NASA Current Technology Development Work for Tele-reach Applications

Kennedy Space Center

Chief Technologist: Karen Thompson

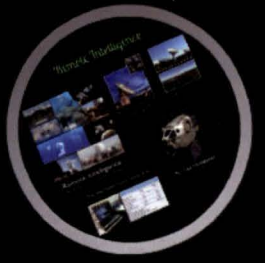

photo credit Nasa / Goddard Space Flight Center / Reto Stockli

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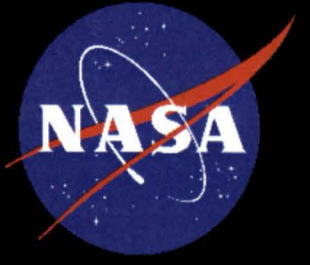
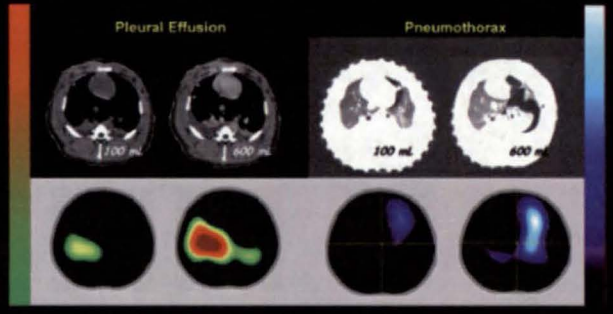


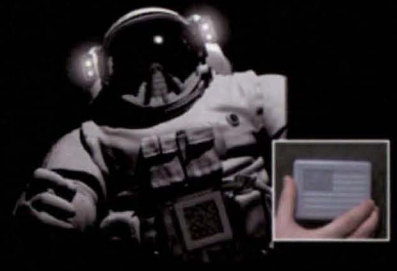
photo credit Nasa / Goddard Space Flight Center / Reto Stöckli

Health and Medical

•Virtual Presence: visual, tactile feedback, real-time and delayed
•Provide training for onboard medics

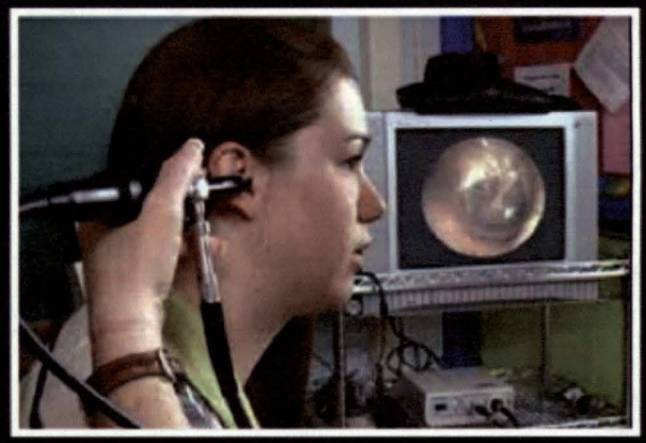


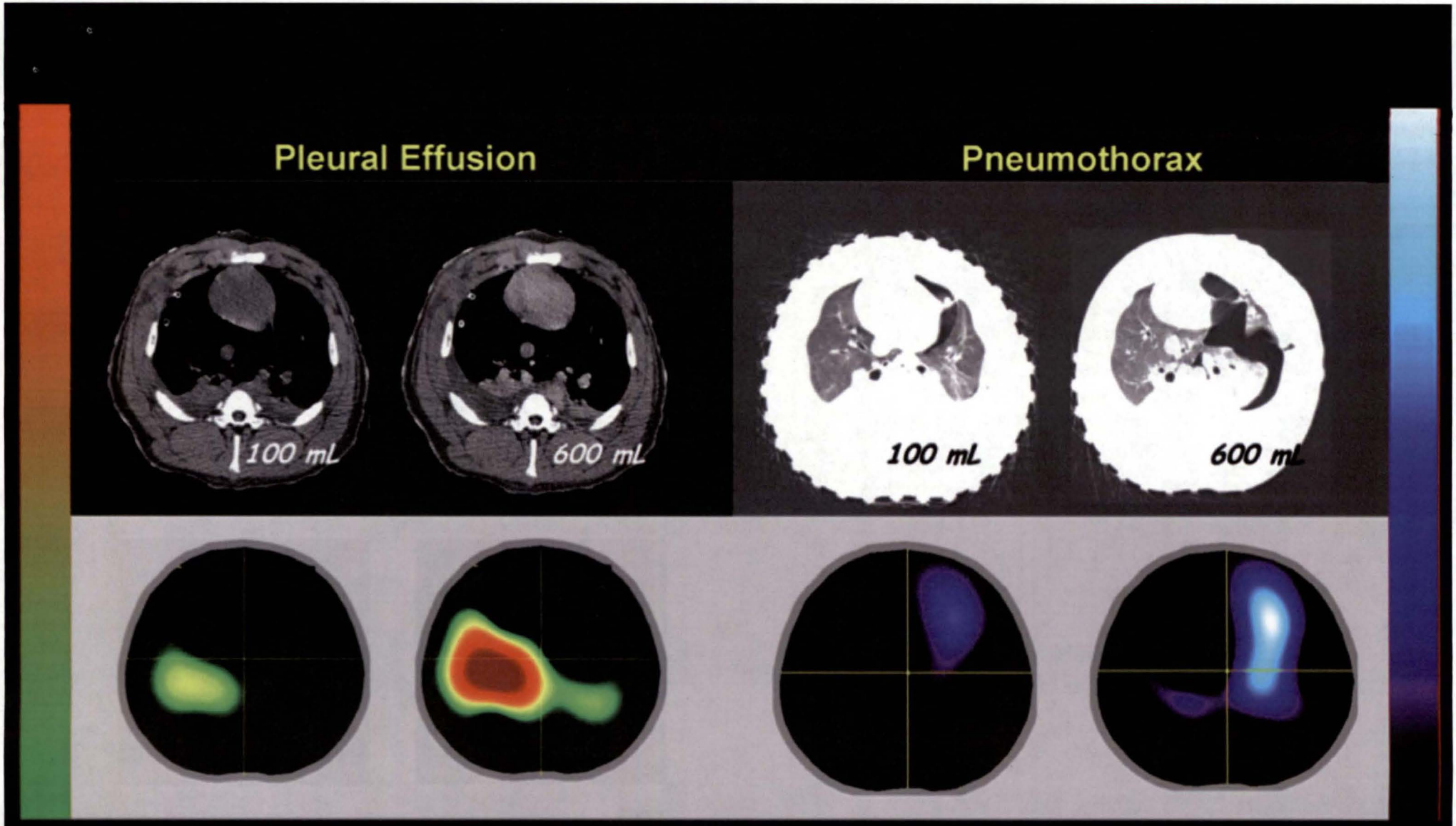
Electrical Impedance Tomography Device – Development of a portable, lightweight device providing two-dimensional internal imaging of the human body using electrical impedance



Biomedical Monitoring by a Noncontact Radio Frequency Device – Development of a portable, non-contact device for measuring heart and blood vessel function using radio waves

Neuroa





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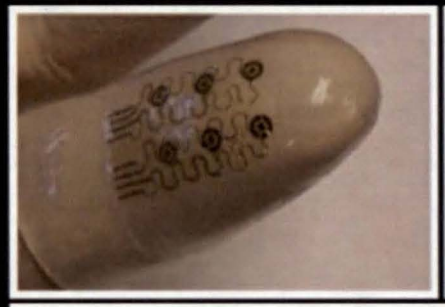
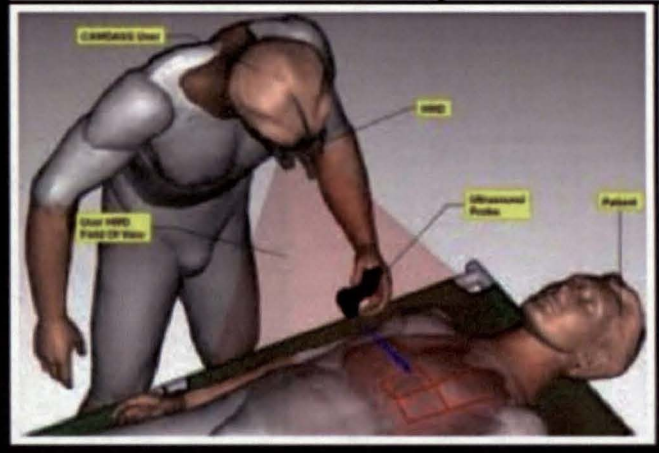
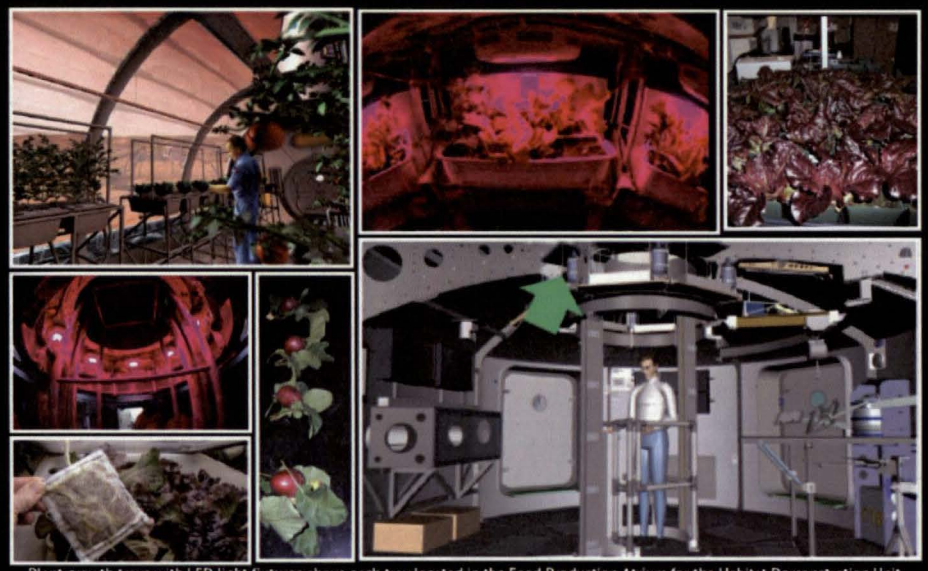




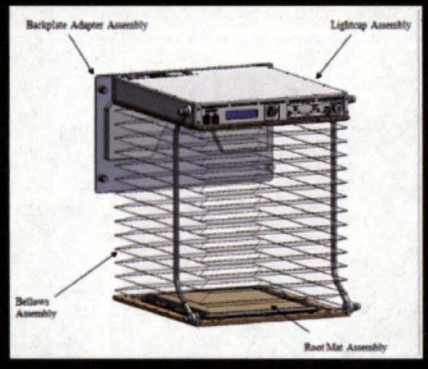
- Virtual Presence: visual, tactile feedback, real-time and delayed
- Provide training for onboard medics


Air and Water Revitalization
LED Lighting
DEEP SPACE
HABITAT
Food Production
Food Production Units
Prezi

Food Production

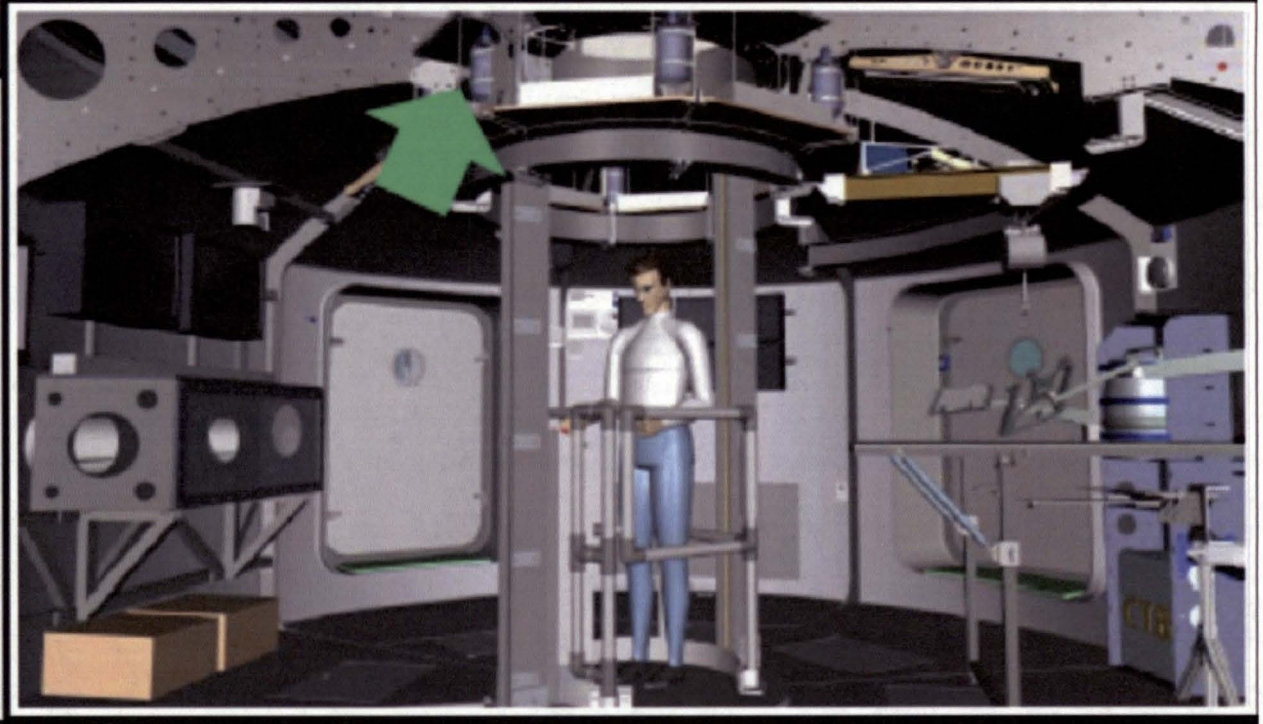


Plant growth trays with LED light fixtures above each tray located in the Food Production Atrium for the Habitat Demonstration Unit.



Food Production Units

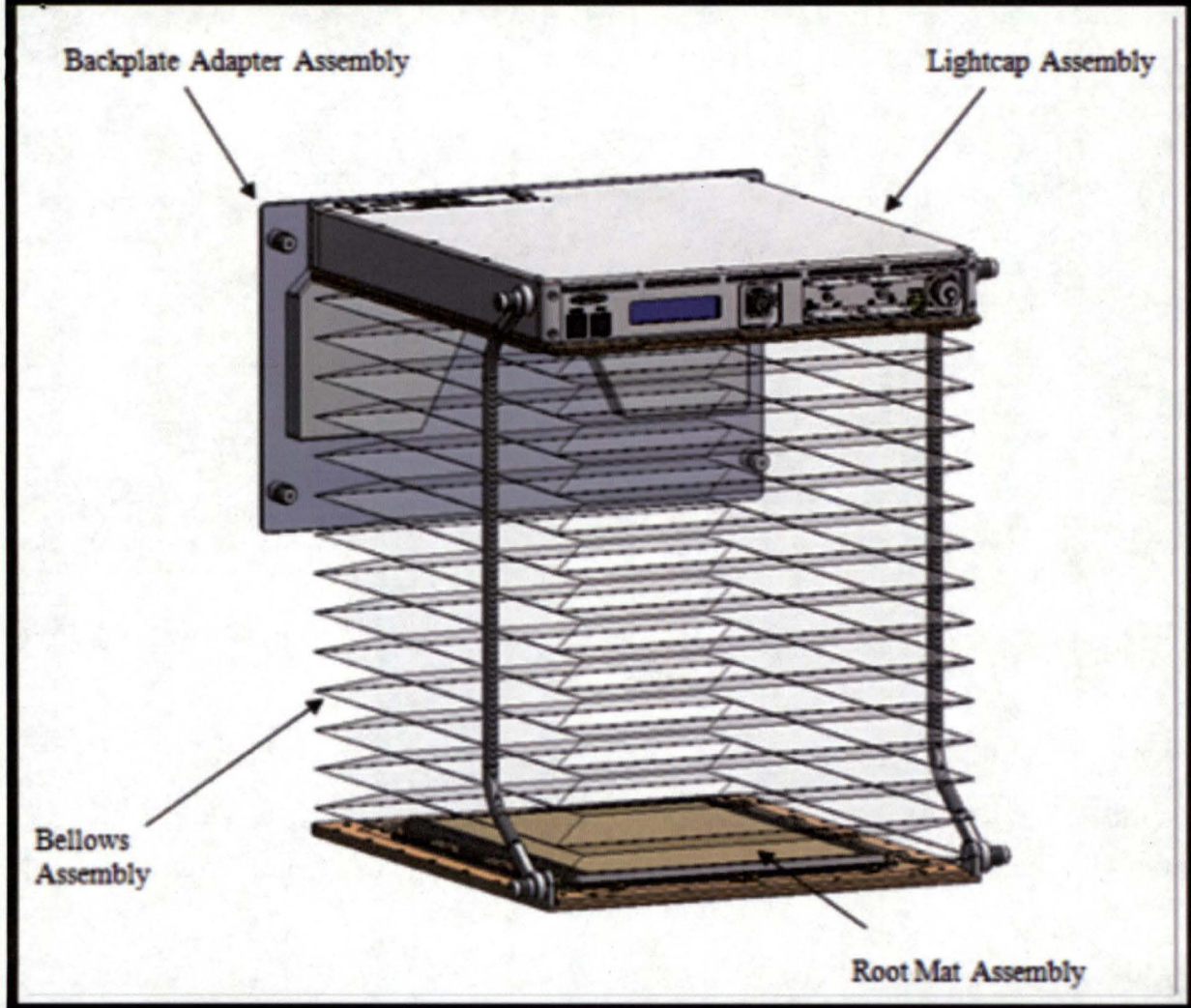
Food Production



Plant growth trays with LED light fixtures above each tray located in the Food Production Atrium for the Habitat Demonstration Unit.

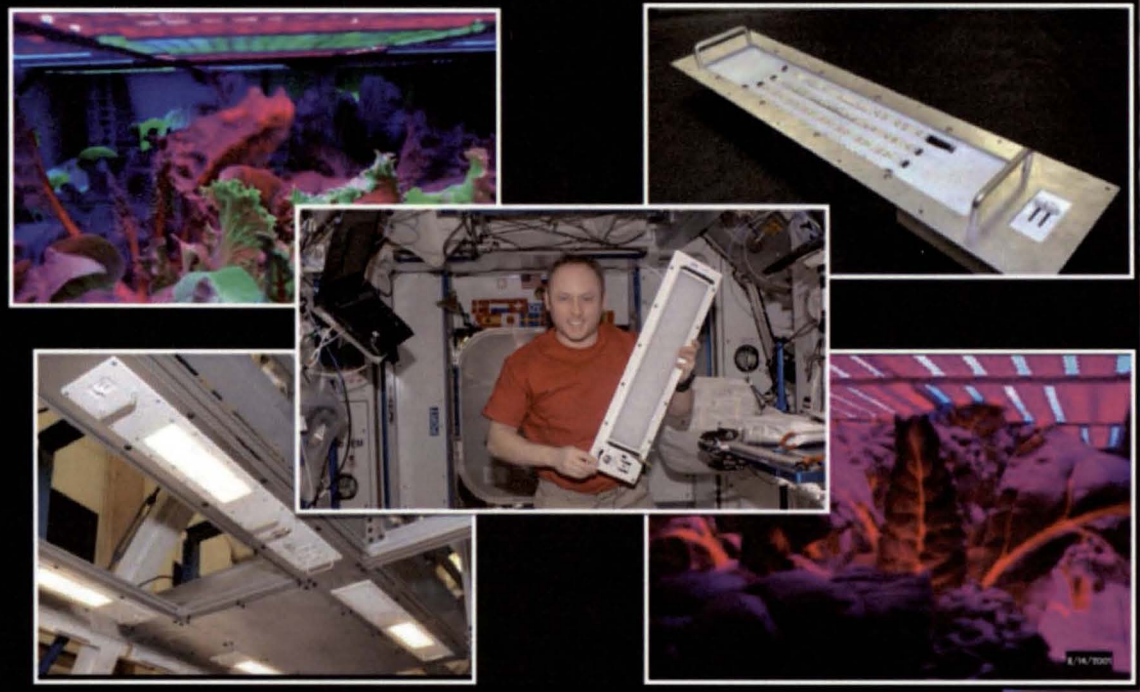
Backplate Adapter Assembly

Lightcap Assembly

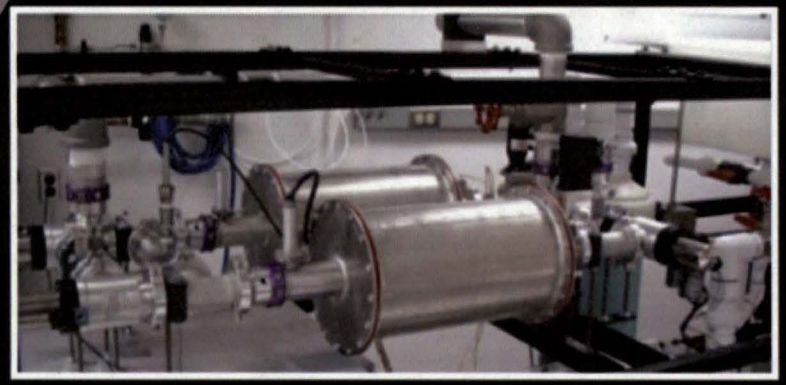


Food Production Units

LED Lighting



Air and Water Revitalization

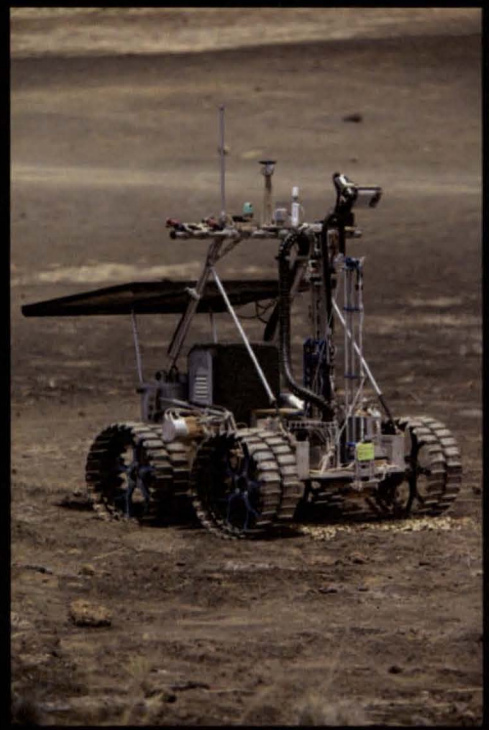


Low Power CO_2 Removal

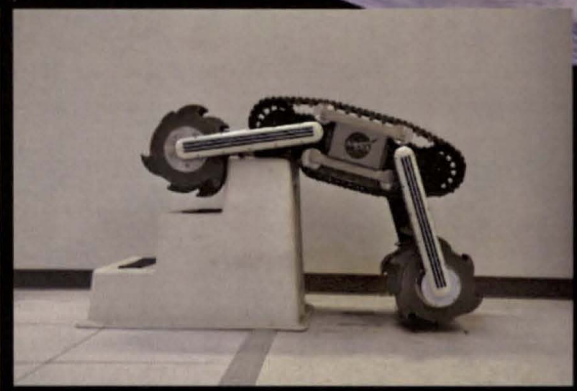
Biological Treatment of Wastewater

Osmotic Filtration

Robotic Development



RESOLVE

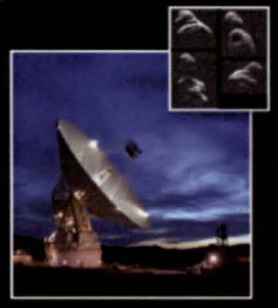


RASSOR

Remote Intelligence

Remote Intelligence

Analog Missions: Space Communications and Navigation



Four Meter Goldstone Imaging of Near Earth Objects

Ka-Band Uplink Array Projects

Multi-Mission Space Exploration Vehicle (MMSEV)

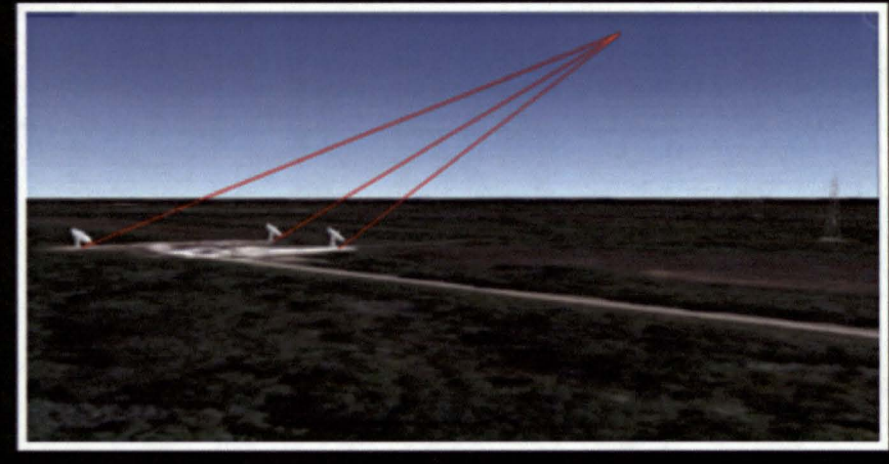
Remote Intelligence

Crew Mobility Systems

Deep Space Communications Delay Emulator

	Closest	Farthest
ISS (Direct Uplink)	0.0019 s	0.0312 s
Earth GEO	0.12 s	
ISS (via TDRSS Relay)	0.26 s	0.28 s
Earth-Moon L1	1.01 s	1.15 s
Lunar Surface[1]	1.21 s	1.35 s
Earth-Sun L1	4.91 s	5.07 s
Near-Earth Asteroids[2]	50.0 s[3]	148.70 s[3]
Mars	148.79 s	1327.59 s

Four Meter Goldstone Imaging of
Near Earth Objects



Ka-Band Uplink Array Projects

Four Meter Gol
Near Ear

Remote Intelligence

Analog Missions: Space Communications and Navigation

Multi-Mission Space Exploration Vehicle
(MMSEV)

mulator

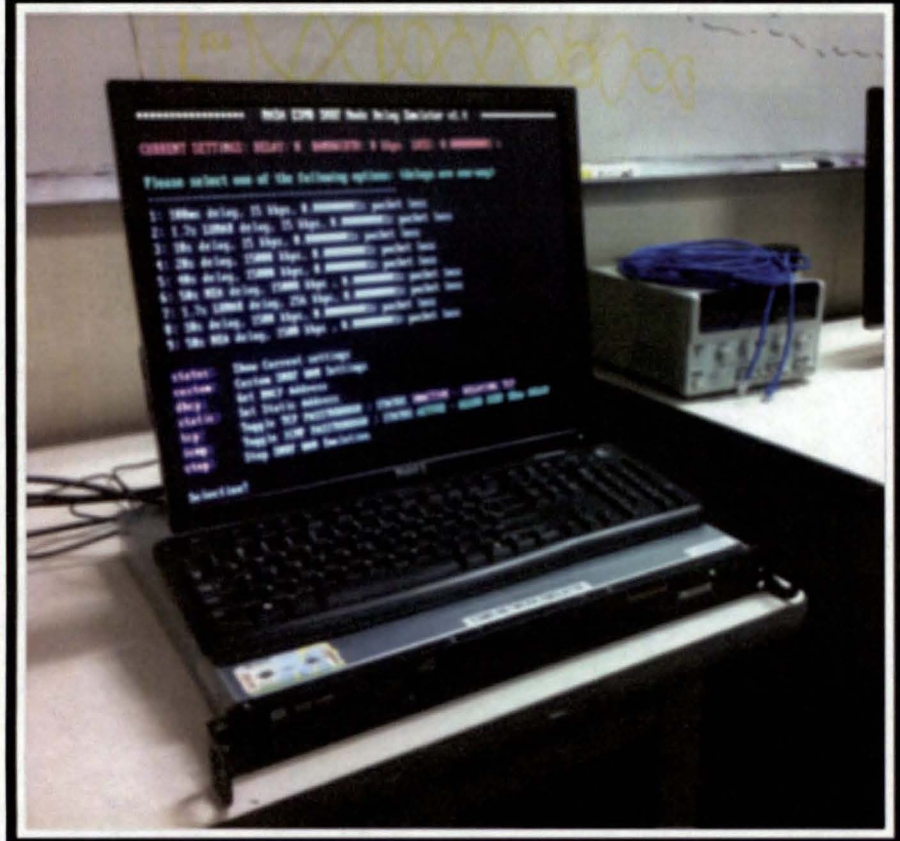
nd Human Destinations[1]
×2 for Round Trip])

	Farthest
	0.0012 s
0.12 s	
	0.28 s
	1.15 s
	1.35 s
	5.07 s
	149.70 s[6]
	1337.59 s

Remote Intelligence

Crew Mobility Systems

Deep Space Communications Delay Emulator



Communication Delays Between Earth and Human Destinations[1]
(Delay Shown for Each Direction [×2 for Round Trip])

	Closest	Farthest
ISS (Direct Uplink)	0.0011 s	0.0012 s
Earth GEO	0.12 s	
ISS (Via TDRSS Relay)	0.25 s	0.28 s
Earth–Moon L1	1.01 s	1.15 s
Lunar Surface[3]	1.21 s	1.35 s
Earth–Sun L1	4.91 s	5.07 s
Near-Earth Asteroids[4]	50.0 s[5]	149.70 s[6]
Mars	186.79 s	1337.59 s

[1] Infrastructure system delays not shown; will add 1–5%
[2] Assumes an average GEO orbit of 35,000 km
[3] Assumes near-side lunar surface; far side adds orbiting relay delay
[4] Near-Earth asteroids of interest are between the Moon and Jupiter
[5] Represents the closest NEO considered for a human mission (0.1 AU) (NASA HEFT2)
[6] For asteroids located as far from Earth as 0.3 AU

Materials for Remote Environments

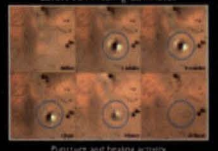
EVA Dust Shields for Space Suits and Habitats

Flat Surface Damage Detection

Materials with Self Healing Properties

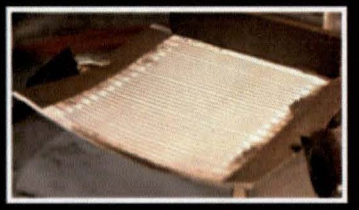
Self Healing Microcapsules

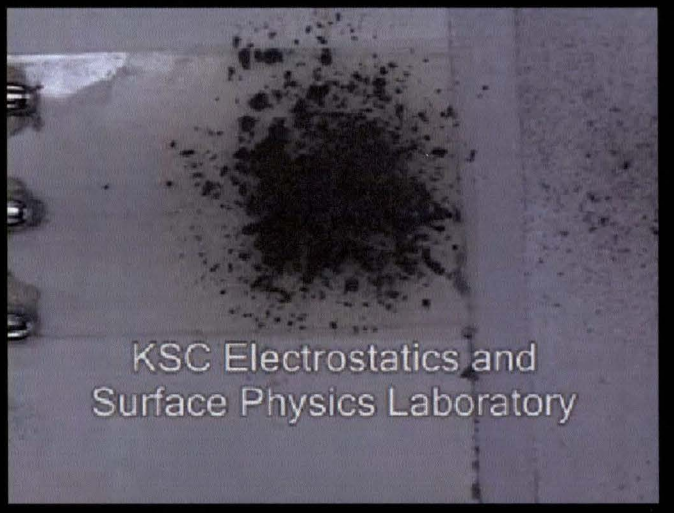
Latest Self Healing Laminates



Early Corrosion Indication

EVA Dust Shields for Space Suits and Habitats



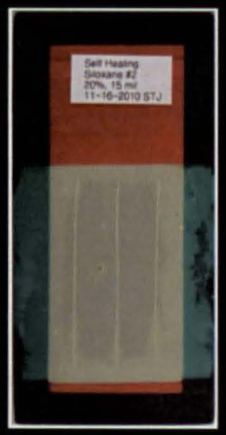


Prezi

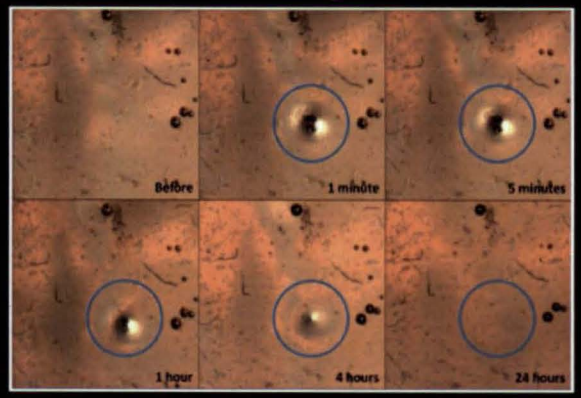
Materials with Self Healing

Materials with Self Healing Properties

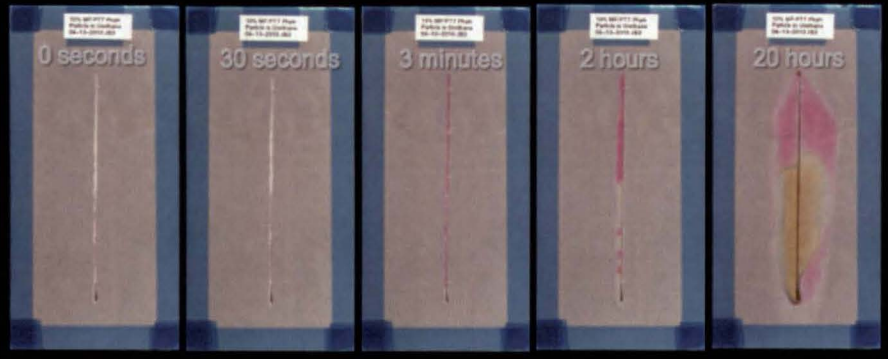
Self Healing Microcapsules



Latest Self Healing Laminates

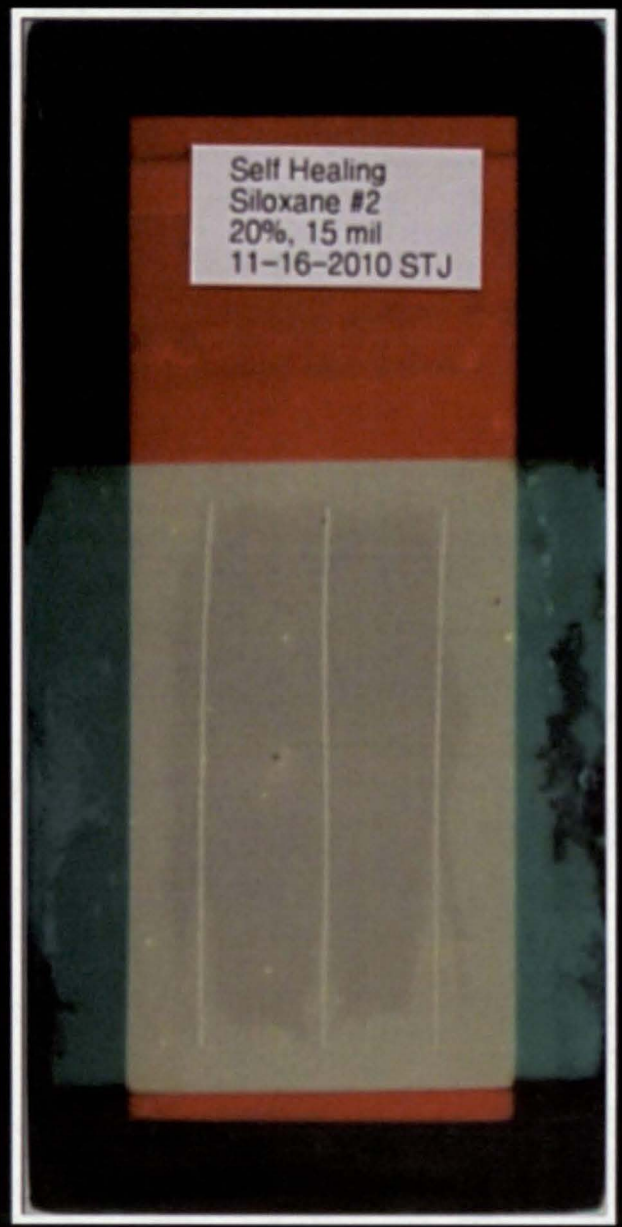


Puncture and healing activity



Early Corrosion Indication

Self Healing Microcapsules



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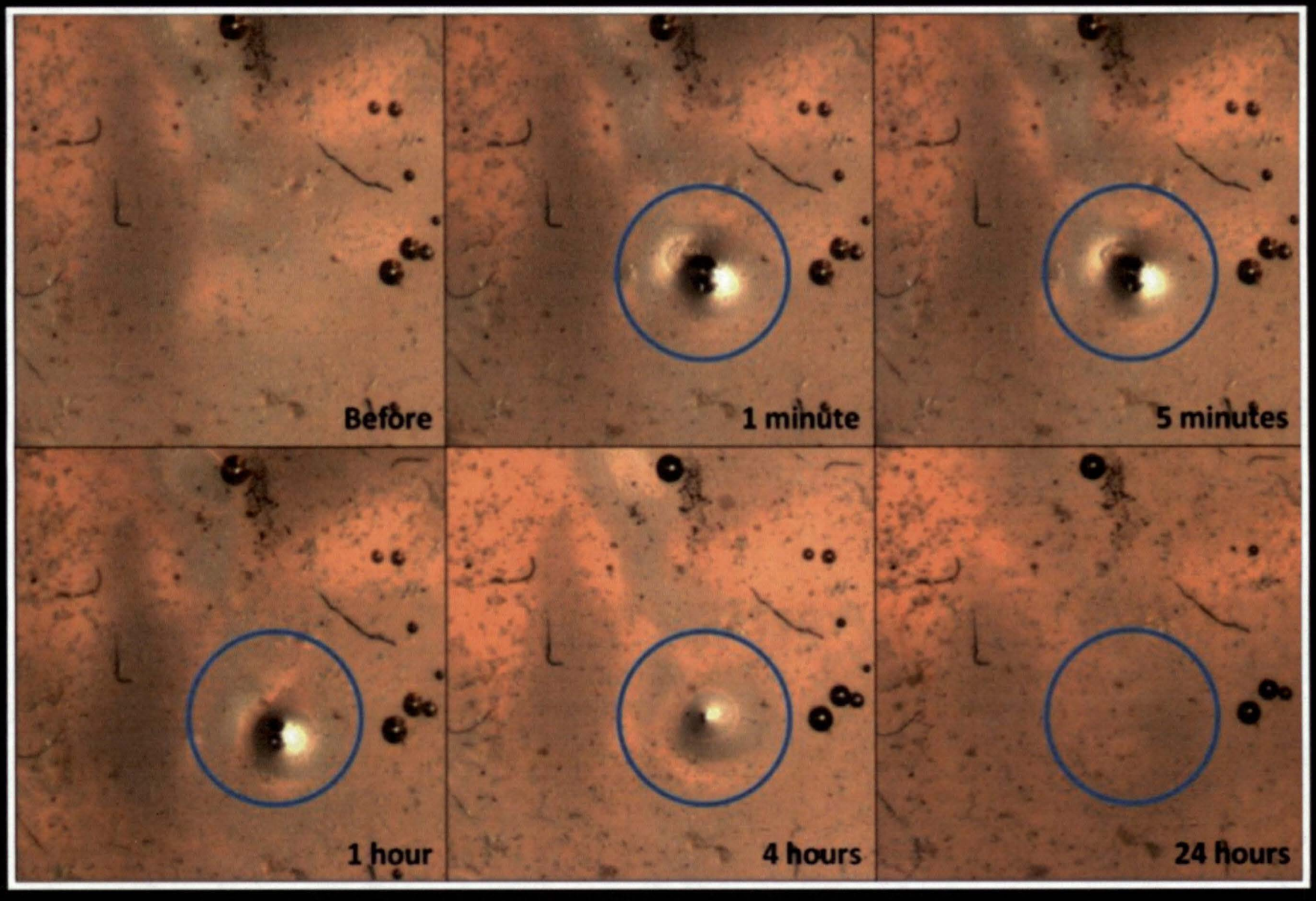
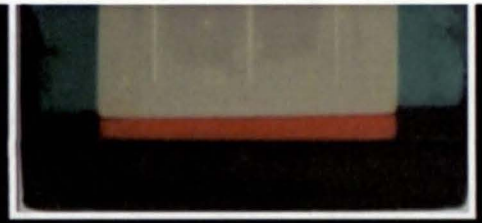


Puncture and healing activity



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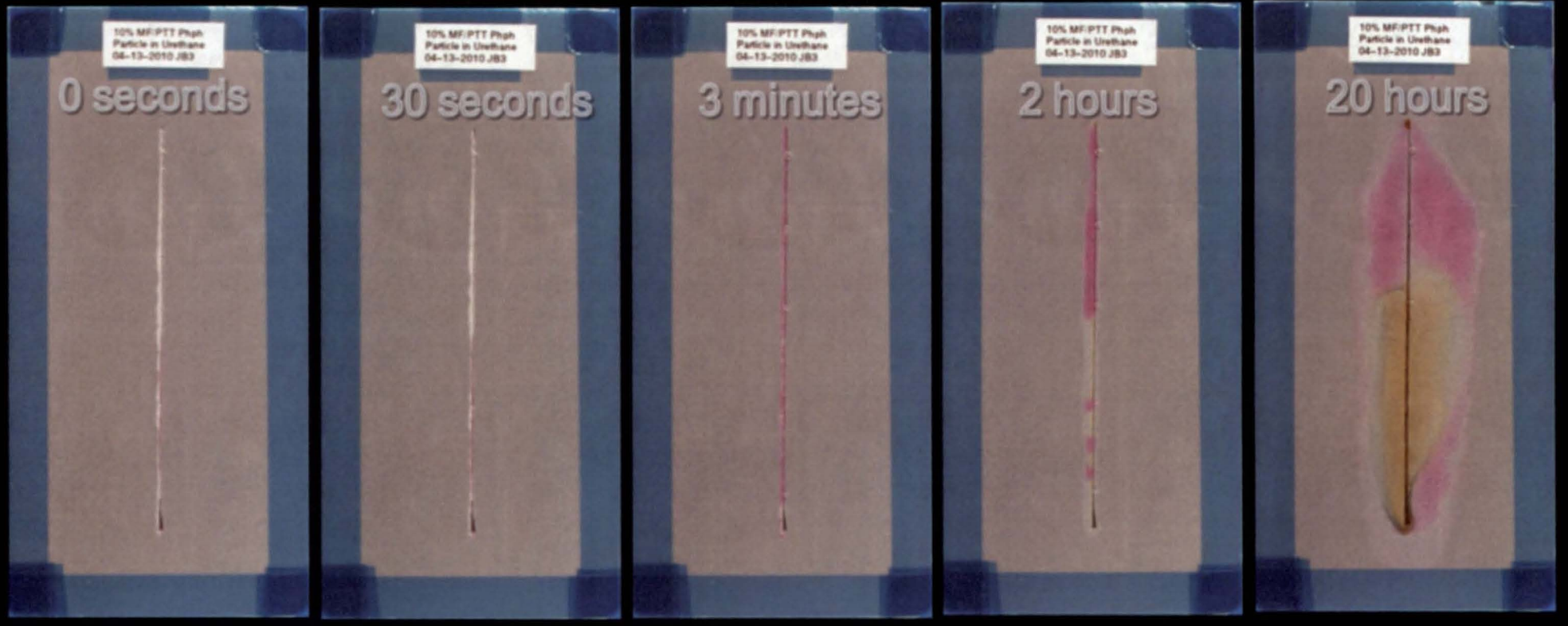


Early Corrosion Indication

Flat Surface Damage Detection

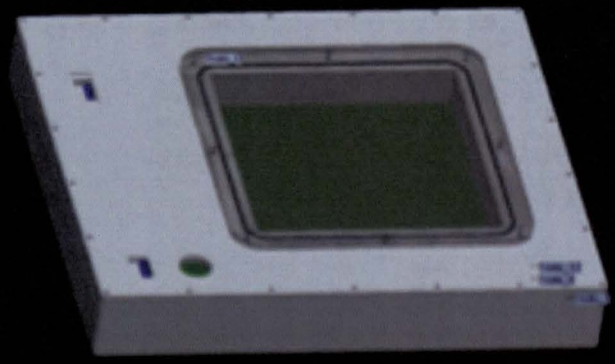
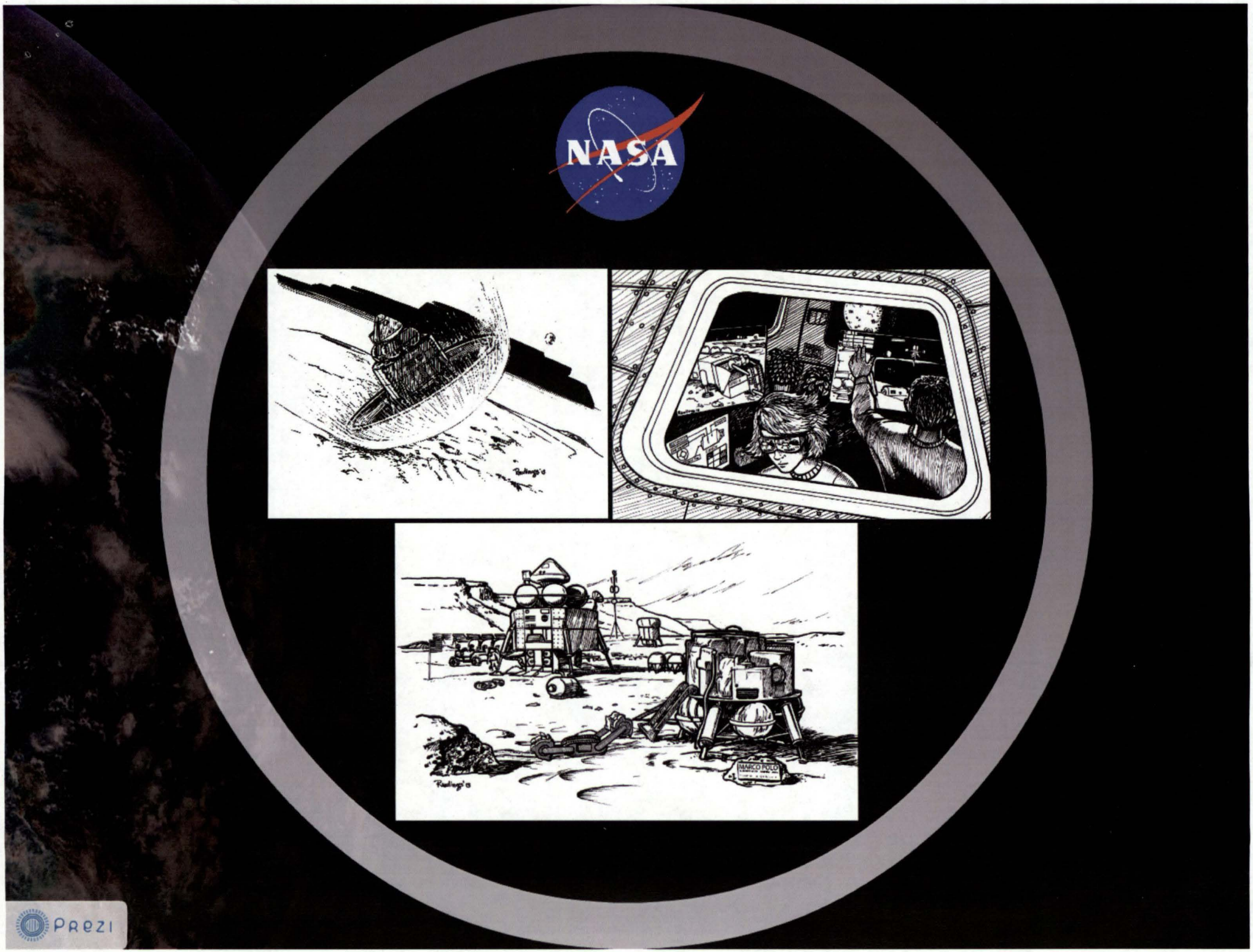
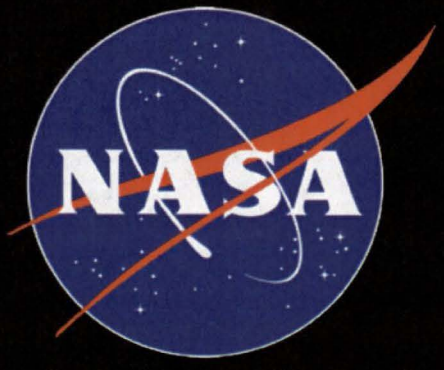


Figure 3 – FSDDS Damage Zone from Desert Rats Testing

erials with Self Healing
Properties


NASA
MARCO POLO

NASA Current Technology Development Work for Tele-reach Applications



Karen L. Thompson
NASA John F. Kennedy Space Center Chief Technologist

Thursday, February 21, 2013

Health and Medical

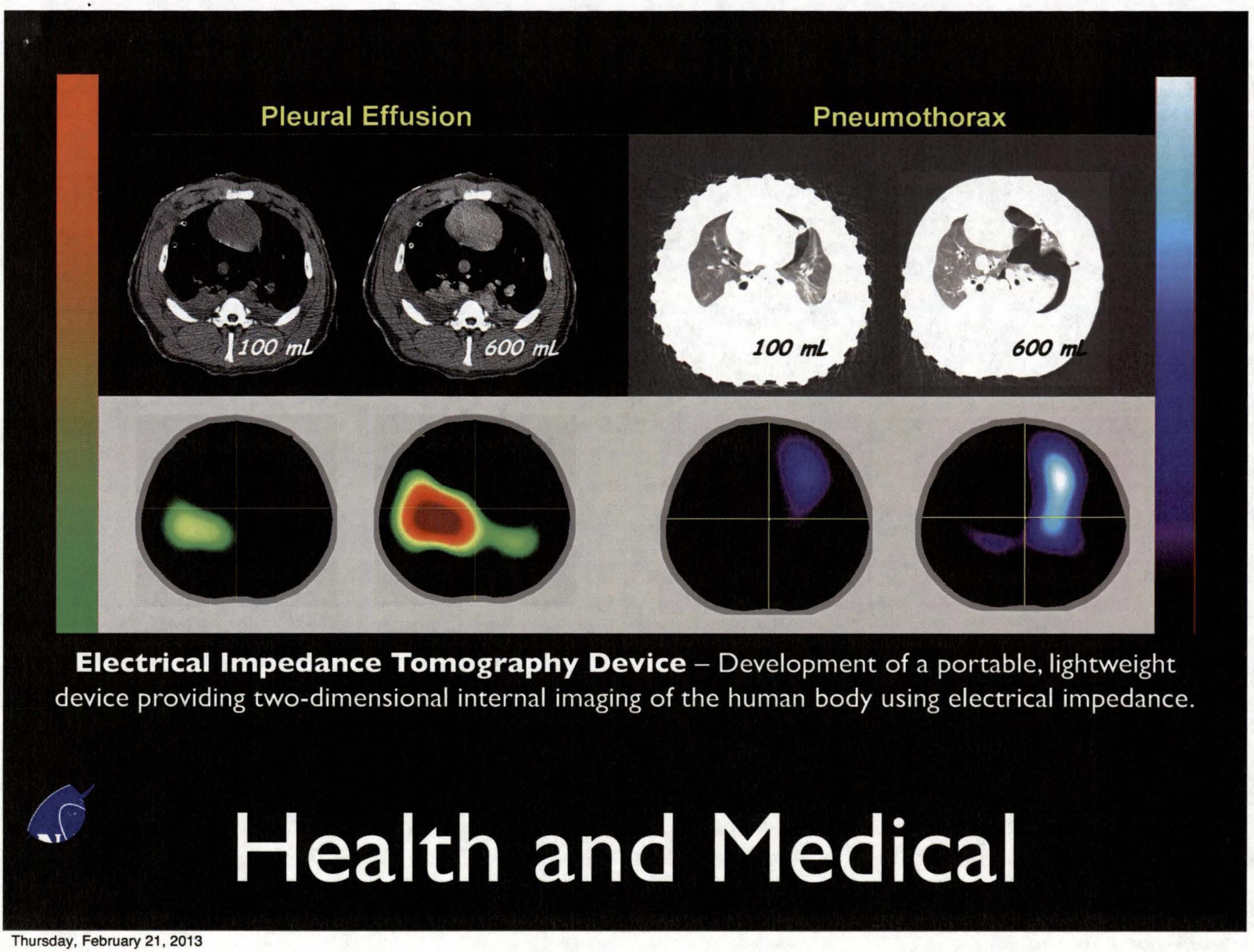
Thursday, February 21, 2013

The NASA John F. Kennedy Space Center (along with collaboration partners from other NASA centers, other agencies including international partners, industry and academia) is currently developing technologies to meet needs of long duration and exploratory class spaceflight that also have important terrestrial benefits.

Biomedical work being performed at the Kennedy Space Center (KSC) in partnership with industry collaborators has led to technologies developed by NASA for astronaut health monitoring that are now being considered for use by emergency medical responders and the military.

These are various pictures of current Telemedicine activities. One is the da Vinci Surgical System (top right) which comprises three components: a surgeon's console, a patient-side robotic cart with 4 arms manipulated by the surgeon (one to control the camera and three to manipulate instruments), and a high-definition, magnified, 3D vision system. Articulating surgical instruments are mounted on the robotic arms which are introduced into the body through cannulas. The original telesurgery robotic system that the da Vinci was based on was developed at SRI International in Menlo Park with grant support from DARPA and NASA. Although the telesurgical robot was originally intended to facilitate remotely performed surgery in battlefield and other remote environments, it turned out to be more useful for minimally invasive on-site surgery.

The da Vinci senses the surgeon's hand movements and translates them electronically into scaled-down micro-movements to manipulate the tiny proprietary instruments. It also detects and filters out any tremors in the surgeon's hand movements, so that they are not duplicated robotically. The camera used in the system provides a true stereoscopic picture transmitted to a surgeon's console. The da Vinci System is FDA cleared for a variety of surgical procedures including surgery for prostate cancer, hysterectomy and mitral valve repair, and is used in more than 800 hospitals in the Americas and Europe. The da Vinci System was used in 48,000 procedures in 2006 and sells for about $1.2 million. The new da Vinci HD SI released in April, 2009 currently sells for $1.75 million.



Electrical Impedance Tomography Device – Development of a portable, lightweight device providing two-dimensional internal imaging of the human body using electrical impedance.

Health and Medical

Thursday, February 21, 2013

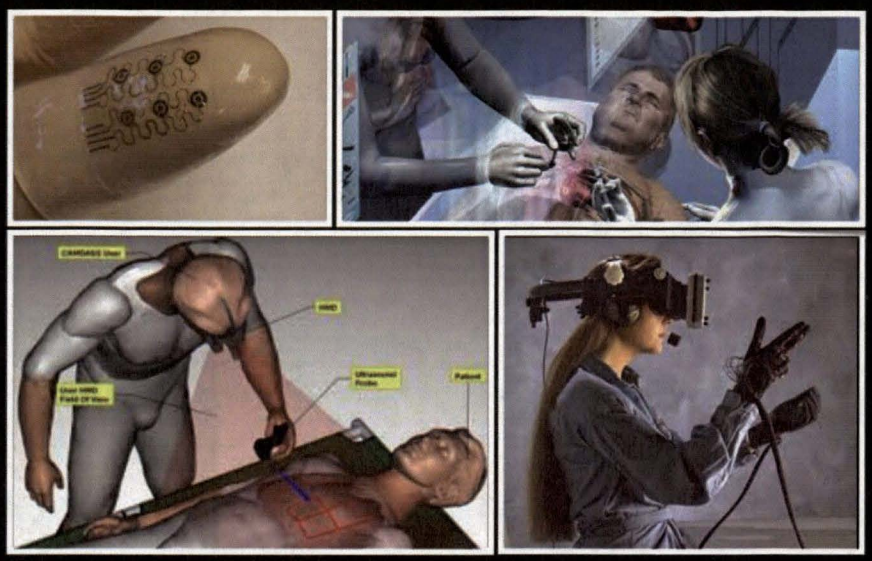
Electrical Impedance Tomography Device – Development of a portable, lightweight device providing two-dimensional internal imaging of the human body using electrical impedance.

Biomedical Monitoring by a Noncontact Radio Frequency Device –
Development of a portable, non-contact device for measuring heart and blood vessel function using radio waves.

Health and Medical

Thursday, February 21, 2013

This device will also measure heart and blood vessel flows using radio waves and send the information to a remote physician for assessment.



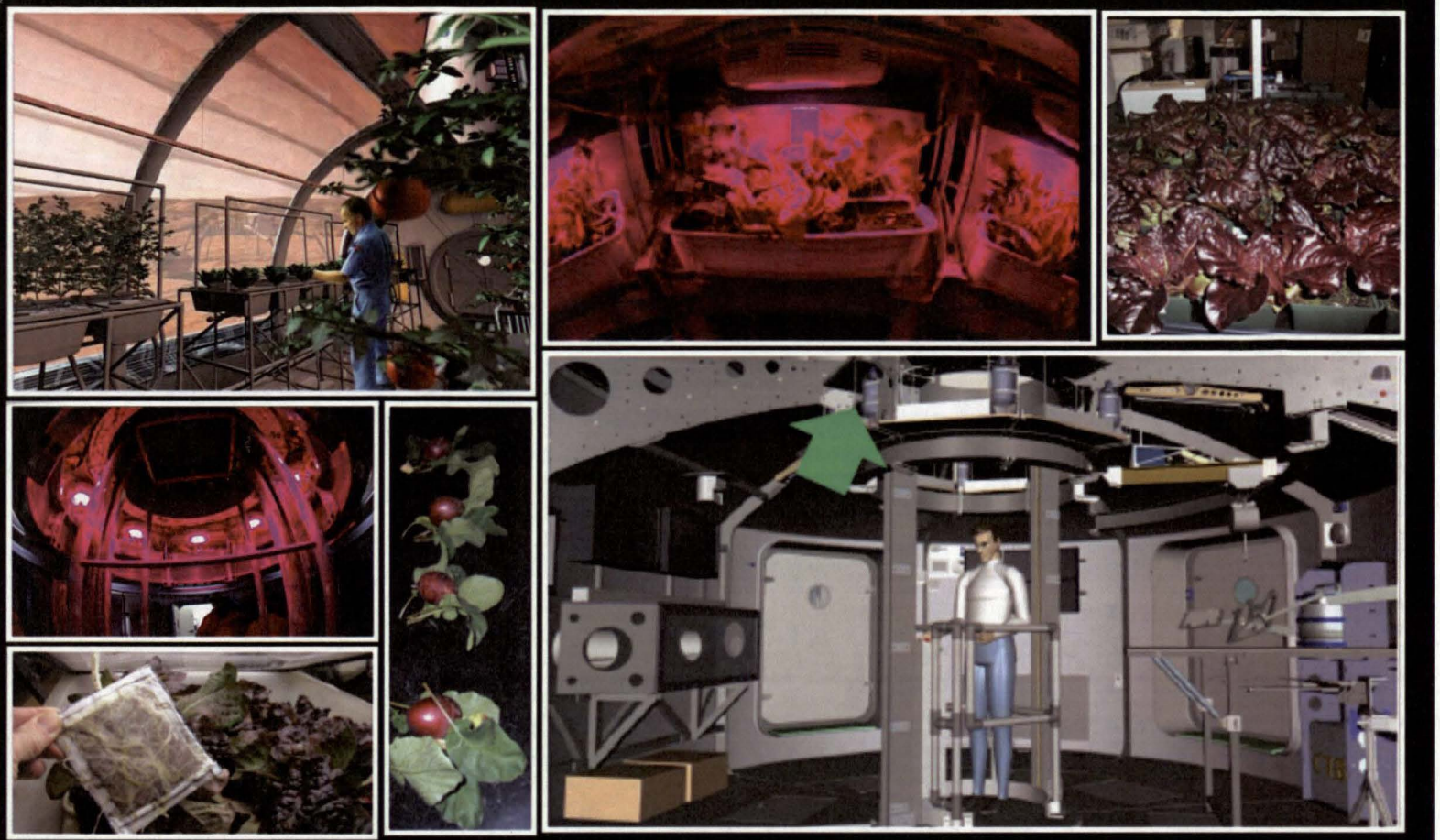
- Virtual Presence: visual, tactile feedback, real-time and delayed
- Provide training for onboard medics

Health and Medical

Thursday, February 21, 2013

The future of telemedicine is bright, only limited by the speed of light. The remote physician will be completely immersed in the reality of his patient, virtually being there. Virtual visual and tactile feedback will help the physician examine and provide treatments remotely in real-time or delayed if extremely far away. This same kind of system will help train onboard medics through simulations to stay competent.

Thursday, February 21, 2013



Plant growth trays with LED light fixtures above each tray located in the Food Production Atrium for the Habitat Demonstration Unit.

Food Production

Thursday, February 21, 2013

Food Production Description

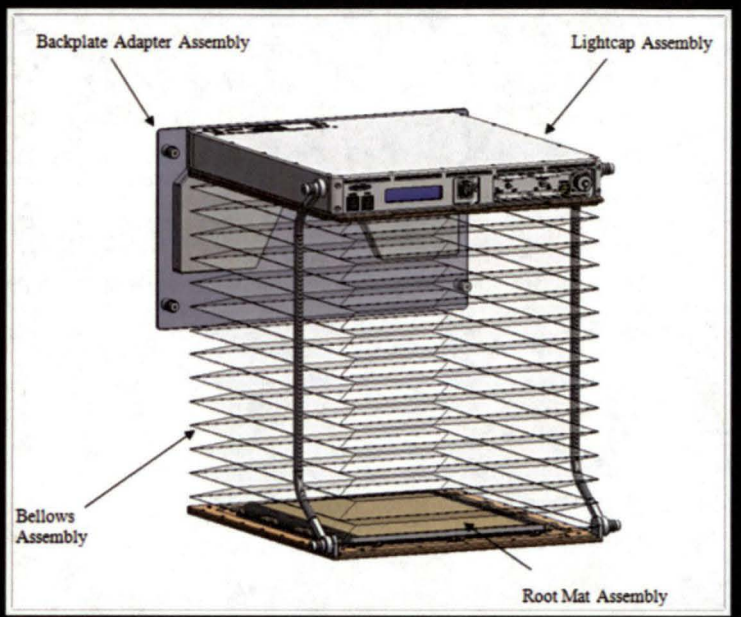
Explore capabilities to grow vegetables and fruits to augment the crew's diet of packaged foods. These fresh foods will add texture, flavor, and variety to the diet and provide bio- available nutrients, which can serve as a radiation
countermeasure. Expanded food production systems for future missions will reduce the need for stowed foods and contribute to CO_2 removal/reduction, O_2 production, and water recycling Production Hardware Concepts
recycling.

Radish plants were harvested from a plant growth chamber. The plants were grown under red and blue LED lights. This plant experiment studies the effects of different types of lighting on plants such as radishes and leaf lettuce.

Red leaf lettuce plants were also harvested from a plant growth chamber grown under red and blue LED lights. The plant experiment at Kennedy is part of the Advanced Exploration Systems, or AES, program in NASA's Human Exploration and Operations Mission Directorate.

Red-leaf lettuce plants growing in rooting pillows for μ–g VEGGIE plant growth unit. Roots take up water through a porous nylon membrane.

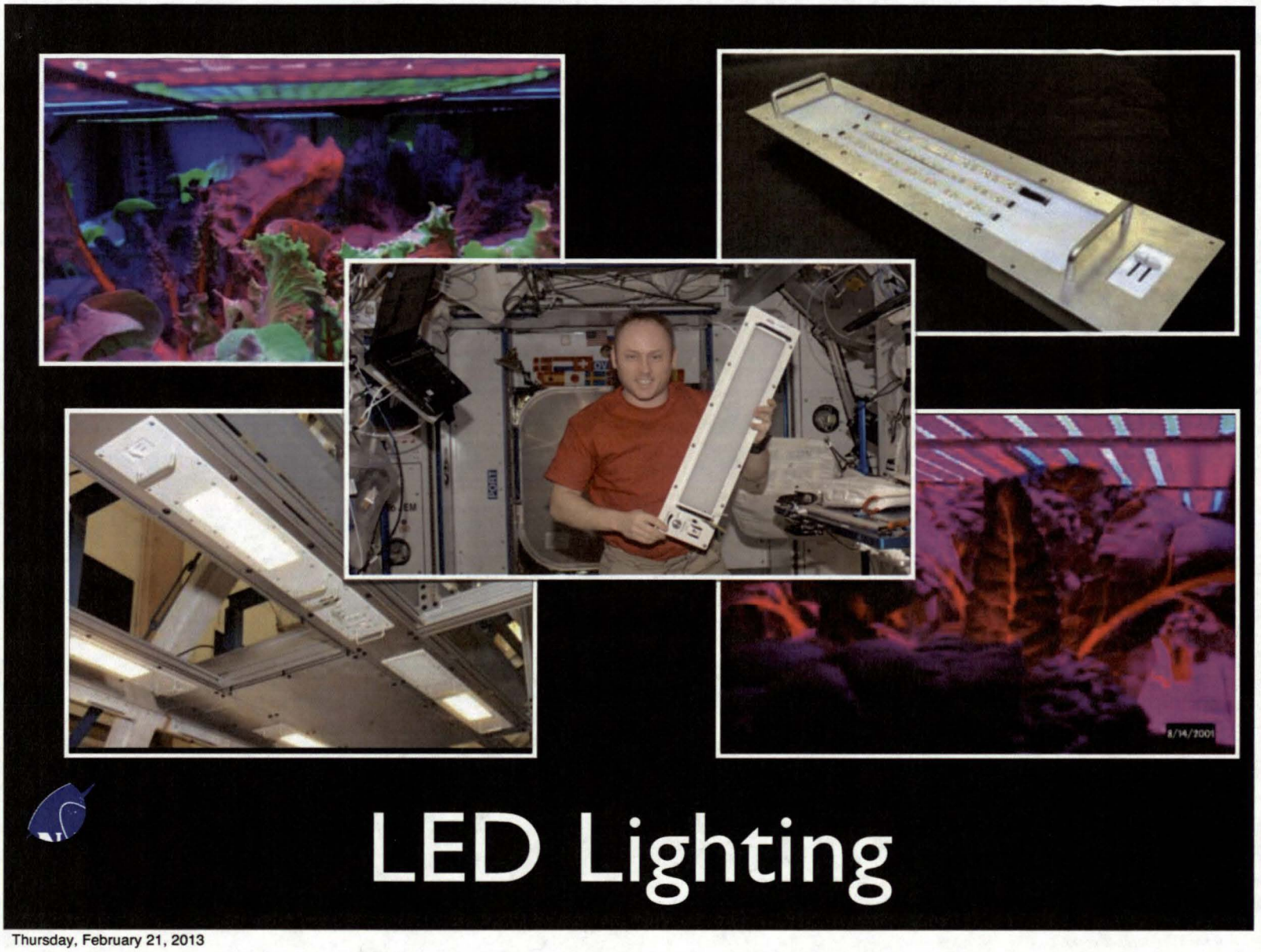
http://www.nasa.gov/centers/kennedy/home/plant_growth.html



Food Production Units

Thursday, February 21, 2013

This is a KSC developed flight payload being prepared for the ISS. The concept is to demonstrate plant growth to supplement the crew's diet with fresh, perishable foods and herbs while on exploration campaigns.

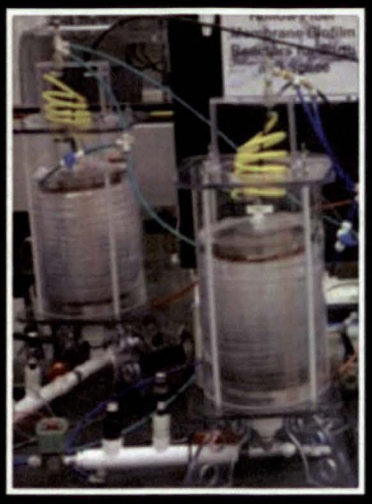


LED Lighting

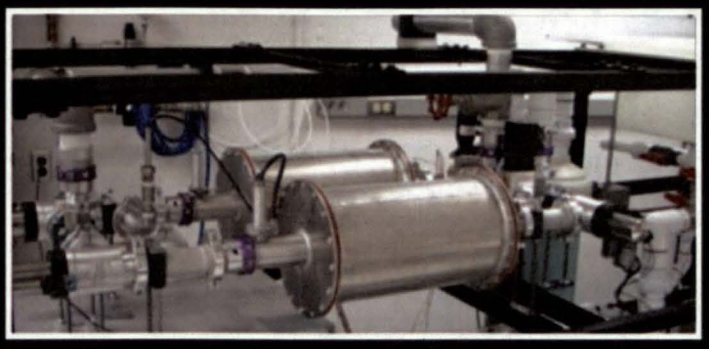
Thursday, February 21, 2013

Developed pathfinding efforts in solid state lighting tailored for plant growth and developing a system to assist in circadian adaptation for crew to assist in proper sleep cycles and adjustment to variable work shifts

Plant lighting shows the use of red and blue LEDs which are the wavelengths needed by plants showing prototype light assemblies built for the ISS-derived Deep Space Hab Concept Demonstrator under construction at MSFC.



Biological Treatment of Wastewater



Low Power CO_2 Removal

Osmotic Filtration

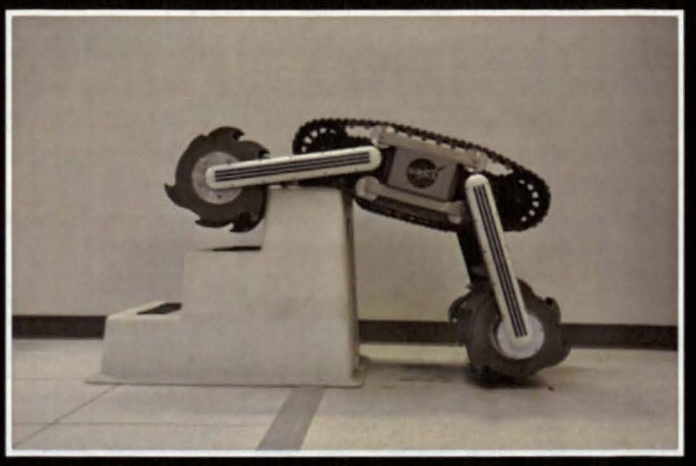
Air and Water Revitalization

Thursday, February 21, 2013

Atmosphere Revitalization Description:
Identify and mature technologies for flexible, reliable atmosphere revitalization to enable efficient Environmental Control and Life Support.
Process technology maturation tasks are conducted for water-save gas drying; trace contaminant control; CO2 removal, conditioning, and reduction to useful products; particulate matter removal and disposal; atmospheric gas
Open Loop Regenerable CO2 Removal System
CAMRAS Evaluation
Advanced (alternative) Trace Contaminant Control (ATCC)
Photocatalytic SystemDevelopment
Control Trace VOC Concentrations
supply, storage, and conditioning; resource recovery, storage, conditioning, and recycling; and supporting infrastructure.

Water Recovery Description:
Enable long duration missions by increasing the percent closure of the water loop and reducing consumable cost recovery systems for water recovery. Reliable primary treatment systems, technologies to recover water from brine, and improved wastewater stabilization and disinfection systems are among the major areas of interest for technology development.

RESOLVE



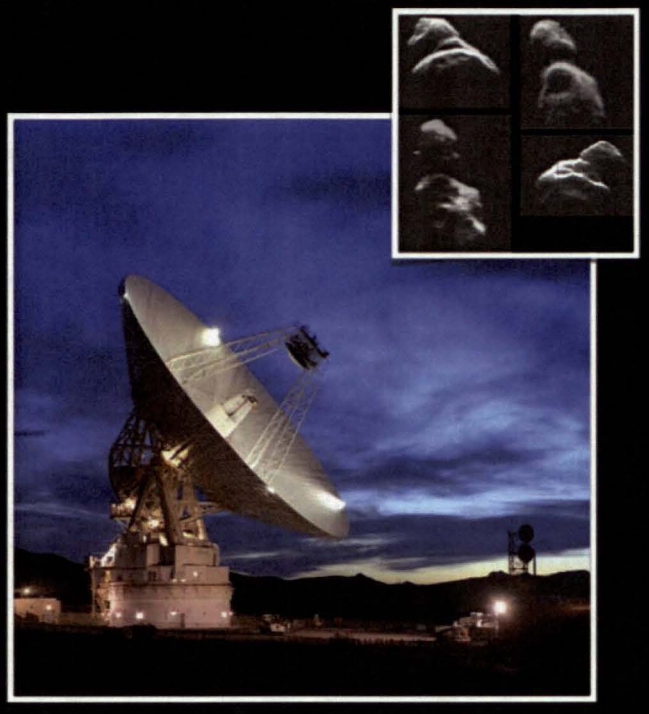
RASSOR

Robotic Development

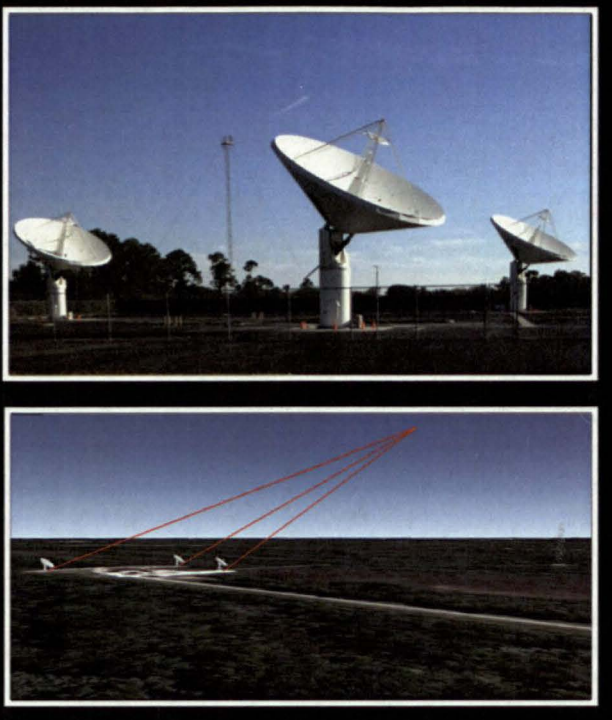
Thursday, February 21, 2013

The Regolith & Environment Science and Oxygen & Lunar Volatile Extraction (RESOLVE) project aims to demonstrate the utility of "in situ resource utilization". In situ resource utilization is a way to rebalance the economics of spaceflight by reducing or eliminating materials that must be brought up from Earth and placed on the surface of the Moon or Mars for human use. RESOLVE is developing a rover-borne payload that (1) can locate near subsurface volatiles, (2) excavate and analyze samples of the volatile-bearing regolith, and (3) demonstrate the form, extractability and usefulness of the materials.

Dubbed RASSOR, for Regolith Advanced Surface Systems Operations Robot and pronounced "razor," the autonomous machine is far from space-ready, but the earliest design has shown engineers the broad strokes of what their lunar soil excavator needs in order to operate reliably.



Four Meter Goldstone Imaging of Near Earth Objects



Ka-Band Uplink Array Projects

Remote Intelligence

Thursday, February 21, 2013

Four Meter Goldstone Imaging of Near Earth Objects

Develop innovative approaches to characterize potential destinations for human exploration. Utilize high-resolution Goldstone Solar System Radar (GSSR) imaging of near-Earth objects (NEOs). KSC participation includes analysis activities, and exposure to uplink radar methodologies to prepare for future KSC projects.

Relevance to Human Spaceflight:

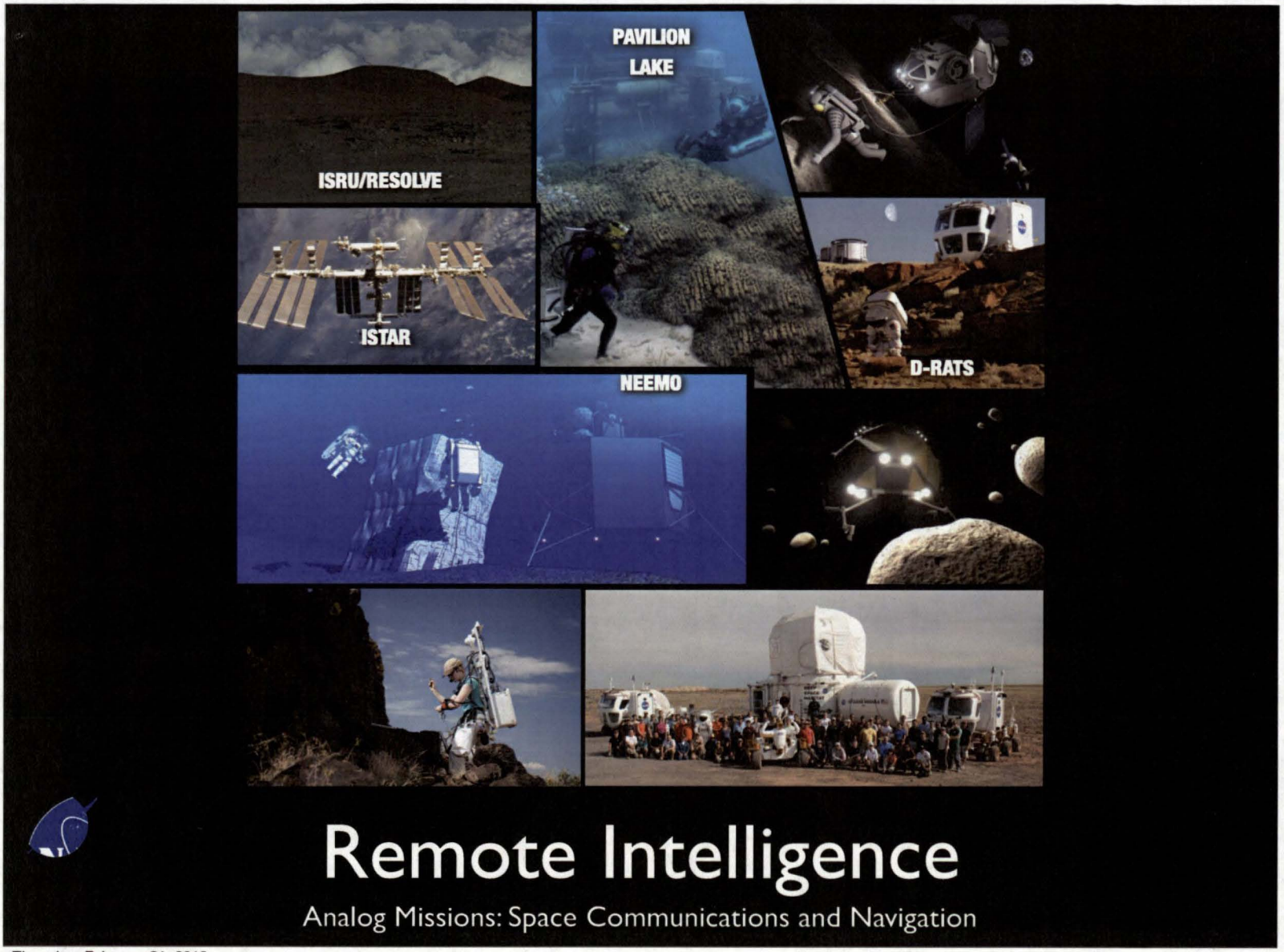
The US Space Policy directs NASA to send a human to an Asteroid to conduct scientific investigations by 2025. Characteristics of most of the 600,000 NEO's/NEA's are minimally understood. Human missions will most likely be preceded by robotic missions. Identifying the most promising NEO's/NEA's to explore requires Earth-based radar investigation and down-selection prior to mission definition.

Ka-Band Uplink Array Projects

Uplink array radar is performed today at X and C bands. It is useful for a variety of applications, including imaging of orbital debris, and Near-Earth Asteroids. KSC is standing-up an Uplink Array Testbed this year, with the goal of performing Ka-band uplink arraying with a larger array down the road.

Relevance to Human Spaceflight:

Improved means to image orbital debris are needed. Characteristics of most of the 600,000 NEO's/NEA's are minimally understood. Human missions will most likely be preceded by robotic missions. Identifying the most promising NEO's/NEA's to explore requires Earth-based radar investigation and down-selection prior to mission definition.



Remote Intelligence

Analog Missions: Space Communications and Navigation

Thursday, February 21, 2013

Analog Missions: Space Communications and Navigation

The "proving grounds" for low to mid TRL capabilities for future human spaceflight

KSC personnel are responsible for designing, developing, deploying, and operating a communications, networking, timing and navigation infrastructure for NASA/HEO Analog missions that resembles concept future Human Spaceflight mission architectures.

KSC personnel maintain a "common analogs communication capability" for all AES analogs and year-round home center testing.

Multi-Mission Space Exploration Vehicle
(MMSEV)

Remote Intelligence

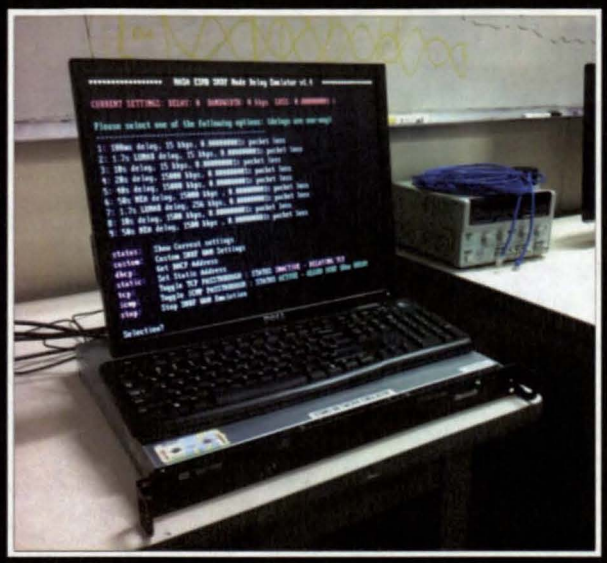
Crew Mobility Systems

Thursday, February 21, 2013

KSC personnel are designing, developing, prototyping, and testing sequential generations of critical communication and networking avionics for the Multi-Mission Space Exploration Vehicle (MMSEV).
The team validates future avionics concepts in relevant terrestrial environments in preparation for flight test demos. The goal is to advance the capabilities of future avionics, and enable avionics commonality across other spacecraft (SLS, Deep Space Habitat, MPCV, etc)

Relevance to HSF:
The MMSEV plays a prominent role in design reference missions (DRM) for crew exploration at a near earth asteroid (NEA) and on surfaces. Lean development approaches and common components will be utilized to perform early spacecraft design and development at a low cost.

Deep Space Communications Delay Emulator



Communication Delays Between Earth and Human Destinations[1] (Delay Shown for Each Direction [×2 for Round Trip])

	Closest	Farthest
ISS (Direct Uplink)	0.0011 s	0.0012 s
Earth GEO	0.12 s	
ISS (Via TDRSS Relay)	0.25 s	0.28 s
Earth–Moon L1	1.01 s	1.15 s
Lunar Surface[3]	1.21 s	1.35 s
Earth–Sun L1	4.91 s	5.07 s
Near-Earth Asteroids[4]	50.0 s[5]	149.70 s[6]
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[1] Infrastructure system delays not shown; will add 1–5%
[2] Assumes an average GEO orbit of 35,000 km
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[5] Represents the closest NEO considered for a human mission (0.1 AU) (NASA HEFT2)
[6] For asteroids located as far from Earth as 0.3 AU

Remote Intelligence

Information Management

Thursday, February 21, 2013

Other important areas of development work involving KSC are enabling systems like computer processing, data transfer, remote intelligence and information management in a very computationally adverse environment.

Communication Paradigms
186,000 miles per second is just too slow
No matter the bandwidth, "C" is still just "C"
We can send voice mail, send text messages and e-mail, but talking with more than a 5 second delay is worse than any bad cell phone call ever made.
Imagine a chat window where everyone is always 5 messages ahead of you

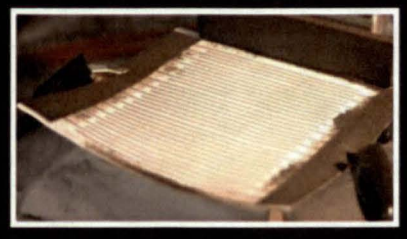
We have to re-learn how to communicate
Multiple, parallel conversations, spread out over time as opposed to quick serial communications
And, space explorers will have significantly more autonomy than ever before
Enter the FaceBook generation...

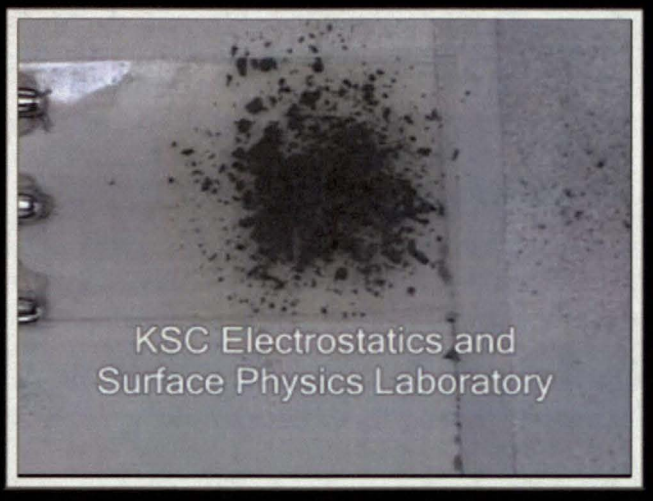
KSC engineers designed, developed, deployed (7 systems), and trained other Centers to operate a low-cost, Layer 3, configurable, and bidirectional IP space network delay emulation system.
The systems were first tested in FY09 and continue to be used by multiple Agency analog teams to delay mission telemetry and commands at a variety of deep-space rates.

Field testing revealed that current Mission Operations methods were not adequate for real delays, and the Agency must develop new tools and methods to conduct future human spaceflight missions beyond cislunar space.

Simulation
We need to understand systems of systems today, and track for 50 years
Multiple developers, architects, countries, technologies, time points (architecture can span 20 years), goals, dependencies and futures.
How does todays technology fit, how does tomorrows technology fit, how does 2040 technology fit.
We will to do this
https://www.youtube.com/watch?v=4e-bqzaZh-o
On an asteroid, the Moon and Mars.
In some cases we have, we just cannot share, yet.

Kennedy is leading tool development, standards and integration activities to address this need.



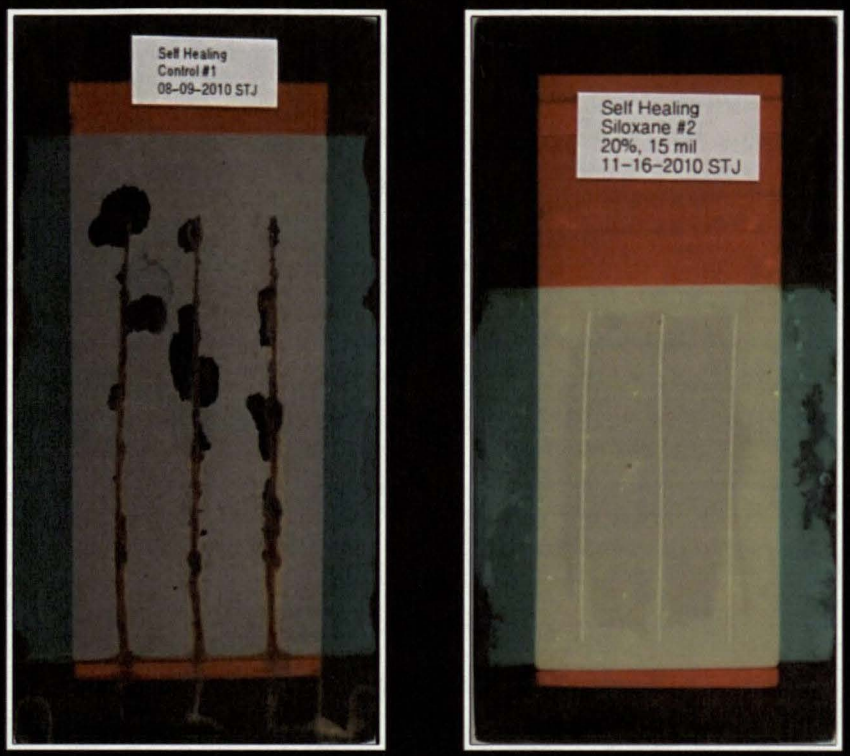


EVA Dust Shields for Space Suits and Habitats

Thursday, February 21, 2013

Embedded circuits cause traveling wave fields that can dispel dust on doors, seals, visors, solar panels, space suits, etc.

Self Healing Microcapsules



Materials with Self Healing Properties

Thursday, February 21, 2013

700 hours of salt fog testing results of carbon steel panels coated with a control coating system (left panel) and the same coating with a self healing system (right panel).

Space Applications

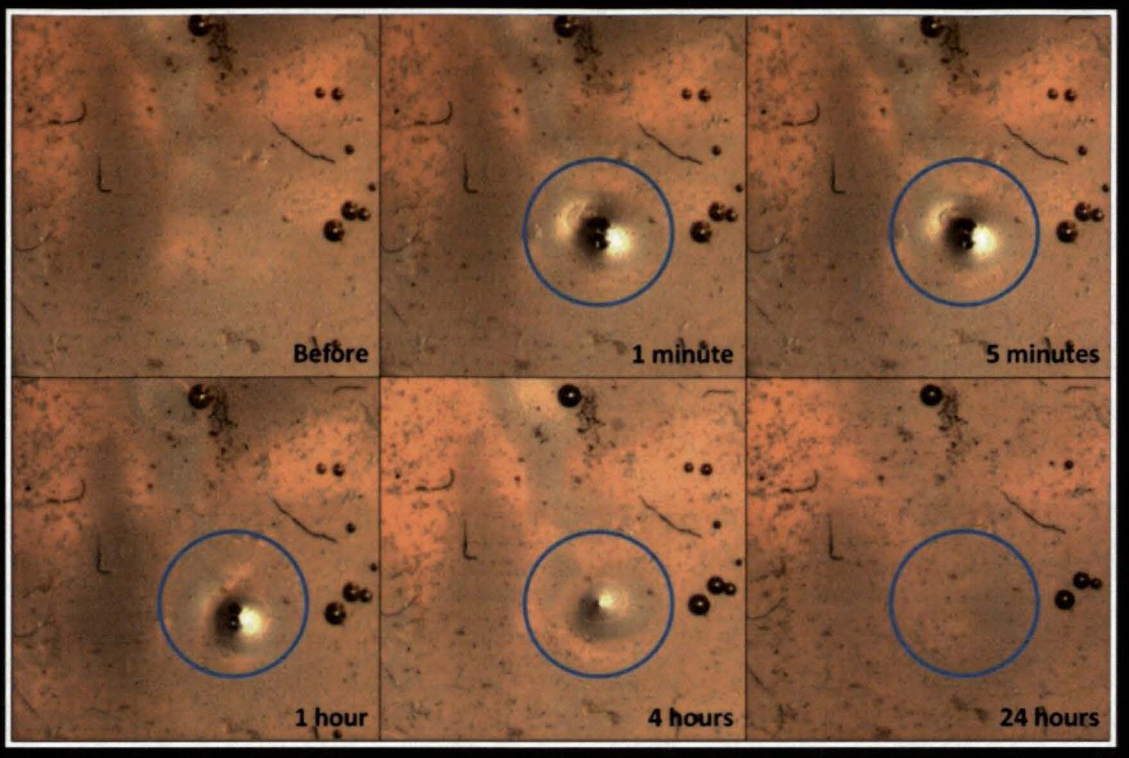
To enable development of new drug delivery devices which can protect astronauts on long-duration space missions and provide alternative delivery routes and countermeasures to injured or sick crew members.

To detect and self-repair damage of critical components.

Earth Applications

The utilization of microcapsules will benefit the treatment of several diseases here on Earth. Microcapsules can be inhaled to deliver antibiotic and immune stimulant drugs to treat inhaled bacterial infections of the lungs. Microcapsules can be injected directly into solid tumors to provide local, sustained release, of anti-cancer drugs. The microcapsules can be imaged with C-T scans or ultrasound to insure that the combinations of medications can be delivered directly to the target tumors. Since the drug release is local, using microcapsules reduces the unwanted side effects of systemic (intravenous) chemotherapy, which involves large amount of drugs producing major side effects throughout the entire body.

Latest Self Healing Laminates

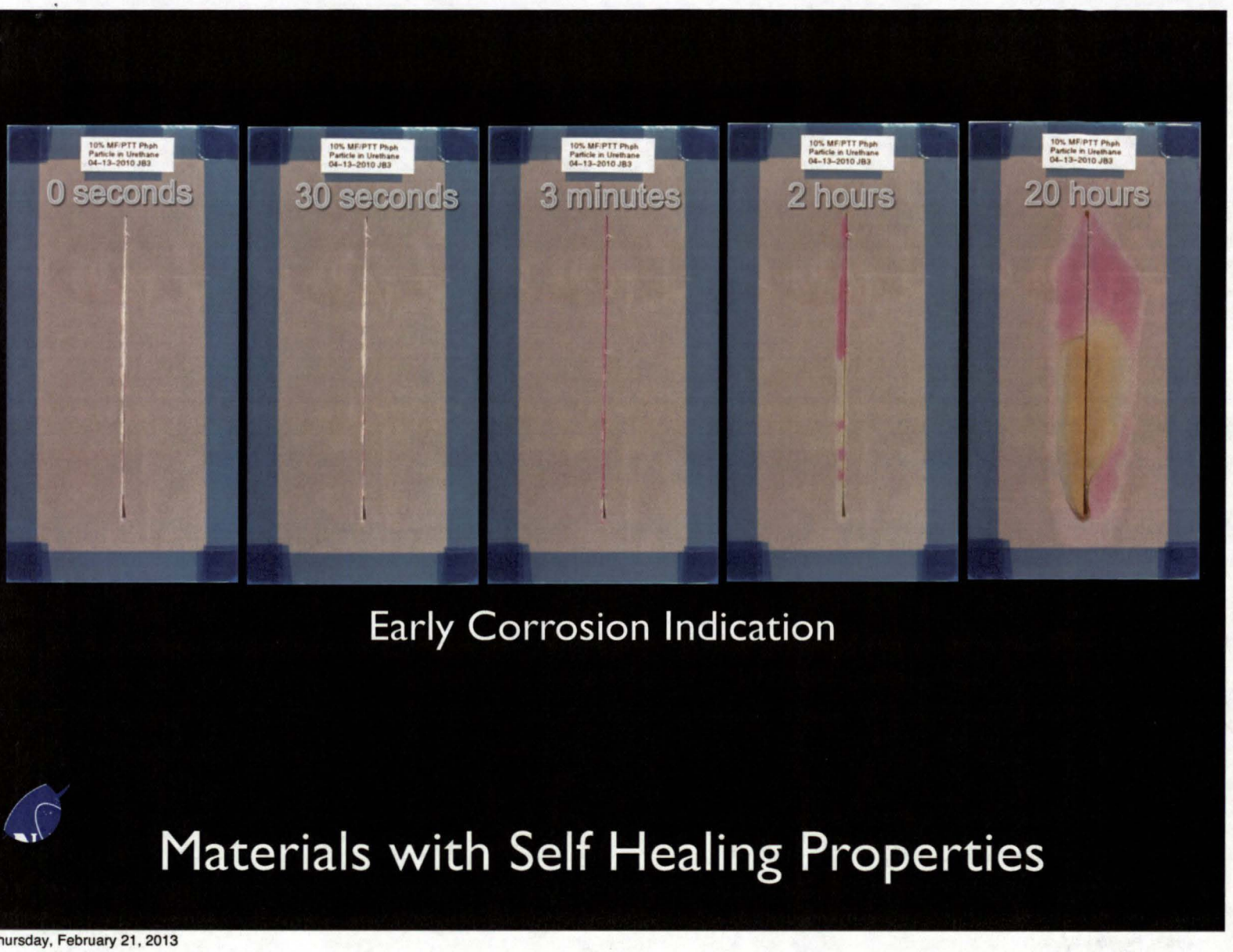


Puncture and healing activity

Materials with Self Healing Properties

Thursday, February 21, 2013

24 hour time lapse photos of puncture evaluation in a self healing laminate system as shown



Thursday, February 21, 2013

Yet another area of technology involving KSC that has gained much external interest is in the area of new materials with self-healing properties for reduced maintenance—important for remote destinations with limited crew time for such work and of interest for numerous terrestrial applications for reduced costs and increased safety of all types of systems.

Salt immersion results of panels coated with a clear polyurethane coating with encapsulated corrosion indicator. The coating detects corrosion at a very early stage (less than a few seconds) before the appearance of rust is visible (about 2 hours).

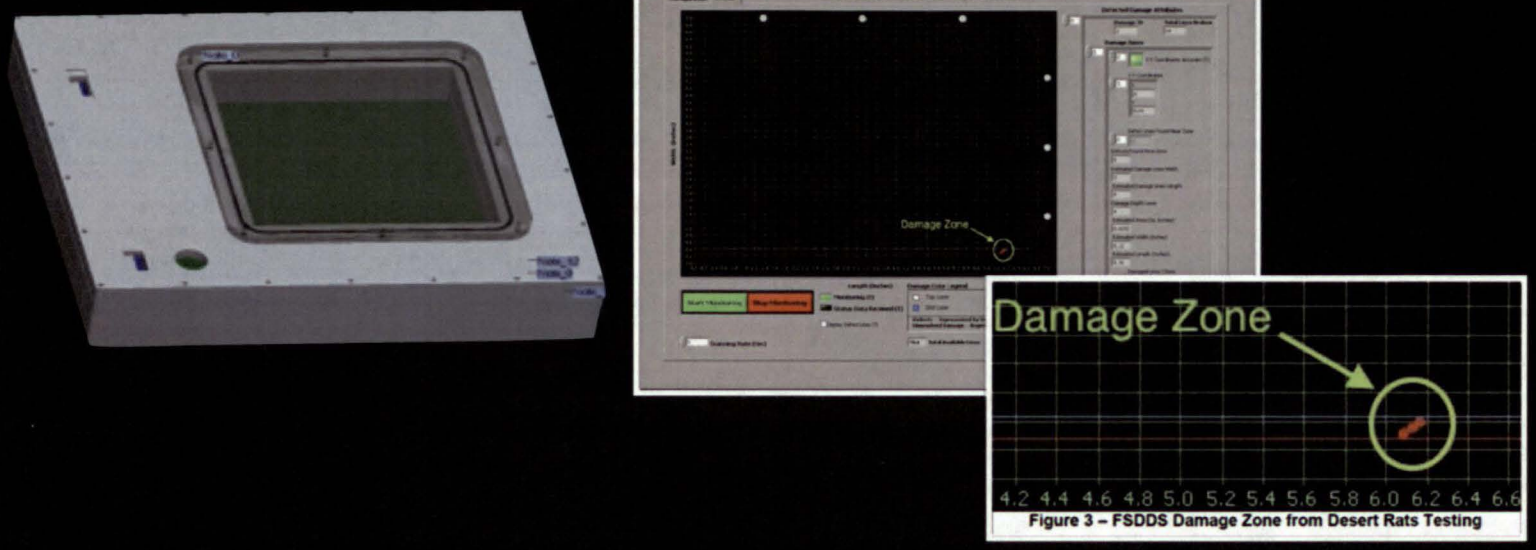


Figure 3 – FSDDS Damage Zone from Desert Rats Testing

Flat Surface Damage Detection

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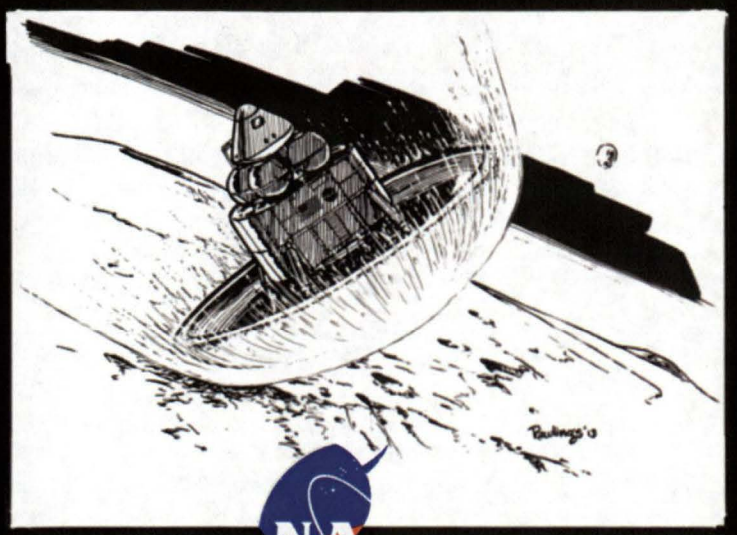
The Flat Surface Damage Detection system uses a series of two-dimensional detection systems and printed conductive circuitry to demonstrate a detection system for real time damage diagnosis (location and percent damage). This system will provide the ability to monitor the integrity of an inflatable habitat during in situ system health monitoring.

An example of spacecraft telemetry display showing where damage occurred



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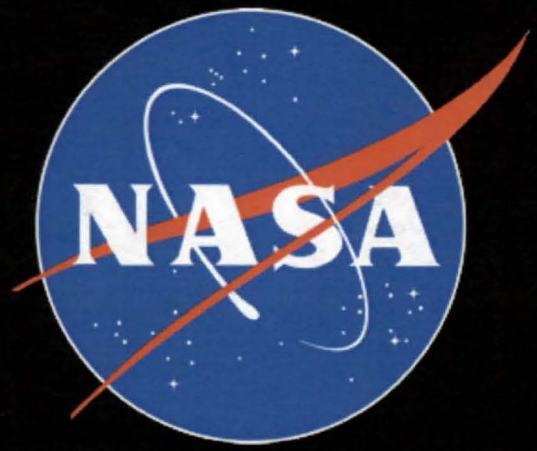
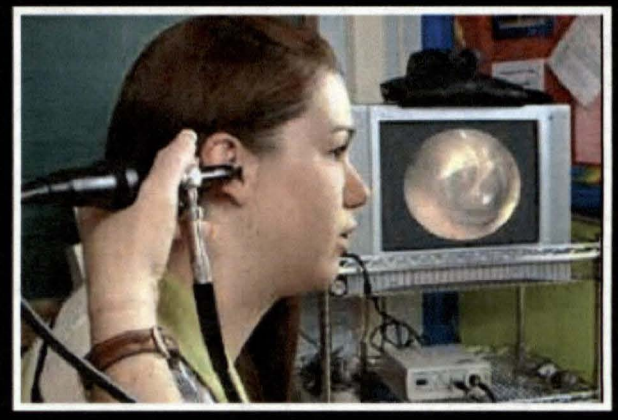
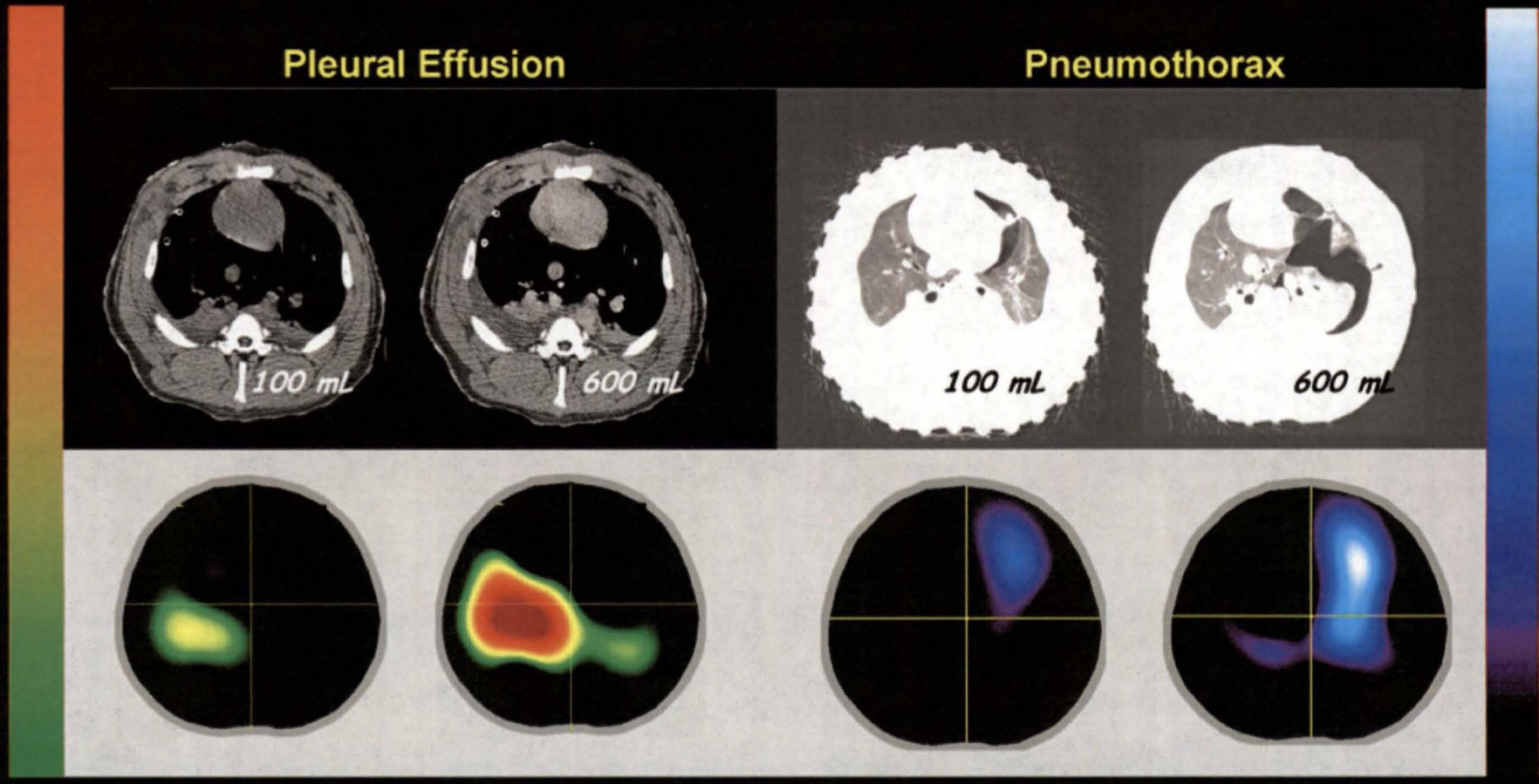
NASA Current Technology Development Work for Tele-reach Applications



Karen L. Thompson
NASA John F. Kennedy Space Center Chief Technologist



Health and Medical

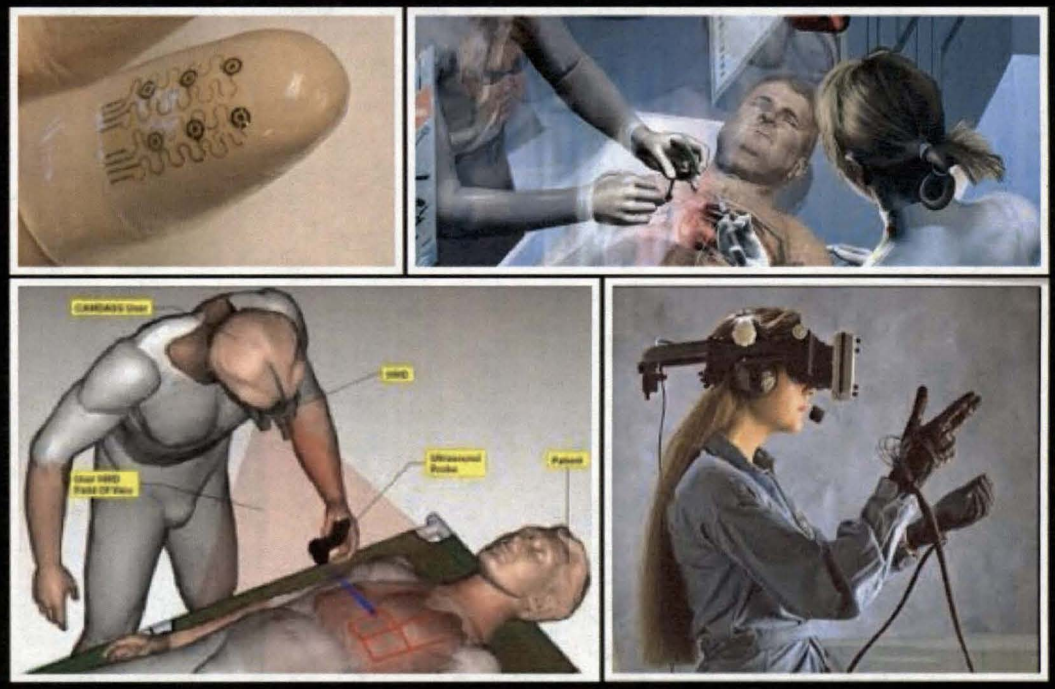


Electrical Impedance Tomography Device – Development of a portable, lightweight device providing two-dimensional internal imaging of the human body using electrical impedance.

Health and Medical

Biomedical Monitoring by a Noncontact Radio Frequency Device –
Development of a portable, non-contact device for measuring heart and blood vessel function using radio waves.

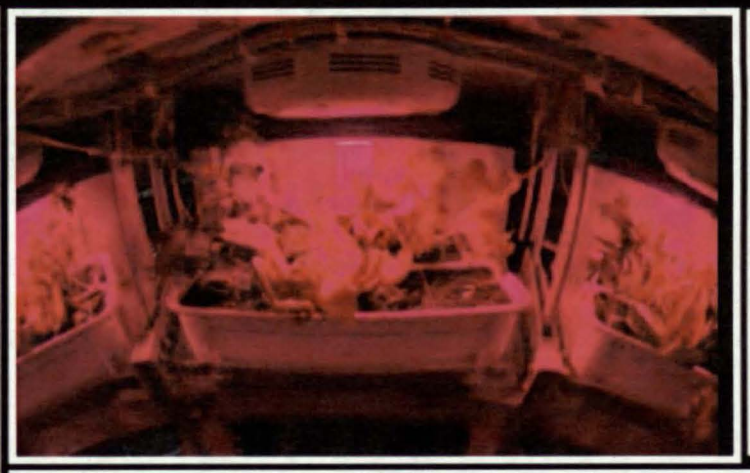
Health and Medical

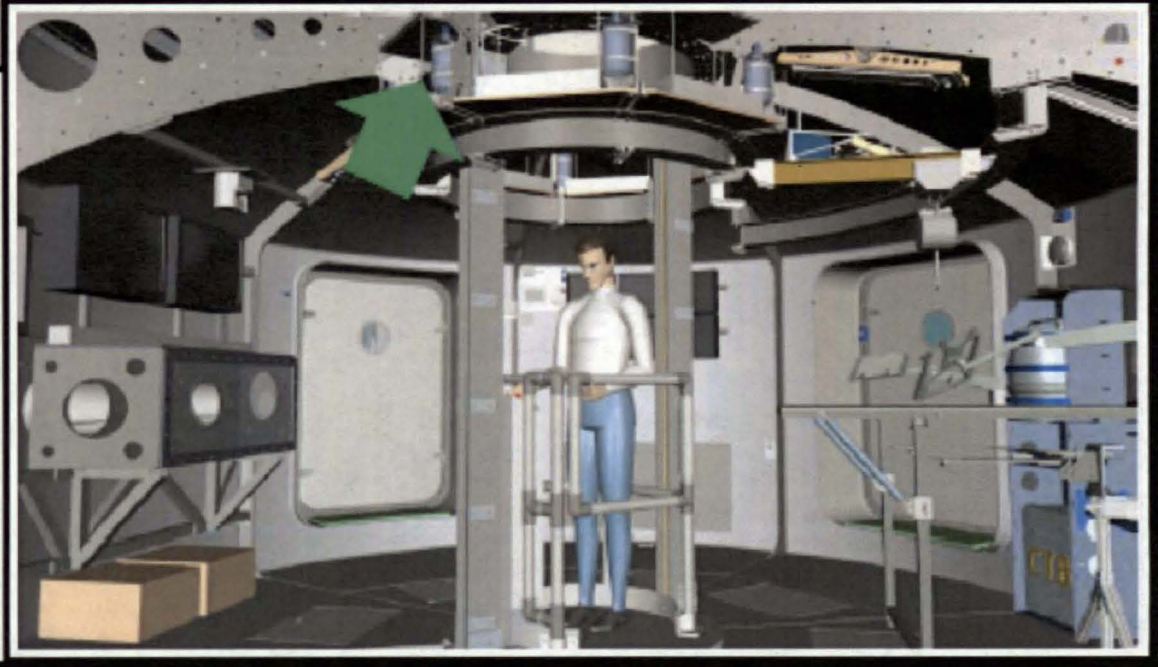


- Virtual Presence: visual, tactile feedback, real-time and delayed
- Provide training for onboard medics

Health and Medical

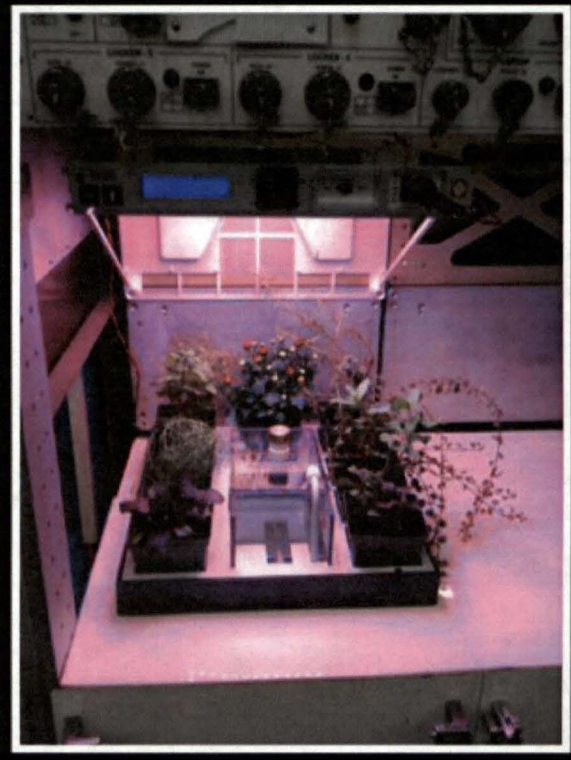

DEEP SPACE
HABITAT



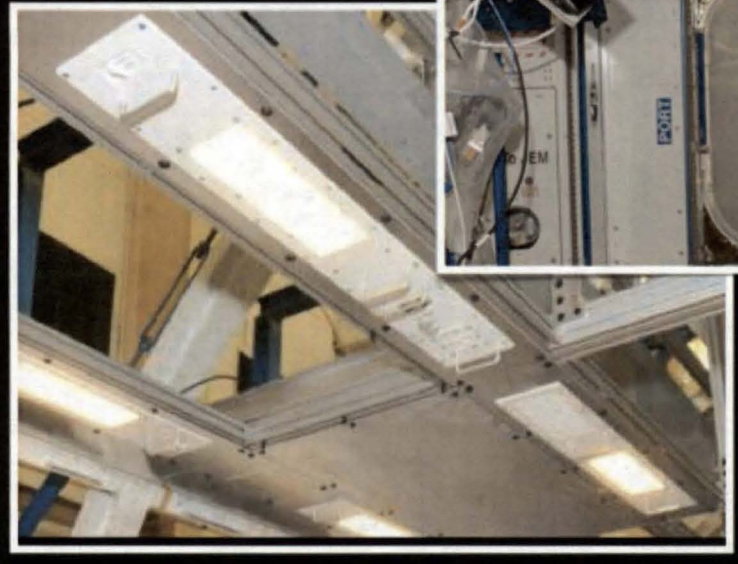


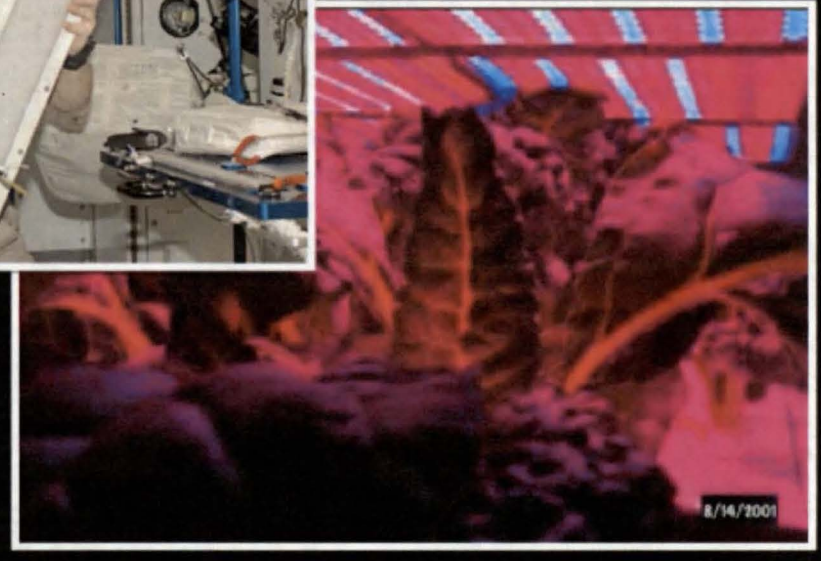
Plant growth trays with LED light fixtures above each tray located in the Food Production Atrium for the Habitat Demonstration Unit.

Food Production

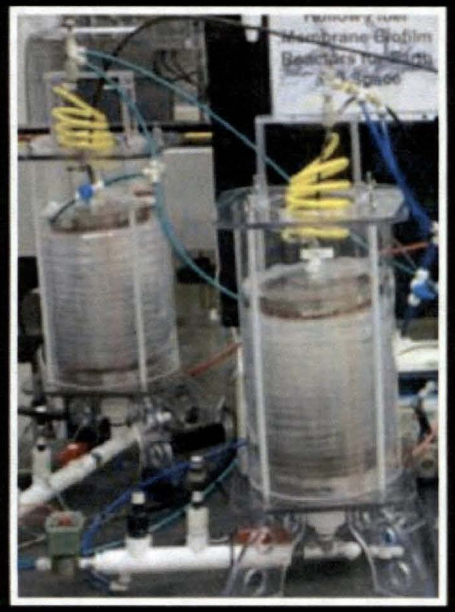


Food Production Units

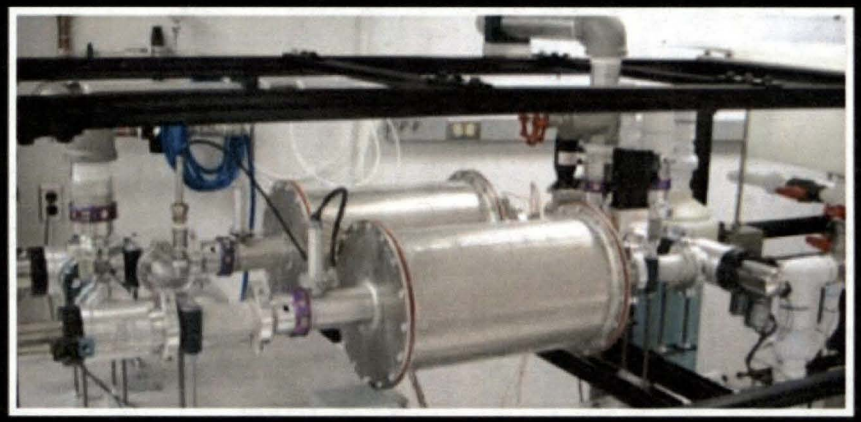




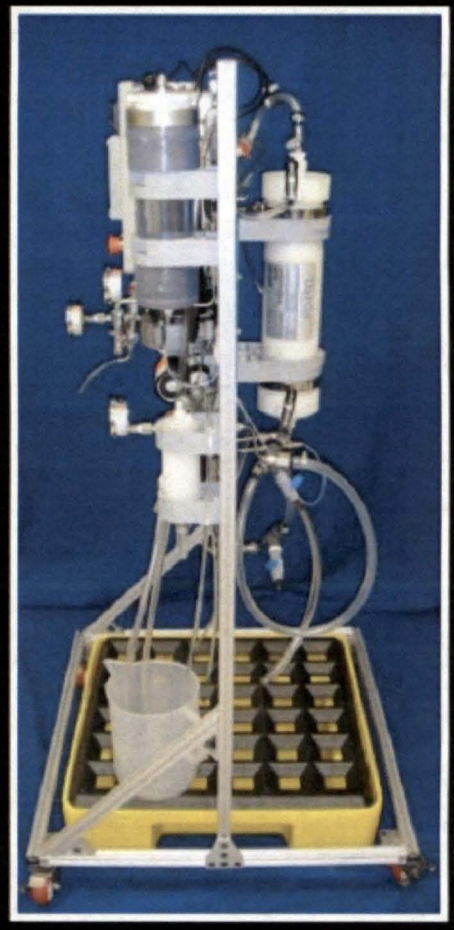
LED Lighting



Biological Treatment of Wastewater

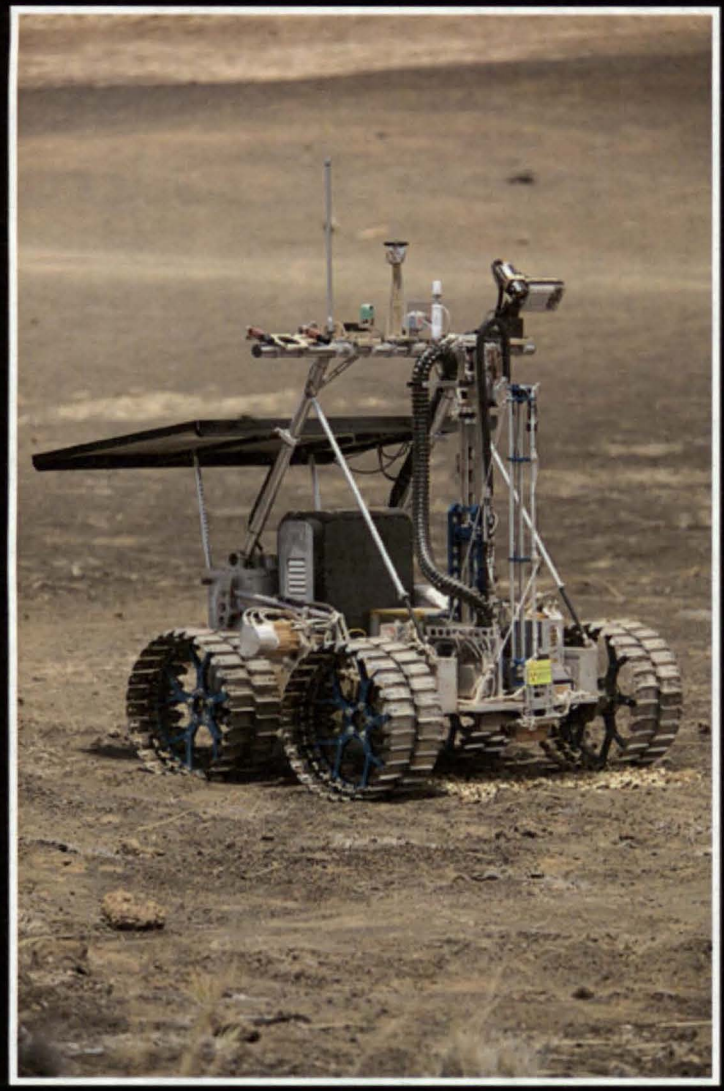


Low Power CO_2 Removal

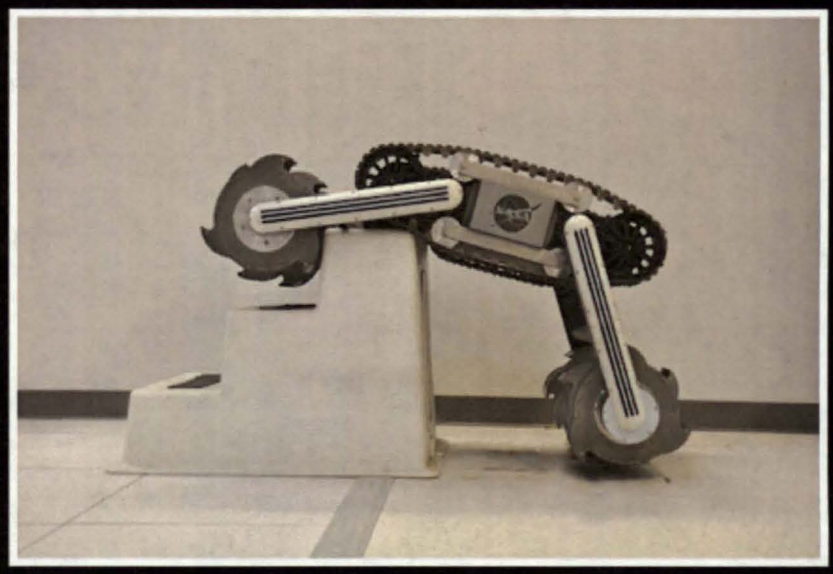


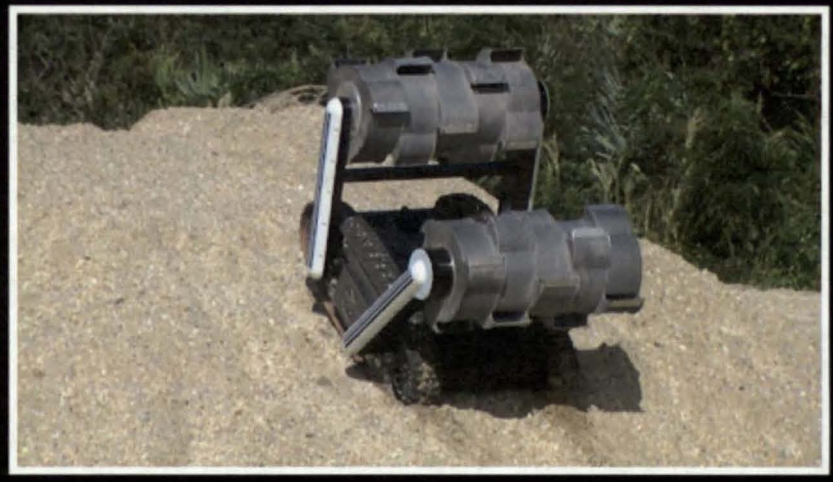
Osmotic Filtration

Air and Water Revitalization



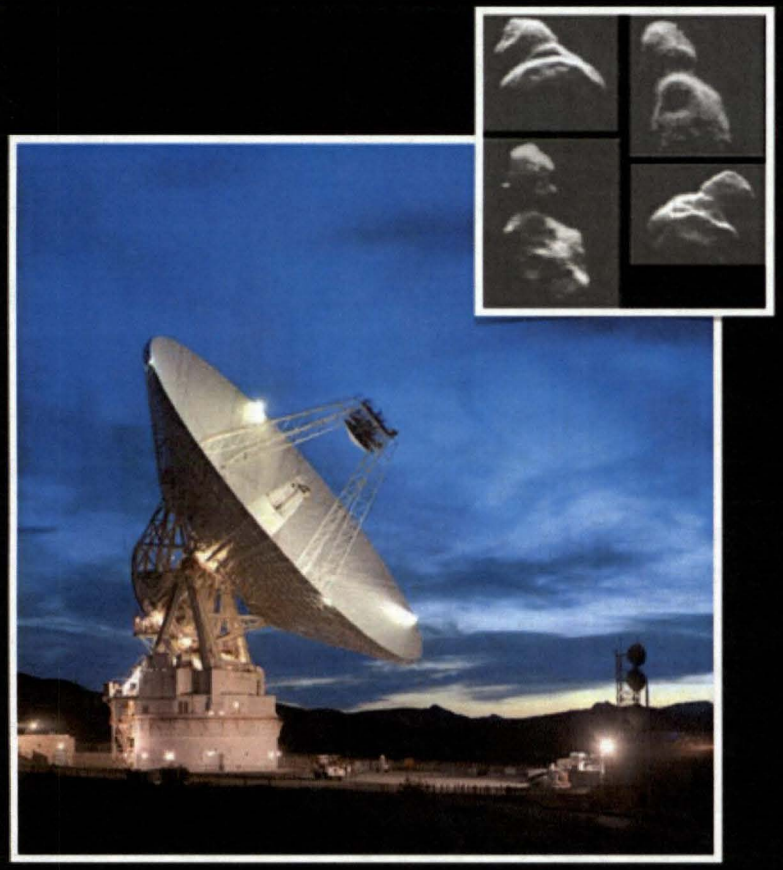
RESOLVE





RASSOR

Robotic Development



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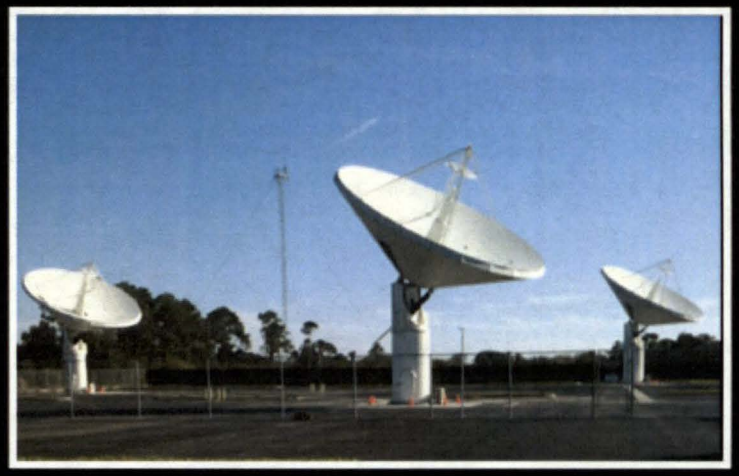
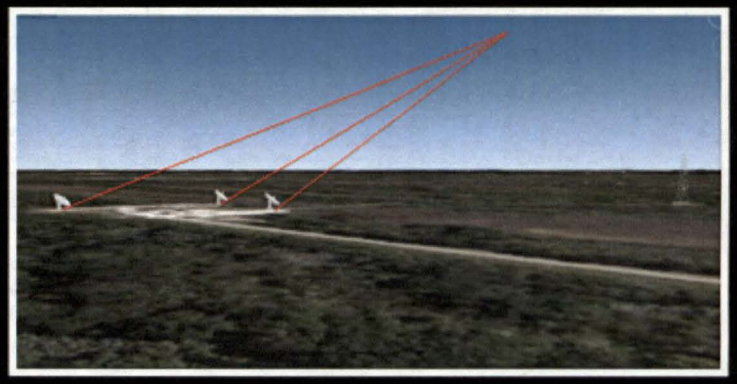
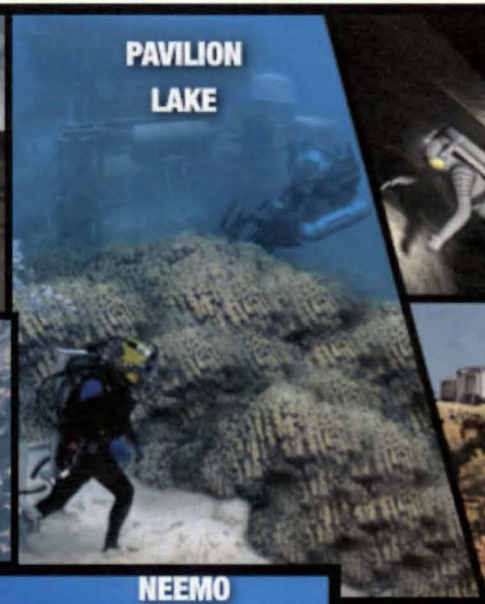
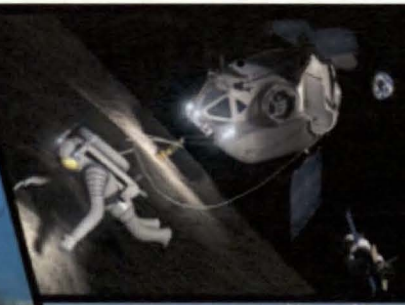


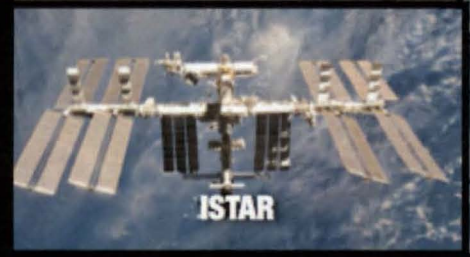


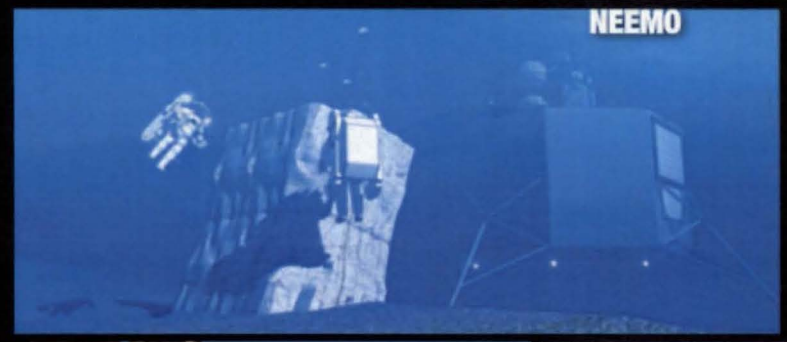
Ka-Band Uplink Array Projects

Remote Intelligence









Remote Intelligence

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Multi-Mission Space Exploration Vehicle
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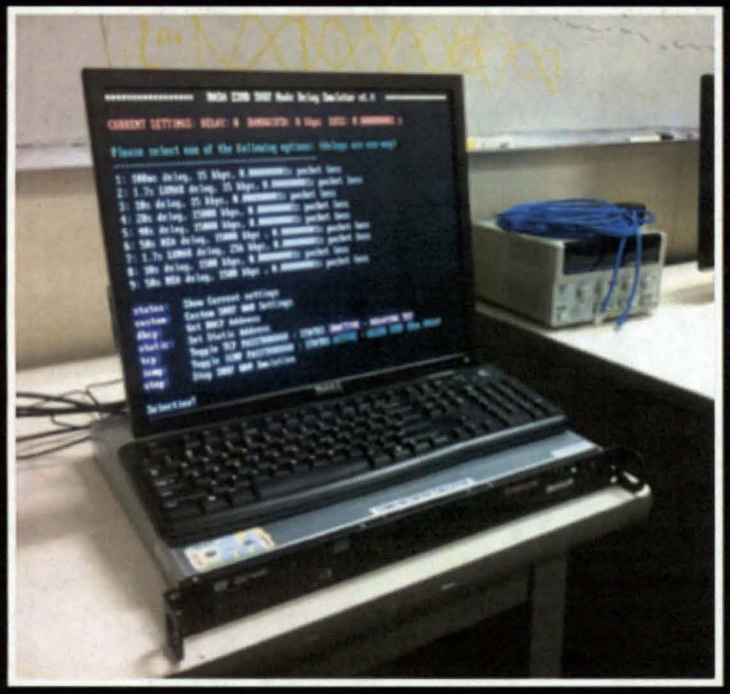
Remote Intelligence

Crew Mobility Systems

Deep Space Communications Delay Emulator



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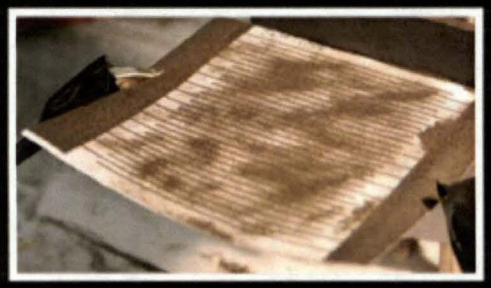
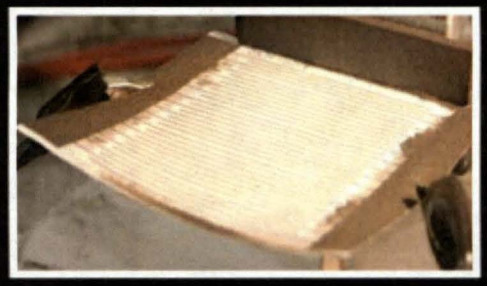
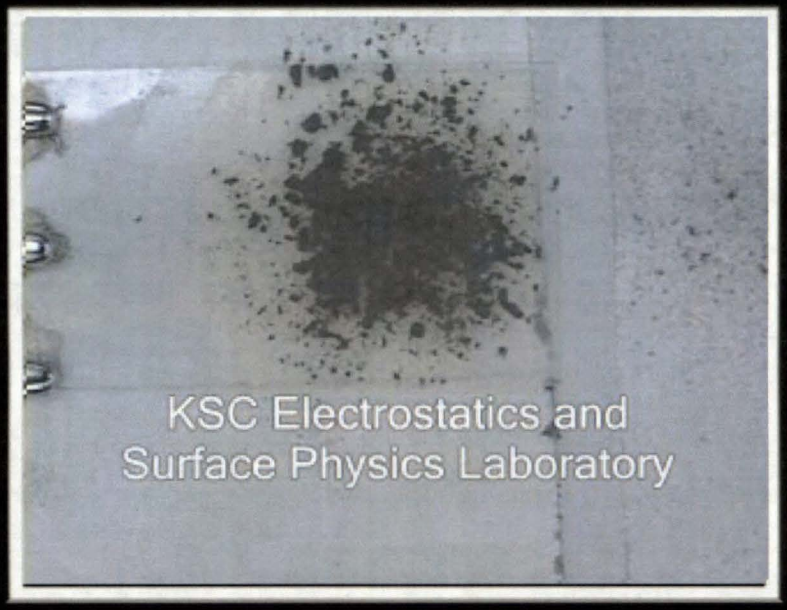
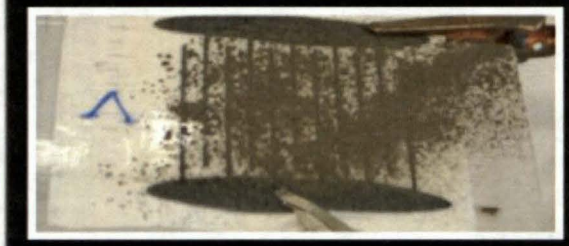
Remote Intelligence

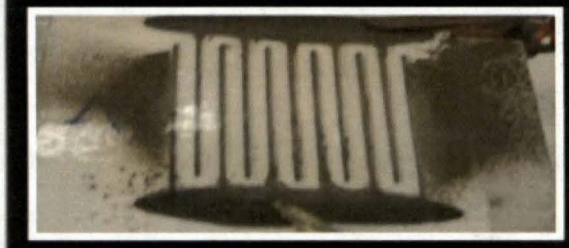
Information Management





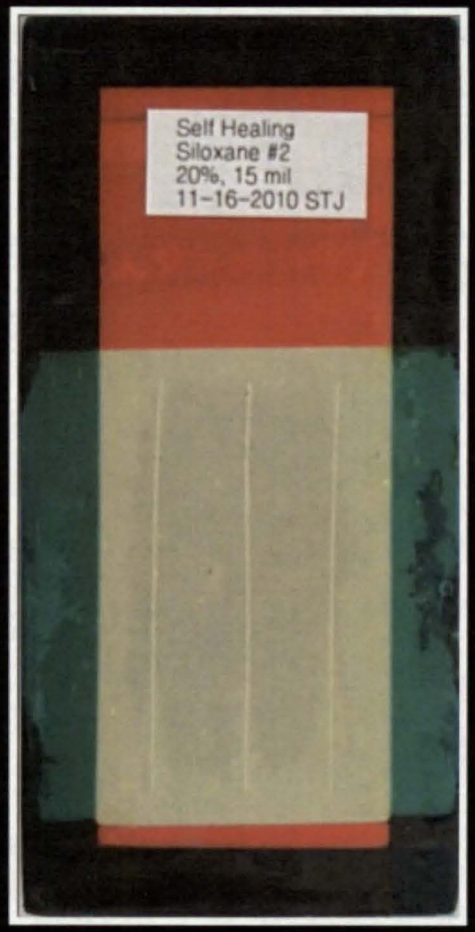






EVA Dust Shields for Space Suits and Habitats

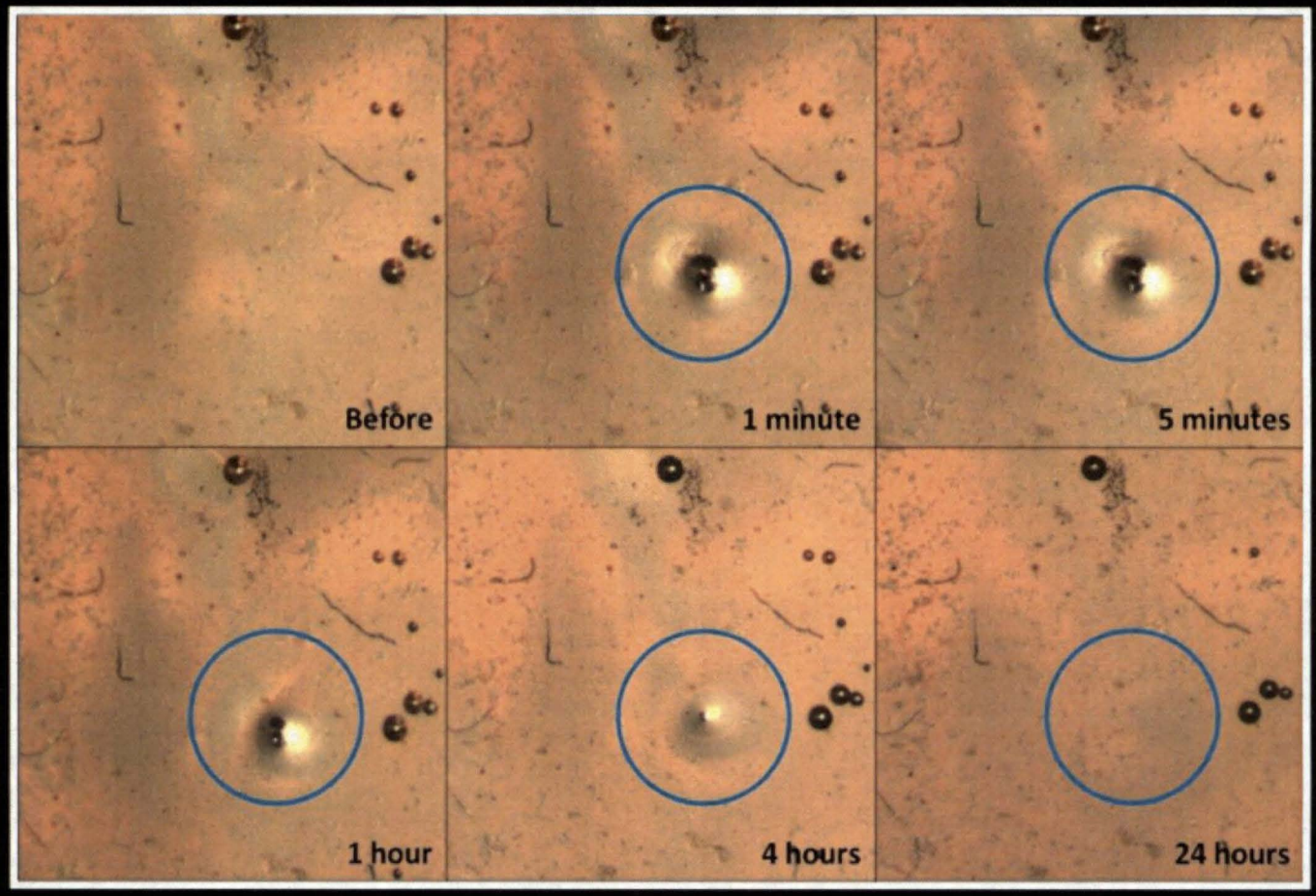
Self Healing Microcapsules



NASA

Materials with Self Healing Properties

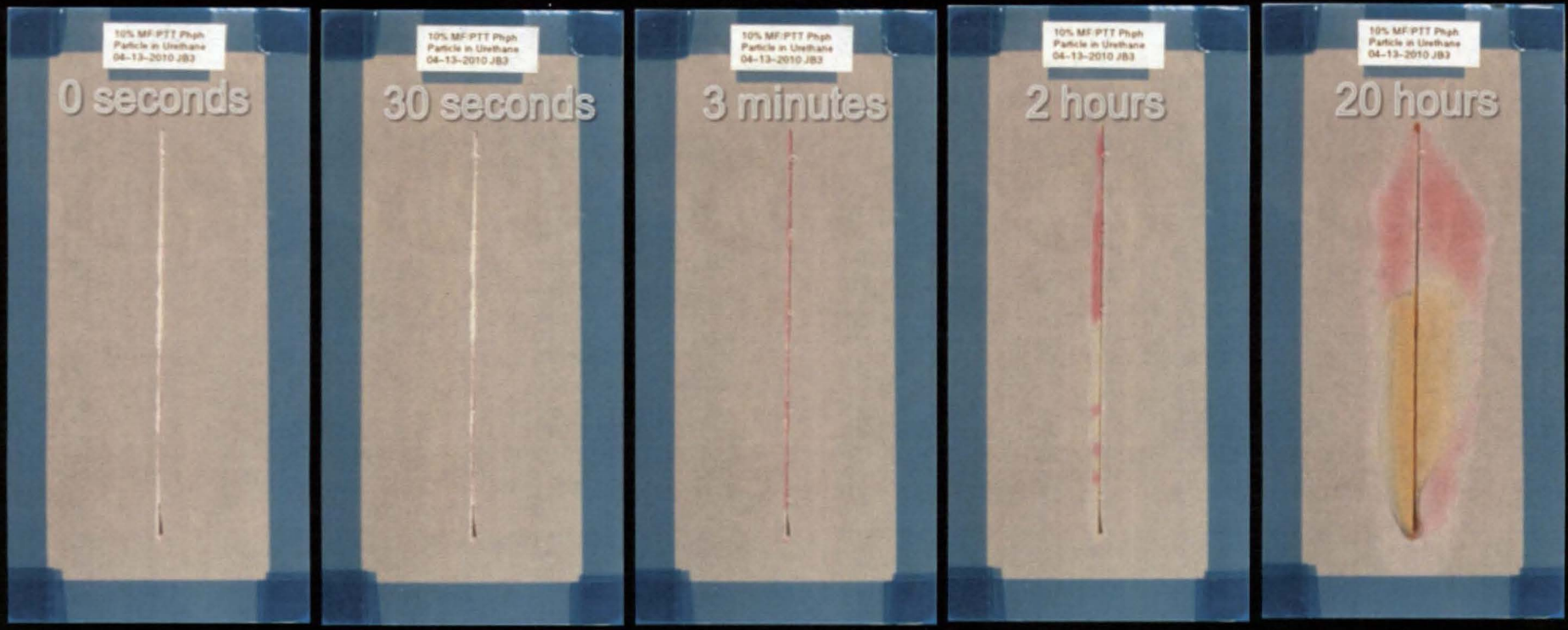
Latest Self Healing Laminates



Puncture and healing activity

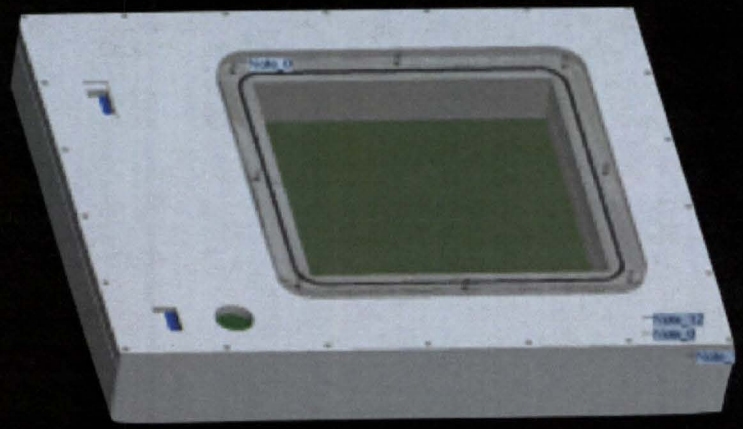
NASA

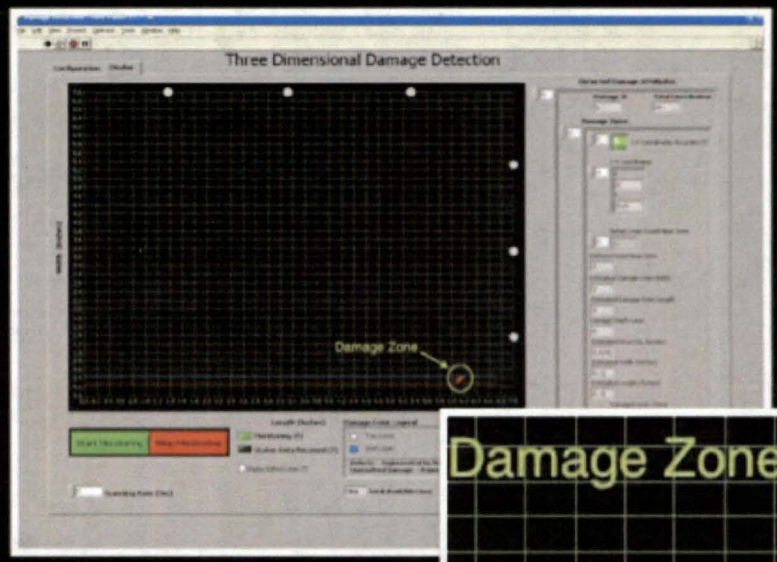
Materials with Self Healing Properties



Early Corrosion Indication

Materials with Self Healing Properties





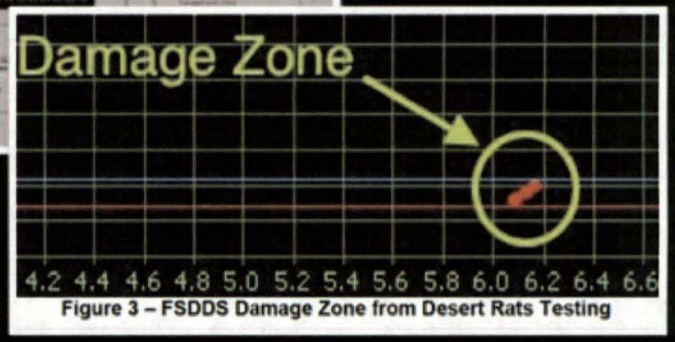
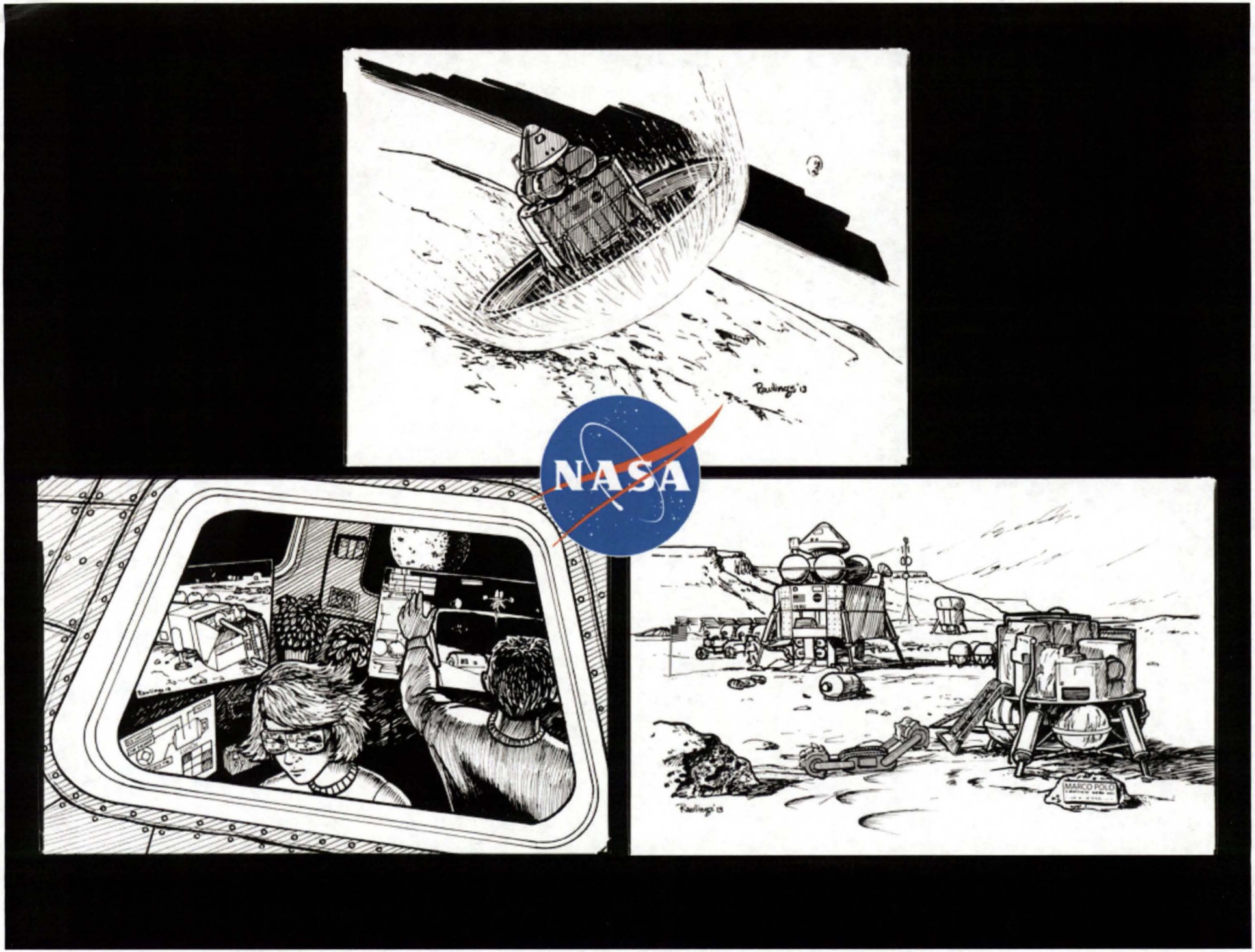


Figure 3 – FSDDS Damage Zone from Desert Rats Testing

Flat Surface Damage Detection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MARCO POLO