

**SEMI-AUTONOMOUS RODENT HABITAT FOR DEEP SPACE EXPLORATION.**

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NASA has flown animals to space as part of trail-blazing missions and to understand the biological responses to spaceflight. Mice travelled in the Lunar Module with the Apollo 17 astronauts and now mice are frequent research subjects in LEO on the ISS. The ISS rodent missions have focused on unravelling biological mechanisms, better understanding risks to astronaut health, and testing candidate countermeasures. A critical barrier for longer-duration animal missions is the need for humans-in-the-loop to perform animal husbandry and perform routine tasks during a mission. Using autonomous or telerobotic systems to alleviate some of these tasks would enable longer-duration missions to be performed at the Deep Space Gateway.

Rodent missions performed using the Gateway as a platform could address a number of critical risks identified by the Human Research Program (HRP), as well as Space Biology Program questions identified by NRC Decadal Survey on Biological and Physical Sciences in Space, (2011). HRP risk areas of potentially greatest relevance that the Gateway rodent missions can address include those related to visual impairment (VIIP) and radiation risks to central nervous system, cardiovascular disease, as well as countermeasure testing. Space Biology focus areas addressed by the Gateway rodent missions include mechanisms and combinatorial effects of microgravity and radiation.

The objectives of the work proposed here are to 1) develop capability for semi-autonomous rodent research in cis-lunar orbit, 2) conduct key experiments for testing countermeasures against low gravity and space radiation. The hardware and operations system developed will enable experiments at least one month in duration, which potentially could be extended to one year in duration. To gain novel insights into the health risks to crew of deep space travel (i.e., exposure to space radiation), results obtained from Gateway flight rodents can be compared to ground control groups and separate groups of mice exposed to simulated Galactic Cosmic Radiation (at the NASA Space Radiation Lab). Results can then be compared to identical experiments conducted on the ISS. Together results from Gateway, ground-based, and ISS rodent experiments will provide novel insight into the effects of space radiation.

Health checks and telemetry measurements will be collected throughout the mission. Rodents are either euthanized on-board and samples stored until opportunity for return to Earth, or animals are returned live to Earth on return vehicle for later analysis. Samples collected on orbit can be further processed on the Gateway using WetLab-style instruments for molecular biology.

Areas ripe for autonomous, telerobotic, or telemetry monitoring and operations include: monitoring animal health, food delivery, and sample processing. We propose a system be developed to achieve these tasks.

In conclusion, more autonomous rodent research systems will facilitate longer duration experiments to be conducted farther from Earth. The capacity for animal experimentation for biological research, in particular, to determine the effects of space radiation exposure at the Deep Space Gateway, has the potential to complement and enable human exploration of space.

**Required Resources:** (1 EXPRESS Rack Locker; a second unit could be added to improve sample size.)

- Max. # of mice: ~20 mice (1 locker).
- Mass ~ 60 lbs / 23 kg (with locker)
- Power ~ 75 W
- Volume ~ 8 in. x 19 in. x 21 in.  
(20 cm x 49 cm x 54 cm)
- Temperature Control: 21-30 °C
- CO<sub>2</sub> control: 0.2 in Hg / 5.32 mm Hg (0.7% at 1atm) or lower.
- Oxygen: average 19.5 - 21% (assuming ambient pressure 760 Torr). Oxygen must be greater than 16%.
- Humidity: 30-70%
- Videocamera and Telemetry capacity: TBD
- Other resource needs:
  - Hardware designed to minimize excess noise and vibration and to provide life support conditions equivalent to those provided for astronauts (oxygen, low CO<sub>2</sub>).
  - Air flow requirement.
  - Radiation dosimetry.
  - Auxiliary Wetlab-like sample processing capability.