Challenges and opportunities of the BLiSS campaign

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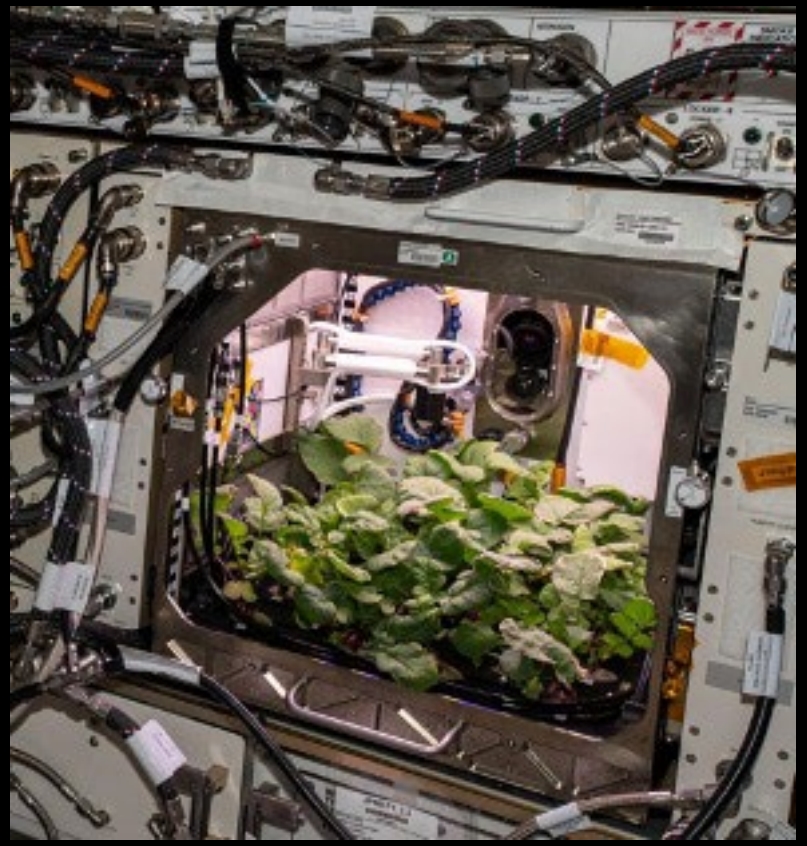
Bioregenerative Life Support Systems (BLiSS) Research Campaign 2025

Integration, a critical challenge for the BLiSS campaign

Biology wrapped in hardware obeying the laws of physics



Radishes growing in the Advanced Plant Habitat on board the ISS. Photo: NASA

Integrate Expertise

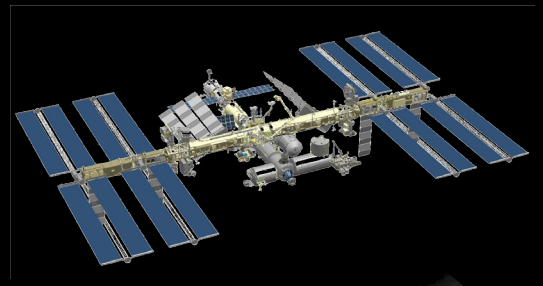
- Government, industry, academia
- Biologists, Engineers, Physicists, Operations

Integrate Systems

- Crew
- Plants
- Microbes
- Algae, fungi, insects...
- Hardware

BLiSS campaign

Use biological systems to make a meaningful contribution to life support



Current: Physico-Chemical- and resupply-based strategies

Near-term: Robust bioregenerative life support systems and enabling technologies to supplement existing capabilities

Long-Term: Extended autonomy and increased independence

*The crew on Mars will not be subsistence farmers

NASA ID: 200623_ISS_1
images-assets.nasa.gov/image/ /PIA04591/PIA04591~orig.jpg
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BLiSS is based on strong foundations

~20 m^2 of plants per crew member for O_2 supply, ~50 m^2 for calories

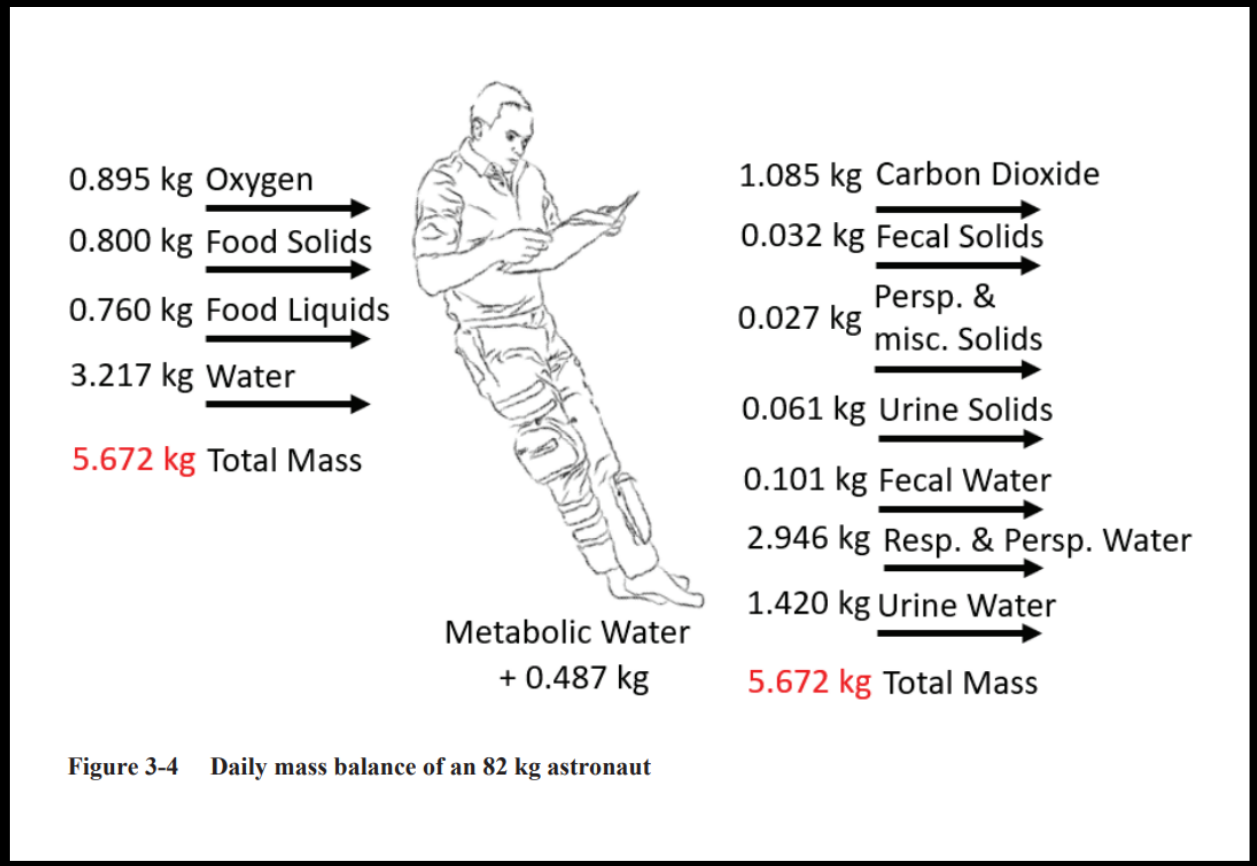
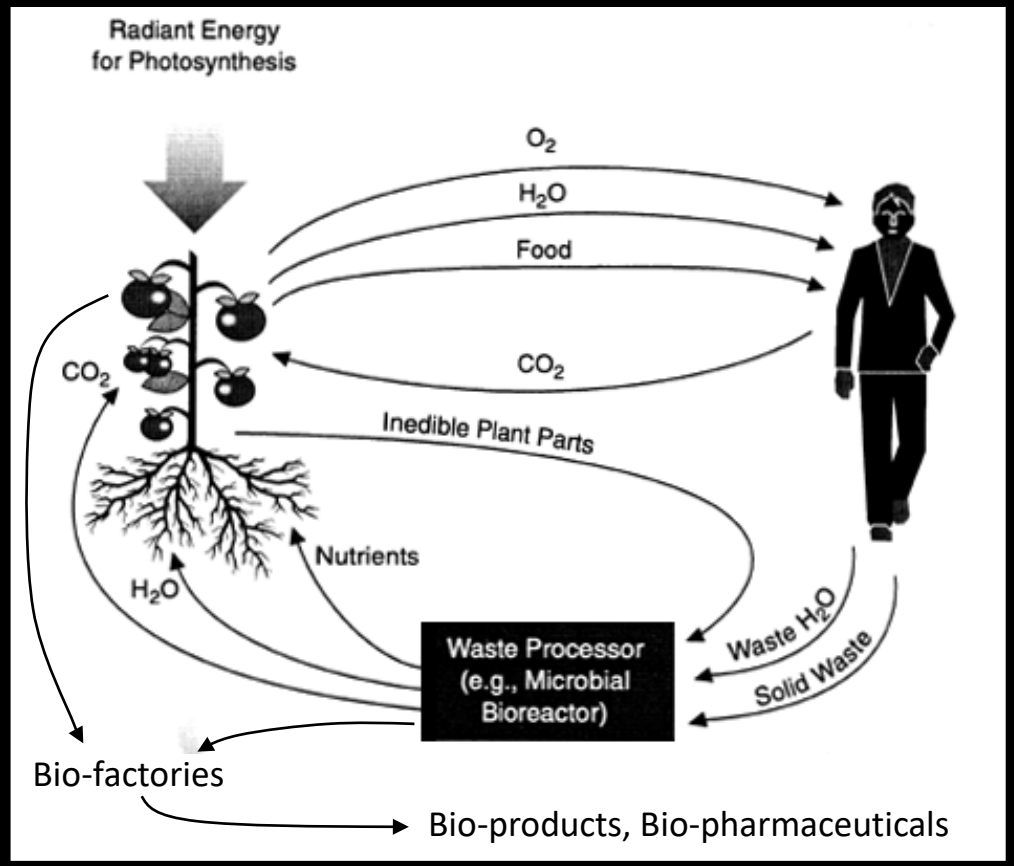


Figure 3-4 Daily mass balance of an 82 kg astronaut

Life Support Baseline Values and Assumptions Document
https://ntrs.nasa.gov/api/citations/20210024855/downloads/BVAD_2.15.22-final.pdf



Advanced Technology for Human Support in Space. National Academy Press:
https://doi.org/10.17226/5826.(1997)

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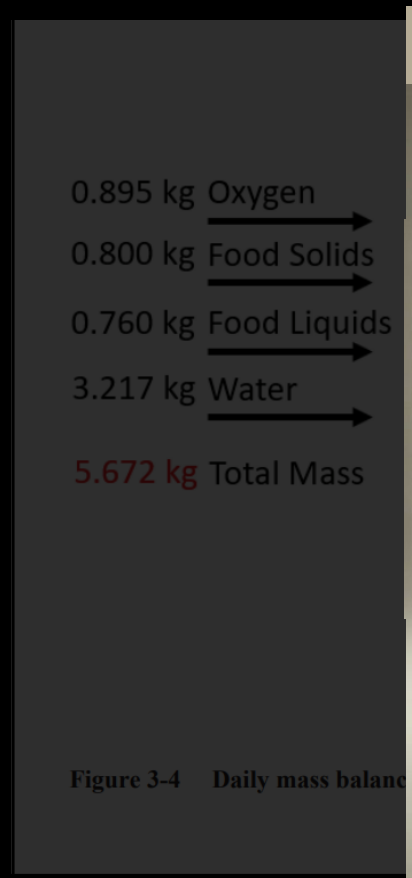
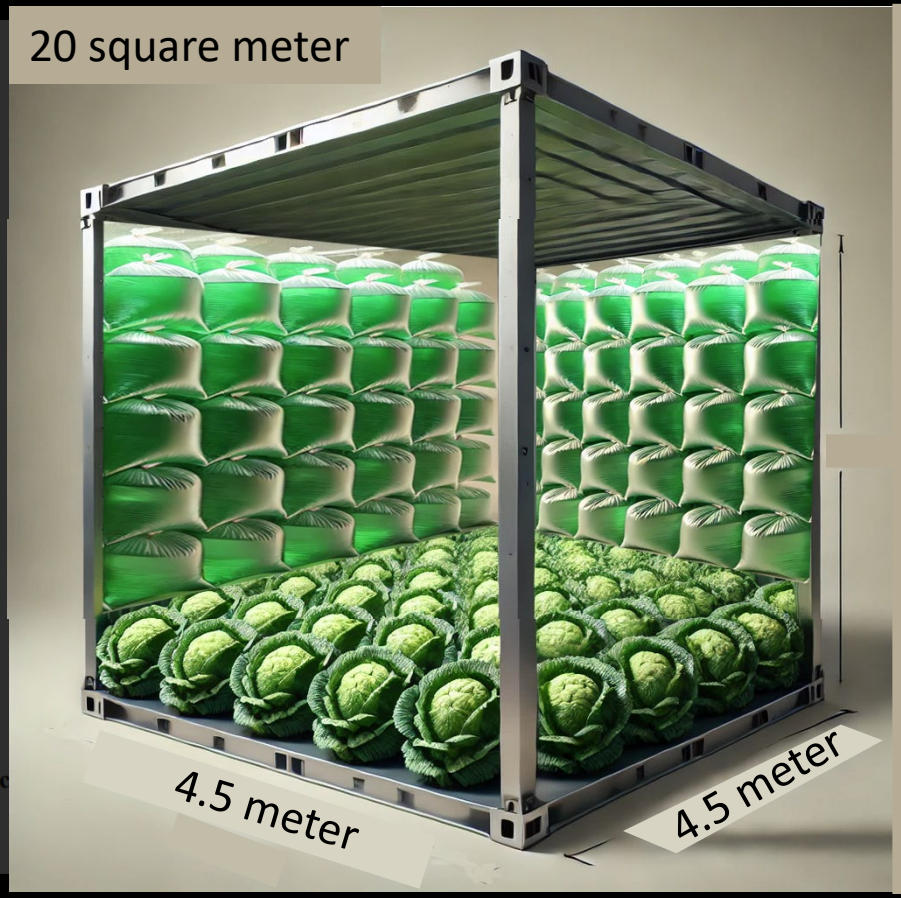
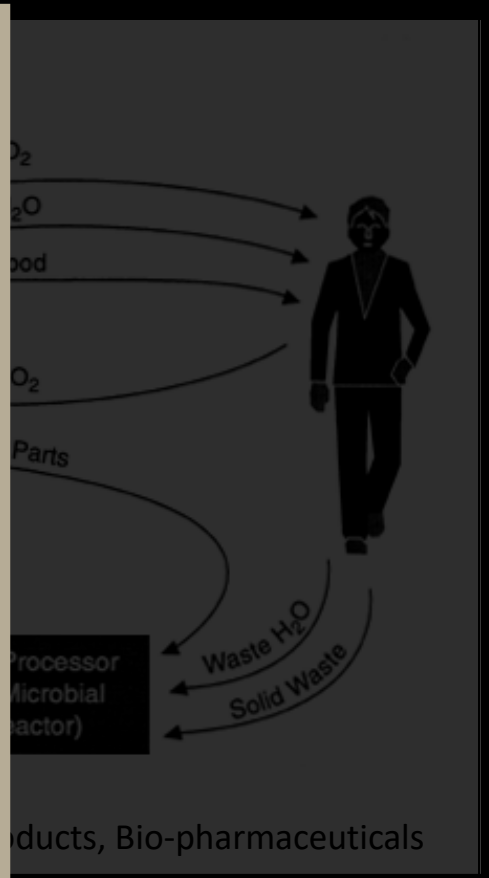




- Algal bioreactors
- Batch vs continuous production
- Thermal management
- Multiphase flow

Biology wrapped in hardware obeying the laws of physics



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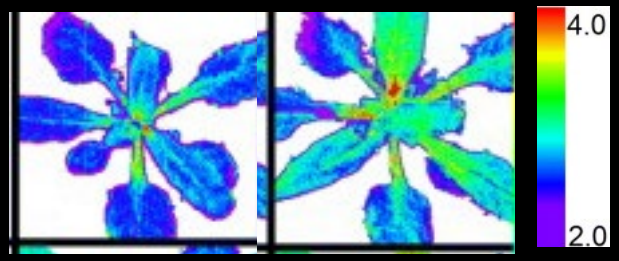
BLiSS campaign near-term enabling technologies

- Understanding the biological responses to spaceflight currently heavily relies on sample return and ground-based analyses
- Sample return become less feasible for missions beyond low earth orbit
- Remote sensing becomes a key enabling technology

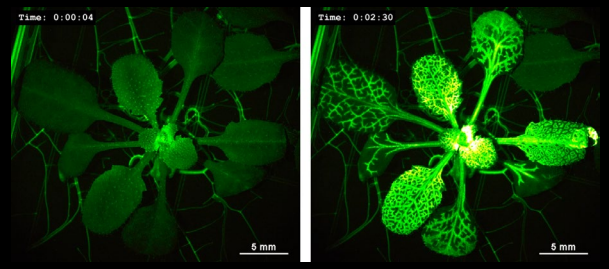
BLiSS campaign near-term enabling technologies

Natural Biomarkers
Hyperspectral imaging



Drought

Engineered Biomarkers
Bio-reporter Fluorescent Proteins



Defense

Both require
monitoring
Hardware
development

AI
Deep learning

Lin et al. (2019) Plant Methods. doi: 10.1186/s13007-019-0392-1
Toyota et al. (2018) Science. doi: 10.1126/science.aat7744

BLiSS campaign near-term enabling technologies

Veg-01 – Fusarium on Zinnia

Shuerger et al. (2021). doi: 10.1089/ast.2020.2399

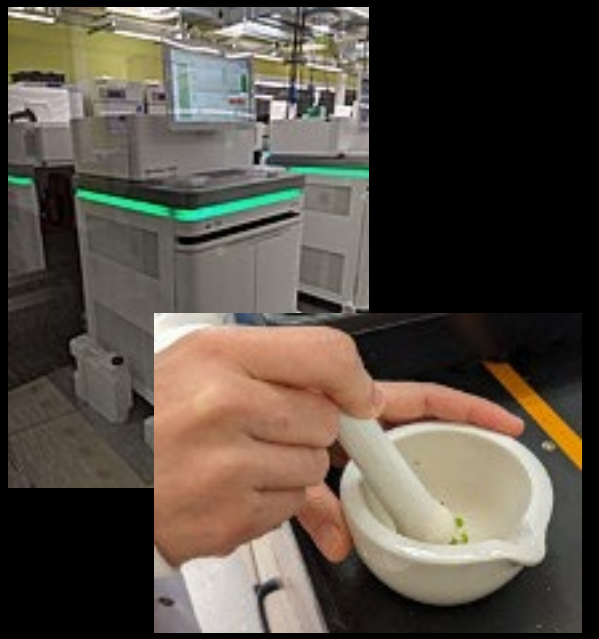
Modern biological research relies on omics-level analyses of DNA, RNA, Proteins, Lipids, Metabolites

- Fundamental understanding
- Monitoring/molecular fingerprinting

In situ analyses will require

- Development of flight compatible analytical equipment
- Development of sample processing

Significant potential for Earth benefits



Meeting the challenge of integration

Biomass Production Chamber
NASA 1980s

Practical

A dedicated testbed focused on BLiSS: multi-user, systems validation and interaction

As solutions and technologies developed in isolation mature, integration becomes a key goal

- Define Interoperability and interdependencies
- Scale can dramatically change system stability
- Understand system management

Meeting the challenge of integration

Biomass Production Chamber
NASA 1980s

1. Establish near- and long-term goals with milestones

Examples of near-term

- Watering systems
- Beneficial microbial communities
- Remote sensing technologies

Examples ‘immediate’ long-term

- Microbial population stability
- Seed longevity

Meeting the challenge of integration

Biomass Production Chamber
NASA 1980s

2. Establish integrated teams to explore Biological- and Engineering-based solutions

Implementation will require inputs from many experts

- Government, industry, academia
- Biologists, Engineers, Physicists, Operations

3. Establish a ‘general contractor’ for BLiSS
Requires leads who are also interpreters


Thank you