

New Developments in NASA's Rodent Research Hardware for Conducting Long Duration Biomedical and Basic Research in Space

Yasaman Shirazi, Ph.D.

Mission Scientist – Rodent Research

ASGSR

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Y. Shirazi-Fard¹, S. Choi², C. Harris², C. Gong², R.J. Fisher¹, J.E. Beegle¹, K.C. Stube², K.J. Martin¹, R.G. Nevitt², R.K. Globus¹

¹ Space Biosciences Division, NASA Ames Research Center, Moffett Field, CA

² KBRWyle, Moffett Field, CA



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- Rodent Research Project's goals:
 - Use of rodents as a translational model
 - To better understand long term adaptation to microgravity
 - To Maximize science return thru BioSpecimen Sharing
 - To expand science capabilities



Rodent Research Hardware



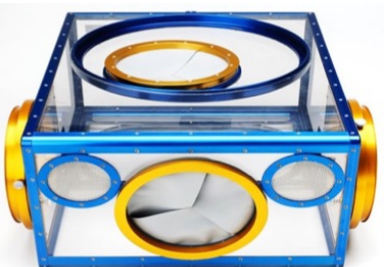
Rodent Transporter

- Houses mice during ascent and descent to/from ISS
- Accommodates up to 10 adult mice in each of the 2 compartments



Rodent Habitat

- Long-term housing on the ISS
- Accommodates up to 10 mice in one or separate compartments
- Continuous telemetry (%humidity, temperature)
- Video capability to monitor health and behavior



Animal Access Unit

- Attaches to Transporter and Habitat
- Used when accessing the animals for transfers, husbandry, or science procedures

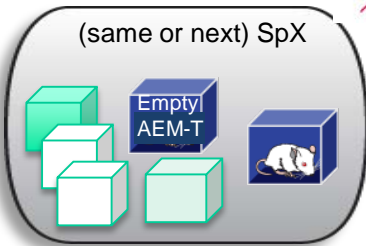
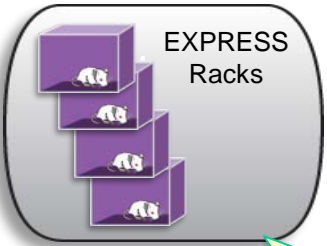


Mouse Transfer Box

- Holds the animals during transfer to/from Transporter, Habitat, or MSG
- Holds animals in the MSG during science procedures



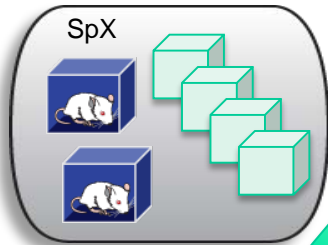
Concept of Operations



4. ISS Dock and Animal Transfer
 NLT Dock + 48 hours, transfer animals from Transporters to Rodent Habitats (w/ AAU). Stow Transporter for return.

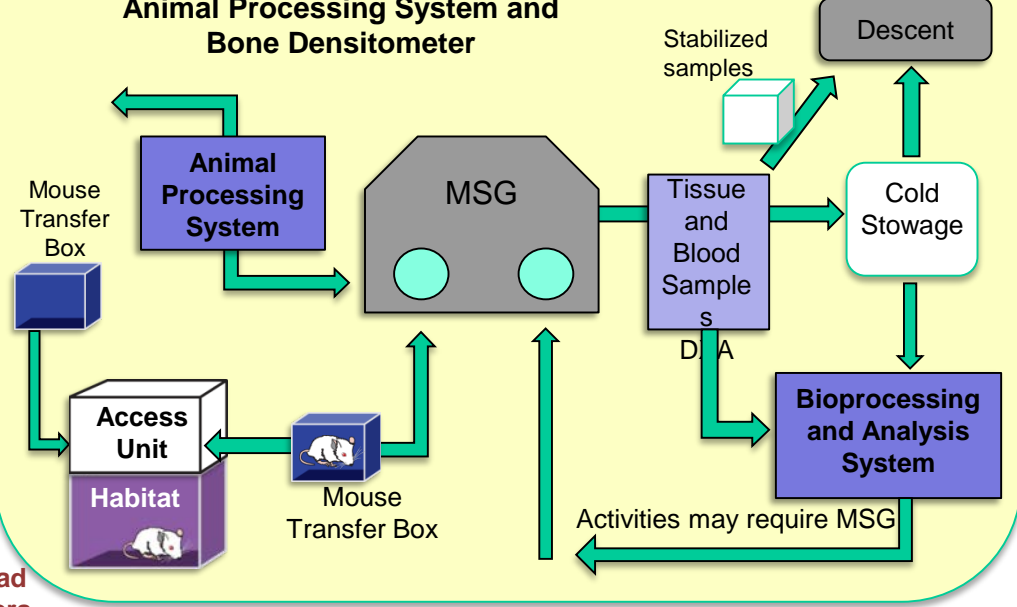
6. Transfer Remaining Live Animals and samples

5. On-Orbit

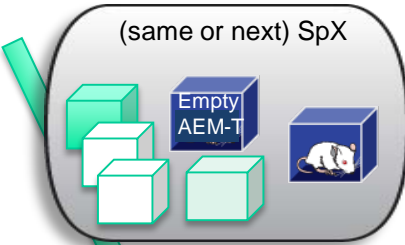


3. Ascent
 ~ 3 days

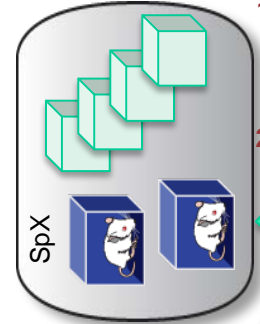
On-Orbit ConOps: Animal Processing System
Dissections and DXA using the Animal Processing System and Bone Densitometer



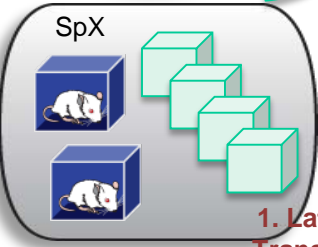
7. Descent



8. Sample Recovery



2. Launch



1. Late Load Transporters

Transporter w/ animals (20 mice, 10 days support)

Rodent Habitat w/o animals (passive transport)

Rodent Habitat w/ animals (10 mice, 30-45 days support)

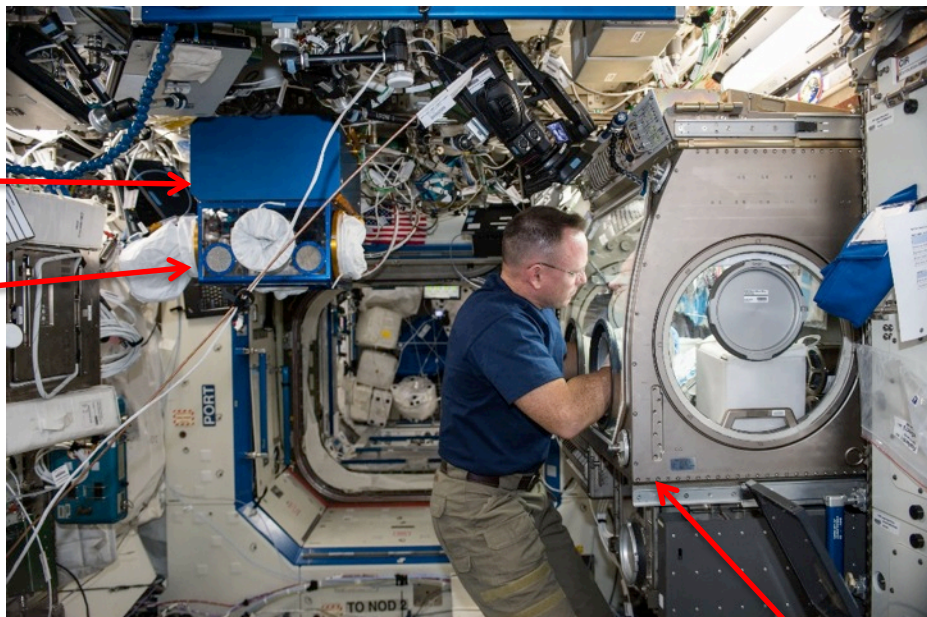
Frozen Samples

Refrigerated

Stabilized



ISS Operations Overview



Habitat

Access Unit



MSG





Rodent Research Capabilities



- Husbandry
 - Supply enrichment
 - Foodbar change out
 - Video health check
 - Group housing
- Environmental Control
 - Telemetry for temperature and %humidity
 - Light cycle
 - Real time alerts
- DXA scanning with anesthesia & recovery
- Sample Recovery and Preservation:
 - Euthanasia & Dissections
 - Cardiac puncture
 - Blood centrifugation
 - Tissue dissection and preservation
 - Fixative swap
 - Grip strength measurements

Bone Densitometry Exam Box



Anesthesia Recovery System (ARS)





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Capabilities: Video Health Checks

- Daily health checks
 - 1hr per habitat during dark cycle
- Extended video collection for behavioral studies



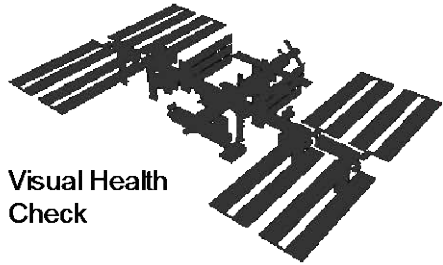


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New Developments: Live Animal Return

Transfer from Habitat to Transporter NET 36hrs before Dragon hatch close

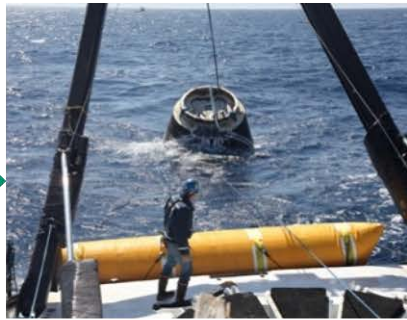


Visual Health Check

~7hrs



Dragon splashdown in Pacific Ocean



~1hr



Transporter/Locker transferred to SeaVan. Telemetry sensors installed.



NASA delivers Transporter to PI designated lab (within 120 mi). Animals will be checked by PI, attending vet, and NASA science team



~3-5hrs



NASA receives payload once SeaVan at Pier



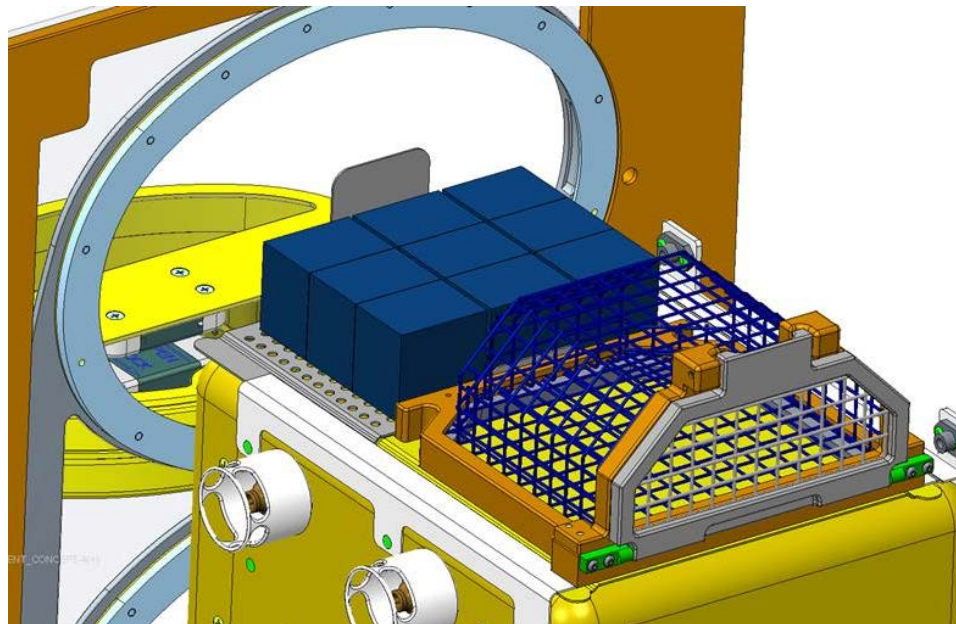
~48 hrs





New Developments: Enrichment Hut

- Enclosure for rodents to huddle and sleep in
- Supplied as a form of enrichment per animal welfare guidelines
- Made of stainless steel mesh, similar to the cage
- Facilitates animal retrieval by the crew





Maximizing Science Return



Working Microgravity is different than working in a lab on earth



vs



- Investigators are used to processing large numbers of samples in a single day – with large teams, lots of space, no restrictions on time worked, etc.
- We work with Principal Investigators to develop an experiment flow that returns the best possible science results within the constraints for spaceflight research
 - Translates to full crew days and multiple days in a row
 - Time critical operations
- These requirements are captured in our Ground Rules and Constraints



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Successfully completed 6 missions to date.



Rodent Research – 1 (SpaceX-4: Sep 21, 2014):

- Objective: Rodent Research Validation Mission
- 20 female C57BL/6J adult mice:
 - 10 (16 week old) for NASA's validation mission
 - 10 (32 week old) for the National Lab's science experiment
- Mission duration:
 - 33 days in microgravity (NASA's Validation)
 - 18 days in microgravity (Novartis)
- Euthanized and dissections performed. Samples returned on SpX5 (Feb 2015)
- Crew times: 75 hrs
- BSP dissection:
 - First thaw: April 2015
 - Second thaw: March 2016





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Rodent Research – 2 (SpaceX-6: April 14, 2015):

- Objective: Evaluate muscle atrophy in microgravity and identify molecular pathways and targets that could be used to develop novel therapies for muscle disease.
- PI: Samuel Cadena, Ph.D. (Novartis, CASIS sponsored)
- 20 female C57BL/6J adult mice:
 - 16 weeks old at launch
- Mission duration:
 - 50 days in microgravity
- On-orbit measurements:
 - Bone densitometry scan
- Euthanized and dissections performed. Samples returned on SpX-?
- Crew times: 157 hrs



Rodent Research – 3 (SpaceX-8: April 8, 2016):

- Objective: Evaluate effects of a drug (anti-myostatin) aimed at preventing muscle loss.
- PI: Rosamund Smith, Ph.D. (Elli Lilly , CASIS sponsored)
- 20 female BALB/c adult mice:
 - 12 weeks old at launch
- Mission duration:
 - 45 days in microgravity
- On-orbit measurements:
 - Bone densitometry scan
 - Grip assessment
- Euthanized and dissections performed. Samples returned on SpX-9
- Crew times: 125 hrs
- BSP dissection:
 - September 2016





Rodent Research – 4 (SpaceX-10: Feb19, 2017):

- Objective: Characterize events associated with bone healing/tissue regeneration in a microgravity environment.
- PI: Rasha Hammamieh, Ph.D. (Dept. of Defense, sponsored by US Army Center for Environmental Health Research)
- 40 male C57BL/6 adult mice – ***First Male Mouse Mission***
 - 10 weeks old at launch
- Mission duration:
 - 22 days in microgravity
- Pre-flight procedure:
 - Bone defect surgery
 - DXA scan
- Euthanized and dissections performed. Samples returned on SpX-10
- Crew times: 101 hrs
- BSP dissection:
 - May 2017



Rodent Research – 5 (SpaceX-11: June 3, 2017):

- Objective: Systemic Therapy of NELL1 for Spaceflight-Induced Osteoporosis
- PI: Chia Soo, Ph.D. (UCLA, CASIS sponsored)
- 40 female BALB/c adult mice – *First Live Animal Return*
 - 32 weeks old at launch
 - 20 for Live Animal Return on SpX-11 (LAR)
 - 20 for ISS Terminal (IT)
- Mission duration:
 - 30 days in microgravity (LAR)
 - 60 days in microgravity (IT)
- On-orbit Operations:
 - Bone densitometry scan
 - IP injections
- Euthanized and dissections performed (20). Samples returned on SpX-12
- Crew times: 130 hrs
- BSP dissection:
 - August 2017





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Rodent Research – 9 (SpaceX-12: Aug 14, 2017):

- Objective: Effects of Spaceflight on Musculoskeletal and Neurovascular Systems, Cerebral Arterial, Venous and Lymphatic Function: Implications for Elevated Intracranial Pressure.
- PI: Michael Delp, Ph.D. (Florida State University, SLPS sponsored)
- 20 male C57BL/6 adult mice – ***New Habitat Configuration***
 - 10 weeks old at launch
- Mission duration:
 - 35 days in microgravity
- Pre-flight measurement:
 - Gait assessment
 - Intraocular pressure
- All 20 mice returned live on SpX-12
- Crew times: 25 hrs
- BSP dissection:
 - Flight group: September 2017
 - Control group: March 2017



Rodent Research – 6 (SpaceX-13, NET Dec 4, 2017):

- Objective: To test the efficacy of sustained subcutaneous delivery of formoterol (FMT) released from nanochannel implants in the microgravity mouse model of muscle atrophy.
- PI: Alessandro Grattoni, Ph.D. (Houston Methodist, Novartis, CASIS sponsored)
- 40 male C57BL/6 adult mice:
 - 30-40 weeks old at launch
 - 20 for Live Animal Return on SpX-13 (LAR)
 - 20 for ISS Terminal (IT)
- Mission duration:
 - ~30 (LAR) or ~60 (ISS Terminal) days in microgravity
- Pre-flight procedure:
 - Nanochannel Delivery System (nDS) implants
 - Tail vein blood collection
- Euthanasia and dissections to be performed (20). Samples to be returned on SpX-14
- Crew times: ~145 hrs
- BSP dissection:
 - TBD





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Summary

- Continuously expanding science capabilities, and refining sample collection and preservation methods
- Achieving both basic and translational research objectives.
- Maximizing science return through the Biospecimen Sharing Program (BSP), sponsored by NASA's Space Biology Program
- Increased frequency of missions allowing for more science investigations



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Rodent Research Mission Integration & Operations Team

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Rodent Research Crew Training

Science Working Group



Questions

