MICROGRAVITY SCIENCE GLOVEBOX (MSG) SPACE SCIENCE’S PAST, PRESENT, AND FUTURE ON THE INTERNATIONAL SPACE STATION (ISS)

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Microgravity Science Glovebox (MSG)

Agenda

• Introduction
• Payload Interfaces and Resources Provided by MSG
• Overview of the Research Accomplished in the MSG Facility to Date
• MSG Operations Planned for 2013
• Life Science Ancillary Hardware (LSAH) Upgrades
• Video Upgrade Equipment (VUE)
• Conclusion
Introduction

- The Microgravity Science Glovebox (MSG) is a double 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 the physics associated 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

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

Engineering Unit Located at MSFC
Current MSG-Provided Payload Interfaces/Resources

- **Work Volume (WV) - Volume**
  - 0.255 m³ = 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

Total Operational Hours = 12,798

Total Investigation Hours = 12,450

Facility Hours = 348
Microgravity Science Glovebox (MSG)

International Utilization of the MSG Facility

as of 08/24/2012
# MSG Investigations

<table>
<thead>
<tr>
<th>Payload Name &amp; Acronym</th>
<th>Sponsoring Organization</th>
<th>Type of Investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustion Synthesis under Microgravity Conditions (COSMIC)</td>
<td>ESA</td>
<td>Combustion</td>
</tr>
<tr>
<td>Microgravity Experiment for the Measurement of Diffusion Coefficients in Crude Oil (DCCO)</td>
<td>ESA</td>
<td>Diffusion</td>
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<td>NANOSLAB</td>
<td>ESA</td>
<td>Zeolite Crystal Growth</td>
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<tr>
<td>Protein Microscope for the International Space Station (PromISS-1,2,3, &amp; 4)</td>
<td>ESA</td>
<td>Protein Crystal Growth</td>
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<td>ARGES</td>
<td>ESA</td>
<td>Light Bulb Technology</td>
</tr>
<tr>
<td>HEAT</td>
<td>ESA</td>
<td>Heat Pipe Technology</td>
</tr>
<tr>
<td>Selectable Optical Diagnostics Instrument (SODI)</td>
<td>ESA</td>
<td>Diffusion and Soret Phenomena</td>
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<tr>
<td>Cell Wall/Resist Wall (CWRW)</td>
<td>JAXA</td>
<td>Plant Growth</td>
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<tr>
<td>Coarsening in Solid Liquid Mixtures-2 (CSLM-2)</td>
<td>NASA</td>
<td>Material Science</td>
</tr>
<tr>
<td>Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions (InSPACE-1,2, &amp; 3)</td>
<td>NASA</td>
<td>Magnetorheological (MR) Fluids</td>
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<tr>
<td>IntraVenous Fluids GENeration and mixing (IV-Gen)</td>
<td>NASA</td>
<td>Human Health</td>
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<tr>
<td>Smoke Aerosol Measurement Experiment (SAME)</td>
<td>NASA</td>
<td>Spacecraft Smoke Detection</td>
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<tr>
<td>Shear History Extensional Rheology Experiment (SHERE)</td>
<td>NASA</td>
<td>Polymer</td>
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<tr>
<td>Smoke Point Coflow Experiment (SPICE)</td>
<td>NASA</td>
<td>Combustion</td>
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<tr>
<td>Critical Velocities in Open Capillary Channels (CCF)</td>
<td>NASA</td>
<td>Fluids</td>
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<tr>
<td>Structure and Liftoff in Combustion Experiment (SLICE)</td>
<td>NASA</td>
<td>Combustion</td>
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<tr>
<td>Burning and Suppression of Solids (BASS)</td>
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<td>Combustion</td>
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<tr>
<td>Boiling eXperiment Facility (BXF)</td>
<td>NASA</td>
<td>Heat Transfer</td>
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<tr>
<td>Pore Formation and Mobility Investigation (PFMI)</td>
<td>NASA</td>
<td>Material Science</td>
</tr>
<tr>
<td>Solidification Using a Baffle in Sealed Ampoules (SUBSA)</td>
<td>NASA</td>
<td>Material Science</td>
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# MSG Operations Planned for 2013

<table>
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<tr>
<th>CY13</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUNE</th>
<th>JULY</th>
<th>AUG</th>
<th>SEPT</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
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<tr>
<td></td>
<td>50P</td>
<td>32S</td>
<td>34S</td>
<td>ATV4</td>
<td>51S</td>
<td>HTV4</td>
<td>52P</td>
<td>HTV4</td>
<td>Orb-1</td>
<td>36S</td>
<td>53P</td>
<td>37S</td>
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<tr>
<td></td>
<td>SPX-2</td>
<td>Orb-D1</td>
<td>33S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SPX-4</td>
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</table>

**InSPACE-3**
- Launch
- Begin Ops
- End Ops
- On-orbit stowage/operational standby
- On-orbit operations
- Downmass - sample/data return

**MSG Yearly Recert**

**CSLM-3**

**BASS**

**CCF**

**SAMS-TSH**

**Fan Screen Cleaning**

**Rodent Research**

**LSAH & VUE**

**SDDI DCMIX (L)**

**Cell Array #2**

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**Launch**

**Begin Ops**

**End Ops**

**On-orbit stowage/operational standby**

**On-orbit operations**

**Downmass - sample/data return**
Life Science Ancillary Hardware (LSAH) Upgrades Available in 2014
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.
Microgravity Science Glovebox (MSG)

**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 combustion 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.
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

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

<table>
<thead>
<tr>
<th>PATHOGEN</th>
<th>BIOSAFETY LEVEL</th>
<th>UV Dose 99% (µW-s/cm²)</th>
<th>PATHOGEN</th>
<th>BIOSAFETY LEVEL</th>
<th>UV Dose 99% (µW-s/cm²)</th>
<th>PATHOGEN</th>
<th>BIOSAFETY LEVEL</th>
<th>UV Dose 99% (µW-s/cm²)</th>
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</thead>
<tbody>
<tr>
<td>Acinetobacter</td>
<td>2</td>
<td>3,600</td>
<td>Ebertelia typhosa</td>
<td>1</td>
<td>4,100</td>
<td>Proteus mirabilis</td>
<td>2</td>
<td>1,600</td>
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<tr>
<td>Adenovirus</td>
<td>2</td>
<td>11,800</td>
<td>Echovirus</td>
<td>2</td>
<td>1,600</td>
<td>Pseudomonas aeruginosa</td>
<td>1</td>
<td>10,500</td>
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<tr>
<td>Aeromonas</td>
<td>2</td>
<td>2,300</td>
<td>Eurotium (rubrum)</td>
<td>1</td>
<td>86,800</td>
<td>Rhizopus</td>
<td>2</td>
<td>34,600 - 896,000</td>
</tr>
<tr>
<td>Aspergillus</td>
<td>2</td>
<td>19,200 - 896,000</td>
<td>Fusarium (solani)</td>
<td>1</td>
<td>62,600</td>
<td>Rhodotorula (spp.)</td>
<td>1</td>
<td>224,000</td>
</tr>
<tr>
<td>Bacillus anthracis</td>
<td>2</td>
<td>8,700</td>
<td>Haemophilus influenzae</td>
<td>2</td>
<td>7,700</td>
<td>Sarcina lutea</td>
<td>1</td>
<td>39,400</td>
</tr>
<tr>
<td>Bacillus magaterium sp. (spores)</td>
<td>1</td>
<td>5,200</td>
<td>influenza A virus</td>
<td>2</td>
<td>6,600</td>
<td>Scopulariopsis</td>
<td>1</td>
<td>576,000</td>
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<tr>
<td>Bacillus magaterium sp. (veg)</td>
<td>1</td>
<td>2,500</td>
<td>Klebsiella pneumoniae</td>
<td>2</td>
<td>8,400</td>
<td>Staphylococcus epidermis</td>
<td>1</td>
<td>57,600</td>
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<tr>
<td>Bacillus paratyphus</td>
<td>1</td>
<td>6,100</td>
<td>Legionella pneumophila</td>
<td>2</td>
<td>2,600</td>
<td>Staphylococcus aureus</td>
<td>1</td>
<td>6,600</td>
</tr>
<tr>
<td>Bacillus subtilis spores</td>
<td>2</td>
<td>11,000</td>
<td>Leptospirocarincola - infectious Ja</td>
<td>1</td>
<td>6,000</td>
<td>Staphylococcus hominis</td>
<td>1</td>
<td>5,500</td>
</tr>
<tr>
<td>Blastomycetes dermatitidis</td>
<td>2</td>
<td>28,000</td>
<td>Listeria monocytogenes</td>
<td>2</td>
<td>31,100</td>
<td>Staphylococcus hominis</td>
<td>1</td>
<td>5,500</td>
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<tr>
<td>Botrytis cinerea</td>
<td>1</td>
<td>50,000</td>
<td>Measles virus</td>
<td>2</td>
<td>4,400</td>
<td>Staphylococcus hominis</td>
<td>1</td>
<td>5,500</td>
</tr>
<tr>
<td>Burkholderia cenocepacia</td>
<td>1</td>
<td>11,600</td>
<td>Micrococcus candidus</td>
<td>1</td>
<td>12,300</td>
<td>Serratia marcescens</td>
<td>1</td>
<td>21,000</td>
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<tr>
<td>Candida albicans</td>
<td>1</td>
<td>150,000</td>
<td>Micrococcus phærophilae</td>
<td>1</td>
<td>15,400</td>
<td>Staphylococcus hominis</td>
<td>1</td>
<td>5,500</td>
</tr>
<tr>
<td>Cladosporum</td>
<td>2</td>
<td>37,800 - 896,000</td>
<td>Mucor (mucedo)</td>
<td>1</td>
<td>120,000</td>
<td>Staphylococcus hominis</td>
<td>1</td>
<td>5,500</td>
</tr>
<tr>
<td>Clostridium perfringens</td>
<td>2</td>
<td>27,100</td>
<td>Mycobacterium avium</td>
<td>2</td>
<td>16,800</td>
<td>Streptococcus pyogenes</td>
<td>2</td>
<td>7,500</td>
</tr>
<tr>
<td>Coronavirus</td>
<td>2</td>
<td>1,400</td>
<td>Mycobacterium kansasii</td>
<td>2</td>
<td>16,000</td>
<td>Streptococcus pyogenes</td>
<td>2</td>
<td>7,500</td>
</tr>
<tr>
<td>Corynebacterium diphtheriae</td>
<td>2</td>
<td>6,500</td>
<td>Mycoplasma pneumoniae</td>
<td>2</td>
<td>1,700</td>
<td>Trichophyton</td>
<td>2</td>
<td>112,000</td>
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<tr>
<td>Cossackievirus</td>
<td>2</td>
<td>23,000</td>
<td>Neisseria catarrhalis</td>
<td>2</td>
<td>8,500</td>
<td>Ustilago (Zea)</td>
<td>1</td>
<td>224,000</td>
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<tr>
<td>Cryptococcus neoformans</td>
<td>2</td>
<td>56,000</td>
<td>Nocardia asteroides</td>
<td>2</td>
<td>56,000</td>
<td>Vaccinia virus</td>
<td>2</td>
<td>143,000</td>
</tr>
<tr>
<td>Curvularia lunata</td>
<td>1</td>
<td>112,000</td>
<td>Phytomonas tumefaciens</td>
<td>1</td>
<td>8,500</td>
<td>Vaccinia virus</td>
<td>2</td>
<td>143,000</td>
</tr>
</tbody>
</table>

### Molds
- Aspergillus flavus
  - 2
  - 99,000
- Aspergillus glaucus
  - 2
  - 88,000
- Aspergillus niger
  - 2
  - 330,000
- Mucor racemosus A
  - 2
  - 35,200
- Mucor racemosus B
  - 2
  - 35,200
- Oospora lactis
  - 1
  - 11,000

### Biological Agents
- Hepatitis A
  - 2
  - 8,000
- Salmonella typhi
  - 2
  - 15,200
- Shigella
  - 2
  - 4,200
- Vibrio cholerae
  - 2
  - 6,500
- Brewers yeast
  - 1
  - 8,800
- Common yeast cake
  - 1
  - 13,200
- Saccharomyces cerevisiae
  - 1
  - 13,200

### Protozoa
- Chlorella Vulgaris
  - 1
  - 22,000
- Paramecium
  - 1
  - 200,000
- Poliovirus - Poliomyelitis
  - 2
  - 6,000
- Tobacco mosaic
  - 1
  - 440,000
Microgravity Science Glovebox (MSG)

Decontamination System

Microorganisms That Can Be Decontaminated Within 12 Hours

2log10 Kill (99%)

Time to Decontaminate Microorganisms

Staphylococcus epidemis

<table>
<thead>
<tr>
<th>Time for 99% Reduction</th>
<th>Percent of Pathogens Killed</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 minutes</td>
<td>37.80%</td>
</tr>
<tr>
<td>1 hour</td>
<td>57.32%</td>
</tr>
<tr>
<td>2 hours</td>
<td>68.29%</td>
</tr>
<tr>
<td>12 hours</td>
<td>92.68%</td>
</tr>
</tbody>
</table>

Microbial 99% Kill Level Energy (µW-s/cm²)
Microgravity Science Glovebox (MSG)

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 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.

Gloves will be provided in three sizes 7,9, & 10.
Video Upgrade Equipment (VUE)
Available in 2014
Current MSG Video System

In addition 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.

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.
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.

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.

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.

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
  – Four terabytes of data storage via two 2 Tb Solid State RAID 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

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

VUE Cameras

GX1050

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

GX1910

Shown with Non-VUE Lenses
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 of 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 National Lab type investigations.
Acknowledgements

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