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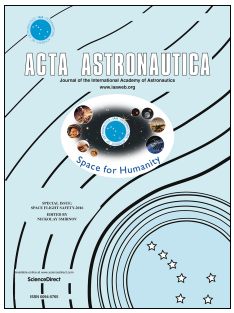

A new planetary structure fabrication process using phosphoric acid

Christoph Buchner, Roland H. Pawelke, Thomas Schlauf, Alexander Reissner, Advenit Makaya

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ACCEPTED MANUSCRIPT

A new planetary structure fabrication process using phosphoric acid

Christoph Buchner[a*], Roland H. Pawelke[a], Thomas Schlauf[a], Alexander Reissner[a], Advenit Makaya[b]

[a]FOTEC Forschungs- und Technologietransfer GmbH, Viktor Kaplan-Strasse 2, 2700 Wiener Neustadt, Austria

[b]European Space Agency, ESTEC, Keplerlaan 1, Noordwijk, the Netherlands

*Corresponding author, email address: buchner@fotec.at

Abstract. Minimising the launch mass is an important aspect of exploration mission planning. In-situ resource utilisation (ISRU) can improve this by reducing the amount of terrestrial materials needed for planetary exploration activities. We report on a recently concluded investigation into the requirements and available technologies for creating hardware on extra-terrestrial bodies, using the limited resources available on site. A trade-off of ISRU technologies for hardware manufacturing was conducted. A new additive manufacturing process suitable for fabricating structures on the Moon or Mars was developed. The process uses planetary regolith as the base material and concentrated phosphoric acid as the liquid binder. Mixing the reagents creates a sticky construction paste that slowly solidifies into a hard, rock-like material. Prior to solidification, the paste is extruded in layers, creating the desired structures in a 3D printing process. We used Martian regolith simulant JSC-Mars-1A, but the process is not selective towards regolith composition. Samples were exposed to thermal cycles and were mechanically characterised. Reduced-scale demonstrator structures were printed to demonstrate structure fabrication using the developed process.

Keywords: In-situ resource utilization; regolith simulant; binder; 3D printing; additive manufacturing; extrusion

1 INTRODUCTION

In-situ Resource Utilization (ISRU) involves any hardware or operation that harnesses and utilises resources available on site to create products and services for robotic and human exploration [1]. There are five major fields of ISRU:

- Resource characterisation and mapping: physical, chemical, mineral properties, type
- Mission consumable production: propellants, life support gases, fuel cell reactants
- Civil engineering and surface construction: radiation shields, landing pads, pathways, habitats
- In-situ energy generation, storage and transfer: electrical, thermal and chemical energy
- In-situ manufacturing and repair: spare parts, wires, trusses, integrated structures, etc.

The amount of resources available for lunar or Martian exploration missions is limited by the cargo capacities of flights from Earth. Using local instead of launched resources to provide a suitable environment for exploration missions would be a supportive or even mission-enabling measure, maximizing the impact of a mission while minimising the mass launched from Earth. Robotics missions could prepare infrastructure such as habitats for human exploration, where protective hardware against hazardous ionizing radiation, micrometeorite bombardment, extreme thermal cycles or dust storms is necessary.

The aim of the activity reported in this article was to investigate the potential of manufacturing technologies using a limited amount of available resources. Preliminary findings have already been reported elsewhere [2–4]. Exploration mission scenarios targeting the two most relevant

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