Johnson Space Center Engineering Directorate
L-8: Enabling Human Spaceflight Exploration Systems
& Technology Development

Montgomery Goforth
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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 capability 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
- **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
- U.S. companies provide access to low-Earth orbit
- The next step: traveling beyond low-Earth orbit
- Expanding capabilities by visiting an asteroid restricted to a lunar distant retrograde orbit
- Developing planetary independence by exploring Mars, its moons and other deep space destinations

[www.nasa.gov](http://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

JSC Engineering: HSF Exploration Systems Development

- 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

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

- Crew Exercise
  - Simulation
  - Autonomy
  - Software
  - Robotics

L-8 Systems & Projects

Integrated Avionic Systems

Propulsion and Power

Aeroscience and Flight Mechanics

Software, Robotics, and Simulation

Crew and Thermal Systems

Structural Engineering

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

AA-2 | iPAS | HESTIA | Morpheus
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

JSC Engineering: HSF Exploration Systems Development

- Shape-Morphing Adaptive Radar Technology (SMART) – L. Erickson
- ISS Capillary Development (CapDev) Test Bed - Sargusingh
- The Modular Wearable Architecture: Lowering the Human-System Barrier – Simon
- Software Graphics Processing Unit (sGPU): Solving the Visual Display Problem for BEO Missions – McCabe
- Novel Passive Thermal Technology In-Flight Demonstration – Alvarez-Hernandez
- Parachute Canopy Instrumentation Package - Alshahin
- Orion Avcoat Material Heat Shield Flight Test - Salazar
- Visual Odometry for Autonomous Deep-Space Navigation – Robinson
- Advanced Analytic Tools & Capabilities for Aerosciences – Kirk
- Mid L/D Mars EDL Pathfinder – Campbell

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

MED-2 Exercise Device Operations – Zumbado
- CFS: Human Spaceflight Product Line – Prokop
- HESTIA Sim Support – Bielski
FY 2017 IRAD Investments Tied to L-8

- 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

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

Speech Recognition Evaluation
Natural Language Processing
Acoustic Echo Cancelation 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

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

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

NDE Tools/Methods for Pyros,
LOx/LCH4 Propulsion Systems,
Lunar/Planetary In-Situ Resource Utilization,
“Propellant-less” Thrusters,
Thermionic Energy Conversion,
Non-Maxwellian Plasma Confinement Systems

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

Integrated L-8 Systems & Projects

Crew and Thermal Systems

Propulsion and Power

Software, Robotics, and Simulation

Structural Engineering

Avionic Systems

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

JSC Engineering: HSF Exploration Systems Development

SpaceCom 2016: NASA Challenges & Solutions Pavilion
• 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 → Technology Collaboration → Solution
  • Partner Technology → NASA Evaluation/Test → Increased Knowledge
  • Partner Need → NASA-unique technology/capability/facility → Desired Results
  • NASA Technology → Partner adapts to terrestrial need → NASA harvests improvements
  • Partner Technology → NASA Adapts to Spaceflight Needs → Partner harvests improvements

We Want Your Help!
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