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Large-scale 3D Printing

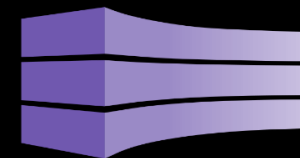
Past, Present and Future Prospect

Behrokh Khoshnevis

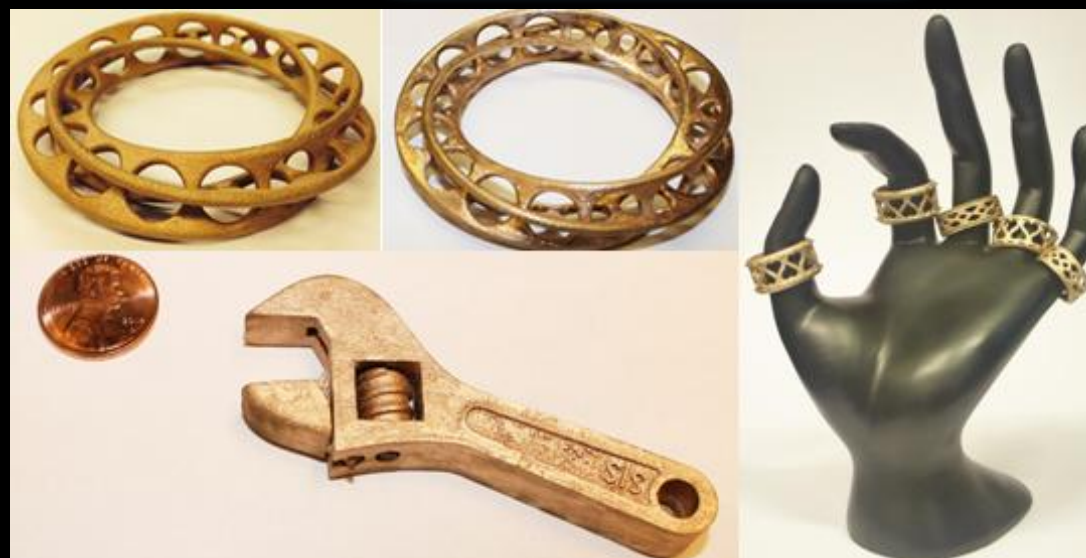
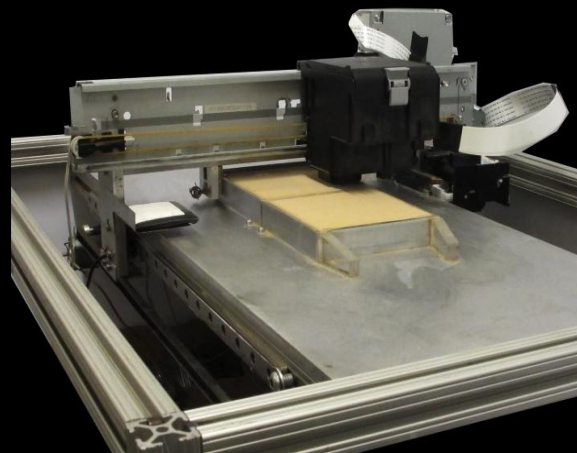
Founder CEO, Contour Crafting Corporation

Dean's Professor, University of Southern California

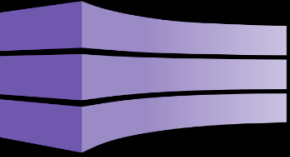
3D Printing & AM technologies invented by Khoshnevis



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Invented by
B. Khoshnevis

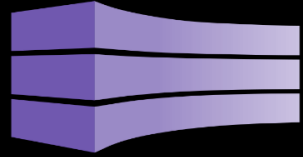


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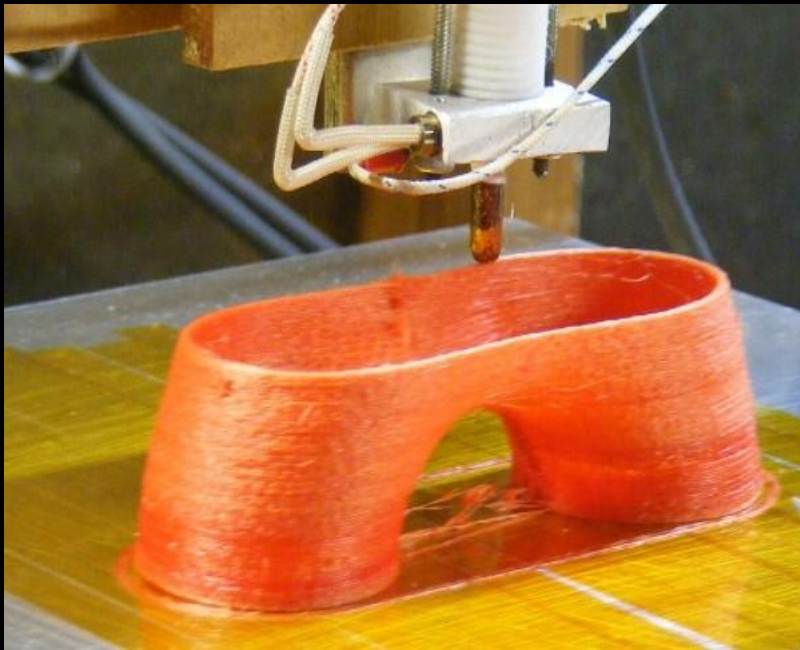
PAST

The realizations in 1994

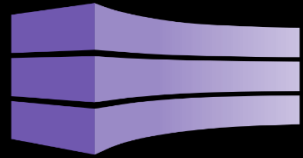
- 3D printing builds layer by layer
- We have been 3D printing for several millennia in **construction**



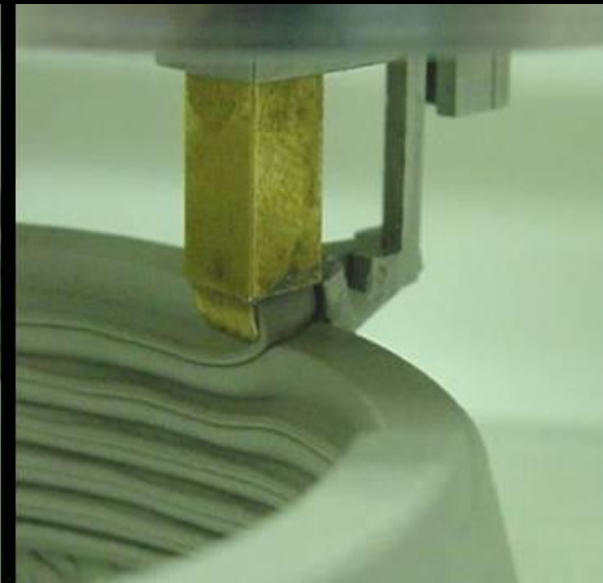
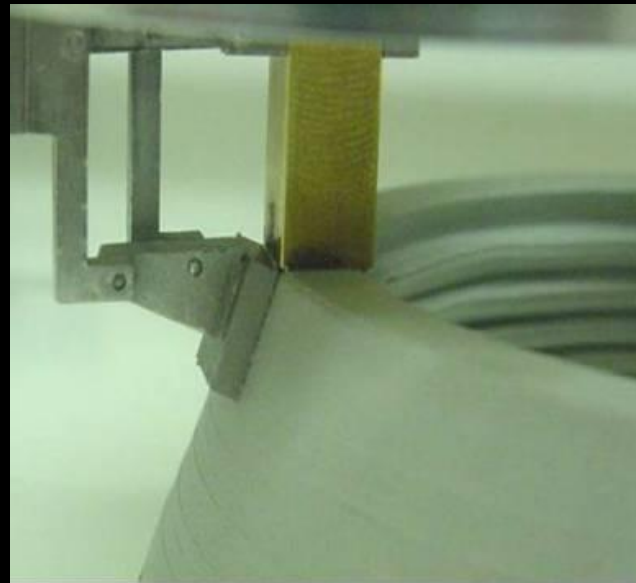
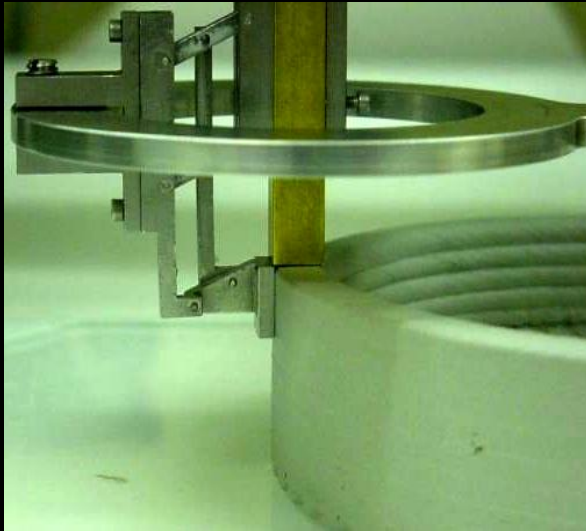
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Invention of Contour Crafting

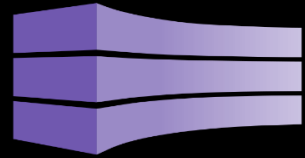


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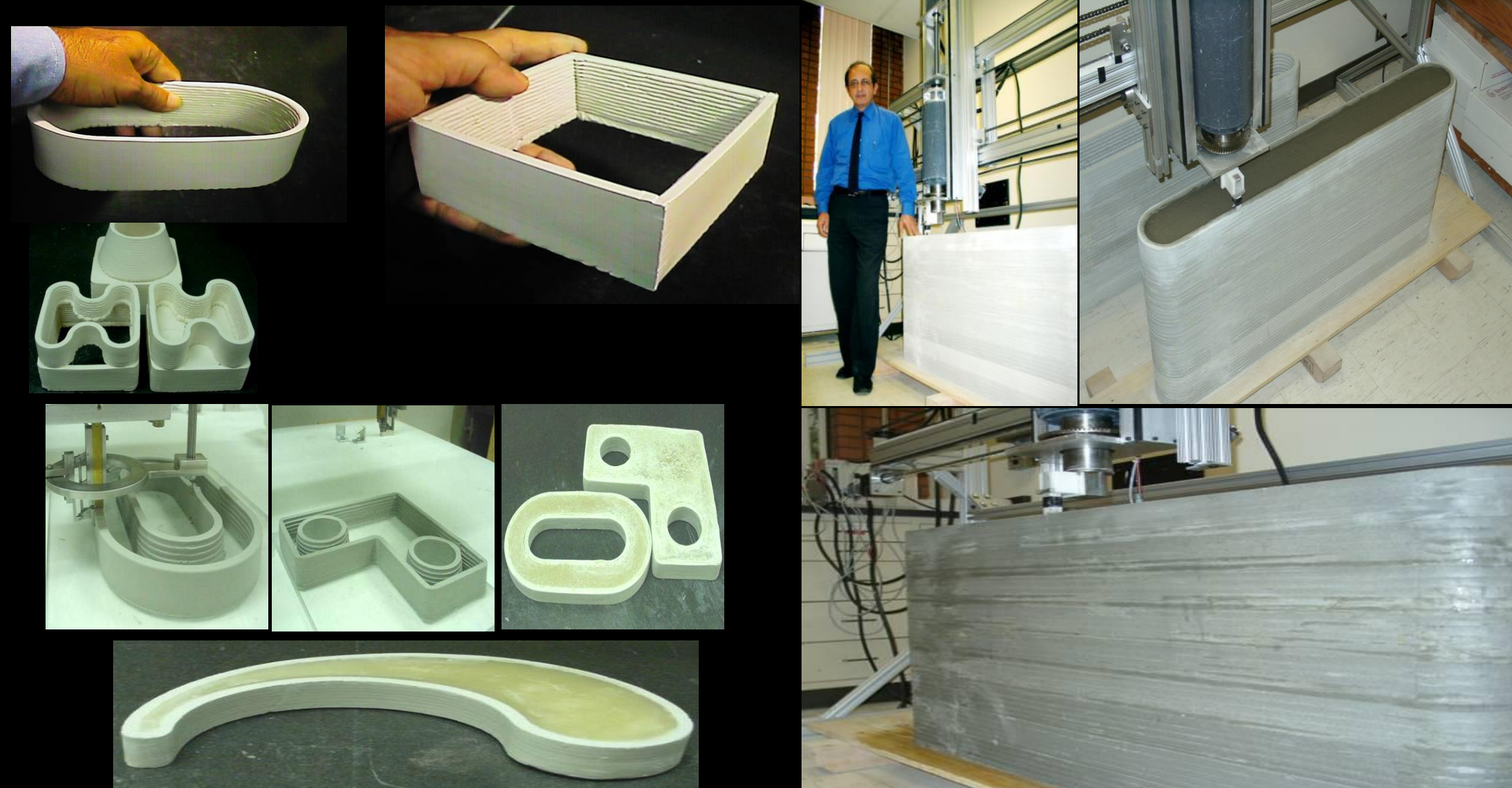


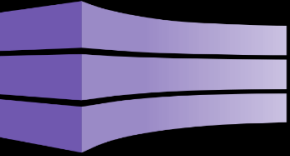
CC is an extrusion based a layered fabrication technology that builds objects with successive “thick” layers as it smoothens out external surfaces

Small scale ceramic to large scale concrete

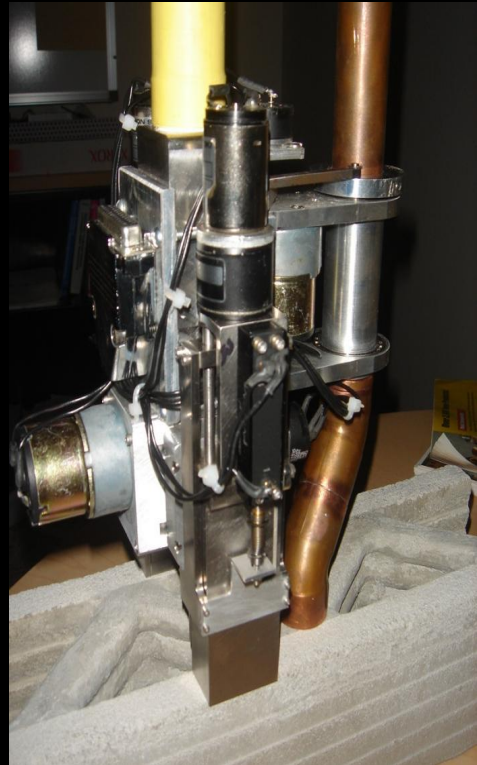


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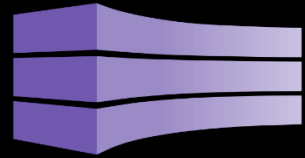
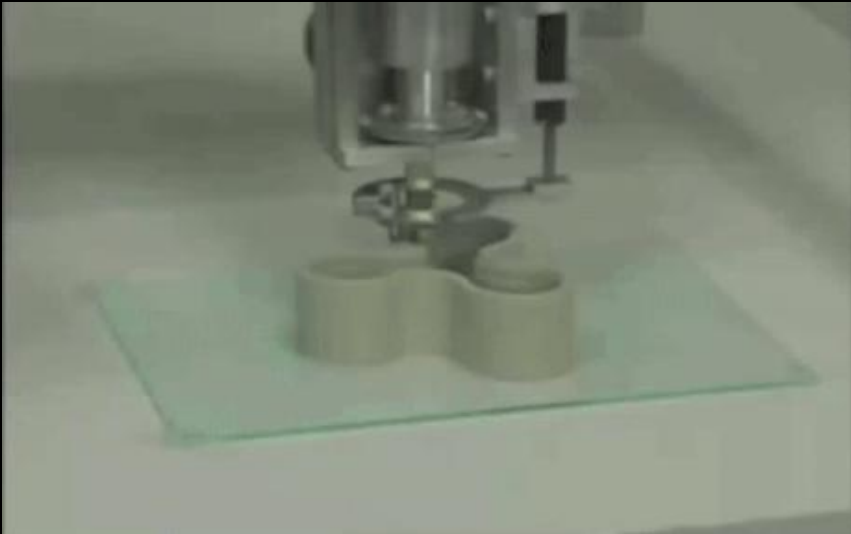




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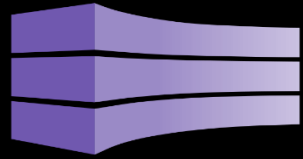


Many modes of fabrication

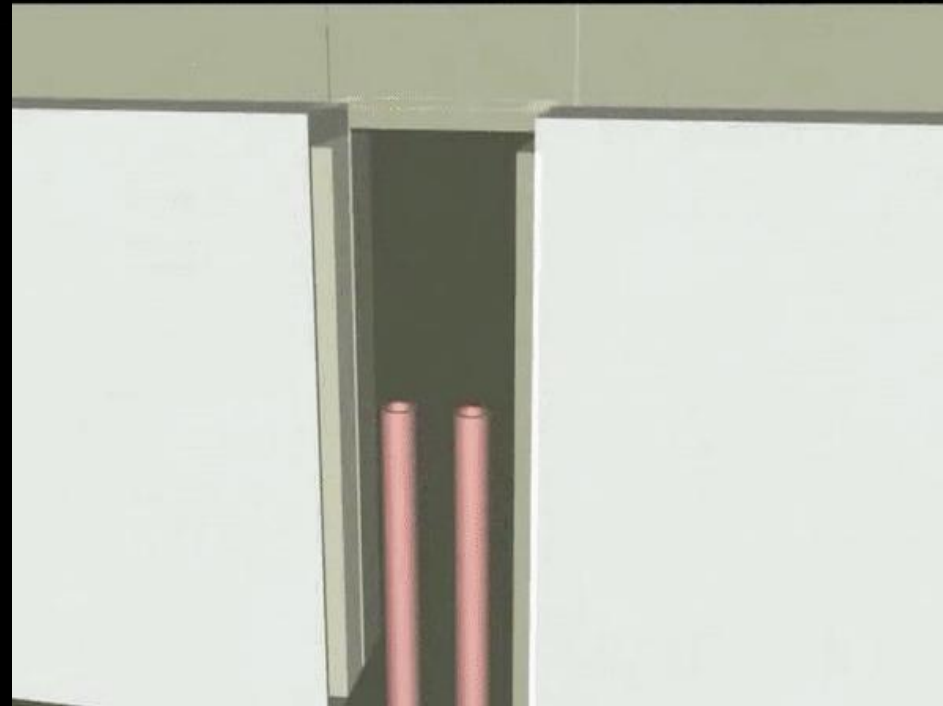
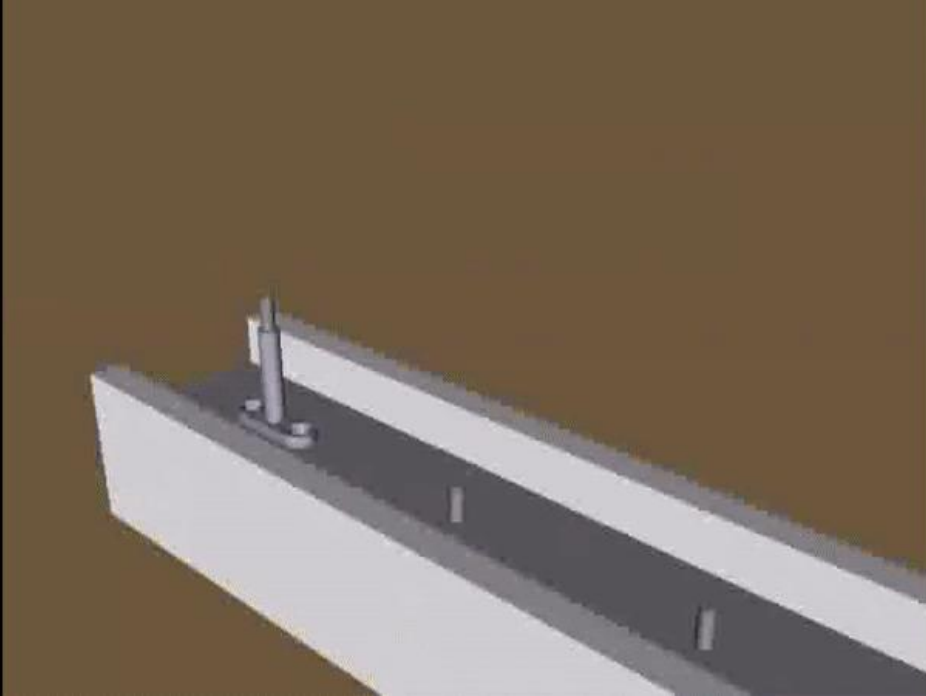


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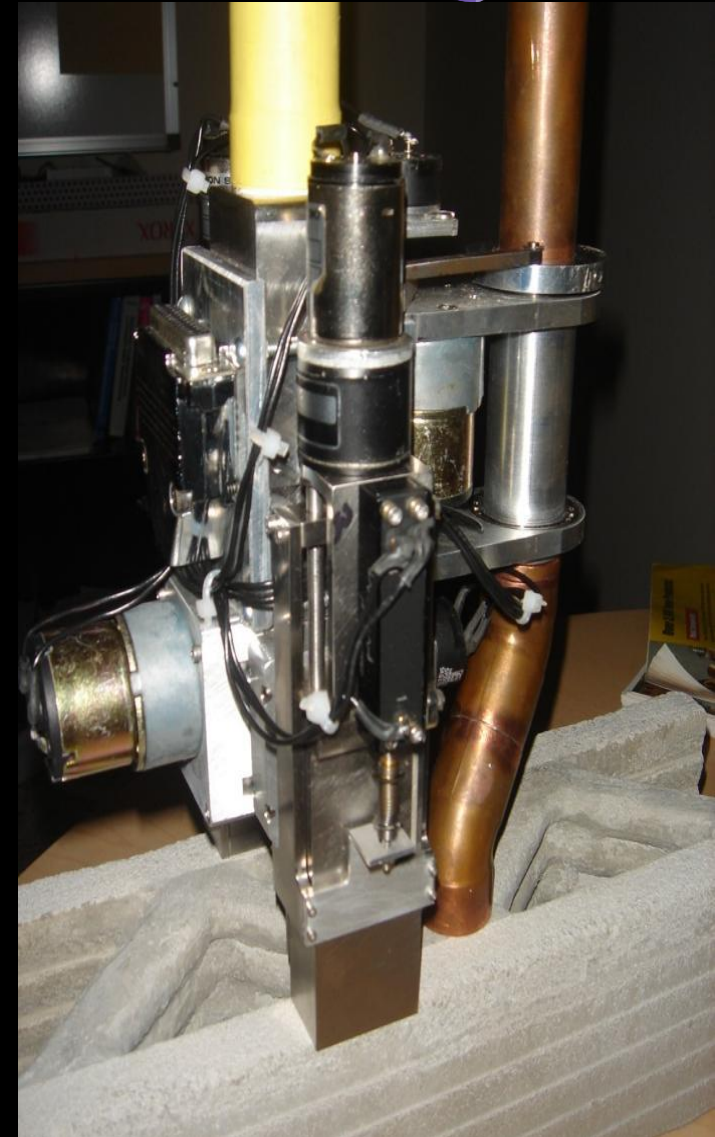
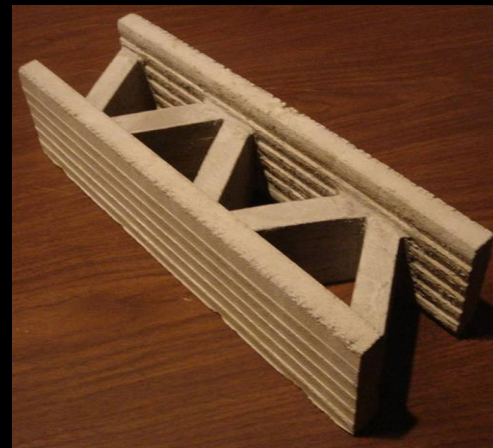
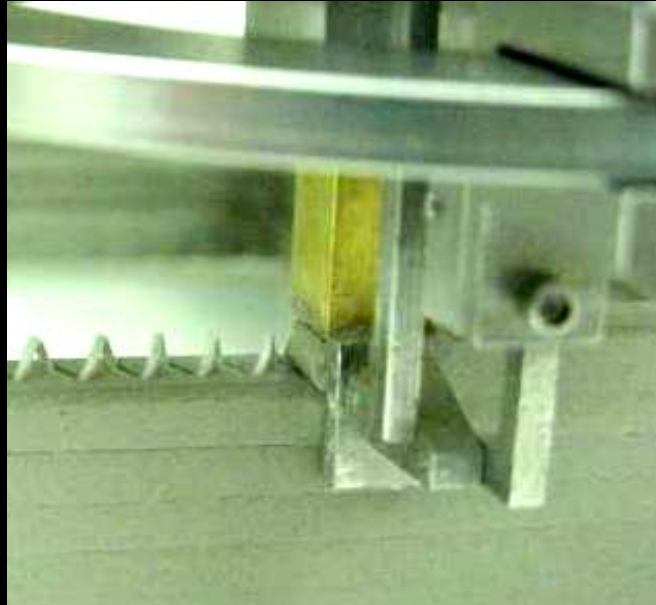
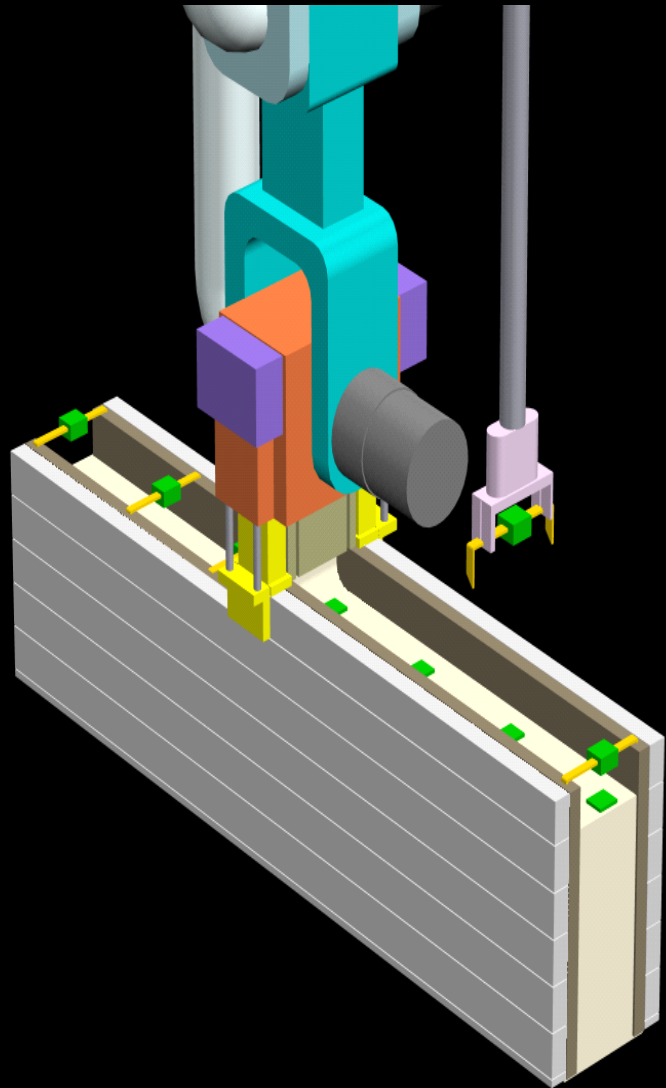
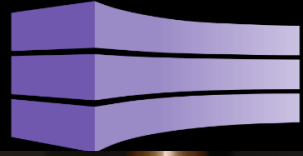
Concurrent object imbedding



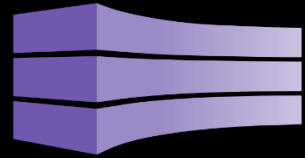
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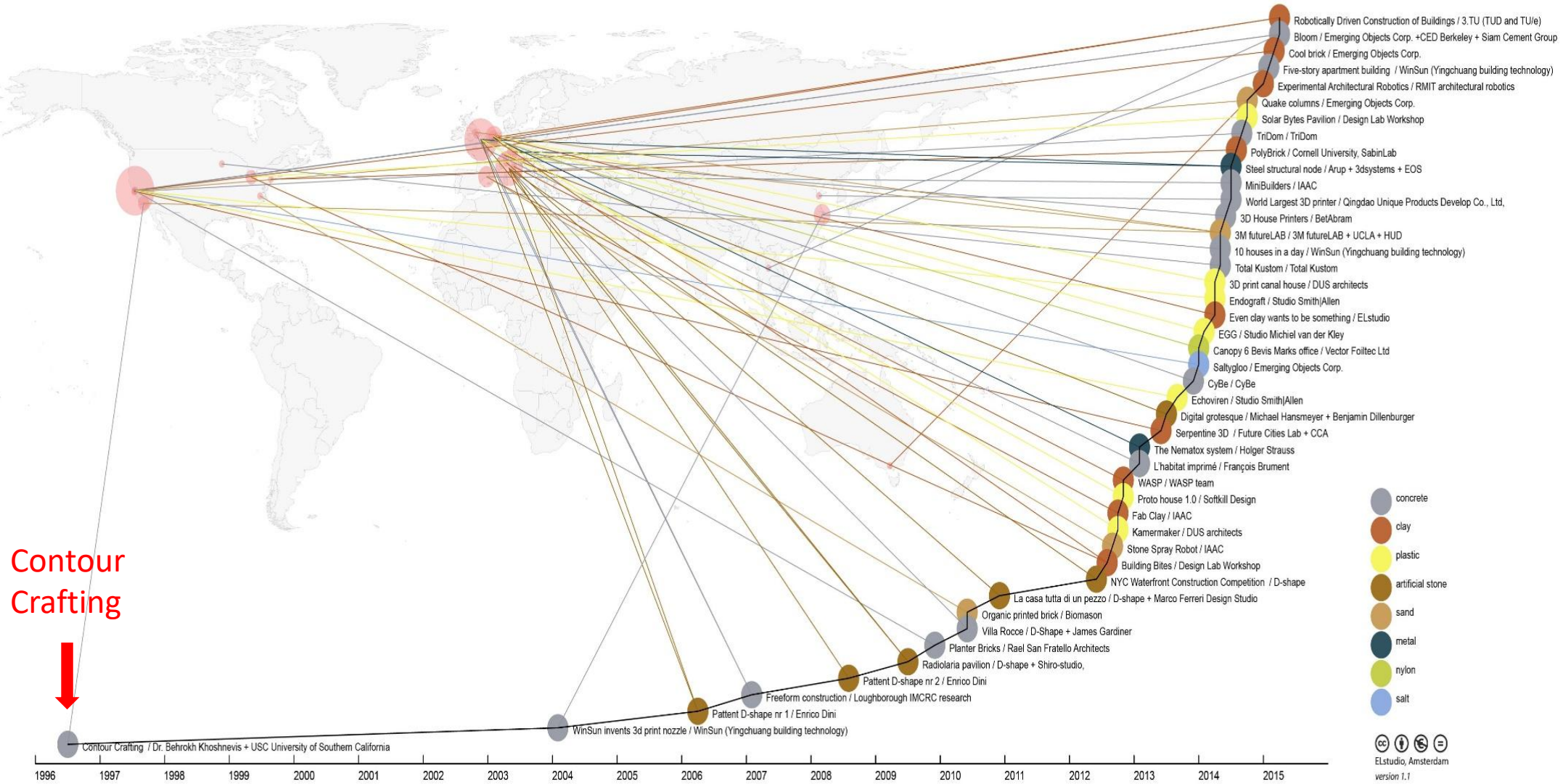
Numerous possibilities for innovation



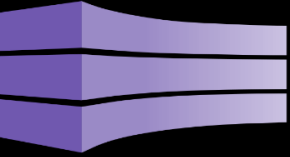
History chart of large scale 3D printing



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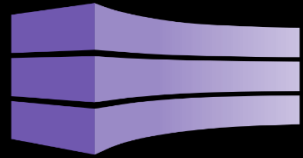
Published by:
Elstudio
Amsterdam, 2016



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PRESENT

Current focus of construction 3D printing community is on Building Construction



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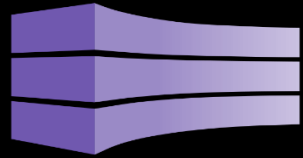
Residential:

- Shortage of 800 million houses worldwide (UN statistics)
- Global Markets are Grossly Under-Served
 - Nearly 2 Billion people are homeless or live in slums
 - Annually 37 million people lose housing due to war and natural disasters

Commercial:

- Shortage of commercial and industrial buildings, especially in developing countries

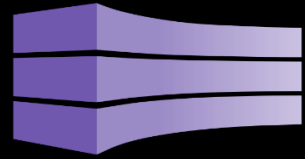
Why construction needs a change



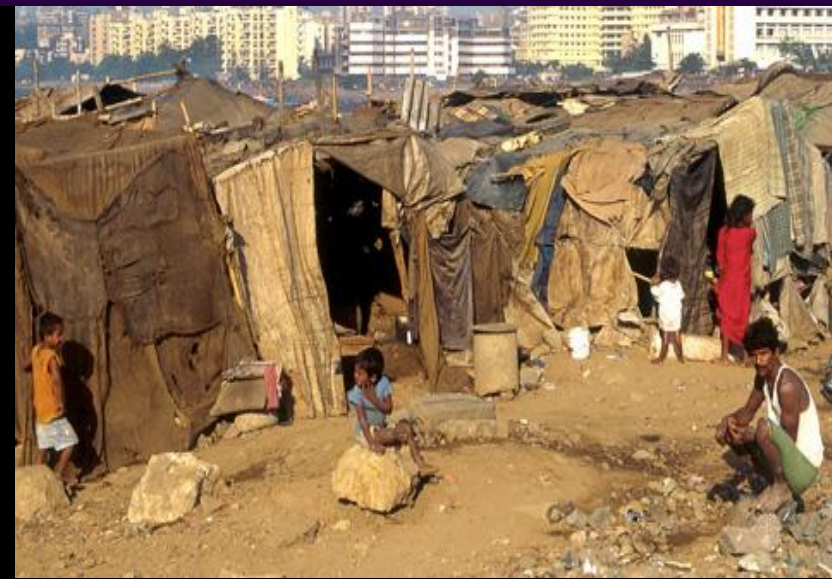
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- Construction is the largest sector (\$5.6T/year) of almost all economies
- Labor efficiency is alarmingly low
- Skilled workforce is vanishing
- Work quality is low
- Control of the construction site is insufficient and difficult
- Accident rate at construction sites is high (> 400,000 / year in US); 60,000 fatalities/year globally
- Waste and trims are high (3 To 7 tons per average home; 40% of all materials used worldwide are for construction)
- Low income housing and emergency shelters are critical
- All other products are fabricated automatically – construction is still largely a manual task

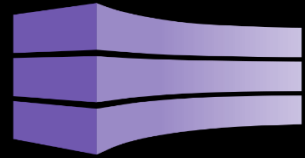
The Homeless, Disaster victims, Refugees



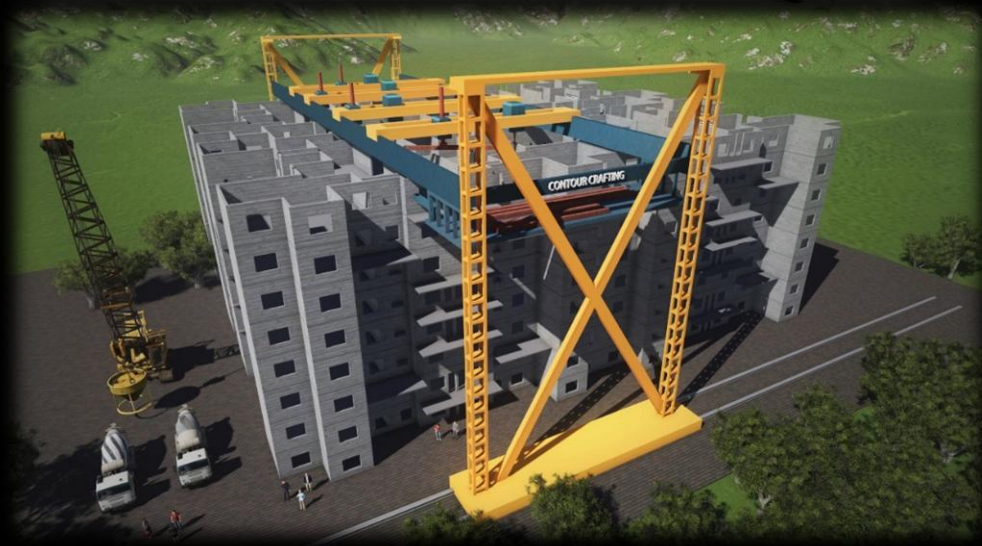
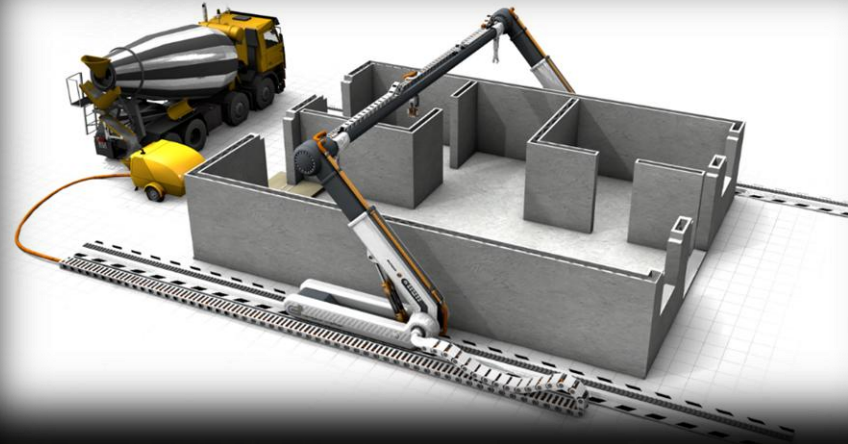
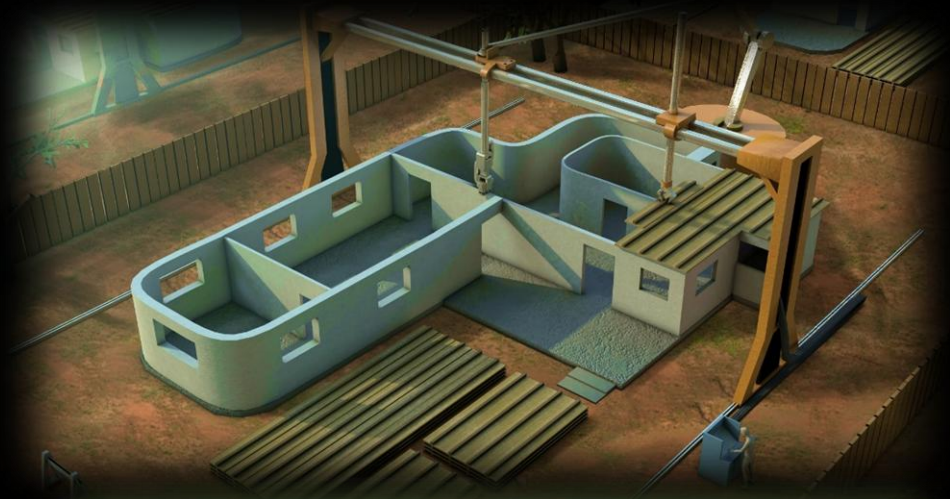
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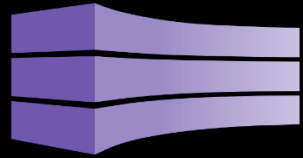
Building Construction



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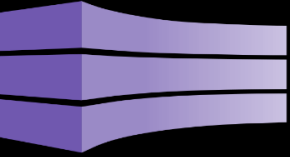


Barriers against implementation in building sector



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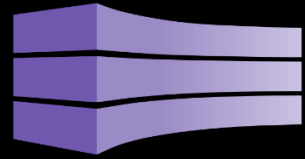
- Conservative industry
- Low profit margin
- Regulatory barrier
- Major paradigm change requirement with respect to inspection
- Labor unions
- At best impacts only the cost of building shell



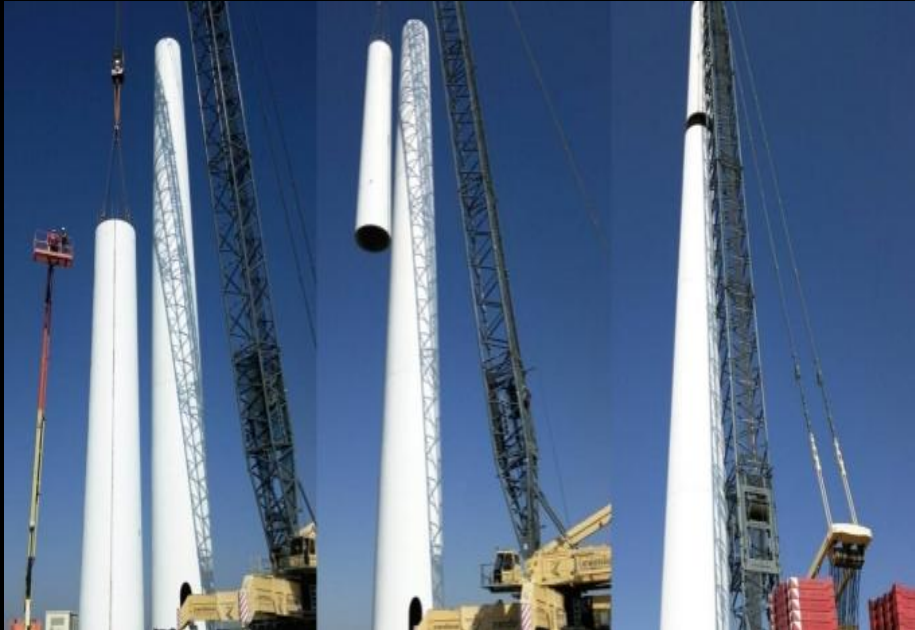
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FUTURE

Infrastructure Construction

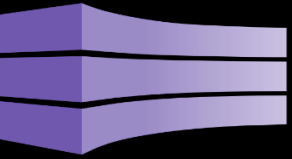


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Application in automated
wind turbine tower
construction



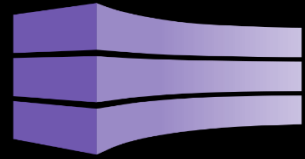


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CRAFT CORP. USA

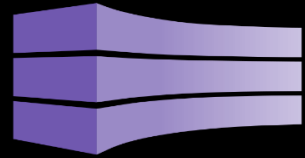
Pylon construction _ Application in the Hyperloop project



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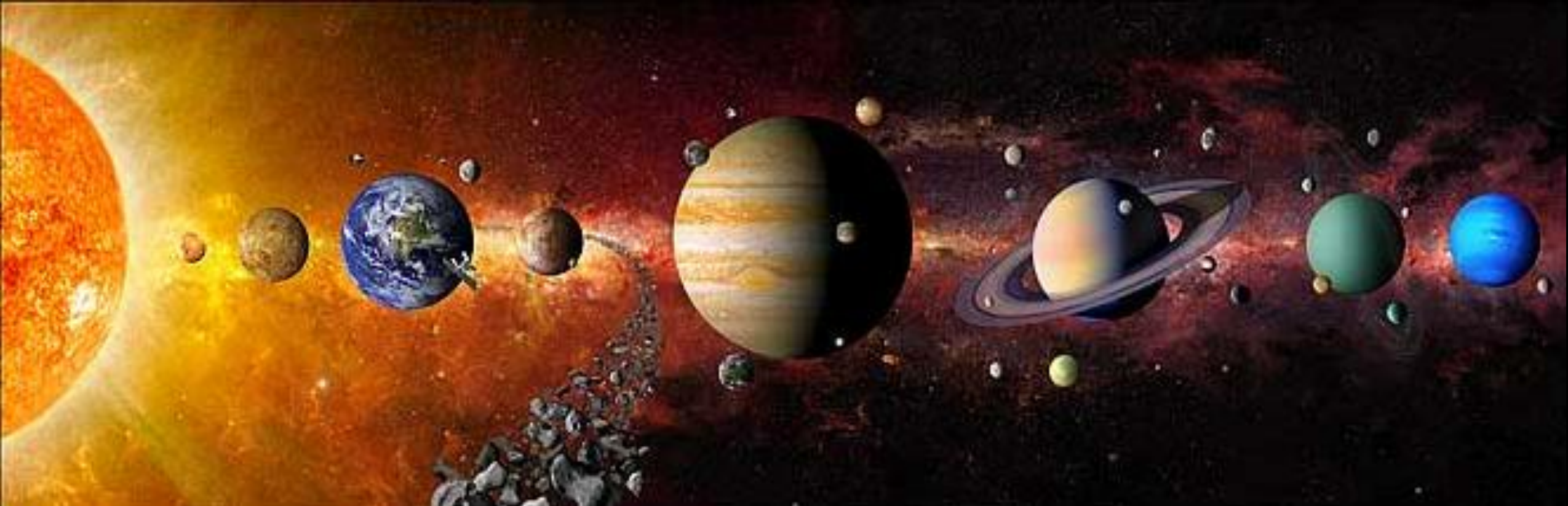


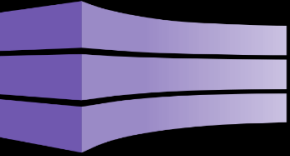
Space Applications



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The next stage after our Earth-bound civilization is the
Solar System Civilization – and it is beginning





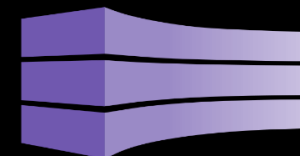
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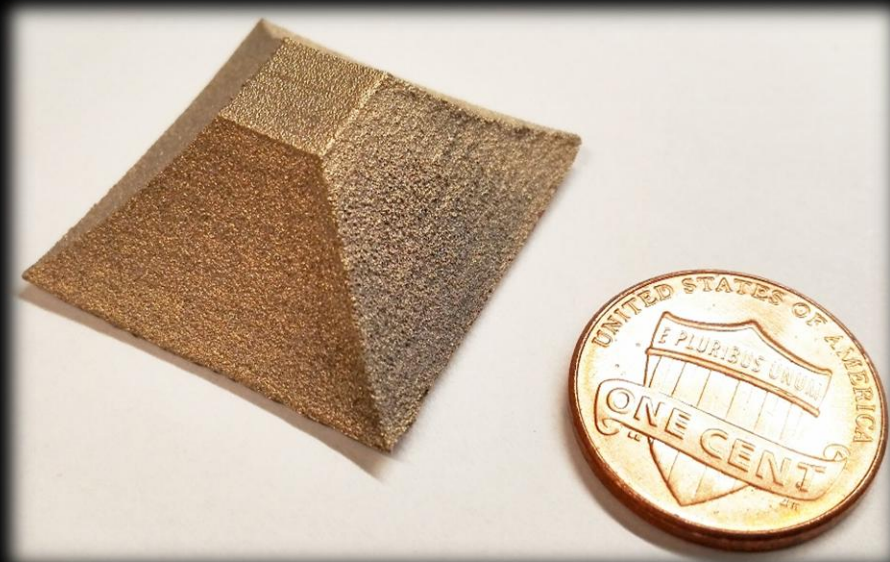
DSi
DEEP SPACE INDUSTRIES

22.01.2013

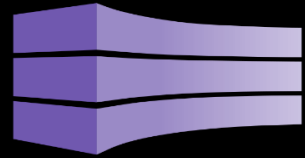
Fabrication in microgravity by SSS



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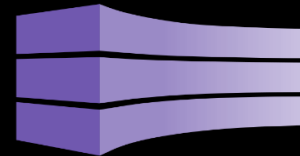
Space mining compaies



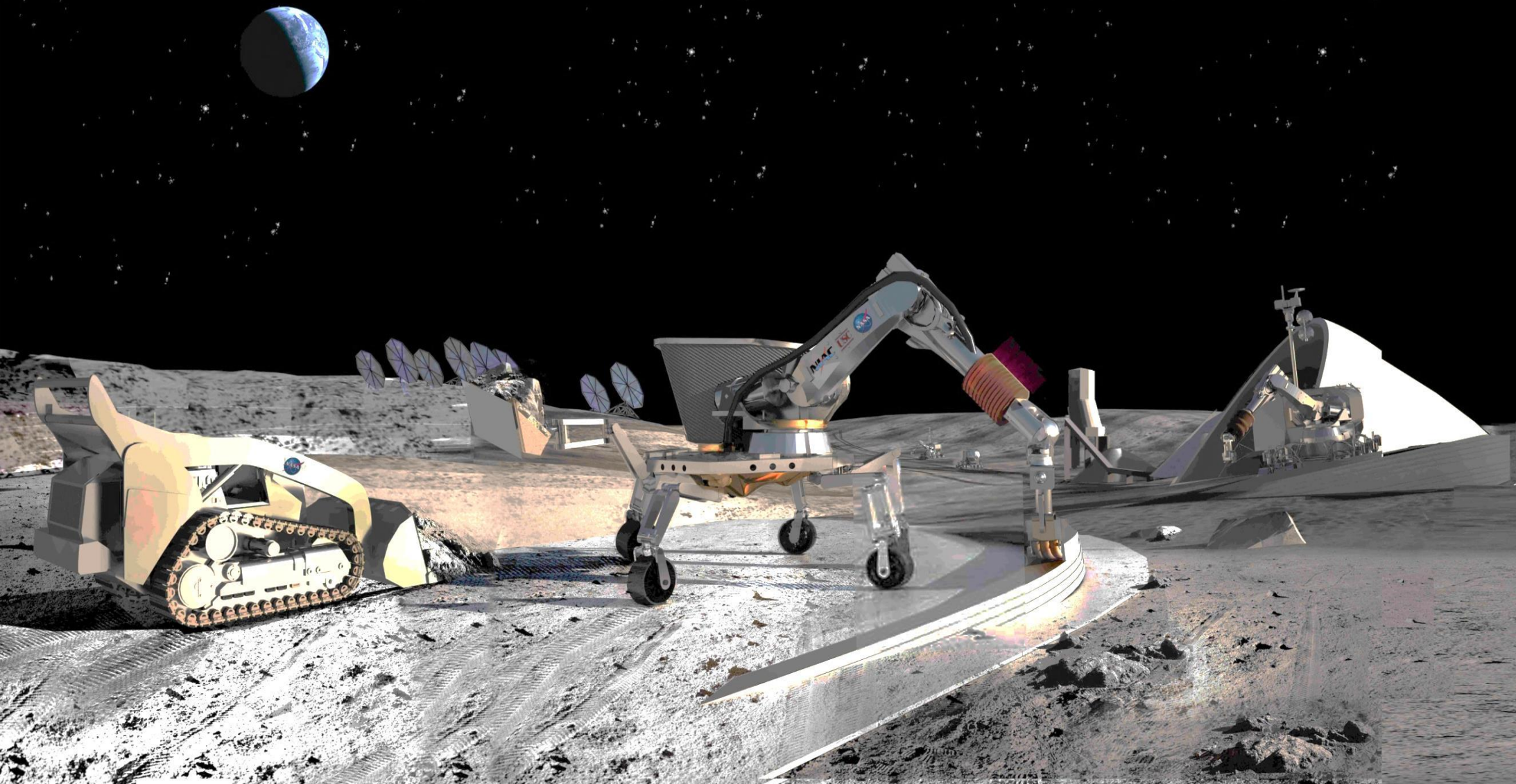
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<u>Company</u>	<u>Target Body</u>	<u>Objective</u>
Astrobotic Technologies	Moon	Water
Shackleton Energy Corp.	Moon	Water
Moon Express	Moon	Metals
Shamayan Innovation Partnerships	Moon/Asteroids	Metals
Planetary Resources, Inc.	Asteroids	Water/Metals
Deep Space Industries	Asteroids	Manufacturing

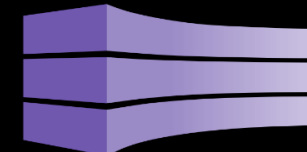
Extraterrestrial Construction by CC



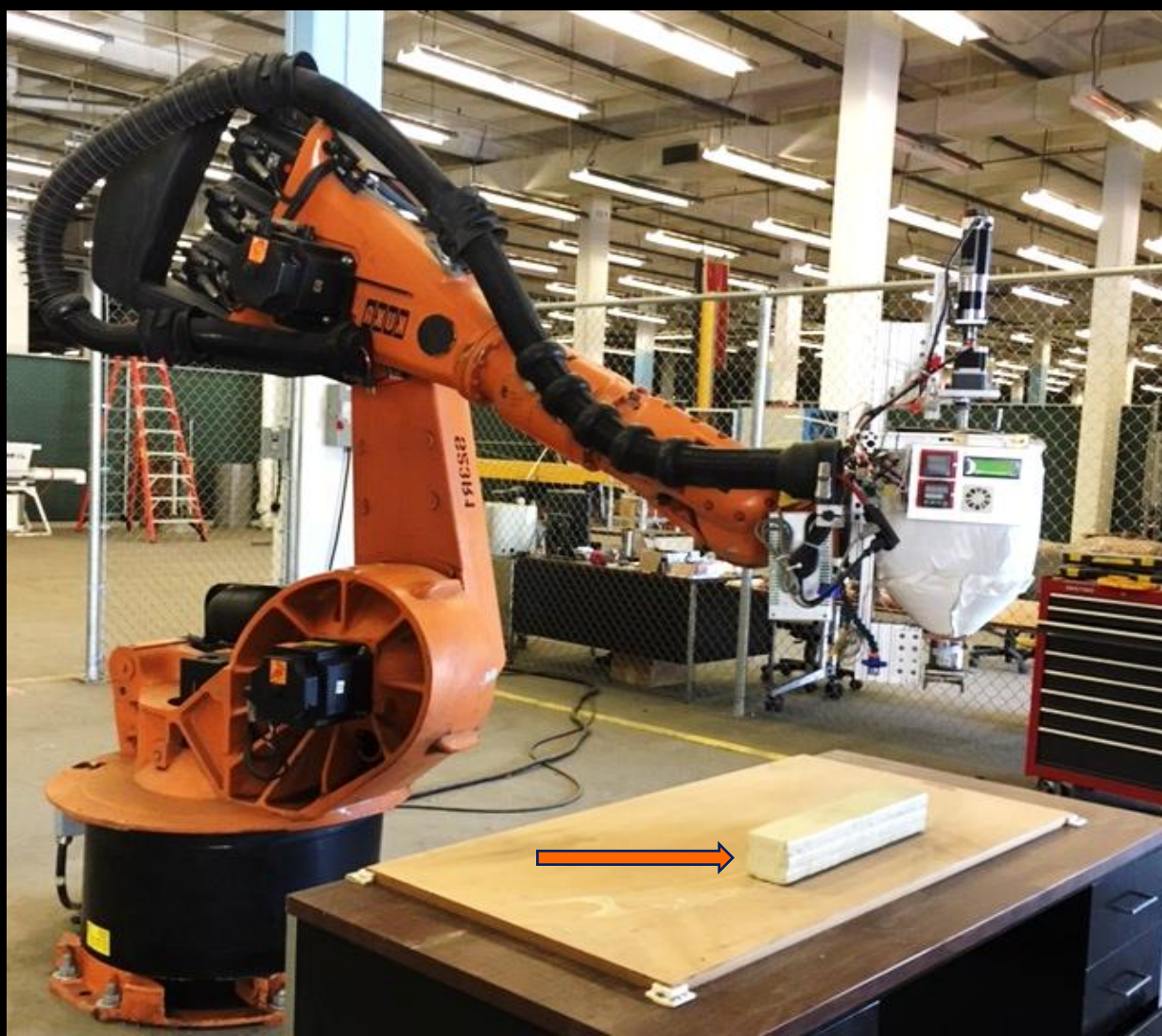
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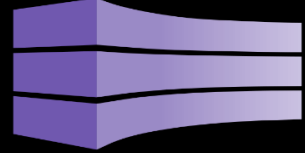


Autonomous construction with **waterless** concrete



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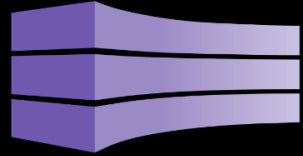




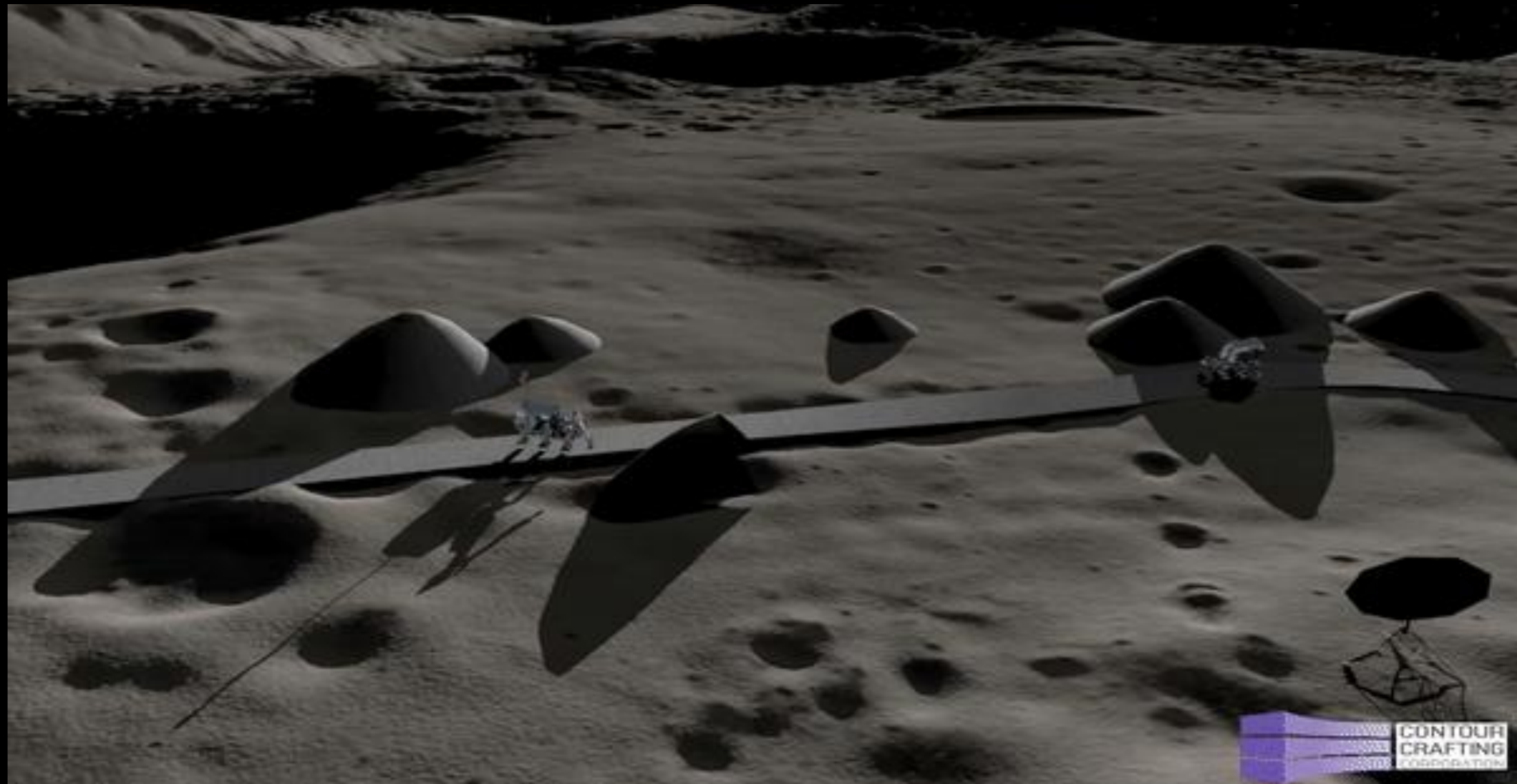
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Planetary construction using in-situ material

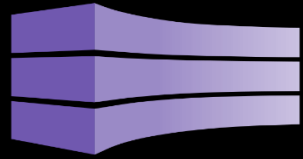


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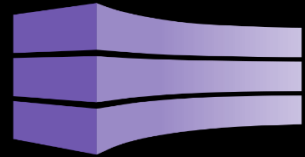


NASA awarded Contour
Crafting the Grand Prize
among 1000+ globally
competing technologies in the
*Create the Future
Design Contest*

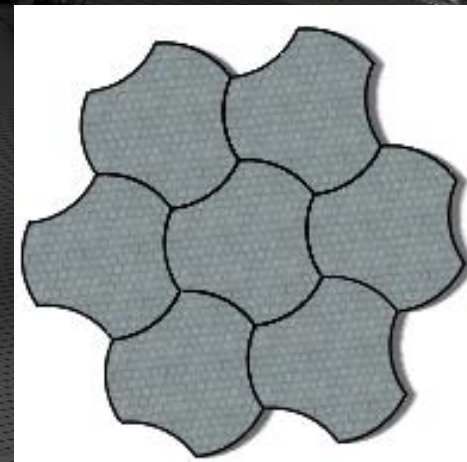
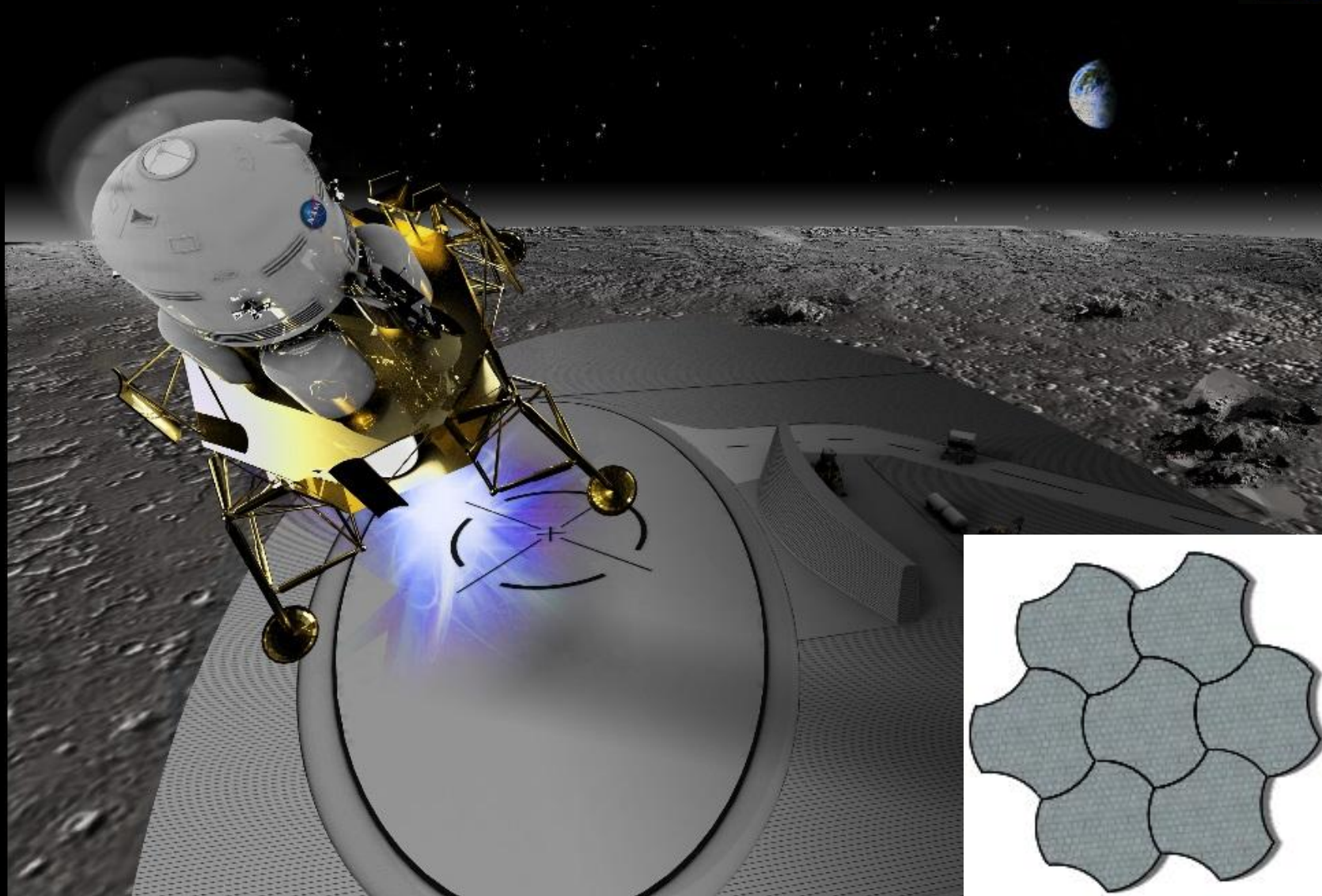


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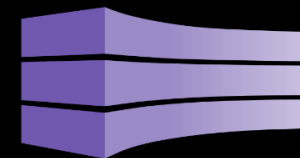
Horizontal construction – Landing Pads



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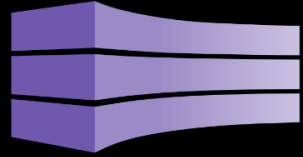
New Large-Scale AM Processes



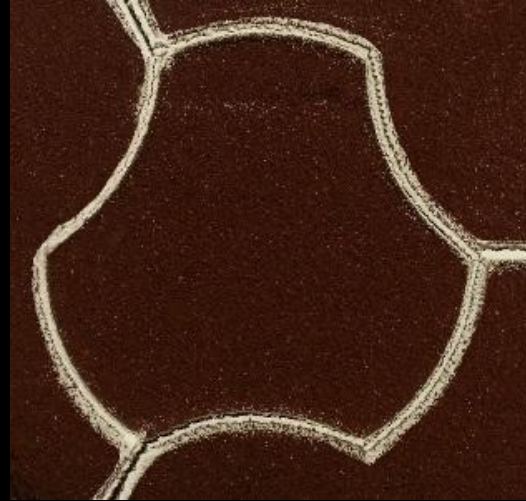
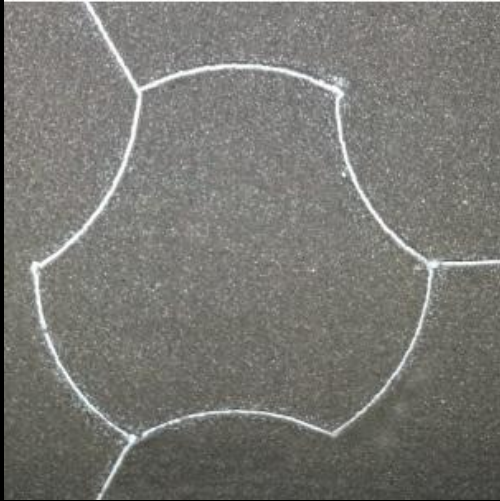
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SSS (Selective Separation Shaping)

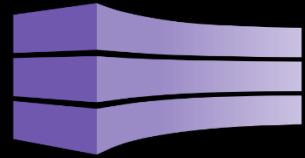


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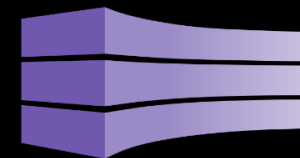
A new large-scale
powder-based 3D
printing Technology

Planetary Deployment



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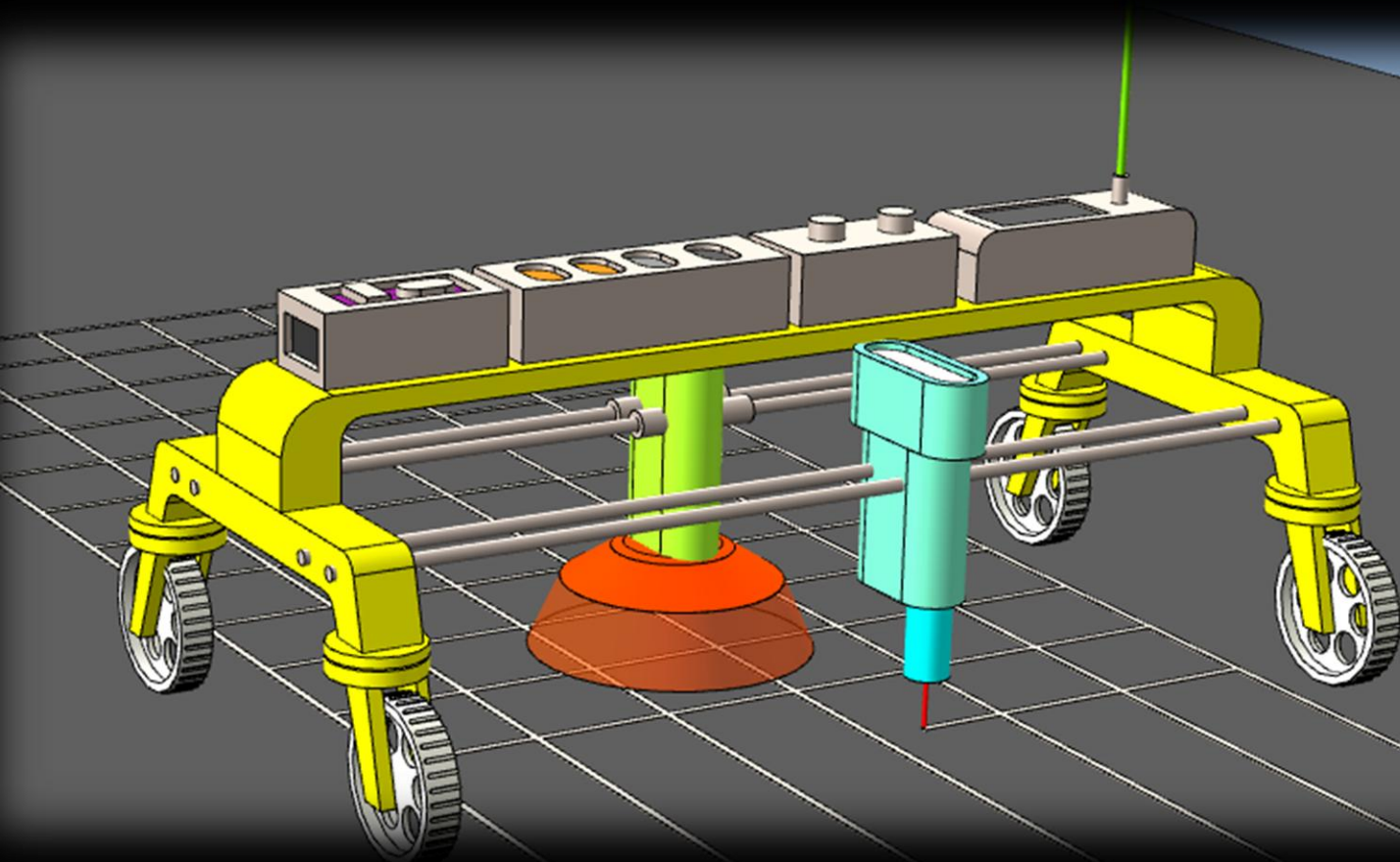
Landing on unprepared surfaces is prone to catastrophic accidents as the redrock surface under the sand may be too slant.



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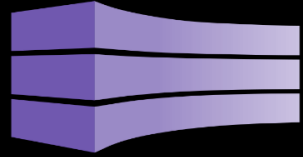


NASA awarded SSS the Grand
Prize in the *International In-Situ
Resource Based Fabrication
Competition*



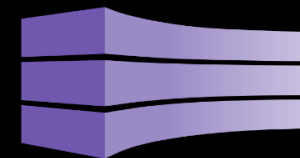
Other research directions

- Process innovation and improvement
- Materials
- Impact on BIM and BIM integration
- IoT roles and synergies

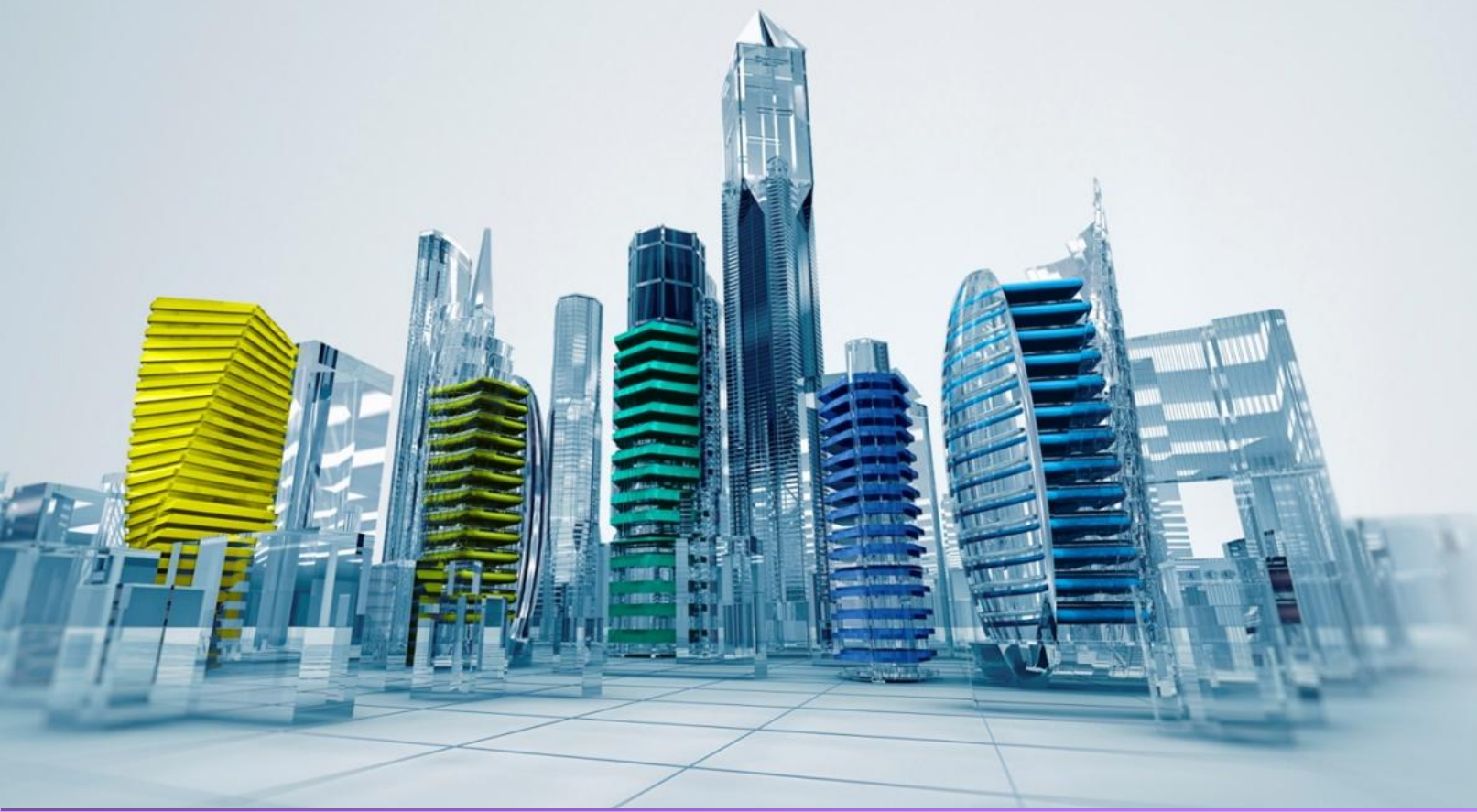


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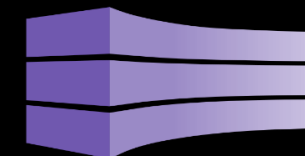
2017 Investment by Doka



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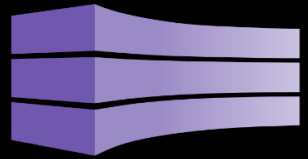


Contour Crafting Corporation (CC Corp)



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