BioNutrients-1 (BN-1) Payload Overview

POIWG #44

Oct 23-25, 2018

Kevin Sims

Ames Research Center (ARC)

Approved for public release, unlimited distribution

Thank you!

NASA SILICON VALLEY

AMES RESEARCH CENTER

BioNutrients-1 Experiment Summary

Principal Investigators	John Hogan, Ph.D. NASA Ames Research Center
Sponsor	Technology and Science Research Office
Funding Authority	NASA / Human Exploration & Operations / Advanced Exploration Systems (AES)
Experiment Duration	Five years
Ground Control	Near-synchronous Ground Control performed at PI Laboratory at Ames
Research Objectives	The goal of the BioNutrients experiment is to determine the effect of long-duration, low-Earth-orbit stowage on the ability to biologically generate nutrients through organism activation and growth.

BioNutrients Key Stakeholders

- **PI** – The Principal Investigator of the BioNutrients Project, Dr. John Hogan at NASA Ames Research Center
- **AES** – The Advanced Exploration Systems Office at NASA Headquarters
- **HRP** – The Human Research Program Office at NASA Johnson Space Center
- **ISS** – The ISS Payload Program at NASA Johnson Space Center
- **Code SC** – The Space Biosciences Division at NASA Ames Research Center
- **Code SCF** – The Flight Systems Implementation Branch at NASA Ames Research Center
- **Code SCB** – The Bioengineering Branch at NASA Ames Research Center
- **ARC OCE** – The Office of the Chief Engineer at NASA Ames Research Center

Need and Goals

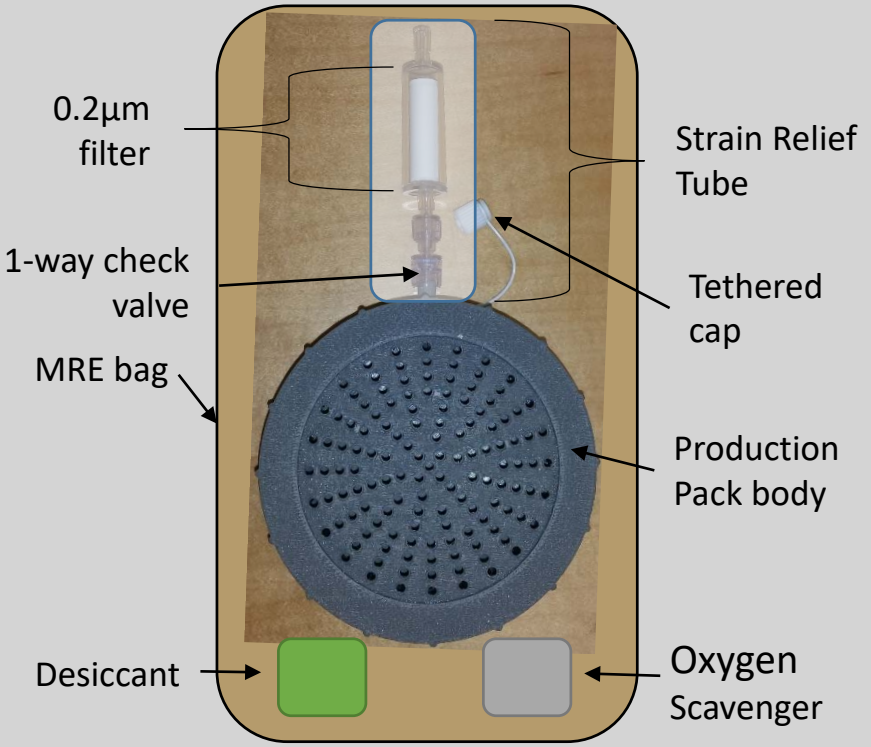
Need: To enable rapid, safe and reliable in situ production of needed dietary nutrients using minimal mass, power and volume for long duration missions.

Goals:

1. Evaluate system for maintaining shelf-life of contents and enabling organism growth and nutrient production on ISS
2. Demonstrate long-term in-situ nutrient production on ISS
3. Collect ISS-based data on long-term viability of candidate future experiment organisms

Hardware Overview

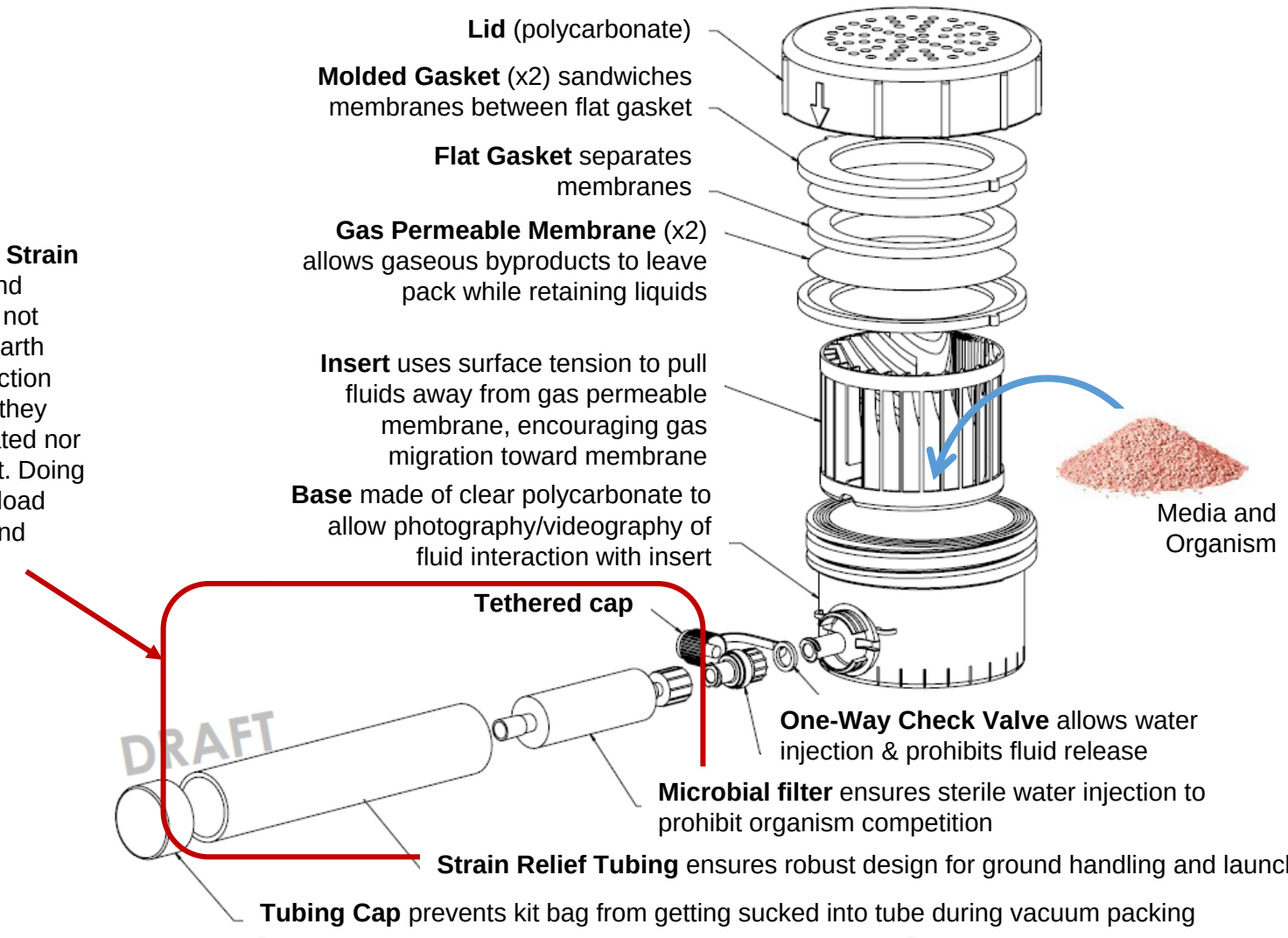
- **Production Packs**
  - **ISS Activation Production Packs** Activated on-orbit. 14 runs over 5 years. 4 packs/run.
  - **Earth Activation Production Packs** *Flown controls.* Activated on Earth after exposure to ISS. 13 returns over 5 years. 4 samples/return.



- **Stasis Packs** – Matrix of various sample types to study changes in organisms and media after exposure to ISS. Candidate samples for future BioNutrients payloads. 13 returns from ISS over 5 years, at specific intervals.

Exploded View of Production Pack

Microbial Filter, **Strain Relief Tubing** and **Tubing Cap** are not included in the Earth Activation Production Packs, because they are not manipulated nor hydrated on-orbit. Doing this reduces payload launch volume and mass.



BioNutrients-1 Experiment Schedule

SpX-17

Ascent (soft stow)
All BioNutrients-1 hardware

Descent (soft stow)
8 **Earth** Production Pack Kits (110532-001)
- 4 Blue
- 4 Purple

4 **Stasis** Pack (110534-001)
- 2 Stasis Pack A
- 2 Stasis Pack B

Post-SpX-17 Unberth

On-Orbit: 8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Single SABL residence event (30C) @ U+7 to 9d (4±d)

On Ground:
- 8 **Earth** Production Packs (Blue/Purple)
- 16 **Ground Controls** (not flown)

SpX-18 Descent

Cold Stow:
8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Soft Stow:
2 **Stasis** Packs (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

SpX-19 Descent (tentative; depends on SpX launch schedule)

Descent (soft stow)
8 **Earth** Production Pack Kits (110532-001)
- 4 Blue
- 4 Purple

2 **Stasis** Pack (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

Post-SpX-19 Unberth

On-Orbit: 8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Single SABL residence event (30C) @ U+7 to 9d (4±d)

On Ground:
- 8 **Earth** Production Packs (Blue/Purple)
- 16 **Ground Controls** (not flown)

SpX-20 Descent

Cold Stow:
8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Soft Stow:
2 **Stasis** Packs (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

SpX-21 Descent (tentative; depends on SpX launch schedule)

Descent (soft stow)
8 **Earth** Production Pack Kits (110532-001)
- 4 Blue
- 4 Purple

2 **Stasis** Pack (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

Post-SpX-21 Unberth

On-Orbit: 8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Single SABL residence event (30C) @ U+7 to 9d (4±d)

On Ground:
- 8 **Earth** Production Packs (Blue/Purple)
- 16 **Ground Controls** (not flown)

SpX-22 Descent

Cold Stow:
8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Soft Stow:
2 **Stasis** Packs (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

BioNutrients-1 Experiment Schedule

SpX-23 Descent (tentative; depends on SpX launch schedule)

Descent (soft stow)
8 **Earth** Production Pack Kits (110532-001)
- 4 Blue
- 4 Purple

2 **Stasis** Pack (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

Post-SpX-23 Unberth

On-Orbit: 8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Single SABL residence event (30C) @ U+7 to 9d (4±d)

On Ground:
- 8 **Earth** Production Packs (Blue/Purple)
- 16 **Ground Controls** (not flown)

SpX-24 Descent

Cold Stow:
8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Soft Stow:
2 **Stasis** Packs (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

SpX-25 Descent (tentative; depends on SpX launch schedule)

Descent (soft stow)
8 **Earth** Production Pack Kits (110532-001)
- 4 Blue
- 4 Purple

2 **Stasis** Pack (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

Post-SpX-25 Unberth

On-Orbit: 8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Single SABL residence event (30C) @ U+7 to 9d (4±d)

On Ground:
- 8 **Earth** Production Packs (Blue/Purple)
- 16 **Ground Controls** (not flown)

SpX-26 Descent

Cold Stow:
8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Soft Stow:
2 **Stasis** Packs (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

SpX-27 Descent (tentative; depends on SpX launch schedule)

Descent (soft stow)
8 **Earth** Production Pack Kits (110532-001)
- 4 Blue
- 4 Purple

2 **Stasis** Pack (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

Post-SpX-27 Unberth

On-Orbit: 8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Single SABL residence event (30C) @ U+7 to 9d (4±d)

On Ground:
- 8 **Earth** Production Packs (Blue/Purple)
- 16 **Ground Controls** (not flown)

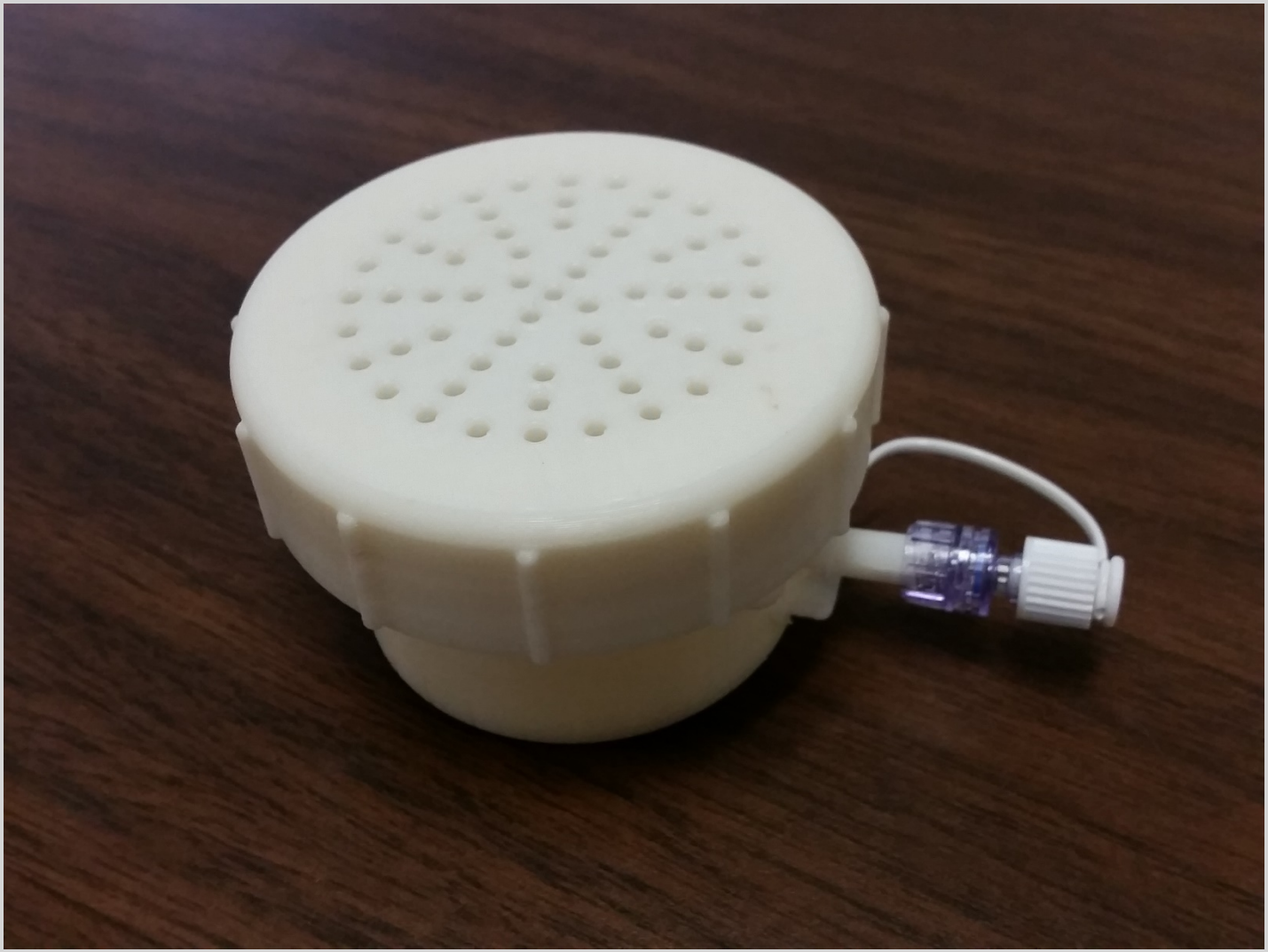
SpX-28 Descent

Cold Stow:
8 **ISS** Production Packs (110554-002)
- 4 Blue
- 4 Purple

Soft Stow:
2 **Stasis** Packs (110534-001)
- 1 Stasis Pack A
- 1 Stasis Pack B

Production Pack Assembly

Configuration Inside SABL



Stasis Pack Kits

Contents, Quantities & Return Timetable

Contents & Number of Vials	1M	4M	8M	12M	16M	20M	24M	30M	36M	42M	48M	54M	60M	Spare	Total
S. Boulardii CAHS +Beta-carotene - dessicated (x4)	1	1	1	1	1	1	1	1	1	1	1	1	1	2	15
S. Boulardii WT -dessicated (x4)															
S. Boulardii CAHS +Beta-carotene +trehalose +Skim milk +MSG (x4)															
Y55 spore +encapsulation (x4)															
Y55 WT spore (x4)															
Bacillus subtilis WT (x4)															
Bacillus subtilis Del-SkfA (x4)															
Media only (x4)															

Return events 1-13 for Stasis Samples

A duplicate of the above set of hardware will be built in-parallel with the to-be-flown hardware, for execution of near-synchronous ground controls.

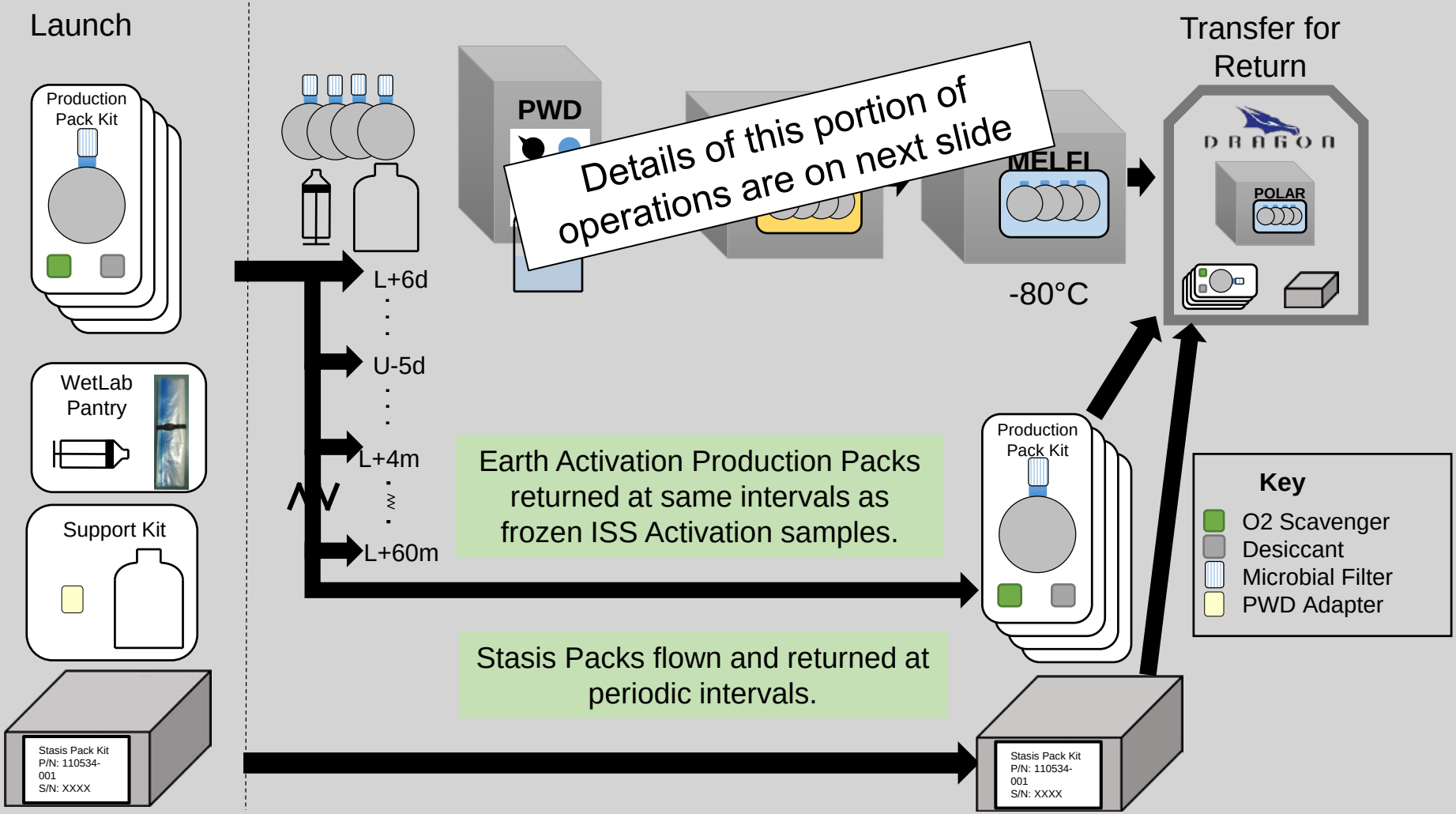
Concept of Operations

Assumptions and Constraints

Assumptions & constraints bound complexity, schedule, and cost, while enabling features needed for quality science:

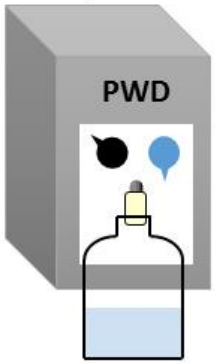
- Pre-flight sample and hardware prep occurs at ARC.
- All hardware launched in single launch event.
- Payload launched soft-stowed at ambient temperature.
- Payload launched to ISS in the SpaceX Dragon spacecraft or comparable vehicle
- ISS Activation Samples return in ≤-70°C cold stowage. Earth Activation Samples and Stasis Samples return at ambient temperature.
- Payload returned from ISS in SpaceX Dragon spacecraft.
- Samples are early de-stow items.
- Earth-bound, near-synchronous ground control is conducted by the PI.

Overview of On-Orbit Operations for All Samples



ISS Activation Sample On-Orbit Experiment

Water Dispense



Draw 1L into bag using PWD adapter and 1L bag provided by JSC EHS group and launched by BioNutrients-1 payload

Water Draw

Use syringe to draw ~50mL water from bag

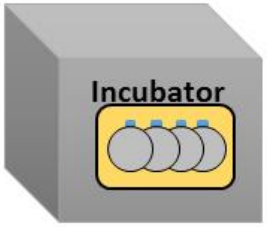
Hydration

Use syringe to inject ~50mL water into production pack. Trash microbial filter.

Agitation #1

Repeat 8x per run

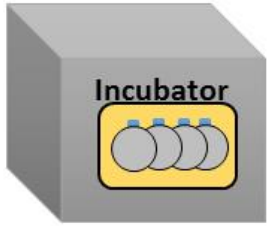
Incubation



~6hrs @ specimen-specific temperature (~24C, 30C, or 37C)

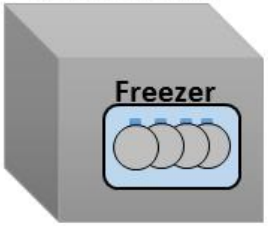
Agitation #2

Incubation



~42hrs @ specimen-specific temp

Preservation

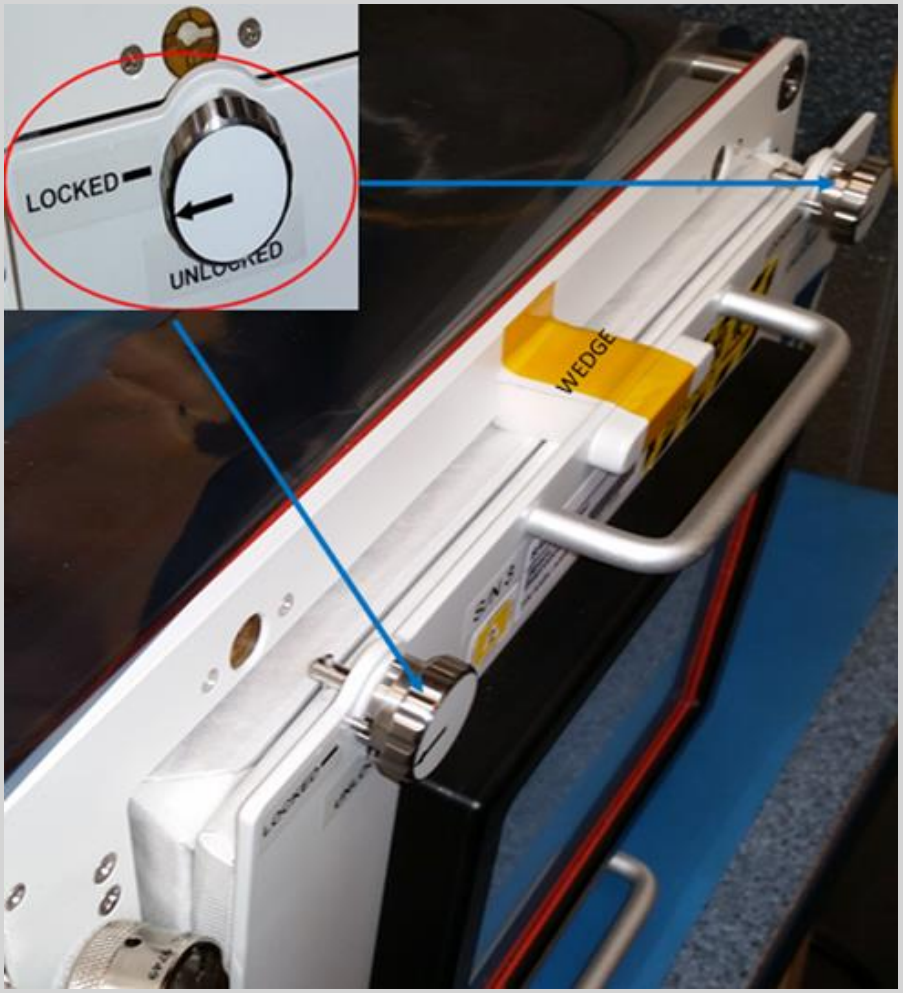


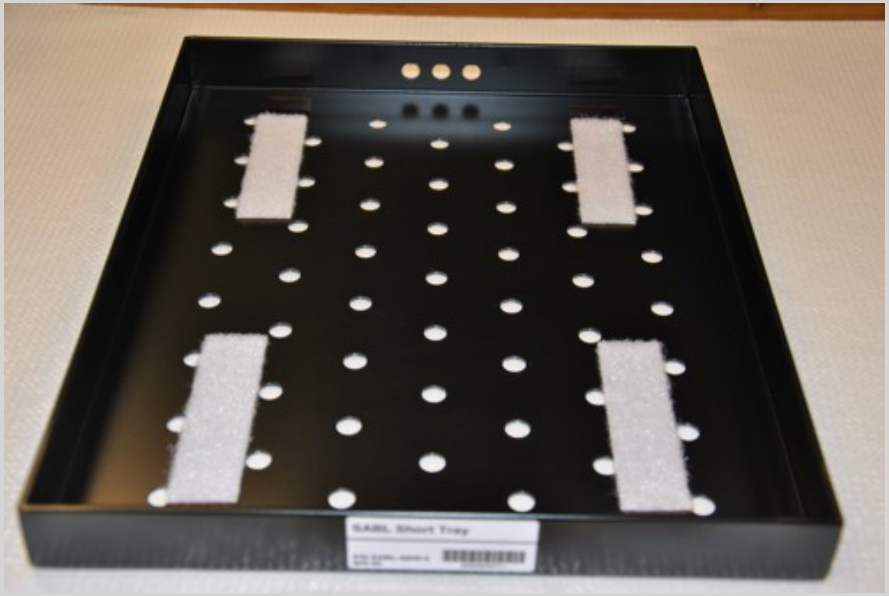
-80°C

Use bitran bag to contain production pack prior to insertion into MELFI.

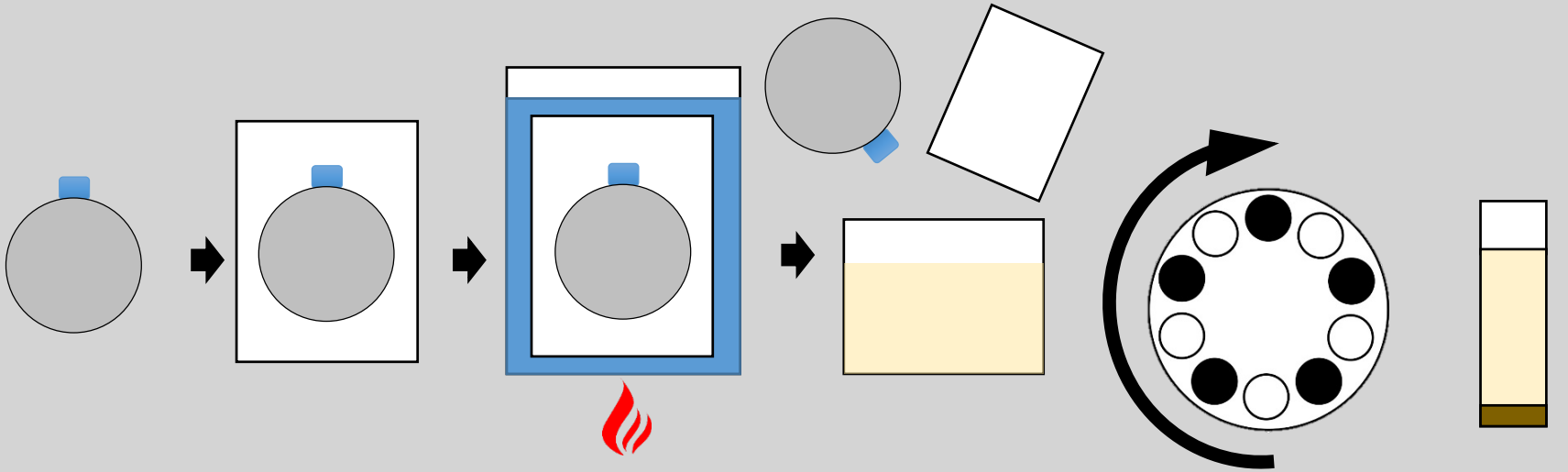
Syringe for hydration and bitran bag for freezer containment obtained from Wetlab Pantry

SABL





Post-Flight Sample Processing



1. Delivery
2. Protection
3. Thaw
4. Empty and Wash
5. Centrifuge
6. Analyze

Payload Safety Package Overview and Status

Phase III Safety Review

- Phase III Safety Review held on September 26, 2018
- All hazard reports were approved with minor editorial modifications and some standard open work.
- One Non-Compliance Report (NCR) was approved with modification as Equivalent Safety
  - NCR addresses temporary lack of fault tolerance regarding containment of the Tox 1 oxygen scavenger
  - The Equivalent Safety designation allows the NCR to be approved by the ISS Safety Review Panel and it will not require approval by the ISS Program

Unique Hazard Reports

- Release of Toxicity Hazard Level 1 Material
  - BN1-001, Critical severity
  - The Oxygen Scavenger has been identified as Toxicity Hazard Level 1 as a potential eye and respiratory irritant
  - Hazard report shows the required two levels of containment (COTS sachet, Kit bag) for almost all operations
  - NCR addresses temporary loss of failure tolerant containment when the Kit bag is opened to retrieve the Production Pack
- Release of Ethanol
  - BN1-002, Critical severity
  - The amount of ethanol produced in the Production Packs each run is considered an ECLSS Level 6 hazard
  - Hazard report shows the required two levels of containment (at least two membranes or seals for any potential release path) at all times following activation

Stowage Overview: SpX-17

Ascent

Soft Stowage

- ISS Activation Production Pack Kit (x40)
  - Each Kit contains two Production Packs, for a total of 80 ISS Activation Production Packs
- Earth Activation Production Pack Kit (x56)
  - Each Kit contains one Production Pack
- Stasis Pack Kit (x15)
  - Each Kit contains 32 sample vials (see slide 9)
- Support Kit (x14)
  - Contains PWD Adapter and Water Bag
  - One Support Kit used to hydrate one set of four ISS Activation Production Packs
  - Trashed onboard after use

Return

Cold Stowage

- ISS Activation Production Pack (x8)
  - -70°C or colder
  - First two sets (L+6d and L+25d)
  - Each Production Pack will be individually bagged in a Bitran bag
  - Early retrieval at Long Beach

Soft Stowage

- Earth Activation Production Pack (x8)
  - First two sets (different organisms)
  - Early retrieval at Long Beach
- Stasis Pack Kit (x1)
  - Return event #1
  - Early retrieval at Long Beach

Stowage Overview: Return on SpX-18 and Subsequent

Cold Stowage

- ISS Activation Production Pack (x4)
  - -70°C or colder
  - Depending on vehicle traffic, may be multiple sets on one vehicle
  - Each Production Pack will be individually bagged in a Ziploc bag
  - Early retrieval at Long Beach

Soft Stowage

- Earth Activation Production Pack (x4)
  - Depending on vehicle traffic, may be multiple sets on one vehicle
  - Early retrieval at Long Beach
- Stasis Pack Kit (x1)
  - Early retrieval at Long Beach


THANK YOU!