

## HOW OFFWORLD'S SWARM ROBOTIC MINING ARCHITECTURE IS OPENING UP THE WAY FOR AUTONOMOUS INSITU MINERAL EXTRACTION – ON THE EARTH AND BEYOND.

J. Keravala (OffWorld, 1983 Locust Street, Pasadena, CA 91107, USA, jim.keravala@offworld.ai), M. Nall, D. Bienhoff, B. Pittman (OffWorld, 1983 Locust Street, Pasadena, CA 91107, USA)

**Introduction:** OffWorld is building millions of smart robots working on the human supervision on earth and in space, turning the solar system into a habitable place for life and civilization. Enabling human expansion off our home planet is the most important objective of our civilization, for three reasons:

- species level life insurance policy,
- sustainable development on earth,
- opening up the new frontier.

What we absolutely require in space is a robotic workforce for tough jobs. We need to be able to excavate underground habitats and extract water ice and materials. From the collective volatile's we need to make drinkable water, breathable air and rocket propellant. In order to sustain expansion we need to be able to manufacture basic structures and solar cells so that we can produce unlimited power. Ultimately, these systems will need to replicate themselves for rapid and economic expansion. In order to do this, we need to emulate the entire infrastructure value chain from mining, processing, fabrication, assembly and construction. However, we cannot just export current Earth-based practices and technology. We must reinvent how we undertake these processes here on earth, and transfer them directly to the expansion of civilization into the solar system.

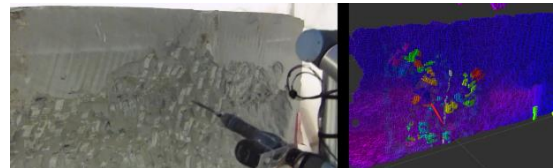


OffWorld has undertaken extensive Research and Development in the field of extreme environment industrial robotics initially applied to the mining and processing sector. The objective is the establishment of an end to end collaborative robotic system comprising of hundreds or even thousands of multi-species robots working together with internal and collective autonomy to achieve defined strategic objectives.

With the ongoing input of mining industry expertise on a daily basis, OffWorld has developed its robotic systems hand in hand with leading edge knowhow

from the mining sector. Initially, we developed baseline systems analysis tools for modelling a variety of scenarios with our robotic architecture, including the objective of rapidly deploying them for space based operations.

Key to the future of operations in space is the ability for robotic systems to undertake multiple complex tasks autonomously and with minimal human intervention. OffWorld has been developing a task agnostic machine learning framework to address and optimize any industrial process. This revolutionary approach to minimally supervised autonomy ushers in a new era of remote operations in extreme environments such as the Lunar or Martian surface. We are already developing the first suite of machine learning agents.



OffWorld proposes to mature our regolith to gaseous oxygen and gaseous hydrogen subsystem using six distinct processes: 1) volatile extraction, 2) water distillation, 3) water vapor superheating, 4) water dissociation, 5) oxygen separation and 6) hydrogen separation. Each process is envisioned as a stand-alone function within an autonomous robotic platform. Our autonomous robotic platforms are currently in development for Earth mining under internal funds with demonstration units planned for testing later this year. Our ISRU Technology subsystem is a subset of OffWorld's overall concept for mining Moon and Mars regolith for volatiles and minerals in addition to processing, manufacturing and construction robots within the same robotic platform.

Our subsequent goals in near-Earth space for the expansion of this modular toolkit are to enable the formation of in-space vehicles, transport, depots and facilities, and orbital workshops for the autonomous recovery and re-utilization of space debris as a resource. Once our machine intelligent robotic system has mastered lunar surface and in-space operations, we will expand their utility to near Earth asteroids and the Martian surface, leveraging lessons learned to enable the expansion of humanity into the solar system.