Johnson Space Center Engineering Directorate

L-8: Enabling Human Spaceflight Exploration Systems & Technology Development

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NASA’s Journey to Mars

Body of Previous Architectures, Design Reference Missions, Emerging Studies and New Discoveries

- Internal NASA and other Government
- International Partners
- Commercial and Industrial
- Academic
- Technology developments
- Science discoveries

2010 Authorization Act, National Space Policy, NASA Strategic Plan

- Establish capacity for people to live and work in space indefinitely
- Expand human presence into the solar system and to the surface of Mars

Evolvable Mars Campaign

Human Exploration
NASA’s Journey to Mars

Earth Reliant
Mission: 6 to 12 months
Return to Earth: Hours

Proving Ground
Mission: 1 to 12 months
Return to Earth: Days

Earth Independent
Mission: 2 to 3 years
Return to Earth: Months

- Mastering fundamentals aboard the International Space Station
- Expanding capabilities by visiting an asteroid restricted to a lunar distant retrograde orbit
- U.S. companies provide access to low-Earth orbit
- The next step: traveling beyond low-Earth orbit with the Space Launch System rocket and Orion spacecraft
- Developing planetary independence by exploiting Mars, its moons and other deep space destinations

www.nasa.gov
Engineering Priorities

1. Enhance ISS: Enhanced missions and systems reliability per ISS customer needs
2. Accelerate Orion: Safe, successful, affordable, and ahead of schedule
3. Enable commercial crew success
4. Human Spaceflight (HSF) exploration systems development
   - Technology required to enable exploration beyond LEO
   - System and subsystem development for beyond LEO HSF exploration
• Priorities are nice, but they are not enough.
• We needed a meaningful goal.
• We needed a deadline.

• Our Goal: Get within 8 years of launching humans to Mars (L-8) by 2025
  • Develop and mature the technologies and systems needed
  • Develop and mature the personnel needed
Characterizing L-8

L-8 Is Not:
- A program to go to Mars
- Another Technology Road-Mapping effort

L-8 Is:
- A way to translate Agency Technology Roadmaps and Architectures/Scenarios into a meaningful path for JSC Engineering to follow.
- A way of focusing Engineering’s efforts and identifying our dependencies
- A way to ensure Engineering personnel are ready to step up to the plate when the next program is defined
- A framework supplying rationale for our proposals to obtain funding for technology development
- An organizing principle for our Domain Implementation Plans
JSC Engineering’s Domain Implementation Plan

- Life Support
- Active Thermal Control
- EVA
- Habitation Systems

- Human System Interfaces
- Wireless & Communication Systems
- Command & Data Handling
- Radiation & EEE Parts

- Lightweight Habitable Spacecraft
- Entry, Descent, & Landing
- Autonomous Rendezvous & Docking
- Vehicle Environments

- Entry, Descent, & Landing
- Autonomous Rendezvous & Docking
- Deep Space GN&C

- Reliable Pyrotechnics
- Integrated Propulsion, Power, & ISRU
- Energy Storage & Distribution
- Breakthrough Power & Propulsion

- Crew Exercise
- Simulation
- Autonomy
- Software
- Robotics
Avionics Systems Domain Implementation
Plan Decomposition Example

Areas of Emphasis (AOEs):
- RFID ALM
- RFID Sensing
- Delay Tolerant Networking (DTN)
- Mesh Networking
- Wireless Development Flight Instrumentation
- Proximity Communications
- Reconfigurable/Software defined radio
- Innovations for C&T testing and validation
- Innovative applications of RF technology
- Proximity antenna technologies
- Optical Communication

Pathstones:
- RF Interrogator development
- Fabric antenna development
- System integration and modularization

A SpaceCom 2016 Collaboration Opportunity
“L-8: RFID technology and sensor interrogators for wireless sensing/telemetry”
– Ray Wagner
FY 2016 IRAD Investments Tied to L-8

**Integrated L-8 Systems & Projects**

- **Avionic Systems**
  - Shape-Morphing Adaptive Radar Technology (SMART) – L. Erickson
  - Software Graphics Processing Unit (sGPU): Solving the Visual Display Problem for BEO Missions – McCabe
- **Crew and Thermal Systems**
  - ISS Capillary Development (CapDev) Test Bed – Sargusingh
  - The Modular Wearable Architecture: Lowering the Human-System Barrier – Simon
  - Novel Passive Thermal Technology In-Flight Demonstration – Alvarez-Hernandez
- **Aeroscience and Flight Mechanics**
  - ISS Capillary Development (CapDev) Test Bed – Sargusingh
  - The Modular Wearable Architecture: Lowering the Human-System Barrier – Simon
  - Novel Passive Thermal Technology In-Flight Demonstration – Alvarez-Hernandez
- **Propulsion and Power**
  - Integrated Lox/LCH4: A Unifying Technology for Future Exploration (Phase II Work) – B. Banker
  - Solid State Thermionics Power – J. George
  - Regenerative Gas Dryer for Integrates ISRU Systems – A. Paz
  - LOX/LCH4 Propulsion Test in Space Environment – Morehead
  - Q-Thruster Work
- **Structural Engineering**
  - Integrated Lox/LCH4: A Unifying Technology for Future Exploration (Phase II Work) – B. Banker
  - Solid State Thermionics Power – J. George
  - Regenerative Gas Dryer for Integrates ISRU Systems – A. Paz
  - LOX/LCH4 Propulsion Test in Space Environment – Morehead
  - Q-Thruster Work
- **Software, Robotics and Simulation**
  - Visual Odometry for Autonomous Deep-Space Navigation – Robinson
  - Advanced Analytic Tools & Capabilities for Aerosciences – Kirk
  - Mid L/D Mars EDL Pathfinder – Campbell
  - MED-2 Exercise Device Operations – Zumbado
  - CFS: Human Spaceflight Product Line – Prokop
  - HESTIA Sim Support – Bielski
- **Parachute Canopy Instrumentation Package** – Alshahin
- **Orion Avcoat Material Heat Shield Flight Test** – Salazar
- **Integrated Lox/LCH4: A Unifying Technology for Future Exploration (Phase II Work)** – B. Banker
- **Solid State Thermionics Power** – J. George
- **Regenerative Gas Dryer for Integrates ISRU Systems** – A. Paz
- **LOX/LCH4 Propulsion Test in Space Environment** – Morehead
- **Q-Thruster Work**
FY 2017 IRAD Investments Tied to L-8

JSC Engineering: HSF Exploration Systems Development

Shape-Morphing Adaptive Radar Technology (SMART) II – Erickson
Laser Processed Heat Exchangers - Hansen
A Low Power, Solid State, Method of Oxygen Supply - Graf

Magnetic Radiation Shielding for Human Space Exploration - Arndt

Orion Heat Shield Spectrometer – Holland
Entry Vehicle (Dragon) On Demand Instrumentation - Wells & Bouslog
Charring Ablator Response (CHAR) Sublimation - Remark
Aluminum Orbital Arc Weld Development - Luna
Inflatable Airlock EVA Interface - Litteken

Pulsar Navigation for Crewed Exploration of the Solar System - D’Souza
Mid-L/D Ballistic Range Aerodynamics Test - Sostaric
Retiring the Side Wall Rupture Risk with Li-Ion – Darcy
SMR/SOFC System Integration for LOx/LCH4/ISRU – Mwara
Cubesat Q-Thruster Technology for Exploration – White
Flat H Redundant Frangible Joint (RFJ) - Brown
Augmented Reality Authoring Tool - Wang
Fatigue Reduction and Dexterity Improvements via Space Suit Glove Grasp Strength Augmentation - Rogers
Core Flight Software (CFS) Human Spaceflight Product Line (CITO) - Prokop
Integrated System Demonstration for Spacecraft Autonomy (Basics) - Badger
### Potential Collaborations with Academia

#### JSC Engineering: HSF Exploration Systems Development

**CO2 Removal, CO2 Reduction**
- Trace Contaminant Control, Particulate Filtration
- Reliable Brine Water Recovery (Low Volume)
- Air Monitoring Techniques/Strategies
- Variable Heat Rejection Technologies/Trades
- Lightweight Bio-resistant CHX
- Advanced Phase Change Materials
- In-Situ Thermal Fluids Chemical Analysis
- Solvent Generation for Reusable Wipes
- Antimicrobial Omniphobic Surface Coatings

**Speech Recognition Evaluation**
- Natural Language Processing
- Acoustic Echo Cancellation Algorithms (e.g., in a spacesuit)
- Wearable Technologies
- Power Scavenging Sensors
- Mesh Network Implementations
- RF over IP for testing
- E-textile & 3D-printed antennas
- Advanced manufacturing techniques for Sparing of Electronics

**Additive Manufactured Lattice Core Designs**
- Thin Ply Composites
- Inflatable materials Creep characterization
- Impact & Leak Detection for Inflatables
- Acrylic & Ceramic Window Development & Characterization
- Integrated Thermoelastic Design/Analysis Methods for Heatshields

**Integrated Thermoelastic Design/Analysis Methods for Heatshields**

**Wind Tunnel Tests for Supersonic Retro Propulsion & Mid-L/D Re-entry bodies**
- Large Mass Mars Entry Trades
- Autonomous Landing
- Hazard Avoidance Algorithms
- Optical Tracking and Navigation


**Autonomous Grasping**
- Humanoid Walking
- Integrated Dynamic Systems Simulation
- Trick-based Software Simulation Enhancements
- Rover/Mars Ascent Vehicle Cabin Design Integration
- Augmented Reality Research & Applications
- Autonomy Tools (Robotics Planning, Flight Director In a Box)
Advanced Concepts for O2 Concentration and storage – Graf

Space Environments Test Capability / James Webb Space Telescope (JWST) – Holman

Non-Venting Thermal Control Systems for Space Vehicles – Smith & Massina

RFID technology and sensor interrogators to develop low cost sensor suites - Wagner

Docking Systems and other Attachment/Release mechanisms and related technologies – Lewis

Modeling the integration of hardware and software systems of spacecraft using tools such as SysML - Carrejo

Entry Descent and Landing at Mars - Sostaric

Aeroscience and Flight Mechanics

Propulsion and Power

Software, Robotics and Simulation

Structural Engineering

Avionic Systems

Crew and Thermal Systems

Integrated Systems & Projects

In Situ Resource Utilization (ISRU) Capabilities – Sanders

NDE Methods for Ultimately Reliable Pyrotechnics – Scott & Hinkel

Safe Li-Ion batteries – Darcy & Scott

Spacecraft Autonomy – Badger

Advanced Vehicle Mobility – Junkin

Optimizing Virtual Reality and Tracking Systems for Zero-G Space Environments - Paddock

Using Human-Machine Interactions to Enhance Astronaut Performance and Adaptation in Reduced Gravity Environments - Burkhart

Entry Descent and Landing at Mars - Condon
• Our L-8 efforts have identified a lot of problems to be solved before we can go to Mars, and we need partnerships to help solve them.

• Partnerships with NASA JSC can take many forms:
  • Similar Problems, Different Capabilities $\rightarrow$ Technology Collaboration $\rightarrow$ Solution
  • Partner Technology $\rightarrow$ NASA Evaluation/Test $\rightarrow$ Increased Knowledge
  • Partner Need $\rightarrow$ NASA-unique technology/capability/facility $\rightarrow$ Desired Results
  • NASA Technology $\rightarrow$ Partner adapts to terrestrial need $\rightarrow$ NASA harvests improvements
  • Partner Technology $\rightarrow$ NASA Adapts to Spaceflight Needs $\rightarrow$ Partner harvests improvements
We want to ensure that HSF technologies are ready to take Humans to Mars in the 2030s.

Our Goal: Get within 8 years of launching humans to Mars (L-8) by 2025.

We have a number of specific partnership opportunities we’re discussing at SpaceCom 2016.

If you’re interested in one of these, or you have other ideas, let us know at:

https://nasajsc.secure.force.com/ConnectForm