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Vision for Space Exploration

ILS Issues and Approaches

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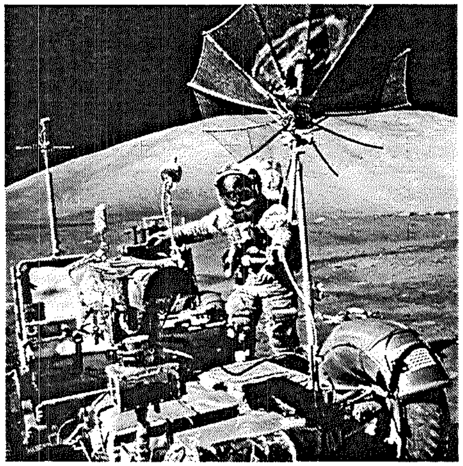
The Vision



Undertake lunar exploration activities to enable sustained human and robotic exploration of Mars and more distant destinations in the solar system.

Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than the year 2020.

Develop and demonstrate power generation, propulsion, life support, and other key capabilities to support more distant, more capable, and/or longer duration human and robotic exploration of Mars and other destinations.

ESA

Conduct human expeditions to Mars after acquiring adequate knowledge about the planet using robotic missions and after successfully demonstrating sustained human exploration missions to the Moon.

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Spiral Development Approach

- Spiral 1
  - Human spaceflight in low-Earth orbit
  - Robotic precursor missions to Moon
- Spiral 2
  - Lunar human missions with durations of 4 - 7 days
  - Crew size: 4 – 6
  - Additional lunar riobotic missions likely
  - Robotic missions to Mars for science and as precursors to human missions
- Spiral 3
  - Human lunar missions of 42 – 98 days
  - Testbed for long-duration human missions
  - Additional robotic precursor missions to Mars
- Spiral 4/5
  - Human missions to Mars vicinity and surface

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Major Milestones

- 2008: Initial flight test of boilerplate Crew Exploration Vehicle (CEV)
- 2008: Launch first lunar robotic orbiter
- 2009 – 2010: Robotic mission to lunar surface
- 2010: Space Shuttle retires
- 2011: First uncrewed CEV flight
- 2014: First crewed CEV flight
- 2015 – 2020: First human mission to the Moon
- >2020: Continued human lunar missions extending from days to months in duration

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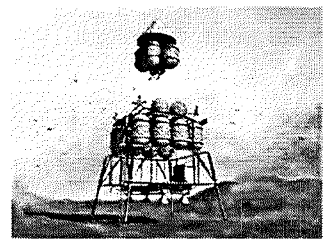
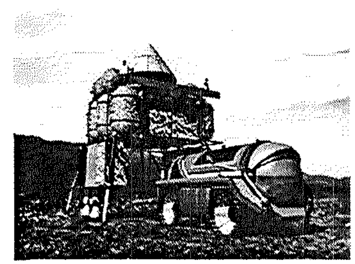
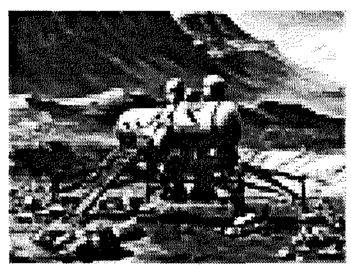
Potential Mission Hardware Elements



- CEV
- Transit vehicle/habitat
- Lander/ascent vehicle
- Surface habitat
- Surface mobility – unpressurized and pressurized rovers
- Deployed power systems – solar or nuclear
- *In-situ* Resource Utilization plants
- Drill
- Uncrewed cargo vehicles





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ILS Approach and Challenges

Approach

- Develop an ILS concept for human missions to Mars
- Validate that concept during the human lunar missions

Challenges

- Human missions to Mars may last as long as 3 years
- No resupply capability – roughly 2-year intervals between launch opportunities
- High level of crew autonomy – up to 40 minute round trip communications time
- Mass and volume constraints

We've Been Down this Road Before

Robert Peary discussing provisioning of polar expeditions:

"After the expedition has cast loose from civilization there is no chance to rectify mistakes or omissions. No rush wires or cables can be sent back to ship this or that article by next rain or steamer. The little ship which bears the hopes of a polar expedition must contain in its restricted space everything to supply all the needs of its people for two or three years in a region where nothing can be obtained..."

Secrets of Polar Travel, Robert Peary, 1917
cited in Polar Journeys, Robert E. Feeney, 1997

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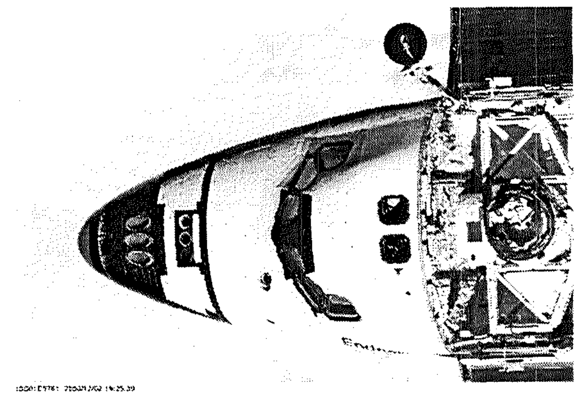
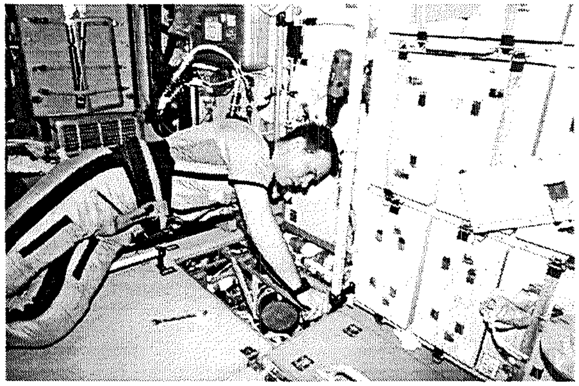
ILS Concept

- Minimize mass and volume of spares
  - Emphasize repair rather than simply remove and replace
  - Repair at lowest possible hardware level – components or pieceparts
- Multi-level maintenance capability
  - Level selected based on situation (e.g. longer missions, more time, lower level)
- Impose commonality: at all levels across all elements
- Introduce capability for fabrication of structural and mechanical replacement parts as-needed.
- DoD inspirations:
  - Navy 2M Electronic Repair Program
  - Army Mobile Parts Hospital





Implications

- Imposition of commonality requirements on designers.
- Increased capability to access lower levels of hardware.
- Significant expansion of technical data available to crew and ground personnel.
- Increase in number of potential procedures by order of magnitude. How do we handle this?
- Significantly more technological capability for maintenance and repair.
- Do we introduce any new single-points-of-failure?
- Potential increase in crew time required for maintenance.
- Still need item-by-item LSA to ensure that everything is covered.

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Selected Lessons Learned from ISS

- Ensure requirements for supportability, maintainability and reliability start with the highest level program document and flow down to the lowest level specification.
- Create a partnership between logistics & designer, instead of an adversarial relationship.
- Standardize! No standardization requirement/constraint on Station designers resulted in proliferation of connector types and ORU interfaces.
- Establish direct access requirement/constraint, not just overall crew time requirement. For many ORUs access takes longer than the remove /replace procedure.
- Avoid external maintenance.
- We can do more than we thought we could.

ref. W. Robbins, Dept. Mgr. ISSPO L&M