FABRICATING FOR, AND IN SPACE

HARNESSING THE REVOLUTION…..

…. ~~or~~ and JUMPING ON THE BANDWAGON

FAB 8 - New Zealand

John W. Hines
Chief Technologist
NASA-Ames Research Center
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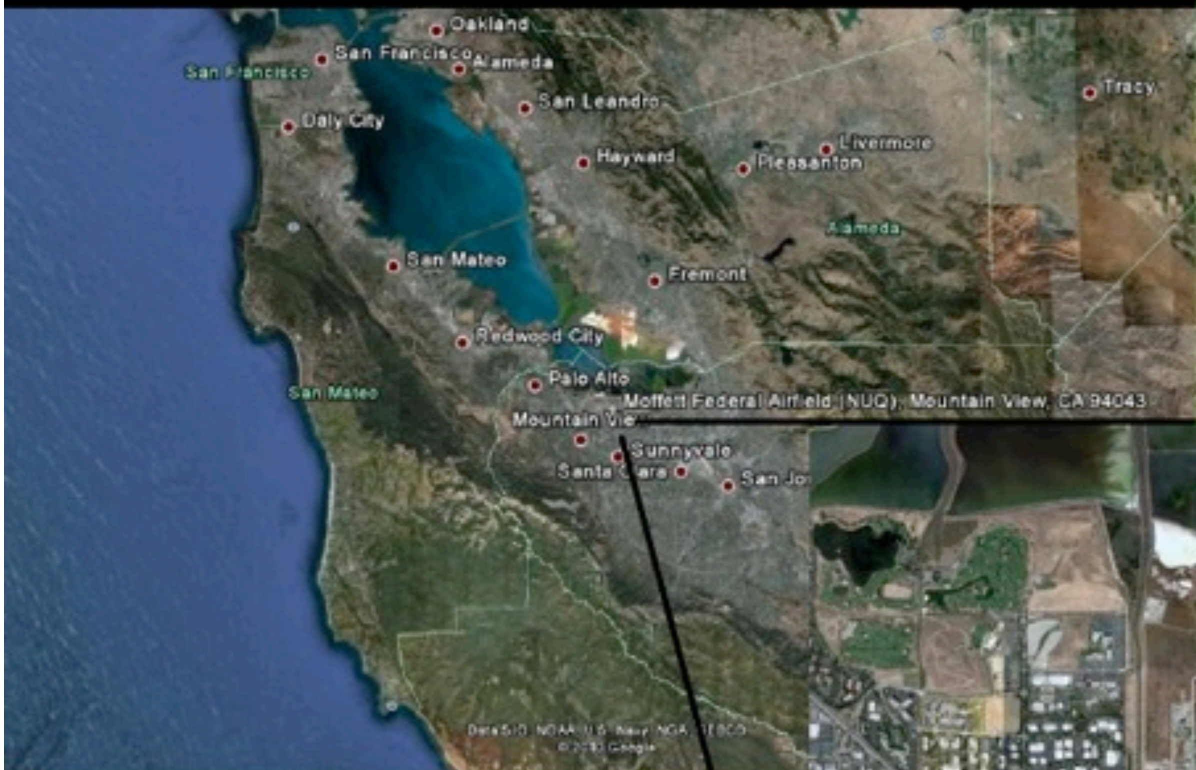
650-604-5538

AUGUST 27, 2012

Ames Research Center
in Silicon Valley…
…Innovation starts here

NASA-Ames Research Center



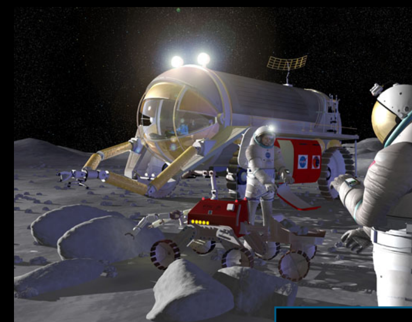
San Francisco Bay
Area
CA, USA

Ames Research Center
in Silicon Valley...
...Innovation starts here

NASA's Missions

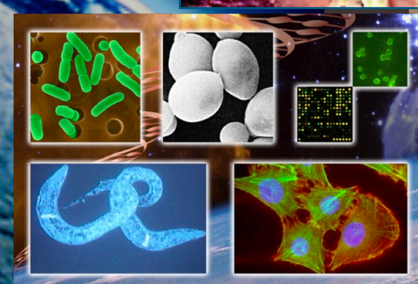

Exploration

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



Science

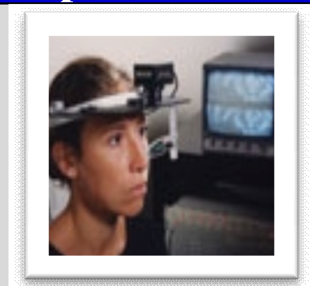
- Understand the nature of the solar system and universe
- Near Earth Objects (NEO)
- Lunar sciences
- Astrobiology
- Earth Science/Environmental Monitoring/Energy Mgmt




Space Technology Grand Challenges

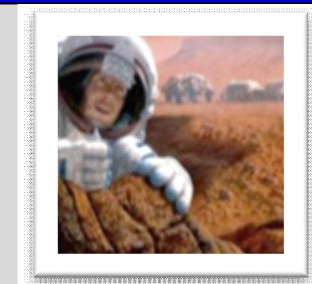
Expand Human Presence in Space

Economical Space Access



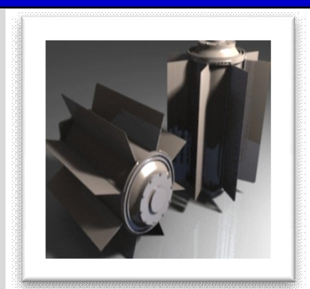
Space Health and Medicine

Telepresence in Space

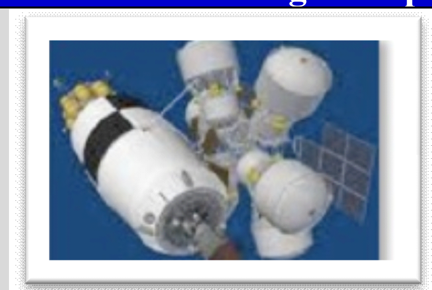


Space Colonization

Manage In-Space Resources

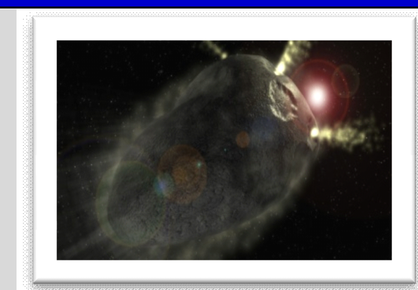


Affordable Abundant Power



Space Way Station

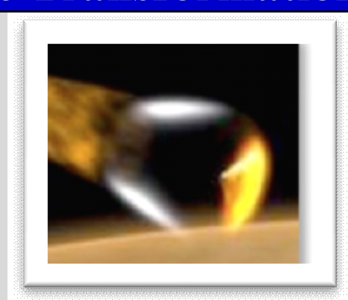
Space Debris Hazard Mitigation



Near-Earth Object Detection and Mitigation

Enable Transformational Space Exploration and Scientific Discovery

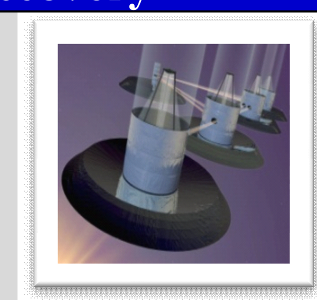
Efficient In-Space Transportation



High-Mass Planetary Surface Access

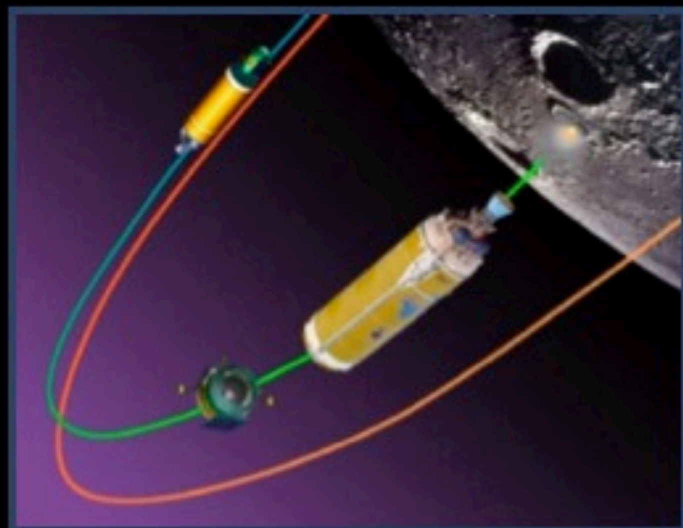
All Access Mobility

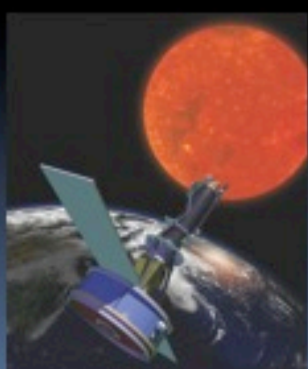
Surviving Extreme Space Environments



New Tools of Discovery

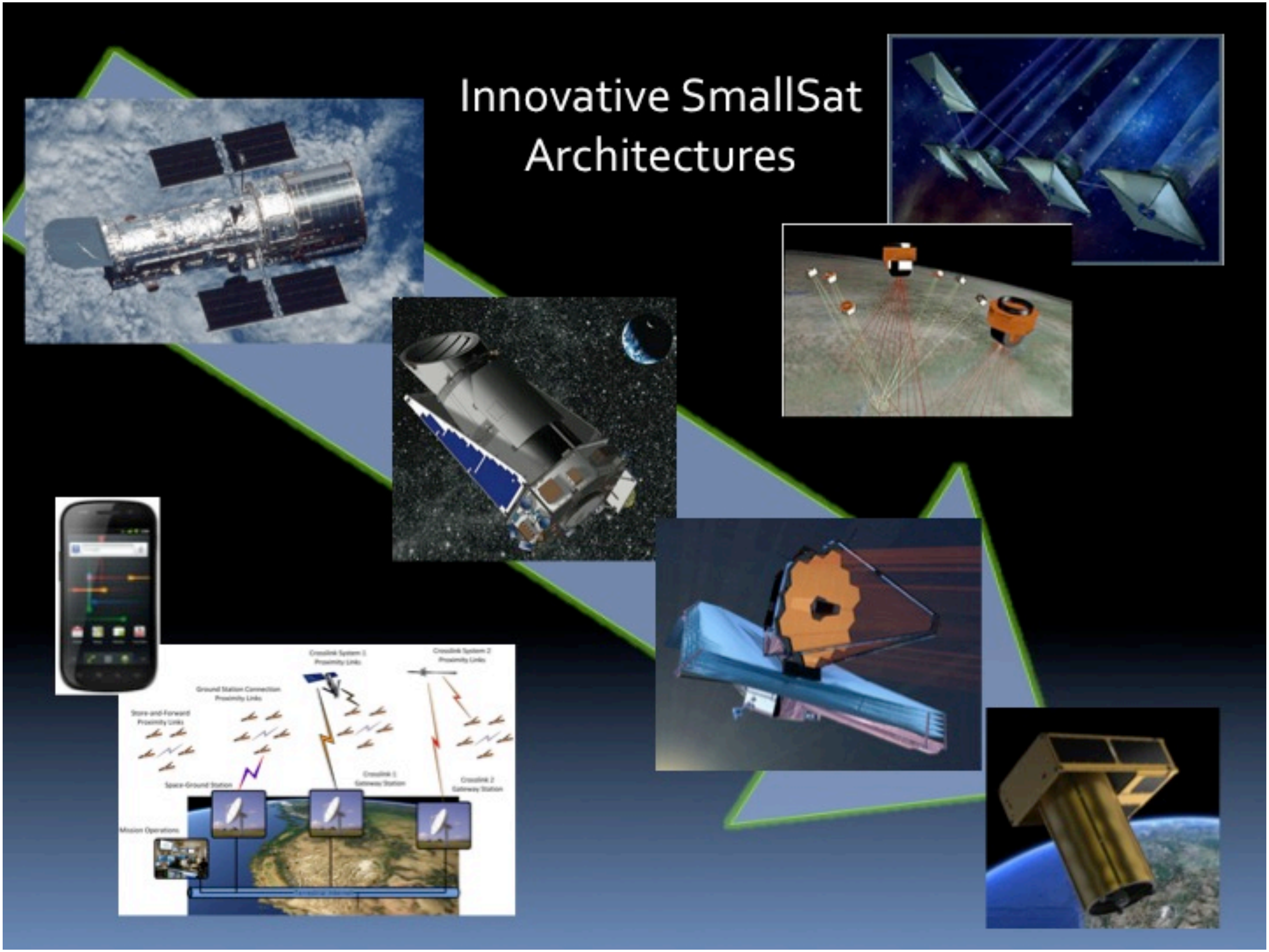
Innovation in Small Satellites





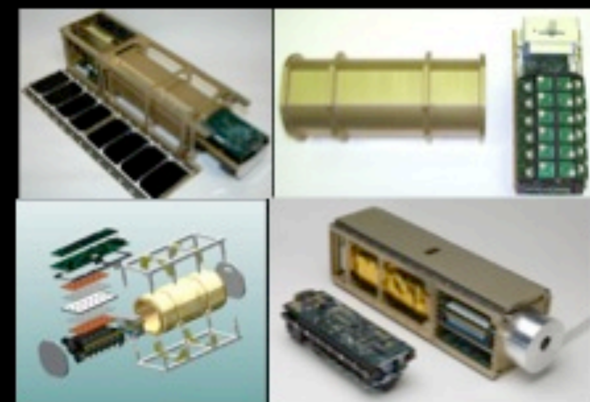
IRIS

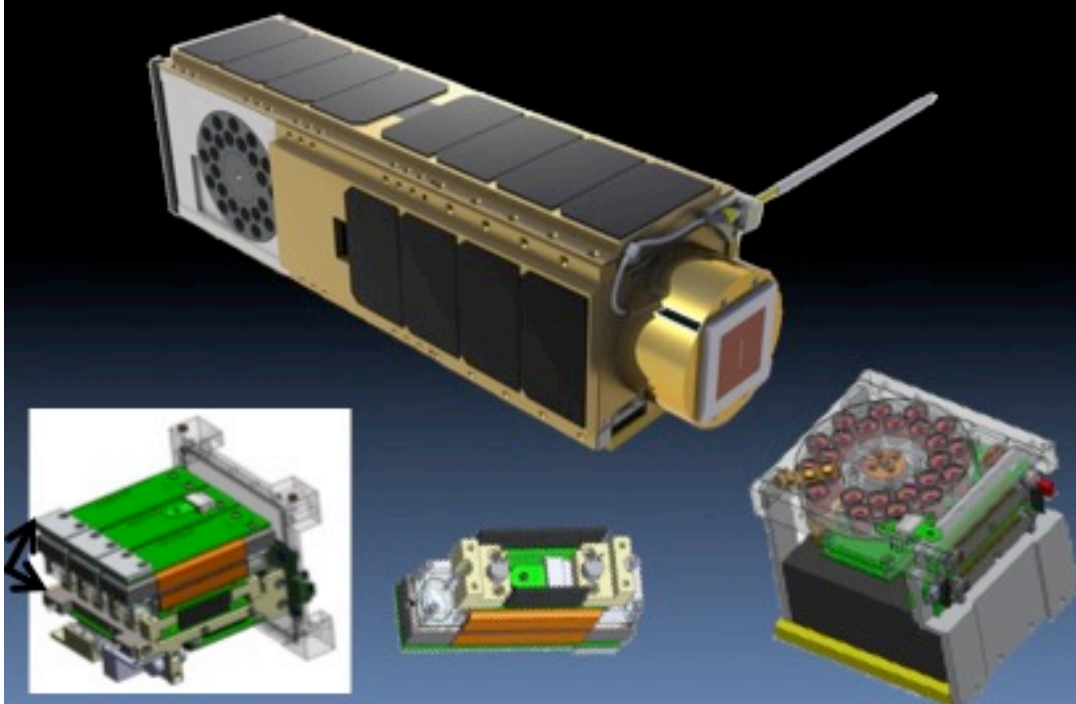
O/OREOS

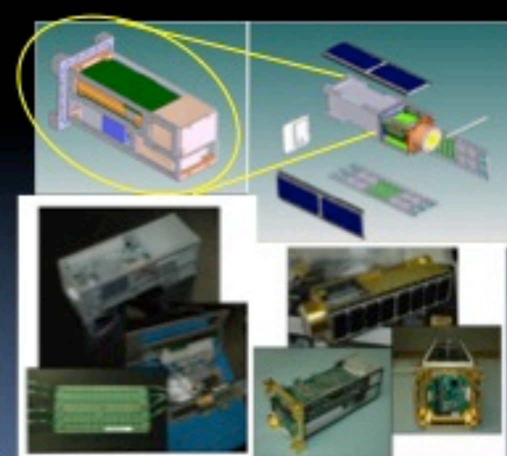

Innovative SmallSat Architectures
Crosslink System 1 Proximity Links
Crosslink System 2 Proximity Links
Ground Station Connection Proximity Links
Store-and-Forward Proximity Links
Space-Ground Station
Crosslink 1 Gateway Station
Crosslink 2 Gateway Station
Mission Operations

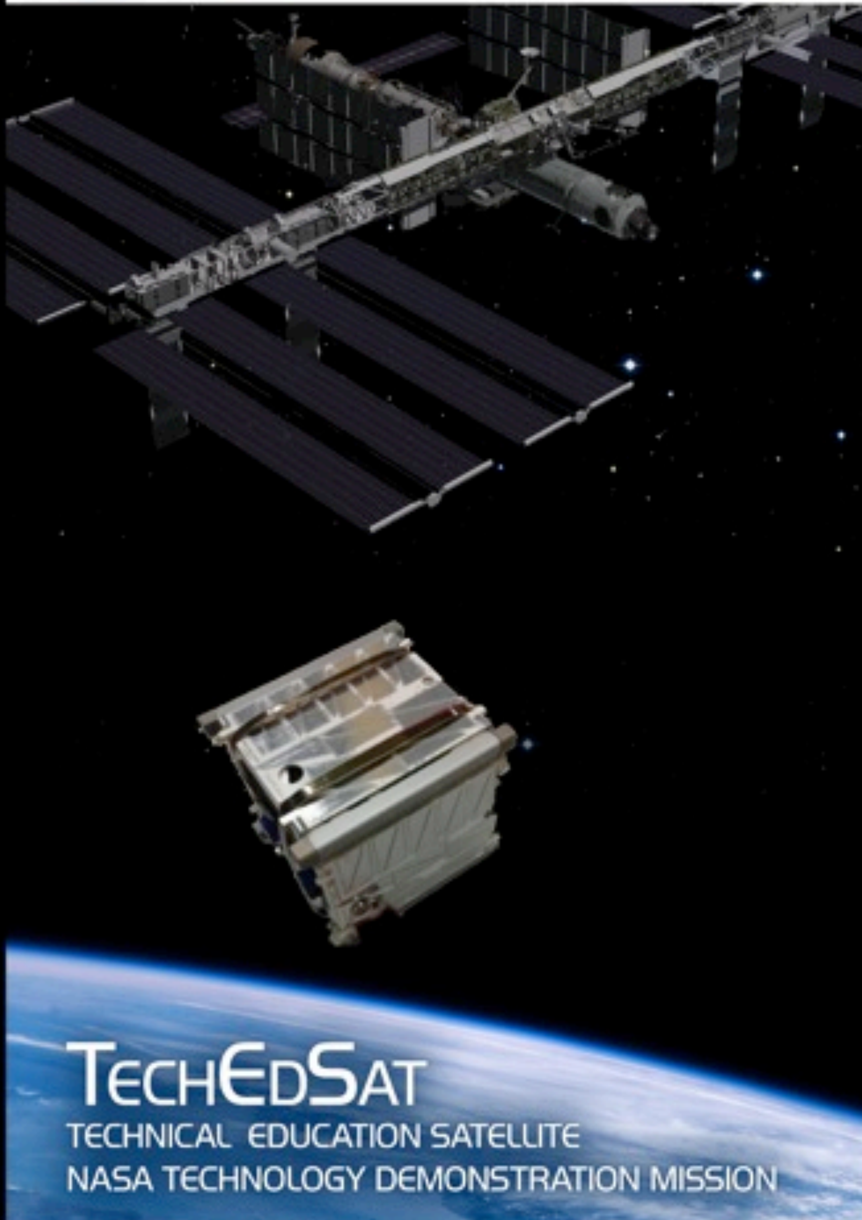
Cubesats: Biological Missions

- Gene-Sat 1
- Pharmasat-1
- O/OREOS









RYMDSTYRELSEN Swedish National Space Board

AAC Microtec

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.

TechEdSat with the Remove Before Flight pin installed

Internal CAD configuration, showing Quake Global's Q1000 ORBCOMM modem

AAC Microtec's nanoRTU™ device with SPA

Deployer plate with the two Japanese Experiment Module (JEM) Small Satellite Orbital Deployer (J-SSOD) cases installed

TechEdSat will deploy from the J-SSOD in 09/2012

Japan Aerospace Exploration Agency (JAXA) JEM Remote Manipulator System with the two J-SSOD's deploying CubeSats

Project Schedule

- PDR Date: 12/02/2011
- CDR Date: 04/10/2012
- Hardware Delivery Date: 05/12/2012
- Launch Date: 06/26/2012
- Release from ISS: 09/2012
- End of Mission: Approximately 12/12/2012

San Jose State University Team

Front row left to right: Marcus Murbach, Periklis Papadopoulos, Michelle Migliosi, Adrianna Aguilar, Alyssa Villanueva, Gabriel Alvarez, and Greenfield Trinh

Middle row left to right: Bob Nickel, Aaron Cohen, Al Guymeros Luna, Darryl LeVasseur, Carleton Bounds

Top row left to right: Andres Martinez, Julie Carlson

Points of Contact

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AAC Microtec Team

Henrik Löfgren, Per Selin, Jan Schulte

NASA acknowledges the contributions of the following:

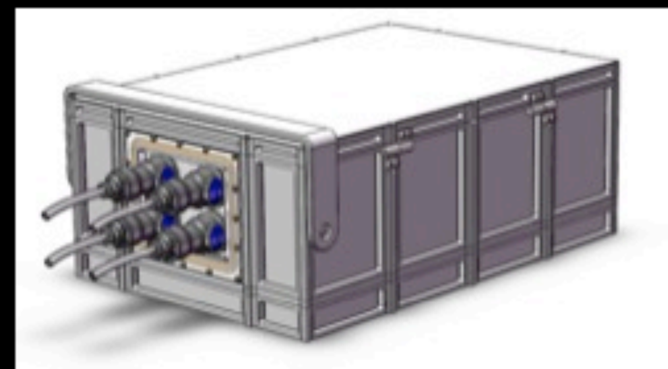
NCASST JAXA agi SPACE SYSTEMS LORAL

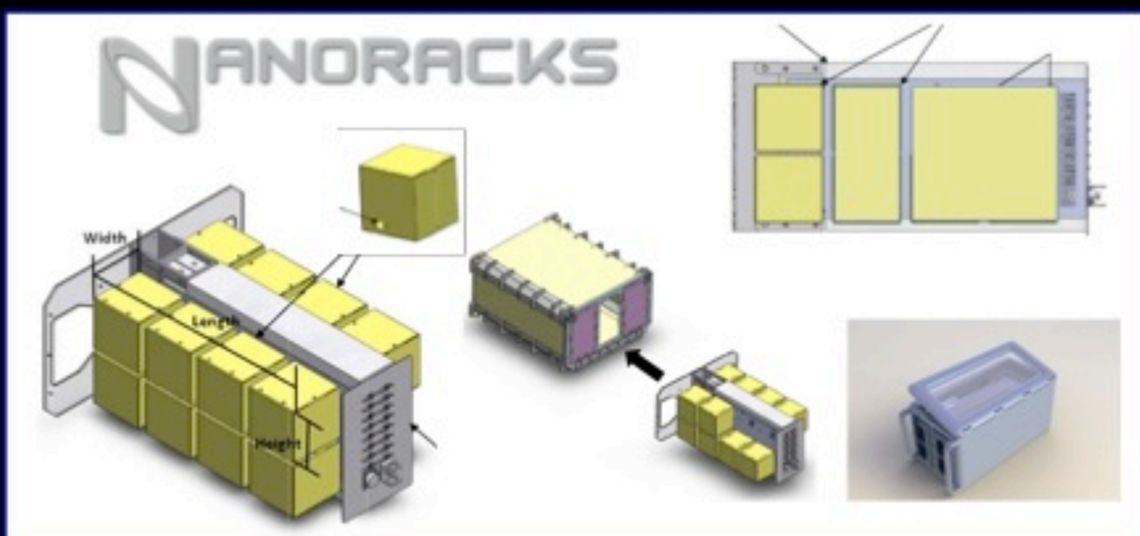
NASA AMES
70
YEARS OF INNOVATION
Platinum Jubilee

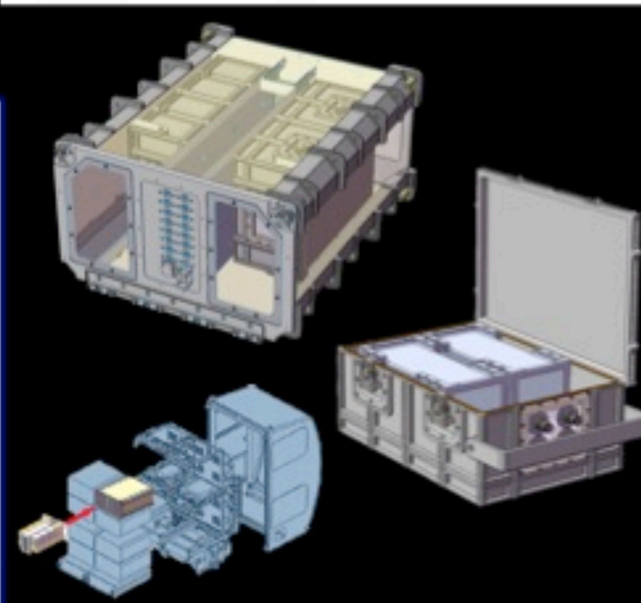
Cubesat Payloads on the ISS

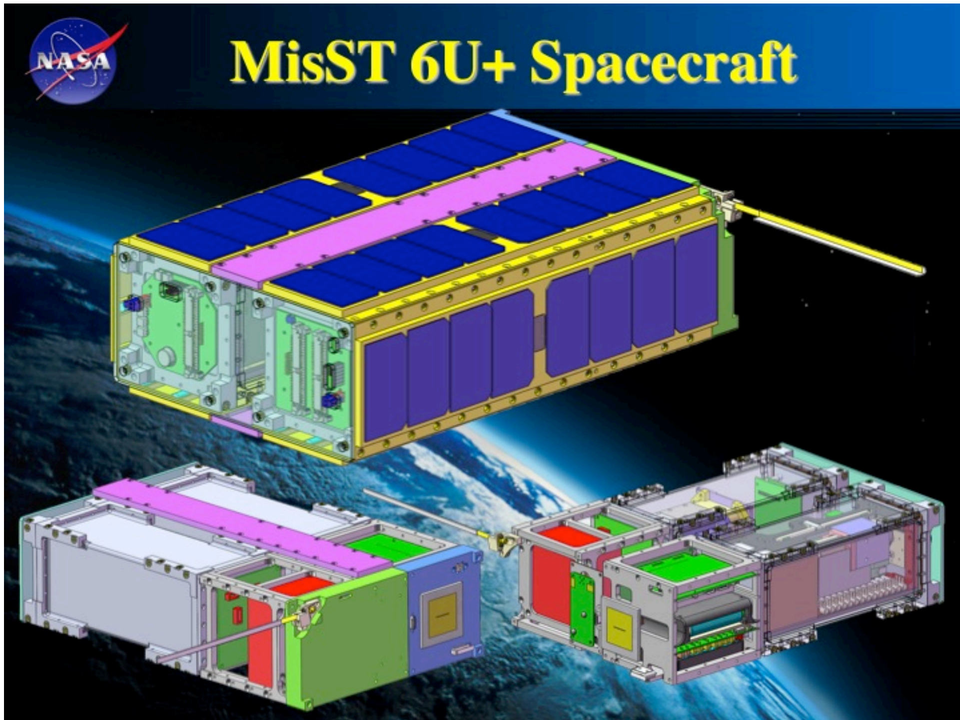
NASA

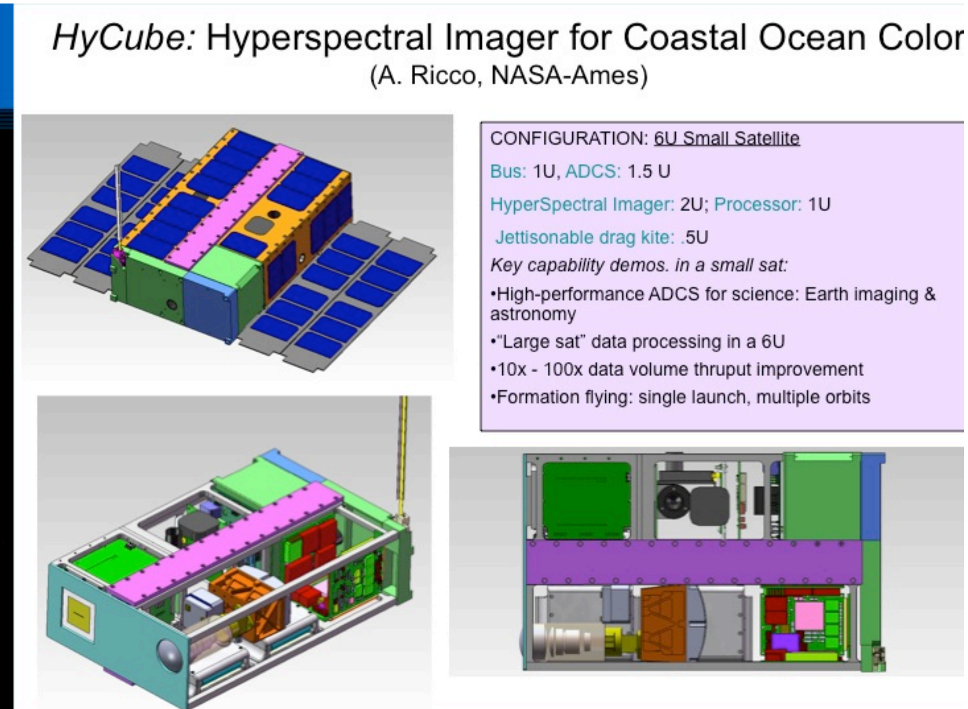
NanoLab

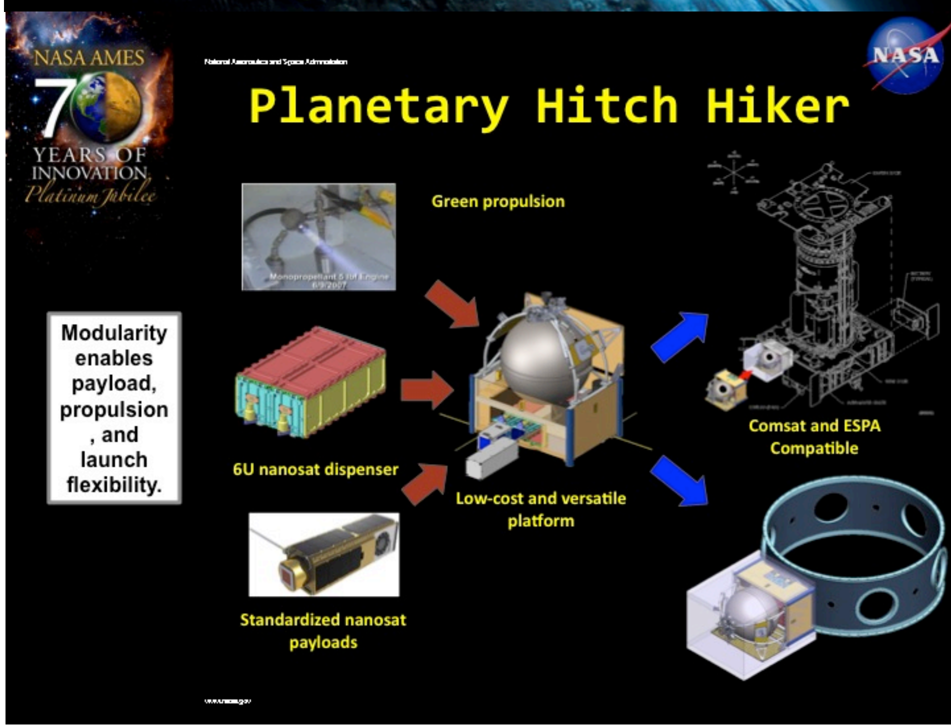


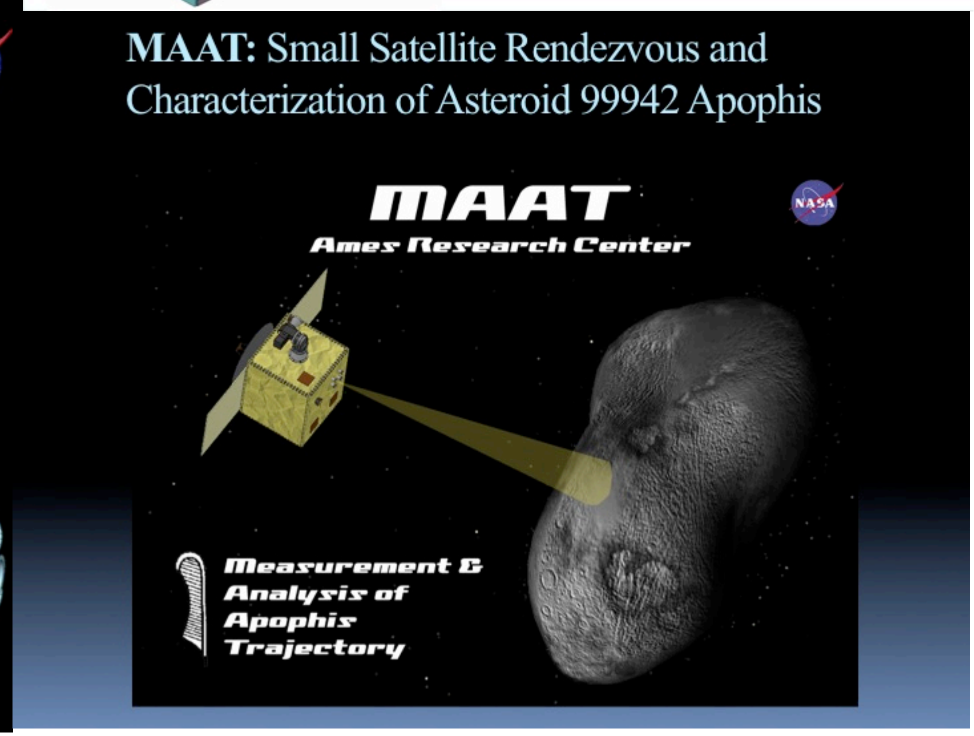





NASA
MisST 6U+ Spacecraft

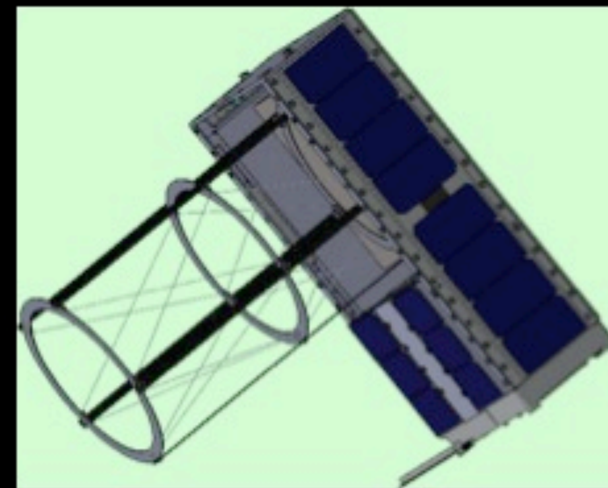

HyCube: Hyperspectral Imager for Coastal Ocean Color
(A. Ricco, NASA-Ames)
CONFIGURATION: 6U Small Satellite
Bus: 1U, ADCS: 1.5 U
HyperSpectral Imager: 2U; Processor: 1U
Jettisonable drag kite: .5U
Key capability demos. in a small sat:
•High-performance ADCS for science: Earth imaging & astronomy
•"Large sat" data processing in a 6U
•10x - 100x data volume thruput improvement
•Formation flying: single launch, multiple orbits


NASA AMES
70
YEARS OF INNOVATION
Platinum Jubilee
NASA
Planetary Hitch Hiker
Green propulsion
Modularity enables payload, propulsion , and launch flexibility.
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
NASA
Measurement & Analysis of Apophis Trajectory

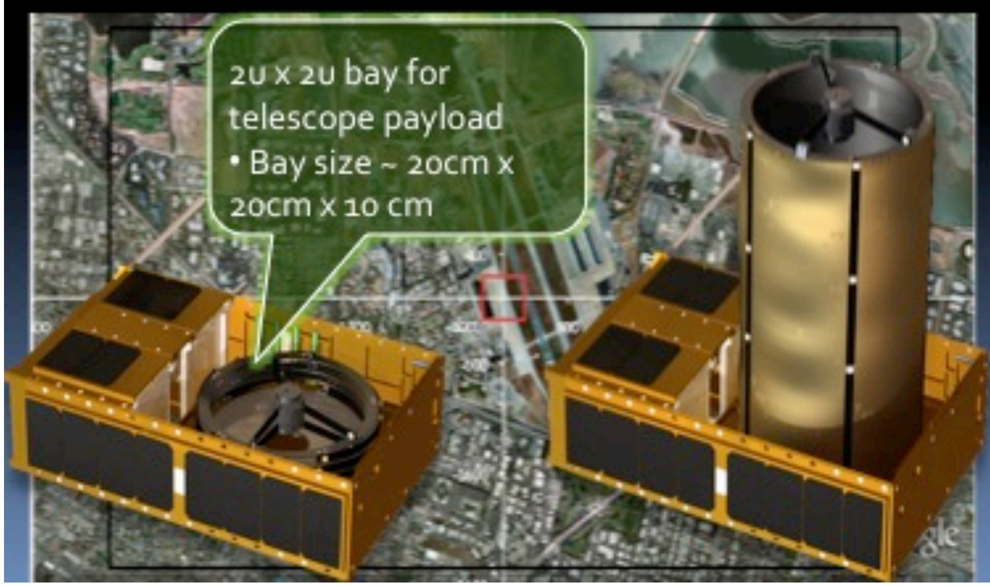
Collapsible Dobson Space Telescope

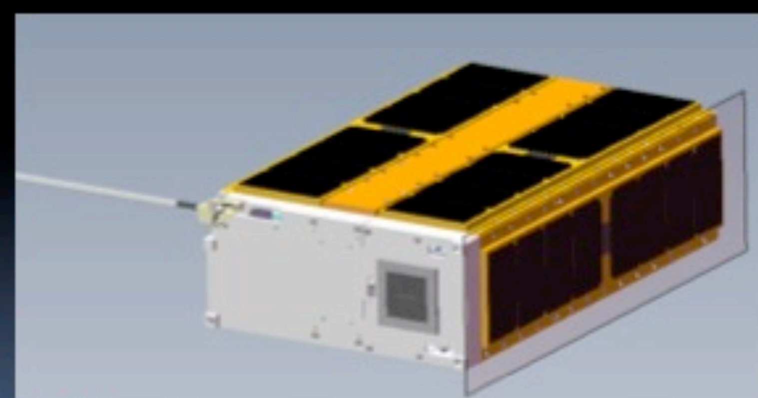
A. Rademacher, NASA-Ames



Design to fit within a 6u nanosatilite architecture

- 6in, f8 Telescope
- 1250mm focal length



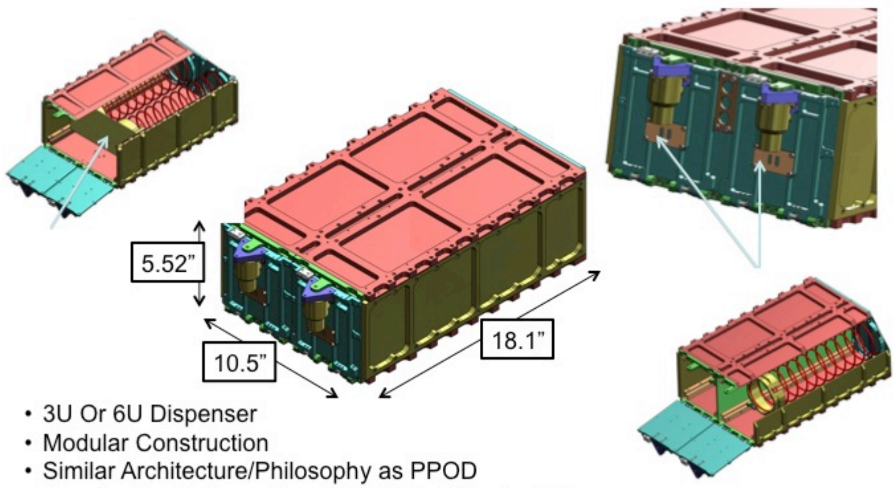


San José State University

NSBE

Houston Space Chapter

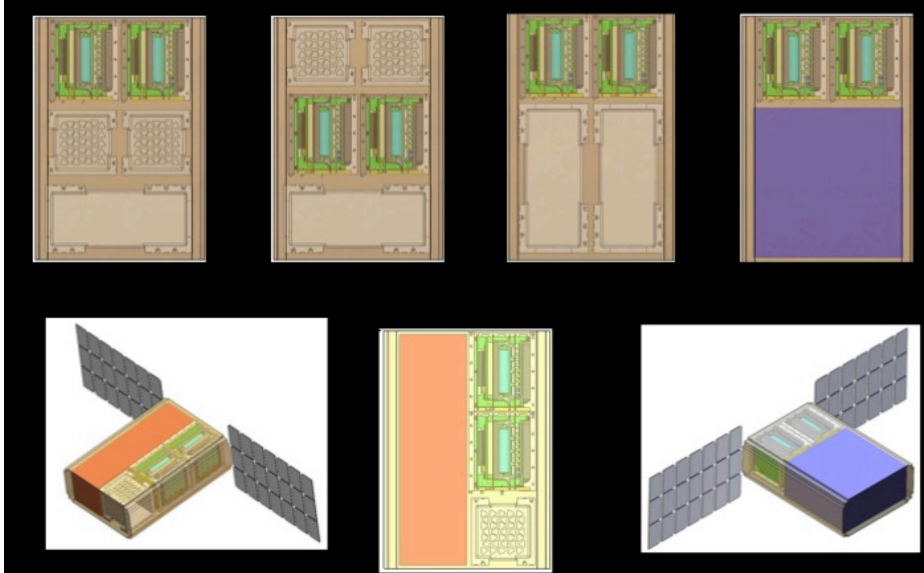
ARC 6U+ Dispenser

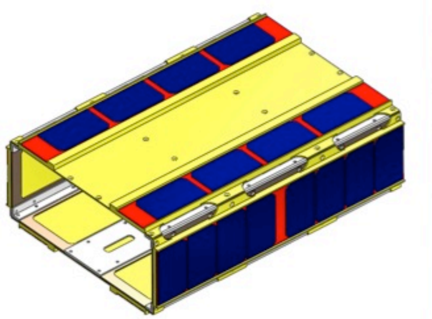


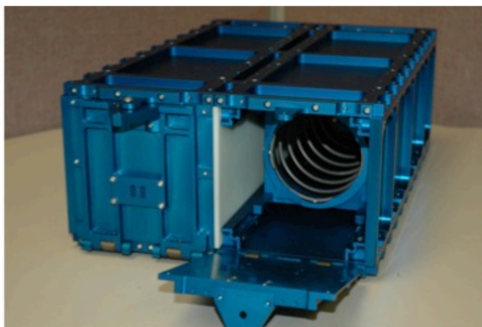
- 3U Or 6U Dispenser
- Modular Construction
- Similar Architecture/Philosophy as PPOD
- Mounts Identically as Two 3U PPODs Side by Side
- Dispenser Satellite Release Velocity Range: 1.18 M/S –2.03 M/S

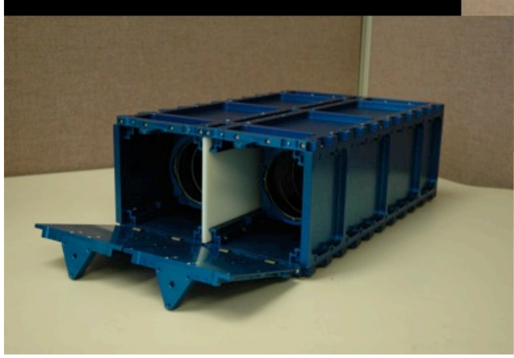
6-Pack Nanosatellite Possible Configurations (2N/6Cube)

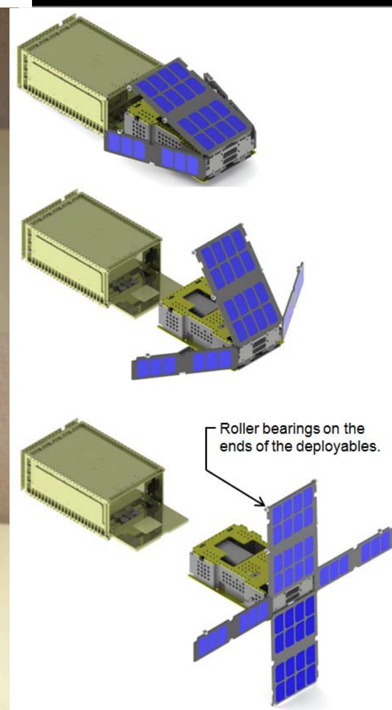
[assumes 2U equivalent bus, 4U payload volume]



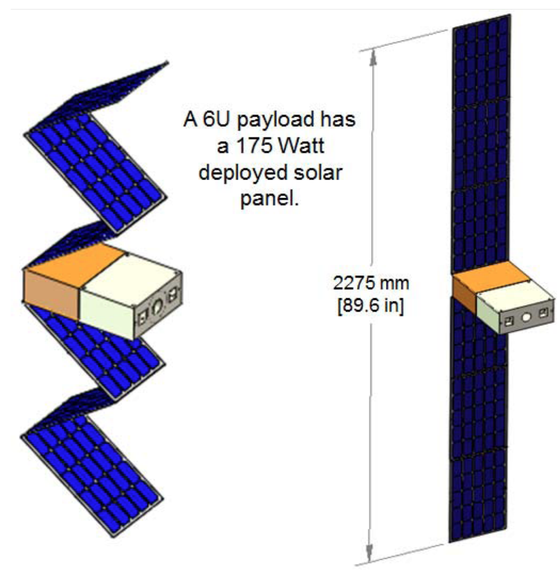








Planetary Systems Corporation



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

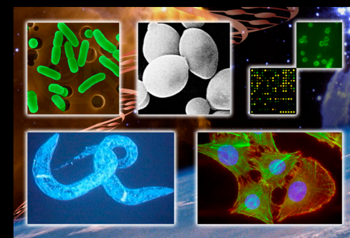
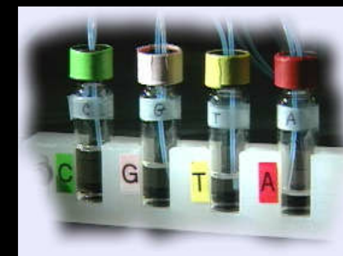
The Past:
We took familiar biological organisms into space, and engineered environments to suit them.

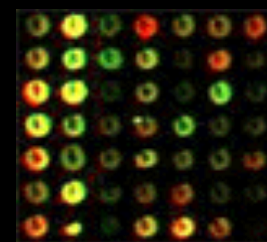
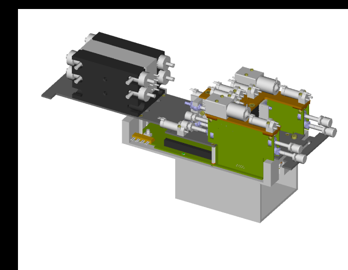
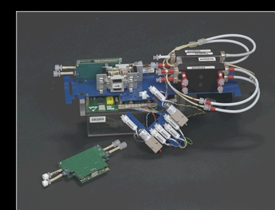
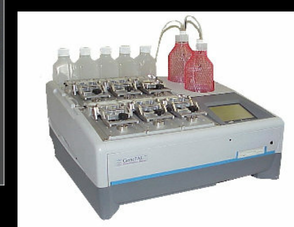
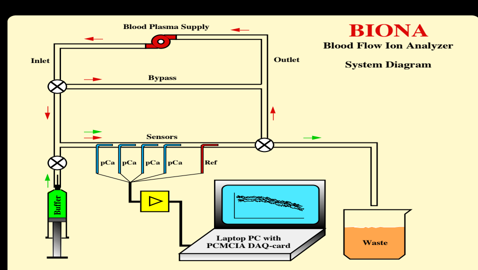
The Future:
We will engineer biological systems to make them suited to extraterrestrial environments, and employ these systems in new kinds of missions

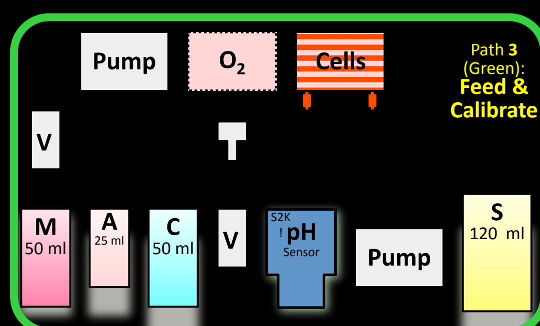
"Over the next 20 years, synthetic genomics is going to become the standard for making anything. The chemical industry will depend on it. Hopefully, a large part of the energy industry will depend on it. "
- J. Craig Venter, 2007

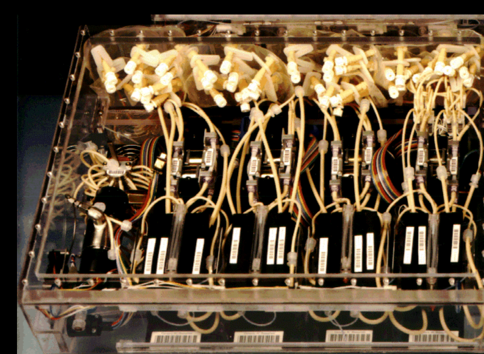
Space Synthetic Biology HW Elements

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





ADVANCED MANUFACTURING

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

National Center for Advanced Manufacturing
Louisiana Partnership

Manufacturing Innovation Project (MIP)

Ames Research Center
in Silicon Valley..
...Innovation starts here

ADVANCED DIGITAL MATERIALS and MANUFACTURING for SPACE (ADMMS)

COMMERCE DATA TOOLBOX EVENTS CONTACT

MANUFACTURING.GOV

- *Advanced Manufacturing (AM) Home*
- *AM National Program Office*
- *Advanced Manufacturing Partnership (AMP)*
- *Agency Programs*
- *Materials Genome Initiative*
- *National Network for Manufacturing Innovation (NNMI)*
- *Get Involved*
- *Events*
- *News*
- *Related Links*
- *Contact Info*

NATIONAL NETWORK FOR MANUFACTURING INNOVATION (NNMI)

Administration Takes Next Steps On National Network for Manufacturing Innovation And Pilot Institute for Manufacturing Innovation

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.*

how best to strengthen the U.S. innovation infrastructure to help manufacturers improve capabilities, develop new, advanced products and processes, gain

ARC Strategic Technology Initiatives 2012

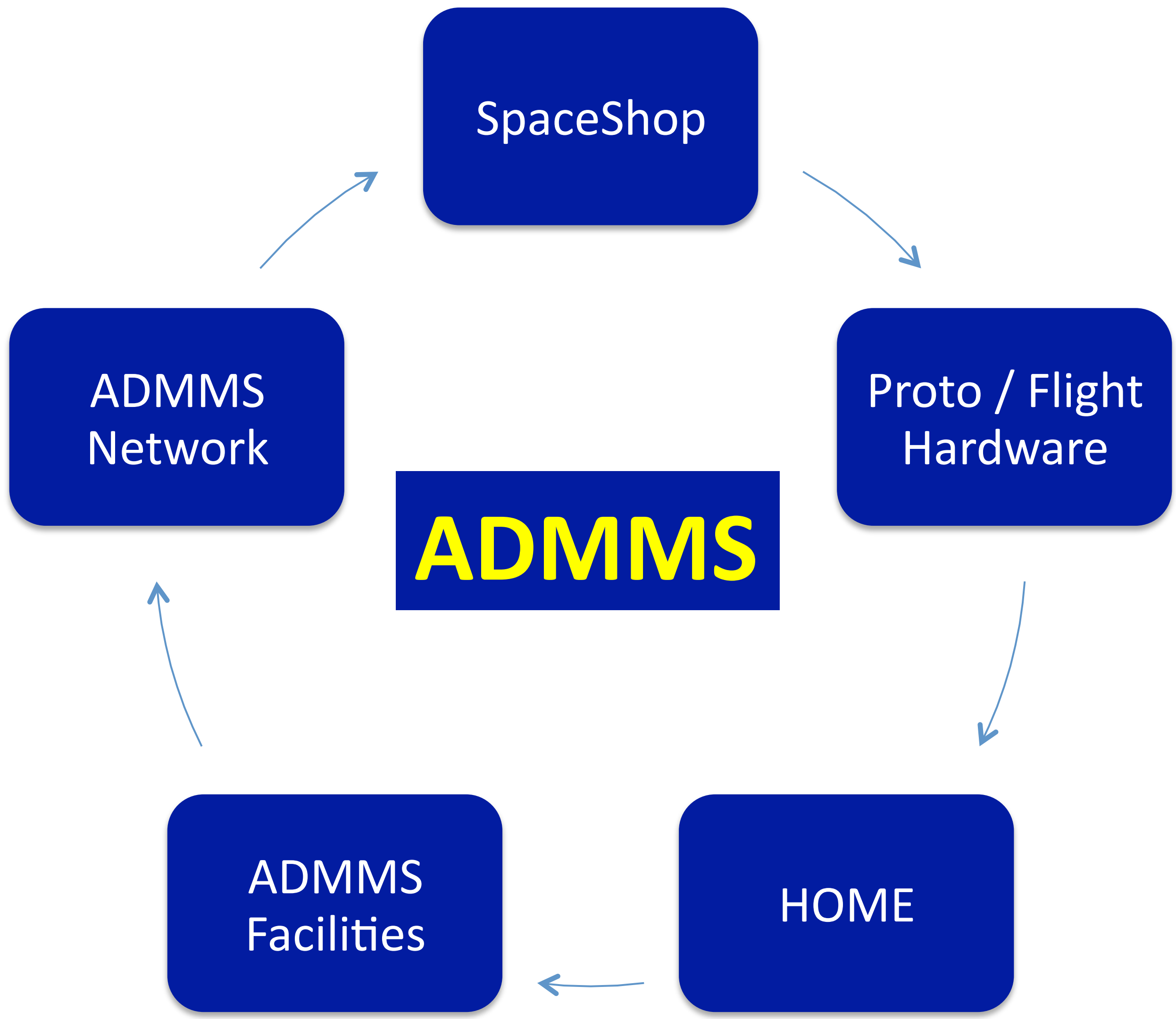
Active Initiatives

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

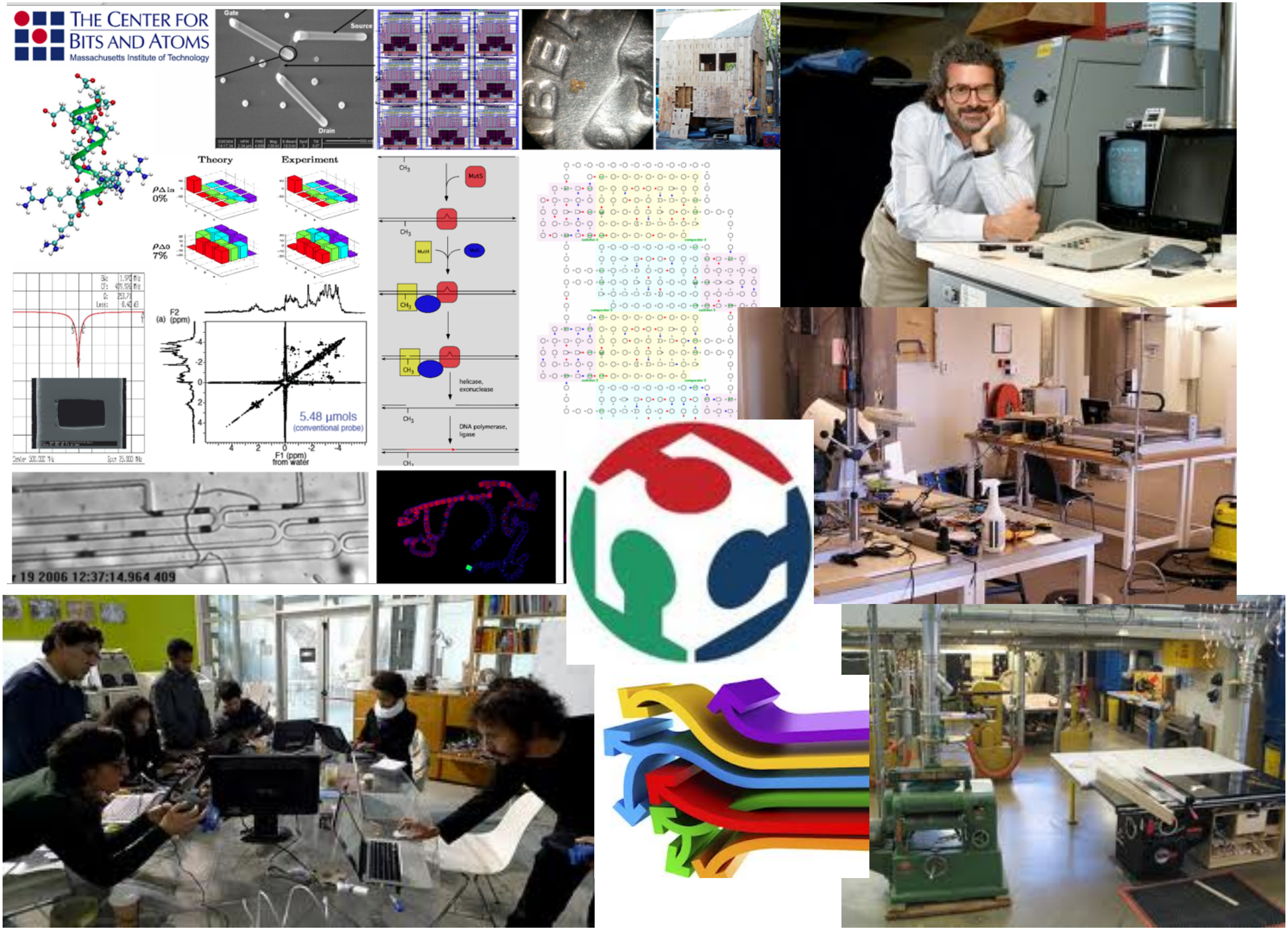
1. First Responder, Emergency, and Diasaster Assistance (FREDA)
2. Emerging Aeronautics Systems and Technologies (EAST)
3. GREEN Technologies (Technologies for Sustainability)

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



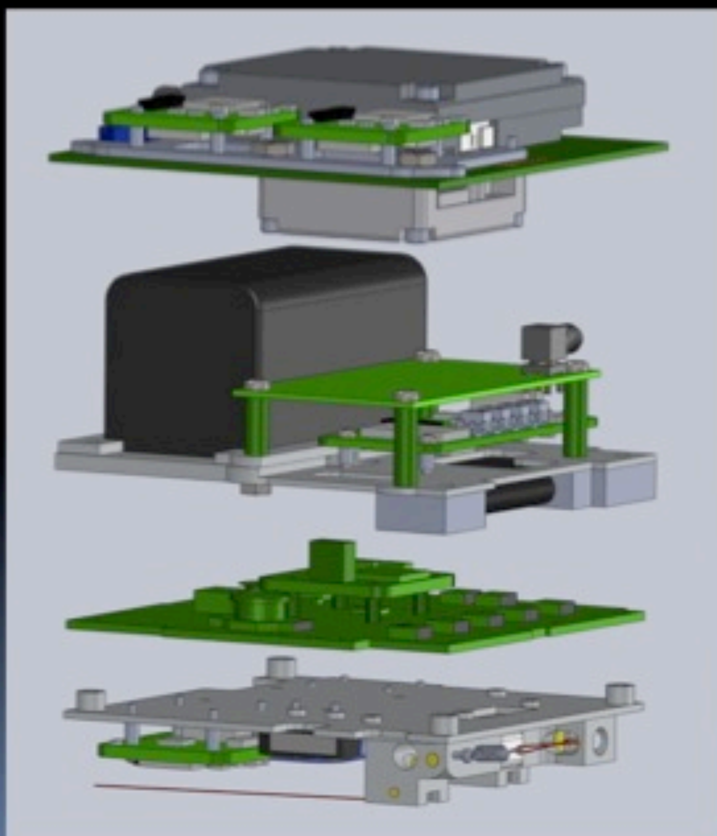
ADVANCED DIGITAL MATERIALS and MANUFACTURING for SPACE

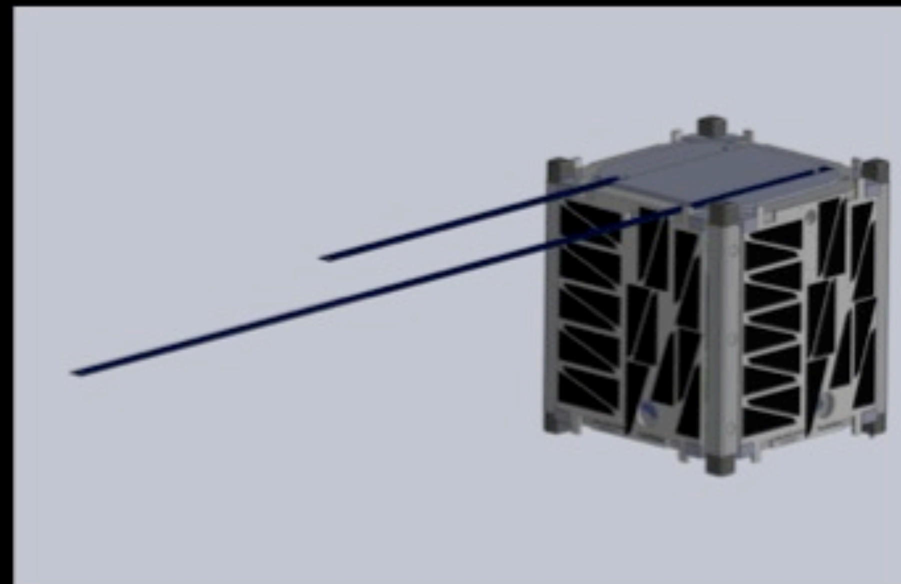

HAAS
SL 10

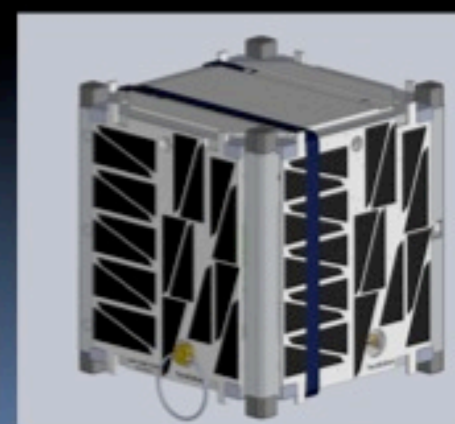

THE CENTER FOR BITS AND ATOMS
Massachusetts Institute of Technology
Gate
Source
Drain
Theory
Experiment
5.48 µmols
(conventional probe)
F2 (ppm)
F1 (ppm) from water
MutS
MutH
helicase, exonuclease
DNA polymerase, ligase
r 19 2006 12:37:14.964 409

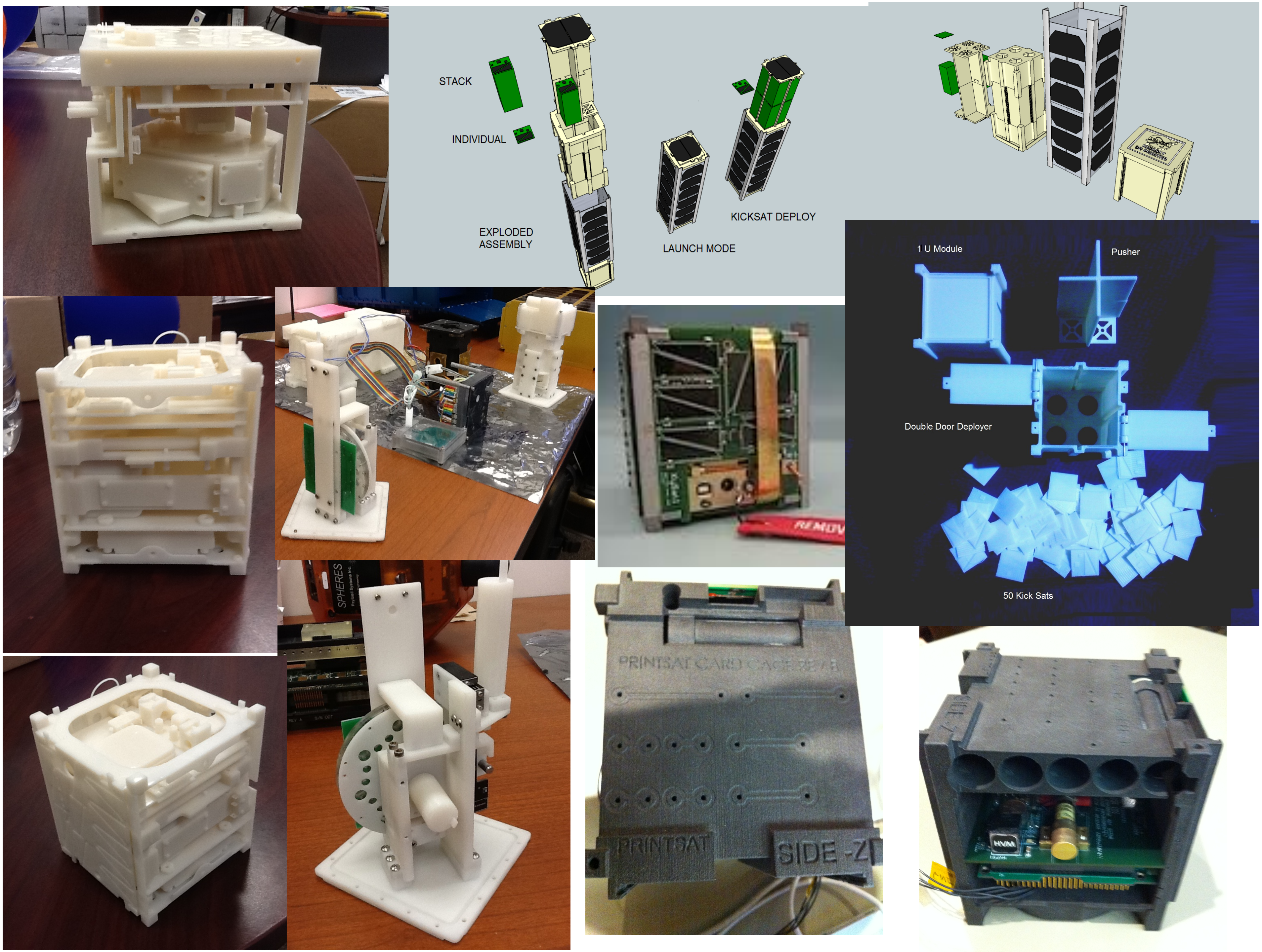
TechEdSat-1.1

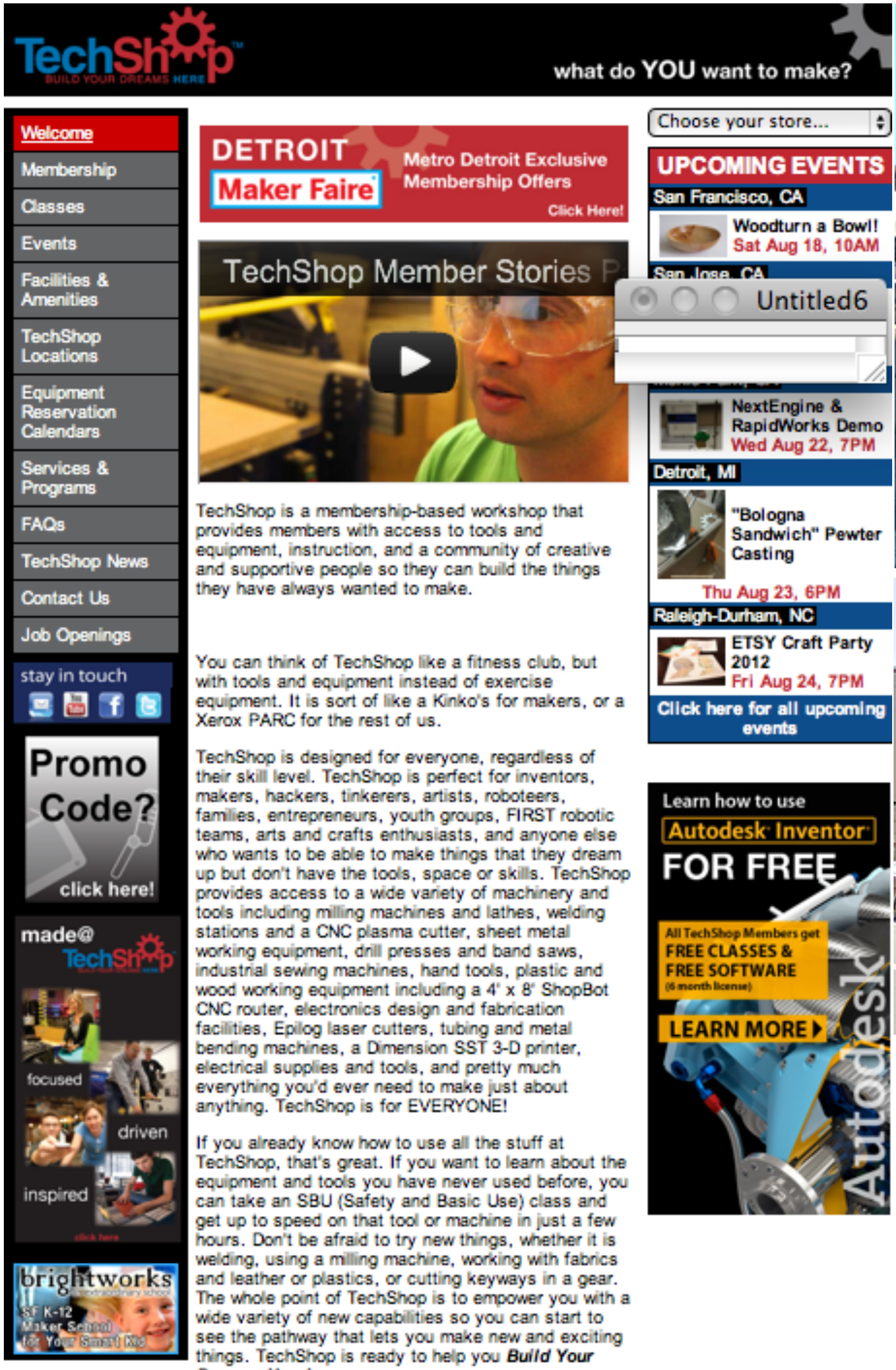
Launch 21JUl2012








STACK
INDIVIDUAL
EXPLODED ASSEMBLY
LAUNCH MODE
KICKSAT DEPLOY
1 U Module
Pusher
Double Door Deployer
50 Kick Sats
SPHERES
PRINTSAT
SIDE -Z



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 Kinko'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, roboteers, 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*

Untitled6

Why Quickparts?

1. One of the World's Largest Providers of Custom Parts
2. Patented Instant Online Quoting
3. Widest selection of Processes, Materials, and Lead Times
4. Superior Customer Service
5. ISO 9001 and ITAR Certified

Rapid Prototyping

- SLA
- Manufactured Plastic Prototypes
- **SLS**
  - Material Properties
  - Process Comparison Table
  - Case Study
  - Process Gallery
  - PDF Brochure
  - Finishing
  - Quickparts Advantage
- ZPrint
- FDM
- ProJet
- PolyJet
- Cast Urethanes
- CNC Machined Parts
- Sheet Metal
- Prototype Metal Casting
- Metal Casting
- 3DTouch™ 3D Printer
- Rapman 3.2 3D Printer

- Process Details
- Quality Control
- Lead Time Options
- Prototyping Sample Kit

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"x19"x19". 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.

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WINDFORM®

MATERIALS FOR ADDITIVE MANUFACTURING

WINDFORM XT 2.0

Example of application in the aerospace industry.
The image shows the building of a CUBESAT with Additive Manufacturing with the WINDFORM XT. The project has been presented to the IAA Conference University Satellites Missions.

WINDFORM XT 2.0 is the evolution of the ground breaking high performance WINDFORM XT, the carbon fiber reinforced composite material, known for its mechanical properties, which made it particularly suitable in demanding applications such as motorsport sector, aerospace and UAV's.

WINDFORM XT 2.0 is an innovative material, and will replace the WINDFORM XT, as the "Top Level" of the current Windform range.

WINDFORM XT 2.0 improves mechanical properties compared to "traditional" WINDFORM XT, while maintaining the same workability for Laser Sintering machines in order to better fulfill the needs of Additive Manufacturing required to produce end use parts and prototypes.

WINDFORM XT 2.0 retains the matte black color of the previous version and features improvements in mechanical properties: +8% in tensile strength, +22% in tensile modulus and +46% increase in elongation at break.

WINDFORM XT 2.0 allows for the creation of accurate, reliable and durable prototypes and is perfect for functional applications.

FEATURES

Class of material
Polyamide based material carbon filled

Technology
Additive Manufacturing

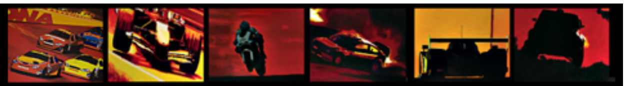
APPLICATIONS

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 satellite, 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

WE MAKE YOU RACE



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WINDFORM

MAIN SPONSOR

THE RIGHT PARTNER FOR PERFORMING TECHNOLOGY

The right partner for just-in-time manufacturing and customized service for high-performance applications. CRP believes in Engineering as the art of applying science to the service of man, translating knowledge into reality.

"Motor racing, mountain climbing and bull fighting are the only true sports. All the rest are children's games played by adults" (E. Hemingway)

MATERIALS

EXPERIENCE AND KNOWLEDGE IN MATERIALS

CRP Meccanica is able to process a wide range of materials with CNC Machining, Rapid Casting and Rapid Prototyping like MMC and Super Aluminium, Titanium alloys, Steel alloys, Aluminium alloys, Magnesium and Copper, Superalloys and Windform materials.CRP Technology is centre of excellence not only for materials but also for applied technologies that are the result of meaningful...

TODAY CASE STUDY

EARNHARDT CHILDRESS RACING ENGINES AND WINDFORM LX ALTERNATOR SHROUD

With the jostling and bumping that occur, it is sometimes easy to forget that at its heart Stock Car racing is an endurance event. Top NASCAR teams work to ensure reliability for every race on every component. Each part is designed to ensure that 400 or 500 miles pass without incident. If there is a component that does show problems or appears to be a liability the challenge must be...

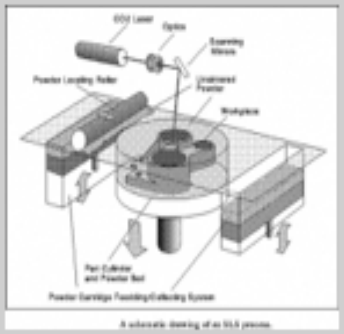
PROCESSES

CENTRE OF EXCELLENCE FOR INNOVATION

CRP Group deals with CNC machining (high speed); EBM and SLM; Titanium, Steel or Superalloys Rapid Casting; service of Rapid Prototyping, Rapid Manufacturing, Additive Manufacturing with SLS technology and with composite materials Windform; selling of composite materials Windform for Rapid Prototyping and Additive Manufacturing; Engineering, Reverse Engineering and Co-Engineering.

PARTNERS:

Focus: Selective Laser Sintering (SLS)

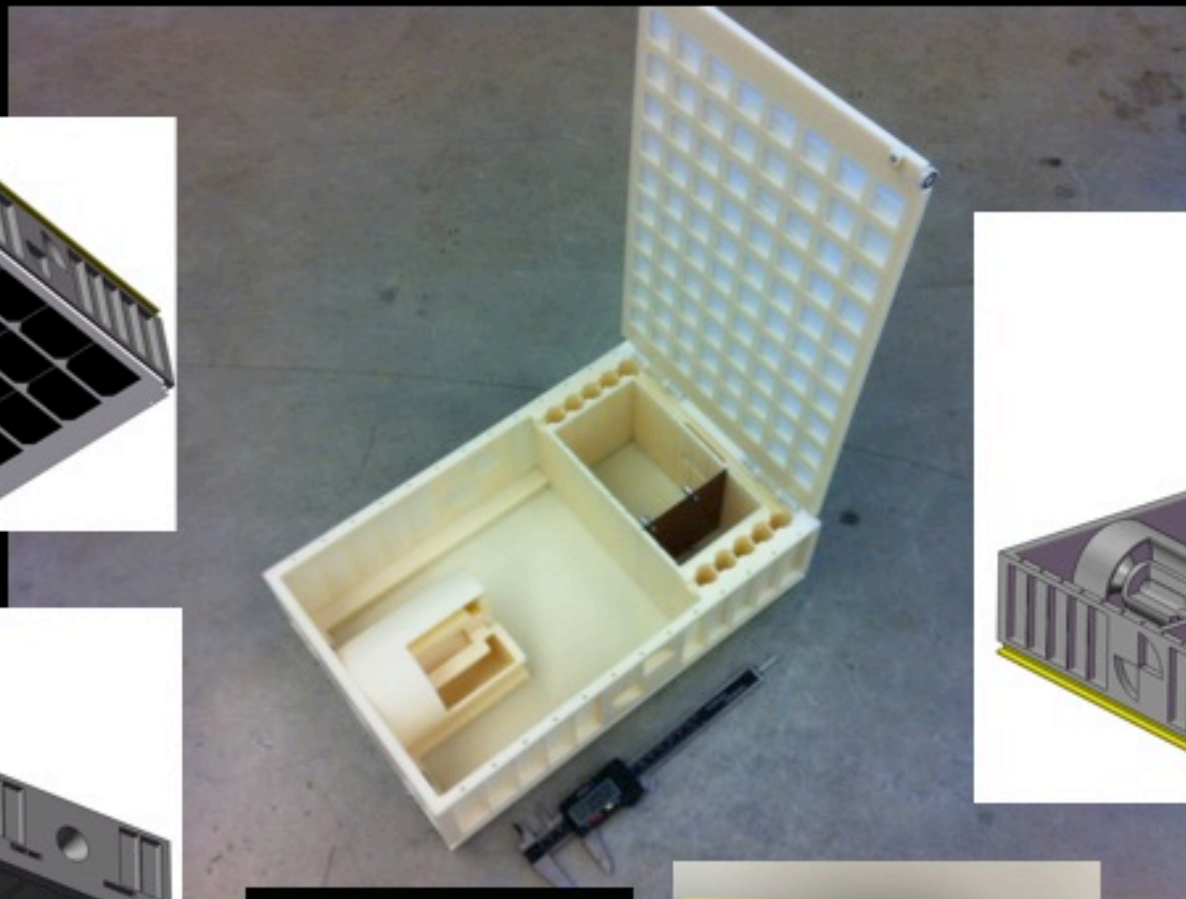


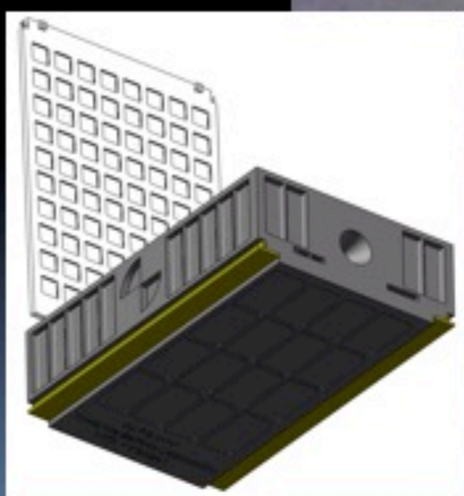
The **selective laser sintering** can produce a prototype by layer overlapping of polymeric material.

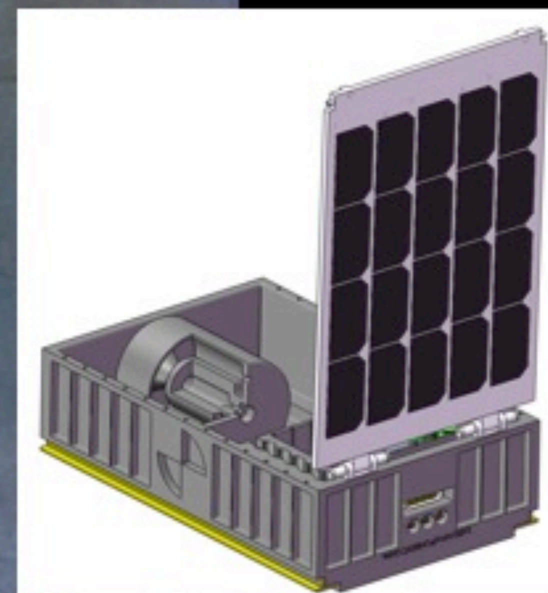
In an inert atmosphere room and with a constant temperature a roller rotating at opposite direction towards its forwarding, lays a thin layer of powder on a platform where the addressed laser ray sinters the material providing the Δ necessary to melting the powders.

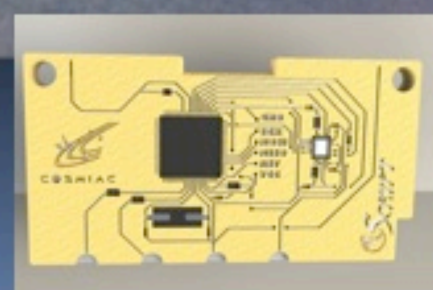
The system does not need supports because the parts stand thanks to non-sintered powders.

AFRL-COSMIAC 6U (3D printed)









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 carbondioxide (CO_2) – 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 CO_2 – 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 CO_2 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 then 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.

Need of the Hour

- **Everything, from** toilet seats to parts of complicated scientific equipment, can break in space anytime
- **So far,** space missions have attempted to anticipate and plan for every such possible situation
- **However, not** every situation can be planned for in advance
- **Made in** Space provides a solution through "3D printing", where layers of materials are put together to create the object

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 scientific 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.

India Emerging profiles next generation technology start-ups from the Silicon Valley, USA, in this fortnightly column

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!

"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. It hopes 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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NASA
The Space Environment
• ISS
• Free Flyers
• Asteroids
• Moon
• Mars
• Beyond