



Human Exploration Systems and Mobility Capability Roadmap Progress Review

**Chris Culbert, NASA Chair
Jeff Taylor, External Chair
March 29, 2005**



Agenda



- **Capability Roadmap Team**
- **Capability Description and Capability Breakdown Structure**
- **Benefits of the Human Systems and Mobility Capability**
- **Roadmap Process and Approach**
- **Drivers and Assumptions for the whole team**
 - **Current State-of-the-Art, Assumptions and Requirements will be covered in the appropriate sections**
- **Capability Presentations by Leads under Roadmap (Repeated for each capability under roadmap)**
 - **Capability Description, Benefits, Current State-of-the-Art**
 - **Capability Requirements and Assumptions**
 - **Roadmap for Capability**
 - **Capability Readiness Level**
 - **Technology Readiness Level**
 - **Figures of Merit**
- **Summary of Top Level Capability**
- **Significant Technical Challenges**
- **Summary and Forward Work**



Human Exploration Systems and Mobility Capability Roadmap Team



Co-Chairs

- NASA: Chris Culbert, NASA/JSC
- External: Jeff Taylor, University of Hawaii

Team Members

– Government

Ken Baker, NASA/JSC
John Dorsey, NASA/LaRC
Rick Eckelkamp, NASA/JSC
David Kohrsmeyer, NASA/ARC
Dennis Lawler, NASA/JSC
Wendell Mendell, NASA/JSC
Rud Moe, NASA/GSFC
Jeff Patrick, NASA/JSC
June Zakrajsek, NASA/GRC
Wayne Zimmerman, NASA/JPL

– Academia/Industry

David Adlis, Aerospace Corp.
Jim Blacic, Los Alamos Labs
David Carrier, Bromwell & Carrier
Wendell Chun, Lockheed Martin
Mark Henley, Boeing
Jud Heddecock, Oceanering
Larry Taylor, Univ. of Tennessee
Robert Yowell, Aerospace Corp.

Coordinators

Directorate: Betsy Park and Doug Craig, NASA/HQ/ESMD
APIO: Tom Inman, NASA/MSFC



9.0 Capability Description



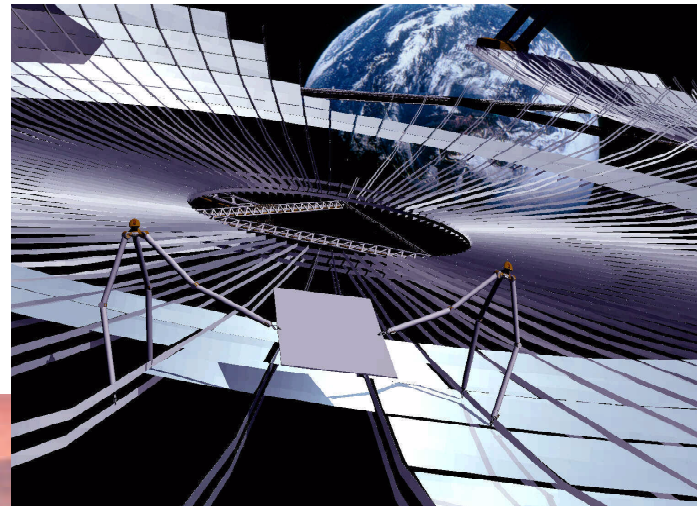
Supports human exploration activities in space and on planetary surfaces. Includes a wide range of capabilities to allow scientific observations, instrument deployment, and resource exploration. Divided into four major categories:

9.1 Exploration Activities

9.2 Mobility

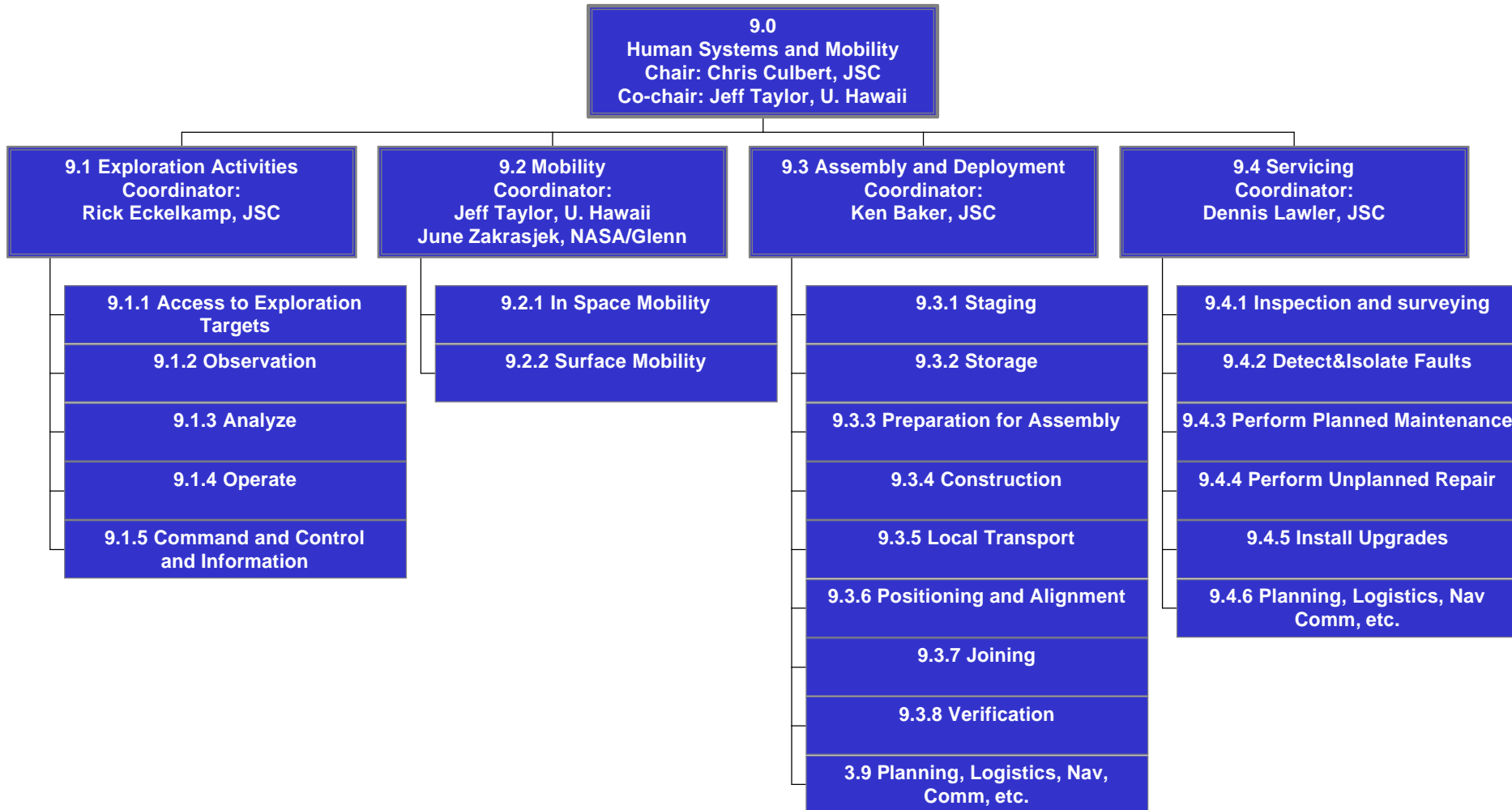
9.3 Assembly and Deployment

9.4 Servicing





Capability Breakdown Structure





Human Exploration systems are required to:

- Support human presence for long-duration spaceflight or missions to planetary surfaces
- Allow deployment of complex scientific instrumentation in space, such as large interferometric telescopes
- Allow installation of instrumentation and sophisticated scientific facilities on planetary surfaces
- Enhance human access to scientific targets on planetary surfaces
- Provide global access on the Moon, Mars, and other planetary bodies
- Enhance human-robot partnerships to make the most efficient and effective use of each



Roadmap Process and Approach



- **Team members chosen to represent wide range of expertise and experience (including Apollo experience) for this broad topic**
- **Devise CBS and choose working groups through a series of telecons, email exchanges, and meetings**
- **Details of subcapabilities fleshed out by working groups, vetted by entire team**
 - Define capabilities and appropriate levels of subcapabilities, their benefits, figures of merit, and estimate of the amount of development needed
 - Assessment of technologies required and when they will be needed
- **Working groups use the above to devise roadmap for each capability, with review by whole team**
- **Presentation to NRC**
- **Revise plan based on comments**
- **Write detailed capability document**



Requirements / Assumptions for Human Exploration Systems and Mobility



General drivers

Long duration (> 180 day) human presence on the Lunar surface

Short duration (< 180 day) human presence on the Mars surface

Assume reliable access to all 'useful' points in the Earth – Mars area

Gateway type facility on-orbit for Moon (assembly, refueling, staging, etc.)

Infrastructure rich locations on the surface with 'sorties' going out from them

Power readily available (100s of KW available to bases)

Thermal control, heat rejection technologies considered by other teams

Communications – very high bandwidth will be provided at least locally

Human safety considerations are critical; systems will be fault tolerant

Human productivity/efficiency considerations – no more than 25% of human time spent on routine maintenance & housekeeping

Systems are capable of at least supervised autonomy



Requirements /Assumptions for Human Exploration Systems and Mobility



General drivers (cont'd)

Radiation shielding provided for normal environment & solar flares.
Environment protection also provided for:

- Dust

- Meteorites/orbital debris

- Secondary ejecta

- Electric fields on the moon

Locally information rich and information accessible

Local science analysis capability is necessary and some sample return is still necessary

Assume design for modularity, assembly and maintenance will be used and standards developed for broad application and commonality

Payload size and mass will not significantly change over the next 20 – 25 years. In other words, we won't have a 100 metric ton lift vehicle with significantly larger shroud size than today's launch options.



Assumptions on Dates



Date Assumptions

- In the absence of specific mission definitions, the team reviewed existing material on the Vision for Space Exploration and the Spiral development models and defined a rough outline of dates (below) for development needs.

	Beyond LEO	Moon	Mars
Initial Presence			
Robotic Precursors	2008-2015	2008-2015	2012-2022
Initial Human Presence		2015-2020	2022-2030
Infrastructure Operational Deployment			
In Space	2015-2025		
Surface		2012-2020	2020-2025
Long Duration Human Presence			
Exploration Sorties		2015-2030	
ISRU Production	2020-2030	2017-2030	2020-2030
Facility Operation and Maintenance	2020-2030	2020-2030	



Significant Technical Challenges



Key technical challenges:

- We will summarize the most significant technical challenges, across all of the technical areas.



Do the Capability Roadmaps have connection points to each other when appropriate?



- **Have not done much work in this area yet, and won't really address until after the NRC discussion.**



Summary/ Forward Work



- **Make changes to roadmaps based on verbal feedback from NRC review**
- **Consider overlap with other Capability Roadmap teams and eliminate duplication**
- **Receive the draft Strategic Roadmaps**
- **Review and Assess all applicable Strategic Roadmaps and their requirements for Human Exploration Systems**
- **Make changes to Human Exploration Systems roadmaps to ensure consistency with Strategic Roadmaps requirements**
- **Develop rough order of magnitude cost estimates for the Human Exploration Systems Roadmap**
- **Prepare for 2nd NRC Review which will address 4 additional questions:**
 - **Are there any important gaps in the capability roadmaps as related to the strategic roadmap set?**
 - **Do the capability roadmaps articulate a clear sense of priorities among various elements?**
 - **Are the capability roadmaps clearly linked to the strategic roadmaps, and do the capability roadmaps reflect the priorities set out in the strategic roadmaps?**
 - **Is the timing for the availability of a capability synchronized with the scheduled need in the associated strategic roadmap?**