Space Exploration: Technology Drives Innovation For the Benefit of All

Wearable Technology Capabilities and Challenges for Space and Terrestrial Applications

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Building Blocks to Deep Space

**ORION – SPACE LAUNCH SYSTEM – EXPLORATION GROUND SYSTEMS**

While far away, Mars is a goal within our reach. We are closer to sending humans on a journey to Mars than at any point in NASA’s history. We will journey in phases, leveraging our experience on the space station to step out into the Proving Ground—the volume of space around the moon featuring multiple stable staging orbits for future deep space missions.

**Human Missions Beyond Low-Earth Orbit**

Human missions in the lunar vicinity and on the lunar surface would allow international partners to advance the capabilities needed for future Mars missions, while using the presence of the crew to explore the Moon and near-Earth asteroids. Missions to Mars will need reliable transportation, habitation, and other critical capabilities which can be advanced in the lunar vicinity and at the surface of the Moon.
Next Phases for Human Space Exploration

**Now**
Using the International Space Station

**2020s**
Operating in the Lunar Vicinity (proving ground)

**After 2030**
Leaving the Earth-Moon System and Reaching Mars Orbit

**Phase 0**
Continue research and testing on ISS to solve exploration challenges. Evaluate potential for lunar resources. Develop standards.

**Phase 1**

**Phase 2**
Complete Deep Space Transport and conduct yearlong Mars simulation mission.

**Phases 3 and 4**
Begin sustained crew expeditions to Martian system and surface of Mars.
LEADING FUTURE EXPLORATION - To The Moon and Beyond

Industry Sectors Relevant to NASA Technology

- Advanced Manufacturing
- Advanced Technologies
- Energy
- Life Sciences/Human Performance
- Transportation & Logistics
JSC’s Technology Priority Areas

- Autonomy – Robotics – Automated Rendezvous & Docking
- Environmental Control/Life Support Systems
- Space Suits
- Human Class Entry Descent and Landing
- Human System Research and Human System Development
- In-Situ Resource Utilization
- Radiation Protection and Mitigation

The following charts show examples of how wearable technology can support these technology needs
Virtual Reality (VR) and Augmented Reality (AR) systems, i.e. goggles, heads-up displays, robotic gloves, can be used for continuing training, in-situ assembly and repairs, assistance in medical diagnostics, and some immersion therapy for long-term exploration.
Studying astronaut health, for current status and multiple physical effects during long duration missions, is a paramount priority.

CO2 and noise levels are just a few environmental issues that are heavily monitored in both space and terrestrial work.
Suits keep astronauts alive. They are very complex systems and function as a spacecraft. Besides human health, electrical, communication, and environmental monitoring, suits include many types wearable sensors, tactile displays and alternative informatics.

Wearable technology for suits includes the human factor requirements of dexterity and range of motion, comfort and “wearability” of garments, fatigue management and assist, and much more.
Wearable technology includes smart, flexible fabrics and sensors for heat shields. These materials are important for human and craft protection and for studying performance of materials at different temperatures.

Environmental monitoring for entry, descent and landing includes imaging the scene, measuring temperature, weather conditions, radiation levels in-situ.
Crew health and human system research and development are the heart of human space exploration. Physiological research often takes a majority of the science time for crews on orbit.

- Monitoring motion perception and inner ear and balance issues
- Circadian and sleep studies on brain activity
- Physiological research often takes a majority of the science time for crews on orbit.
- Exercise and general work station health is monitored, often using smart watches and wireless or wired sensors.

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➢ In-Situ Resource Utilization (ISRU)

ISRU supports advanced exploration systems and space technology.

Capabilities / Services
• Oxygen, water, and fuel production and waste processing
• Methane regeneration
• Solar energy for oxygen extraction
• Lunar regolith particle separation for further processing
• Regolith excavation and handling
• Habitation and Radiation Shielding
• Dust Mitigation
• Rocket Plume Blast Effects
• Robotics and Tele-Robotics
• COTS analytical instrumentation modification for flight

Augmented and Virtual Reality can be used for in-situ operations.

Smart fabrics, coatings, and additional characteristics can be used for dust mitigation.
Radiation Protection and Mitigation

NASA is evaluating various materials and concepts to shield the crew from galactic cosmic rays (GCRs). Researchers are developing and evaluating shielding concepts for transport vehicles, habitats and spacesuits with state-of-the-art models.

Radiation shielding garment to protect vital organs during space exploration activities.

Bigelow Expandable Activity Module, or BEAM
We are working to enhance protection from solar and cosmic radiation, space debris, and other contaminants.
"’Off the Earth, For the Earth’ offers an stirring title for the framework for America’s space program based on today’s needs and tomorrow’s opportunities. Implementing this framework starts with the full realization of the potential of the International Space Station. It also includes the groundbreaking work taking place at NASA and in commercial and academic research programs around the world to accelerate the pace of technology development. We have been able to solidify the role of commercial providers of cargo and soon, crew, transportation to low Earth orbit.”

- William H. Gerstenmaier
NASA Associate Administrator for Human Exploration and Operations

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At NASA, we have a unique perspective on Earth. Every day, we observe its grandeur from our International Space Station orbiting 250 miles above the planet and capture a wealth of scientific data about how our planet is changing from our fleet of Earth observing satellites.

Space exploration has always created benefits for humankind -- from new technologies and discoveries, to deepening international relationships and inspiring young people to pursue careers in science, technology, engineering and math.

Partnering with institutions of higher learning, like Rice University, allows us great opportunities to collaborate and work together to solve numerous technological challenges. Wearable technologies are becoming better and smarter tools for many applications and solutions found today could be benefiting us all tomorrow, out in the solar system or right here at home.