

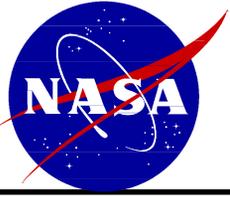
ISS Centrifuge Accommodation Module (CAM) and Contents

Presentation to the Space Station Utilization Advisory Subcommittee (SSUAS)

Dr. Terri Lomax

Director, Fundamental Space Biology Division
Office of Biological and Physical Research

July 29, 2003



CAM and Contents

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Presentation to SSUAS

QuickTime™ and a
Gzip file decompressor
are needed to see this picture.

Video of ISS/CAM and inside CAM

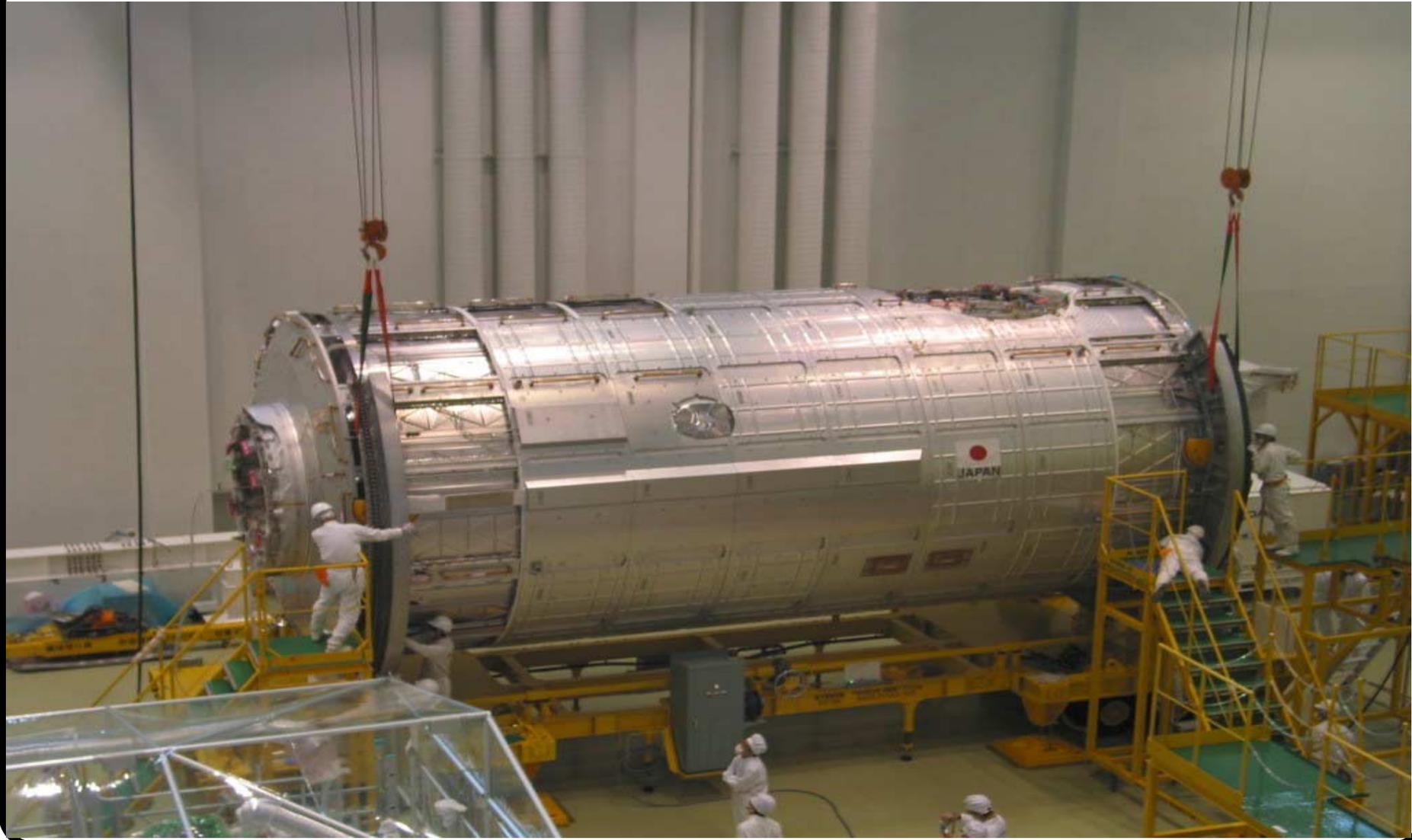


Japanese Enclosure Module (JEM)

Similar to Centrifuge Accommodation Module (CAM)

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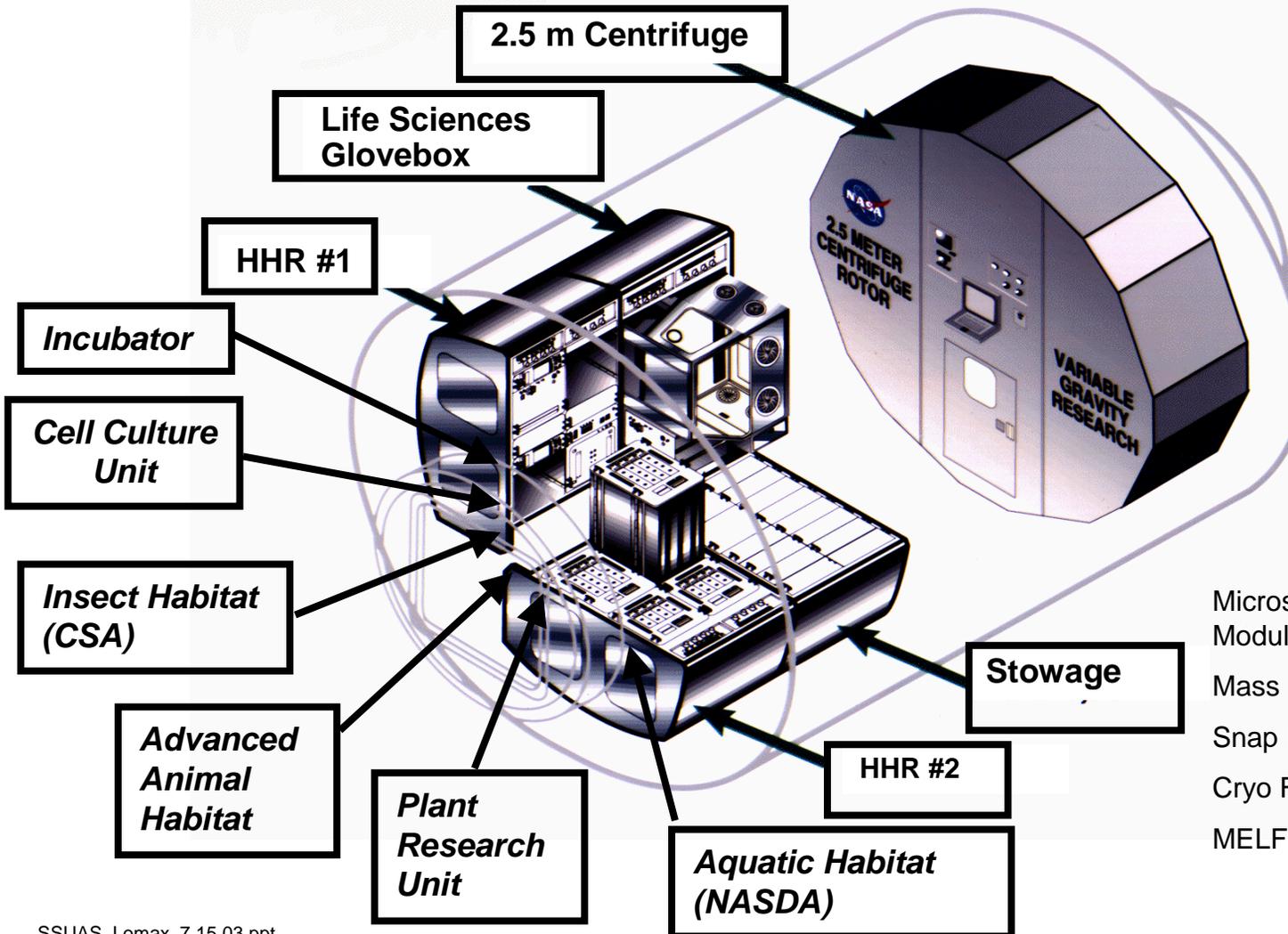


Baseline Integrated Facility

Current Launch Date CAM and Rotor:
4/07

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Presentation to SSUAS



Centrifuge Accommodation Module

Laboratory Support Equipment

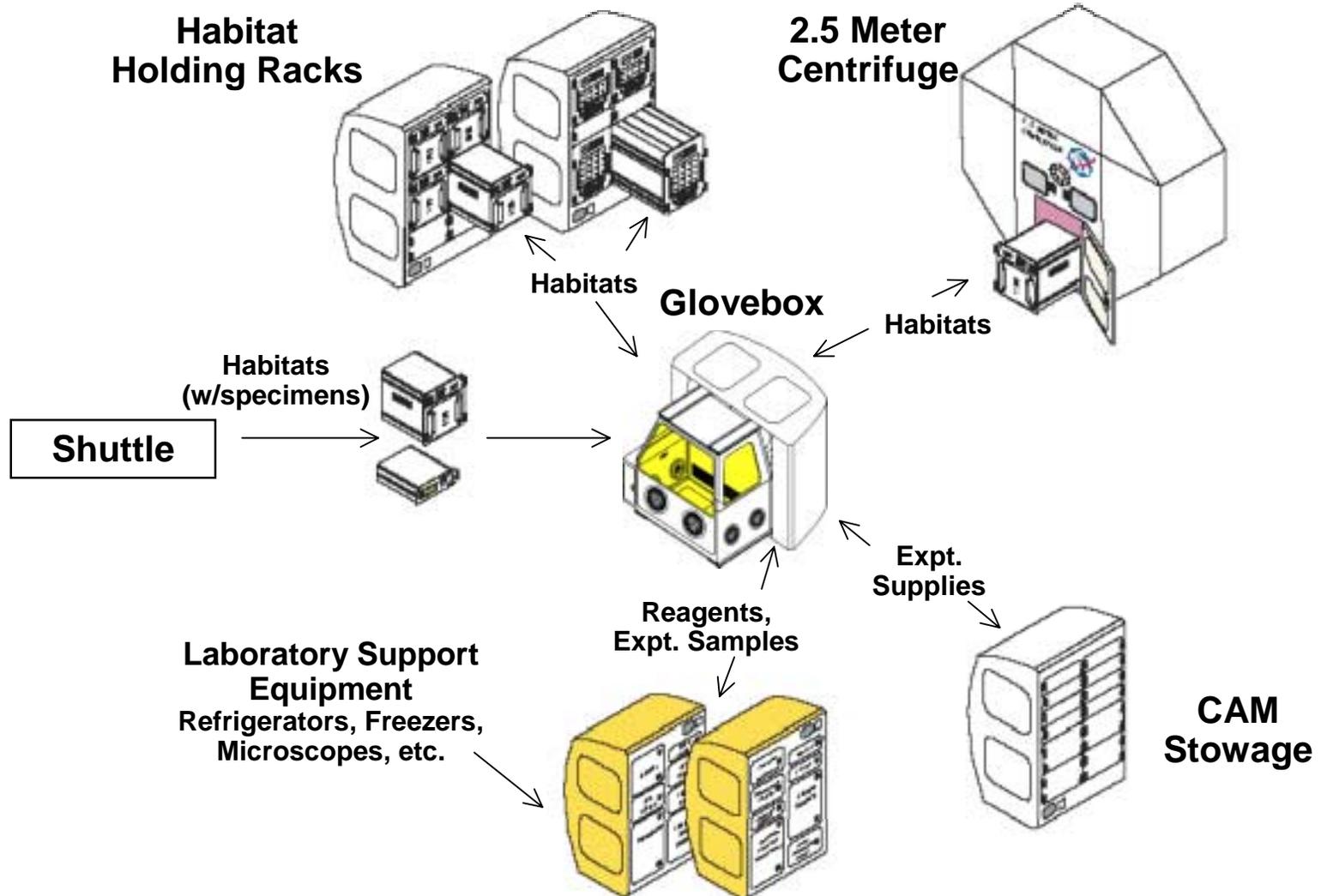
- Microscope (Light Microscopy Module) (Glenn MFP)
- Mass Measuring Devices (TBD)
- Snap Freezer (ESA)
- Cryo Freezer (ESA)
- MELFI (U.S. Lab) (ESA)

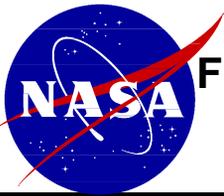


Space Station Research Project: Research Hardware Elements

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Presentation to SSUAS





Habitat Holding Racks (HHR)

Flight Hardware Available : HHR #1 1/04

HHR #2 8/07

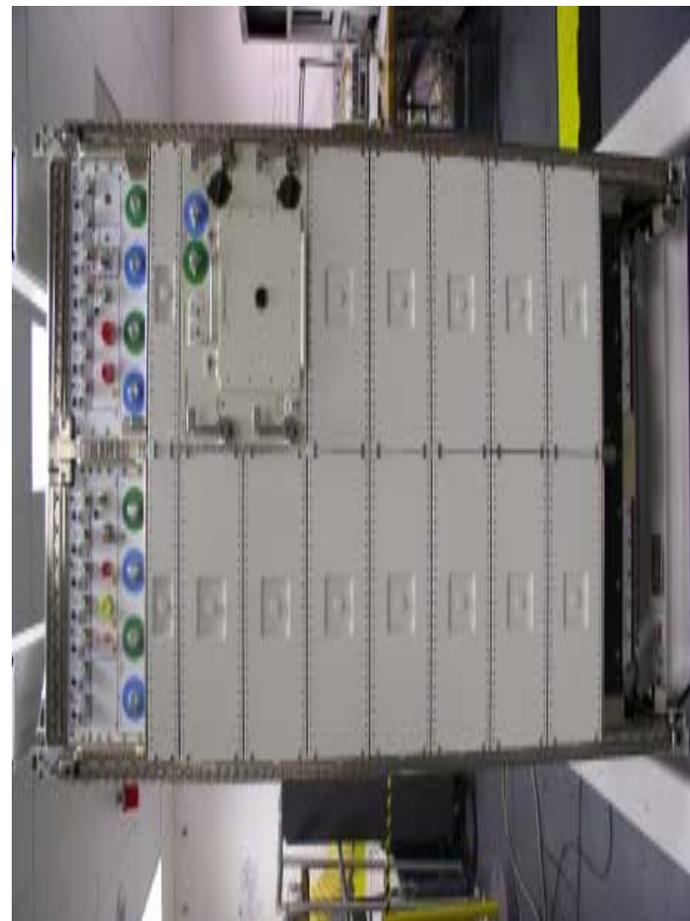
Contractor: Boeing

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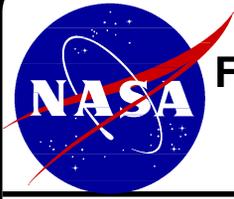
Presentation to SSUAS

Rack Capabilities:

- Accommodates four 24.5" high habitats
(2 HHRs provide 2 groups of 4 habitats)
- Accommodates four 87 kg habitats
- Power
 - 1700W to payloads
 - Primary/Backup power to payloads
 - Auxiliary power automatic switchover to separate power strings. (Specimen Survival Mode) (SSM)
- Data
 - Manual, Time-Based, Value-Based Commanding
 - Command Sequence Execution
 - Realtime/Stored Data Downlink Control
 - 5 GB Storage
 - Data/Video Display



Qual Rack w/Incubator



Habitat Holding Racks (HHR)

Flight Hardware Available : HHR #1 1/04

HHR #2 8/07

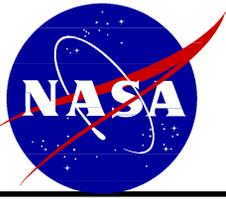
Contractor: Boeing

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Presentation to SSUAS

Rack Capabilities, continued:

- Video
 - Video Compression (2 channels)
 - ISS & JEM Video I/Fs
- Thermal
 - 1450 Watts Air Cooling
 - LTL or MTL supply to payload complement.
 - 4 payload fluid supply/return interfaces
- Rapid installation and removal of Habitats (with or without power)
- Vibration isolation from ISS environment



Life Sciences Glovebox (LSG)

NASDA provided

Flight Hardware Available : 7/05

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Presentation to SSUAS

LSG capabilities:

- Accommodate two habitats simultaneously
- Provide direct access to habitats
- Satisfy experiment operations needs
- Accommodate Lab Support Equipment inside Work Volume water cooling/ power/data
- Accommodate two crew members working simultaneously
- Accommodate wide anthropometric range of crew members
- Maintain bio-isolation between cabin and work volume
- Accommodate operations with hazardous materials
 - Chemical and Radioactive
- Provide video capability to support remote monitoring and coaching
- Airlock for passing equipment and samples in/out during containment operations.



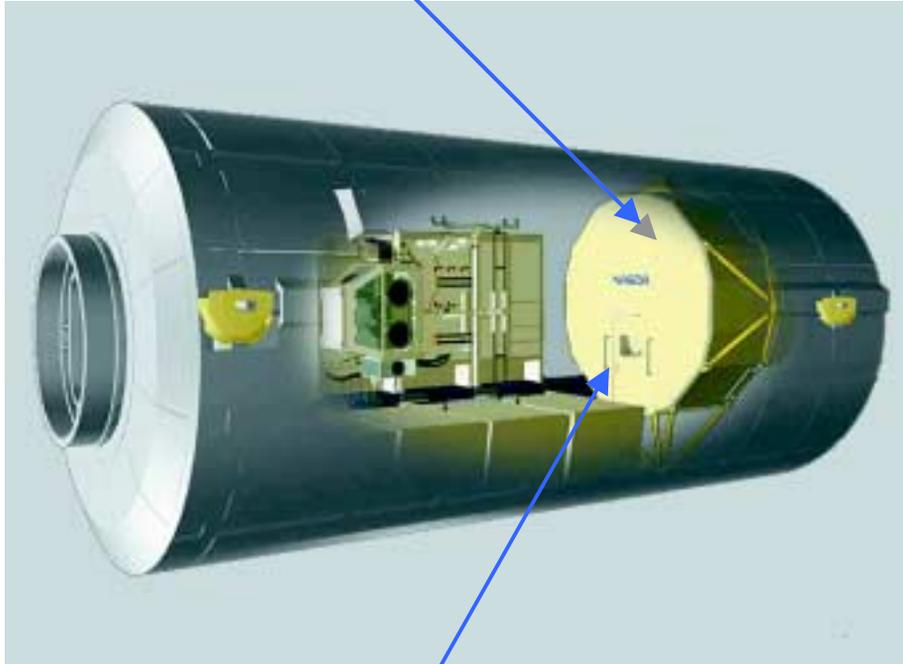


Centrifuge Rotor (CR)
NASA provided
Flight Hardware Available: 11/06

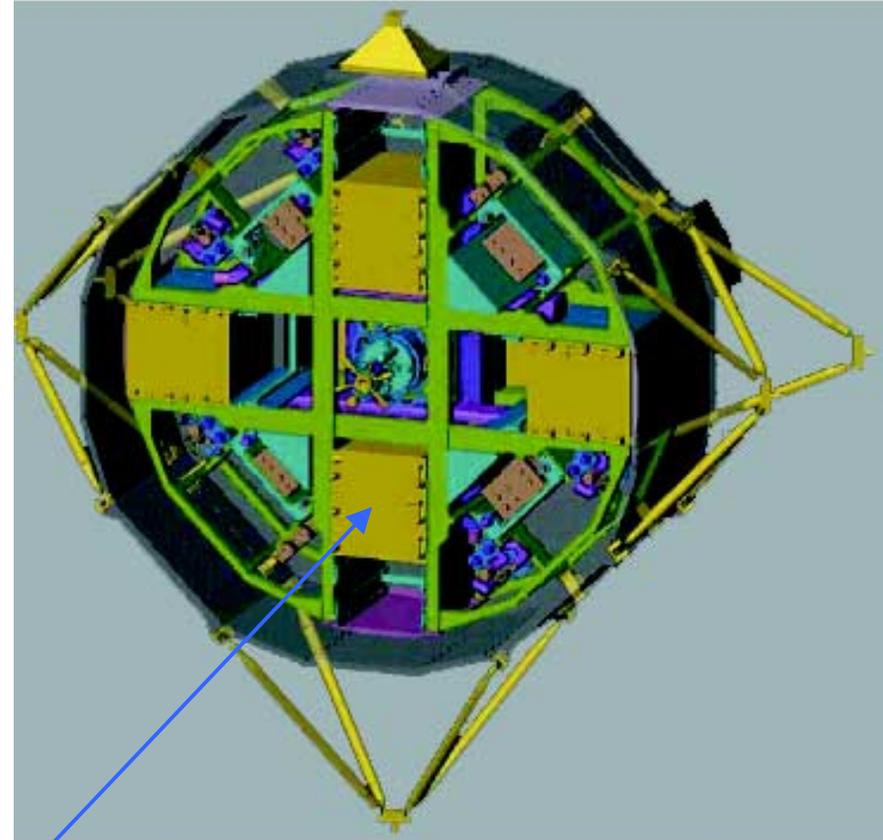
Terri Lomax / NASA Headquarters

Presentation to SSUAS

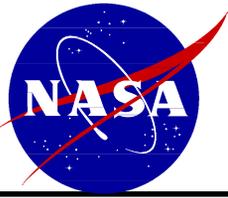
Shroud over Centrifuge Rotor



Habitat Access Door



Habitat



Centrifuge provides the capability to:

- Expose a variety of biological specimens to artificial gravity levels between 0.01g and 2g
- Simultaneously provide two different artificial gravity levels
- Provide partial g and hyper g environment for specimens to investigate altered gravity effects and g-thresholds
- Provide short duration partial g and hyper g environment for specimens to investigate temporal effects of gravity exposure
- Provide Earth simulation environment on ISS to isolate microgravity effects on specimens
- Provide Earth simulation environment on ISS to allow specimens to recover from unexpected microgravity effects
- Provide *in situ* 1g controls for specimens in micro-gravity



CR Habitat Accommodation

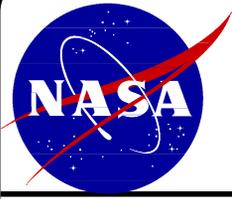
NASDA provided

Flight Hardware Available: 11/06

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Presentation to SSUAS

- Accommodates four 24.5" high habitats (ISIS Compatible)
- Accommodates four 87 kg habitats
- Power
 - 1700W to Payloads
 - Primary/Backup Power to Payloads
 - Specimen Survival Mode
 - Automatic Auxiliary Power Switchover to separate power strings
- Data
 - Manual, Time-Based, Value-Based Commanding
 - Command Sequence Execution
 - Realtime/Stored Data Downlink Control
 - 5 GB storage requirement
 - Data/Video Display



CR Habitat Accommodation
NASDA provided
Flight Hardware Available: 11/06

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Presentation to SSUAS

- Video
 - Video Compression (2 channels)
 - ISS Video I/Fs
- Thermal
 - 1450 Watts Air Cooling
 - LTL or MTL supply to payload complement.
 - 4 payload fluid supply/return interfaces
- Rapid installation and removal of Habitats (with or without power)
- Vibration isolation from ISS environment for Habitats
- Designed to meet stringent ISS disturbance requirements (*See Backup, pg 31, for worst case loading vs ISS requirements*)



Incubator (INC)

Flight Hardware Available: 7/04

Contractor: Lockheed-Martin

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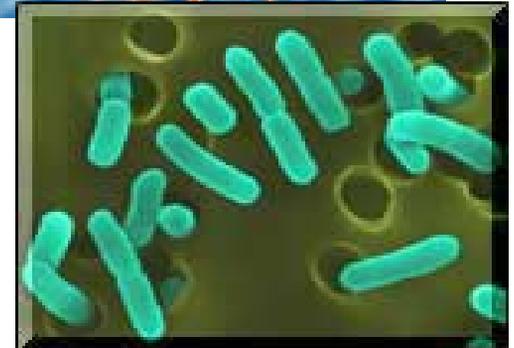
Presentation to SSUAS

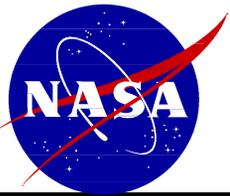
- **Model Specimens**

- Nematode, *C. elegans*
- Fruit fly, *D. melanogaster*
- Microbes, bacteria, yeast

- **Science Requirements**

- Glovebox and Centrifuge compatible
- Temperature controlled environment
- Accommodate multiple chambers
- Data/video port
- Power supply





Incubator (INC)

Flight Hardware Available: 7/04

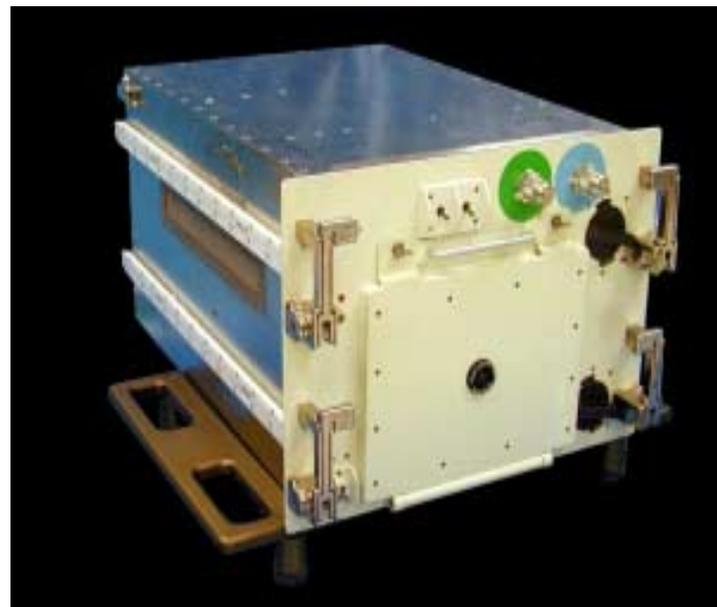
Contractor: Lockheed-Martin

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Presentation to SSUAS

• Habitat Capabilities

- Specimen Chamber Temperature Control: 4 - 45 °C
- External geometry conforms to an 8-Panel Unit (PU) ISIS drawer
- Specimen Chamber exchanges air with Space Station via Cabin Air inlet/outlet canisters
- Battery backup
 - Capable of recording data for 1 hour minimum during loss of Host System Power.
- Capable of recording data for 24 hours minimum during loss of communication with the Host
- Forced air circulation in specimen chamber
- 11 Data ports - 2 analog, 1 ethernet, 1 calibration, 1 video, 2 power (60w ea.), 4 temperature



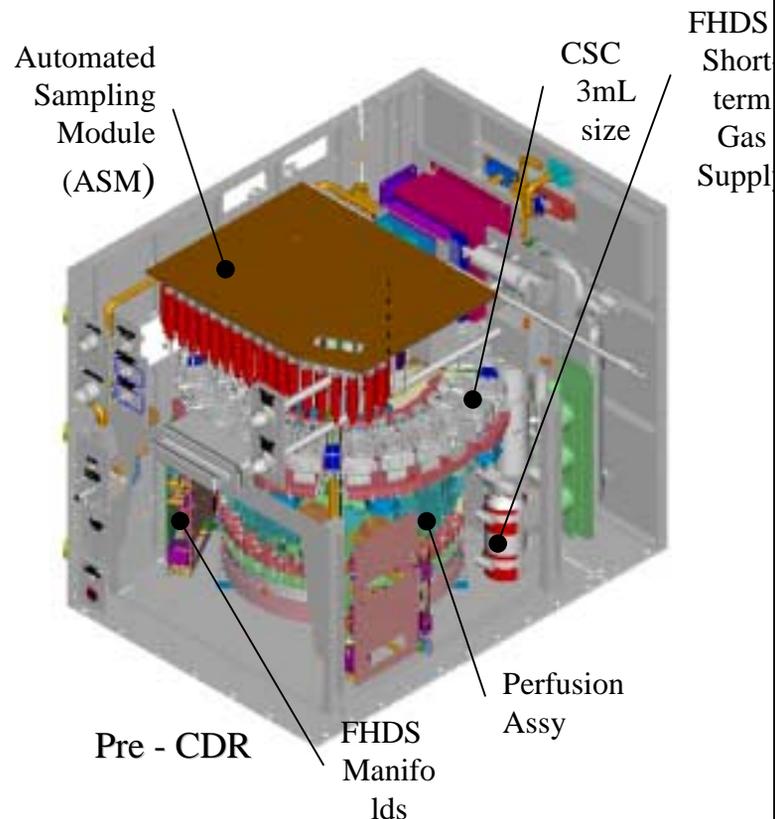


Model Specimens

- Animal, microbial, and plant cell and tissue cultures and non-feeding small aquatic specimens: C₂C₁₂ muscle, muscle organoids, bone cells, *Euglena*, tobacco BY2, Yeast

Habitat capabilities

- Support experiments for up to 90 days
- Centrifuge and LSG compatible. (Go to LSG as "Safe haven")
- 3 ml, 10, and 30 ml Cell Specimen Chambers (CSCs)
- Specimen lighting
- Magnetic stirring to assist with cell suspension





Cell Culture Unit (CCU)

Flight Hardware Available: 3/06

Contractor: PSI, Inc

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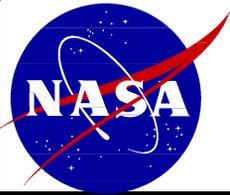
Presentation to SSUAS

- **Habitat capabilities, (con't.)**

- Video microscopy, differential interference contrast, fluorescence, and phase contrast
- 60 sample containers (2ml each) stored on-board @ 4° C
- On-orbit changeout of Cell Specimen Chambers (CSCs), sample containers, and fresh/spent media
- Automated on-orbit ops sampling, perfusion, mixing , video, & addition of additive/fixatives

- **Environmental Conditions**

- .Metabolic gas exchange
- 3 thermally-conditioned volumes for maintaining chambers at different temps (up to 6 cell chambers per sector)
- Culture temperature 4° - 39°C, with heat shock up to 45°C
- pH 3.5 - 8.5



Advanced Animal Habitat

Flight Hardware Available: 6/07

Contractor: STAR-SHOT

Terri Lomax / NASA Headquarters

Presentation to SSUAS

- **Specimens**

- Rats (up to 6/habitat)

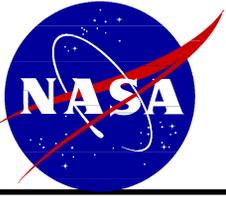
- **Environmental conditions**

- Temperature: 23 ° - 31 °C \pm 1 °C
- Controllable lighting levels 0 - 40 lux with IR dark cycle
- Monitor CO₂ levels

- 3 Science Evaluation Units (SEUs) fabricated in 2002 for AAH science testing

- 90 day biocompatibility test in SEUs with adult male Sprague Dawley rats completed in 2002
- Automatic low power mode (Specimen Survival Mode) to maintain animal well being in the event of ISS failure





Advanced Animal Habitat

Flight Hardware Available: 6/07

Contractor: STAR-SHOT

Terri Lomax / NASA Headquarters

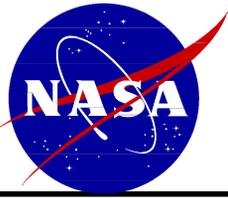
Presentation to SSUAS

Habitat capabilities

(Compatible with HHR, LSG, & 2.5m centrifuge)

- Continuous centrifugation for 2 weeks
- Food, water and waste management
- 0-2 g living environment
- Video monitoring of animals, B&W and color
- Future accommodations:
 - Biotelemetry such as ECG, EMG, EEG, blood pressure
 - Mice - 12 per habitat
 - Individual housing
 - Nursing insert
 - Food and H₂O measurement





- **Specimens**

- 38cm root/shoot growing height (allows full development of *Arabidopsis thaliana*, *Brassica rapa*, & dwarf wheat varieties)
- 550 cm² total growing area

- **Environmental conditions**

- Shoot zone temperature: 20° - 30°C
- Fluid temperature entering the root zone: 15° - 30°C
- Relative humidity: 60 - 90 %
- Carbon dioxide: 300 to 5000 ± 50 PPM
- Provide variable photon flux of 0 to 1000 μmol/m²/s with controllable light / dark cycle



Plant Research Unit (PRU)

Flight Hardware Available: 1/08

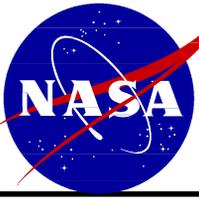
Contractor: ORBITEC

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Presentation to SSUAS

- **Science Requirements**
 - Glovebox and Centrifuge compatible
 - Growing height: up to 38 cm
 - Two chambers per unit
 - Sampling and video imaging
 - LED lighting
 - *In-situ* measurement of photosynthesis, respiration, and transpiration
 - On-orbit access for manipulation and sampling
 - Independent control diagnostics of temperature, humidity, CO₂, ethylene, LED light level, photoperiod, and event recording

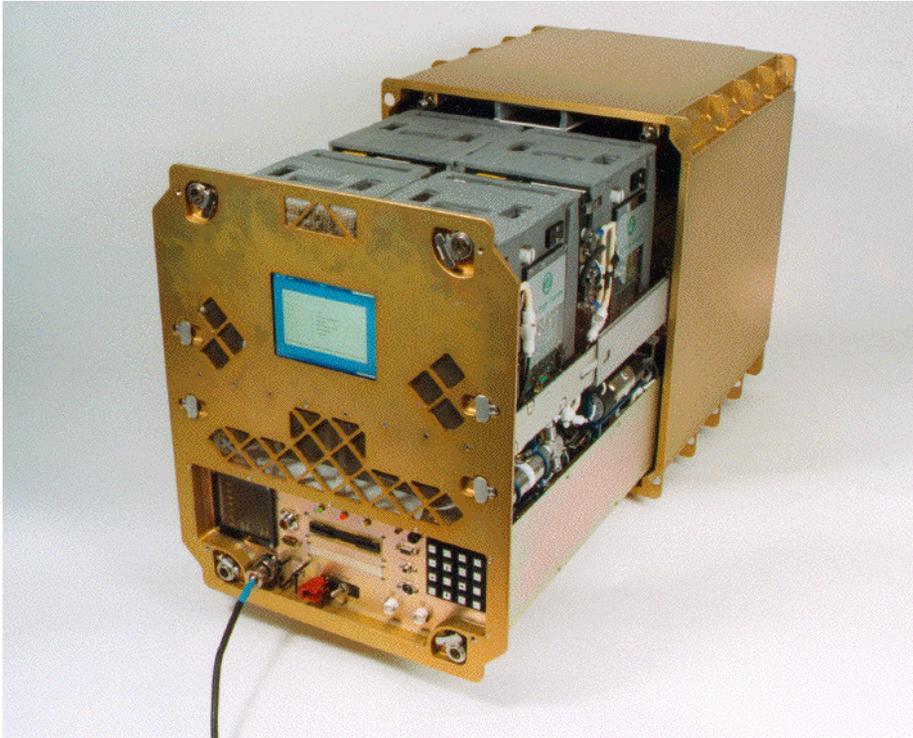




Biomass Production System (BPS)
Precursor to the Plant Research Unit
Orbital Technologies Corporation,
(ORBITEC)

Terri Lomax / NASA Headquarters

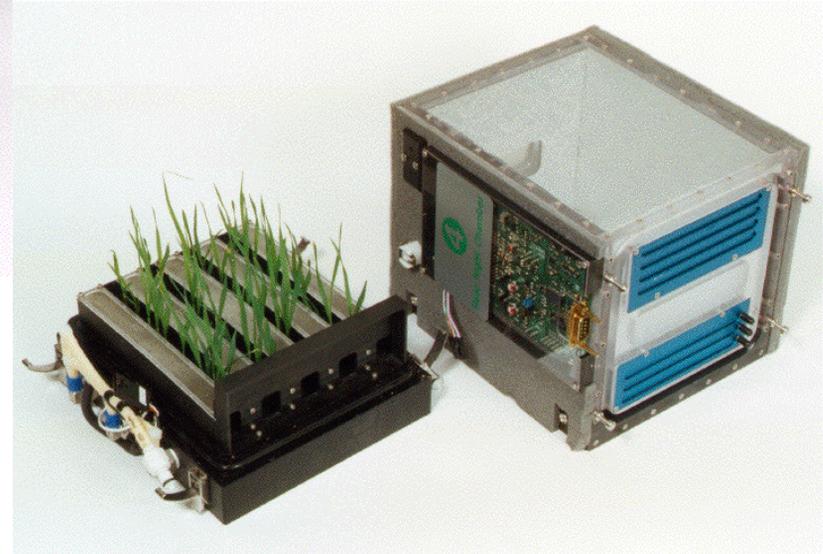
Presentation to SSUAS

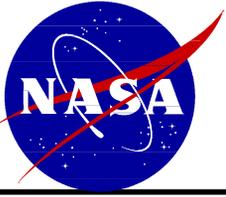


• **Experiment capabilities**

- Operate up to 90 days
- Video imaging
- Sample collection:
 - gas
 - nutrient medium

- BPS flew on ISS 8-A(STS-110, 4/02)
- PI: G. Stutte
- PRU Subsystems tested successfully





Insect Habitat (IH)

Launch Readiness: TBD
To be provided by the CSA

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Presentation to SSUAS

- **Specimens**

- Insects: *Drosophila*, beetles, etc.

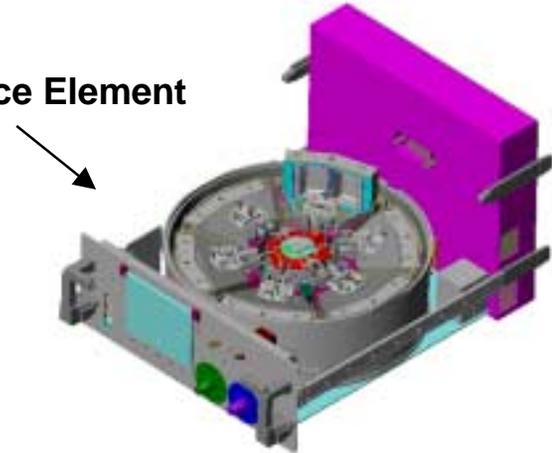
- **Environmental conditions**

- CO₂ to <1% with O₂ content of 16.5% to 23.8%
- Temperature from 4° C - 40° C ± 1° C
- Relative humidity 20% - 95% ± 5%
- Photo period and light level from 0 to 20 μW/cm², at wavelength 350-750 nm
- Food supply for larval growth and development

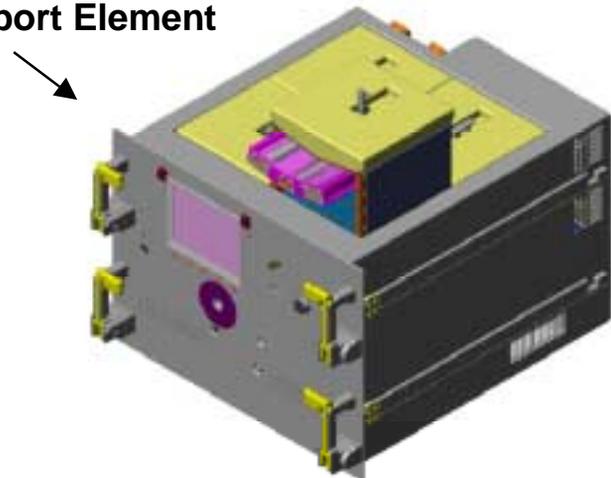
- **Habitat capabilities**

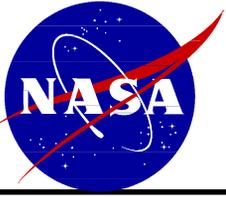
- Separation of successive generations for up to 90 days
- Imaging up to 20x magnification
- Specimen collection, preservation and storage

Science Element



Transport Element





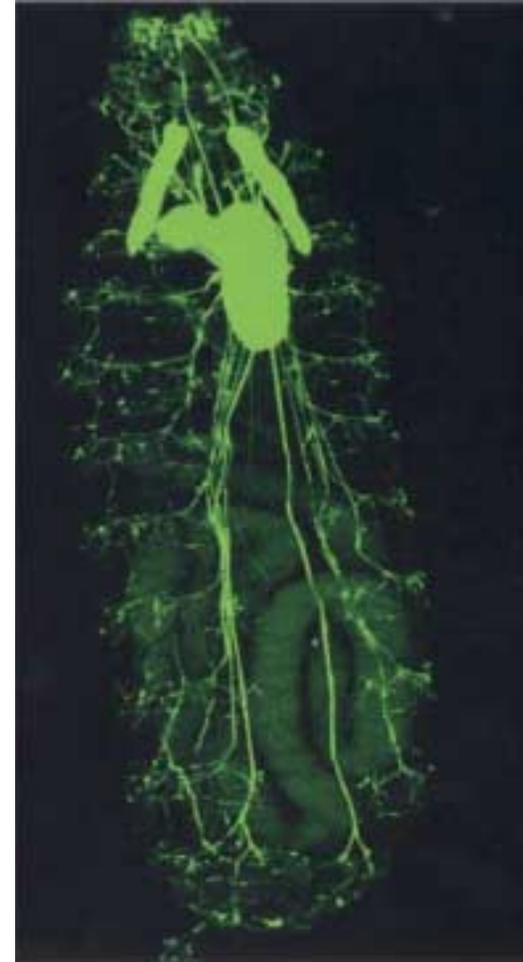
Insect Habitat (IH)

Launch Readiness: TBD
To be provided by the CSA

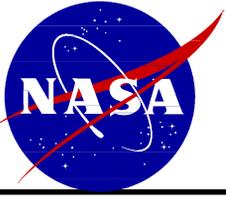
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Presentation to SSUAS

- **Model Specimens**
 - *Drosophila melanogaster*
- **Science Requirements**
 - 12 independent chambers
 - Support separation of generations
or multiple short duration experiments
 - Internal variable gravity from 0 to 2g
 - Glovebox compatible



GFP Neurosystem, *Drosophila* maggot, H. Keshishian



Aquatic Habitat (AQH)

Launch Readiness: TBD

NASDA provided

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Presentation to SSUAS

- **Specimens**

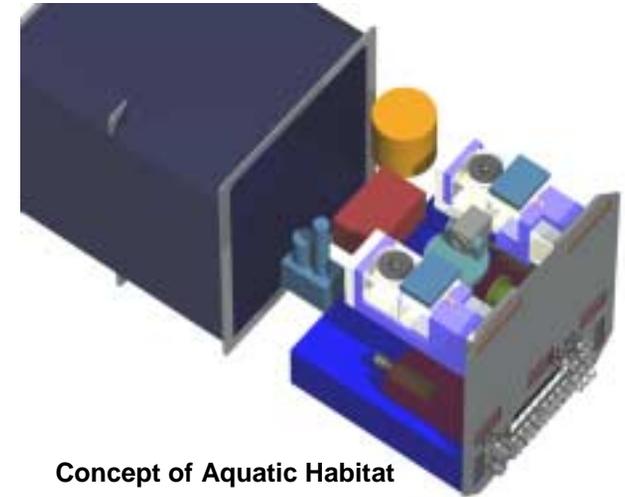
- Fresh and marine aquatic species (e.g. Japanese Medaka and Zebra fish)
- Accommodate appropriate number of specimens to allow reproduction to occur

- **Environmental conditions**

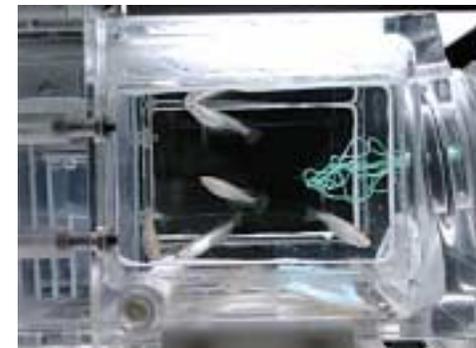
- Manage water quality (pH and dissolved oxygen level in the water)
- Nutrient delivery for all life stages
- Temperature: 14 ° - 30 °C

- **Habitat capabilities**

- Compatible with 2.5m centrifuge
- Support aquatic specimens for 16 to 90 days on orbit
- Provide video imaging of specimens including eggs and larvae
- Provide direct access to specimens
 - Provide capability for specimen fixation



Concept of Aquatic Habitat



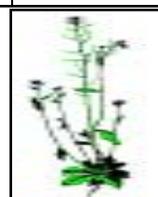
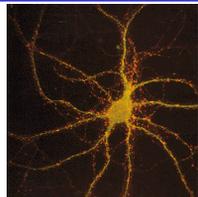
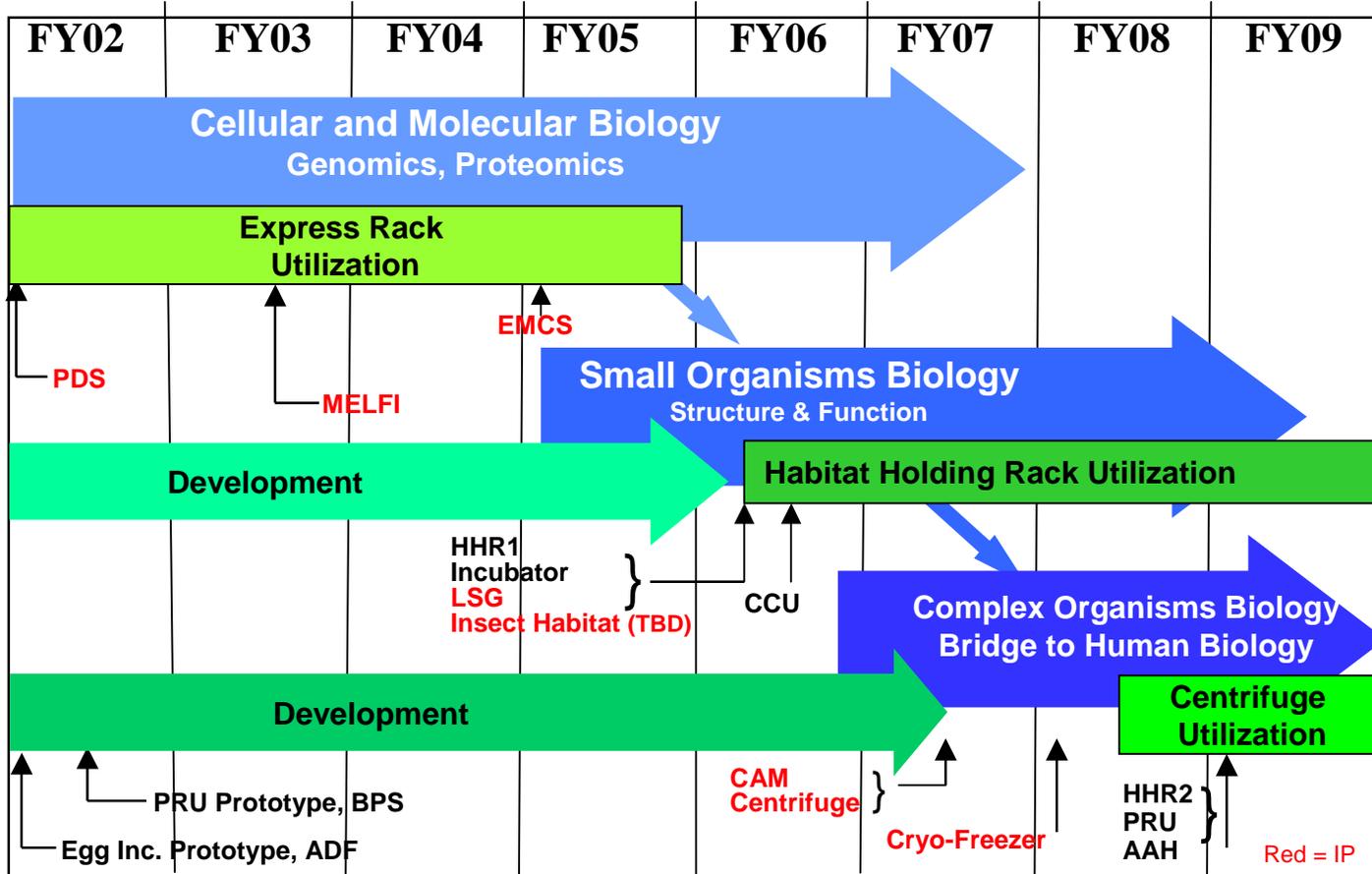
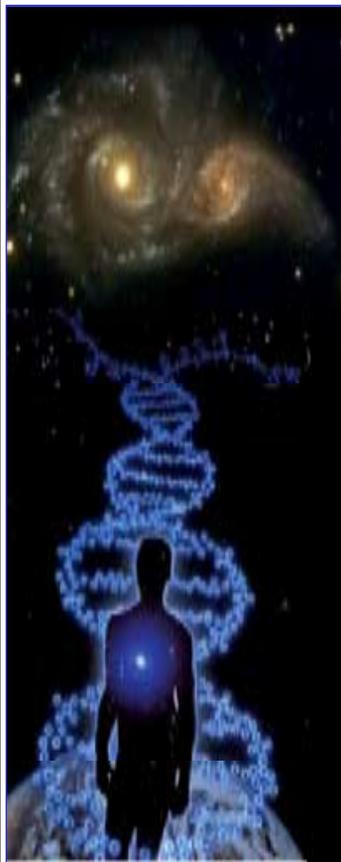
Specimen Chamber

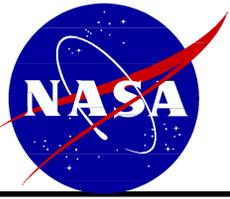


Progression of Fundamental Biology Research on the ISS

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Presentation to SSUAS



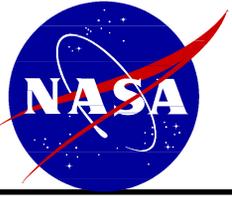


Conclusion

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Presentation to SSUAS

- The CAM increases the US volume for research by 70%.
- The CAM contents are a highly integrated suite of research equipment.
- The hardware to support research using a broad spectrum of biological specimens is under development; plant and egg prototypes have flown successfully.
- Both NASA and ISLSWG plans and workshops are planned to provide additional capabilities to the core equipment.
- Selection of experiments to utilize this hardware is through a coordinated international review process.

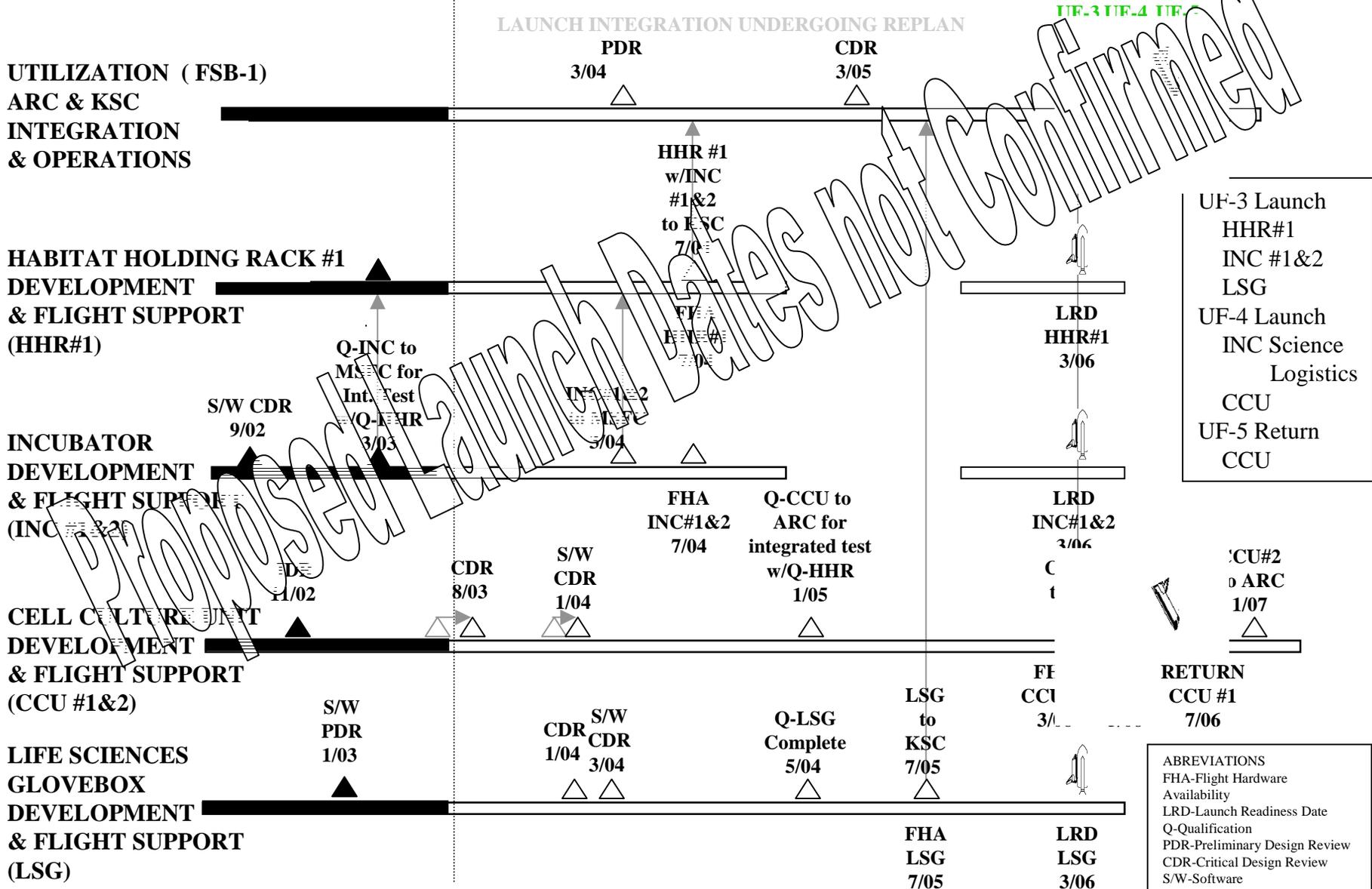
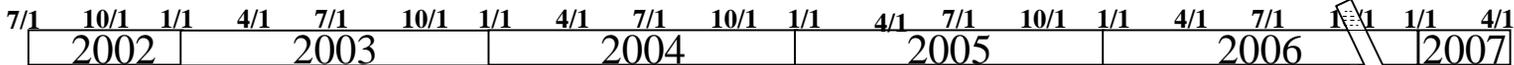


BACKUP



SSBRP Master Schedule

STATUS AS OF 7/8/03



Proposed Launch Dates Not Confirmed



Other hardware has centrifuges.
Why do we need another one?
(Are all centrifuges created equal?)

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Presentation to SSUAS



Coriolis effects

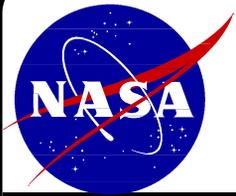
Bigger = Better

"0" g

g gradient

"1" g

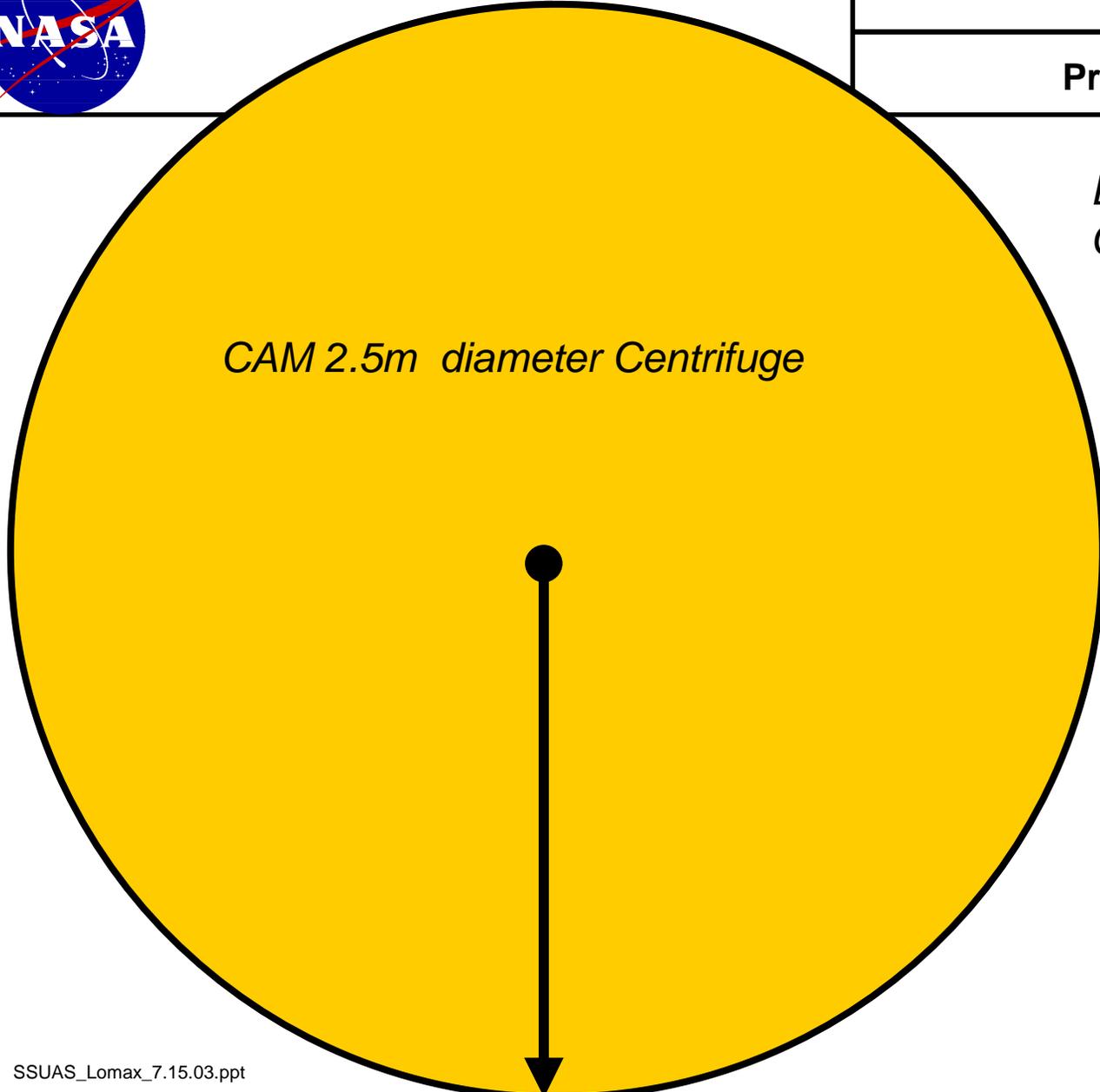
Inertial shear accelerations



Rotor Comparison

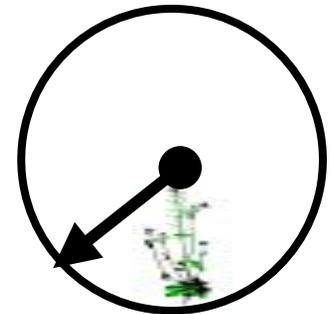
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CAM 2.5m diameter Centrifuge

EMCS 0.6 m diameter Centrifuge

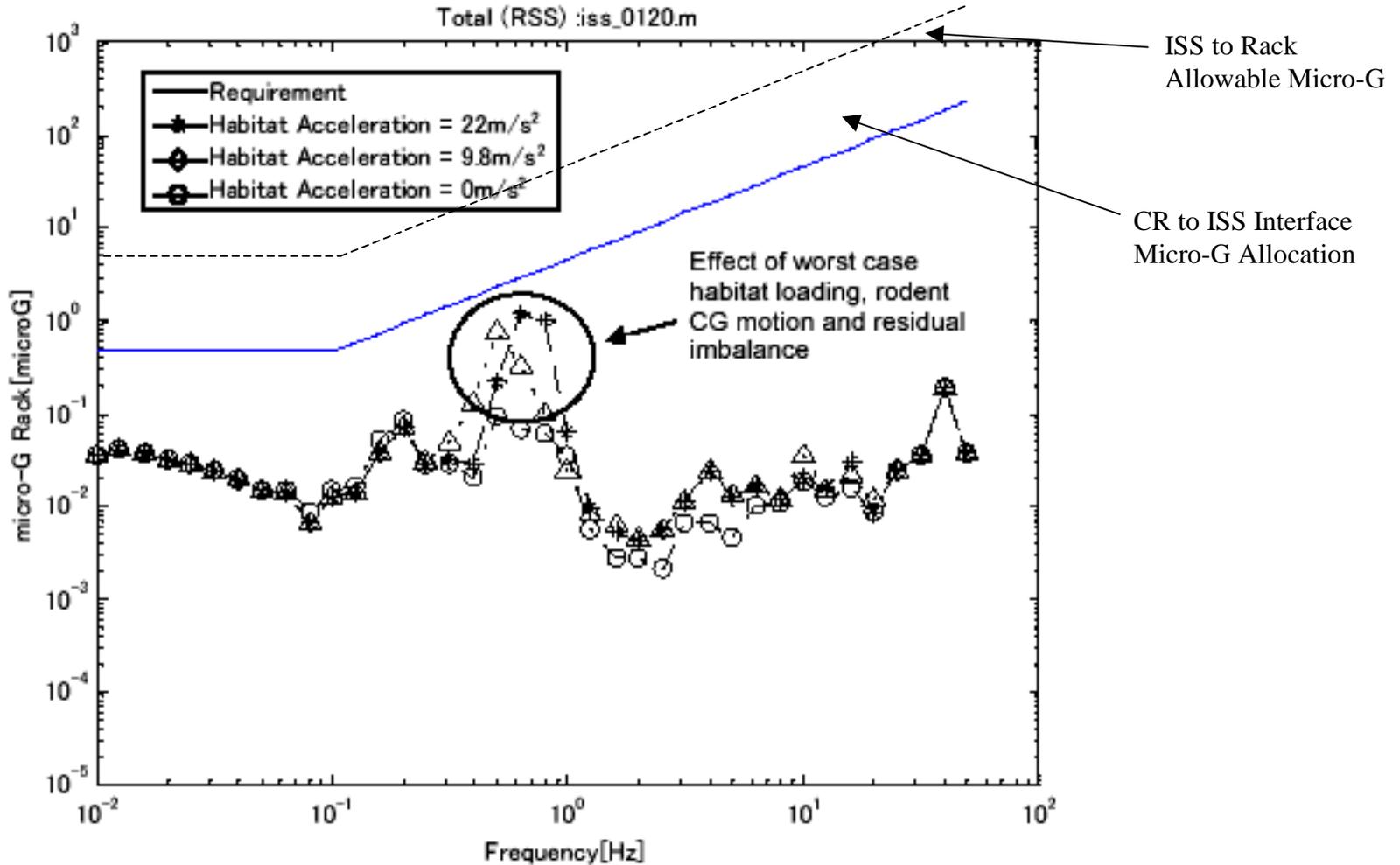




Total CR Microgravity Environment at Micro-G Rack

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Integrated Facility International Space Station

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Centrifuge Accommodation Module (CAM)