology demonstration, surface characterization
 - Potential human landing preparation – both sortie and outpost missions
 - Delivery of regular logistics and consumables to a lunar base
 - Delivery of surface assets for accelerated lunar outpost build up
- Consider a notional NASA Lunar Exploration scenario
 - Outpost-centric
 - Sortie mission profiles would likely see similar benefit
- **ESA Capability Assumptions: 2 ESA landers per year added to notional scenario**
 - Early flights for site characterization and human landing preparation can be beneficial but not analyzed in detail
 - Assumed ESA lander would arrive while crew was present on lunar surface
- Preliminary assessment of the utilization of the ESA Lander for the delivery of pressurized logistics

How to do Pressurized Logistics Delivery?

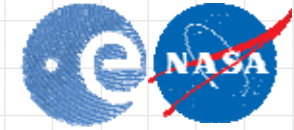


ATV Heritage System



Altair Lander Derived System

Notional NASA Lunar Exploration Scenario – Outpost-centric

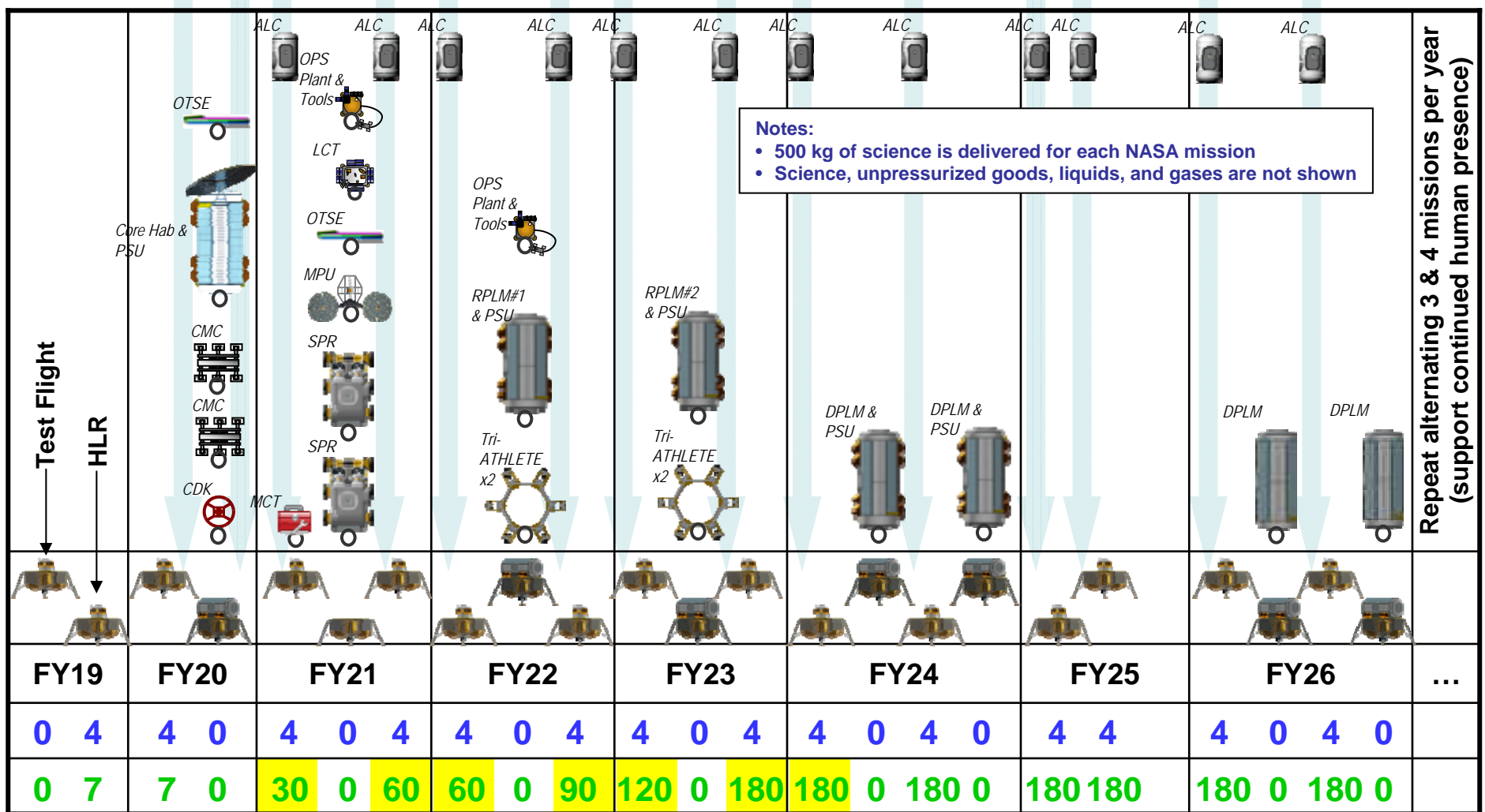
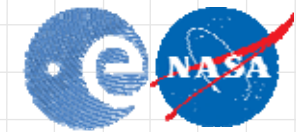


Test Flight ↓ HLR ↓		 	 	 	<div style="border: 1px solid black; padding: 5px;"> Notes: • 500 kg of science is delivered for each NASA mission (exception on FY20 cargo mission where 150 kg was removed to enable delivery of pressurized goods) • Science, unpressurized goods, liquids, and gases are not shown </div>			 		 	Repeat alternating 3 & 4 missions per year (support continued human presence)
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 0	4 0 4 0				
0 7	7 0	14 0 14	14 0 30	60 0 85	90 0 180 0	180 180 0	180 0 180 0				

Crew Size

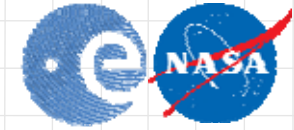
- Surface Duration

Option 3: Pressurized & Non-pressurized Logistics Delivery by ESA Lander



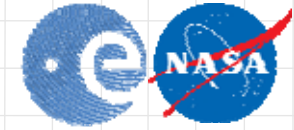
Crew Size # - Surface Duration

Joint NASA/ESA Scenario Results



Scenario Options	Days Through First 9 Crewed Flights	Percent Increase	Number of Ares V Cargo Missions Eliminated
Notional Scenario	321	--	0
Pressurized & Unpressurized Cargo Delivery w/ESA Lander	734	128%	1

CAA Findings: Summary



- **NASA and ESA are both facing major development decisions from 2010 to 2011**
- **There is a clear strategic benefit for both ESA and NASA in finding ways to cooperate in the development of a lunar exploration architecture**
 - Longer duration human missions
 - Redundancies for critical capabilities can increase safety and reliability
 - Increased opportunities for science
 - Potential for better synergy between robotic and human missions
- **Early perspective on opportunities for long-term collaboration between NASA and ESA**
 - There are several areas for continued fruitful discussion