

Role of ISRU in Mars Exploration and the Importance of Innovative Small Business Contributions

Eric E. Rice
Orbital Technologies Corporation

ORBITEC Mission Statement

To serve government and industry by developing and demonstrating innovative technologies and advanced products that enhance the quality of human life and support mankind's exploration of the Universe.

Discussion Topics

- ❖ AIAA position on ISRU
- ❖ ORBITEC's involvement
- ❖ Other small business involvement
- ❖ Concluding remarks

AIAA Position Paper on ISRU

- ❖ Position paper developed by the AIAA Microgravity and Space Processes Technical Committee in 1997
- ❖ Paper printed and distributed
- ❖ Discusses benefits
- ❖ Provides key recommendations to NASA to develop an active ISRU program

Overview

- ❖ ISRU Program will reduce launch masses and costs by producing return-trip and locally used propellants
- ❖ Mission analyses indicate ISRU could reduce launch masses by up to 63%
- ❖ A small investment in developing ISRU technologies now will return huge savings in future exploration

Lunar-Derived Propellants

- ❖ O₂ can be "mined" from lunar regolith via direct heating and addition of H₂ or C
- ❖ Leading lunar propellants include: H₂O, H₂/O₂, Al/O₂, and CH₄/O₂
- ❖ Mars missions can be enhanced by using lunar-derived propellants
- ❖ Analyses indicated that Al/O₂ propulsion reduces initial mass to LEO by 54% to 63%

Mars-Derived Propellants

- ❖ Mars offers ISRU propellants: H₂/O₂, CH₄/O₂, CO/O₂, C₂H₂/O₂, C₃H₈/O₂, SiH₄/O₂
- ❖ The Mars atmosphere could be dissociated into O₂ and CO and used as a simple propellant
- ❖ Use of lunar SiH₄/O₂ reduce initial launch mass by 36%
- ❖ Use of Mars O₂ and CH₄ reduce initial launch mass by 50% to 60%

AIAA Recommendations

- ❖ Establish and implement a strategic plan and cost-benefit study for ISRU
- ❖ Establish a NASA office to be the focus for the ISRU program
- ❖ Provide a robotic vehicle and lander capability for ISRU missions to the Moon and Mars and support flight experiments
- ❖ Consider ISRU applications in all mission planning for Moon/Mars
- ❖ Encourage other government agencies to support the program
- ❖ Develop an annual conference dedicated to ISRU

ORBITEC's ISRU/Mars Mission Related Activities

- ❖ Propulsion, propellants, and power
- ❖ ISRU materials processing
- ❖ Life support and habitats
- ❖ Automation and robotics

Propulsion, Propellants, and Power

- ❖ CO/O₂
- ❖ C₂H₂/O₂
- ❖ CH₄/O₂
- ❖ O₂/H₂
- ❖ Liquid metal fuels/O₂
- ❖ Solid metal fuels/O₂
- ❖ Beamed propulsion
- ❖ Nuclear propulsion

ISRU Materials Processing

- ❖ Water ice from lunar poles
- ❖ Carbon-based reduction for O₂ and Fe and Si
- ❖ Hydrogen-based reduction for O₂ and Fe
- ❖ Processing of regolith volatiles from He, H₂, etc.
- ❖ Processing of Mars Atmosphere for CO/O₂
- ❖ Storage technology for ISRU gases
- ❖ Lunar concrete development
- ❖ Radiation shielding

Life Support and Habitats

- ❖ Controlled environments for plants, animals, and humans
- ❖ Plant growth systems for Earth orbit research and flight crews
- ❖ Plant growth systems for Mars transit and planetary surface
- ❖ Inflatable habitats

Automation and Robotics

- ❖ Sample retrieval and processing systems
- ❖ Micro-g A&R systems for space station and flight vehicles
- ❖ IVA robotic servicing vehicles for Mars transit vehicles
- ❖ IVA robotic inspection systems for space vehicles
- ❖ Robotic applications on the surface

Other Small Business Involvement

- ❖ **Physical Sciences Inc.** "Optical Waveguide Solar Energy System for Lunar Materials Processing"
- ❖ **Carbotek, Inc.** "Lunar Oxygen Processing"
- ❖ **Pioneer Astronautics** "Mars Aromatic Hydrocarbon and Olefin Synthesis System" and "Methanol Mars In Situ Propellant Production"

- ❖ **Adroit Systems, Inc.** "Atmospheric Water Vapor Adsorption for Mars In Situ Resource Utilization"
- ❖ **EnviroGen, Inc.** "A High Performance, Gravity Insensitive, Enclosed Aero-ponic System for Food Production in Space"
- ❖ **Nextech Materials, Ltd.** "Oxygen Generation System Using Carbon Dioxide"
- ❖ **Vertigo, Inc.** "Inflatable Structure for Mars Trans Hab"
- ❖ **Nanomaterials Research Corp.** "Low-Power, In-Situ Oxygen Extraction/Separation Technology"
- ❖ **EIC Laboratories, Inc.** "Electrochromic Thermal Control Container for Payloads"
- ❖ **Orbital Technologies Corporation (ORBITEC)** "Inflatable Module for Lunar/Mars Surface Facilities" and "Carbon-based Reduction of Lunar Regolith"
- ❖ **Physical Sciences, Inc.** "Solar Plant Growth System for Life Support in Space"

Concluding Remarks

- ❖ Promising ISRU technology needs to be developed and thoughtfully used for exploration
- ❖ Small businesses should provide significant innovations to support technology and hardware development for HEDS
- ❖ All of us need to improve communication to the public about HEDS