EXPLORATION COMMITTEE

April 17, 2008

For Section 508 Compliance charts with photos, illustrations and/or graphics are described on the following page

Exploration Committee

LGEN James Abrahamson (Chair)
Dr. Ken Ford
Dr. Don Fraser
Capt. Rick Hauck
Dr. John Logsdon

Executive Secretary: Dr. Louis Ostrach
Admin Assistant: Ms. Jane Parham

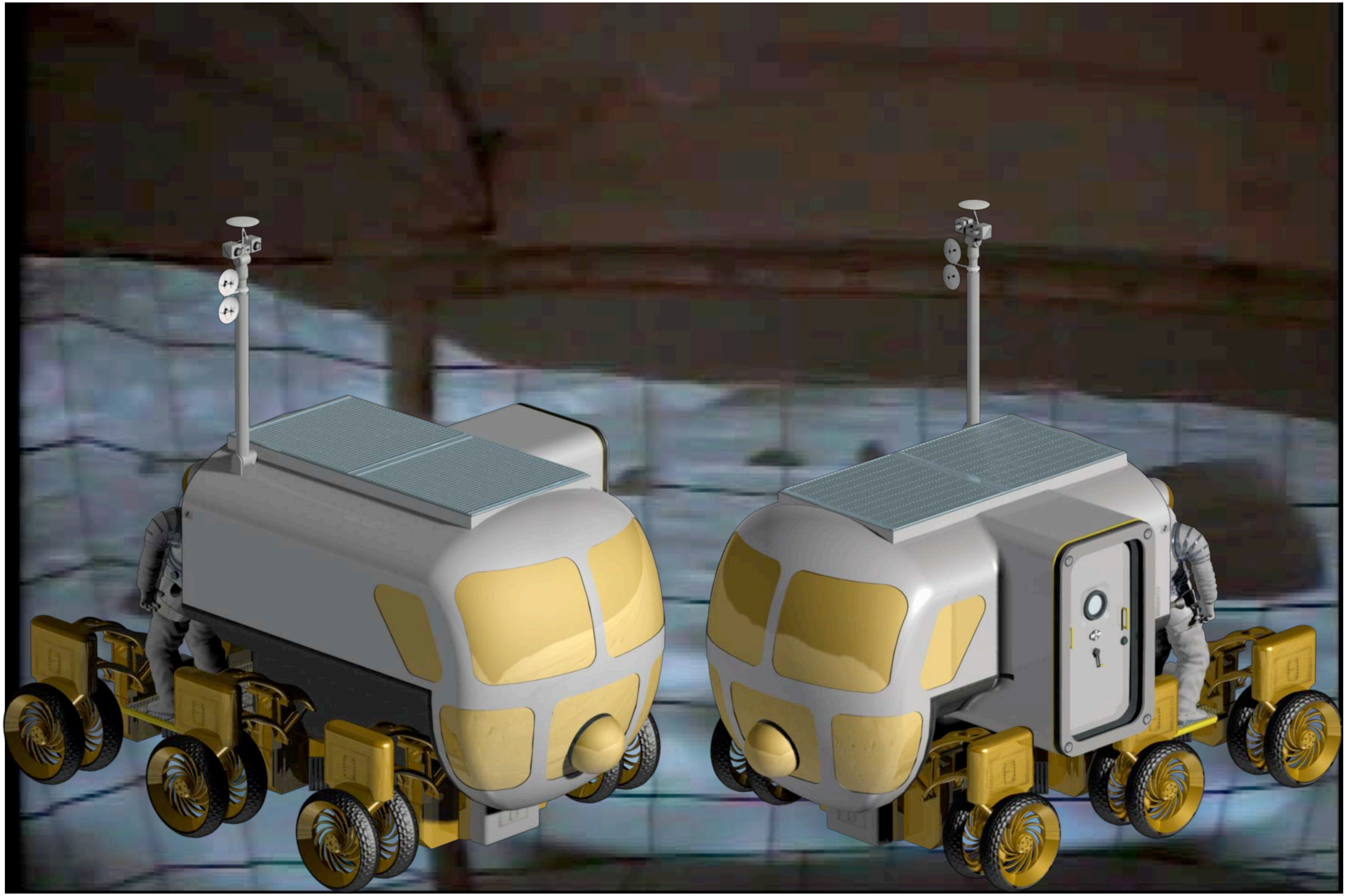
Agenda

Human System Standards - Dr. David Longnecker

Thrust Oscillation Focus Team Progress Report -
Dr. Donald Fraser

Small Pressurized Rover – LtGen Abrahamson

Small Pressurized Rover Concept



page 4 illustration: Small Pressurized Rover Concept

Two rovers parked face-to-face: The concept is multi-wheeled, with wheels able to rotate in all directions. The intent of these small rovers is to be able to provide a habitat that can be a safe haven with life support of at least 72 hours, a place to live, a way to extend the exploration range, and a means to limit dust and other problems for people living on the surface. Dr. Abrahamson showed a chart that depicted the design features. One of the key features is the suits—they are carried outside, and the structure inside is such that the astronaut can get into the suit easily and quickly with minimal air loss. The rover is a simple chassis with SUV-size living accommodation on top—a VW-type of concept. The small pressurized is not much bigger than the unpressurized Apollo rover. Water provides radiation protection. There is a very small window on the top as well as a window on the front. It is sized for crew of two, although it can accommodate four in an emergency situation. Dr. Abrahamson showed some of the interior concepts for exercise, privacy, and sleeping. The chassis exists, and some tests are currently being performed.

Drivers for an Integrated EVA/Mobility System to Optimize Human Safety and Performance in Planetary Exploration

Provide a rapidly accessible safe haven with life support of at least 72 hours to protect against:

- Significant Solar Particle Events (SPE)
- Acute suit malfunctions
- Other medical emergencies (e.g. decompression sickness treatment)

Substantially extend exploration range

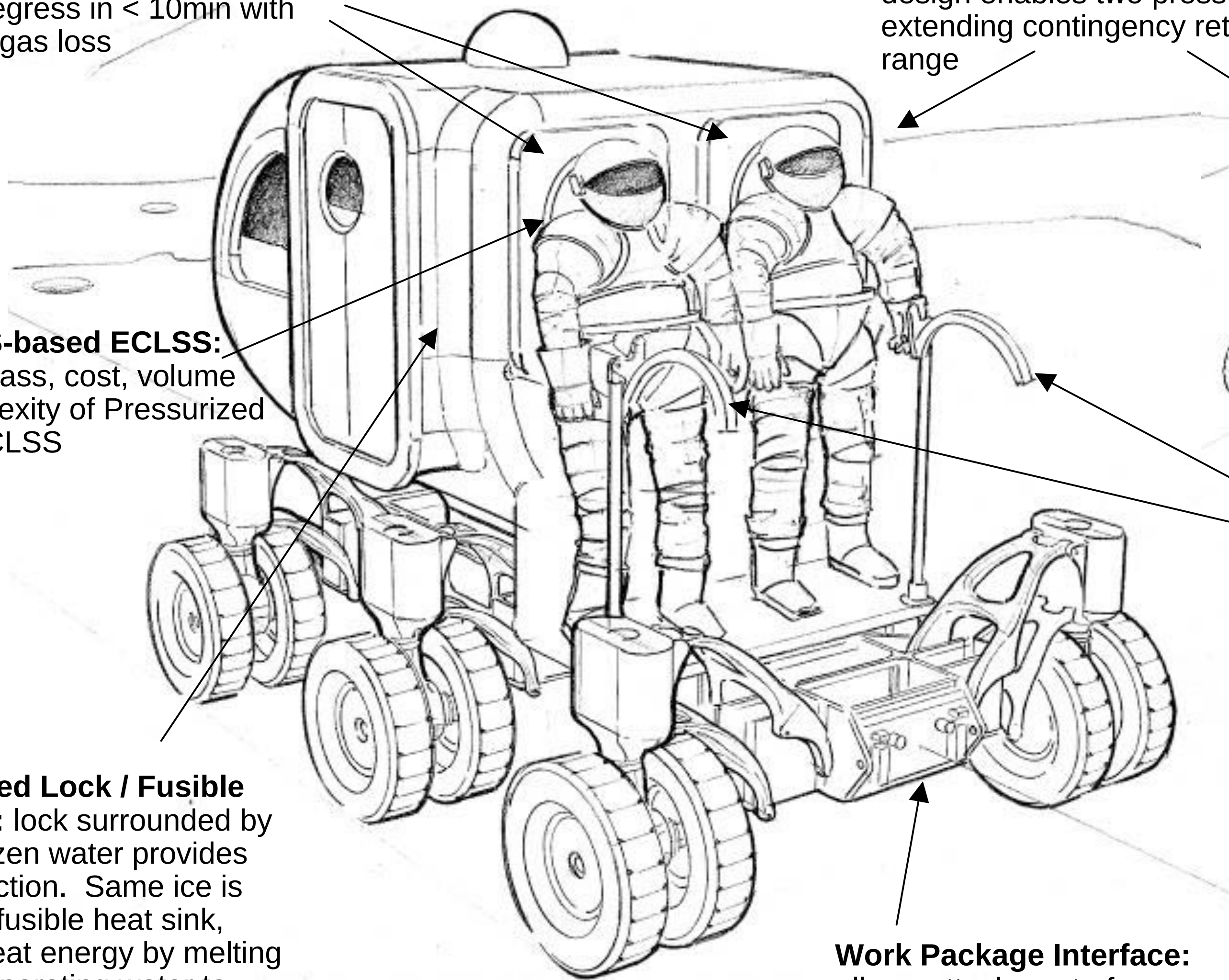
Significantly increase the EVA Work Efficiency

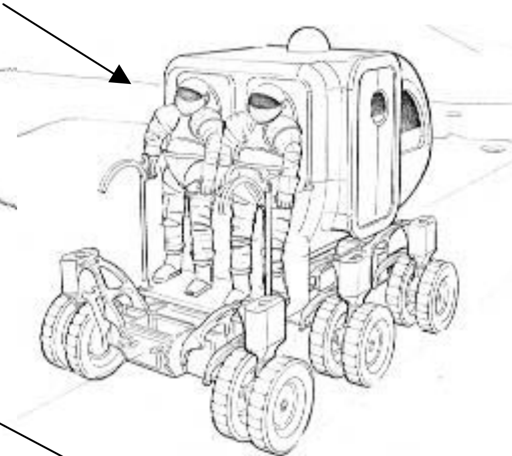
Provide a means to limit dust from habitable volume

Small Pressurized Rover Design Features
(Slide 1 of 2)

Suitports: allows suit donning and vehicle egress in < 10min with minimal gas loss

Two Pressurized Rovers: low mass, low volume design enables two pressurized vehicles, greatly extending contingency return (and thus exploration) range



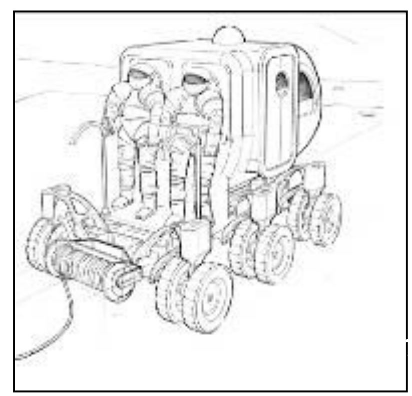


Suit PLSS-based ECLSS: reduces mass, cost, volume and complexity of Pressurized Rovers ECLSS

Chariot-Style Aft Driving Station: enables crew to drive rover while EVA, also part of suitport alignment

Ice-shielded Lock / Fusible Heat Sink: lock surrounded by 5.4 cm frozen water provides SPE protection. Same ice is used as a fusible heat sink, rejected heat energy by melting ice vs. evaporating water to vacuum.

Work Package Interface: allows attachment of modular work packages e.g. winch, cable reel, backhoe, crane



Page 7 illustration: small pressurized rover design features

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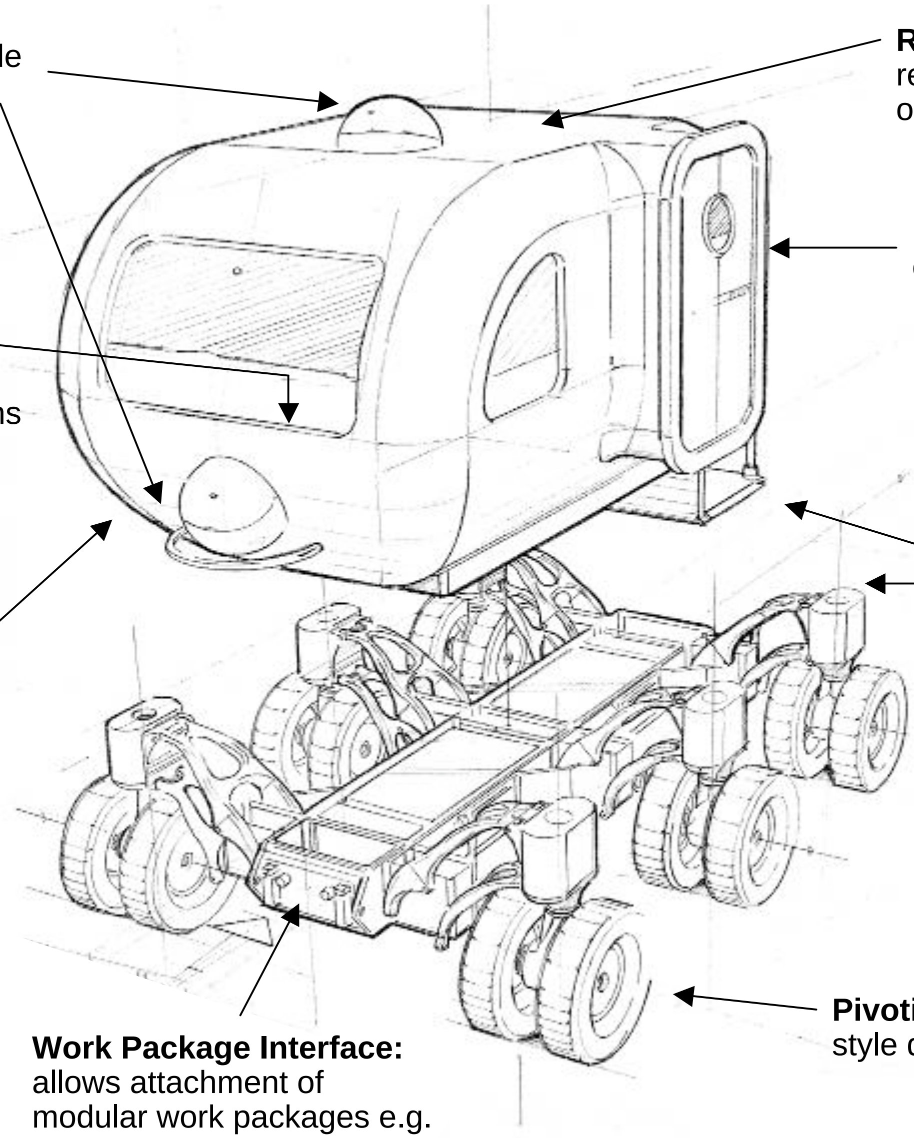
Small Pressurized Rover Design Features
(Slide 2 of 2)



Dome windows: provide visibility as good, or better than, EVA suit visibility

Radiator on Roof: allows refreezing of fusible heat sink water on extended sorties

Docking Hatch: allows pressurized crew transfer from Rover-to-Habitat, Rover-to-Ascent Module and/or Rover-to-Rover

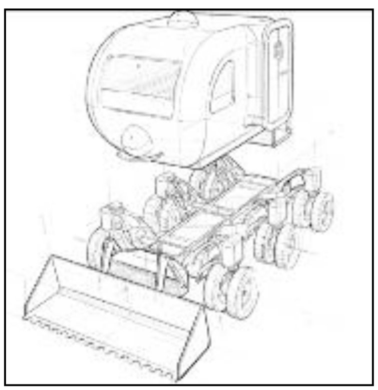
Exercise ergometer (inside): allows crew to exercise during translations

Modular Design: pressurized module is transported using Mobility Chassis. Pressurized module and chassis may be delivered on separate landers or pre-integrated on same lander.

Cantilevered cockpit: Mobility Chassis does not obstruct visibility

Pivoting Wheels: enables crab-style driving for docking

Work Package Interface: allows attachment of modular work packages e.g. winch, cable reel, backhoe, crane



Page 9 illustration: small pressurized rover design features

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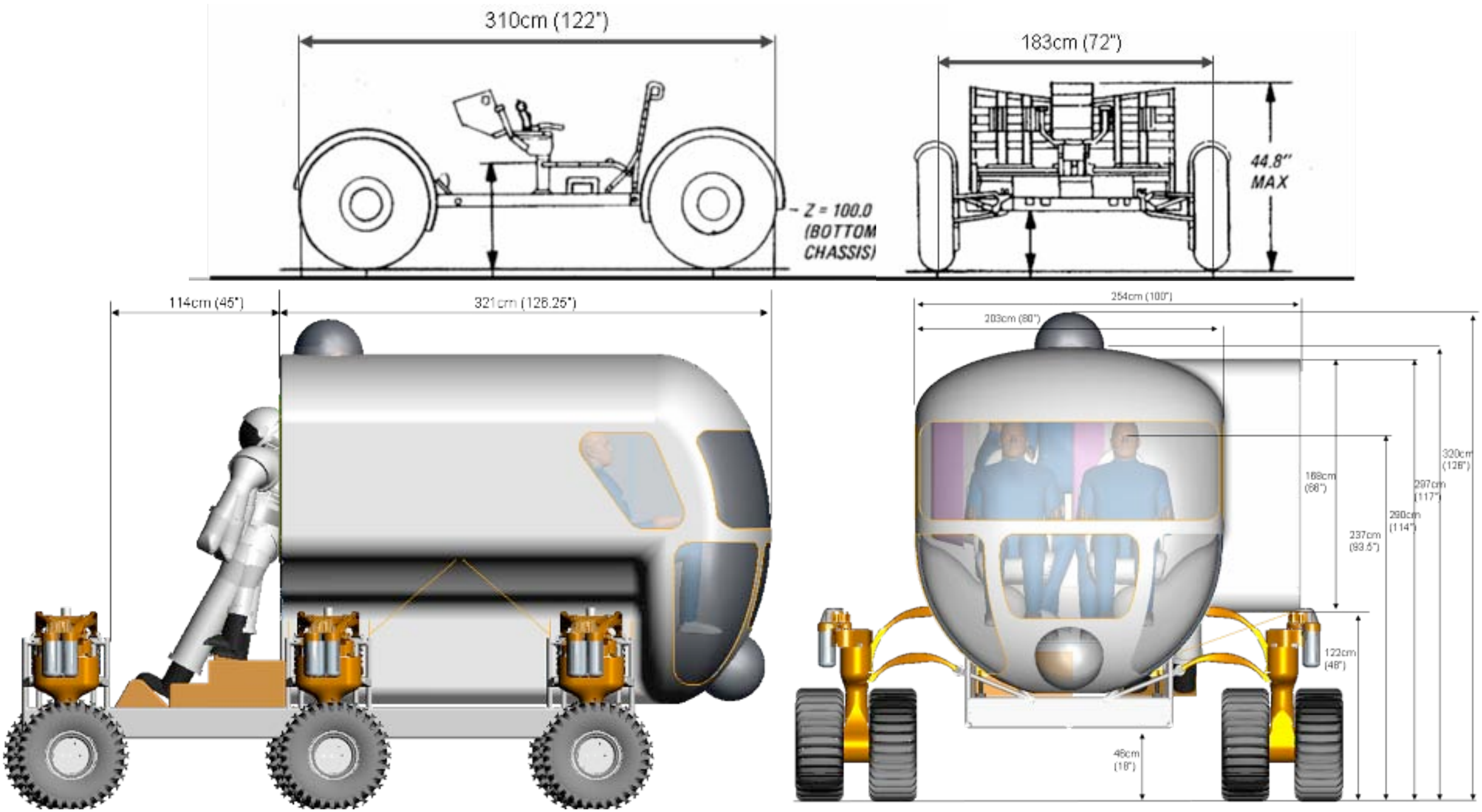
Size Comparison of SPR vs. Unpressurized Rover



Page 11 illustration: Size Comparison of small pressurized rover vs. Apollo Unpressurized Rover

Side View comparison of Apollo rover with small pressurized rover:

Apollo rover was 310 cm (122 inches) long, Small pressurized rover cabin will be 321 cm (128.25 inches) long, chassis will extend 114 cm (45 inches) toward the rear to accommodate suits and workpackage interface.

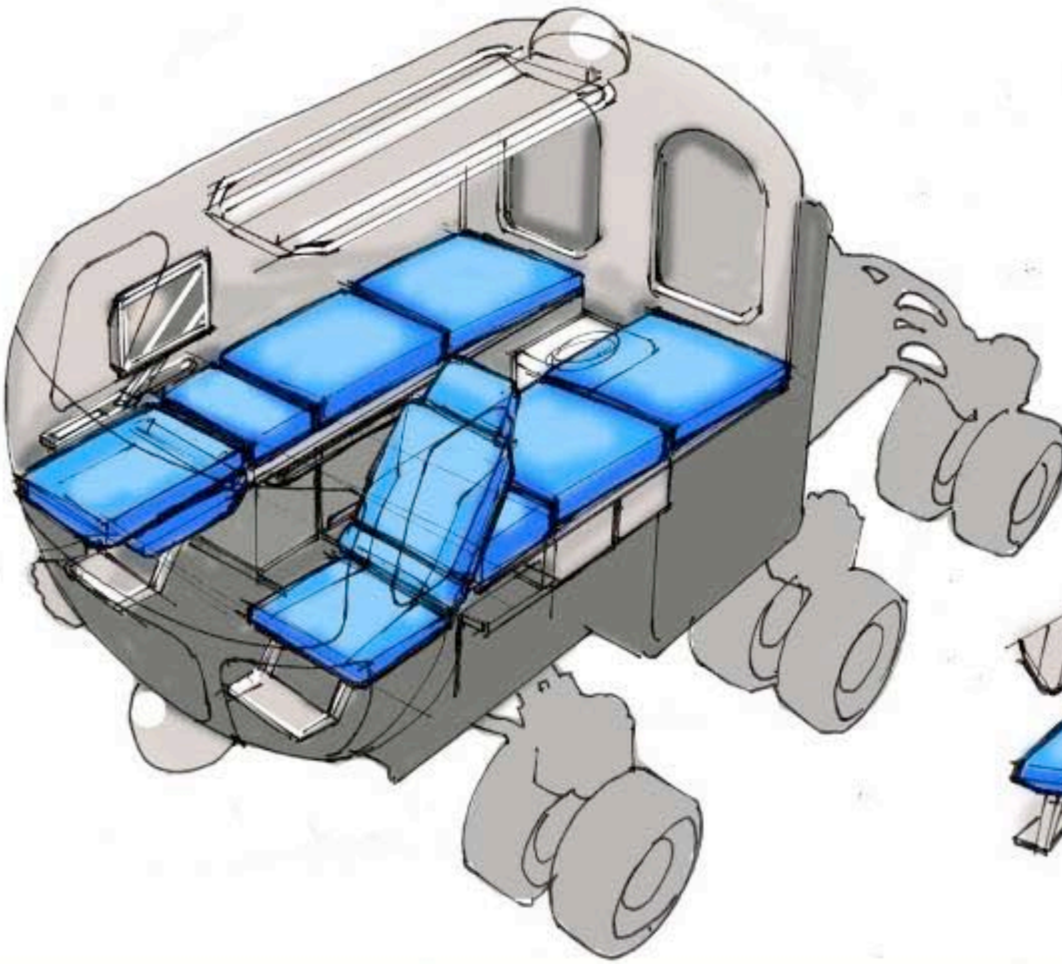
Front view comparison of Apollo rover with small pressurized rover:

Apollo rover was 183 cm (72 inches) wide and 113.8 cm (44.8 inches) high

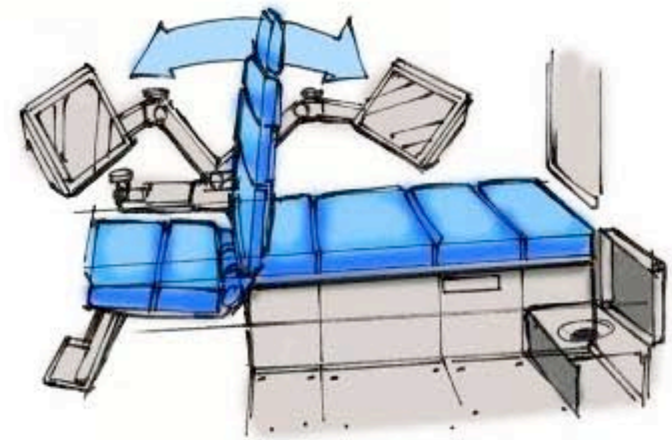
Small pressurized rover cabin will be 203 cm (80 inches) wide with the chassis and wheels extending laterally beyond and 320 cm (126 inches) high

SPR Interior Concepts

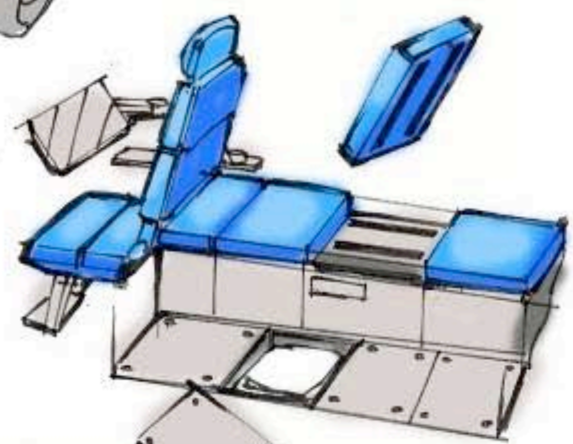
GENERAL CONFIGURATION



Smooth continuous surfaces increase perceived volume and crew comfort.
Soft upholstery and versatile, adjustable surfaces for multiple uses.



Seating and D&C convertible for use in either direction.



Removable upholstery and panels for under-floor stowage.

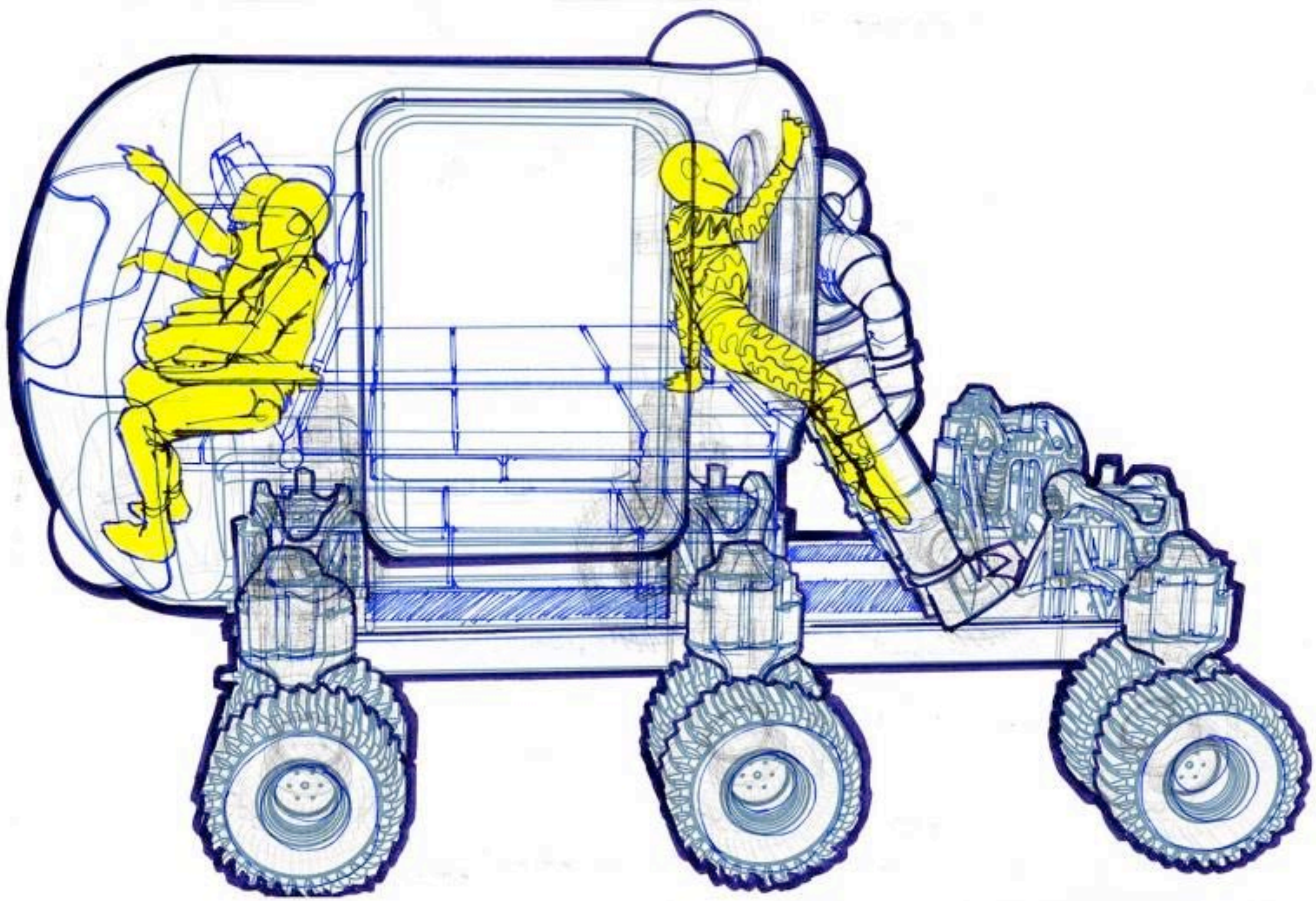
Page 13 illustration: interior general configuration

Three views of interior concepts for seating: Smooth continuous interior surfaces as in a sailboat cabin increase perceived volume and crew comfort. Soft upholstery and versatile, adjustable surfaces for multiple uses. cushioned seats fold down singly into beds.

Removable upholstery and panels for under-floor stowage.

SPR Interior Concepts

POSTURE – DRIVING/ SUIT DONNING



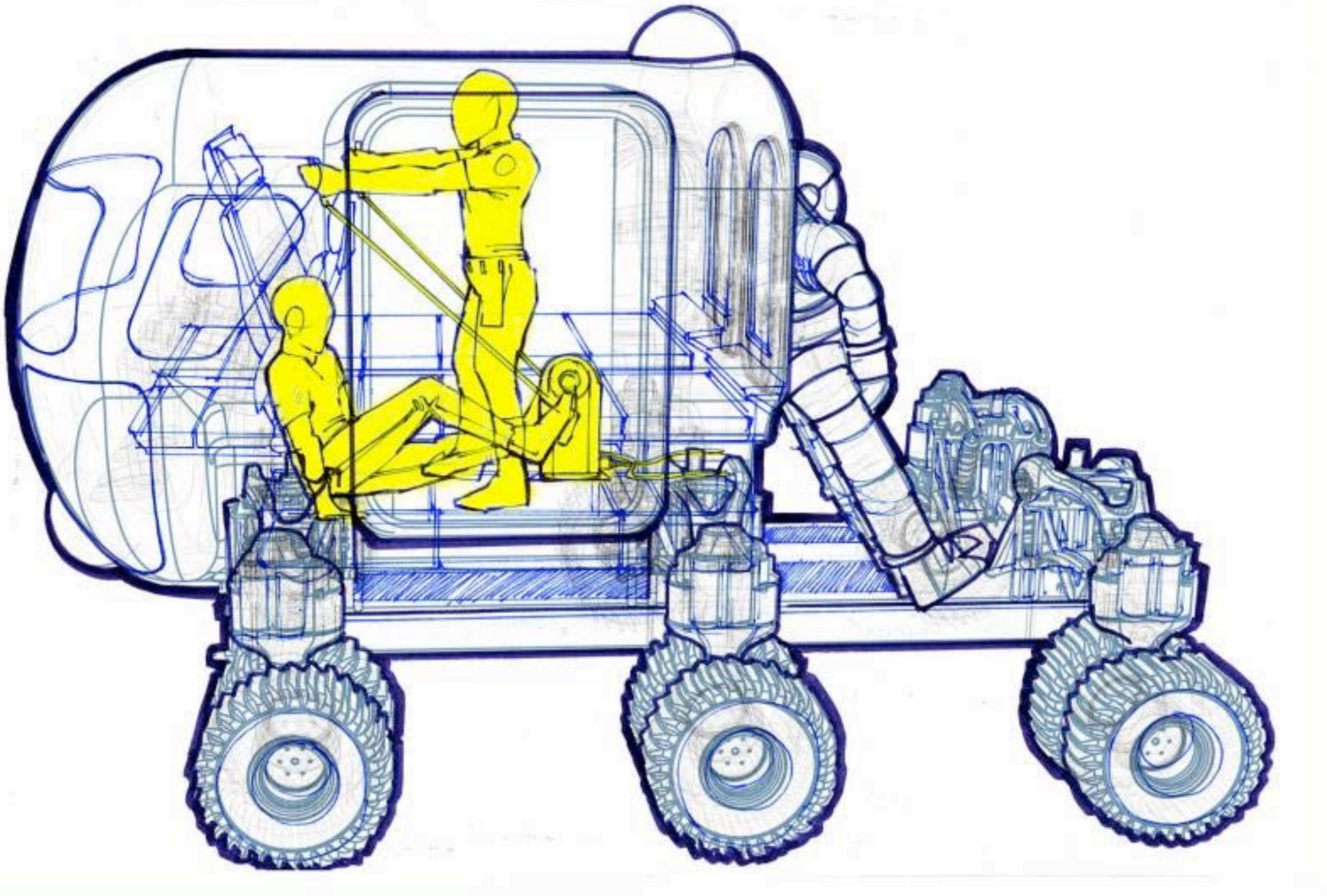
Page 15 illustration: driving, suit donning

Transparent side view of small pressurized rover showing two seated people looking out of the front windows, one driver and one person slipping into the EVA suit through a small hatch in the rear of the cabin; the two suits hang on the exterior of the cabin and are never brought inside.

SPR Interior Concepts

ECP Device mounts to floor panel. Van be used in either seated or standing position.

POSTURE – EXERCISE



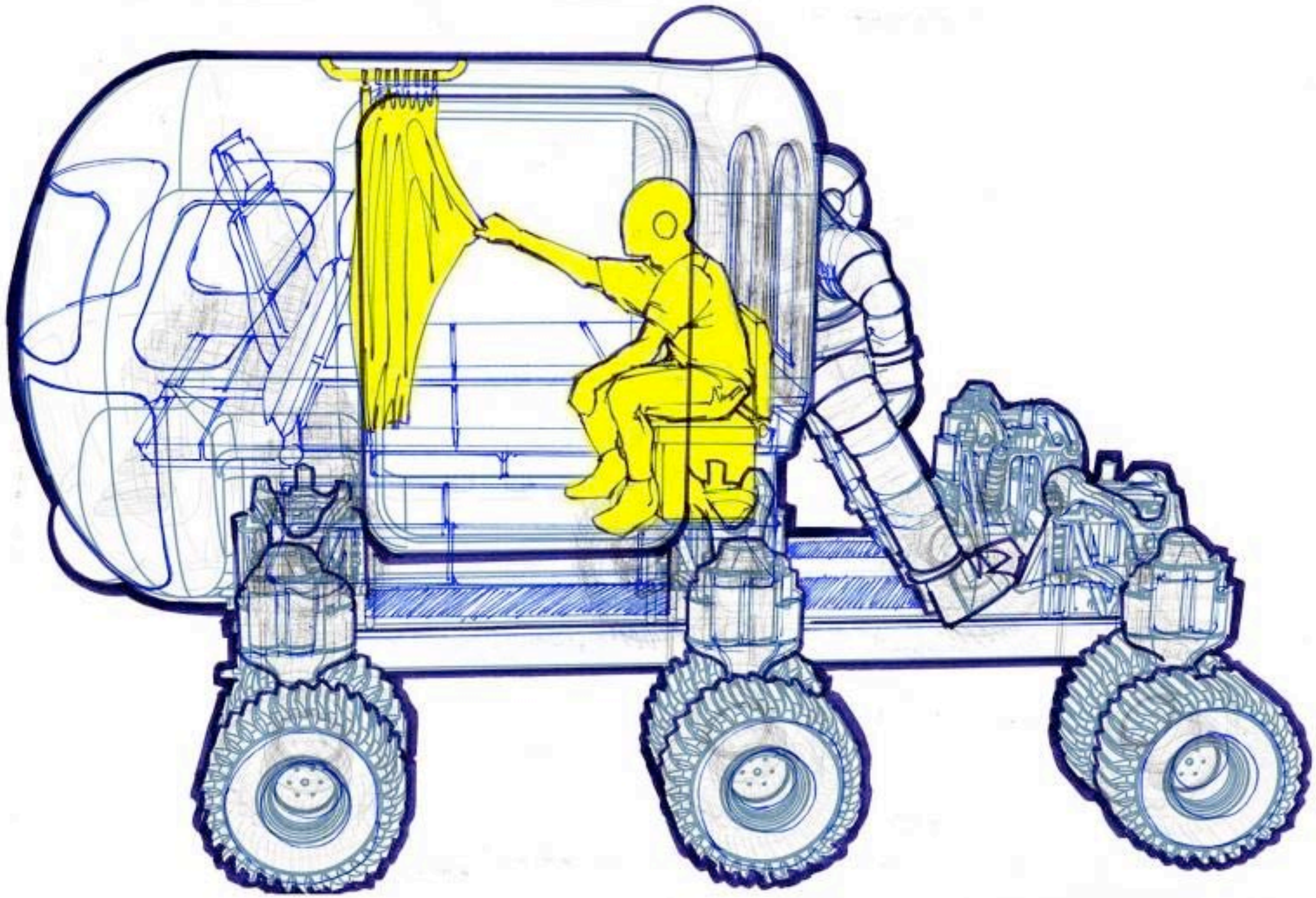
Page 17 illustration: posture - exercise

Transparent side view of small pressurized rover showing one person seated on the cycle ergometer for leg and cardiovascular exercise and one person standing upright using bungee cord straps for upper body exercise

SPR Interior Concepts

Adjustable/deployable privacy curtain. Toilet uses PETT toilet concept with disposable WAG BAGS.

POSTURE – WASTE/ HYGIENE



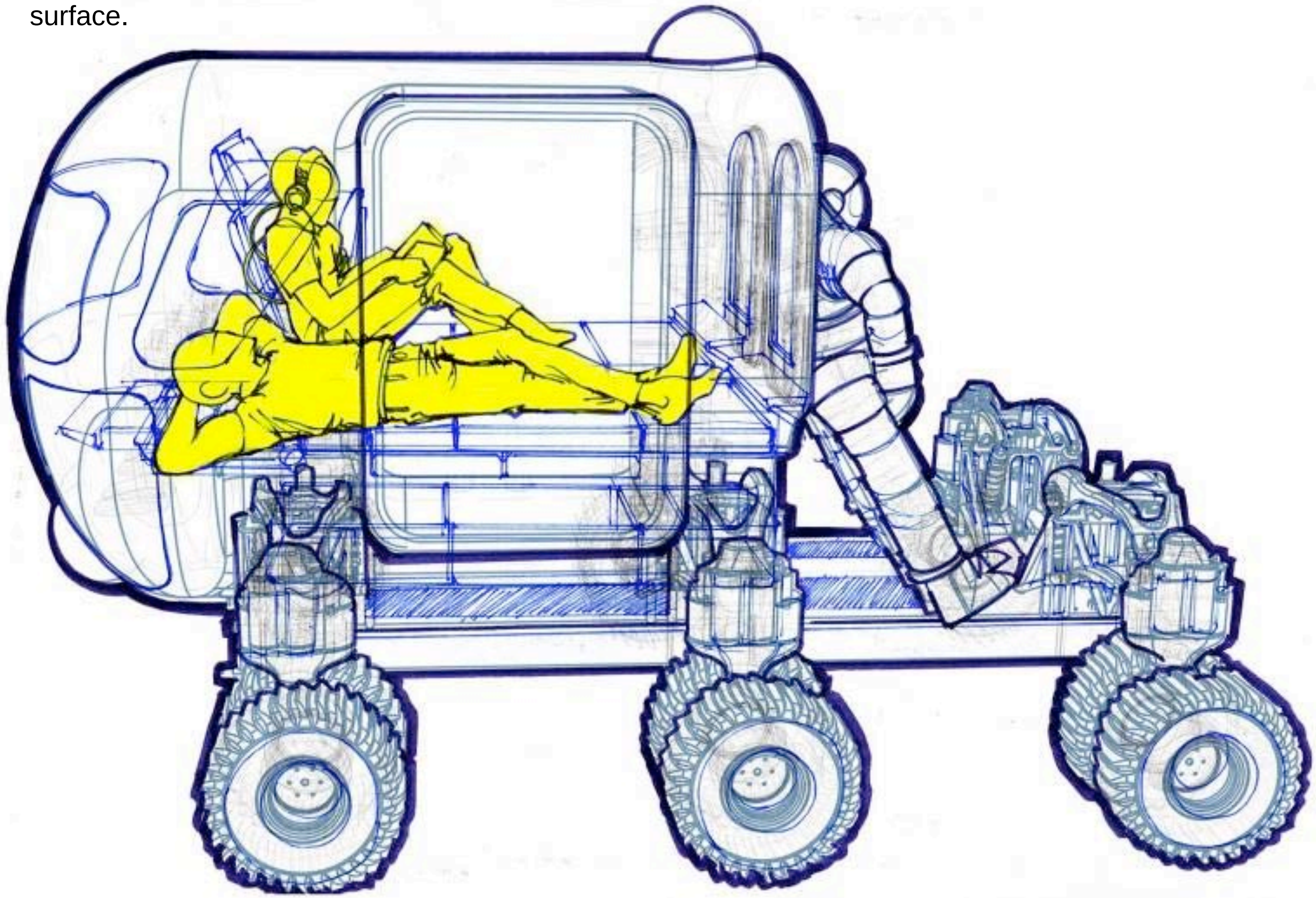
Page 19 illustration: posture - waste, hygiene

Transparent side view of small pressurized rover showing one person seated on the toilet which is positioned between the two couches at the rear of the cabin with a retractable screen for privacy.

SPR Interior Concepts

Seating adjusts for use in both directions and flips completely flat for a long, even sleeping surface.

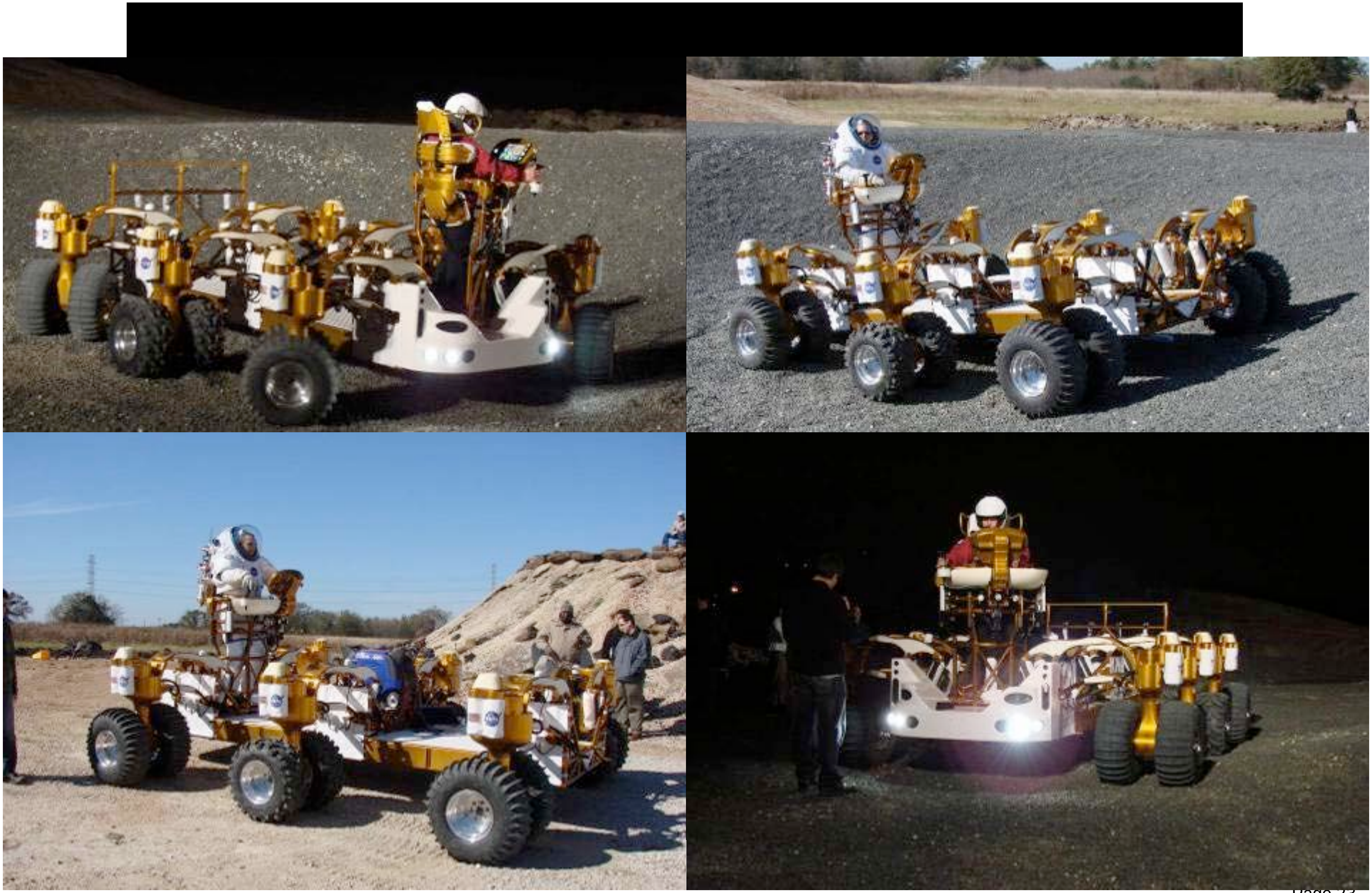
POSTURE – SLEEP/ RELAXATION



Page 21 illustration: Posture - Sleep, Relaxation

Transparent side view of small pressurized rover showing two people reclining. Seating adjusts for use in both directions and flips completely flat for a long, even sleeping surface.

Mobility Chassis



Page 23 Mobility Chassis Photo

Four views of prototype rover chassis with driver operating the unit chariot style in simulated lunar environment showing 6 wheels which can be independently steered to allow maneuvering in complex terrain, lights for visibility in darkness

October Field Test Objectives

- **Simulation of CxAT_Lunar EVA reference science sorties with SPRs and Unpressurized Rovers**
  - Crew Performance Metrics e.g. Time-in-suits, boots-on-surface
  - Science Return Metrics
- **Evaluation of window placement options for optimal visibility**
- **Evaluation of single person EVA operations (one EVA astronaut with a second astronaut providing support from inside SPR)**
- **Evaluation of a 3 day sortie**
- **Simulation of a Solar Particle Event**
- **Simulation of a suit malfunction**
- **Evaluation of incapacitated crewmember recovery**

DRAFT RECOMMENDATION (1 of 3)

Background

The presentation on the Small Pressurized Rover (SPR) by astronaut and project manager Michael Gerhardt was very impressive in terms of the innovative thinking that has been associated with the development of the SPR concept. The Committee recognizes that the SPR concept is one of the options being examined to provide surface mobility in the initial stages of lunar exploration. Whatever option is pursued, it will be a central and very visible feature of the earliest lunar missions. It is the Committee's judgment that this capability should be provided by the United States.

DRAFT RECOMMENDATION (2 of 3)

Recommendation

NASA should amend its list of U.S.-provided lunar architecture elements to include initial surface mobility, since such surface mobility is an extension of the transportation elements that the United States has already indicated its intent toprovide. This is consistent with the extant policy of providing U.S. Space Transportation for Exploration of the Moon.

DRAFT RECOMMENDATION (3 of 3)

Rationale

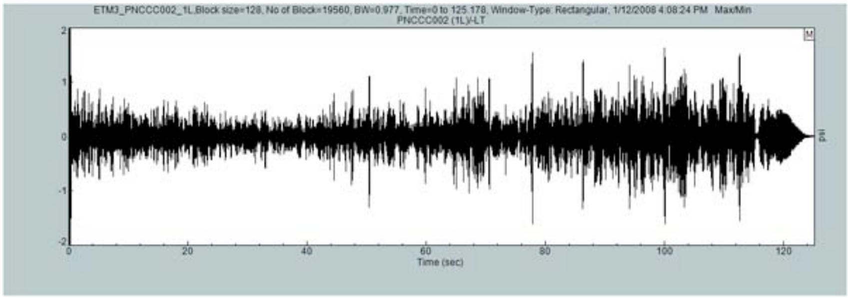
The United States has communicated to potential international partners that it will develop the transportation system to bring crew and cargo to the surface of the Moon. It would seem incomplete to transport crews to the lunar surface without also providing the mobility necessary to identify suitable locations for outpost build-up and otherwise conduct initial exploratory activities. Without this initial mobility element, the space transportation capabilities are truncated. In addition, the surface mobility systems will be a focus of intense public attention and global visibility. It is in the U.S. interest that they be clearly identified as U.S.-provided elements of the lunar architecture to be delivered on a schedule that is compatible with the first U.S. missions. This ensures that fully successful round-trip missions can be successfully accomplished but does not necessarily imply that the U.S. would object to parallel development by international partners of complementary capabilities.

Thrust Oscillation Focus Team Checkpoint Report
Don Fraser

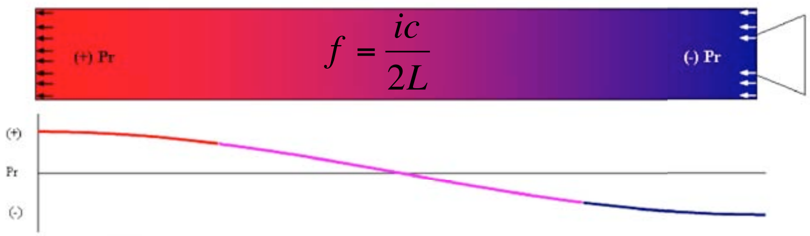
NASA Presenter: Michael Gernhardt

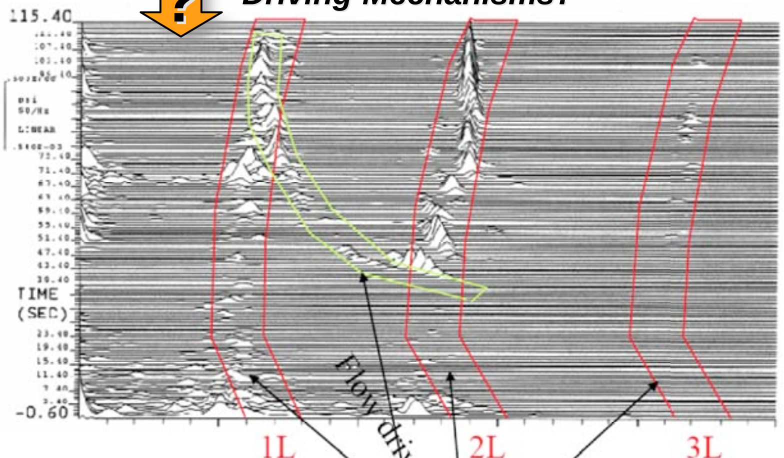
Motor Test Data -> Forcing Function -> Structural Response

Motor Test Pressure



Acoustic Modes





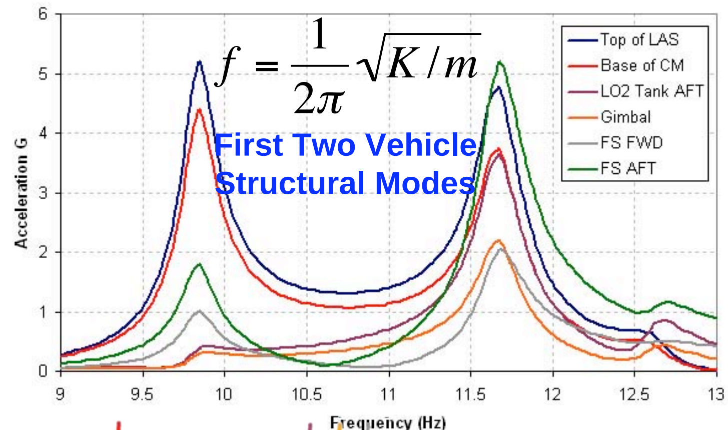
Driving Mechanisms?

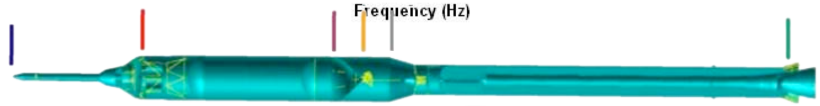
Acoustic Modes (1L-3L)

Data Distribution? Dispersions?

Population Anomalies? 4 to 5-segment Conversion?

Structural Response

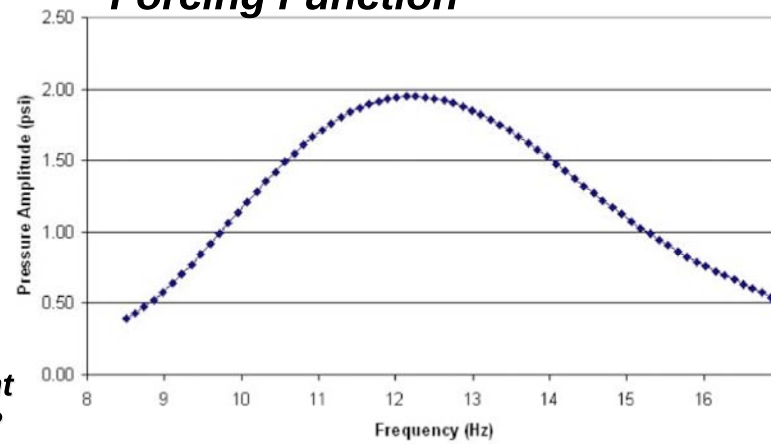




Pressure to Thrust Conversion? Transfer Function? Dynamic Uncertainty? Damping Factor?

110-120 s 1L = 12.14 Hz

Forcing Function



Page 30 graphic: Motor Test Data -> Forcing Function -> Structural Response

4 graphics showing Motor Test Pressure data, Acoustic Modes, a graph of the distribution of data with frequency (Hz) on the x-axis and pressure amplitude (psi) on the y-axis showing a bell shaped curve, and a graph of the Structural Responses along the length of the CLV with frequency (Hz) on the x-axis and acceleration (G) on the y-axis demonstrating two peaks with one below the Orion capsule and one toward the middle of the solid rocket motor.

TOFT Charter

Charter a Thrust Oscillation Focus Team (TOFT) to:

- Review the forcing functions, models and analysis results to verify the current predicted dynamic responses of the integrated stack
- Identify and assess options to reduce predicted responses
- Validate and quantify the risk to the Ares I vehicle, Orion spacecraft, crew, and other sensitive subsystems and components to the extent allowed by the Ares I/Orion design maturity
- Establish and prioritize mitigation strategies and establish mitigation plans consistent with the CxP integrated schedule

The TOFT will deliver the above assessment no later than the March CxP PDR Checkpoint and provide weekly status updates.

The TOFT membership will consist of centers discipline engineering, Ares and Orion systems engineering, Vehicle Integration, the NESC, Aerospace Corporation, ATK, and identified national discipline experts

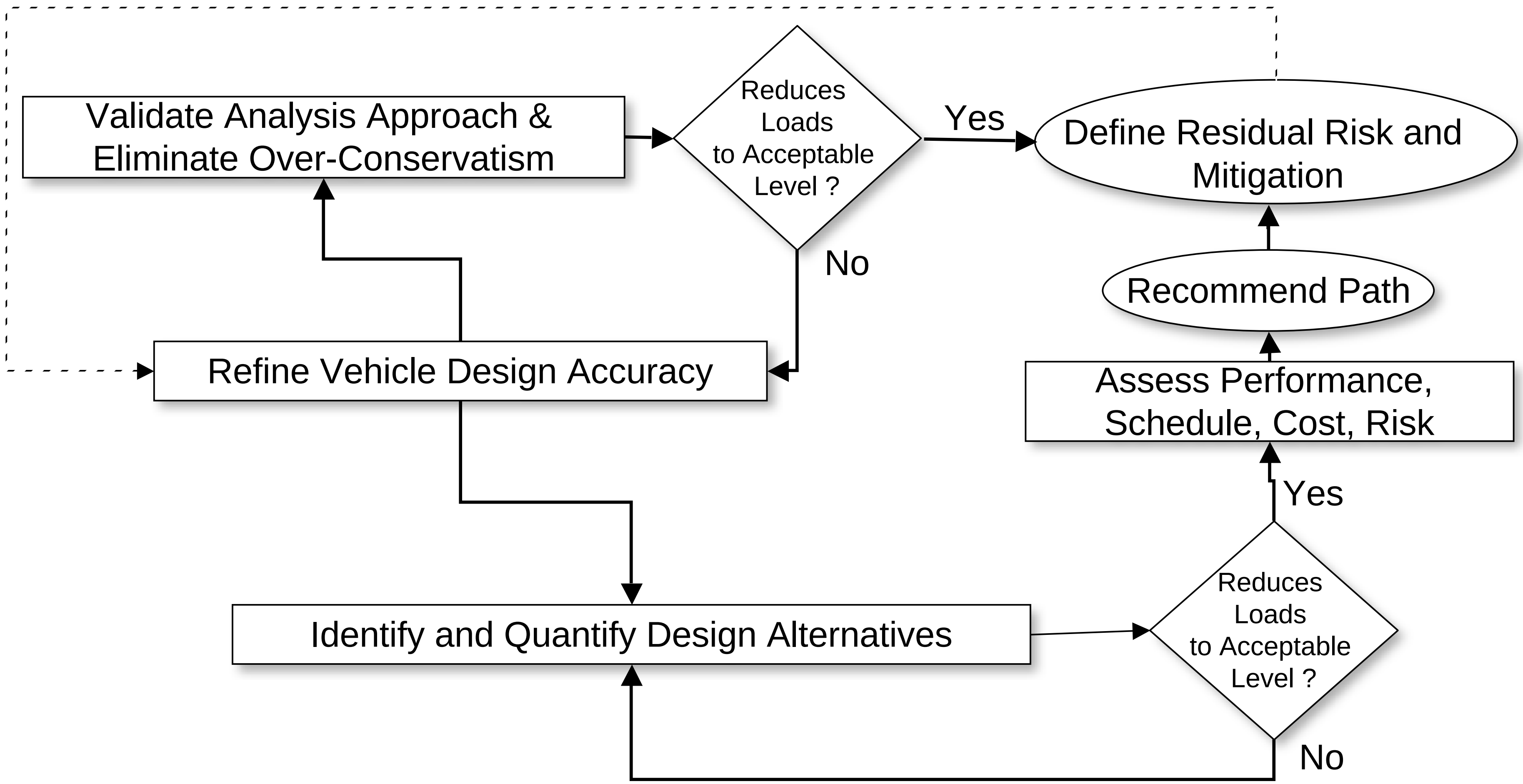
The TOFT will conduct a kickoff TIM on 15 and 16 November to review current analyses and historical data and to develop a detailed forward plan for concurrence by the PSE and Ares Project

Thrust Oscillation Focus Team
Team Membership

Leads - Garry Lyles / Eli Rayos (ILSM SIG)
Chief Engineer's Office - Leslie Curtis
Vehicle Loads Analysis- Jeff Peck / Isam Yunis / Pravin Aggarwal
Vehicle Controls Analysis - Steve Ryan
Motor Analysis - Tom Nesman / Jonathan Jones / Dan Dorney / Jeremy Kenny / ATK Engineering (Tyler Nester / Terry Boardman)
Ares Vehicle Systems Integration - Rob Berry (Element Integration Lead)/ Bob Werka (Global Mitigation Lead)/ Belinda Wright / James Sherrard
Orion Systems Engineering - Chuck Dingle / Corey Brooker / Thomas Cressman (SM) / John Stadler (LAS) / Tom Goodnight (SM) / Keith Schlagel (LM)
Ares Systems Engineering - Joe Matus (US) / Rick Ballard (USE) / Wendy Cruit (FS)
Safety and Mission Assurance - Ho Jun Lee / Chris Cianciola
Crew and Human Factors - Phil Root / Bernard Adelstein

NESC Structures and Dynamics Team - Curt Larsen / Alden Mackey
NESC Consultants - Scott Horowitz / Gloyer-Taylor Labs (Paul Gloyer, Tim Lewis, Gary Flandro, Fred Culick, Vigor Yang)
Independent Structural Dynamics Discipline Experts - Hal Doiron / Bob Ryan / Luke Schutzenhofer / George Zupp / Ken Smith / Jim Kaminski / Jim Blair / George James
Boeing - Ted Bartkowicz / Steve Tomkies
Shuttle Booster Project Engineering - Mike Murphy / Steve Ricks / Sam Ortega
Aerospace Corporation - John Skratt / Kirk Dotson , et al
Pratt and Whitney Rocketdyne - Tom Kmiec / Steve Mercer

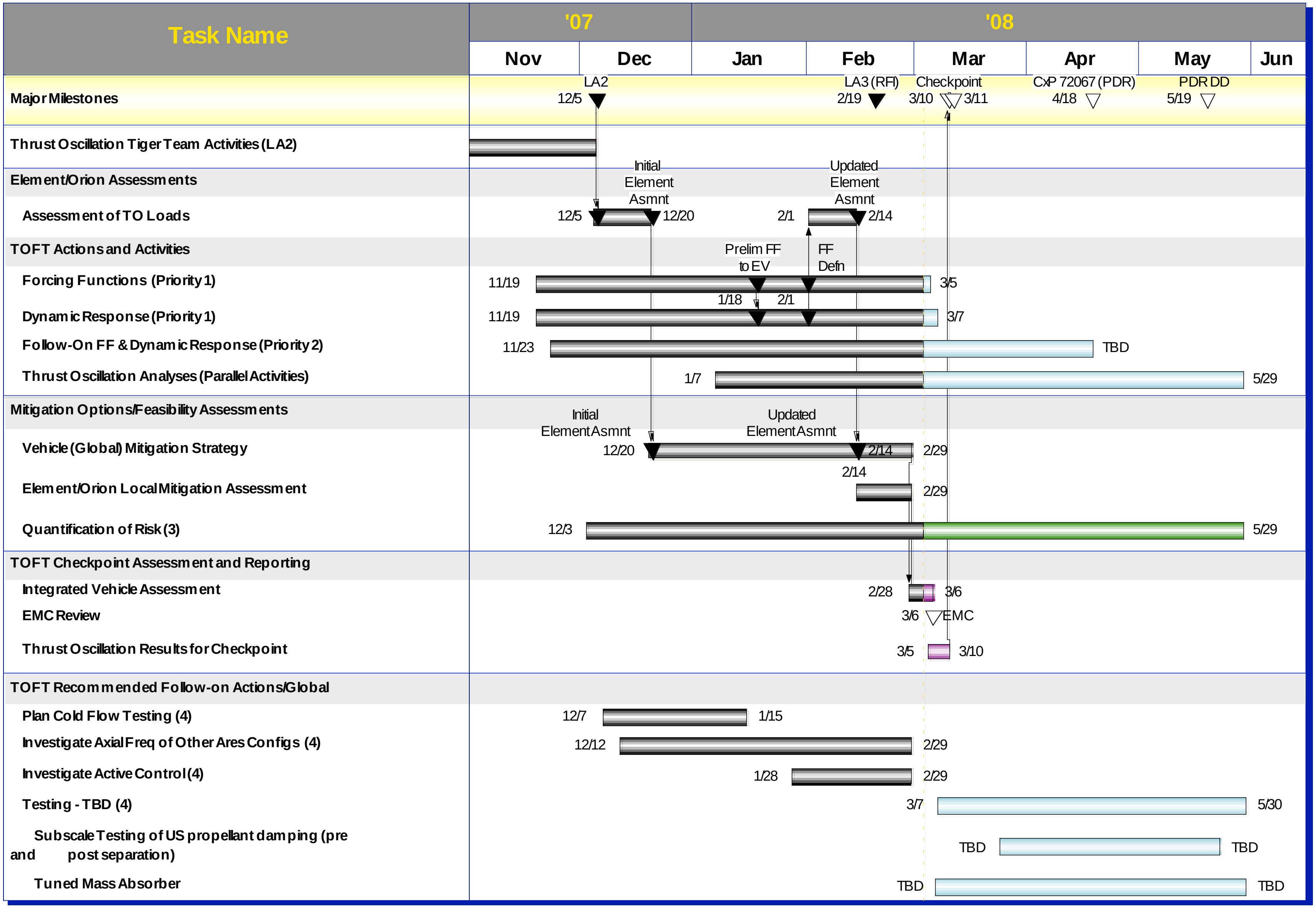
Roadmap



Validate Analysis Approach & Eliminate Over-Conservatism
Reduces Loads to Acceptable Level ?
Yes
Define Residual Risk and Mitigation
No
Recommend Path
Refine Vehicle Design Accuracy
Assess Performance, Schedule, Cost, Risk
Yes
Identify and Quantify Design Alternatives
Reduces Loads to Acceptable Level ?
No

Thrust Oscillation

Page 1 3/3/08



Page 35 Schedule

The graphic is the schedule for the Thrust Oscillation Study Team activities all of which are on target for a May 29, 2008 completion.

Status

Six potential solutions have been identified.

These fall into two categories:

- Modifications to engine
- Isolating stack from engine oscillation

Exploration Committee Findings

Thrust oscillation has been an issue in other projects.

The Ares Thrust Oscillation Team has professionally addressed this issue.

There is a high likelihood that one or more of the identified solutions will work.

The team utilized the full depth of NASA's capability including advanced CFD tools and Ames supercomputing center. In addition to enhancing understanding of this issue the result has been an advance in large solid rocket motor design tools.

Standards for Crew Habitability and Environmental Health

ad hoc Biomedical Committee
Dr. David Longnecker

April 17, 2008

NASA Presenter: Dr. Jeffrey R. Davis
Director
Space Life Sciences Directorate

PURPOSE

Since 1987, NASA-STD-3000 has been the NASA human engineering standard.

The NASA Chief Health and Medical Officer directed that crew health standards be established to:

- drive future vehicle design and operations requirements
- aid in decision making during space missions

APPROACH

Develop Space Flight Human System Standards **(SFHSS), a new Agency-level crew health and habitability standard:**

Volume 1 - Crew Health (CV, respiratory, fitness, etc.)

Volume 2 - Habitability and Environmental Health (habitability, environmental, and human factors)

Create Human Integration Design Handbook **(HIDH) to include updated design considerations, knowledge base and lessons learned, including examples.**

These documents will guide the derivation of program-specific requirements.

Schedule: Submit to OCHMO and NASA Technical Standards Program Office for NASA-wide review by 10/08

Space Flight Human System Standard – Vol 2

Atmosphere Quality Requirements

The vehicle/habitat atmosphere shall meet the quality reqmts specified in current NASA Spacecraft Maximum Allowable Concentration (SMAC) tables …

Human Integration Design Handbook

Chapter on atmosphere

- **Design Considerations**
- **Lessons Learned**
- **Example Applications**
- **Pointer to SMAC Tables**

Constellation Program Human System Integration Requirements

Section on atmosphere

SMAC Tables referenced as a requirement for Constellation vehicles and habitats

Example

SFHH- Standards

"The vehicle atmosphere including pressure, humidity, temperature…shall be controlled in a manner that yields a healthy, comfortable environment for the crew"

HIDH – Data, Guidance, Lessons Learned

- **Data on temperature effects on human health and performance**
- **Guidance for limits and implementation based upon expertise, lessons leaned**

HSIR – Requirements

"The vehicle shall maintain the atmospheric temperature within the range of 18ºC (64.4ºF) to 27ºC(80.6ºF) during all nominal flight operations"

COMMITTEE OBSERVATIONS

The *Standards to Requirements* approach is necessary and appropriate to assure proper consideration of Human Factors in the design process for new exploration-class vehicles.

The development of the Human Integration Design Handbook **(HIDH) includes input from a wide variety of stakeholders (including the astronaut office) and external subject experts, including such organizations as NASCAR (protection from high-impact, high-g incidents, etc.)**

The process is appropriate for achieving the desired results.

FORWARD WORK

Follow up briefing from NASA Advanced Capabilities Division re. linkages with the developing Lunar Sciences Institute.

Follow up briefing from NASA Human Research Program and other subject experts regarding hazards, risks and exposure limits for lunar habitation.

BACKUP INFORMATION

Table of Contents

Chapters

Chapters & Sections match SFHSS

HIDH Topic Areas

HUMAN PERFORMANCE CAPABILITIES
- PERCEPTUAL AND COGNITIVE CAPABILITIES
- ORGANIZATIONAL BEHAVIOR
- TRAINING
- WORKLOAD

NATURAL AND INDUCED ENVIRONMENTS
- GENERAL ENVIRONMENT
- INTERNAL ATMOSPHERE
- WATER
- CONTAMINATION
- ACCELERATION
- ACOUSTICS
- VIBRATION
- IONIZING RADIATION
- NON-IONIZING RADIATION

ARCHITECTURE
- OVERALL ARCHITECTURAL DESIGN
- LOCATION AIDS
- TRAFFIC FLOW AND TRANSLATION PATHS
- HATCHES
- WINDOWS
- LIGHTING
- PERSONAL HYGIENE
- BODY WASTE MANAGEMENT
- FOOD
- CREW QUARTERS
- TRASH MANAGEMENT
- STOWAGE
- EXERCISE COUNTERMEAURES
- MEDICAL

ANTHROPOMETRY AND BIOMECHANICS

USER INTERFACES
- GENERAL
- LAYOUT OF DISPLAYS AND CONTROLS
- DISPLAYS
- CONTROLS
- LABELS
- COMMUNICATION SYSTEMS

HARDWARE AND EQUIPMENT
- GENERAL
- MOBILITY AIDS AND RESTRAINTS
- CLOTHING
- CABLES

FACILITY MANAGEMENT
- HOUSEKEEPING
- MAINTAINABILITY
- INVENTORY CONTROL

INFORMATION MANAGEMENT

EXTRAVEHICULAR ACTIVITY (EVA)
- EVA SAFETY DESIGN
- EVA PHYSIOLOGICAL DESIGN
- EVA WORKLOAD DESIGN
- DECOMPRESSION DESIGN
- EVA VISION DESIGN
- EVA CONTROLS
- SUITED ANTHROPOMETRY
- WORK SYSTEMS DESIGN

HOW VOLUME 2 WILL BE USED

Volume 2 is:

- A set of global principles viewed as authorizing statements applicable to all human spaceflight programs
- Flexible and "durable" and less likely to be outdated by new technologies
- A set of standards and not specific design solutions
- Shorter and more user-friendly (at management level)
- Accompanied by a design handbook (FY07) that serves as a detailed guide for implementation of the standard.

Schedule

HIDH Development and Internal Reviews

3/08 – 8/08

HRP CB Review/SLSD Approval

9/08

Submit to OCHMO and NASA Technical Standards Program Office for NASA-wide review

10/08

SUMMARY

The Space Flight Human Systems Standard (SFHSS) has been developed in response to an OCHMO directive and NASA need.

- drive future vehicle design and operations requirements
- aid in decision making during space missions
- provide Agency-level authorizing statements to guide the derivation of future program-specific requirements

Vol 2 of the SFHSS, Habitability and Human Factors, and the accompanying design handbook cover a wide range of environmental and human factors topics previously contained in NASA-STD-3000.

The Vol 2 development process

- was reviewed and approved by the NASA and JSC Chief Medical Officers before the project was initiated
- included participation by JSC and ARC subject matter experts in medical, biomedical, environmental, human factors, and engineering disciplines

The Feb 2007 version of Vol 2 has been reviewed and approved by a joint medical-human factors JSC control board, the JSC Chief Medical Officer, and review by the Aerospace Medicine Board.