

Building a lunar base with 3D printing

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Lunar base made with 3D printing. Credit: ESA

(Phys.org)—Setting up a lunar base could be made much simpler by using a 3D printer to build it from local materials. Industrial partners including renowned architects Foster + Partners have joined with ESA to test the feasibility of 3D printing using lunar soil.

"Terrestrial 3D printing technology has produced entire structures," said Laurent Pambaguian, heading the project for ESA.

"Our industrial team investigated if it could similarly be employed to

build a lunar habitat."

Foster + Partners devised a weight-bearing 'catenary' dome design with a cellular structured wall to shield against micrometeoroids and [space radiation](#), incorporating a pressurised inflatable to shelter astronauts.

A hollow closed-cell structure – reminiscent of [bird bones](#) – provides a good combination of strength and weight.

The base's design was guided in turn by the properties of 3D-printed lunar soil, with a 1.5 tonne building block produced as a demonstration.



Multi-dome lunar base being constructed, based on the 3D printing concept. Once assembled, the inflated domes are covered with a layer of 3D-printed lunar regolith by robots to help protect the occupants against space radiation and micrometeoroids. Credit: ESA

"3D printing offers a potential means of facilitating lunar settlement

with reduced logistics from Earth," added Scott Hovland of ESA's human spaceflight team.

"The new possibilities this work opens up can then be considered by international space agencies as part of the current development of a common exploration strategy."

"As a practice, we are used to designing for extreme climates on Earth and exploiting the environmental benefits of using local, [sustainable materials](#)," remarked Xavier De Kestelier of Foster + Partners Specialist Modelling Group. "Our lunar habitation follows a similar logic."



The UK's Monolite supplied the D-Shape printer for ESA's 3D-printed lunar base study, with a mobile printing array of nozzles on a 6 m frame to spray a binding solution onto a sand-like building material. 3D 'printouts' are built up layer by layer – the company more typically uses its printer to create sculptures and is working on artificial coral reefs to help preserve beaches from energetic sea waves. First the simulated lunar material with magnesium oxide – turning it

into 'paper' to print with. Then for structural 'ink' a binding salt is applied which converts material to a stone-like solid. Credit: ESA

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"First, we needed to mix the simulated lunar material with magnesium oxide. This turns it into 'paper' we can print with," explained Monolite founder Enrico Dini.

"Then for our structural 'ink' we apply a binding salt which converts material to a stone-like solid.

"Our current printer builds at a rate of around 2 m per hour, while our next-generation design should attain 3.5 m per hour, completing an entire building in a week."

Italian space research firm Alta SpA worked with Pisa-based engineering university Scuola Superiore Sant'Anna on adapting 3D printing techniques to a [Moon](#) mission and ensuring process quality control. The effect of working in a vacuum was also assessed.



For ESA's 3D-printed lunar base concept, Foster+Partners devised a weight-bearing 'catenary' dome design with a cellular structured wall to shield against micrometeoroids and space radiation, incorporating a pressurised inflatable to shelter astronauts. Credit: ESA

"The process is based on applying liquids but, of course, unprotected liquids boil away in vacuum," said Giovanni Cesaretti of Alta.

"So we inserted the [3D printer](#) nozzle beneath the regolith layer. We found small 2 mm-scale droplets stay trapped by capillary forces in the soil, meaning the printing process can indeed work in vacuum."

Simulated lunar regolith is produced for scientific testing by specialist companies, typically sold by the kilogram. But the team required many tonnes for their work.

"As another useful outcome, we discovered a European source of simulated lunar regolith," added Enrico.

"Basaltic rock from one volcano in central Italy turns out to bear a 99.8% resemblance to [lunar soil](#)."

"This project took place through ESA's General Studies Programme, used to look into new topics," Laurent commented.

"We have confirmed the basic concept, and assembled a capable team for follow-on work."

Factors such as controlling lunar dust – hazardous to breathe in – and thermal factors will require further study.

3D printing works best at room temperature but over much of the Moon temperatures vary enormously across days and nights lasting two weeks each. For potential settlement, the lunar poles offer the most moderate temperature range.

Provided by European Space Agency

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