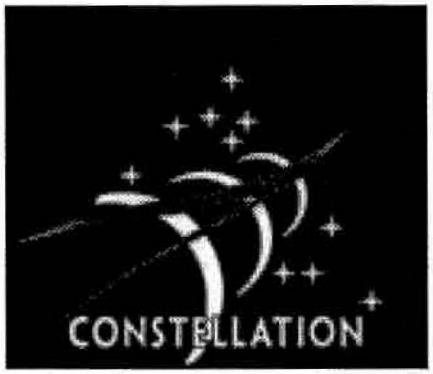
NASA's
Future Human Spaceflight Program – Constellation



Philip J. Scarpa, MD, MS, FAsMA

NASA-Kennedy Space Center
Medical Operations

7 November 2009

NASA History

Aeronautics and Space

- Early Architecture – Shuttle ➡ SS ➡ Moon ➡ Mars

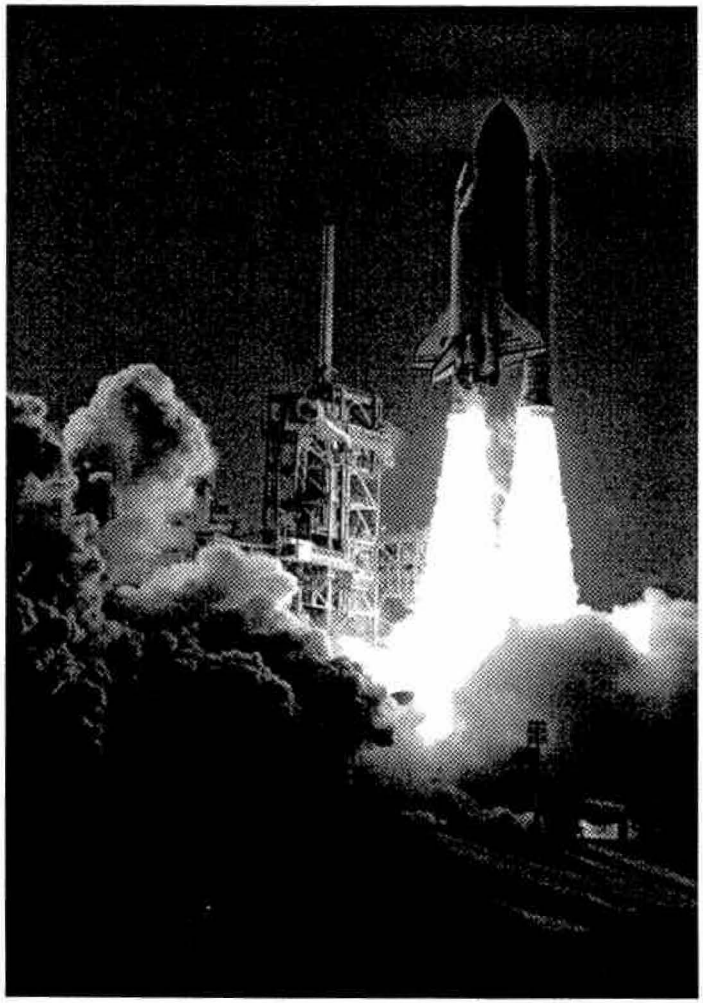
"Space Race"

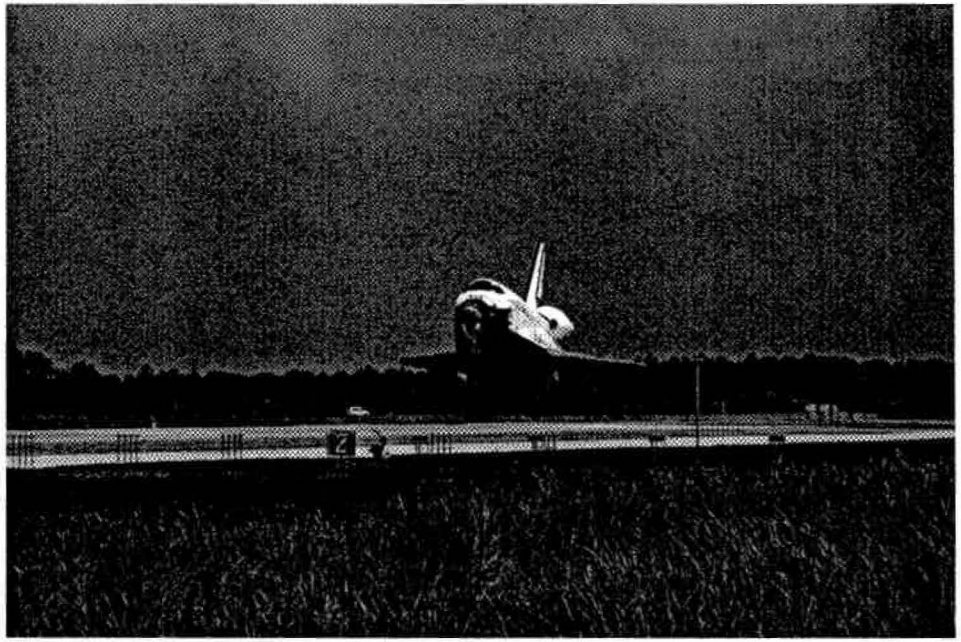
Moon Landings

NASA History

Return to Early Architecture:

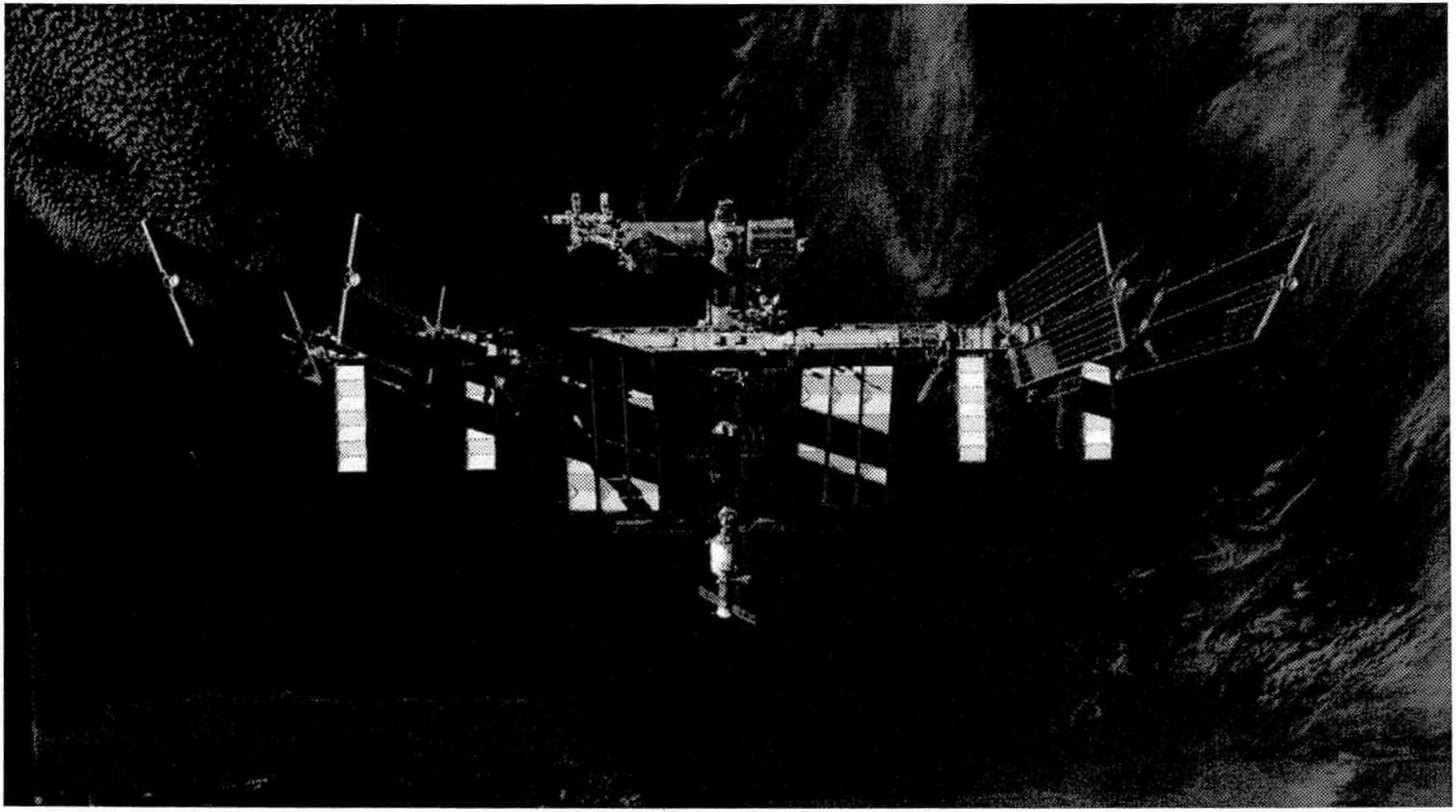
Shuttle – Reusable spacecraft, to/from a space station in LEO





NASA History

International Space Station – LEO permanent presence



Human Exploration Initiative

Based on Early Architecture – Go to LEO, learn from LEO before Moon, learn from Moon before Mars, in logical stepwise fashion

US President Bush Speech January 2004 – outlined HEI

- Finish constructing the ISS
- Retire the Shuttle by 2010
- Support the ISS by 2013-15
- Return to Moon by 2018-20
- To Mars by 2025+

⬇

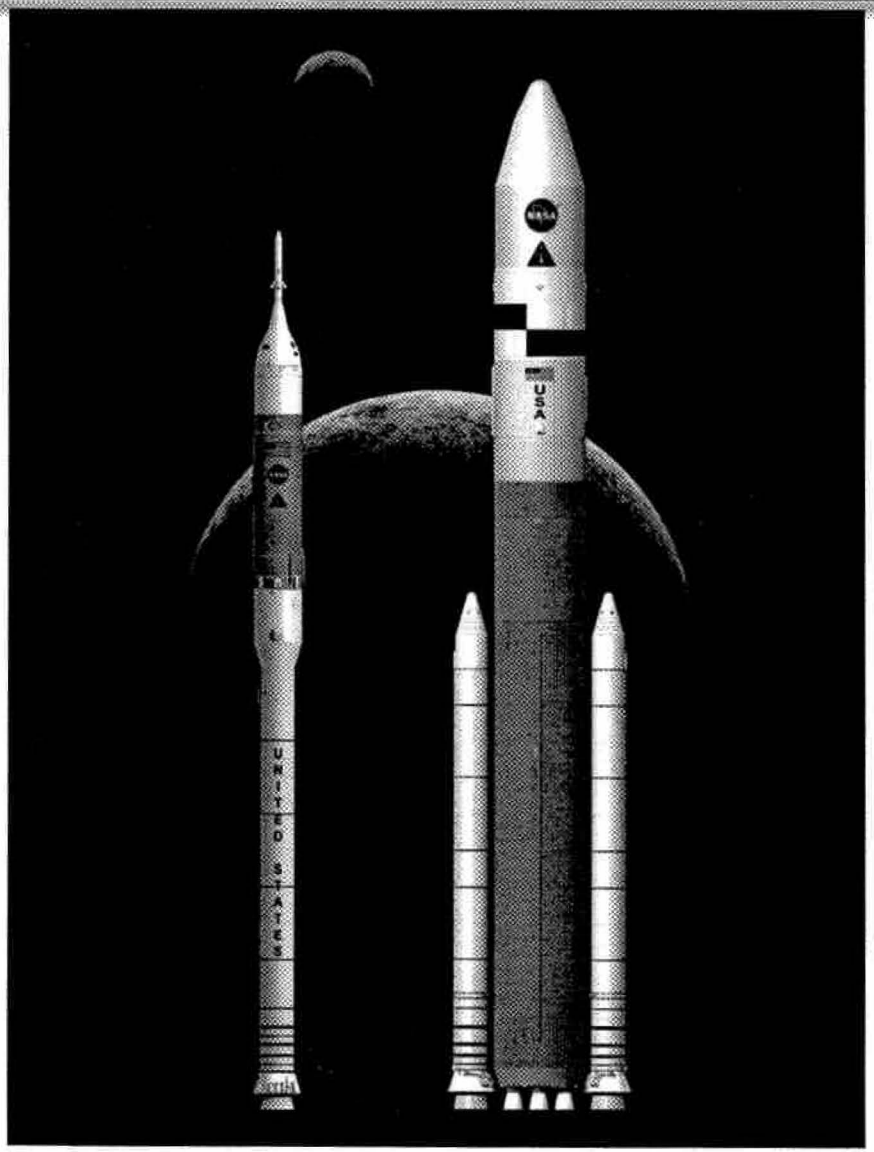
NASA's Constellation Program

Constellation Program

NASA Design Reference Missions

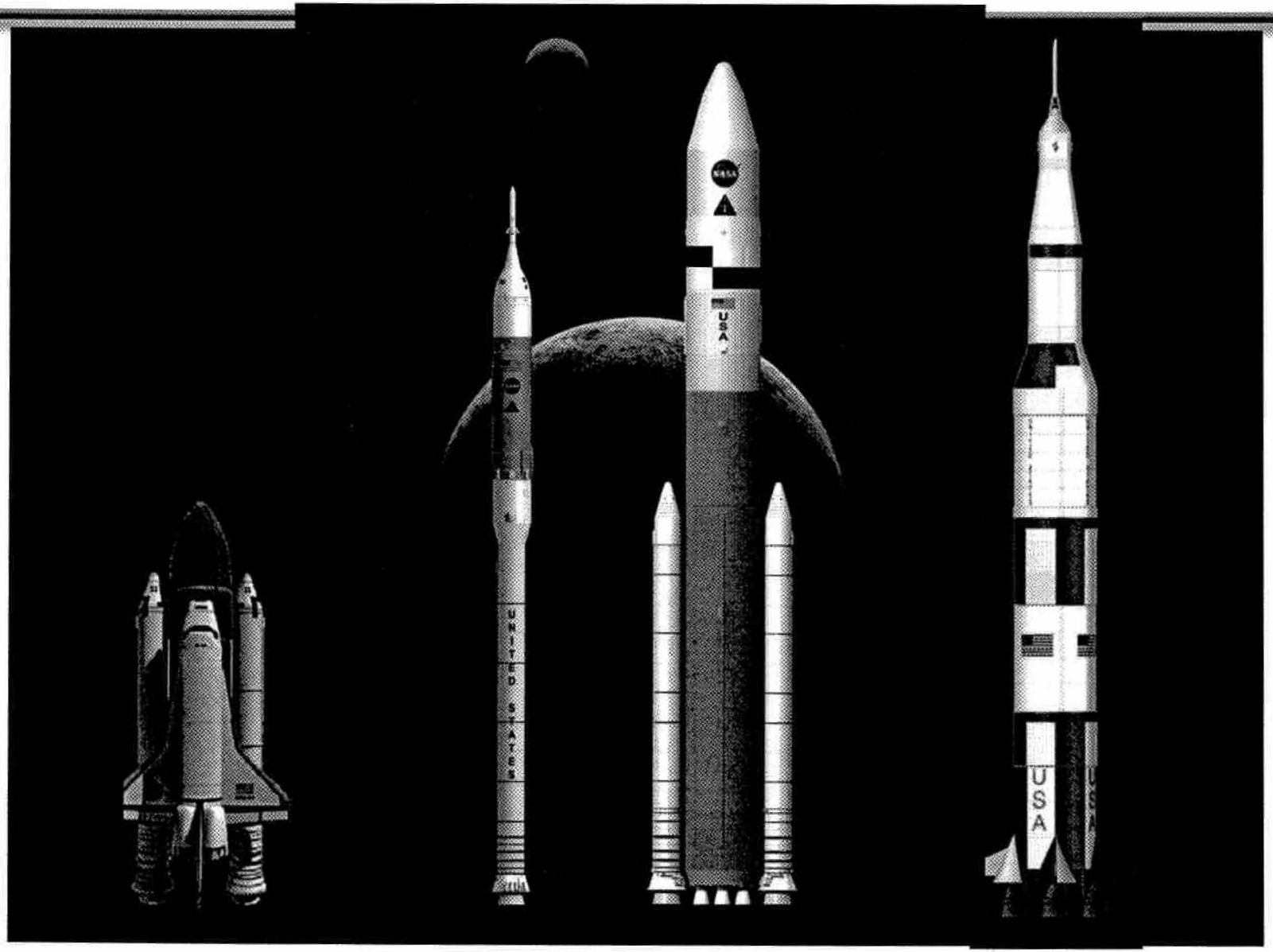
1. Support the ISS – crew of 6, up to 6 mos
2. Lunar Sortie – crew of 4, up to 7 days
3. Lunar Outpost – crew of 4, up to 6 mos, go by lander, live in outpost lander
4. Cargo Lunar Lander – brings heavy equipment, science equipment, and supplies

Vehicles

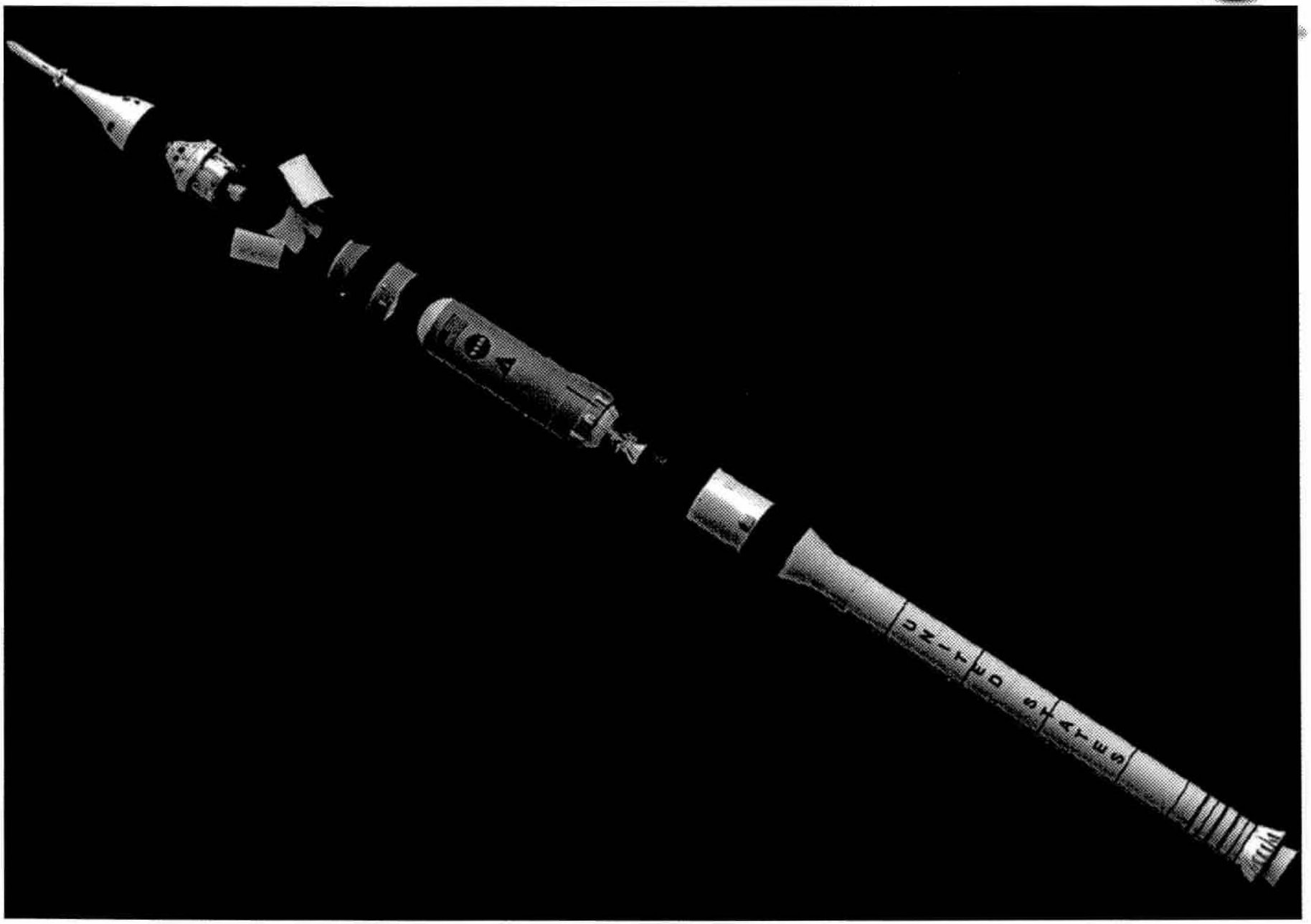


CLV- Ares I CaLV-Ares V

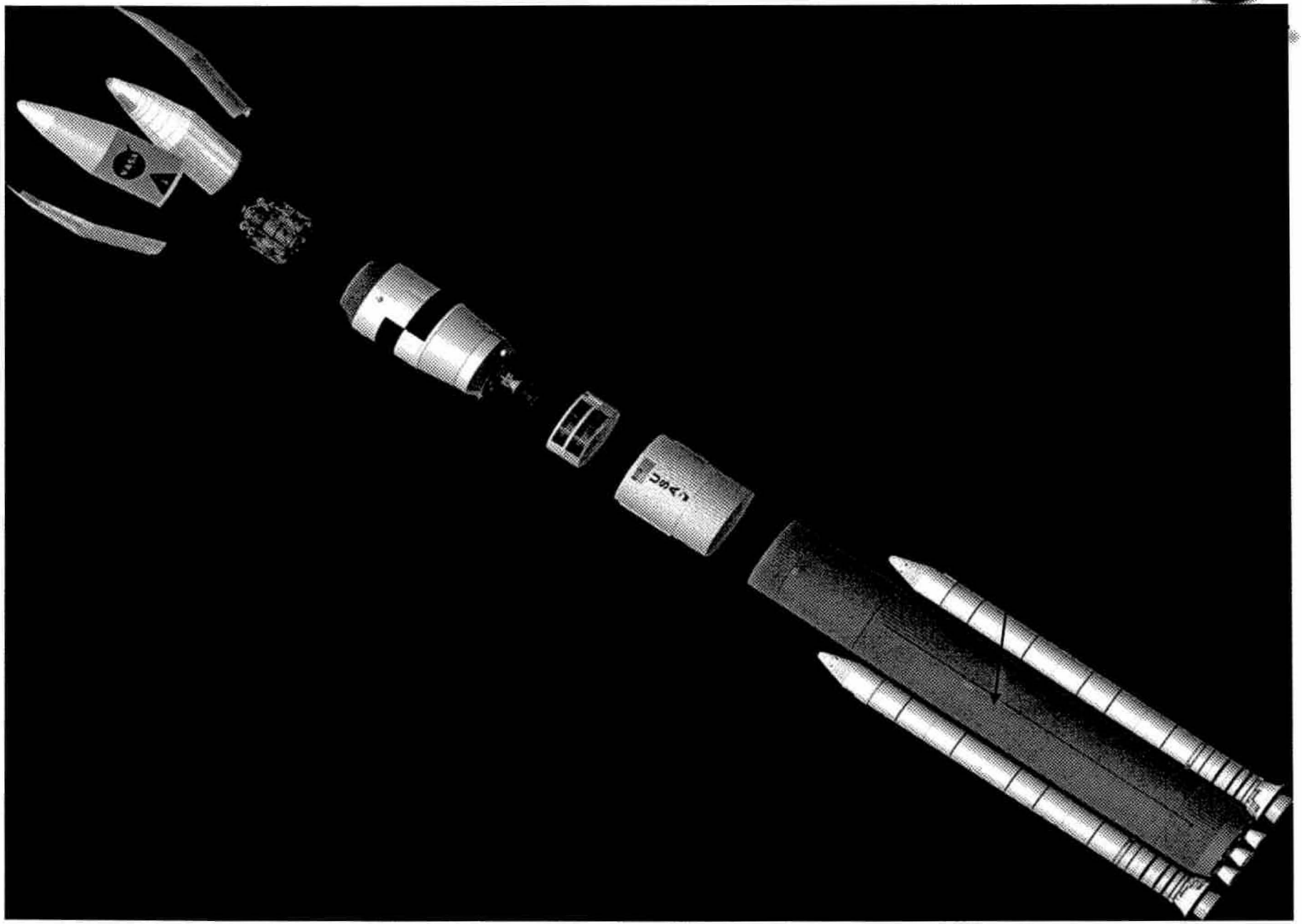
Vehicles



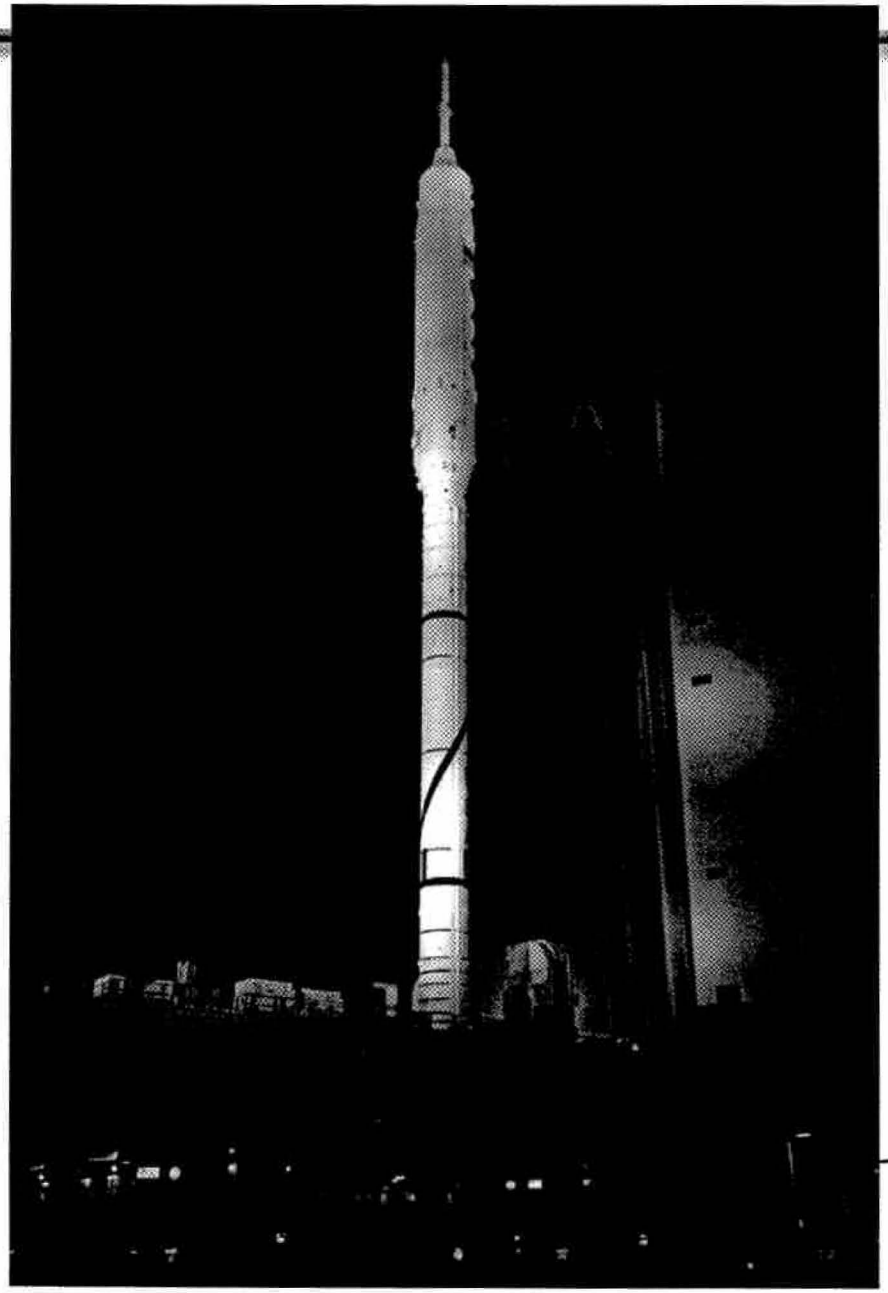
Ares I – Crew Launch Vehicle



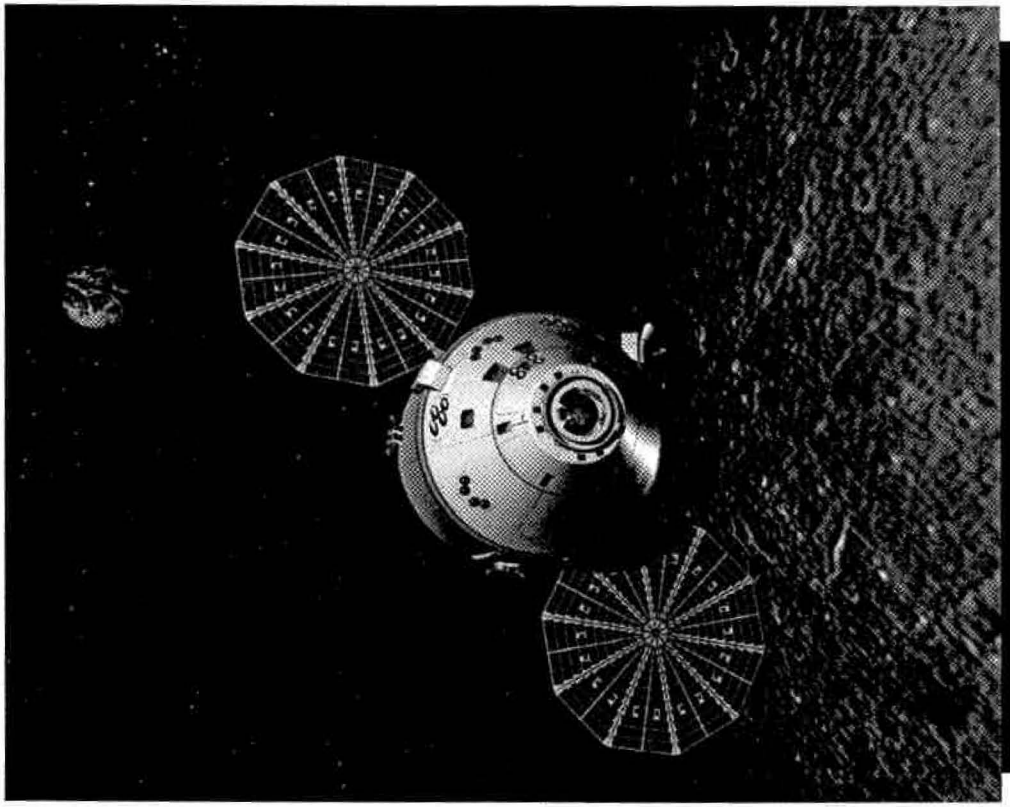
Ares V – Cargo Launch Vehicle

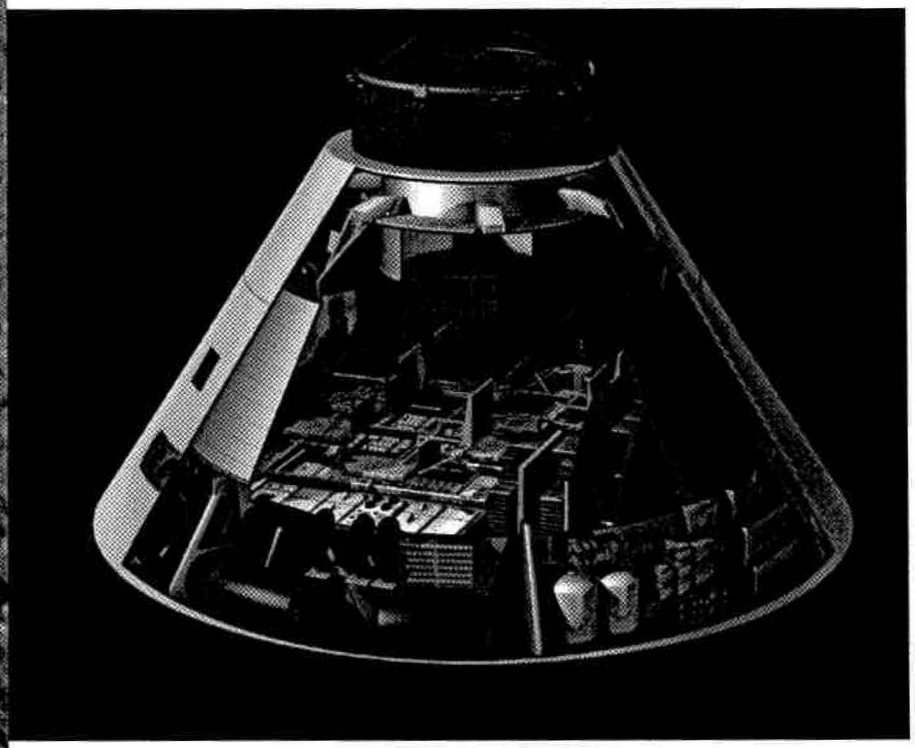


Ares I-X

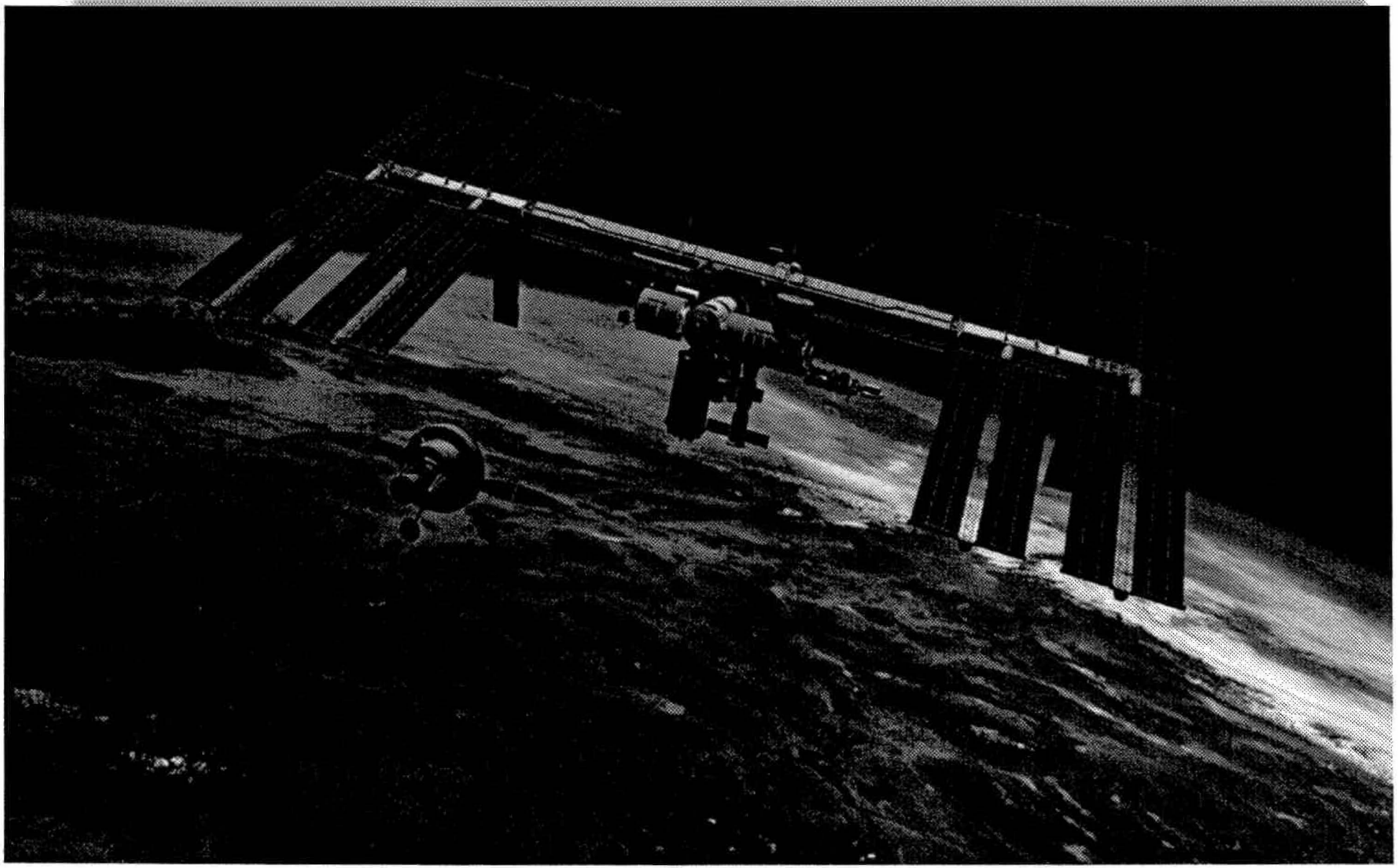


Orion - Crew Exploration Vehicle





Support to ISS



ISS Missions

Orion Crew of 4, stagger crew change outs

Much more science with crew of 6

Simulate Zero-G transit portions of how to perform a Mars mission (ISS/Moon/ISS)

Moon Missions

Moon Missions

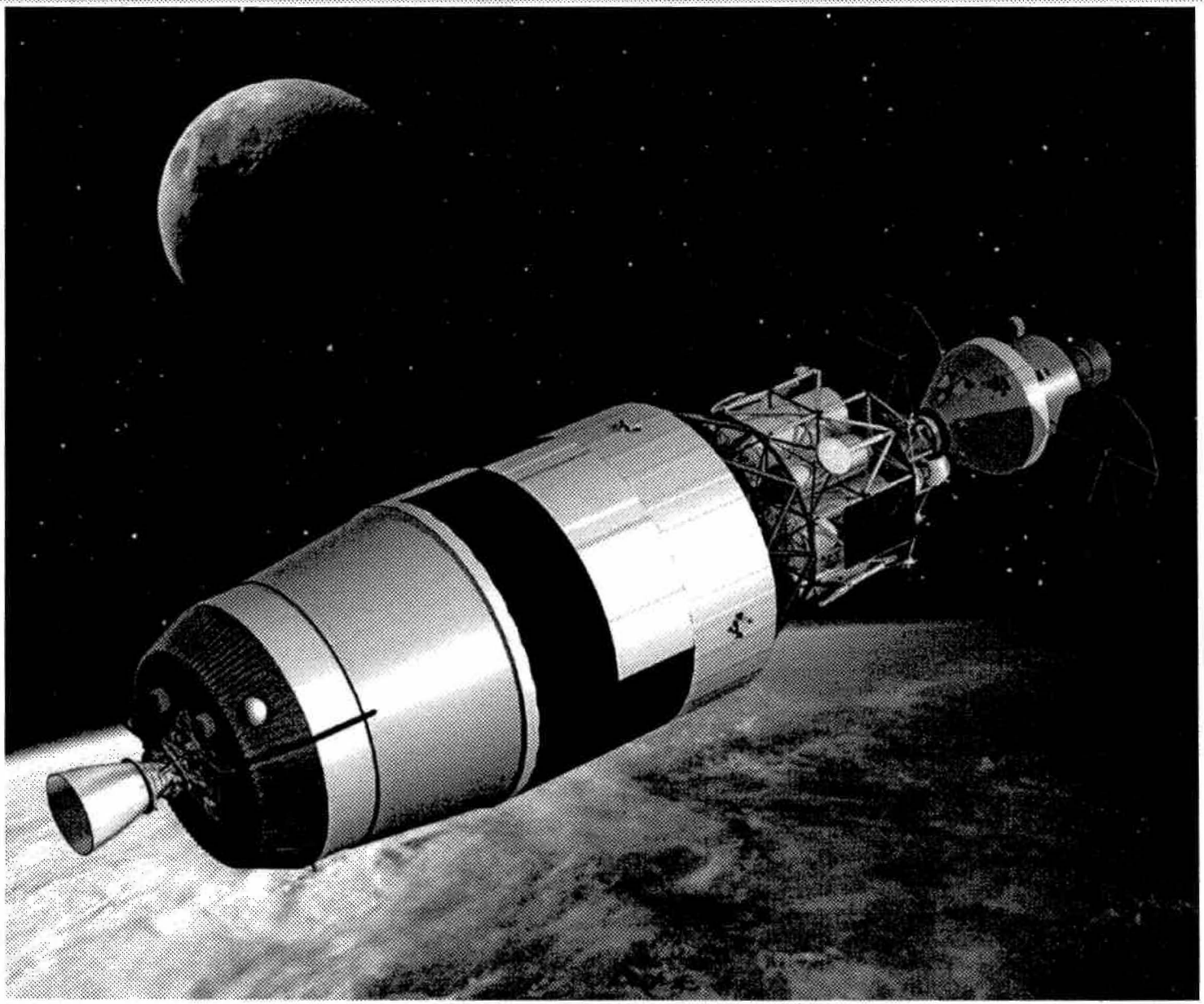
Crew of 4, all to surface

Polar landing sites

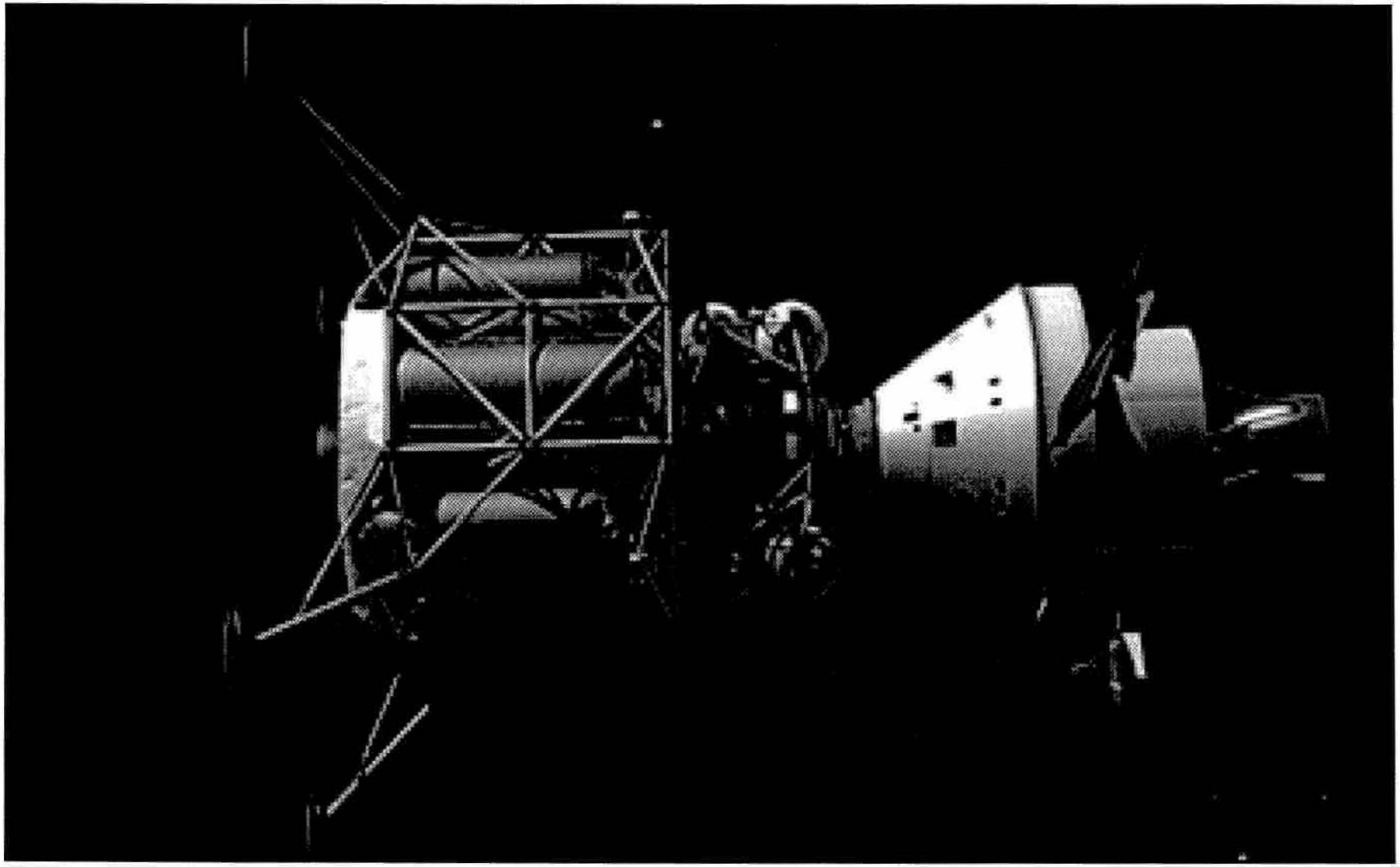
Outpost missions – greater science, more EVAs, Lunar Rover

Learn how to perform surface ops portion of a Mars mission
(ISS/Moon/ISS trial)

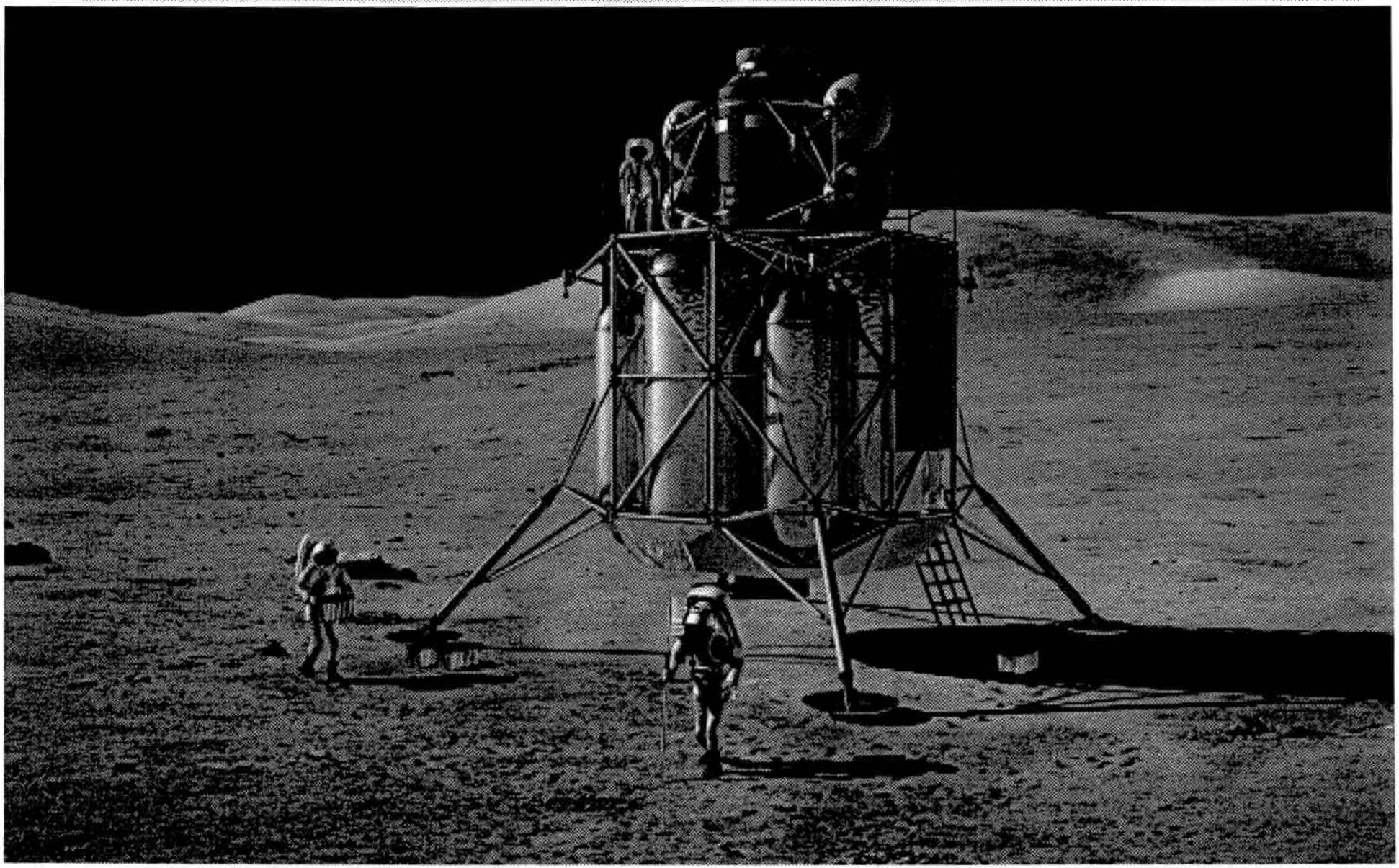
Moon Missions
EDS, LSAM and CEV

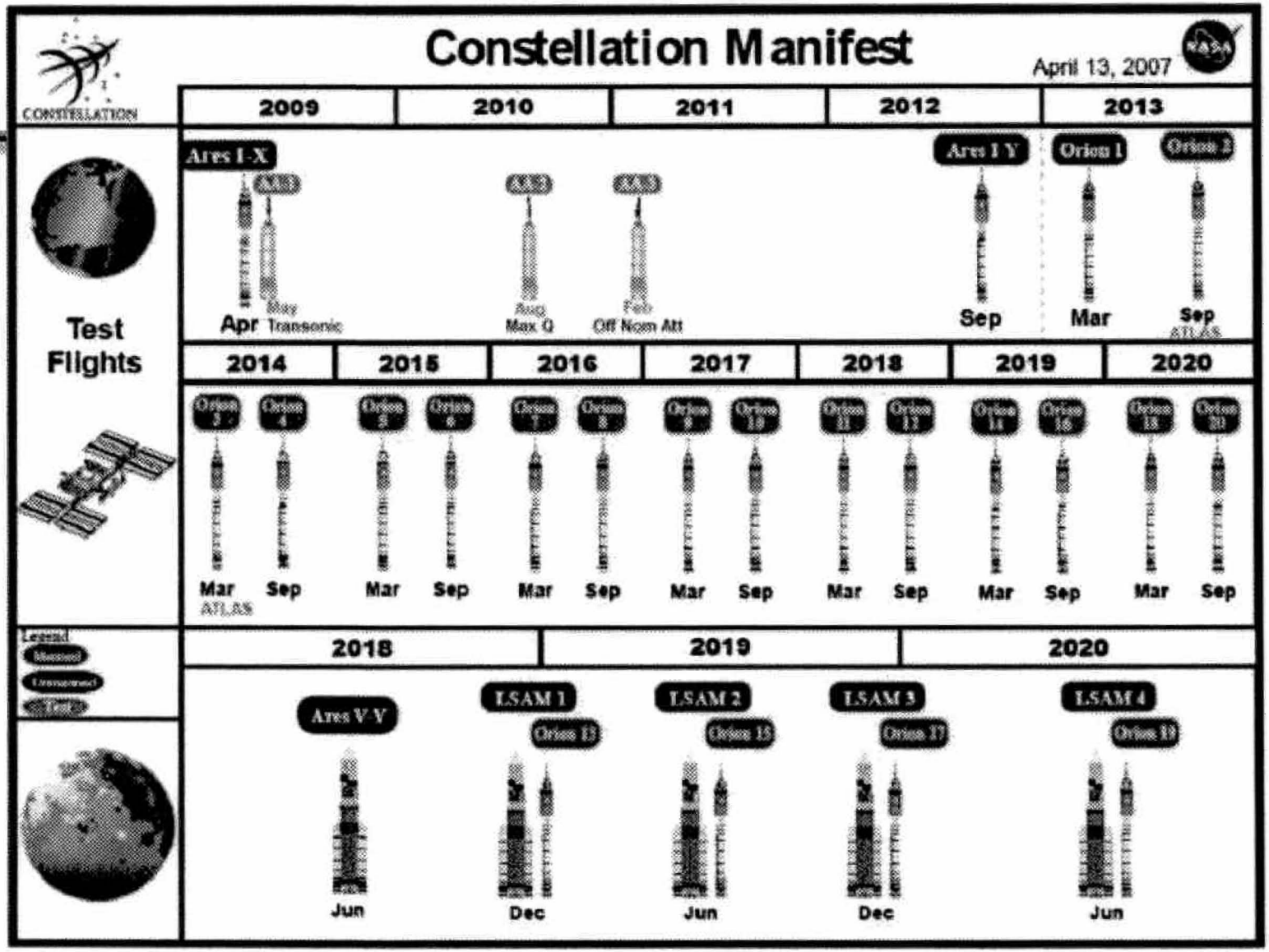


Moon Missions
LSAM and CEV



Moon Missions
Altair – Lunar Surface Access Module





ISS 2-6 per year, Lunar 2-3 per year, Lunar Cargo 2-3 per year

Mars 1 per 2 years, Mars Cargo 1 per 2 years

Constellation Medical Issues

- Vehicle Toxics/Hazards
- Long duration deconditioning
- EVA Suit design
- Moon dust
- Radiation storms
- Lunar Habitats –design and atmosphere
- Lunar Rover
- Medical Care autonomy
- Behavioral Health
- Ground Projects

Constellation Medical Issues

Vehicle Toxics/Hazards

Similar to past spaceflights

Hydrazine fuel

Ammonia coolant

High pressure gases – O2, N2, He

Pryotechnics

Blast

Impact

Temp, Pressure

Constellation Medical Issues

Long duration deconditioning

6 mo, maybe longer

Partial (1/6th G) and micro/zero G

Many more EVAs and physical labor – still bone and muscle loss

Could be at least on own up to 2 hrs for landings (24 off- nominal)

Constellation Medical Issues

EVA Suit design

In Vehicle and Extra Vehicle Suits

Pressure 4.3 psi , 100% O2 (Vehicles & Habitats 8.0 psi, 32% O2)

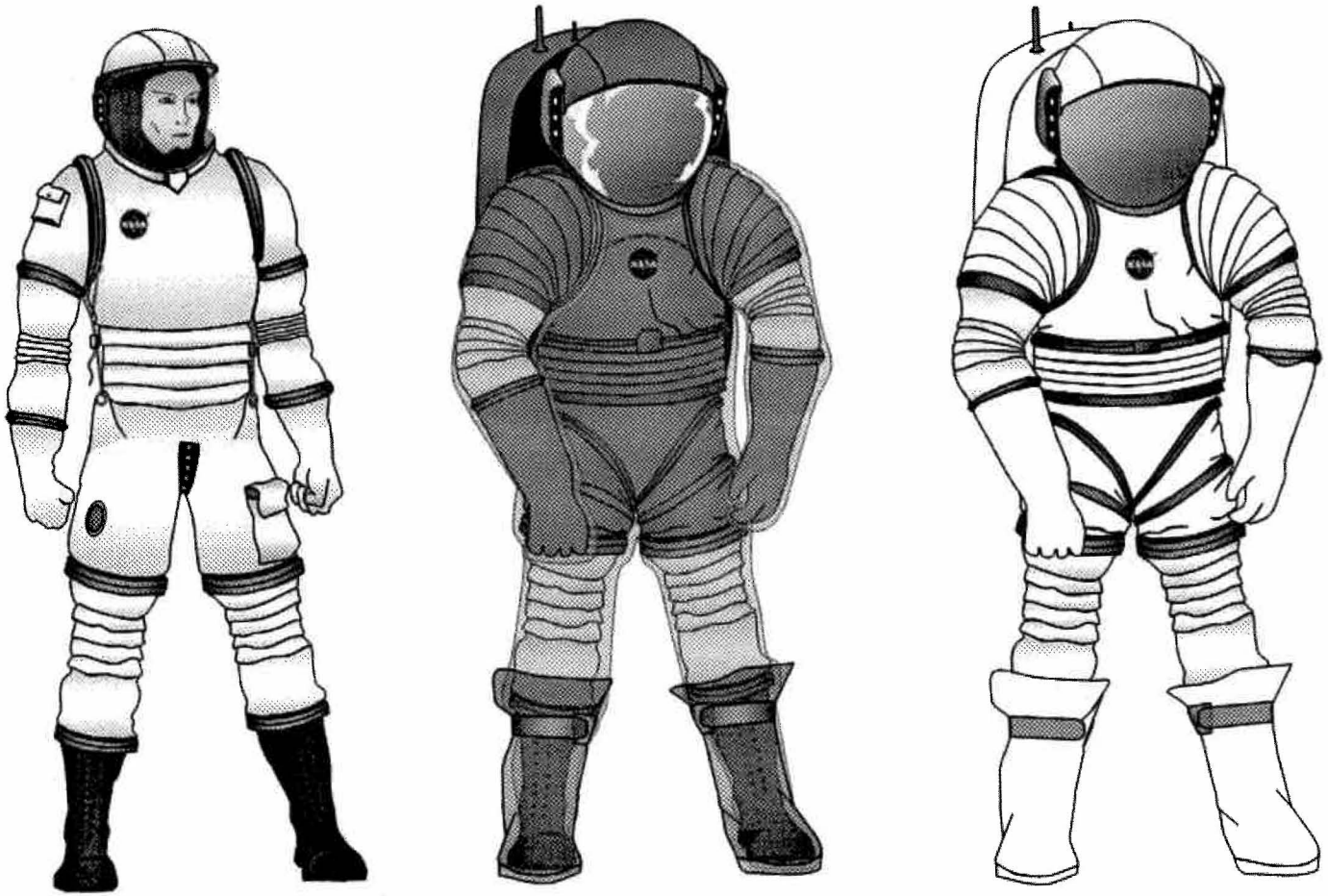
Partial (1/6th G, 1/3rd G) and micro/zero G transitions - SMS

Somatosensory problems on surface – slips, trips, falls (1 fall per crew per EVA in Apollo)

Hard Points assessed – back, neck ring

ECG monitoring – 1 lead in Orion and in EVA suit, 5 lead in Altair and Rover for better assessments after stress

IVA and EVA Suits



Constellation Medical Issues

Moon dust

Very fine particulate, mostly silicone powder
Gets into everything and is everywhere
Irritation to skin and pulmonary (like fiberglass)
Chronic exposure - cause pneumoconiosis?
Air Lock sufficient?

Constellation Medical Issues

Radiation storms

Moon without protective Magnetic field

Acute Solar Particle Events (Protons) and Chronic Galactic Cosmic Radiation (Heavy Ions)

Protection - Habitats provide enough protection from SPEs on the moon for about 1 year on the surface unless get a really large storm, not during EVA.

Bury or Electrostatic Shielding?

No real protection from meteorites either – bury habitats for both?

Constellation Medical Issues

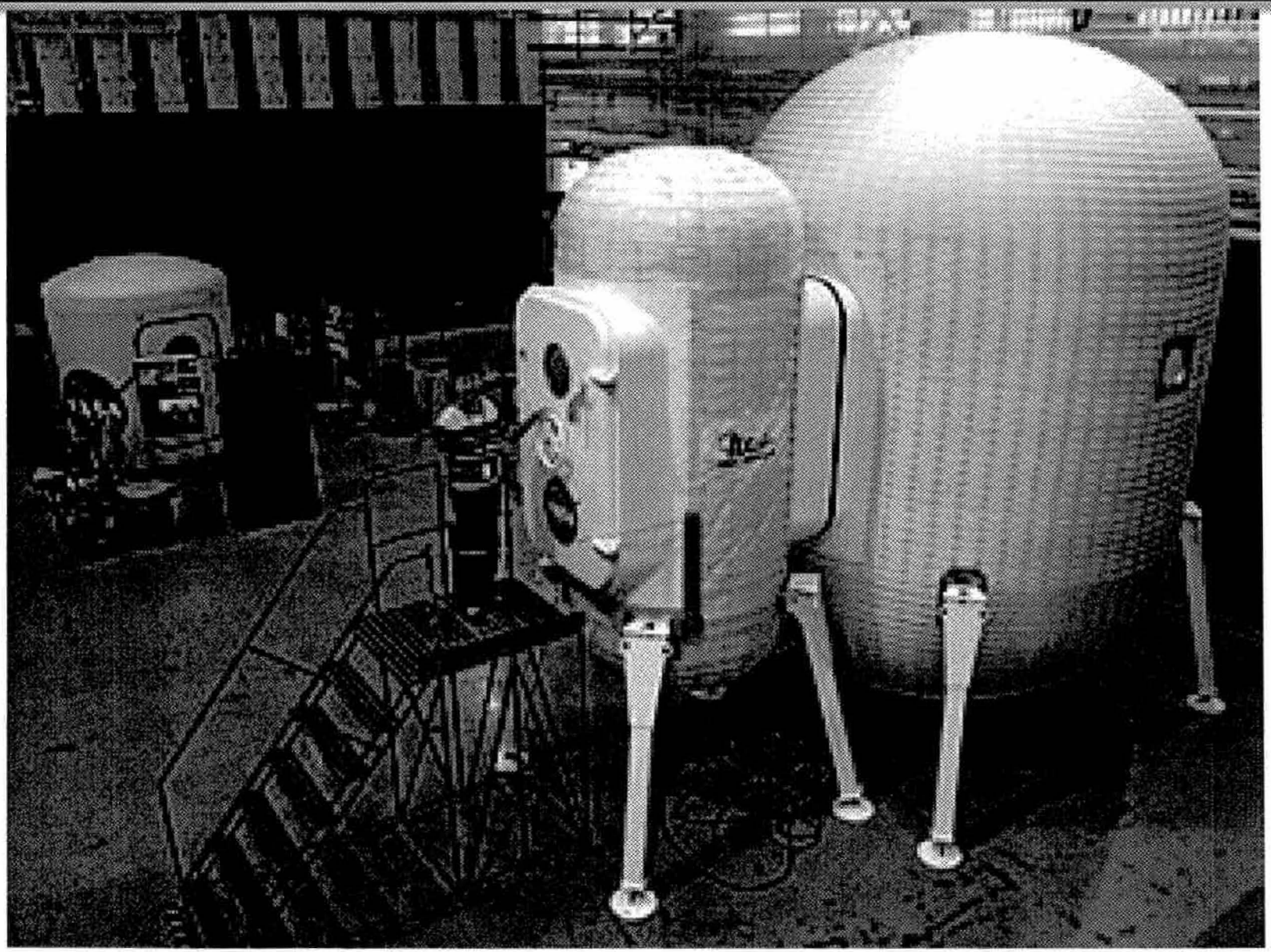
Lunar Habitats design and atmosphere

Fractional pressure with higher O2 to reduce DCS (8.0 psi, 32% O2)

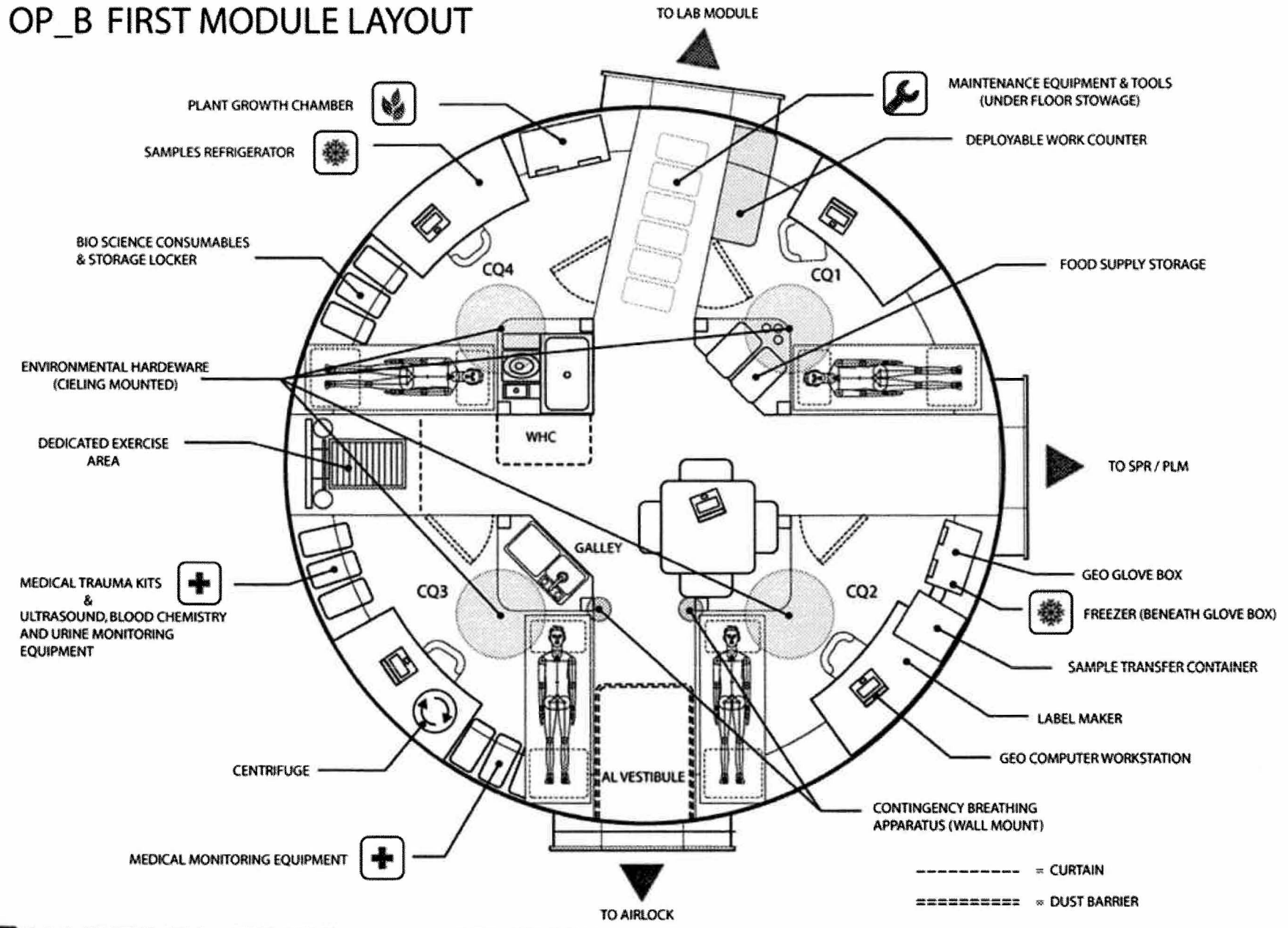
HF - Ergonomics, utility, esthetics

Altair and Inflatable Habitats

Inflatable Lunar Habitats



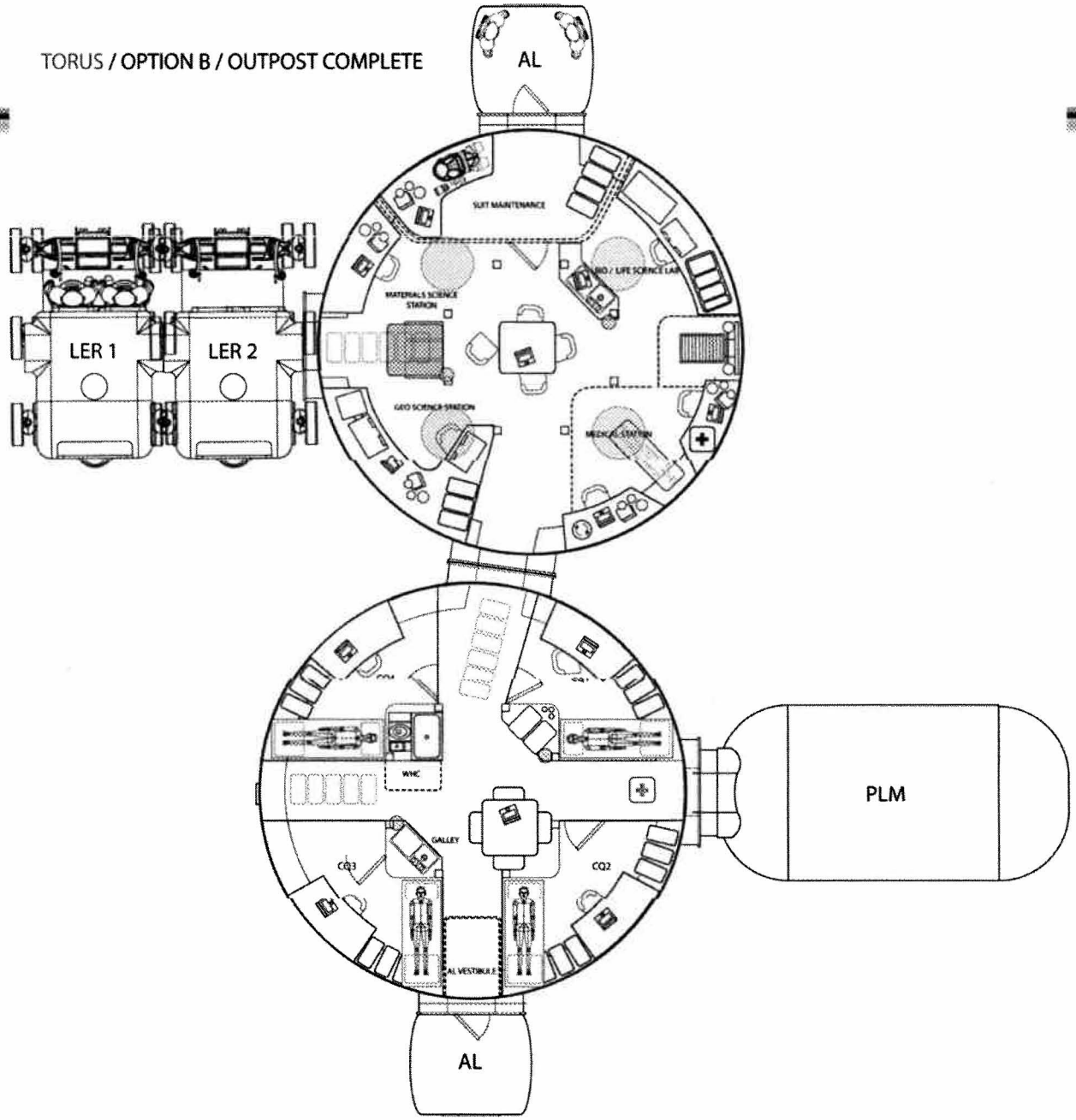
OP_B FIRST MODULE LAYOUT



HABITABILITYDESIGNCENTER

TITLE	PROJECT	DATE	
B220 MOCKUP OUTFITTING	INFLATABLE TORUS	CCONLEE	02.05.2009

TORUS / **OPTION B / OUTPOST COMPLETE**



Constellation Medical Issues

Lunar Rover

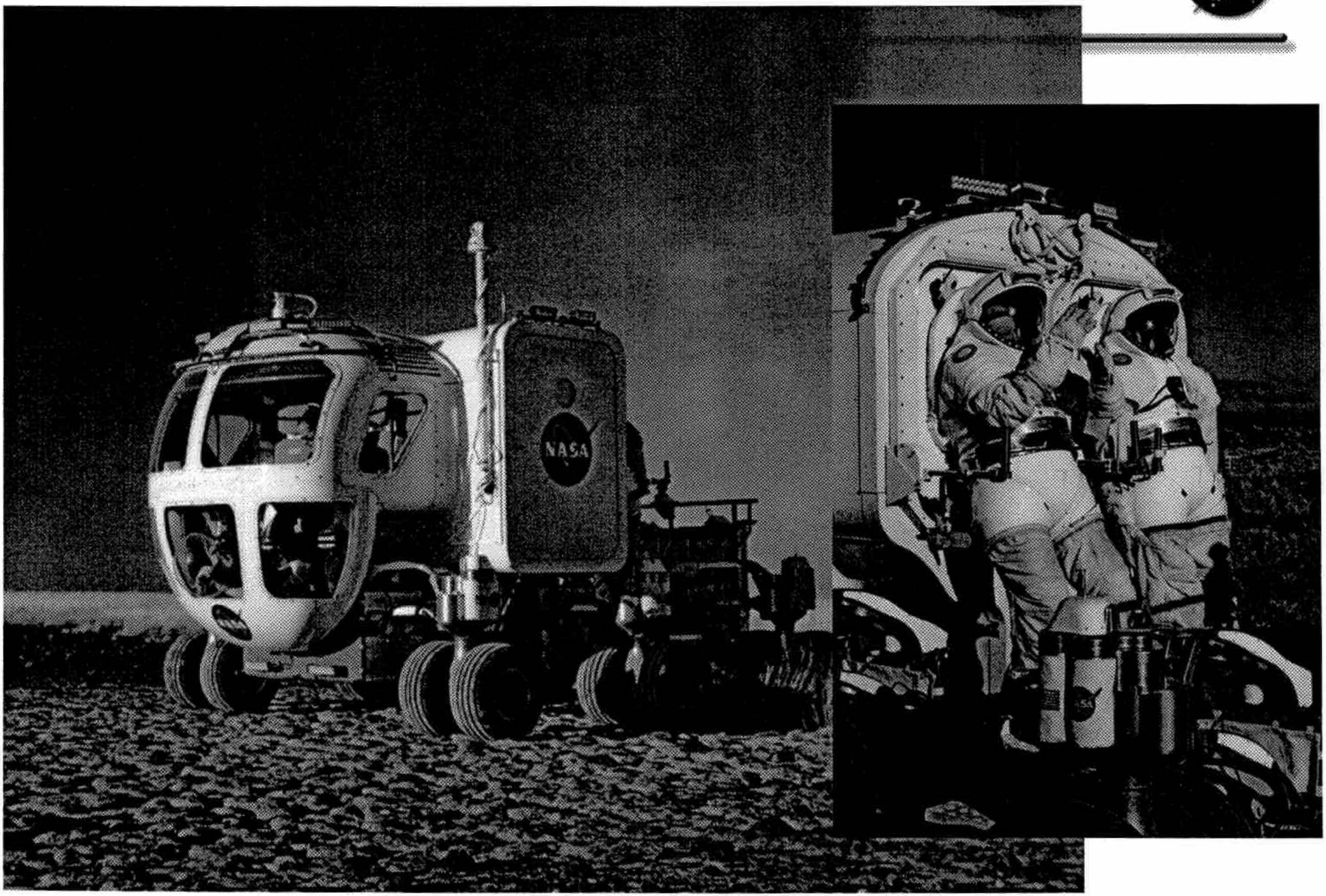
Many more EVAs than ever historically

Much ground to cover

Rover can

- **prevent Fatigue**
- **treat Decompression Sickness**
- **treat medical injuries**
- **provide Radiation shelter**

Lunar Rover



Constellation Medical Issues

Medical Care autonomy

Distance – 3 days to return from Moon, 6-8 mos or more to return from Mars

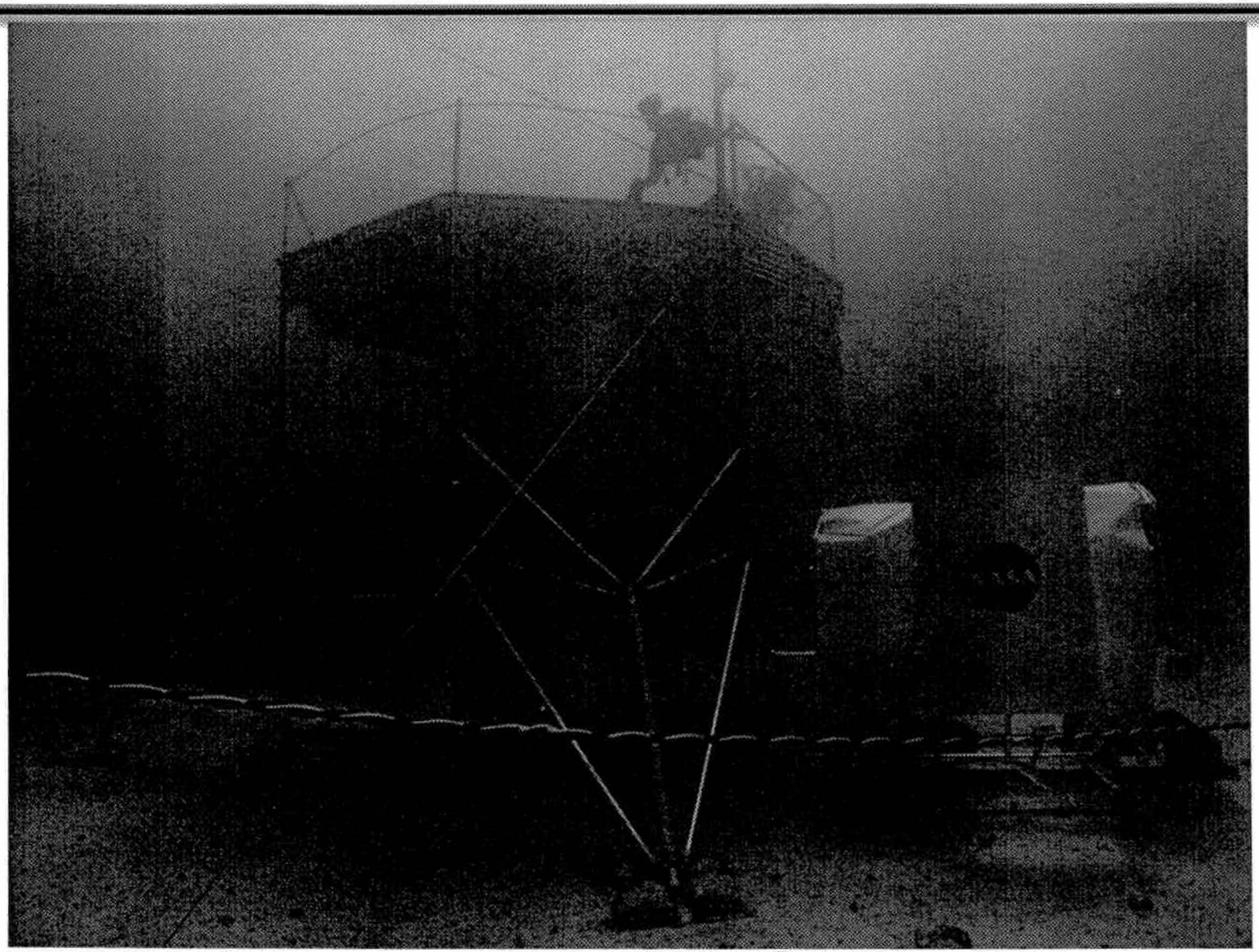
Duration – Long missions planned for Moon (6 mos), 3 years for Mars

Mission medical autonomy

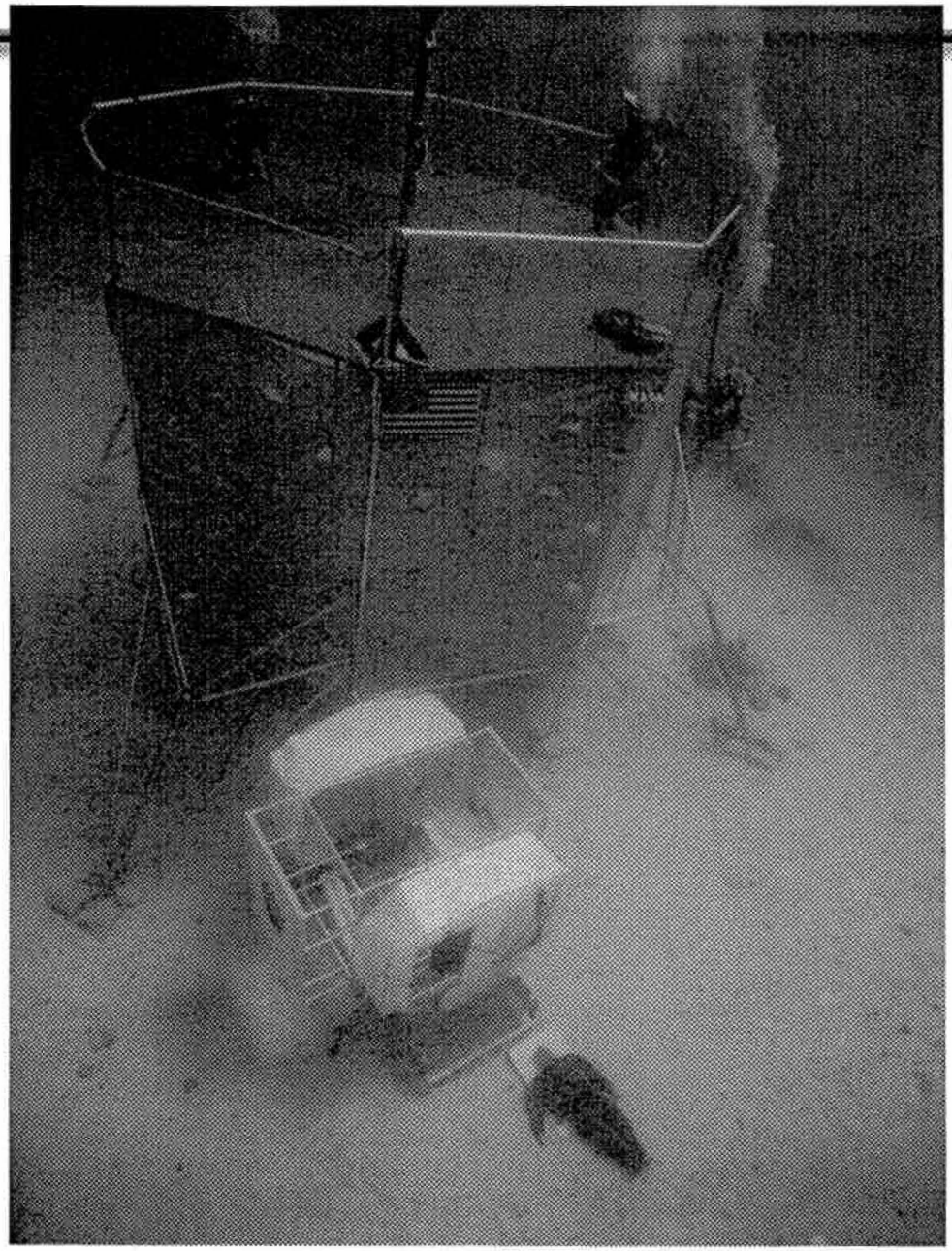
- **Dedicated Medical crewmember(s)**
- **Training in multiple medical specialties including space med**
- **In-flight proficiency training**
- **Advanced Life Support capabilities – Surg, IC**
- **Medical info and Environ linking**
- **Preventive Med /CM**
- **Medical decision support tool**
- **Telemedicine – but time delays**

Lunar Medical Care

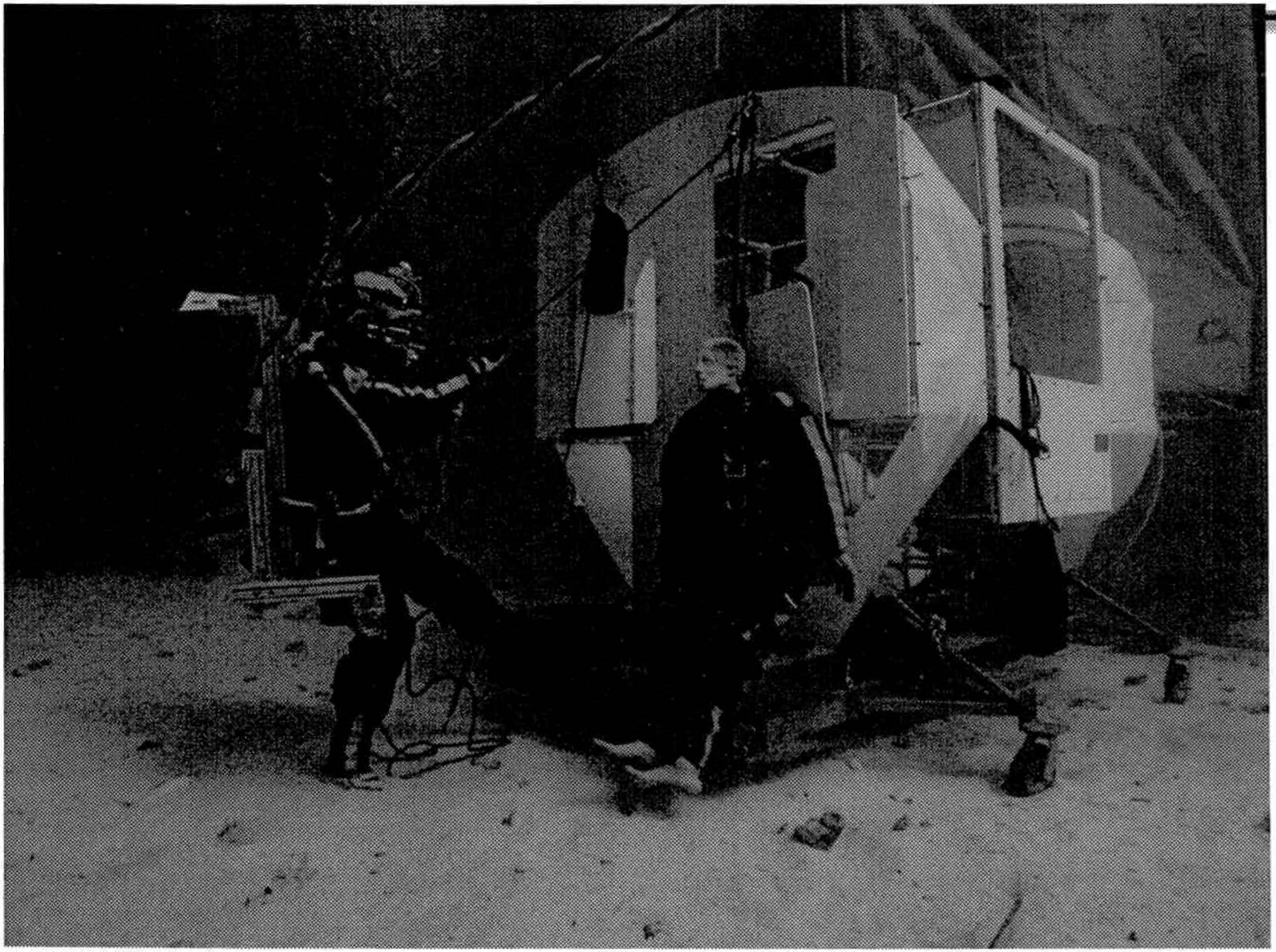
Lunar Ops/Medical Care testing



Lunar Medical Care testing



Lunar Medical Care testing



Constellation Medical Issues

Behavioral Health

Isolation, Confinement

Constant knowledge of Hazards and Stresses

Lack of Social network

Minimal Privacy

Mixed crew cultures, experiences, ages

Chronic Fatigue & Asthenia

Interpersonal tensions/conflicts

Training to recognize issues

Select-out and select-in criteria

Better HF design (larger, brighter, less noise) and scheduling (with recreation and time off)

Comm with the ground

Meds if needed

Constellation Ground Medical Projects

Ground EMS System

Launch at KSC:

Smaller Crew (4) – 2 less DoD Helos and aircrew needed

LAS Abort landings – on water or land at KSC

Pad Rescue, Decon, Triage Site, Stabilization, Medevac

Landing in Pacific Ocean near San Diego:

Recovery Ship

Rescue, Decon, Triage, Stabilization, Medevac

Ascent Abort Modes

Mode 1 = Early Ascent Aborts:

- **1A LAS Aborts on Pad & Low altitude, up to ~ 25 kft**
- **1B LAS Aborts at Mid altitude, between ~25 kft and ~150 kft**
- **1C LAS Aborts High altitude, ~150 kft and LAS jettison (~270 kft)**

Mode 2 = Mid-Ascent Aborts:

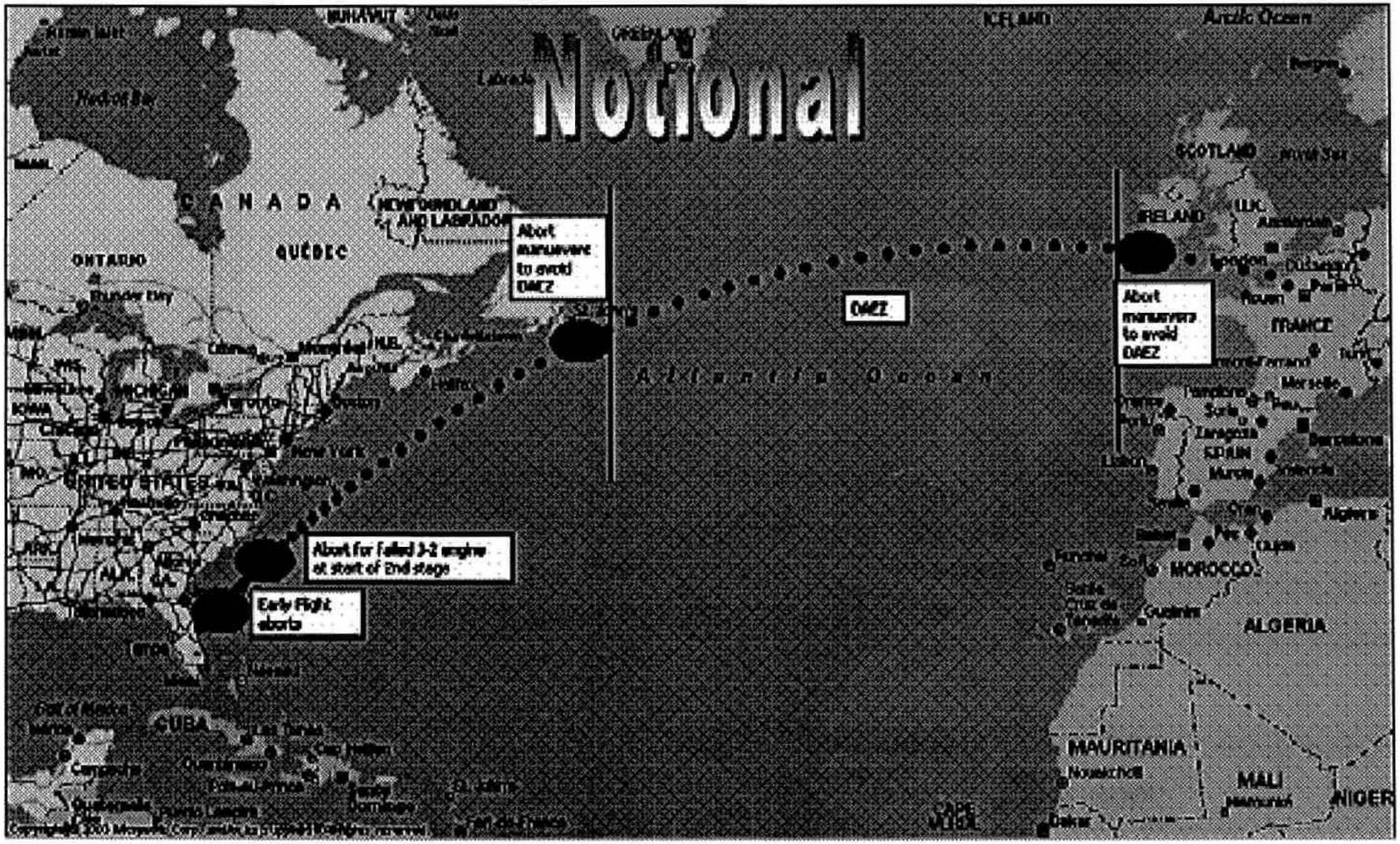
- **Untargeted Abort Splashdown (UAS)**

Mode 3 = Late Ascent Aborts:

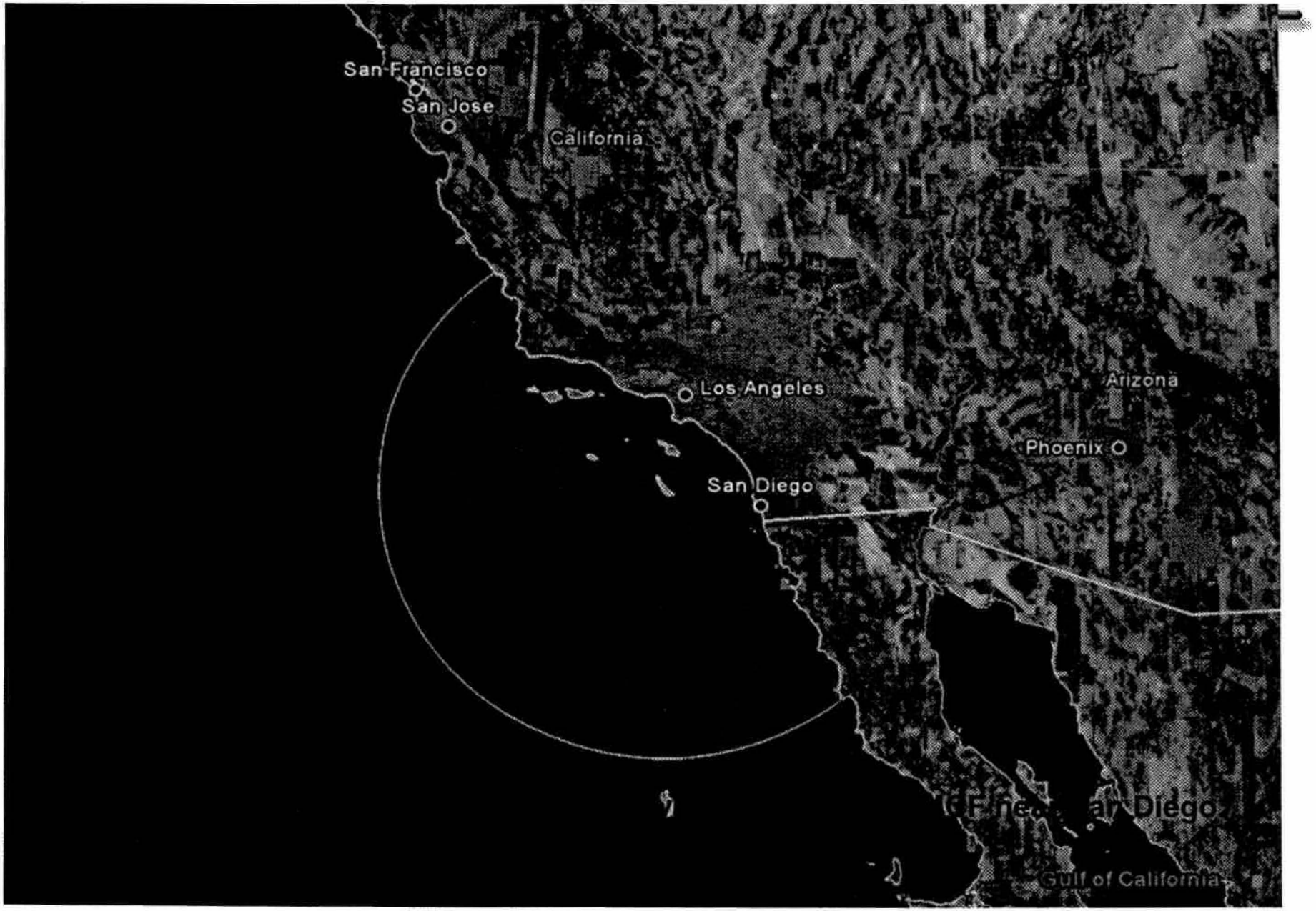
- **Targeted Abort Landing (TAL)**
- **Retrograde Targeted Abort Landing (RTAL)**
- **Abort Once Around (AOA)**

Mode 4 = Abort to Orbit (ATO)

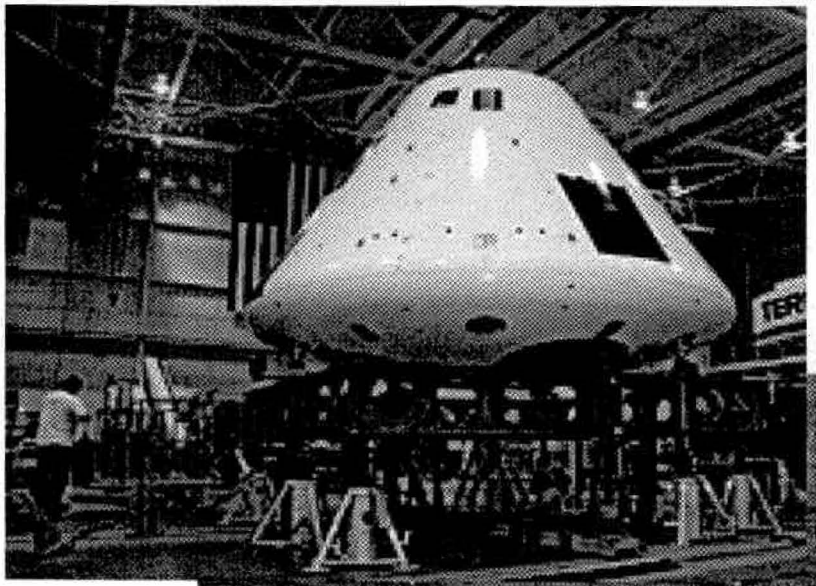
Ascent Abort Modes



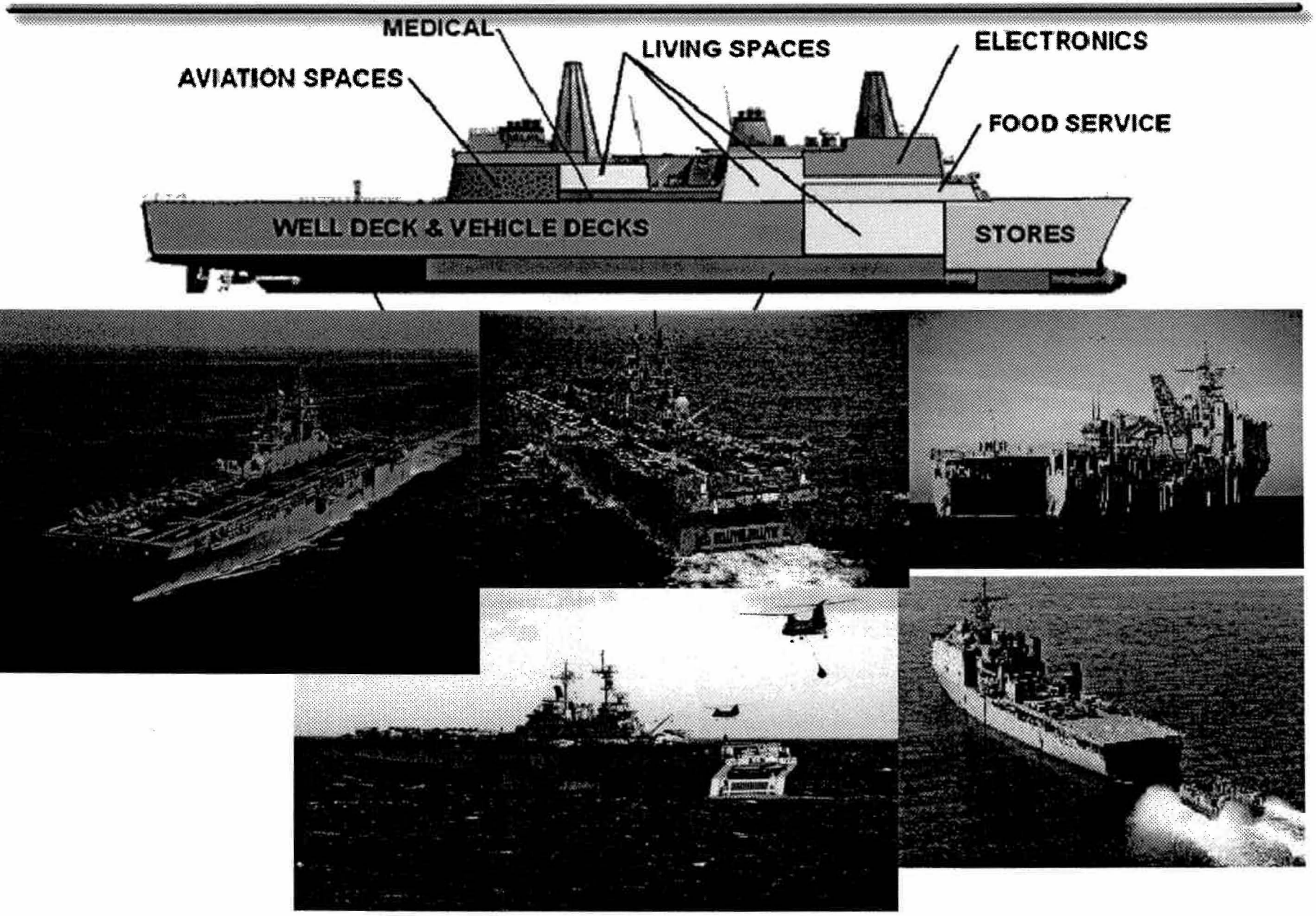
Nominal EOM Landing Zone



Capsule Mockup Testing



Recovery Ship – NASA, Commercial, or DoD



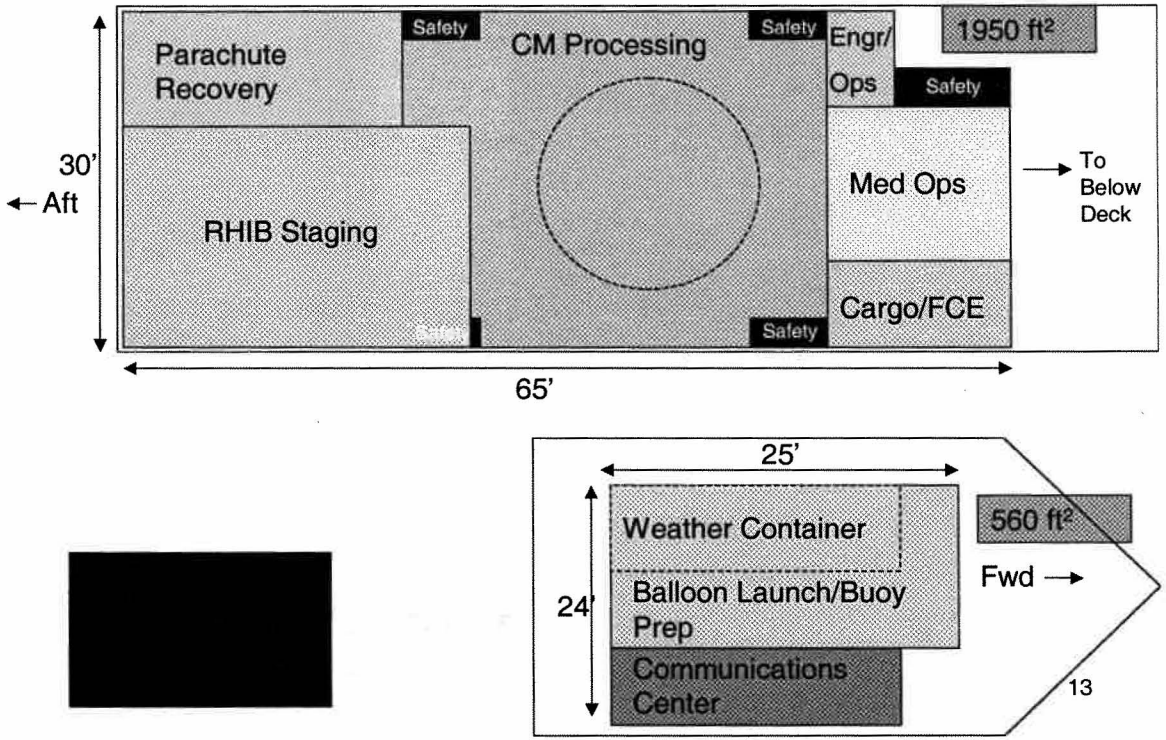
Recovery Ship Requirements

Astronaut Medical Assessment, Stabilization, Medevac if needed

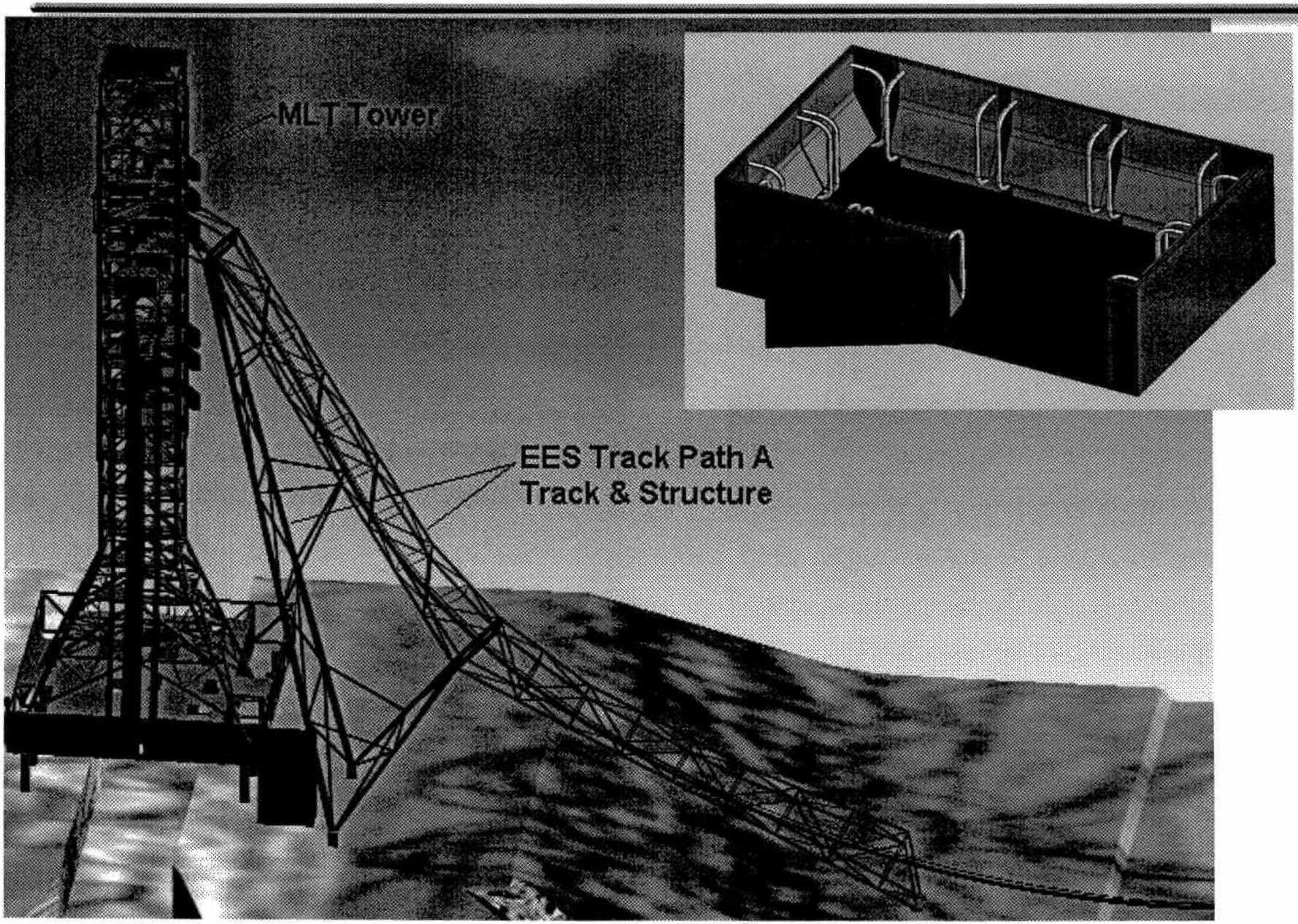
Some Science Data Collection on ship, remainder on land

Turnaround Team Support

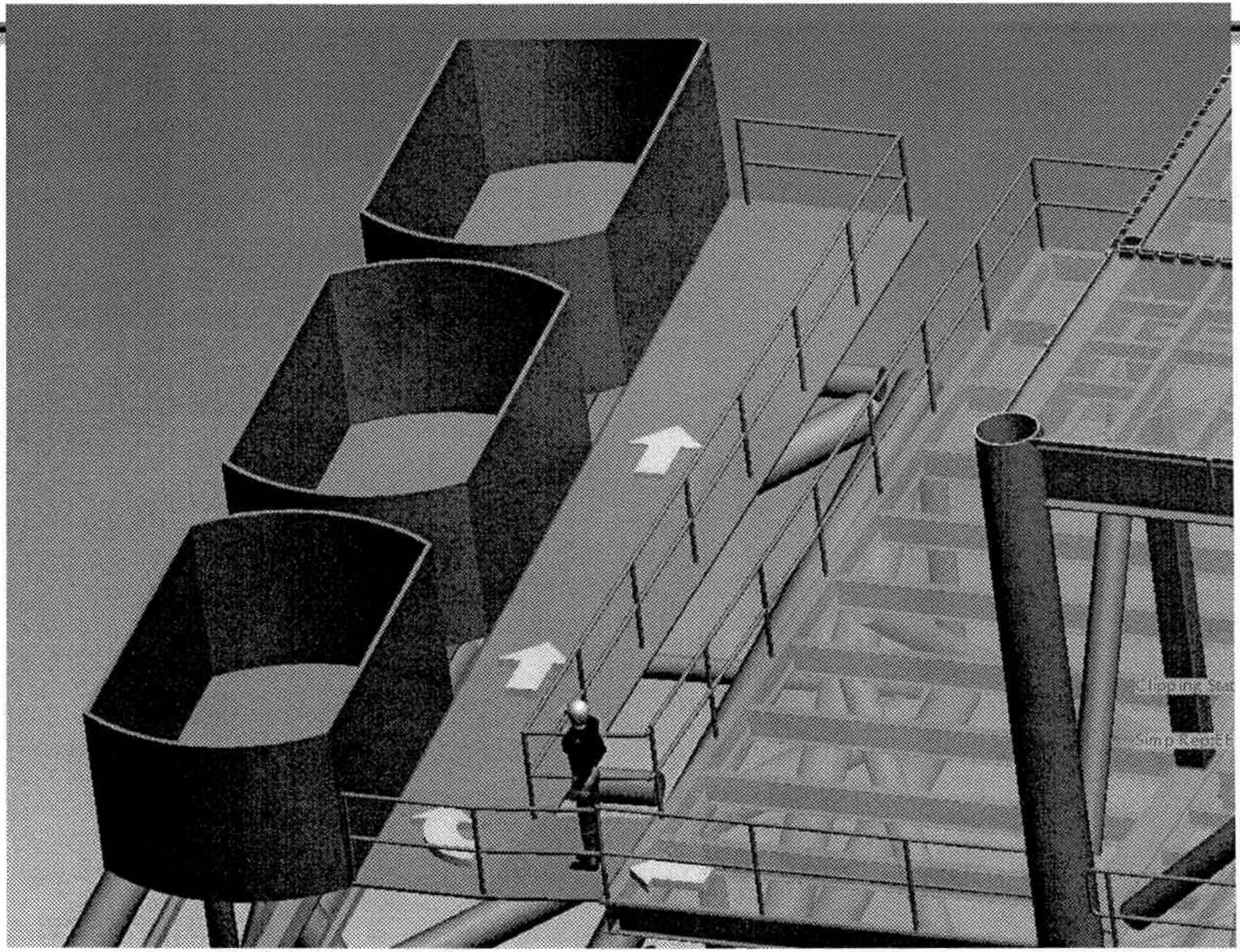
Ship Floor plan



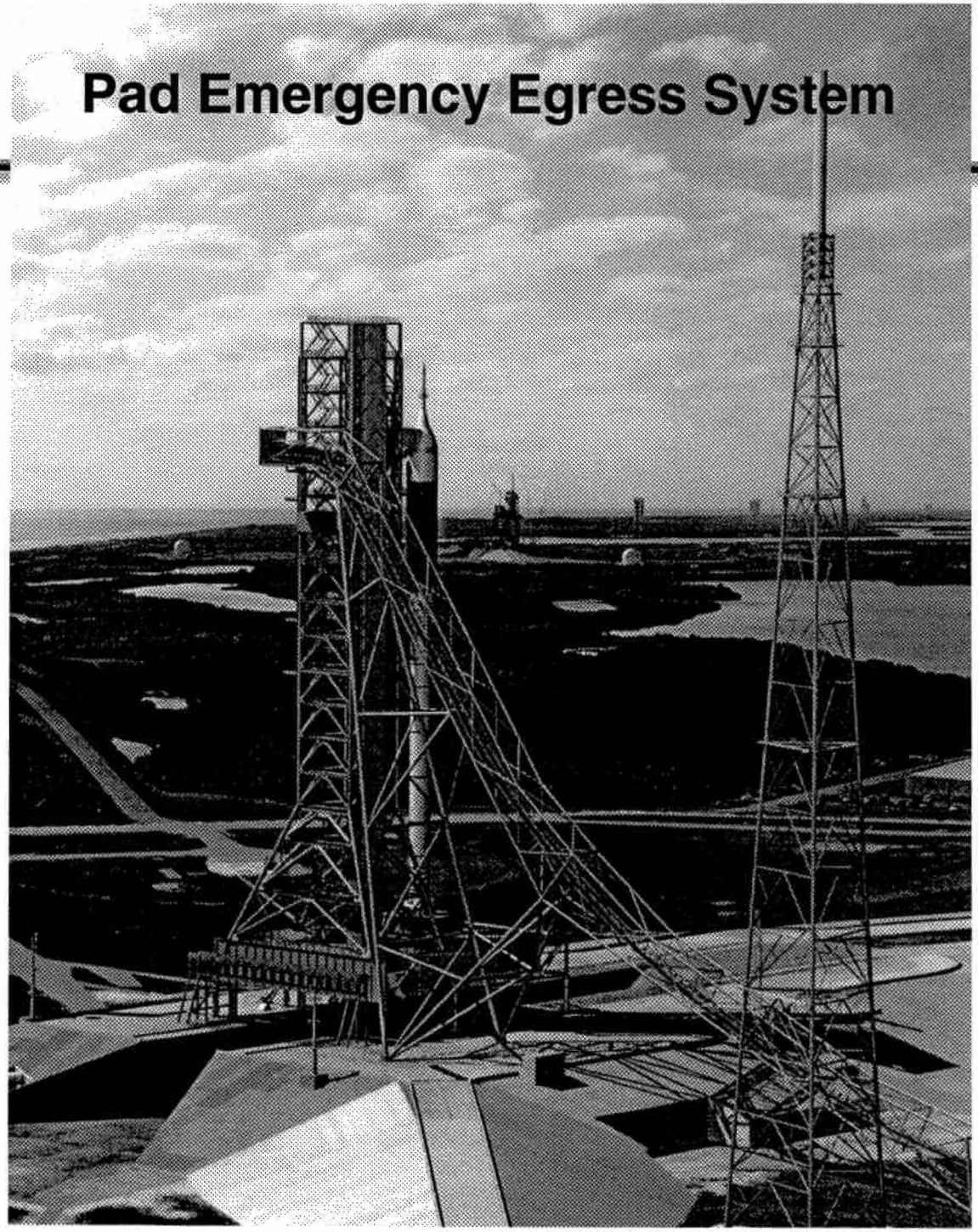
Pad Emergency Egress System



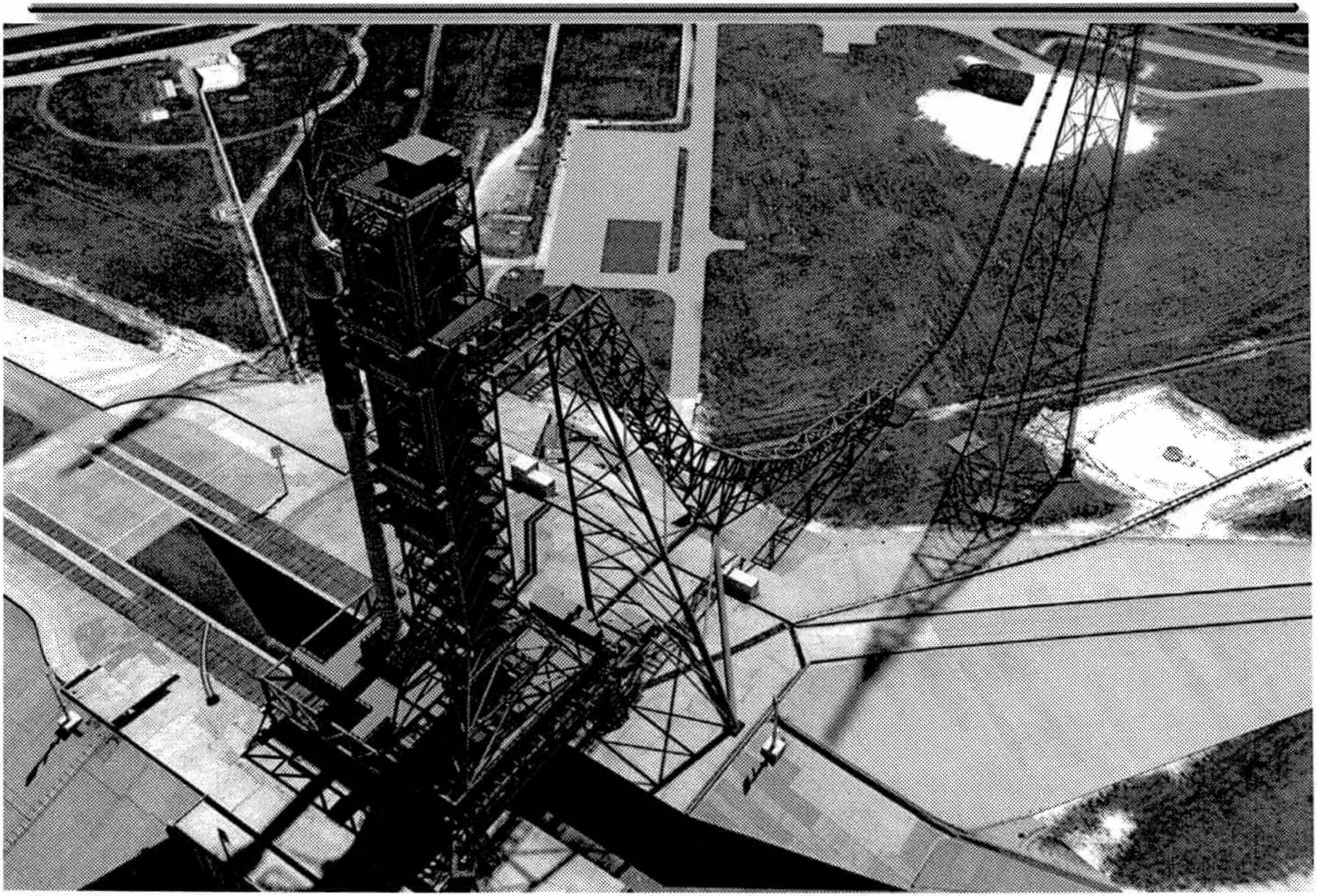
EES Car Loading Platform



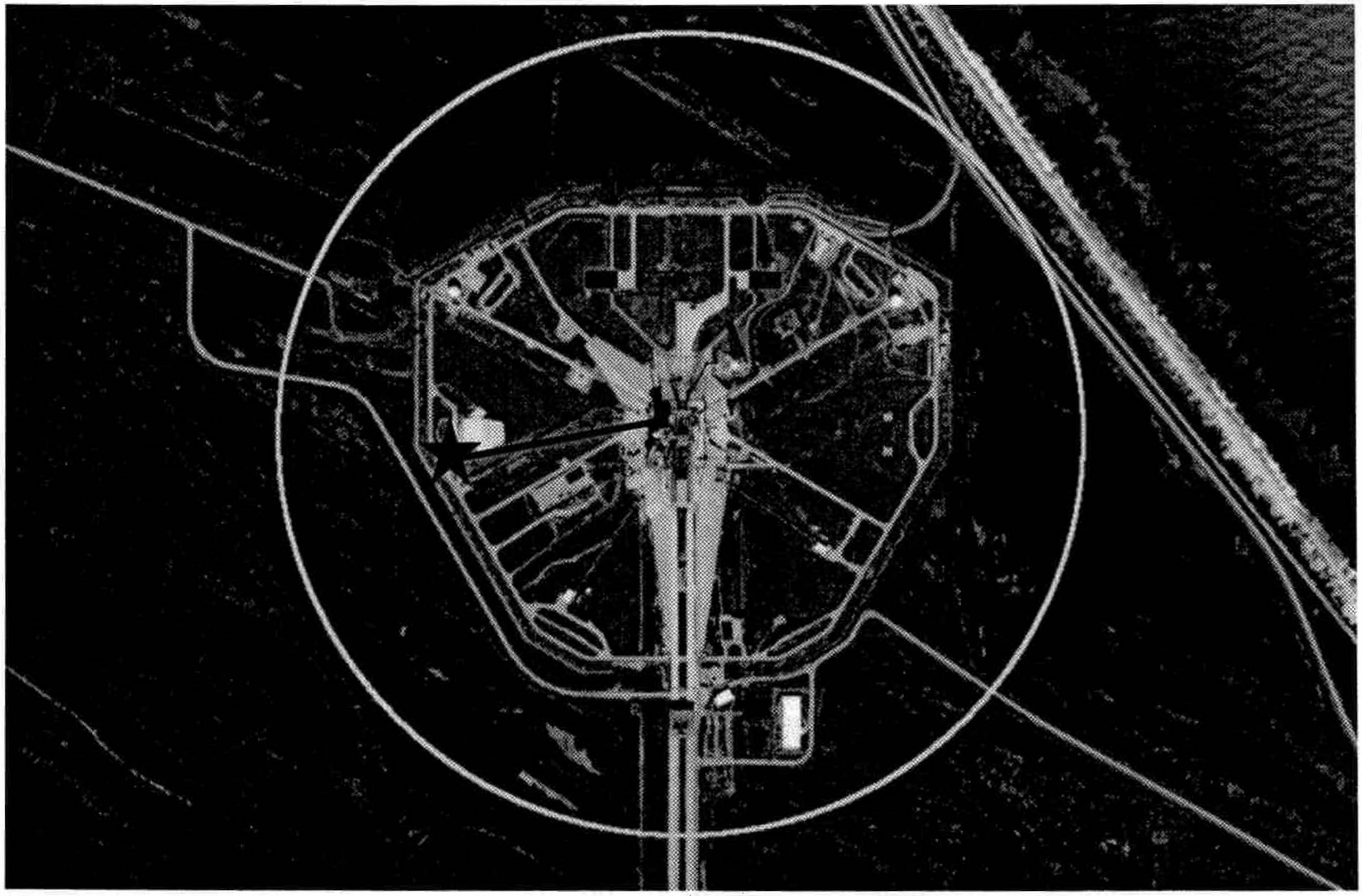
Pad Emergency Egress System



Pad Emergency Escape System

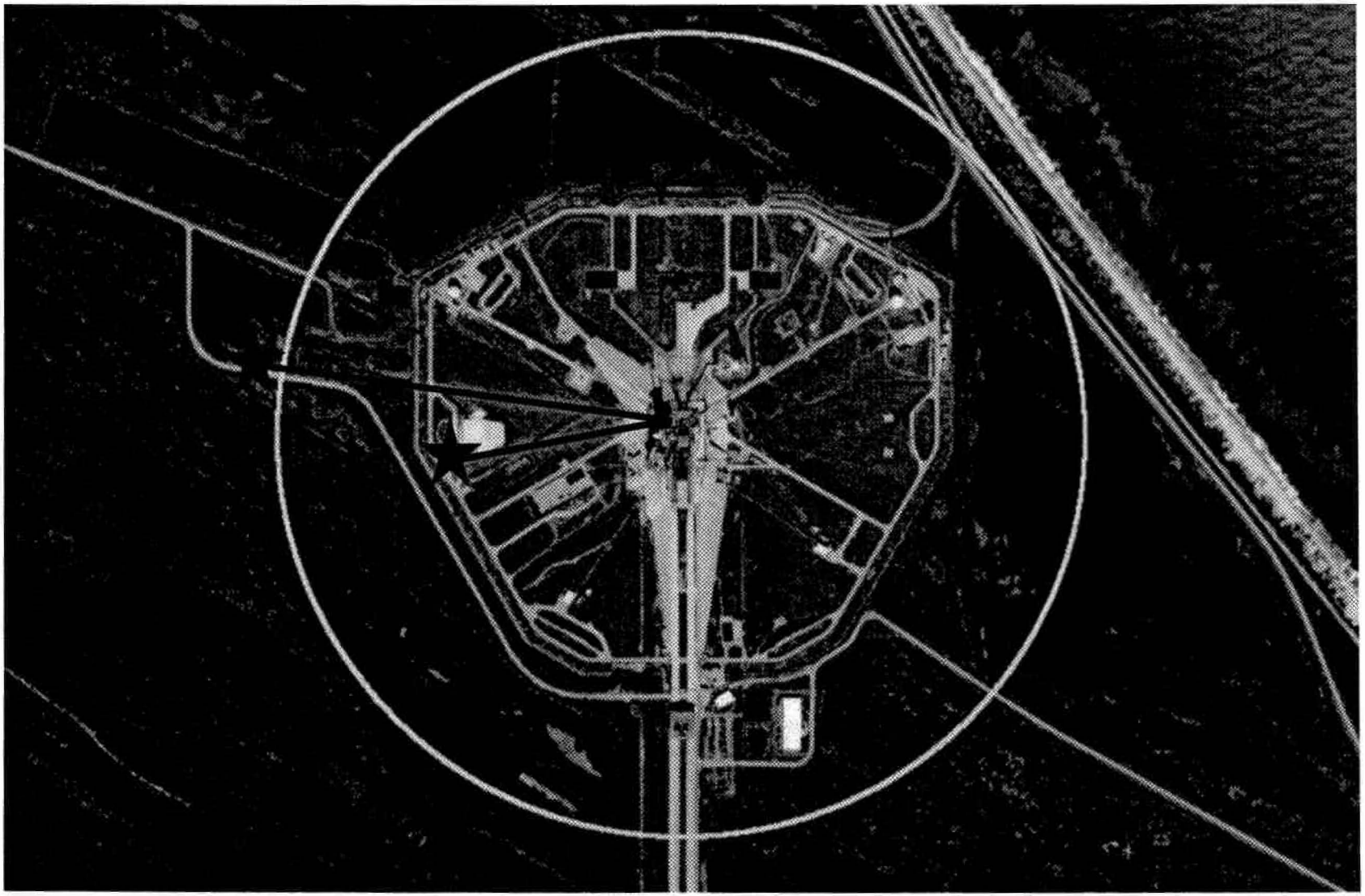


Extension of Emergency Egress System



Yellow Circle indicates Blast Danger Areas for Ares I

Extension of Emergency Egress System



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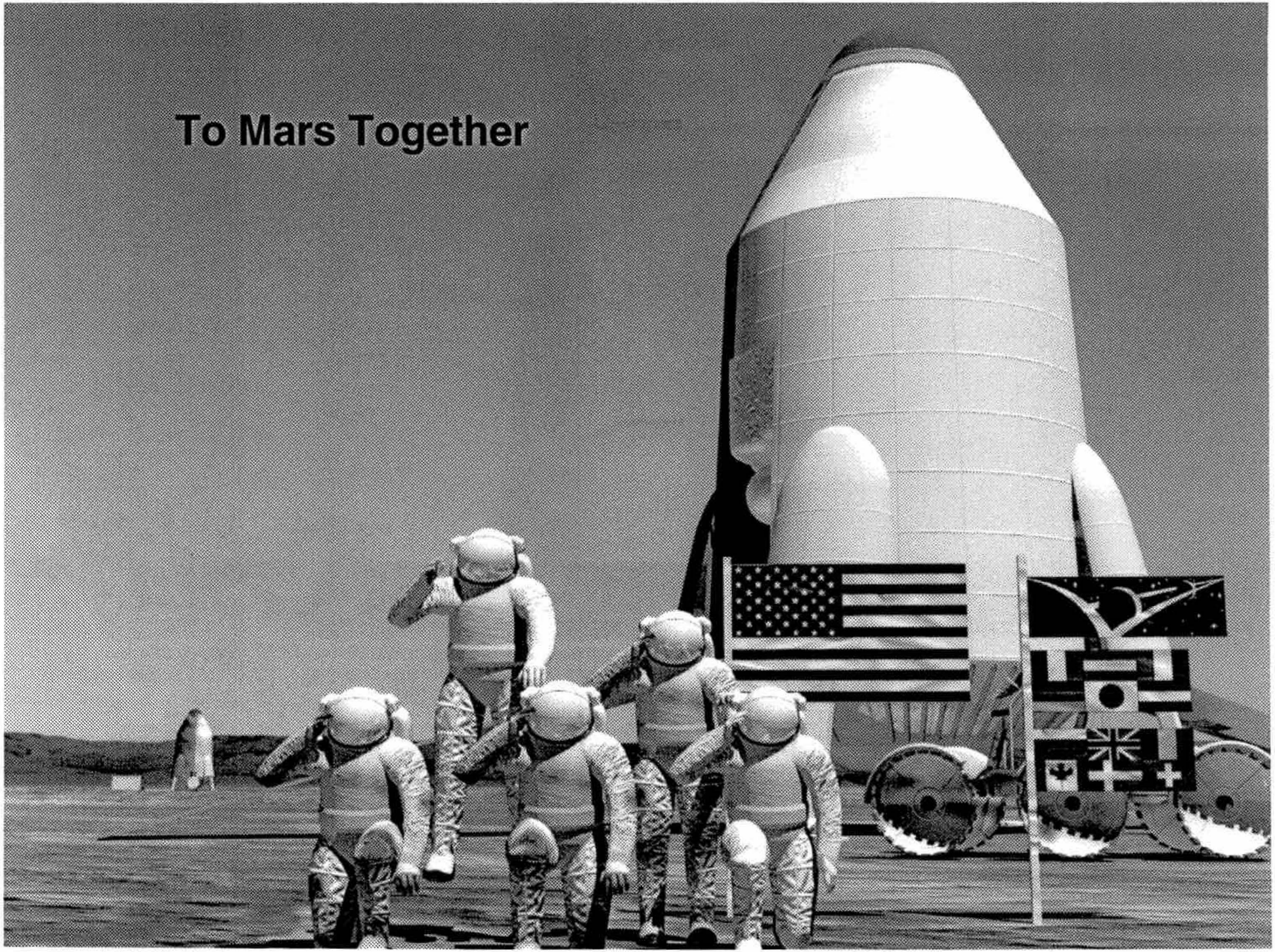
To Mars Together

Back up Slides

Constellation Videos

http://www.nasa.gov/mission_pages/constellation/multimedia/const_videos_archive_1.html

Video Titles-

"Constellation Mission Overview"

"Return to the Moon: The Journey Begins"

"Moon, Mars and Beyond"

Augustine Commission - ??

Scenario	Option 1	Option 2	Option 3	Option 4A	Option 4B	Option 5A	Option 5B	Option 5C
	Program of Record	ISS + Lunar	Program of Record + $	Moon First / Ares-5 Lite	Moon First / Shuttle Extend	Flexible Path Ares-5 Lite	Flexible Path EELV	Flexible Path Shuttle-Derived
Budget	Current Plan	Current Plan	Add $3B/yr.	Add $3B/yr.	Add $3B/yr.	Add $3B/yr.	Add $3B/yr.	Add $3B/yr.
Space Shuttle	2011	2011	2011	2011	2015	2011	2011	2011
Space Station	2015	2020	2015	2020	2020	2020	2020	2020
Ares-1	2017	No	2017	No	No	No	No	No
Ares-5 / Lite	Late 2020s	Late 2020s	Mid 2020s	Early 2020s	No	Early 2020s	No	No
Commercial Cargo	Maybe	2010/11	Maybe	2010/11	2010/11	2010/11	2010/11	2010/11
Commercial Crew *	No	2016	No	2016	2016	2016	2016	2016
Shuttle-Derived Heavy-Lift **	No	No	No	No	Pre 2020s	No	No	Pre 2020s
Commercial Heavy-Lift	No	No	No	No	No	No	2015/16	No
Human Flight Gap	6-7 years	5-6 years	6-7 years	5-6 years	1-2 years	5-6 years	5-6 years	5-6 years
Heavy-Lift Gap	~16 years	~16 years	~13 years	~11 years	~0-5 years	~11 years	~4-5 years	~3-9 years
Moon Landing	2030s	2030s ?	Mid 2020s	Mid 2020s	Mid 2020s	Late 2020s ?	Late 2020s ?	Mid 2020s ?
Mars Exploration	Future Goal	Future Goal	Future Goal	Future Goal	Future Goal	Future Goal	Future Goal	Future Goal
Other Exploration	No	No	No	No	No	Early 2020s	Pre 2020s	Pre 2020s
Technology Dev. Program	No	Yes	No	Yes	Yes	Yes	Yes	Yes

* 2016 estimate for *Commercial Crew* capability does not match some industry claims that a *2013/14* capability is possible.
** Estimates for *Shuttle-Derived Heavy-Lift* capability vary but an availability by *2014* was briefed to the panel by NASA and DIRECT