Canadian Food Production Subsystem Designs for a Lunar Agriculture Module - Ground Test Demonstrator (LAM-GTD)

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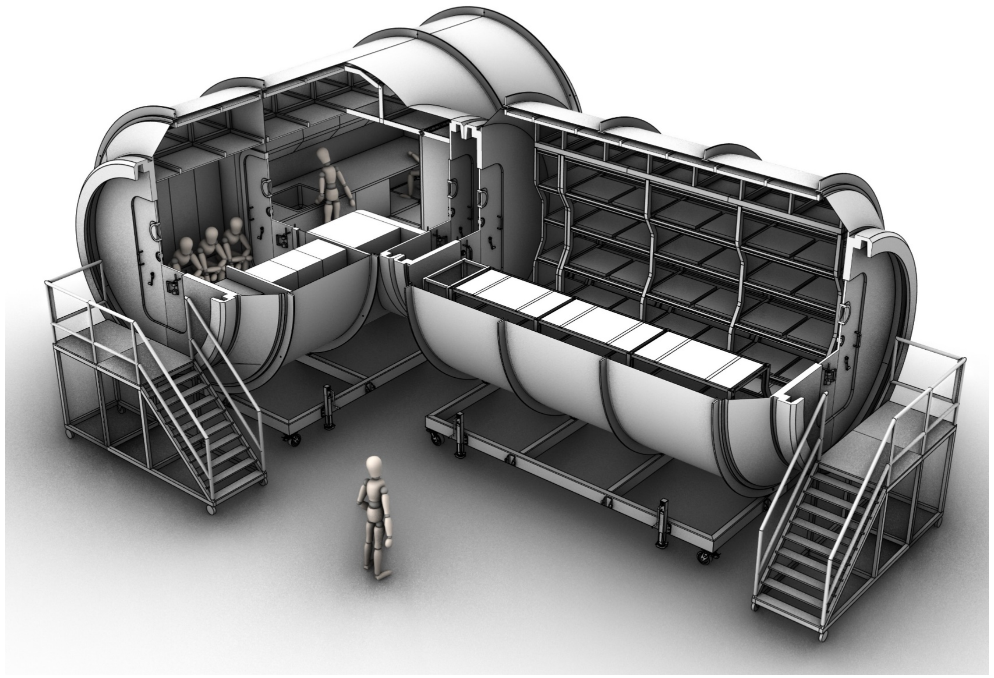
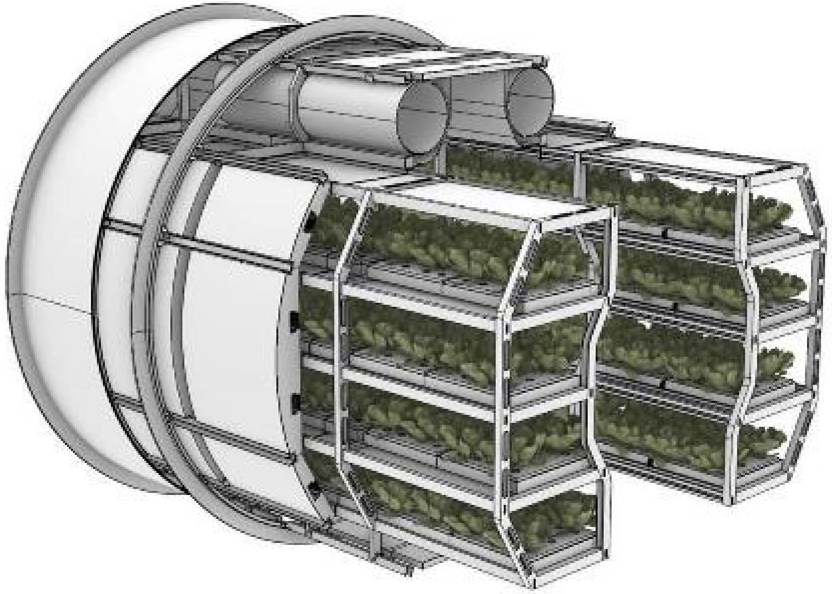
Lunar Agriculture Module – Ground Test Demonstrator

Technology Advancement



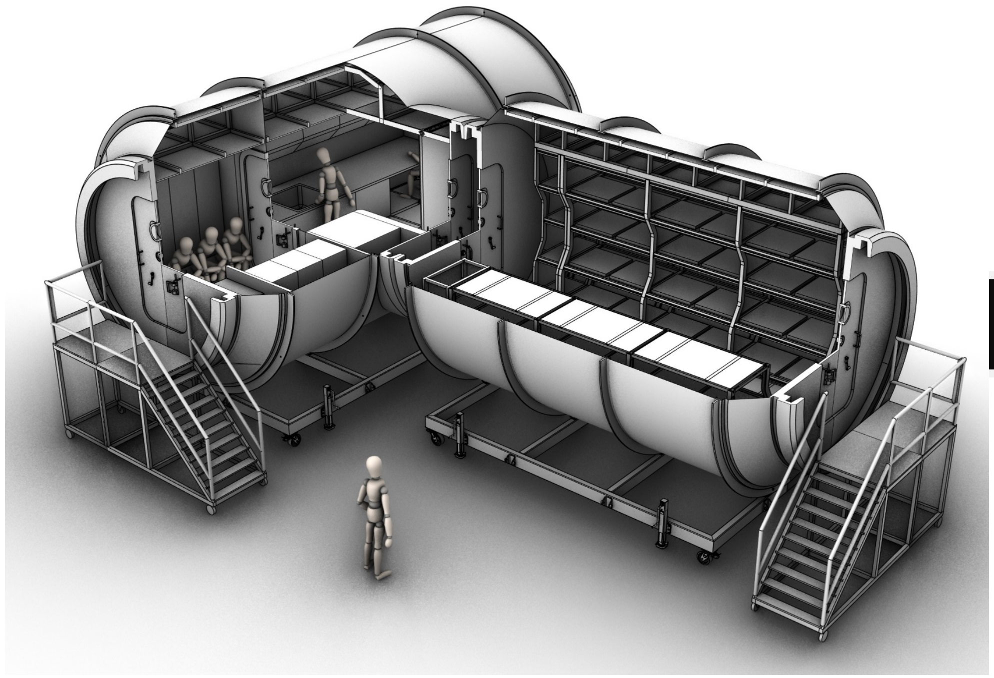
LAM-GTD Render. Credit: DLR



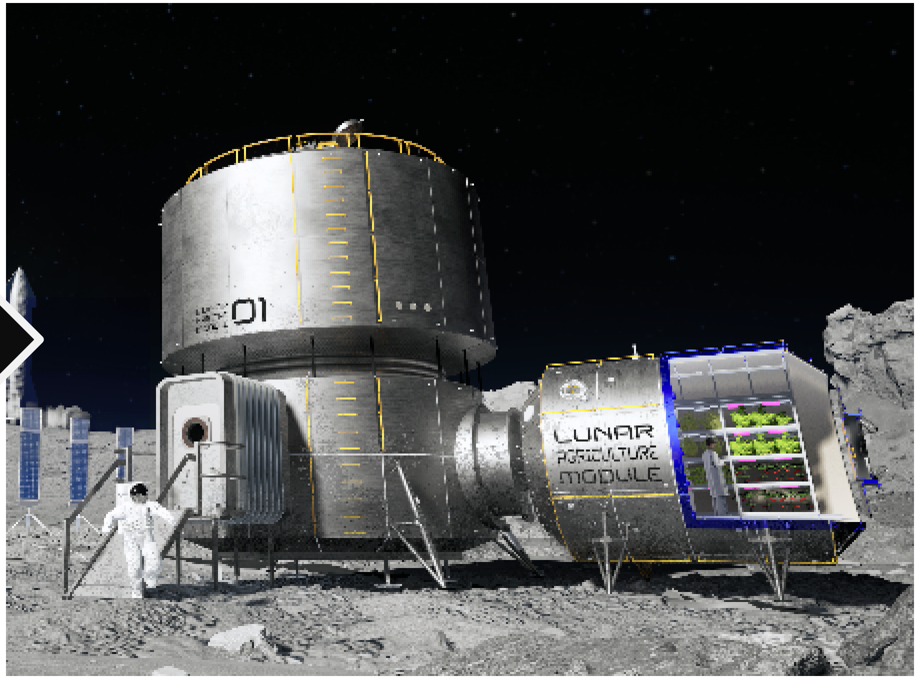
Ground Agriculture Module Render. Credit: DLR

The LAM-GTD will increase Technology Readiness Levels (TRL) of key greenhouse technologies required to generate fresh crops for crew consumption and simulate lunar operations in fully integrated platform

Research and Operations



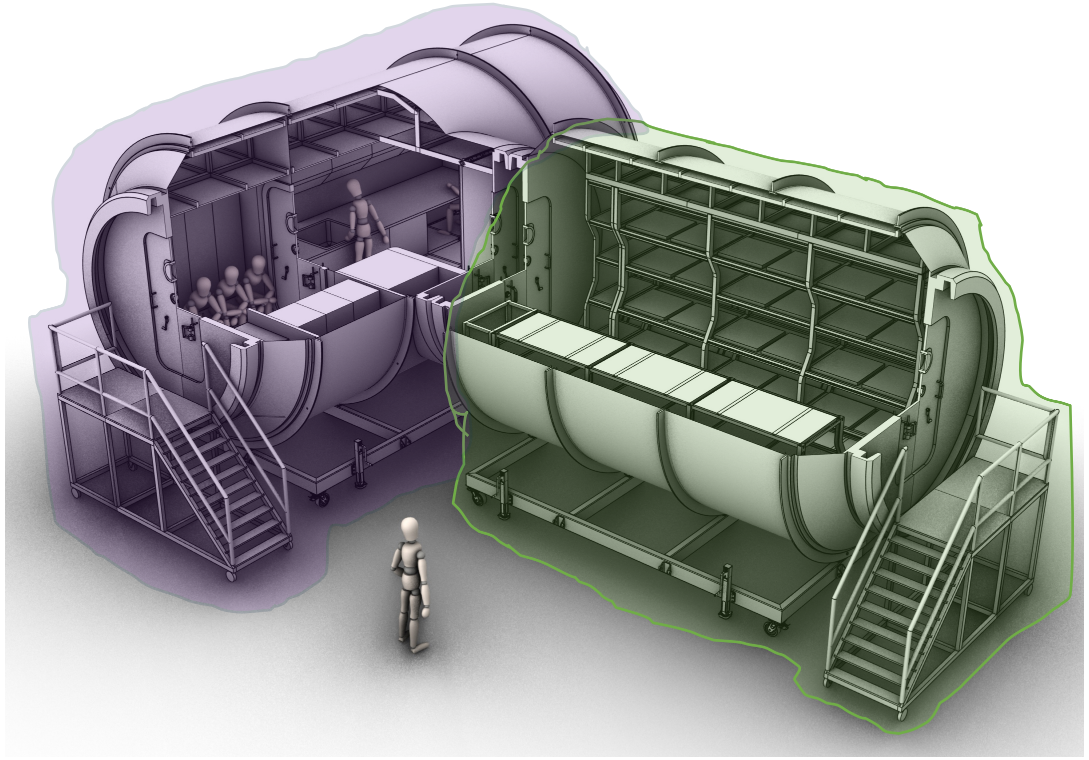
LAM-GTD Render. Credit: DLR



LAM Render. Credit: DLR

Campaigns planned for LAM-GTD will provide engineers and scientists with opportunity to further refine system design and operations concepts before applying lessons towards space-qualified Lunar Agriculture Module (LAM)

System Elements (4)

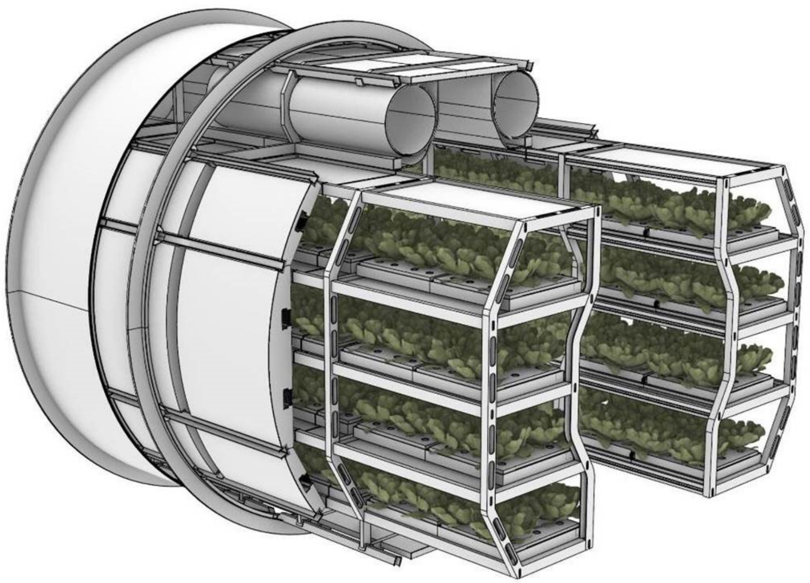


LAM-GTD Render. Credit: DLR

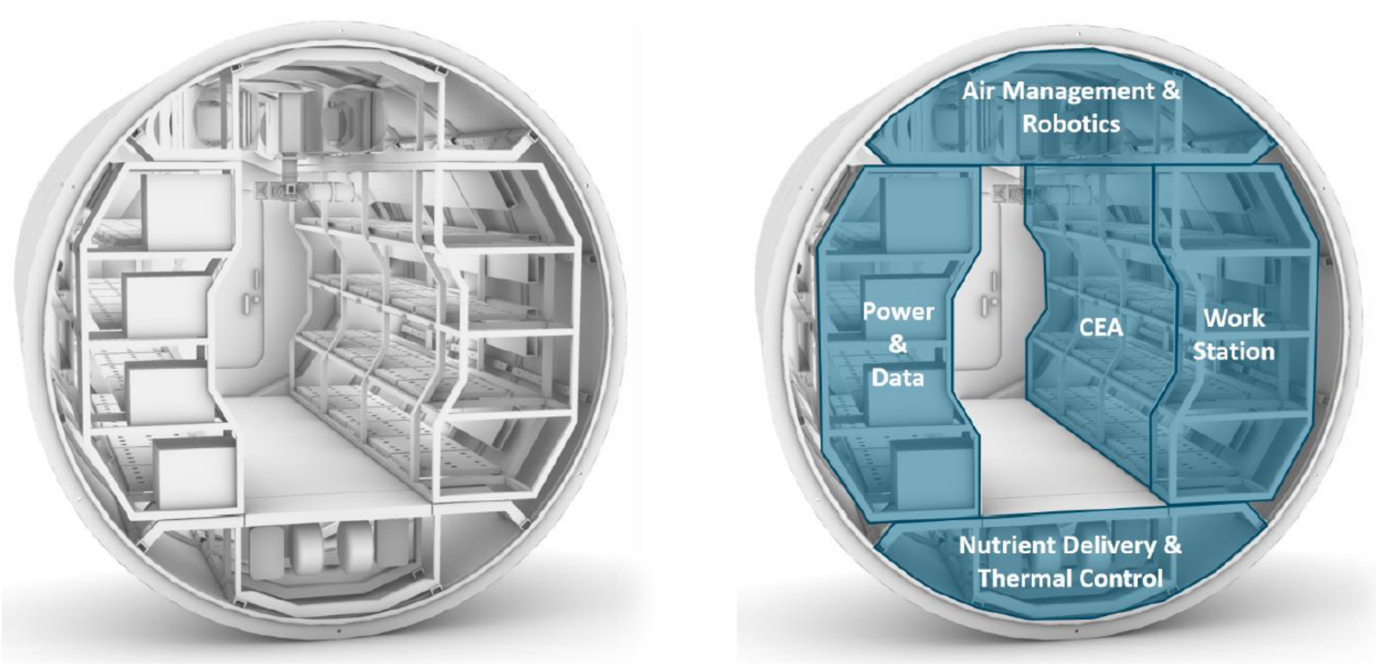
EDEN ISS Mission Control Center. Credit: DLR

Airlock Module, Ground Agriculture Module, Habitat Simulator, Mission Control Centre

Ground Agriculture Module



Ground Agriculture Module Render. Credit: DLR



Ground Agriculture Module Interior Render. Credit: DLR

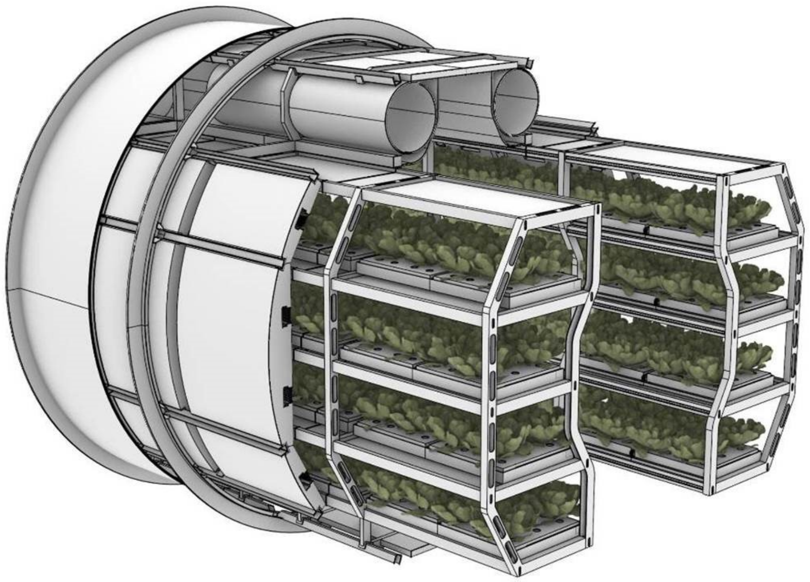
The GAM components must autonomously create, manage and maintain optimal environment for high-density, high-quality crop production.

International Contributions

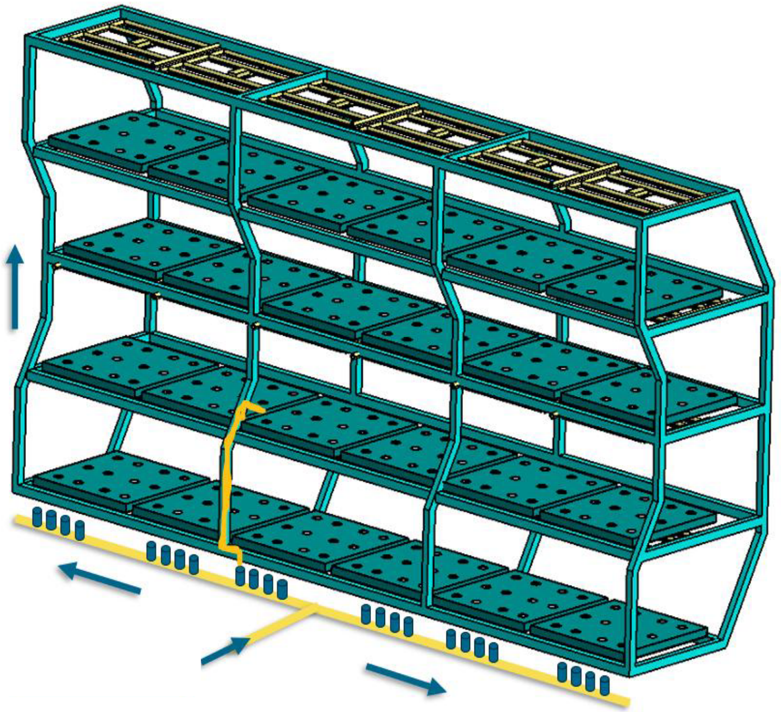
- Nutrient Delivery System,
- Light Control System,
- Plant Health Monitoring System, and
- Versatile Assistant Robotic Arm

- Design of Structure,
- Air Management System,
- Thermal Control System,
- Data Handling and Control System, and
- Electric Power System

Nutrient Delivery System (NDS)

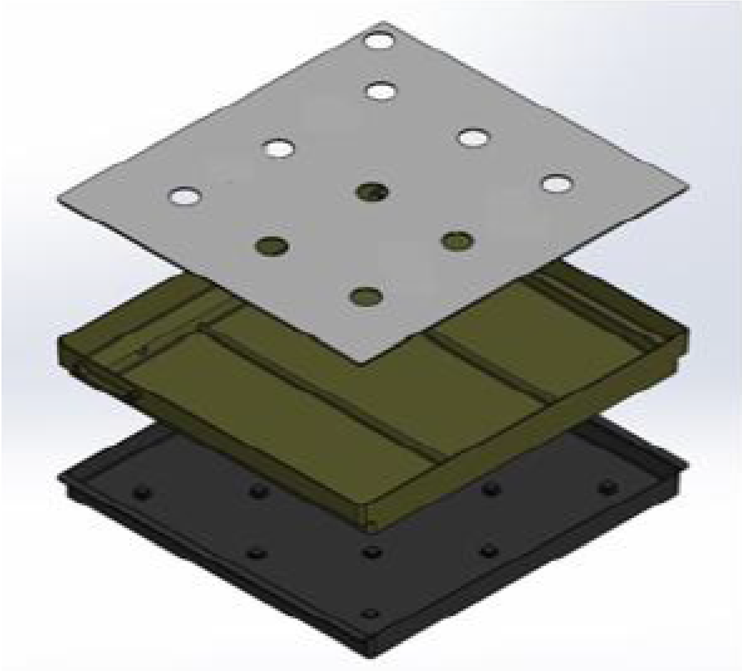


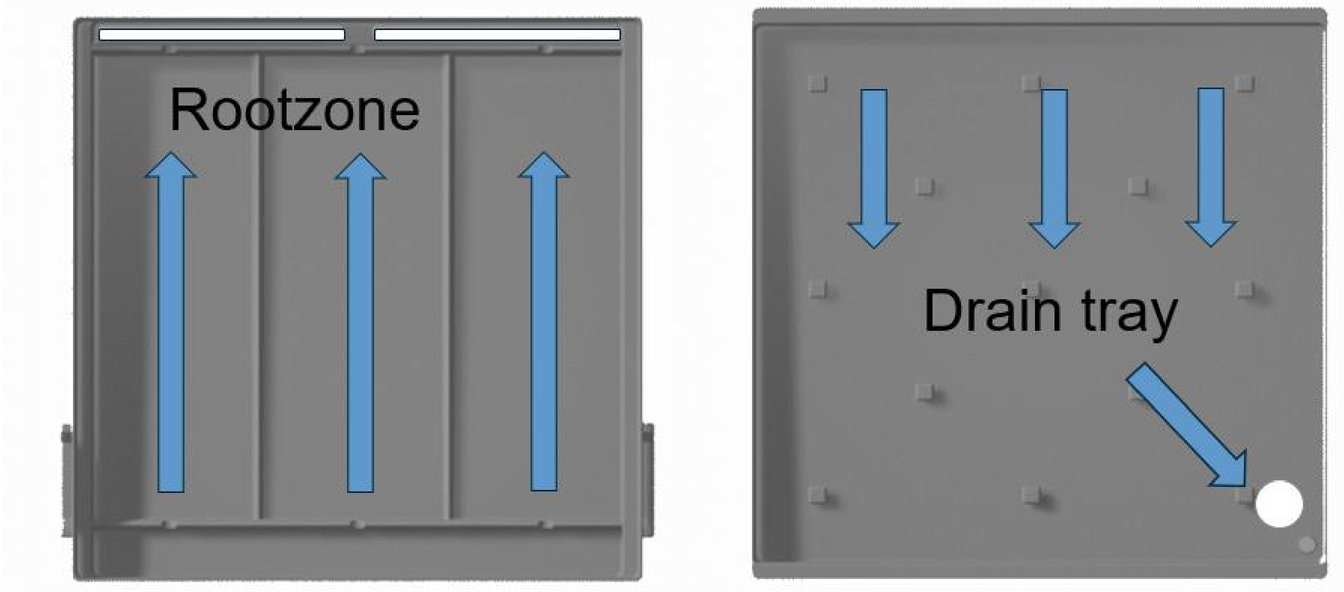
Ground Agriculture Module Render. Credit: DLR



The NDS components include plant growth trays, piping, bulk solution tanks (i.e., fresh, waste, solution, additives), mixing computer, pumps, and sensors. Designed to support up to 25 m^2 of crop production distributed amongst 48 trays

Nutrient Delivery System (NDS)



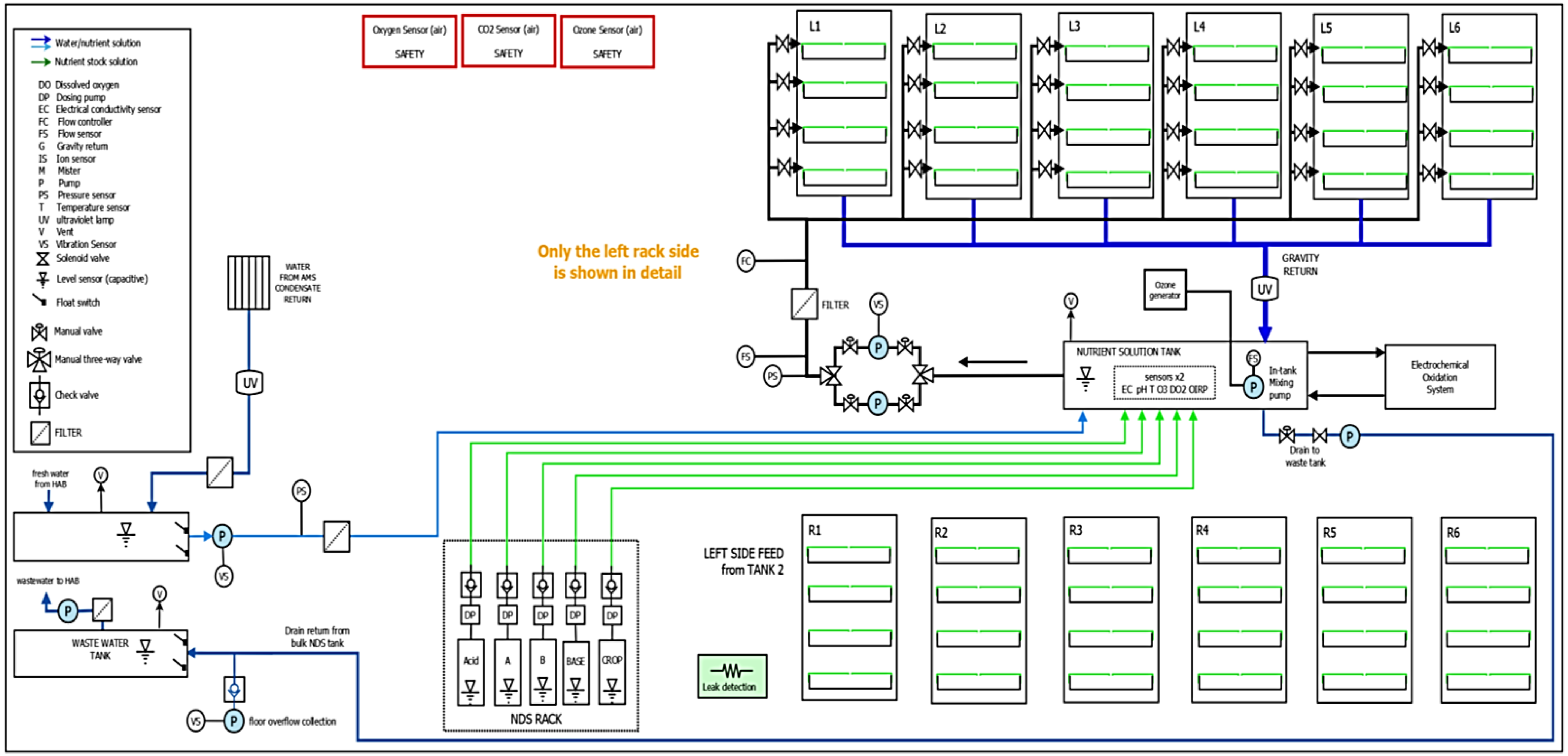


Tray Design. Credit: UofG

Standardized tray design with an interchangeable lid, root zone tray with several water channels, and a drip tray to collect nutrient solution and guide it back towards drain line. Trays designed to slide out to facilitate plant maintenance, harvesting, and cleaning of system.

Nutrient Delivery System (NDS)

UNIVERSITY of GUELPH



Other major components of NDS including tanks (a bulk nutrient solution tank, a wastewater tank, and a freshwater tank, acid, base and stock solution), mixing computer, sensors, and pumps designed to be located in the subfloor

Lighting Control System (LCS)

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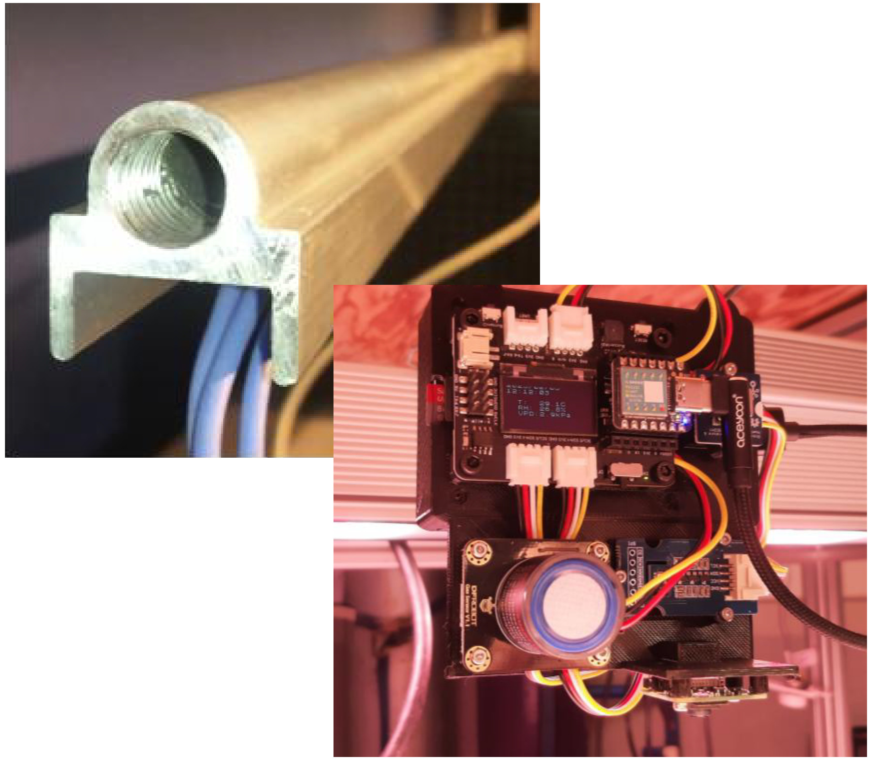
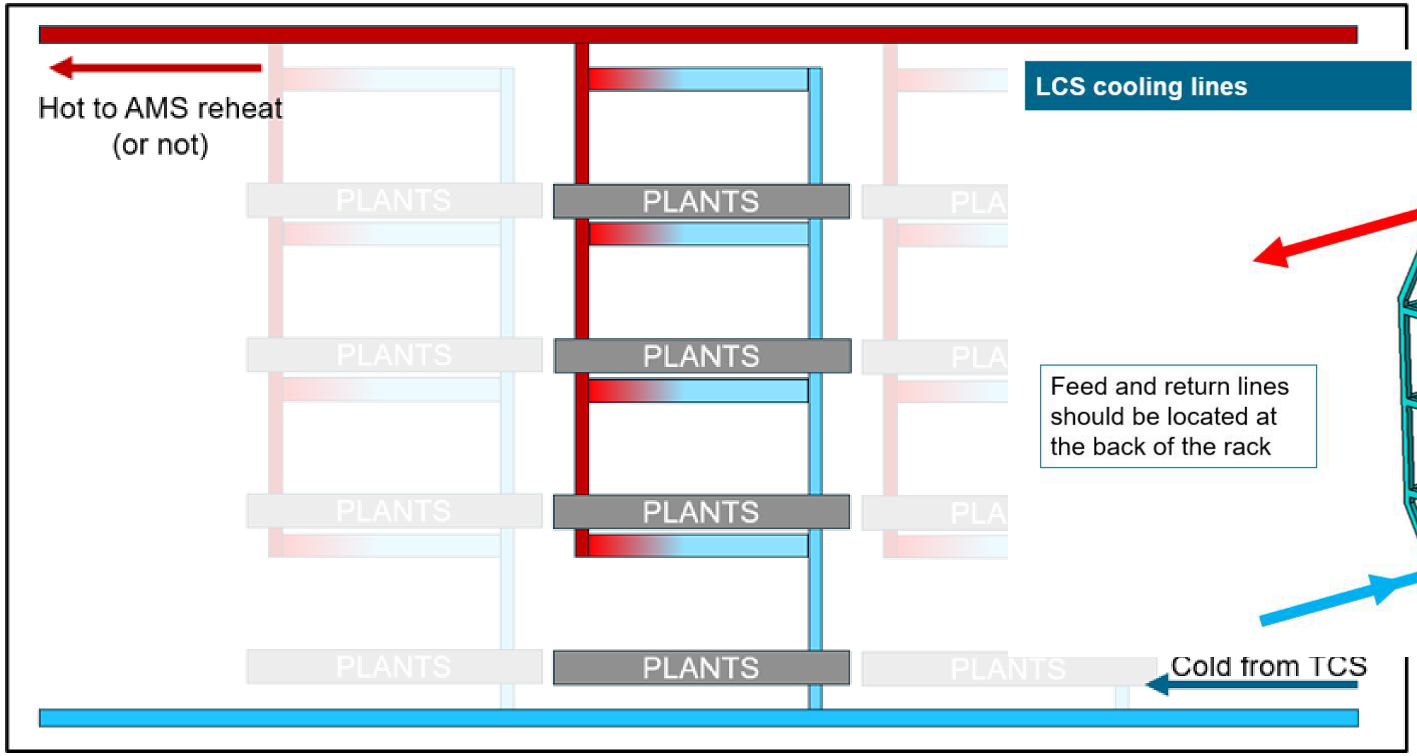
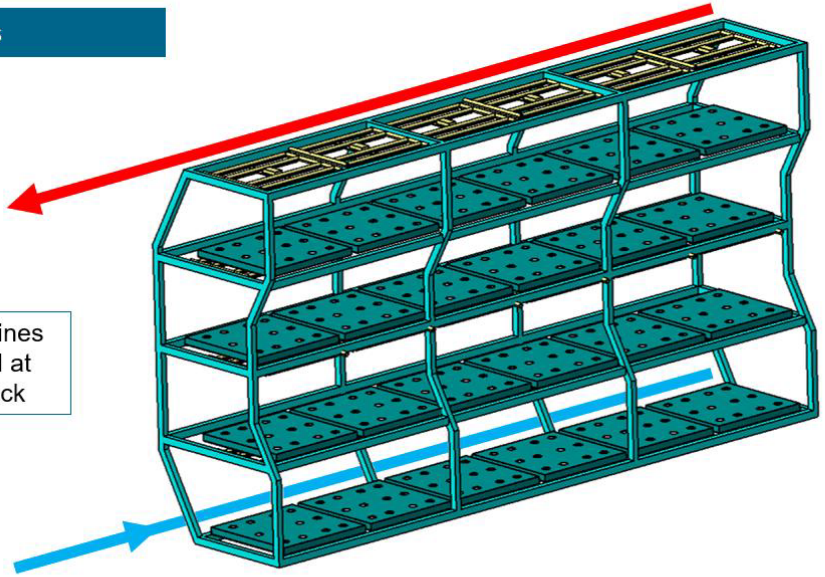


LED Array and Control Units. Credit: UofG

Each of 48 plant growth trays equipped with dedicated LED array capable of providing a consistent and evenly distributed light environment. Compact, low-profile, water-cooled LED array proposed to reduce mass, area, and volume, thus maximizing growth area

Lighting Control System (LCS)

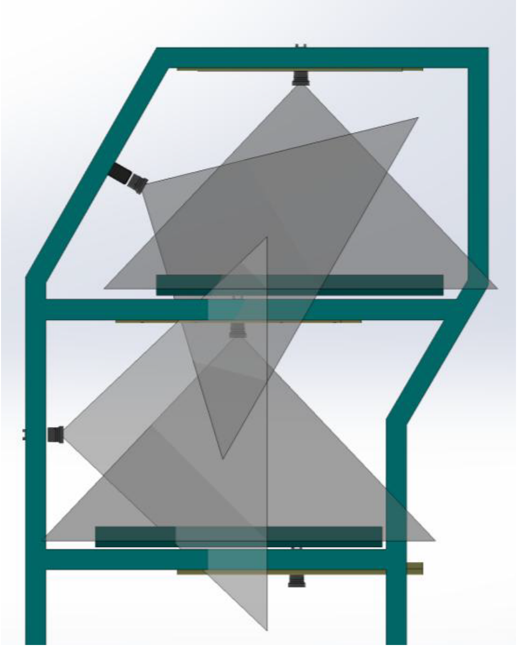


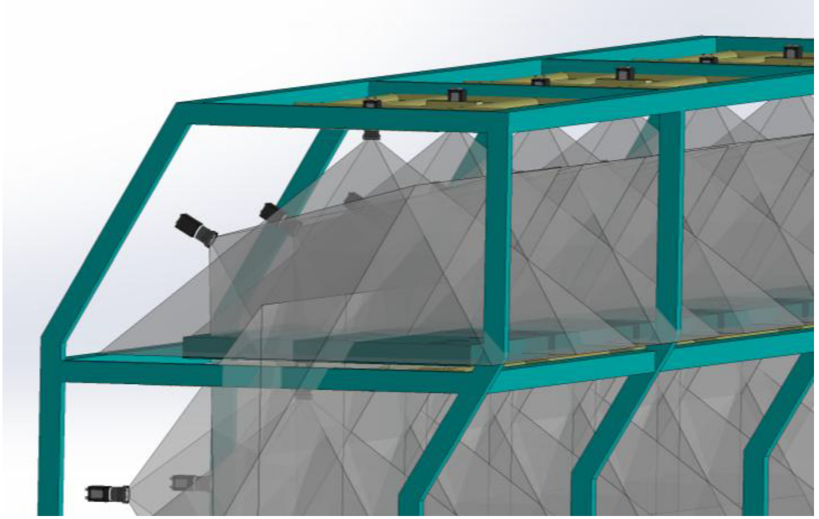


LED Array and Control Units. Credit: UofG

Integration of PHM sensors and fans directly into the LED array providing real-time feedback from the plants, enabling ongoing assessment of their health and productivity. Data processing, storage, and LED control inputs managed by the DHCS using wireless communication

Plant Health Monitoring (PHM)

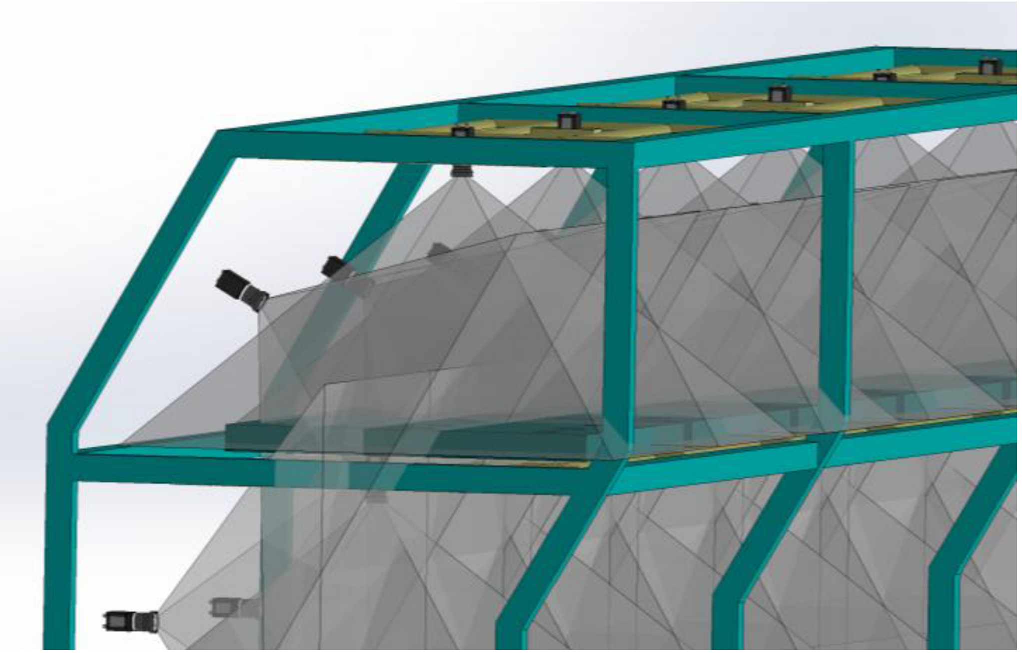




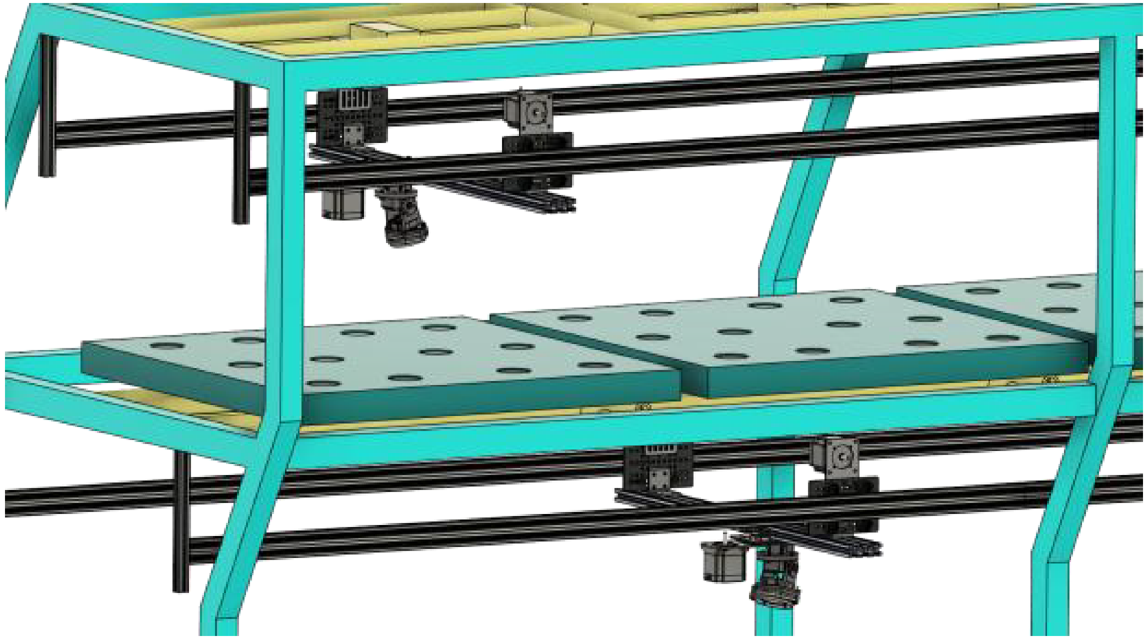
Plant Health Monitoring concept. Credit: McGill University

The GAM will implement an autonomous PHM system to facilitate real-time assessment of plant performance, alert the on-site operator to critical tasks, and enable remote observation by ground crew

Plant Health Monitoring (PHM)



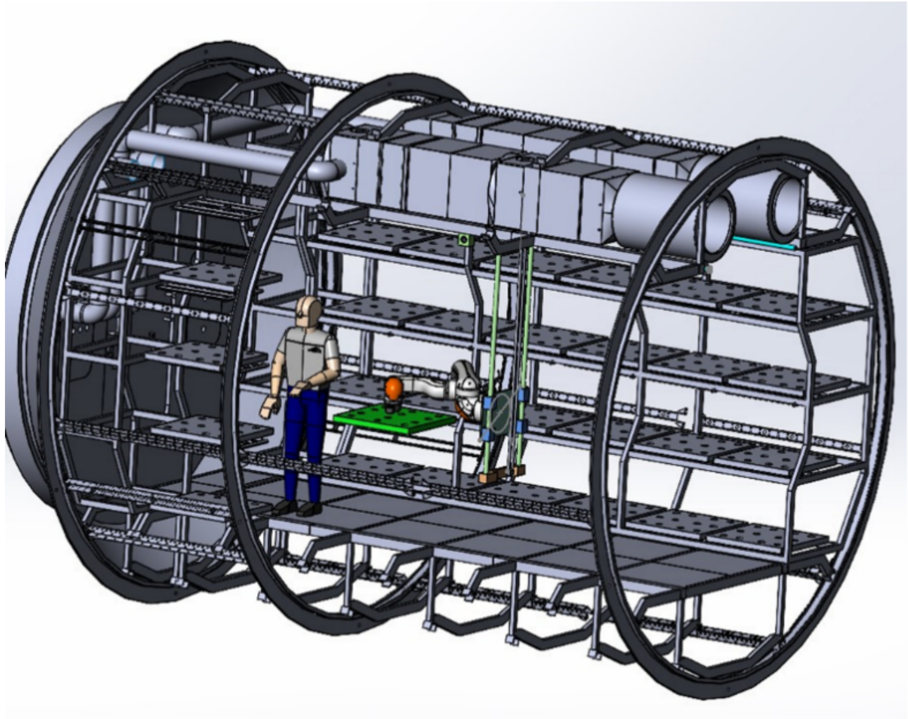
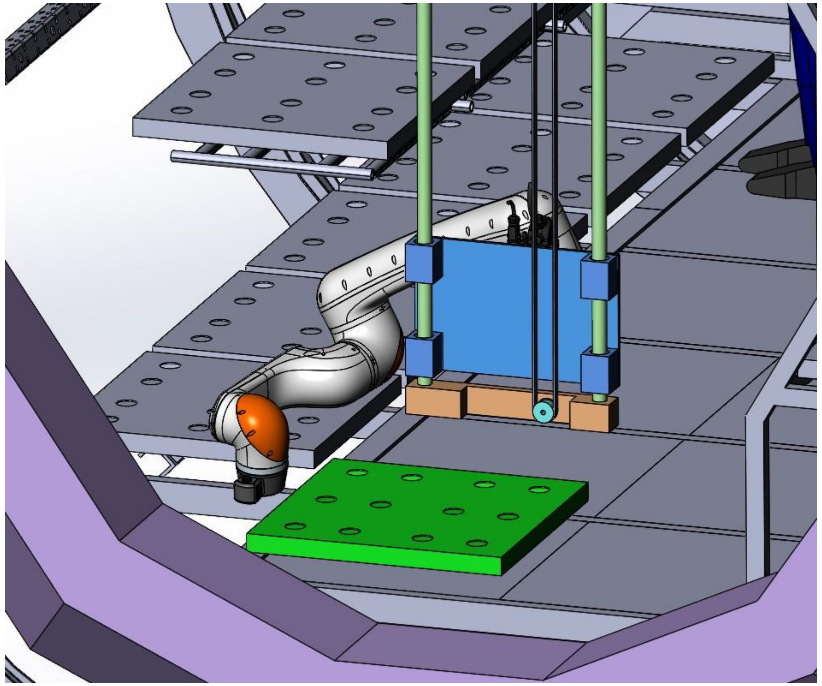
Plant Health Monitoring Fixed Option. Credit McGill University



Plant Health Monitoring Rail Option. Credit McGill University

Trade-off analysis is ongoing to determine the optimal camera modules and to evaluate whether fixed-position cameras or a rail-mounted system would be more suitable

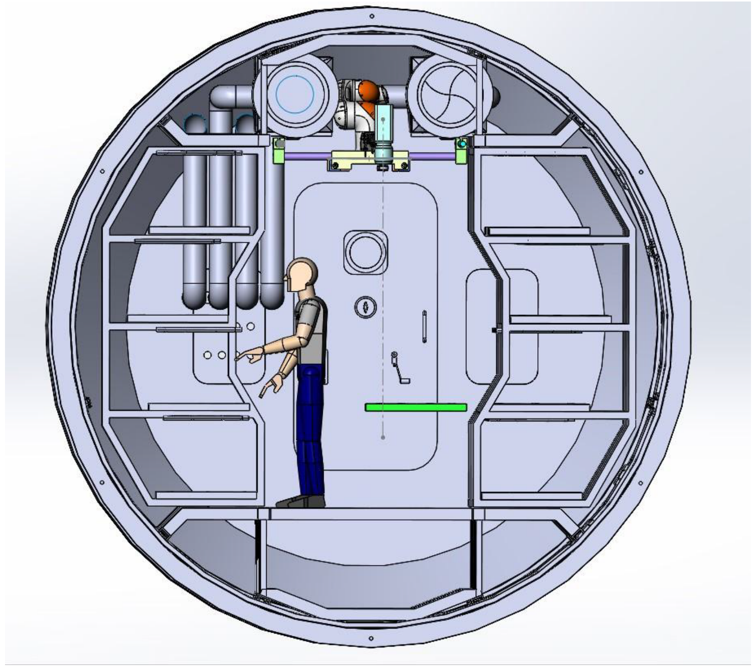
Versatile Assistant – Robotics

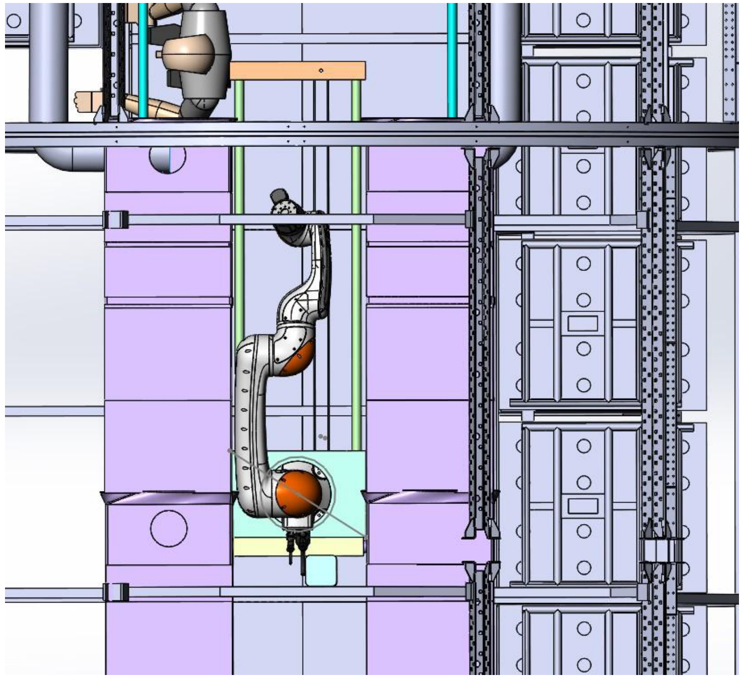



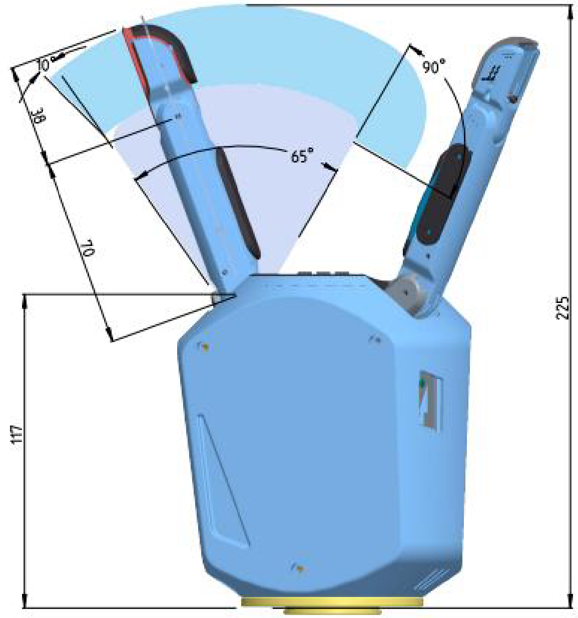

Versatile Assistant robotic arm potential configuration within the Ground Agriculture Module. Credit Canadensys

The GAM will require a VA to operate autonomously and assist with crop production. A Mobile robotic arm will be used to tend crops, remotely perform activities, and system related tasks

Versatile Assistant – Robotics







Versatile Assistant robotic arm potential configuration within the Ground Agriculture Module. Credit Canadensys, DLR

When not in operation, the VA will dock at a designated 'home base' in the ceiling section, which will include an integrated tool selector to exchange multiple end effectors for specialized horticultural management and system maintenance tasks

Conclusion

- LAM-GTD represents critical milestone towards advancing bioregenerative life support systems for lunar and Mars exploration
- Through collaborative efforts of CSA and DLR, work is making significant strides in design of key subsystems necessary
- GAM, along with ALM, HabSim, and MCC form integrated testing platform that would not only simulate lunar operations but also refine essential greenhouse technologies
- By focusing on system autonomy, sustainability and reliability, future bioregenerative life support systems will be capable of improving food security in the North

Thank you for your Attention

Image credits: DLR

Canadian Space Agency

Agence spatiale canadienne