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Overview of the Microgravity Science Glovebox (MSG) Facility and the Research Performed in the MSG

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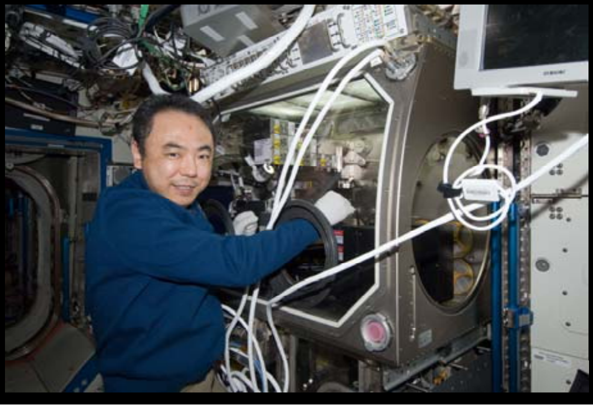
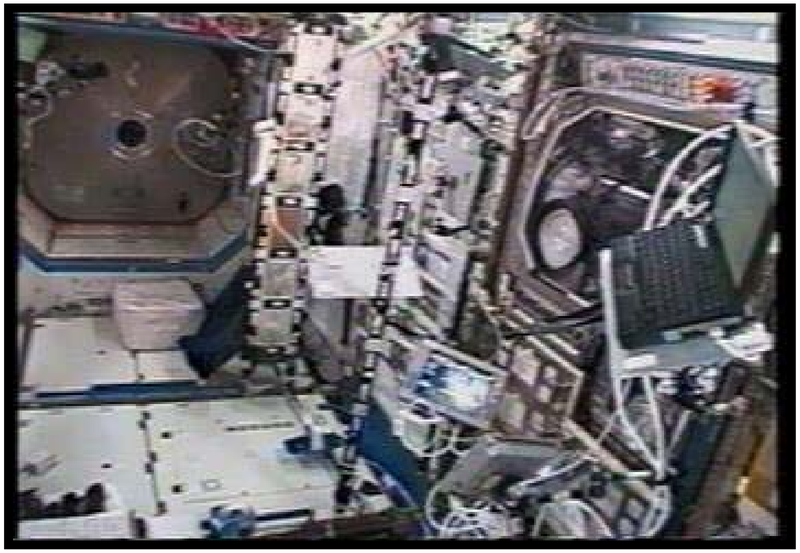
Agenda

- Introduction
- Payload Interfaces and Resources Provided by MSG
- Overview of the Research Accomplished in the MSG Facility to Date
- MSG Operations Planned for 2015
- Life Science Ancillary Hardware (LSAH) Upgrades
- Video Upgrade Equipment (VUE)
- Conclusion



Introduction

- The Microgravity Science Glovebox (MSG) is a rack facility designed for microgravity investigation handling aboard the International Space Station (ISS).
- The unique design of the facility allows it to accommodate science and technology investigations in a “workbench” type environment



- MSG facility provides an enclosed working area for investigation manipulation and observation in the ISS. Provides two levels of containment via physical barrier, negative pressure, and air filtration .
- The MSG team and facilities provide quick access to space for exploratory and National Lab type investigations to gain an understanding of the role of gravity in multiple research areas.

MSG Facility Hardware Overview

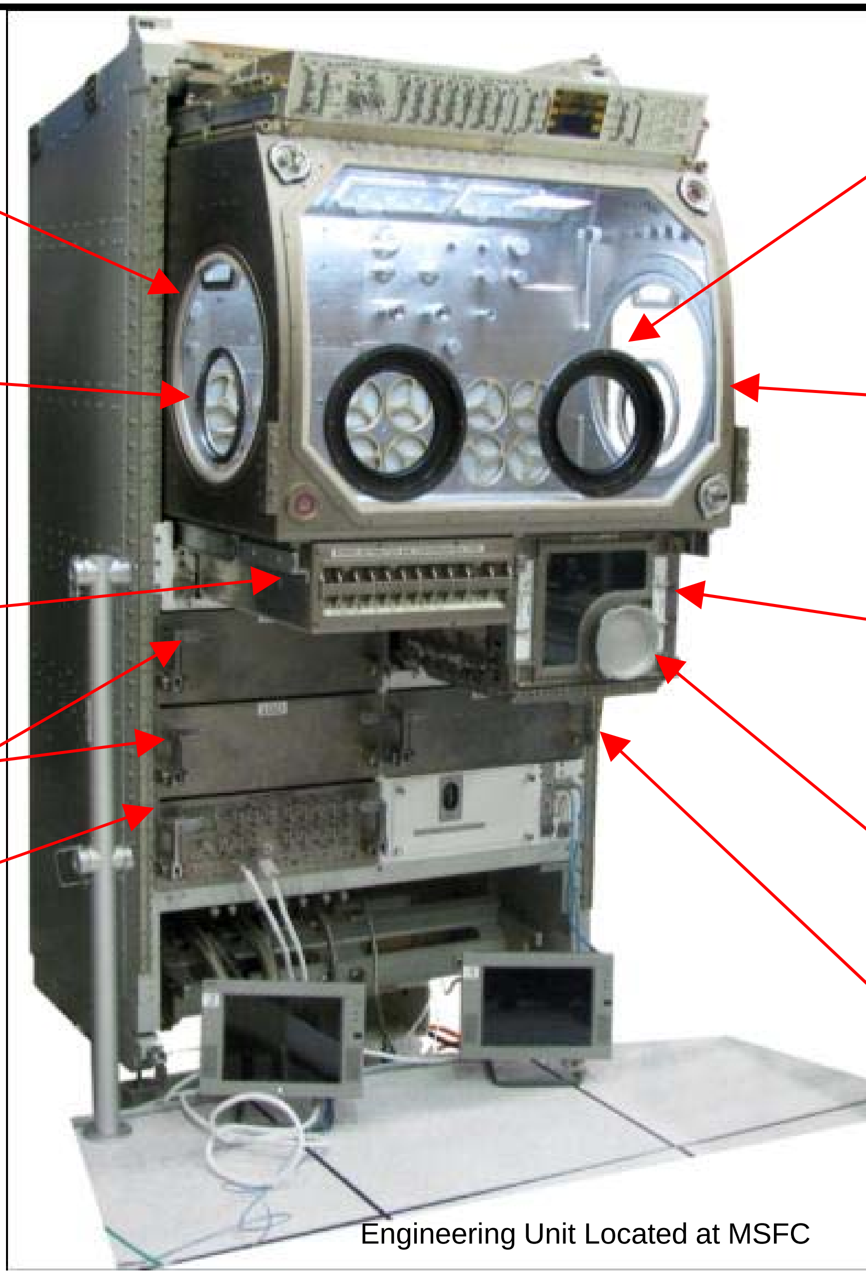
Removable Side Ports
16" diameter on both Left and Right sides for setting up hardware in Work Volume

Glove Ports
Four identical glove ports are located on the left and right side loading ports and the front window

DC Power Switching And Circuit Breakers

Stowage Drawers

Video System Drawer



Engineering Unit Located at MSFC

Front Window Glove Ports
Four 6" diameter glove ports can be fitted with any of three different sized gloves or blanks

Core Facility
Retractable Core Facility includes the Work Volume, Airlock, Power Distribution & Switching Box, and the Command and Monitoring Panel

Airlock
Provides a "Pass Through" for hardware to enter the Work Volume without breaking Containment. The lid of the Air Lock opens up into the floor of the Work Volume

Airlock Glove Port with Blank
A Single 4" diameter glove port can also be fitted with any of three different sized gloves or a blank

Stowage Drawers

Microgravity Science Glovebox (MSG)

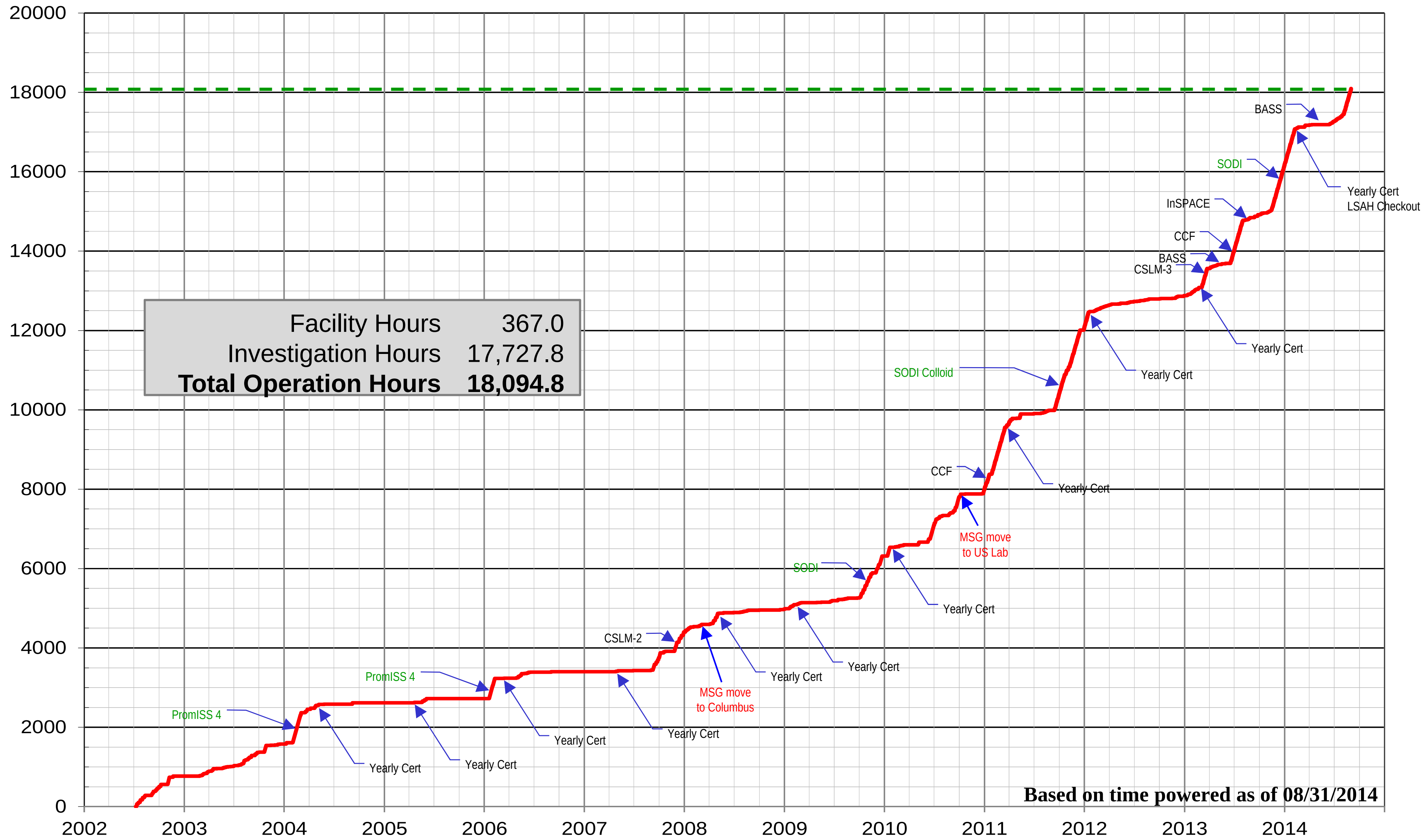
Current MSG-Provided Payload Interfaces/Resources

- Work Volume(WV) - Volume
  - 0.255 m^3 = 255 liters
- Work Volume - Dimensions
  - 906mm wide x 637mm high
  - 500mm deep (at the floor)
  - 385mm deep (at the top)
- Maximum size of single piece of equipment in WV (via side access ports)
  - 406mm diameter
- Payload Attachment
  - M6 threaded fasteners in floor, ceiling, & sides
- Power available to investigation
  - +28V DC at useable 7 amps
  - +12V DC at useable 2 amps
  - -12V DC at useable 2 amps
  - +5V DC at useable 4 amps
  - +120V DC at useable 8.3 amps
- Maximum heat dissipation
  - 1000W Total
    - 800W from coldplate
    - 200W from air flow
- General illumination
  - 1000 lux @ 200mm above WV floor
- Video
  - 4 color Hitachi HV-C20 cameras
  - 2 Sony DSRV10 Digital Recorders
  - 2 Sony GV-A500 Analog 8mm Recorders
- Data handling connections
  - Two RS422-to-MSG for investigations
  - One MIL-BUS-1553B-to-MSG for communication via MLC
  - Ethernet LAN 1 and LAN 2 (in US LAB)
  - MSG Laptop Computer (MLC) – IBM T61P
- Filtration
  - 12 HEPA/charcoal/catalyst WV filters
- 1 HEPA/charcoal/catalyst Airlock filter
- Up to Two Levels of Containment
  - Physical barrier of MSG structures, gloves, etc.
  - Negative pressure generated by MSG fans.
- Other resources available
  - Gaseous Nitrogen
  - Vacuum (VRS & VES)

Microgravity Science Glovebox (MSG)

MSG Flight Unit
Cumulative Hours of Operation

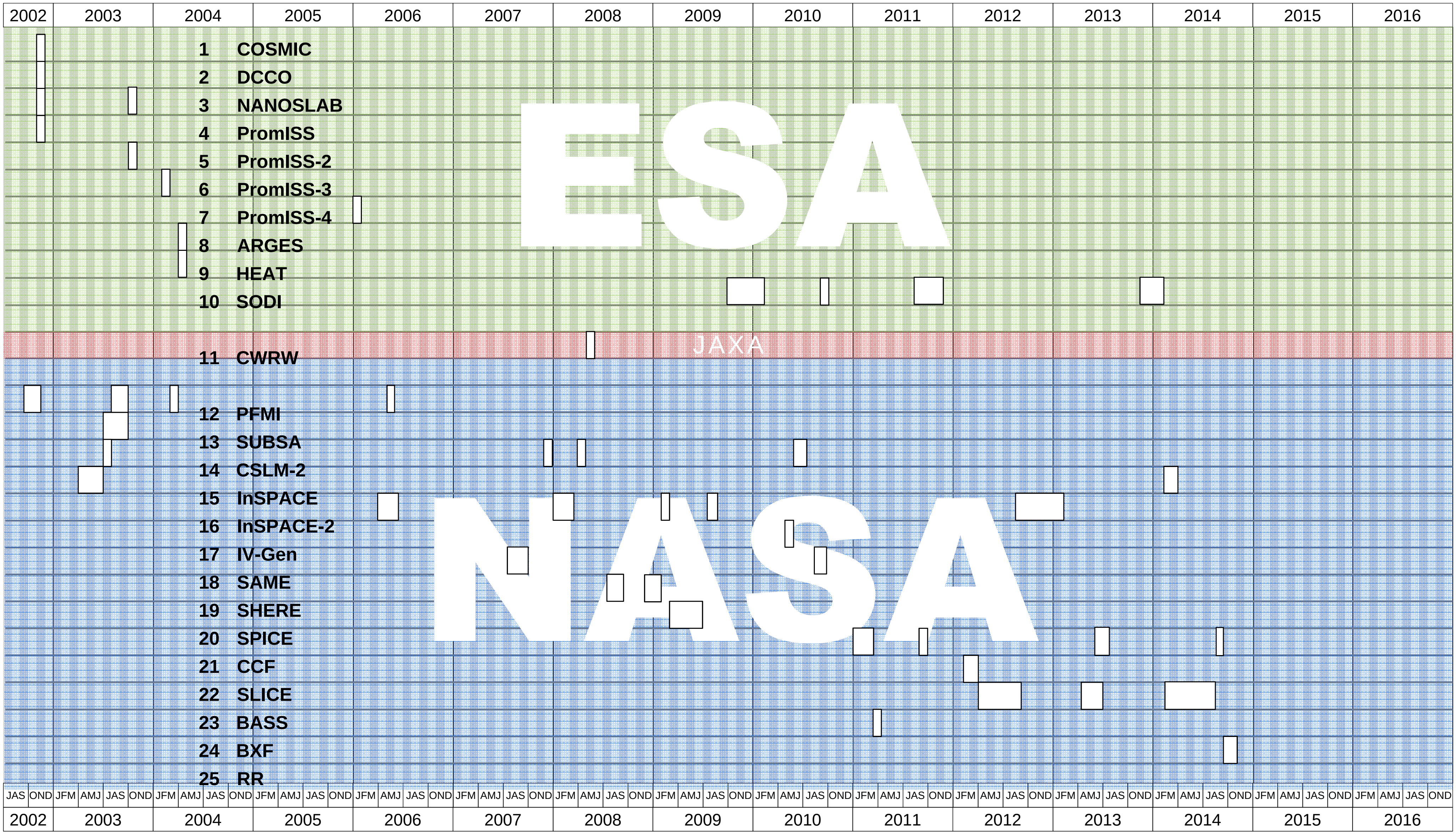
Microgravity Science Glovebox



Microgravity Science Glovebox

Microgravity Science Glovebox (MSG)

Utilization of the MSG Facility



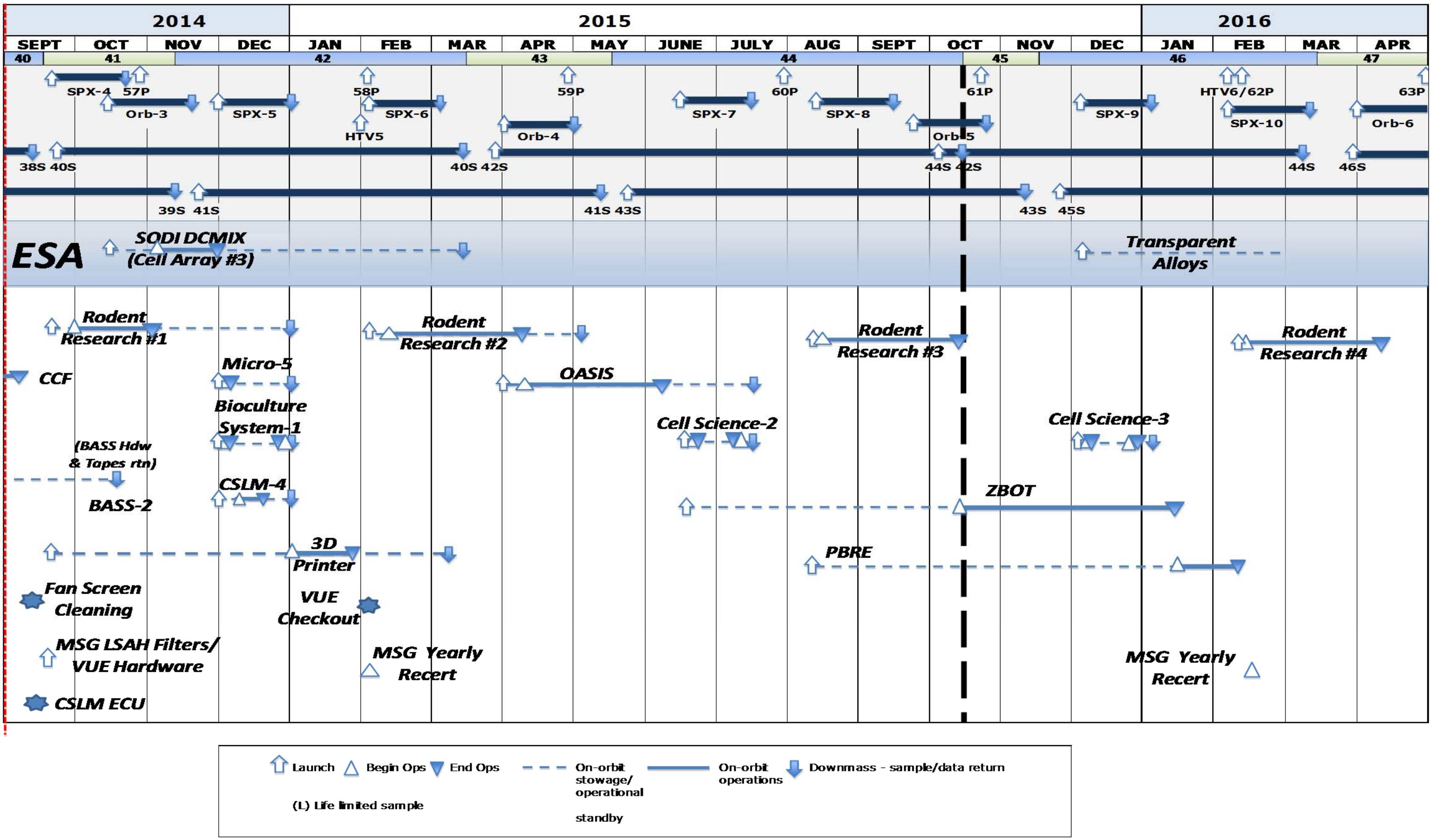
Microgravity Science Glovebox

MSG Investigations

Payload Name & Acronym	Sponsoring Organization	Type of Investigation
Combustion Synthesis under Microgravity Conditions (COSMIC)	ESA	Combustion
Microgravity Experiment for the Measurement of Diffusion Coefficients in Crude Oil (DCCO)	ESA	Diffusion
NANOSLAB	ESA	Zeolite Crystal Growth
Protein Microscope for the International Space Station (PromISS-1,2,3, & 4)	ESA	Protein Crystal Growth
ARGES	ESA	Light Bulb Technology
HEAT	ESA	Heat Pipe Technology
Selectable Optical Diagnostics Instrument (SODI)	ESA	Diffusion and Soret Phenomena
Cell Wall/Resist Wall (CWRW)	JAXA	Plant Growth
Coarsening in Solid Liquid Mixtures-2 (CSLM-2)	NASA	Material Science
Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions (InSPACE-1,2, &	NASA	Magnetorheological (MR) Fluids
IntraVenous Fluids GENeration and mixing (IV-Gen)	NASA	Human Health
Smoke Aerosol Measurement Experiment (SAME)	NASA	Spacecraft Smoke Detection
Shear History Extensional Rheology Experiment (SHERE)	NASA	Polymer
Smoke Point Coflow Experiment (SPICE)	NASA	Combustion
Critical Velocities in Open Capillary Channels (CCF)	NASA	Fluids
Structure and Liftoff in Combustion Experiment (SLICE)	NASA	Combustion
Burning and Suppression of Solids (BASS)	NASA	Combustion
Boiling eXperiment Facility (BXF)	NASA	Heat Transfer
Pore Formation and Mobility Investigation (PFMI)	NASA	Material Science
Solidification Using a Baffle in Sealed Ampoules (SUBSA)	NASA	Material Science
Rodent Research	NASA	Life Science
3D Printer	NASA	Technology Demonstration
Bioculture Systems	NASA	Life Science
Observation and Analysis of Smectic Islands in Space (OASIS)	NASA	Material Science
Zero Boil-Off Tank (Z-BOT)	NASA	Heat Transfer
Packed Bed Reactor Experiment (PBRE)	NASA	Physical Science
Transparent Alloys	ESA	Material Science

Microgravity Science Glovebox

MSG Operations Planned for 2013-2014



Life Science Ancillary Hardware (LSAH) Upgrades Available in 2015

MSG LSAH Upgrades

- Materials utilized by Life Science/Biological Research payloads will require additional capabilities for handling and clean up:
  - Filtration System: a capability added to the existing MSG Work Volume air circulation system that scrubs typical life science biological and chemical contaminants from the MSG Work Volume air.
  - Decontamination System: a capability to reduce released biological contaminants (Bio Safety Levels (BSL) 1 and 2) to levels safe for crew exposure and a capability to remove released contaminants from surfaces within the Work Volume.
  - Exchangeable Glove System this is more suited for various life science activities.
  - Dissection table and rear wall cover for rodent processing

Glove & Gauntlet Configuration

MSG Life Science Filters

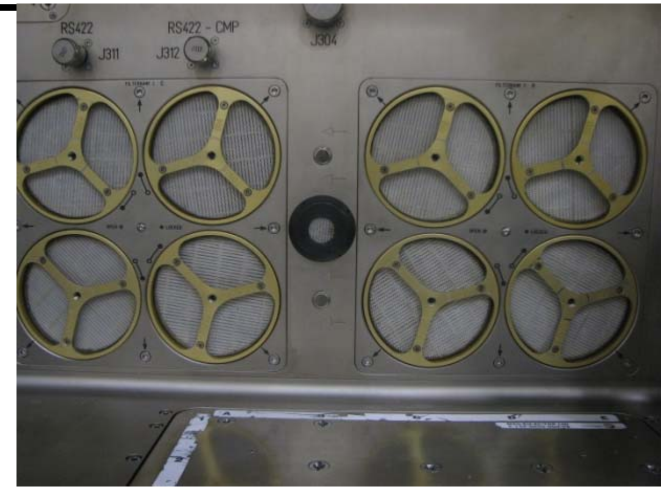
Decontamination System

Iris & Gauntlet w/Disposable Glove

Microgravity Science Glovebox

Biological Filters

- MSG's Air Handling Unit creates negative pressure in the Work Volume to provide one means of containment
  - Filter banks trap contaminants when air passes once through the filters
  - Current filter components trap typical material-science and combustions contaminants



- New filters will be added to the existing MSG filters

- New filters will trap typical life/biological science contaminant/materials
  - Such as preservatives, fixatives, and other byproducts

In MSG's current design, each of the thirteen front filters is easily exchangeable on orbit by the crew.

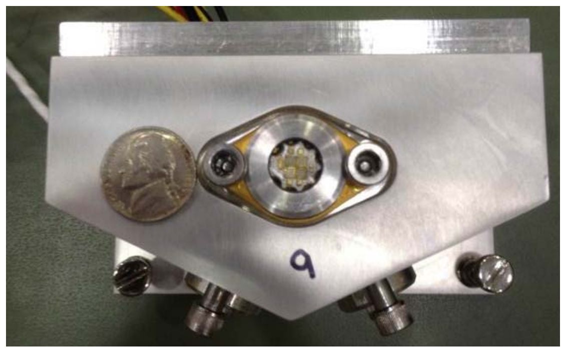
MSG Life Science Filters

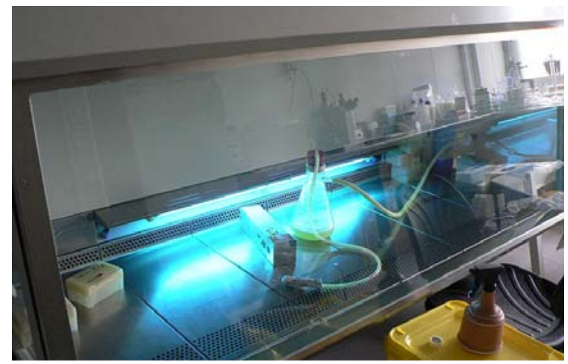
Sundstrom SR 299-2 ABEK1HgP3R Combination Filter

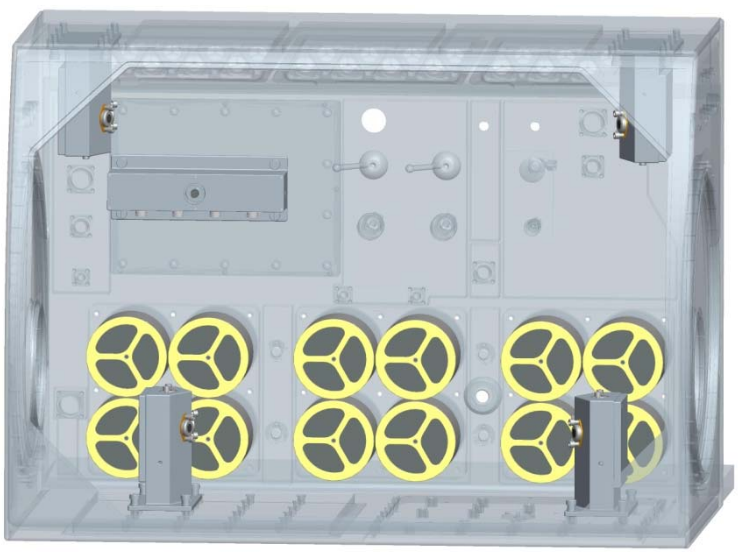
Microgravity Science Glovebox (MSG)

Decontamination System

- New Decontamination Capability within MSG Work Volume
  - Decontaminate before experiment to prevent contamination of biological samples
  - Decontaminate after experiment to disinfect any released biological materials
- Ground-based labs typically use UV Light or Ozone

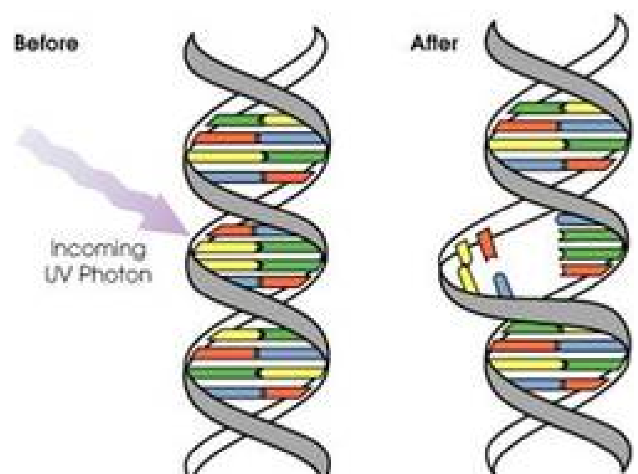






MSG Decontamination System

Ultraviolet germicidal irradiation is a sterilization method that uses ultraviolet light at sufficiently short wavelength to break down microorganisms. It is used in a variety of applications, such as food, air and water purification.

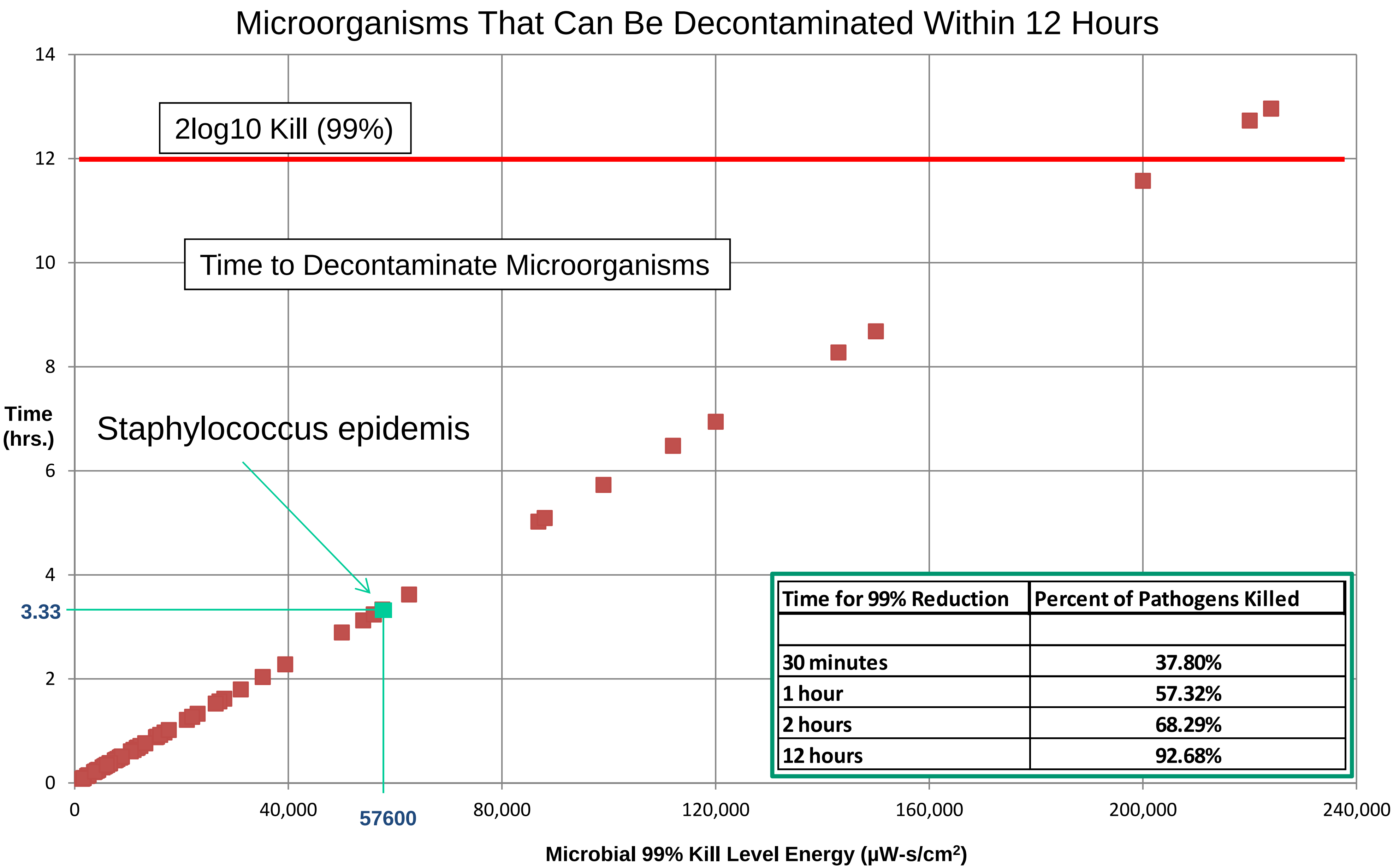


Decontamination System

List of Microorganisms and Associated UV-C Kill Dosage (99%)

PATHOGEN	BIOSAFET Y LEVEL	UV Dose 99% (µW-s/cm²)	PATHOGEN	BIOSAFETY LEVEL	UV Dose 99% (µW-s/cm²)	PATHOGEN	BIOSAFETY LEVEL	UV Dose 99% (µW-s/cm²)
						Proteus mirabilis	2	1,600
Acinetobacter	2	3,600	Ebertelia typhosa	1	4,100	Pseudomonas aeruginosa	1	10,500
Adenovirus	2	11,800	Echovirus	2	1,600	Reovirus	2	54,000
Aeromonas	2	2,300	Eurotium (rubrum)	1	86,800	Rhizopus	2	34,600 - 896,000
Aspergillus	2	19,200 - 896,000	Fusarium (solani)	1	62,600	Rhodoturula (spp.)	1	224,000
Bacillus anthracis	2	8,700	Haemophilus influenzae	2	7,700	Sarcina lutea	1	39,400
Bacillus magaterium sp. (spores)	1	5,200	Influenza A virus	2	6,600	Scopulariopsis	2	578,000
Bacillus magaterium sp. (veg)	1	2,500	Klebsiella pneumoniae	2	8,400	Serratia marcescens	1	21,000
Bacillus paratyphusus	1	6,100	Legionella pneumophila	2	2,600	Spirillum rubrum	1	8,800
Bacillus subtilis spores	2	11,000	Leptospiracanicola - infectious Jau	1	6,000	Sporothrix schenckii	2	56,000
Blastomyces dermatitidis	2	28,000	Listeria monocytogenes	2	31,100	Staphylococcus albus	1	5,720
Botrytis cinerea	1	50,000	Measles virus	2	4,400	Staphylococcus aureus	2	6,600
Burkholderia cenocepacia	1	11,600	Microccocus candidus	1	12,300	Staphylococcus epidermis	1	57,600
Candida albicans	1	150,000	Microccocus sphaeroides	1	15,400	Staphylococcus hemolyticus	1	5,500
Cladosporium	2	37,800 - 896,000	Mucor (mucedo)	1	120,000	Staphylococcus lactis	1	8,800
Clostridium perfringens	2	27,100	Mycobacterium avium	2	16,800	Streptococcus pyogenes	2	7,500
Coronavirus	2	1,400	Mycobacterium kansasii	2	16,000	Streptococcus viridans	2	3,800
Corynebacterium diphtheriae	2	6,500	Mycoplasma pneumoniae	2	1,700	Trichophyton	2	112,000
Coxsackievirus	2	23,000	Neisseria catarrhalis	2	8,500	Ustilago (Zeae)	1	224,000
Cryptococcus neoformans	2	56,000	Nocardia asteroides	2	56,000	Vaccinia virus	2	143,000
Curvularia lunata	1	112,000	Phytomonas tumefaciens	1	8,500			
Molds			**BIOLOGICAL AGENTS**			**Protozoa**		
Aspergillius flavus	2	99,000	Hepatitus A	2	8,000	Chlorella Vulgaris	1	22,000
Aspergillius glaucus	2	88,000	Salmonella typhi	2	15,200	Paramecium	1	200,000
Aspergillius niger	2	330,000	Shigella	2	4,200			
Mucor racemosus A	2	35,200	Vibrio cholerae	2	6,500	**Virus**		
Mucor racemosus B	2	35,200				Bacteriopfage - E. Coli	1	6,600
Oospora lactis	1	11,000	**Yeast**			Poliovirus - Poliomyelitis	2	6,000
Penicillium expansum	2	22,000	Brewers yeast	1	8,800	Tobacco mosaic	1	440,000
Penicillium roqueforti	2	26,400	Common yeast cake	1	13,200			
Penicillium digitatum	2	88,000	Saccharomyces carevisiae	1	13,200			

Decontamination System



Time for 99% Reduction	Percent of Pathogens Killed
30 minutes	37.80%
1 hour	57.32%
2 hours	68.29%
12 hours	92.68%

Dexterous/Tactile Gloves

- **Biotech Gloves**
  - **Thinner Gloves that provide more dexterity and sense of touch**
  - **7 mil Hypalon Glove**
  - **Typical exam gloves are ~6 mils**
- **Will adapt existing MSG design**

MSG Glove & Gauntlet Configuration
(7 mil Hypalon Glove, 15 mil Gauntlet)

MSG has four glove ports; two on the front window and one on each side port. Glove ring assemblies can be installed in any glove ports as required by an investigation.

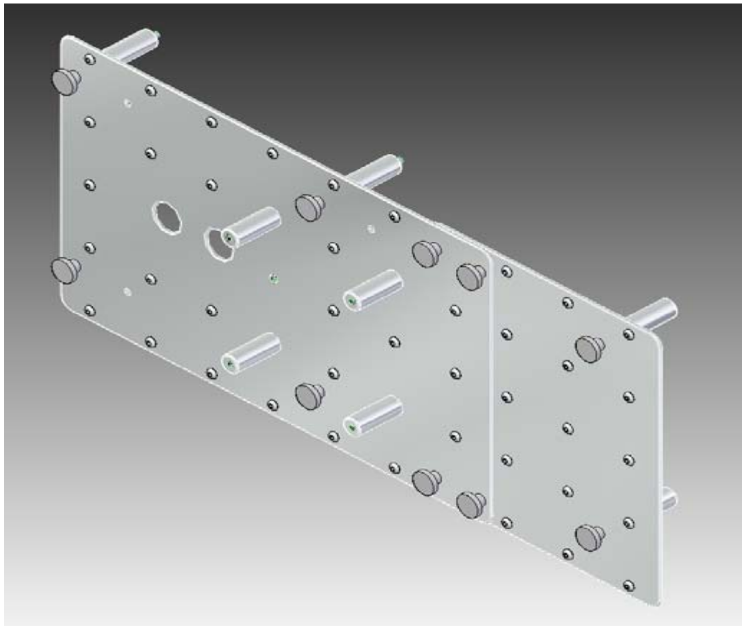
MSG Iris & Gauntlet Configuration

Gloves will be provided in three sizes 7,9, & 10.

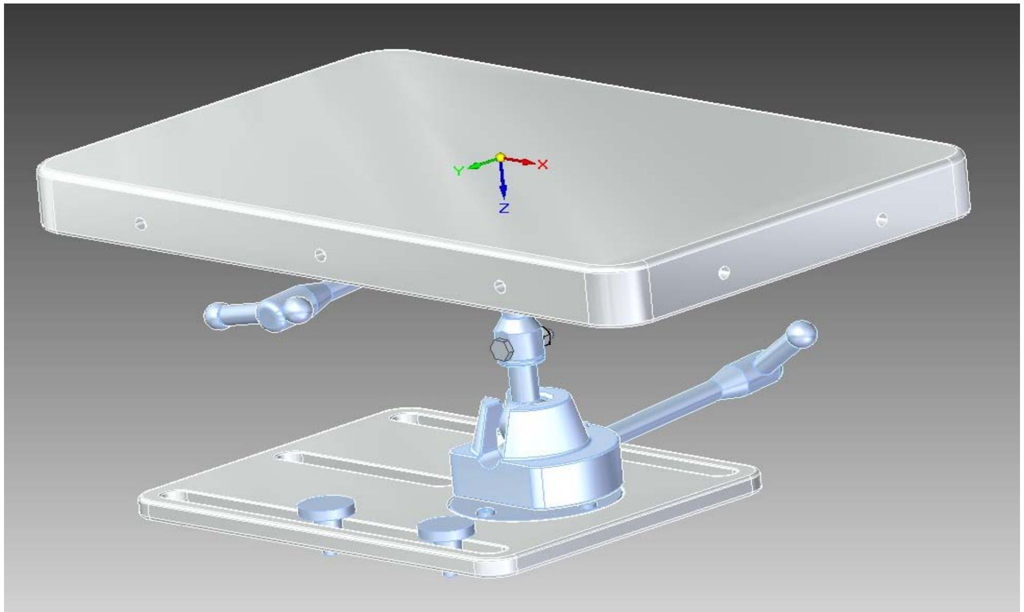
MSG Iris & Gauntlet With Nitrile Disposable Glove

LSAH Dissection Table/Rear Wall Cover

- MSG Enhancements to support rodent handling were approved by the ISS Program; ATP November 2012
- Rodents utilized by Life Science/Biological Research payloads will require additional capabilities for handling and operations
    - Rear Wall Cover: a capability added to the existing MSG Work Volume rear wall to provide additional hard mounting locations for experiment equipment
    - Dissection Table: a capability to aid in the manipulation and harvesting of experiment samples



Rear Wall Cover Assembly



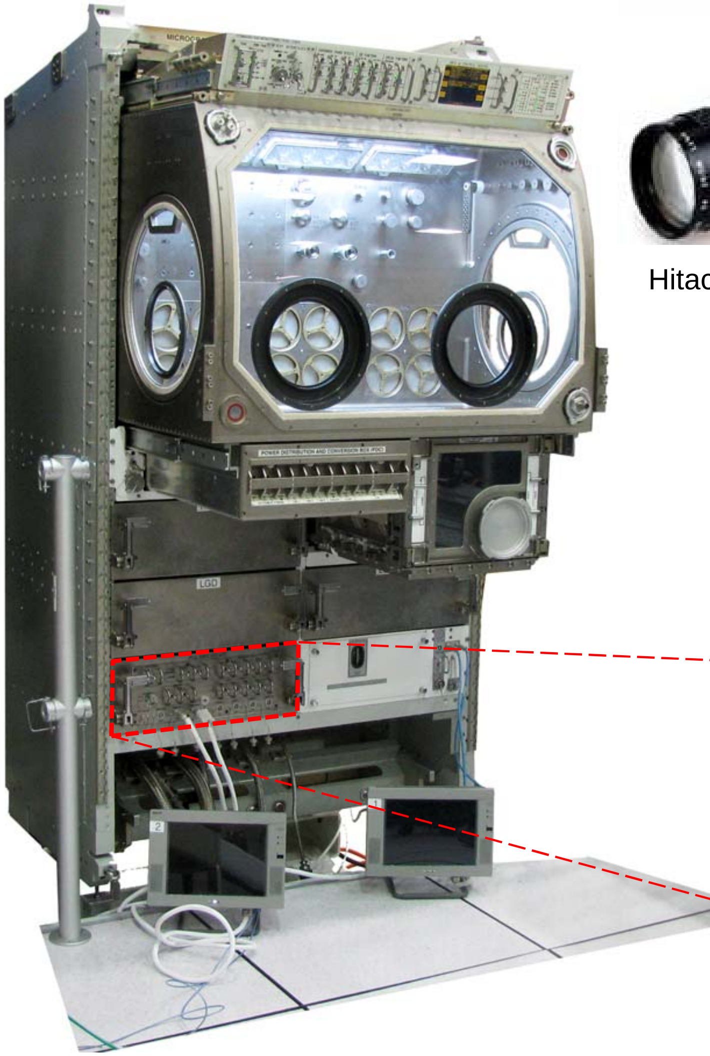
Dissection Table

Video Upgrade Equipment (VUE) Available in 2015

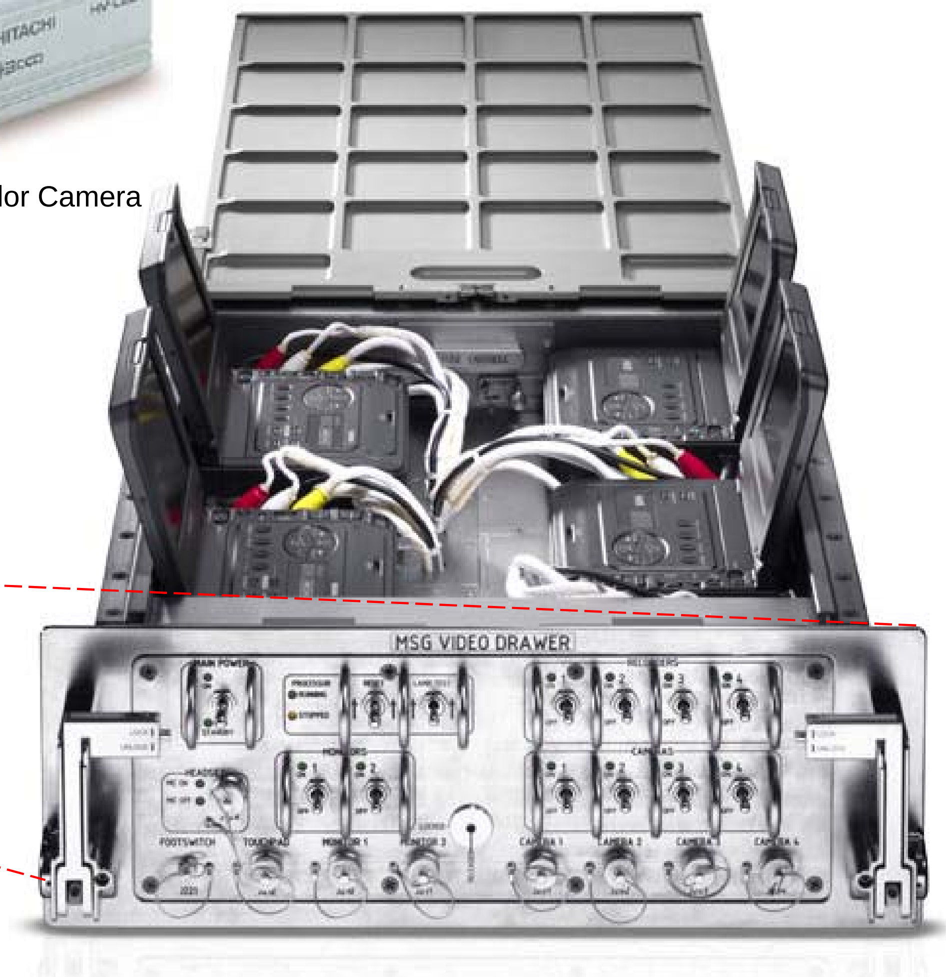
Microgravity Science Glovebox

Current MSG Video System

Marshall Space Flight Center



Hitachi HV-C20 Color Camera



Pictured above in the bottom left drawer location of the MSG Engineering Unit, the MSG Video Drawer is shown connected to two video monitors. The Video Drawer is the main component of the MSG Video System.

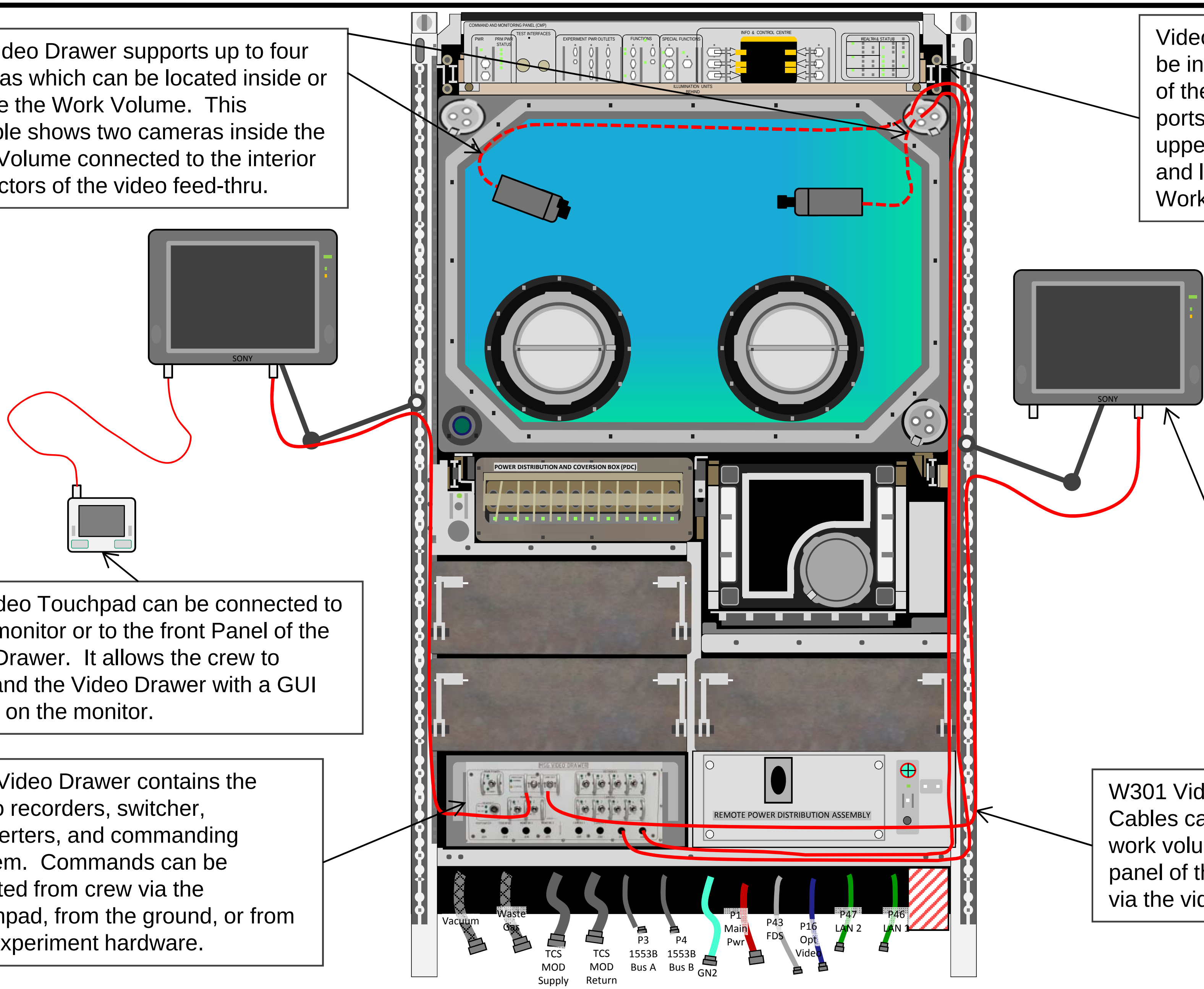
In additional to accommodating 4 exchangeable video recorders, the Video Drawer contains power, communications, and remote control systems. The front panel allows for the crew to switch power to individual cameras, recorders, and monitors and to connect the various external components, including cameras and monitors.

Microgravity Science Glovebox (MSG)

Microgravity Science Glovebox

Marshall Space Flight Center

Typical MSG Video System Setup



The Video Drawer supports up to four cameras which can be located inside or outside the Work Volume. This example shows two cameras inside the Work Volume connected to the interior connectors of the video feed-thru.

Video Feed-thru's can be installed in any or all of the three feed-thru ports located on the upper-left, upper-right, and lower right of the Work Volume.

Two Video Monitors connect to the front panel of the Video Drawer. They could be located inside the Work Volume if required.

The Video Touchpad can be connected to either monitor or to the front Panel of the Video Drawer. It allows the crew to command the Video Drawer with a GUI display on the monitor.

The Video Drawer contains the video recorders, switcher, converters, and commanding system. Commands can be initiated from crew via the touchpad, from the ground, or from the experiment hardware.

W301 Video Extension Cables camera inside the work volume to the front panel of the Video Drawer via the video feed-thru.

Video System Overview

- The MSG Video Upgrade Equipment (VUE) will be capable of recording, storing, and transferring high definition/high resolution/high speed, color digital video data to ISS for downlinking.

- The VUE will utilize significantly higher video resolution and speeds than the existing MSG video system thereby enhancing research observation activities

- The MSG VUE consist of the following enhancements:
  - Powered ISIS drawer containing computer control and supporting electronics
  - High speed/high resolution cameras
  - High definition video cameras
  - GigE compatibility
  - Six terabytes of data storage via two 2 Tb Solid State RAID drives and two 1 Tb conventional hard drives.
  - Digital video data output capabilities for ISS to ground downlink. Downlink rates - up to 6 Mbps or higher depending on available bandwidth of the ISS LAN.

VUE Camera Summary

Name	Type	Resolution	Sensor Size	Max Output
Prosilica 1050C	GigE	1024H x 1024V	1/2” Type CCD	1024 x 1024 w/ 8/12 Bit Color up to 109 fps
Prosilica 1910C	GigE	1920H x 1080V	2/3” Type CCD	1920 x 1080 w/ 8/12 Bit Color up to 55 fps
Flare 2KSDI	HD-SDI	2048H x 1088V (1920H x 1080V)	2/3” Type CMOS	2048 x 1088 w/ 10 Bit Color up to 30 fps
Hitachi HV C20 (Existing – to be replaced)	Analog RGB	768H x 494V	1/2” CCD	768 x 494 @30fps

VUE Cameras

Size w/o lens (inches)
1.7 L x 2.5 W x 2.5 H
(w/o connectors)

Shown with Non-VUE Lenses

VUE Hardware Description Cameras

Camera Info:

- Flight configuration: Two HD-SDI (Flare) cameras & Two Gig-E (Prosilica) cameras
- Two types of Gig-E cameras
  - 1910C 1920Hx1080V @ 56 fps
  - 1050C 1024Hx1024V @ 110 fps
- Each camera has a fixed, 10' long cable w/modified rear housing
  - HD-SDI camera will require a new feed through connector
  - This camera's cable is two headed

Note: Lenses are not installed on the depicted cameras

Prosilica Flare

Microgravity Science Glovebox (MSG)

VUE Hardware Description
Monitors

Monitor Info:

- Flight configuration utilizes two ViewPoint monitors
- Each monitor has a fixed, 10’ long cable
- Monitors are for use external to the MSG Working Volume
- The hardware is COTS

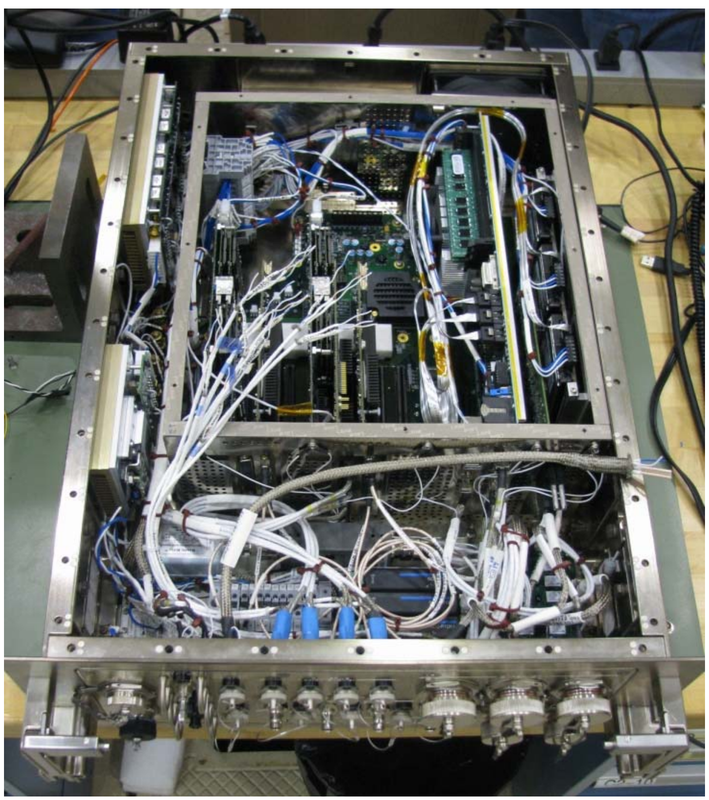
- 12.1” Wide Screen
- Resolution (1280x800 WXGA)
- Viewing Angle from all sides is 88 degrees
- 12VDC @ ~ 20 Watts

* Flight Monitor connectors are located on the bottom right of the units (as viewed from the front).

VUE Hardware Description Drawers

Drawer Info:

- Flight configuration is a single powered ISIS drawer
- Power is sourced through the rear drawer power connector and through a new J01 Jumper Cable
- Drawer is NASA supplied



- Front panel interfaces include:
    - Power jumper and MLC
    - Cameras (8x) & monitors (2x)
    - Ethernet (3x)
    - USB (2x)
- Drawer is a standard 4 panel unit height
- Drawer & CPU tops are affixed w/threaded fasteners

Microgravity Science Glovebox

Conclusion

- The MSG is a very versatile and capable research facility on the ISS.
- The Microgravity Science Glovebox (MSG) on the International Space Station (ISS) has been used for a large body or research in material science, heat transfer, crystal growth, life sciences, smoke detection, combustion, plant growth, human health, and technology demonstration.
- MSG is an ideal platform for gravity-dependent phenomena related research. Moreover, the MSG provides engineers and scientists a platform for research in an environment similar to the one that spacecraft and crew members will actually experience during space travel and exploration.
- The MSG facility is ideally suited to provide quick, relatively inexpensive access to space for Physical Science, Life Science, and Biological Science investigations.

Acknowledgements

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