FABRICATING FOR, AND IN SPACE

HARNESSING THE REVOLUTION.....
.... or and JUMPING ON THE BANDWAGON

FAB 8 - New Zealand

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NASA’s Missions

**Exploration**
- Local space environment
- Return to the Moon
- Manned presence on Mars (future)
- Space Biology/Human Health Science

**Science**
- Understand the nature of the solar system and universe
- Near Earth Objects (NEO)
- Lunar sciences
- Astrobiology
- Earth Science/Environmental Monitoring/Energy Mgmt
### Space Technology Grand Challenges

#### Expand Human Presence in Space

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<tr>
<th>Economical Space Access</th>
<th>Space Health and Medicine</th>
<th>Telepresence in Space</th>
<th>Space Colonization</th>
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#### Manage In-Space Resources

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<th>Affordable Abundant Power</th>
<th>Space Way Station</th>
<th>Space Debris Hazard Mitigation</th>
<th>Near-Earth Object Detection and Mitigation</th>
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#### Enable Transformational Space Exploration and Scientific Discovery

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<th>Efficient In-Space Transportation</th>
<th>High-Mass Planetary Surface Access</th>
<th>All Access Mobility</th>
<th>Surviving Extreme Space Environments</th>
<th>New Tools of Discovery</th>
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Innovation in Small Satellites
Cubesats: Biological Missions

- Gene-Sat 1
- Pharmasat-1
- O/OREOS
TechEdSat
NASA Technology Demonstration Mission

Sponsored by the Office of the Chief Technologist, this mission will demonstrate NASA Ames Research Center's first Space Plug-and-Play Avionics (SPA) satellite with cross-link communications capability.

**Project Schedule**
- PDR Date: 10/02/2011
- CDR Date: 04/15/2012
- Hardware Delivery Date: 06/12/2012
- Launch Date: 06/26/2012
- Release from ISS: 09/2012
- End of Mission: Approximately 12/2012

**Points of Contact**
- NASA
  - John W. Thomas, Director, Advanced Development and Research Center 
  - John M. Hofstra, Deputy Director, Advanced Development and Research Center
- JAXA
  - Takeshi Nakamura, Deputy Director, Advanced Development and Research Center
- AAC Microtec
  - Andreas Berthold, President
  - Marco Schütz, Marketing Manager

NASA acknowledges the contributions of the following:
- NCASST
- JAXA
- AGI
- SPACE SYSTEMS LORAL
Cubesat Payloads on the ISS

Nanolab

NanoRacks
**MisST 6U+ Spacecraft**

**HyCube**: Hyperspectral Imager for Coastal Ocean Color
(A. Ricco, NASA-Ames)

**Configuration**: 6U Small Satellite
Bus: 1U, ADCS: 1.5 U
HyperSpectral Imager: 2U; Processor: 1U
Jettisonable drag kite: .5U
Key capability demos: In a small sat:
- High-performance ADCS for science: Earth imaging & astronomy
- "Large sat" data processing in a 6U
- 10x - 100x data volume throughput improvement
- Formation flying: single launch, multiple orbits

**Planetary Hitch Hiker**

Modularity enables payload, propulsion, and launch flexibility.

- Green propulsion
- 6U nanosat dispenser
- Low-cost and versatile platform
- Comsat and ESPA Compatible
- Standardized nanosat payloads

**MAAT**: Small Satellite Rendezvous and Characterization of Asteroid 99942 Apophis

**MAAT**
Ames Research Center

Measurement & Analysis of Apophis Trajectory
Collapsible Dobson Space Telescope
A. Rademacher, NASA-Ames

Design to fit within a 6u nanosatellite architecture
- 6in, f8 Telescope
- 1250mm focal length

2u x 2u bay for telescope payload
- Bay size ~ 20cm x 20cm x 10 cm
ARC 6U+ Dispenser

- 3U Or 6U Dispenser
- Modular Construction
- Similar Architecture/Philosophy as PPOD
- Mounts Identically as Two 3U PPODs Side by Side
- Dispenser Satellite Release Velocity Range: 1.18 M/S – 2.03 M/S

6-Pack Nanosatellite Possible Configurations (2N/6Cube)

[assumes 2U equivalent bus, 4U payload volume]

A 6U payload has a 175 Watt deployed solar panel.

Roller bearings on the ends of the deployables.

2275 mm
[89.6 in]
SYNTHETIC BIOLOGY

During the next 50 years...

✓ We will travel to the Moon and Mars
✓ We will travel to asteroids
✓ We will use Synthetic Biology to revolutionize our approach to sustaining life in space, and defining our purpose there

The Past:
We took familiar biological organisms into space, and engineered environments to suit them.

The Future:
We will engineer biological systems to make them suited to extraterrestrial environments, and employ these systems in new kinds of missions

"Over the next 20 years, synthetic genomics is going to become the standard for making anything. The chemical industry will depend on it. Hopefully, a large part of the energy industry will depend on it."

- J. Craig Venter, 2007
Space Synthetic Biology HW Elements

- Specimen Habitat
- Sample Handling
- Process Monitoring
- Process Control
- Bioreactor
- Mfg, Prod (scale up)
- Application/Utilization
ADVANCED MANUFACTURING

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National Center for Advanced Manufacturing
Louisiana Partnership

Manufacturing Innovation Project (MIP)

ADVANCED DIGITAL MATERIALS and MANUFACTURING for SPACE (ADMMES)

Ames Research Center in Silicon Valley...
...Innovation starts here
In his remarks on March 9, 2012, at the Rolls-Royce Crosspointe jet engine disc manufacturing facility in Virginia, the President announced a proposal to create a National Network for Manufacturing Innovation made up of up to 15 Institutes for Manufacturing Innovation around the country. The Institutes will bring together industry, universities and community colleges, federal agencies, and regional and state organizations to accelerate innovation by investing in industrially-relevant manufacturing technologies with broad applications. The President also announced that the Administration will take immediate steps to launch a Pilot Institute for Manufacturing Innovation, using existing resources from the Departments of Defense, Energy, and Commerce, and the National Science Foundation (NSF).

The Administration is moving quickly to act on these announcements. An interagency team is proceeding with steps, beginning in April, to engage manufacturing innovation stakeholders in the industrial, academic, and regional and state communities. This collaborative process will result in:

- the award of the Pilot Institute and
- a detailed design for the full Network that will support Congressional consideration.
ARC Strategic Technology Initiatives 2012

Active Initiatives
1. Biological Technologies for Life Beyond Low Earth Orbit (BT4LBLEO)
2. Small Spacecraft and Missions Enterprise (SSME)
3. Science Instruments for Small Missions (SISM)
4. Advanced Digital Materials and Manufacturing for Space (ADMMS)
5. Designing High-Confidence Software and Systems (DHCSS)
6. Cyber-Physical Systems Modeling and Analysis (CPSMA)

Other Suggested Initiatives
1. First Responder, Emergency, and Diasaster Assistance (FREDA)
2. Emerging Aeronautics Systems and Technologies (EAST)
3. GREEN Technologies (Technologies for Sustainability)
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ADMMS

SpaceShop

Proto / Flight Hardware

ADMMS Network

ADMMS Facilities

HOME

ADVANCED DIGITAL MATERIALS and MANUFACTURING for SPACE
TechEdSat-1.1
Launch 21JUL2012
TechShop is a membership-based workshop that provides members with access to tools and equipment, instruction, and a community of creative and supportive people so they can build the things they have always wanted to make.

You can think of TechShop like a fitness club, but with tools and equipment instead of exercise equipment. It is sort of like a Knik's for makers, or a Xerox PARC for the rest of us.

TechShop is designed for everyone, regardless of their skill level. TechShop is perfect for inventors, makers, hackers, tinkerers, artists, roboters, families, entrepreneurs, youth groups, FIRST robotic teams, arts and crafts enthusiasts, and anyone else who wants to be able to make things that they dream up but don't have the tools, space or skills.

TechShop provides access to a wide variety of machinery and tools including milling machines and lathes, welding stations and a CNC plasma cutter, sheet metal working equipment, drill presses and band saws, industrial sewing machines, hand tools, plastic and wood working equipment including a 4' x 8' ShopBot CNC router, electronics design and fabrication facilities, Epilog laser cutters, tubing and metal bending machines, a Dimension SST 3-D printer, electrical supplies and tools, and pretty much everything you'd ever need to make just about anything. TechShop is for EVERYONE!

If you already know how to use all the stuff at TechShop, that's great. If you want to learn about the equipment and tools you have never used before, you can take an SBU (Safety and Basic Use) class and get up to speed on that tool or machine in just a few hours. Don't be afraid to try new things, whether it is welding, using a milling machine, working with fabrics and leather or plastics, or cutting keyways in a gear.

The whole point of TechShop is to empower you with a wide variety of new capabilities so you can start to see the pathway that lets you make new and exciting things. TechShop is ready to help you Build Your Dreams Here.
Selective Laser Sintering (SLS)

Selective Laser Sintering (SLS) uses a laser to sinter powder based materials together, layer-by-layer, to form a solid model. The system consists of a laser, part chamber, and control system.

The part chamber consists of a build platform, powder cartridge, and leveling roller. A thin layer of build material is spread across the platform where the laser traces a two-dimensional cross section of the part, sintering the material together. The platform then descends a layer thickness and the leveling roller pushes material from the powder cartridge across the build platform, where the next cross section is sintered to the previous. This continues until the part is completed.

Once the model is complete, it is removed from the part chamber and finished by removing any loose material and smoothing the visible surfaces.

**SLS Highlights**

- Ideal for durable, functional parts with a variety of applications. Capable of producing snap fits and living hinges.
- Maximum dimension for instant quote: 28" x 19" x 19". Parts with larger dimensions are also available. Please contact your sales manager to discuss.
- SLS Material choices include: Nylon (Duraform PA), Glass-Filled Nylon (Duraform GF), Flame Retardant Nylon and Durable Nylon (Duraform EX).
- Standard Tolerances: of +/- 0.005" for the first inch, and +/- 0.003" for each additional inch.
- In the z height (vertical), standard tolerances of +/- 0.01" for the first inch, +/- 0.003" on every inch thereafter.
- Layer Thickness: 0.004".
- Good Choice for high-heat & chemically resistant applications.
- Lead Time Options: Next-day Delivery, Standard, and Economy.

Samples available upon request.
**WINDFORM XT 2.0**

**FEATURES**

- Class of material: Polyamide based material carbon filled
- Technology: Additive Manufacturing

**APPLICATIONS**

WINDFORM XT 2.0 is the high-tech material for Additive Manufacturing chosen by those working in the Motorsport, Automotive (suitable for example for components under the hood, such as intake manifolds and functional cooling ducts), Air (for components: UAV, Unmanned Aerial Vehicle) Aerospace (useful also to create prototype satellites, such as the CubeSat) and Design, as it allows applications that are fully functional, as well as bench testing, or testing and racing on the track.

These applications are given only as an example to show the different fields of usage: the product's versatility, combined with the technology used can assure users of infinite possibilities.

**TECHNICAL**

*Focus: Selective Laser Sintering (SLS)*

The selective laser sintering can produce a prototype by layer overlapping of polymeric material.

In an inert atmosphere room and with a constant temperature a roller rotating at opposite direction towards its forwarding, lays a thin layer of powder on a platform where the addressed laser ray sinters the material providing the Δ necessary to melting the powders.

The system does not need supports because the parts stand thanks to non-sintered powders.
Printing Solutions in Outer Space

Silicon Valley startup creates a 3D printing device that can print out a replica of the desired object in spacecrafts

Bold Valley Startup

Remember Apollo 13? The third manned mission to the moon, and arguably humankind’s greatest space catastrophe, was immortalised on celluloid by actor Tom Hanks’s famous lines “Houston, we have a problem.”

Among other complications, its oxygen tank had exploded and excessive carbon dioxide (CO2) – from the astronauts’ own exhalations – threatened the lives of the astronauts. Led by Captain Jim Lovell, the crew had heroically managed to fix the lithium hydroxide (LiOH) canisters – responsible for filtering out the CO2 – from the lunar module with whatever they could find, like duct tape and notebook covers! Even then, there were only two LiOH canisters to provide filtering for two men for two days. “With the trip back to Earth being at least four days in length, and three men on board, the CO2 content of the cabin air would rise to poisonous levels, and the crew would expire without a solution,” NASA engineer Jerry Woodfill had said. NASA had called it a “successful failure” because even though the craft never landed on the moon, its crew had battled all odds and miraculously returned home alive!

But it had taken incredible engineering prowess, amazing improvisation and every ounce of human spirit. The event, with all its complexities, has since been a continuous lesson for various space and engineering activities. Made in Space, a Silicon Valley startup in the NASA Ames campus, has designed the perfect solution within just 20 minutes of looking at the problem, with the final product being manufactured and ready to use in just a few hours! It has built a filter adapter that served the same purpose as the Lunar Module’s cartridge but connects perfectly to the Command Module’s square cartridge filter.

The product was created by 3D Printing or Additive Manufacturing. The process is similar to printing a document on your home printer. Only here, instead of ink on paper, layers upon layers of materials (like plastics and metals) are put together to create the object. So a three-dimensional object is the “printout.”

This means that virtually any object, no matter how complex its geometry, can be “printed” as and when needed. From toilet seats to parts of complicated space equipment, things break in space all the time. True to its name, Made in Space, this little startup plans to manufacture emergency solutions on demand in zero gravity, in outer space for as many of those broken parts as possible. This is revolutionary because the attitude in space so far has been to anticipate and plan accordingly for every such possible situation.

“Today, if you need coffee in space, you need to order it 18 months ahead of time! And because you need it so much in advance, you need to undertake a lot of planning as well as pay a lot of money for it,” says Made in Space Co-founder and CEO Aaron Kemmer.

But as the Apollo 13 incident has shown, it is almost impossible, incredibly stressful, expensive and, at times, life threatening to do so. The current attitude is especially not feasible for future missions to Mars and asteroids, which could be incredibly lengthy ranging from several months to over a year. You never know what will break and Made in Space’s approach of 3D printing on demand seems to be the best option.

Kemmer recalls how an International Space Station (ISS) experiment box’s connectors had broken and new connectors had to be sent up from Earth. This took several months and many millions of dollars in tests just so that the parts could survive the launch!

“We were companies able to launch the equipment – 3D printers – into space that could manufacture tools, equipment and even scaled up habitable structures, instead of sending humans, this would have greatly reduced the cost,” says Richard David, CEO of NewSpace Global, an information service provider with a speciality in aerospace.

The startup already has a couple of contracts with NASA. But its first major goal is to have their 3D printer up and running by 2014, building anything that breaks and needs repair aboard the ISS, a large spacecraft cum science lab in the Earth’s orbit where international astronauts live.

The startup’s 3D printer has already successfully demonstrated its ability to manufacture objects and parts in zero gravity. It currently prints only in plastics but aims to eventually graduate to high-quality aerospace materials like titanium. It is also in no rush to make money or meet business goals.

“We are not your typical startup. We are taking it one step at a time focusing on demonstrating that we can 3D print useful and valuable objects in space,” says Kemmer. Although that obviously includes tools, devices and parts, Kemmer hopes that the company will make small satellites and eventually pretty much everything needed in space, to be a services-based platform that will work together with government bodies for whatever they need in space, potentially charging regular customers a subscription fee for its services.

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The Space Environment

- ISS
- Free Flyers
- Asteroids
- Moon
- Mars
- Beyond