Planetary Regolith Delivery Systems for In Situ Resource Utilization

J.G. Mantovani (NASA Kennedy Space Center) and I.I. Townsend (Craig Technologies-ESC / KSC)

Presented by James Mantovani
Granular Mechanics and Regolith Operations Lab
NASA Kennedy Space Center, Florida USA

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What is In Situ Resource Utilization?

TO DO LIST:
- Invent smaller Post-it Notes
Example of In Situ Resource Utilization for Oxygen Productions

Carbothermal Regolith Reduction Module (ORBITEC)

Solar Energy Collection and Delivery Module (PSI)
Regolith Transfer and ISRU Processing Steps

1. Excavator Delivers Regolith to Hopper
2. Regolith is Transferred into a Regolith Supply Bin
3. Regolith is Conveyed to an ISRU System for Analysis or Processing
4. Spent Regolith is Conveyed out of the ISRU System
5. Regolith is Analyzed or Reacted to Yield Useful Products Like Oxygen and Metals such as Titanium

   E.g., Carbothermal, Hydrogen Reduction, Molten Oxide Electrolysis
Regolith Feed Systems Field Tested for ISRU Reactors

Mechanical Systems
(Inclined Auger)

Non-Mechanical Systems
(Pneumatic Conveyor)

ROxygen I
2008

PILOT 2008
(Precursor ISRU Lunar Oxygen Testbed)

Reduced Gravity Flight
2009, 2010

Carbothermal Field Demo Unit
2010
Using a Mechanical Auger for Regolith Delivery to an ISRU Reactor
Pneumatic Regolith Delivery System

Reduced gravity setup to pneumatically convey 17 kg of planetary regolith 1.5 meter vertically using compressed dry air and helium gases.
Pneumatic Regolith Transfer

Amount of regolith mass (JSC-1A) conveyed as a function of time for given gas pressures applied to a supply cylinder for fluidizing 17 kg of regolith, and to the eductor gas inlet for conveying the regolith.

Fluidization Pressure: 24.7 PSIA
Eductor Pressure: 20.1 PSIA

Fluidization Pressure: 24.7 PSIA
Eductor Pressure: 16 PSIA
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Pneumatic Regolith Transfer

![Diagram of pneumatic regolith transfer system with graphs showing mass flow and gas flow relationships.](image-url)
Pneumatic Regolith Transfer

Mass flow rate versus eductor inlet gas pressure

Mass flow rate versus eductor inlet gas flow rate

Pneumatic conveying of JSC-1A into ambient air under 1-g using compressed dry air as the convey gas. Upper curves (solid circles) are for the supply cylinder fluidized at a pressure of 24.7 psia, while the lower curves (solid diamonds) are for a fluidization pressure of 19.7 psia.
Hybrid Regolith Delivery System
Using Hopper Lift and Auger Mechanisms

Regolith Delivery System designed for an ISRU 2012 Field Test
to be conducted at NASA JSC
ISRU 2012 Field Test at JSC will use a Mockup Lander

JSC Morpheus Lander

Regolith Hopper Lift.mp4
Conclusions ISRU 2012 Field Test at JSC Using a Mockup Lander

- Pneumatic delivery systems convey are compact and versatile in deployment, have been demonstrated in reduced gravity and can convey regolith at significant mass flow rates, but they require a source of compressed gas.

- Standalone mechanical auger systems convey regolith in a simple, reliable and well understood way, but contain moving parts that are susceptible to wear and jamming from contact with regolith and can be bulky for transferring regolith over large distances.

- A hybrid mechanical system that combines a hopper lift with an auger makes the system more versatile and compact than a standalone auger system, but still contains moving parts that are susceptible to wear and jamming by contact with regolith particles.