Human Surface Operations

ESA

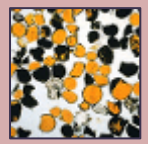
ESA-ESRIN, 16 January 2009

Surface Scenarios Assessment

AES Study / ISECG-ISWG **	Sortie	Super-Sortie	Human-Tended Outpost	Polar Outpost
	Apollo-like visit	*Long duration Apollo-like stay*	*Multiple visits to sites of major assets*	*Permanent human presence*
Altair only				
Pre-deployed assets	X			
Night survival		X		
Minimum outpost			(X)	
Full Outpost				X
Early Robotic Outpost				

** ISECG-ISWG: International Space Exploration Coordination Group – Interface Standards Working Group

Surface Activities on the Moon

Activities	Sortie	Super-Sortie	Man-Tended Outpost	Polar Outpost
Geological Fieldwork 	Primarily exploration of locale rather than fieldwork as such: - Observations - Collecting/caching samples - Logging of data	Reasonable level of fieldwork involved plus: - Limited tele-robotic survey assistance possible	Reasonable level of fieldwork involved plus: - Limited tele-robotic survey assistance possible	Extensive, long-term field investigations can be supported plus: - Tele-robotic survey assistance likely
Laboratory Analysis 	Very limited simple analyses capability	Limited analyses capability, maybe screening for return to Earth or caching	As for super-sortie	Significant in-situ analyses capability
Mission Support Tasks 	Very limited maintenance for nominal short-duration mission plus Health & performance	Limited maintenance likely required plus Health & performance Limited OTJ training	High level of maintenance required, plus Health & performance Limited OTJ training	Extensive range of support tasks required Health & performance Periodic OTJ Training
Life/Physical Sciences Experiments 	Limited experiment capability, e.g questionnaire, diet, exercise : Limited human physiology, etc. Possibly technology demonstrations	As for sortie	As for super-sortie	Significant in-situ capability (similar to Human Research Facility and European Physiology Modules racks on ISS) plus small mammal experiments? Biology experiments “Greenhouse” and/or regenerative ECLS and fuel cell development and implementation Psychological experiments Physical sciences: Experiments more applied-technology focused rather than fundamental research.

Surface Activities on the Moon

Activities	Sortie	Super-Sortie	Man-Tended Outpost	Polar Outpost
ISRU Processing 	Demonstration on early missions, possibly small plant later on to support mission Mapping of lunar Resources	Primarily mapping of lunar resources	As for super-sortie	Operation of large plant to support base activities (mainly O2 production) in long-term maybe propellant production Mapping of lunar resources
Commercial - Lunar Exploitation 	Commercial activities unlikely	Limited media/entertainment and educational activities possible	As for super-sortie	Extensive ISRU, mining, tourism, media & entertainment, education possible
Commercial - Space Services 	Commercial activities unlikely	Commercial activities unlikely	Communications and/or power elements could be commercially operated	Transportation services, in-orbit services, communications elements, power could be commercially operated

Altair Lunar Lander Characteristics

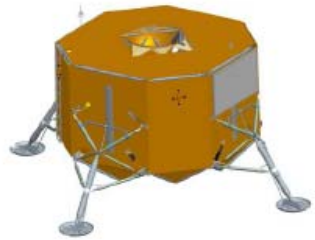
- Transportation of 4 crew to/from the lunar surface.
- Up to 7 days on the surface.
- Global access capability.
- Anytime return to Earth.
- Capability to land 14-17 tonnes of dedicated cargo.
- Airlock for surface activities.
- Descent stage: Liquid oxygen /liquid hydrogen propulsion.
- Ascent stage: Hypergolic propellents or liquid oxygen/methane.

Sortie Variant

Descent Module
Ascent Module
Airlock

Outpost Variant

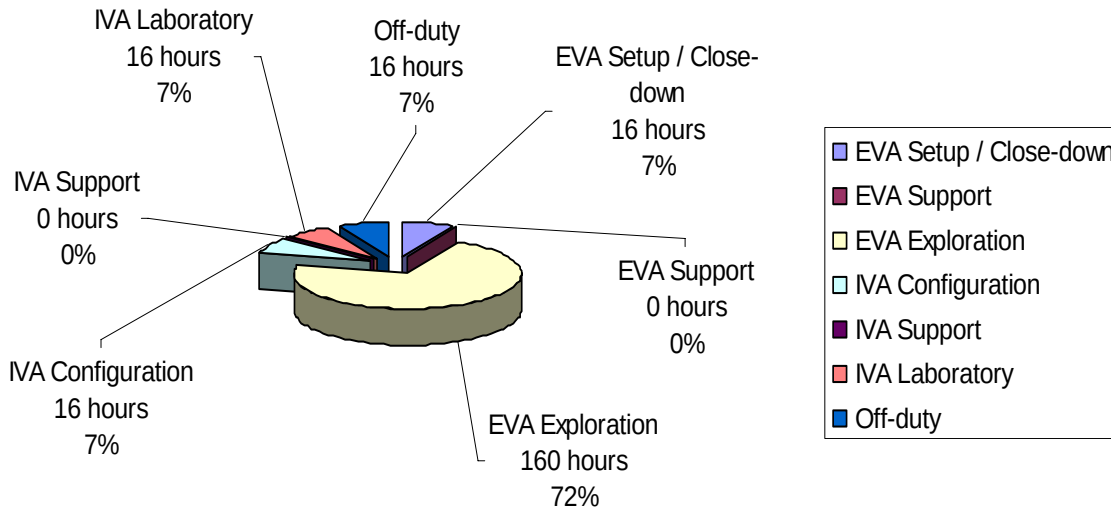
Descent Module
Ascent Module



Cargo Variant

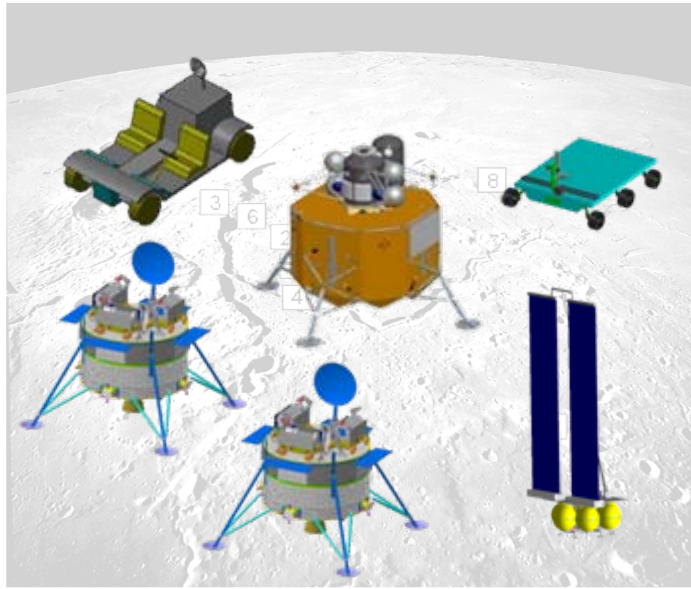
Descent Module
Cargo on Upper Deck

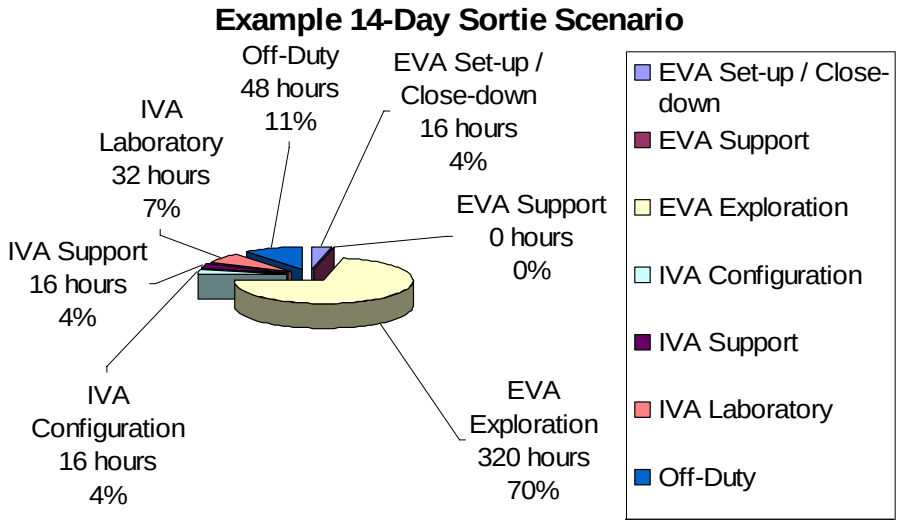
Example 7-Day Reference Sortie Scenario



Example 14 Day Lunar Sortie

- 4 crew on surface
- Provision of:
  - Un-pressurised rover
  - Power element
  - Element transport vehicle
  - Additional consumables
- A total of 320 hours of EVA surface activities, i.e., ~70% of the total surface time, together with three half days of rest for each crew member during the 14 day mission.
- Total mass to the surface:
  - 16,514 kg
- Requires:
  - 2 medium landers
  - 1 Altair Sortie lander



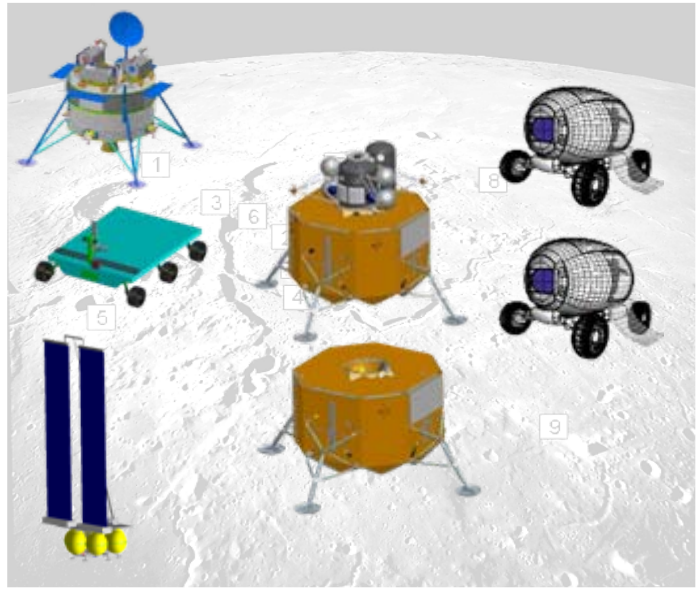


Example 42 Day Lunar Super Sortie

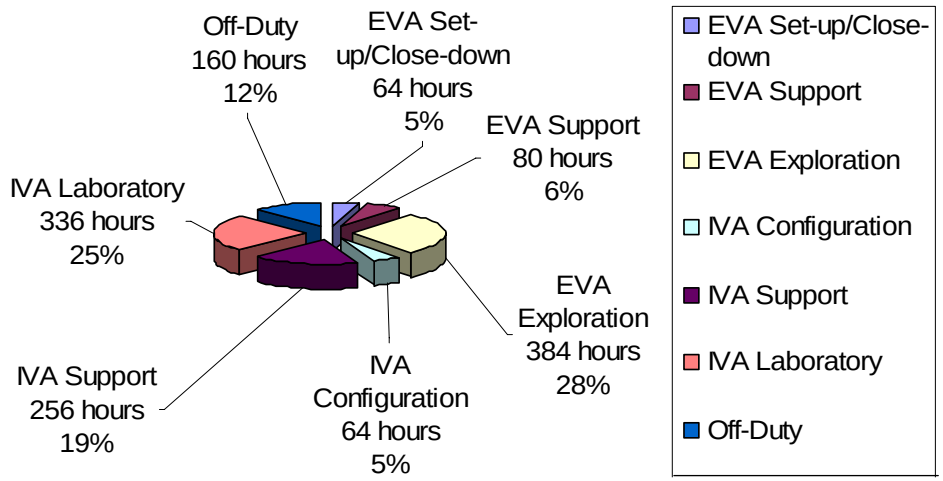
- Science-focused exploration
- 4 crew on surface
- Provision of:
  - Pressurised rovers
  - Power element
  - Element transport vehicle
  - Additional consumables
- A total of 384 hours of EVA surface activities, i.e. 28% of the total surface time, together with four days of rest for each crew member during the 42 day mission.

- Total mass to the surface:
  31,900 kg

- Requires:
  1 medium lander
  1 Altair Sortie lander
  1 Altair Cargo lander

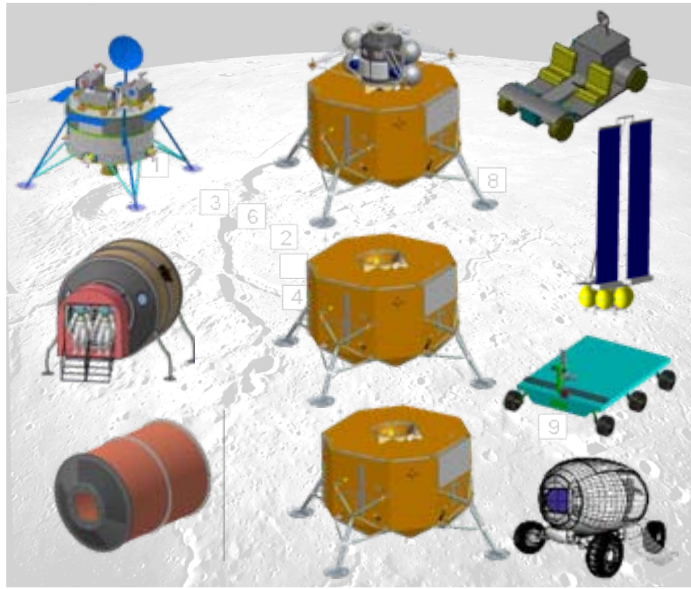


Example 42-Day Super Sortie Scenario

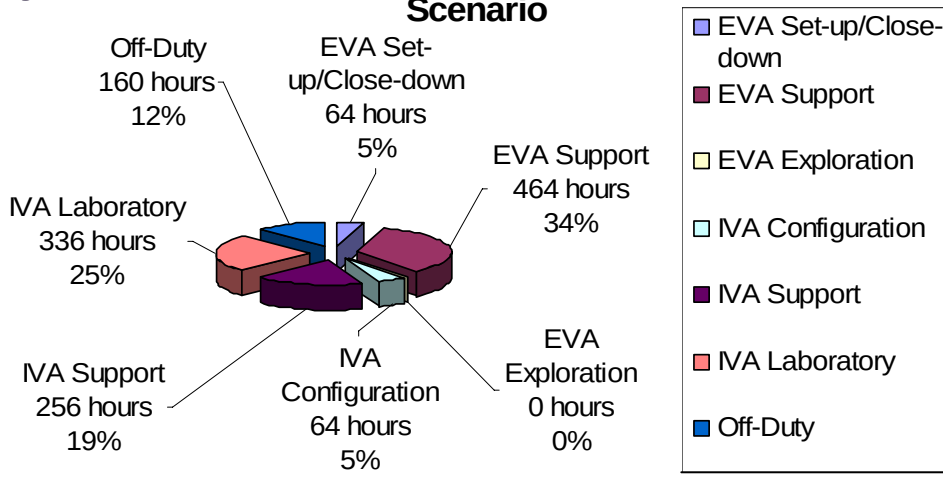


Example Human-tended Outpost Scenario (42-Day)

- Multiple visits for maintenance and/or construction of major assets.
- 4 crew on surface
- Provision of:
  - Un-pressurised rover
  - Habitat (Mini-Hab)
  - Pressurised Logistic Element
  - Pressurised rover
  - Power element
  - Additional consumables
- A total of 464 hours of EVA support activities, i.e. 34% of the total surface time, together with four days of rest for each crew member during the 42 day mission.
- Total mass to the surface:
  37,900 kg
- Requires:
  1 medium lander
  1 Altair Sortie lander
  2 Altair Cargo landers

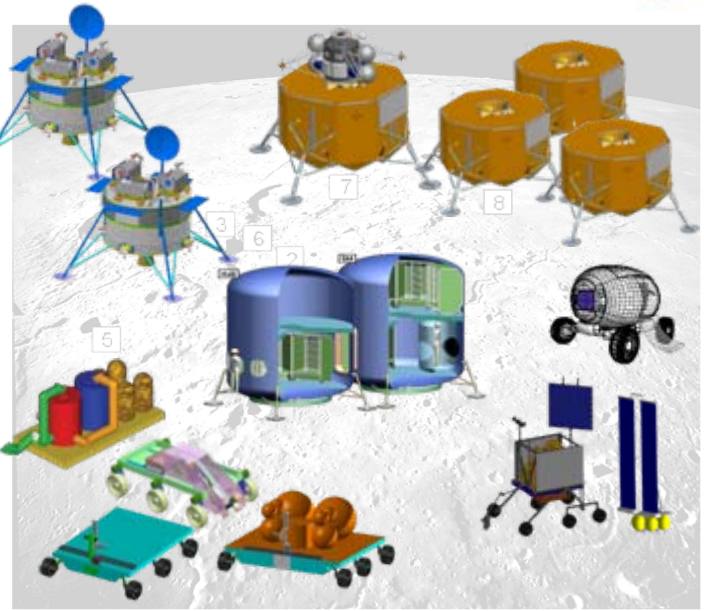


Example 42-Day Human-tended Outpost Scenario

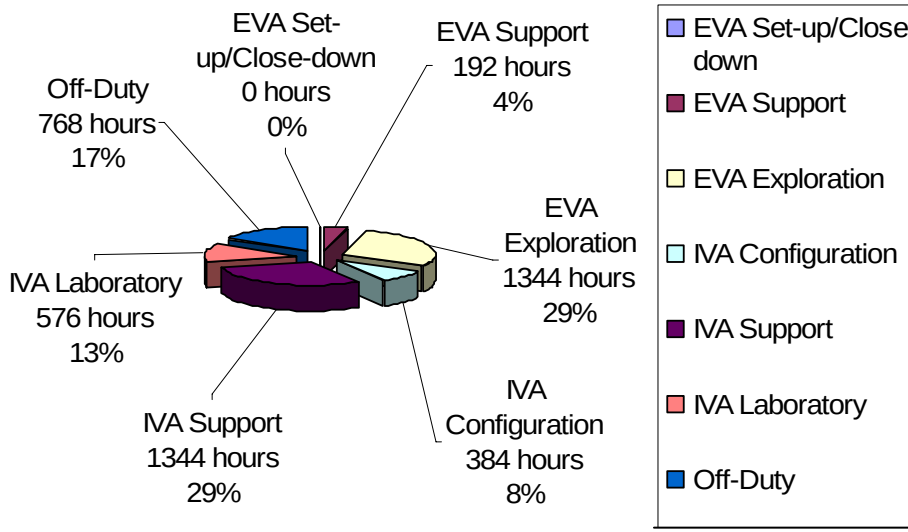


Example 6-month Polar Outpost Scenario

- A continuous human presence lunar outpost located at the South Pole.
- 4 crew on surface
- Provision of:
  - Pressurised rover
  - Habitat modules
  - Power element
  - Element transport vehicle
  - Deep driller
  - ISRU elements
- A 180-day schedule is indicated here (scaled from a monthly schedule of 28 days)
- Total mass to the surface:
  61,302 kg
- Requires:
  ~2 medium landers/year for logistics supply
  1 Altair Sortie lander
  3 Altair Cargo lander



Example 6 Monthly Outpost Scenario

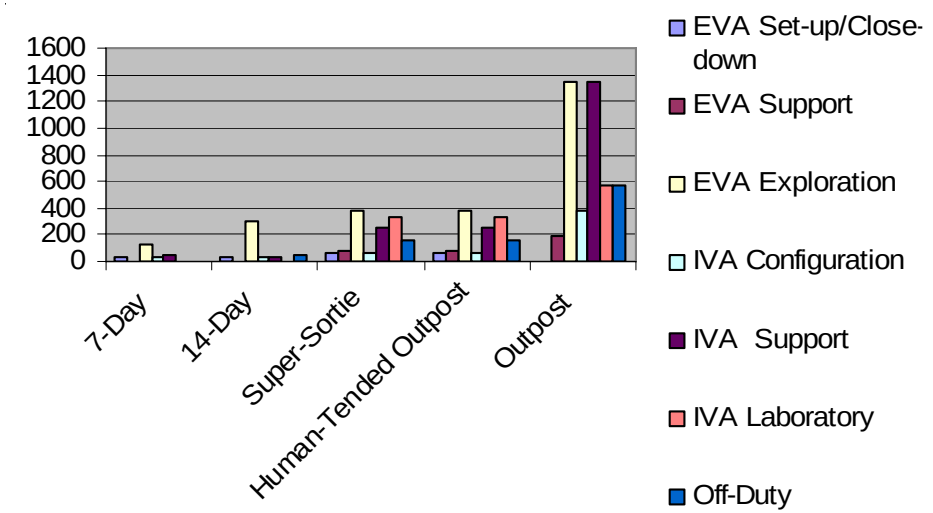


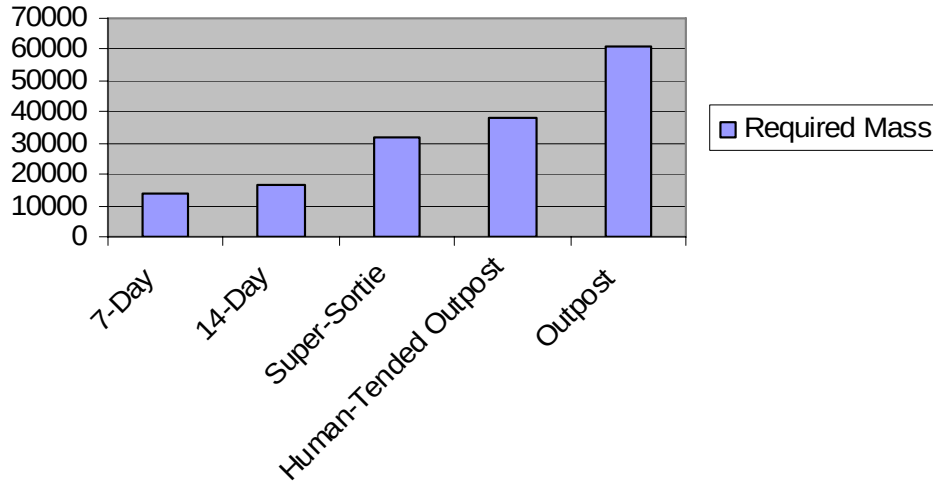
Moon-Mars Operations Synergies

- Risk mitigation and enabling of sustainable human exploration
  - Validation of long-term system reliability
    - Surface habitation: closed loop life support systems
    - Radiation protection: protocols/systems
    - Mobility systems: environment, especially dust
    - EVA suits
    - Mobile life support
    - Long-term power supply
- Crew aspects:
    - Physical (reduced gravity, radiation)
    - Psychological (habitable environment, Earth-out-of-view)
- ISRU technologies
- Exploration campaign strategies:
    - Fieldwork procedures/techniques
    - Human-robotic interaction (tele-operation)
    - Planetary protection strategies

Summary & Conclusions

- Four lunar surface operations scenarios have been investigated, basis for studying future international cooperation opportunities
- Planning timelines have been produced for all four lunar scenarios, basis for assessing efficiency and effectiveness of individual scenario “value”
- Lunar surface architecture strongly depends on exploration scenario





Summary & Conclusions

7 - Day Reference Scenario

14-Day scenario:

- Increased EVA time
- Increased science return

42-Day Super-Sortie:

- Increased mobility
- Increased science return

Outpost:

- Enables in-situ analysis
- Life science research
- Provides commercial opportunities
- Mars-forward

Back-up Slide (Info only)

Task Classification	Description
Setup & Close-down (EVA/IVA)	Activities involved in system set-up upon arrival on the lunar surface, and system shutdown on departure from the lunar surface.
EVA Support	Activities related to external maintenance, system upgrading, repair and testing, deployment and operation of ISRU plant(s).
EVA Exploration	Includes geological fieldwork, deployment of science-related instrumentation and surface resource mapping.
IVA Support	Internal maintenance and system upgrading, repair and testing, and training.
IVA Laboratory	Performing physical and life science activities in the laboratory, e.g. sample analysis, data logging, preparation of samples for return to Earth. Also includes physiological/biological experiments involving the crew member as subject, and tele-operation of external robotic assets.
Off-Duty	These are the rest days which occur periodically throughout the timeline.