LEIDEN, NETHERLANDS - DECEMBER 2015

CLOSING REMARKS

NANORACKS

BLUE ORIGIN

AIRBUS DEFENCE & SPACE

#FUTUREISS

MADE IN SPACE

Since 2010, Made In Space has been the leaders of In-Space Manufacturing

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Digital Deliveries with our ISS 3D Printer

The Additive Manufacturing Facility

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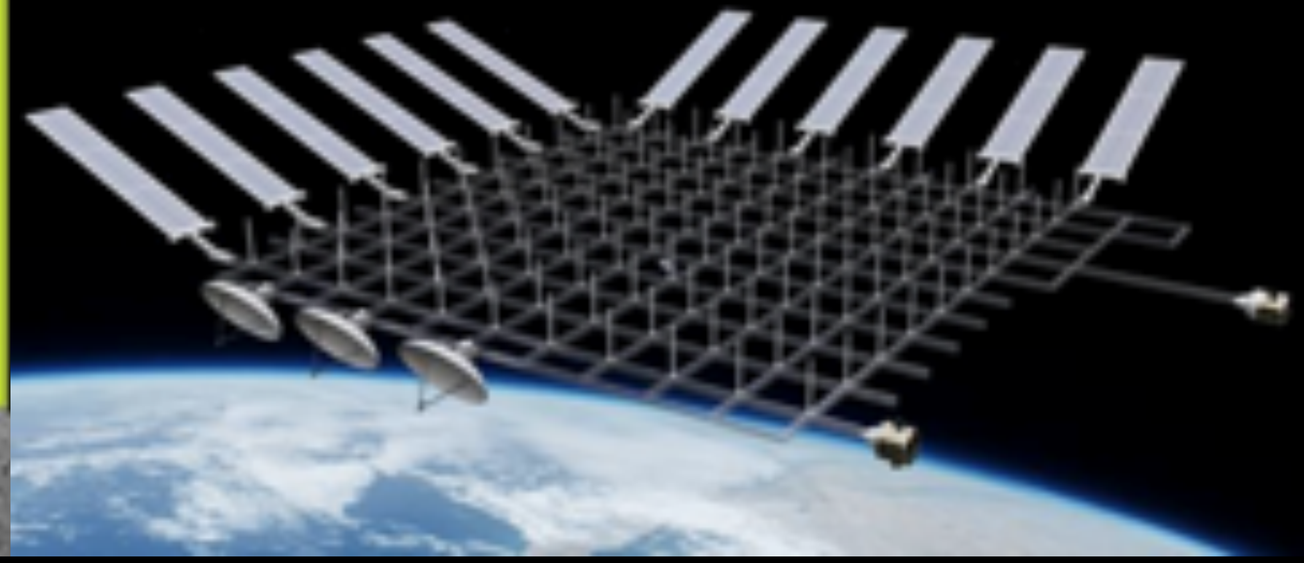
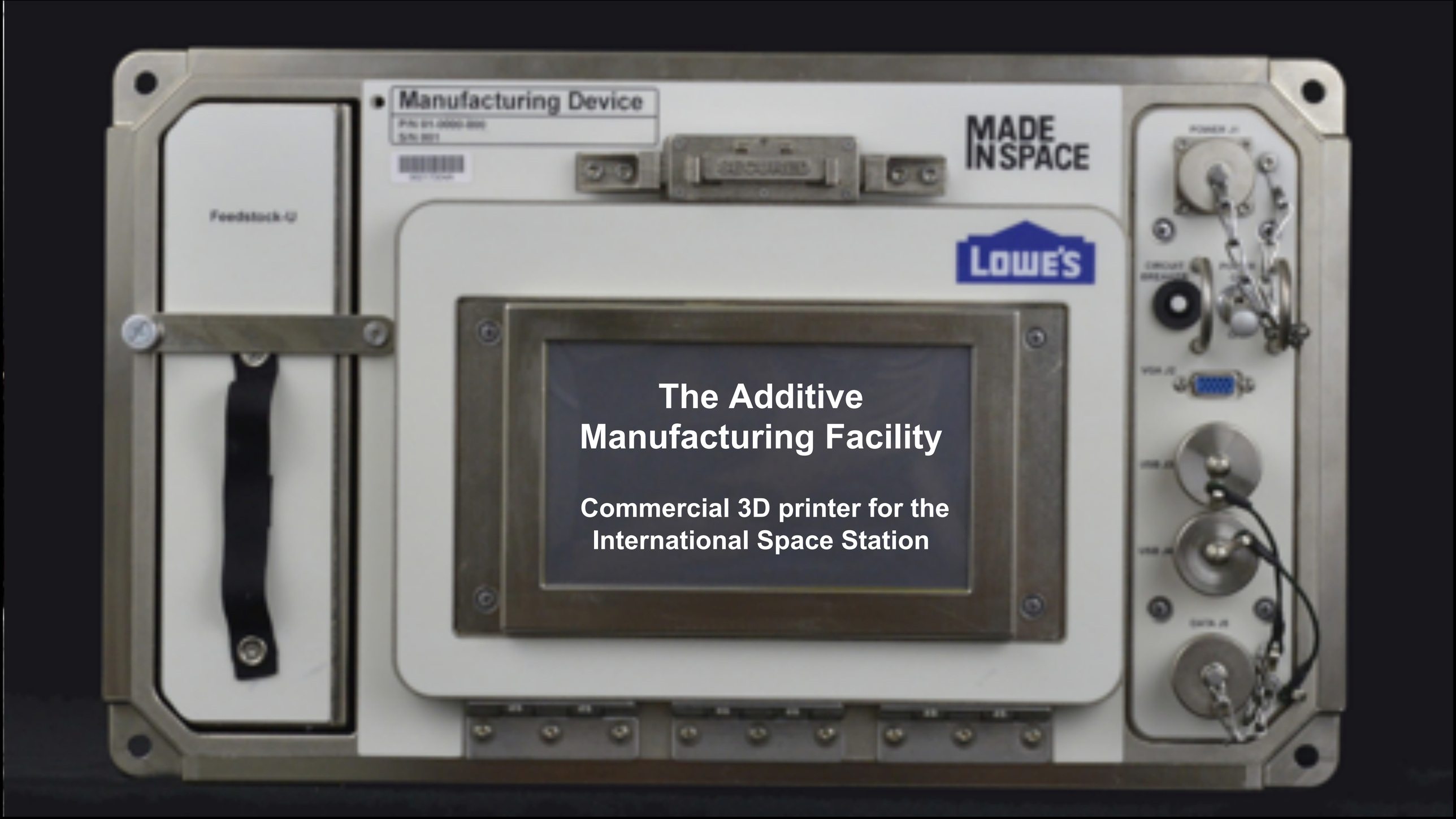
Building the future of space manufacturing




Manufacturing Device
MADE IN SPACE
LOWE'S
Feedstock U
The Additive Manufacturing Facility
Commercial 3D printer for the International Space Station

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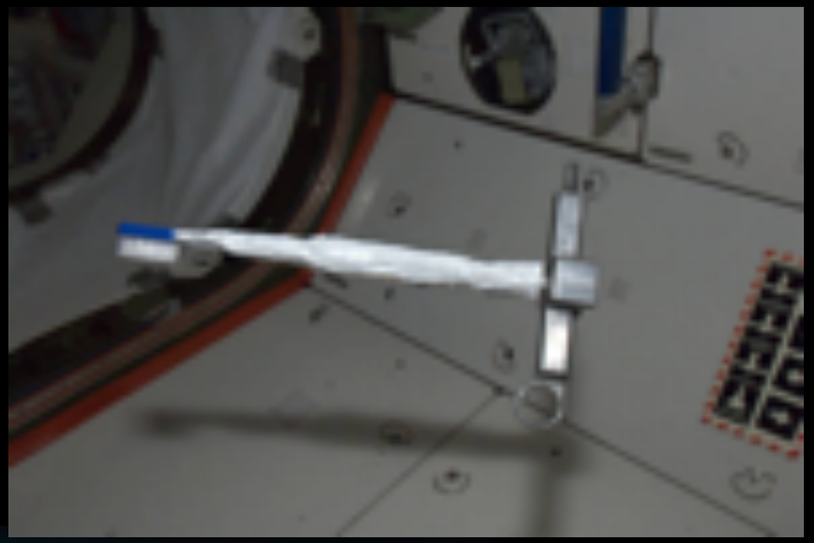
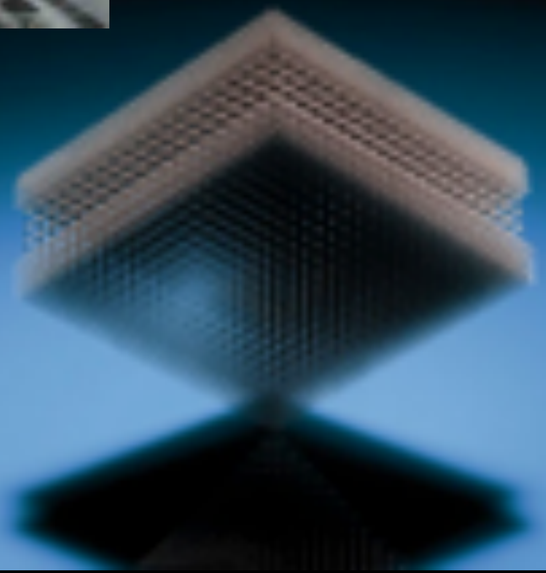
Why manufacture on the ISS?





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STEM

low cost access to space

3D Printing In Zero-G Experiment

The 1st 3D Printer in Space

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3D Printing In Zero-G Experiment Results

Mission Success!

- Demonstrated 3D printing in microgravity to create ABS plastic items
- Completed full set of 21 parts and 4 calibration prints in just 3 weeks
- Demonstrated remote operation of 3D printing
- Demonstrated on-demand uplinking and printing of part (ratchet)
- Developed on-orbit operations for in space manufacturing
- Planning underway for more printing

Technology developed and lessons learned were applied to our 2nd on-orbit 3D printing system:

Additive Manufacturing Facility
(AMF)

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The first items 3D printed in space.

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5 Main Technological Challenges:

1. Fluctuating Forces → Gravity Independence
2. Unreliable Prints → Mission Critical Engineering
3. Complex Interface → Remote Operations Design
4. Safety Requirements → Strict NASA Requirements
5. Toxic Gasses → Environmental Control Unit

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Additive Manufacturing Facility

2nd Generation ISS 3D Printer

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Additive Manufacturing Facility Overview:

Key Specifications

- Extrusion based 3D printing technology
  - Suitable for a range of Polymers as well as Composite materials
- Designed to operate in an EXPRESS Rack MDL.
- Integrated printed part Verification system
- Replaceable Subassemblies

Bigger, Better, Faster

Additive Manufacturing Facility Specifications:

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Print Volume
Up to 18 cm x 14 cm x 10 cm

Materials
ABS - Rigid and strong polymer material used on the 3D Printing in Zero-G experiment

PEI/PC - Aerospace grade Engineering Plastic with low outgassing and flammability

HDPE - Durable and flexible polymer

Resolution
Down to 75 micron layer height

Print Features
Thin walls down to 1mm
Thru holes
Threaded holes >M10
Overhangs up to 3 inches

Spares and Consumables
- 1 year supply of material
- Quick swap components

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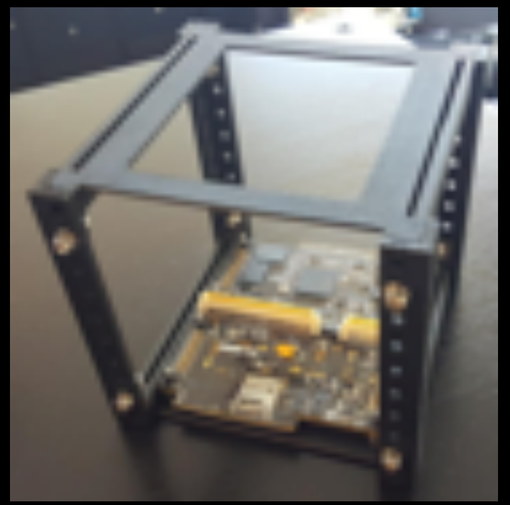
Example Applications:

- ❏ 3D printing in microgravity science
- ❏ Support Experiments
- ❏ Consumables
- ❏ Replacement parts
- ❏ On-demand items
- ❏ Crew Tools
- ❏ Design iterations
- ❏ Satellites
- ❏ Hardware emergencies
- ❏ Many more..



Concept of Operations:

- Customer supplies design CAD and/or requirements
- MIS creates printable file configured for AMF
- Test print on Ground Unit supplied for fit check
- File uplinked to AMF on ISS for printing
- Print initiated and monitored by MIS Ground Crew
- ISS Crew removes part from AMF

“Email your hardware to space”

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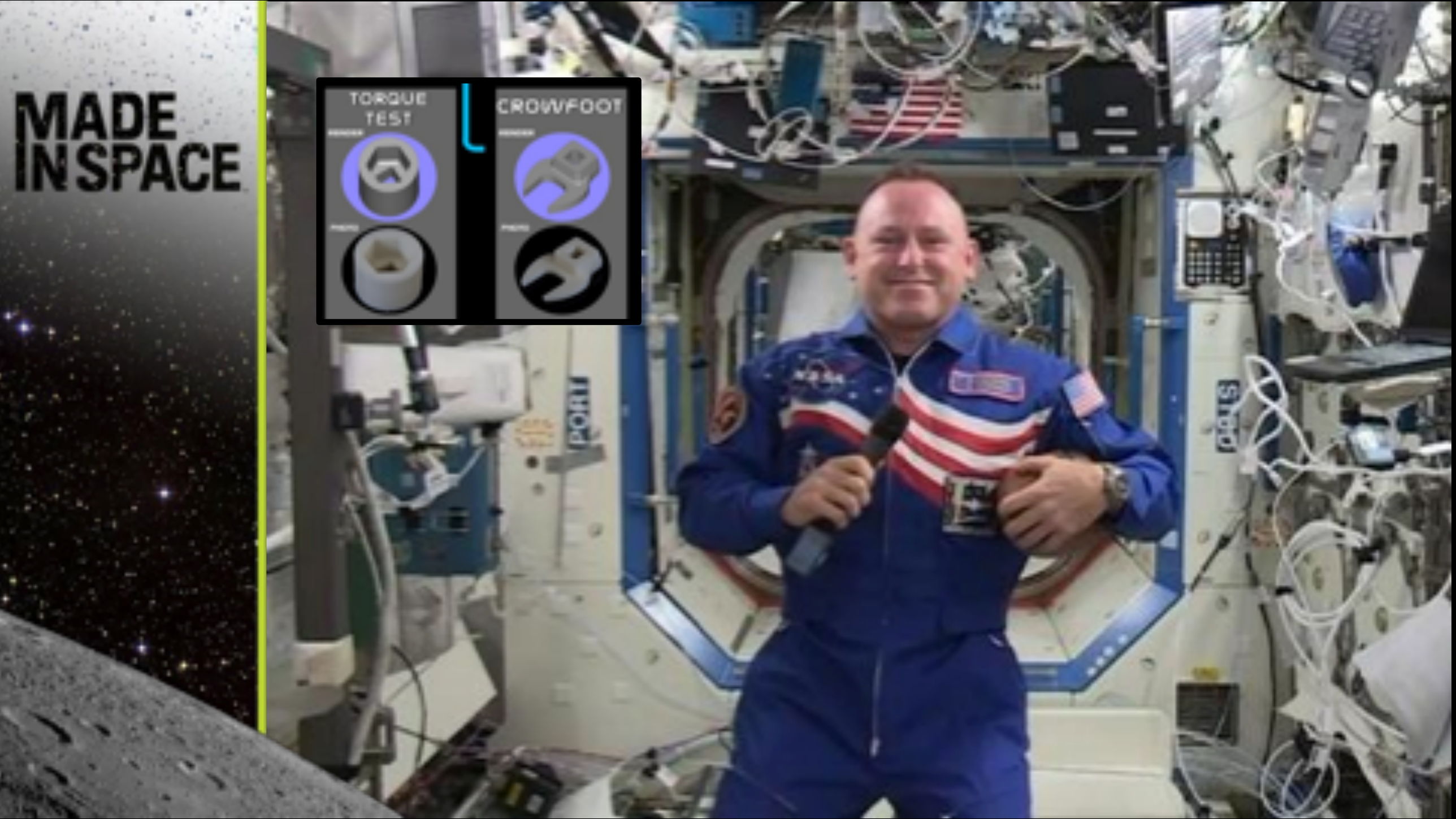
Concept of Operations Case Study:


MADE IN SPACE
TORQUE TEST
CROWFOOT


MADE
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acer


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IN SPACE

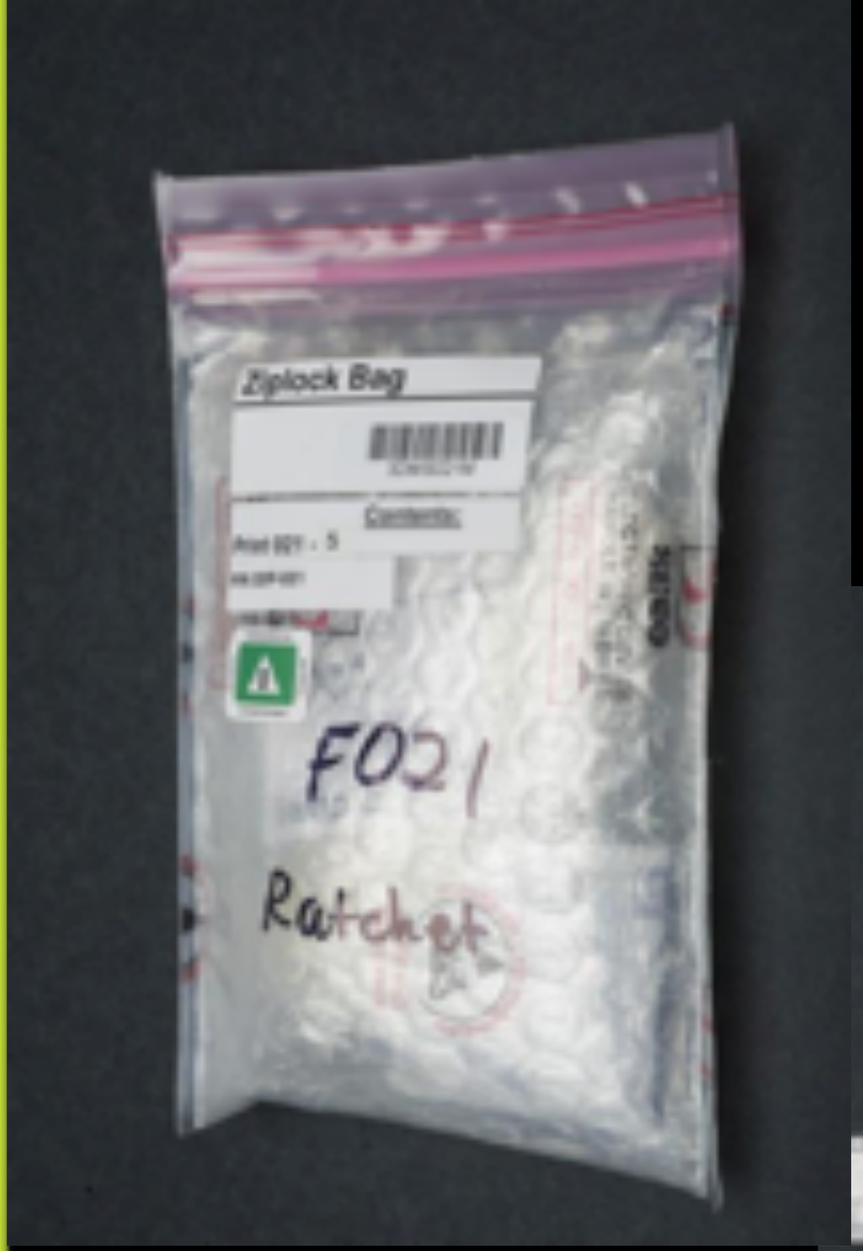
MADE IN SPACE

MADE IN SPACE


MADE IN SPACE
3 in-lb
3 in-lb
2450/70C | 50mm/sec | 0.2mm Layer Height | 5 hours
NASA
3D PRINTED WRENCH
3 in-lb
3 in-lb
3 in-lb

MADE IN SPACE

MADE IN SPACE



F021 - Ratchet

End Use Options:

- Bagged and down massed for analysis
- Integrated into another payload
- Standalone payload
- Crew item or tool
- Launch from ISS (satellites)

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On-demand Satellites

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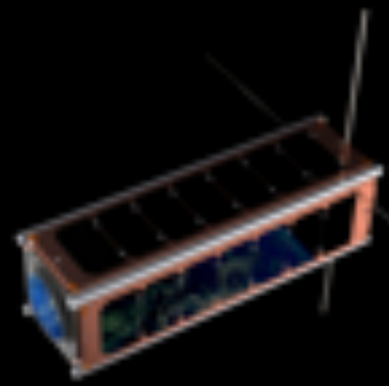
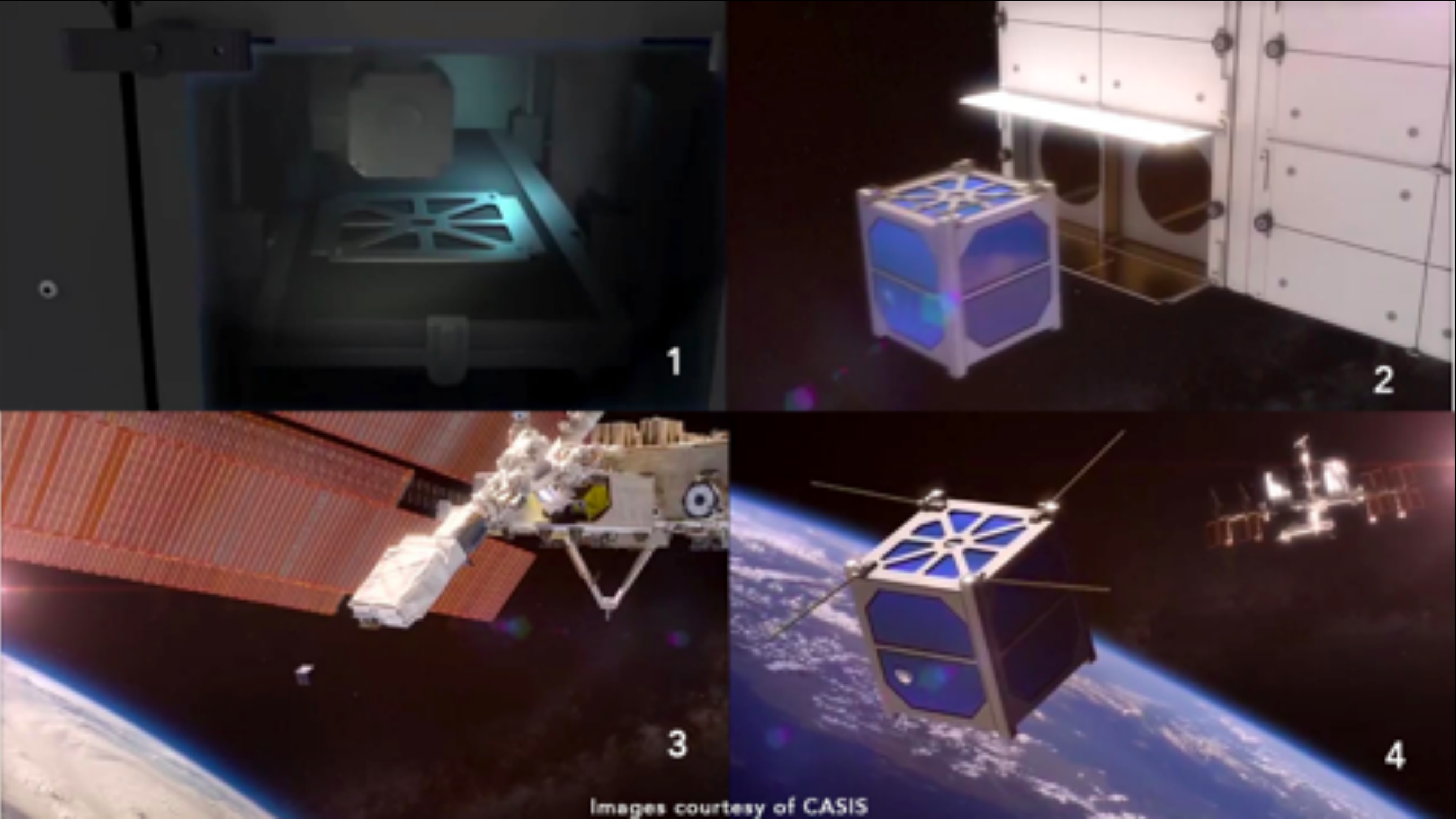


Stash-and-Deploy

Commercial Manufacture and Deployment of CubeSats from Orbit



Images courtesy of CASIS

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In-Space Manufacturing

- On the International Space Station
- Large Space Structures
- On-demand Satellites

Questions

Contact Made In Space or Nanoracks for more information:

Matthew Napoli
matt@madeinspace.us