Guest Article by Professor Dr. Alexander Höhn / Colorado University

Space Life Science Research Prepares Mankind for Long-Distance Space Travel

Dr. Alexander Höhn, adjunct Associate Professor of Aerospace Engineering Sciences at Colorado University, talks about the challenges and demands on life science research in space. Vaisala sensors have supported Dr. Höhn and his team on several projects that are simply out of this world.

Imagine the future with manned flights to Mars and long-distance space exploration missions. Long travel times make it impossible to pack all the clean water, fresh air and food supplies to go. Instead, food and life support consumables, such as water and oxygen, must be produced on-site. Space life science research helps mankind to realize the vision.

Understanding the Effects of Microgravity

Astronauts lose bone and muscle mass during long space missions as they no longer have to work against gravity. The same happens to plants and animals. Space life science research explores how the lack of gravity, more precisely microgravity, affects living organisms. In addition, this research helps to develop advanced life support systems, including agriculture and water purification bioreactors, for long-distance space missions.

The only way to explore how microgravity influences living organisms is to go to space. In the small sealed space capsules, however, the effects of gravity need to be isolated from other environmental factors, such as the amount of light, varying temperature and humidity levels, as well as fluctuating carbon dioxide, oxygen and trace gas contaminant concentrations. Researchers often apply on-board centrifuges to create artificial gravity in space. With the help of centrifuges, on-board space shuttle plant growth experiments can be performed both in microgravity and at defined artificial gravity while keeping other variables constant. This test set-up attempts to ensure that the effects of gravity can be isolated from other factors.

Controlled Environments in Space

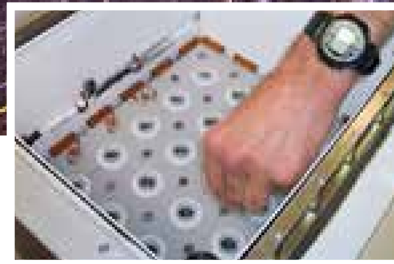
Life science and space biology experiments, whether cellular organisms, plants in small greenhouses, or rodents in their habitats, may be severely affected by changes in the environmental conditions. The carbon dioxide level in a spacecraft can reach as high as 1%, even in the presence of scrubbers that clean the air by selectively removing carbon dioxide. Temperature and humidity often fluctuate between +18 to +30°C and 40-60 %RH, respectively, excluding even larger fluctuations during the pre-flight integration and launch periods. For biology experiments, such spacecraft environmental controls are often not adequate.

Scientists at BioServe Space Technologies at the University of Colorado have been using Vaisala's carbon dioxide, humidity, and temperature sensors to control life science experiments both onboard Space Shuttle flights and at the International Space Station (ISS) since 1992 to regulate plant growth and animal habitat environments.

Project Risk Management

The costs of an individual space life science project are difficult to estimate. Space flights are typically carried out for multiple purposes, thus the launch costs are not carried by an individual research project. However, building a miniature greenhouse that is viable in space costs around one million USD. The typical weight of such a greenhouse is approximately 100 kg. On the average, launching 1 kg of goods costs around 10 – 20 000 USD. Thus the greenhouse launch costs are around 1-2 million USD.

Space shuttles no longer fly, and resupply and transport missions to the ISS now take place less frequently using smaller, rocket-launched space



capsules. Thus careful planning is necessary to get the job done right on the first go. Regarding instrumentation, Vaisala has taken away the risk by building products that are waterproof, environmentally protected, can just be plugged in, and they work. Vaisala sensors have never shown unexplained behavior in our applications. They have far exceeded expected and certified calibration and stability levels and usable periods. As there are plenty of things to worry about when planning a life science experiment in space, Vaisala has been chosen time after time to avoid unnecessary risks.

New Focus on Preventing Bone and Muscle Loss

During the last 10 years the focus in space life science research using plants and space agriculture has been somewhat reduced, and higher emphasis was given to finding ways to prevent bone and muscle mass loss due to microgravity. In order to study this, a future flight will resume US animal research aboard the ISS and transport 20 mice to the International Space Station. A fail-proof life support system with trustworthy sensors is a necessity to ensure their survival during transport to space.

Due to the long history of reliable operation and positive experience, excellent stability and ease of integration in the past, HMP110 sensors were again selected to control the payload that provides essential life support functions for the mice during the transport flight. The HMP110s will be used both for controlling humidity through scrubbers, and to record temperature and humidity for post-flight science and engineering analysis. Active carbon dioxide feedback controls are not implemented as the scrubbers are operational throughout the flight.

A Long Journey with Vaisala Sensors

We found Vaisala in early 1990s while searching for small, rugged carbon dioxide sensors. The humidity probe HUMITTER 50Y was taken into service at the same time. Sensors from other manufacturers were also tested but nothing else worked as reliably.

Over the years, the legacy sensors have been replaced with GMM220 series CO_2 modules and HMP110 humidity and temperature probes. However, the long retired sensors are still functional and continue to show reasonable readings after almost 20 years. This is quite impressive considering they have been exposed to environmental conditions far exceeding their design envelope such as condensation during unpowered payload phases, high launch vibrations, as well as microgravity and spaceflight environments.

About the author

Professor Dr. Alexander Höhn, born in Stuttgart, Germany, works as an Associate Professor of Aerospace Engineering Sciences at Colorado University. He holds a PhD in Aerospace Engineering Sciences and has developed payloads for over 35 missions including NASA's Space Shuttle Program, the International Space Station, as well as parabolic and sounding rocket flights over the past 25 years. The span of life science experiments ranges from cellular organisms and bioreactors to plant growth chambers as well as small rodent habitats for space biology and medicine experiments.