SPACESHIP EAC – Fostering activities relevant to Lunar Exploration and ISRU: A. Cowley[1], T. Haefner[1], J.C. Beltzung[1], A. Meurisse[2], [1]European Astronaut Centre, Linder Höhe, D-51147 Cologne, Germany, aidan.cowley@esa.int, [2]German Aerospace Centre (DLR), Institute of Materials Physics in Space, Linder Höhe, Building 21, D-51147 Cologne, Germany.

Introduction: *"Spaceship EAC initiative"* was initiated in 2012 by the Head of the European Astronaut Centre (EAC) Frank De Winne with the aim of fostering human space flight activities and operations beyond ISS, with the involvement of EAC and its cooperation with member states. In this context, human Lunar exploration is an important theme as outlined within the inter-organisational roadmaps. One of the areas where this inititiative is engaged with is additive manufacturing.

In-situ-resource utilisation (ISRU) in combination with 3D printing may evolve into a key technology for future exploration. Setting up a lunar facility could be made much simpler by using additive manufacturing techniques to build elements from local materials – this would drastically reduce mission mass requirements (and thus cost) and act as an excellent demonstrator for ISRU on other planetary bodies. Fabricating structures and components using Lunar regolith is an area of interest for ESA, as evidenced by the successful General Studies Program (GSP) conducted with Foster & Partners Architects [1]; within Spaceship EAC this technology was followed up into a General Support Technology Program (GSTP) project with DLR looking at using directed solar energy to sinter regolith into a building element (i.e. a brick).

A number of projects looking into the behavior of Lunar regolith simulants, their compositional variants and approaches to sintering such material are underway at EAC with the aim of increasing the material utilisation potential for future missions. We report on early studies into utilizing conventional thermal sintering approaches of simulants as well as microwave sintering of these compositions. Both techniques are candidates for developing a 3d printing methodology using Lunar regolith. It is known that the differences in microwave effects between the actual lunar soil and lunar simulants can be readily ascribed to the presence of nanophase metallic Fe [2], native to Lunar regolith but lacking in simulants.

In compostions of simulant with increased Illmenite ($FeTiO_3$) concentrations, we observe improved regolith response to microwave heating, and the readily achieved formation of a glassy melt in ambient atmosphere. The improved response relative to untreated simulant is likely owing to the increased Fe content in the powder mix. We are aiming to use the outputs from these sintering experiments as feedstock for an improved simulant which would contain micron to nanosize granules of Fe^0, mimicking the actual regolith composition itself. We also discuss our work on optimisation of the grain-size distribution of Lunar simulant materials and improvements to the porosity control of sintered samples.

Fig. 1 *– Processed DNA sintered simulant via conventional resistive heating oven (vacuum).*

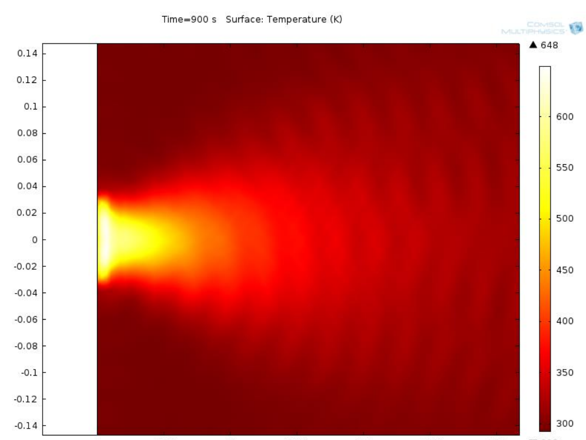

Fig. 2 *– Multiphysics simulation (COMSOL) of 2.4 GHz Microwave propagation into Lunar simulant.*

References:

[1] ESA GSP study on Lunar Base 3D printing: http://www.esa.int/Our_Activities/Space_Engineering_Technology/Building_a_lunar_base_with_3D_printing

[2] Taylor, L. and Meek, T. (2005). "Microwave Sintering of Lunar Soil: Properties, Theory, and Practice." *J. Aerosp. Eng.*, 18(3), 188–196