SOLAR 3D PRINTING OF LUNAR REGOLITH. Alexandre Meurisse[1], Aidan Cowley[2], Samantha Cristoforetti[2], Advenit Makaya[3], Laurent Pambaguian[3] and Matthias Sperl[1], [1]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt, 51170 Köln, Germany (alexandre.meurisse@dlr.de), [2]ESA-EAC , 51170 Köln, Germany, [3]ESA-ESTEC, 2201 AZ Noordwijk, Netherlands.

Introduction: In-Situ Resource Utilization (ISRU) has become in the last decades one of the most prominent approaches for the building of a settlement on the Moon. The use of local resources to reduce up-mass, cost and risk of mission is now an essential consideration in future exploration scenarios. Within this trend, lunar regolith, the loose layer of crushed rock covering the Moon surface, has a key role to play. Its high metallic oxides content could offer a sustainable way of producing oxygen and it could also be used as a construction material via, for instance, a sintering process. By means of solar concentration [1], microwaves [2] or radial heating elements [3], this process would create solid building elements that could be used for roads, launch pads or habitats.

Additive manufacturing (AM) technology, commonly called 3D-printing, is widely used on Earth. Building parts layer by layer allows the realization of complex shapes, does not create wasted material and requires low post-processing work. The shift from casting to AM in aerospace and automotive industries shows the leading place given today to such technology. AM in microgravity has already been used in space since 2014 with a first polymer 3D printer on-board the International Space Station (ISS).

Combining AM with ISRU offers a way of building-up a permanent lunar outpost with a limited amount of upload from Earth. Proof of concepts using lunar regolith as main building material were given with the contour crafting [4] and D-shape approaches[5]. Both technologies create a mixture similar to concrete with the lunar soil and terrestrial consumable materials. Making any large-scale construction is therefore dependent on Earth shipments which is not viable for long term missions. In this work we demonstrate how, only using concentrated sunlight, we can 3D print a solid material from lunar regolith.

Background: Potential landing sites for first, lunar landers and then, the settlement of a Moon village are located at the lunar South Pole region, near the Shackleton crater, where continuous illumination during several months exists [6]. Long-term missions are indeed essentially limited to locations with favourable illumination for power generation thus adding interest to the use of the numerous hours of sunshine for other purposes.

Results: In the DLR solar oven, a custom solar 3D printer was constructed capable of sintering building elements using only lunar regolith simulants and concentrated sunlight. The realisation of a brick, Figure 1, has proven the concept, opening the path to further improvements and more challenging constructions designs.

Figure 1: Brick of size 240mm x 120mm x 30 mm produced from custom 3D printing protocol at DLR's solar oven in Cologne. Support is made from a porous silica brick and JSC-2A is used as lunar simulant.

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