BioNutrients-1 (BN-1) Payload Overview

POIWG #43

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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

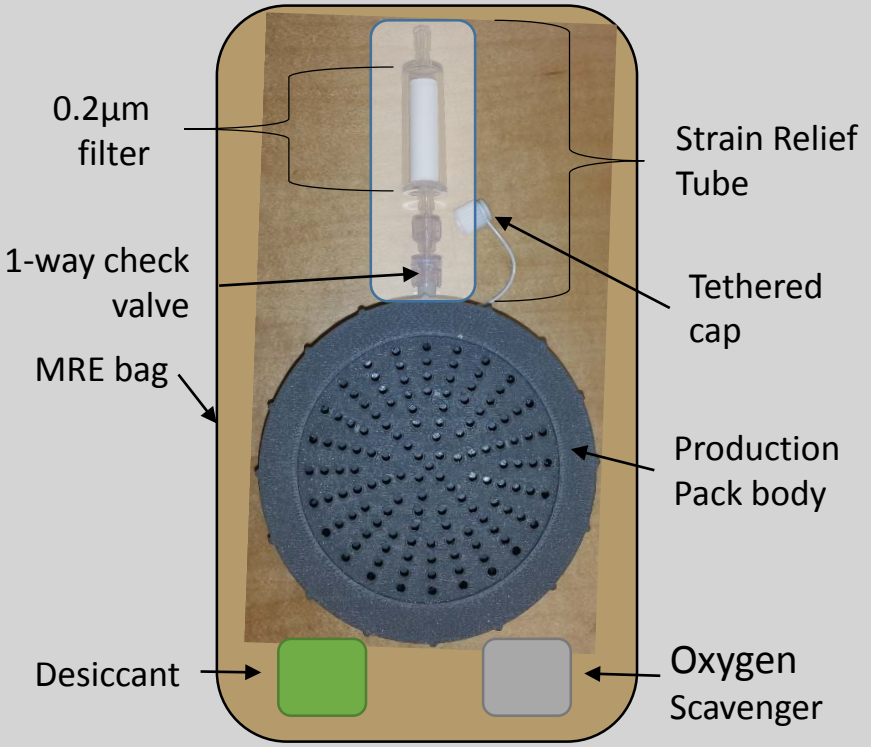
Need: To enable rapid, safe and reliable in situ production of needed dietary nutrients using minimal mass, power and volume for long duration missions.

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

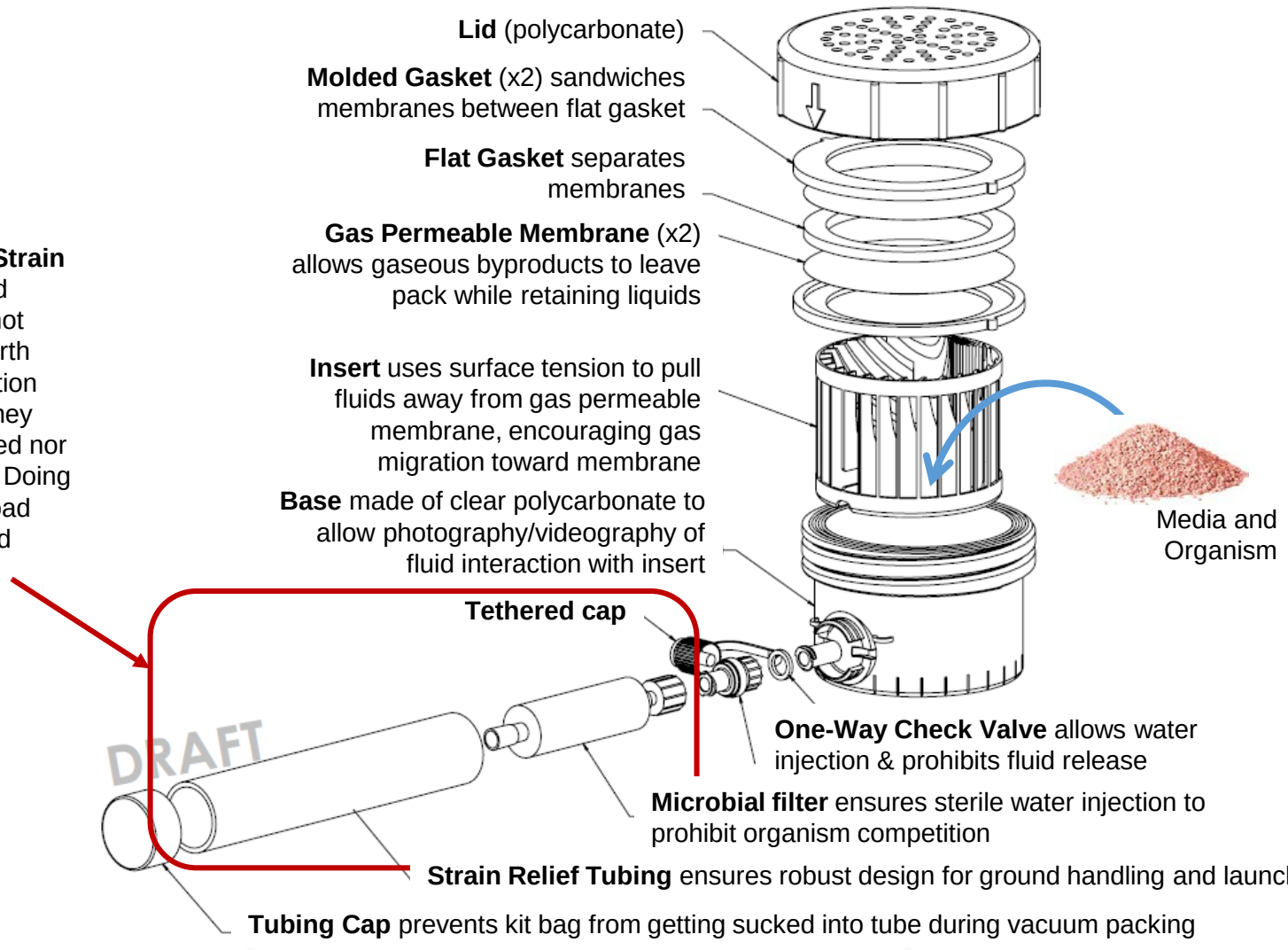
- **Production Packs**
  - **ISS Activation Production Packs** Activated on-orbit. 14 runs over 5 years. 4 packs/run.
  - **Earth Activation Production Packs** *Flown controls.* Activated on Earth after exposure to ISS. 13 returns over 5 years. 4 samples/return.



- **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.



Production Pack Kits

Contents, Launched Quantities & Return Timetable

Sample	~6d	~25 d	4 M	8 M	12 M	16 M	20 M	24 M	30 M	36 M	42 M	48 M	54 M	60 M	Spare			Total
ISS Activation Samples	4 run 1	4 run 2	4 run3	4 run4	4 run5	4 run6	4 run7	4 run8	4 run9	4 run10	4 run11	4 run12	4 run13	4 run14	8	8	8	80
Earth Activation Samples	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0	0	0	56
																	Total	136

<u>Organism Legend</u>:

Blue = *Saccharomyces boulardii* (Yeast)

Yellow = Y55 strain of *Saccharomyces cerevisiae* (Yeast)

Pink = *Bacillus subtilis* (Bacteria)

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.

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.

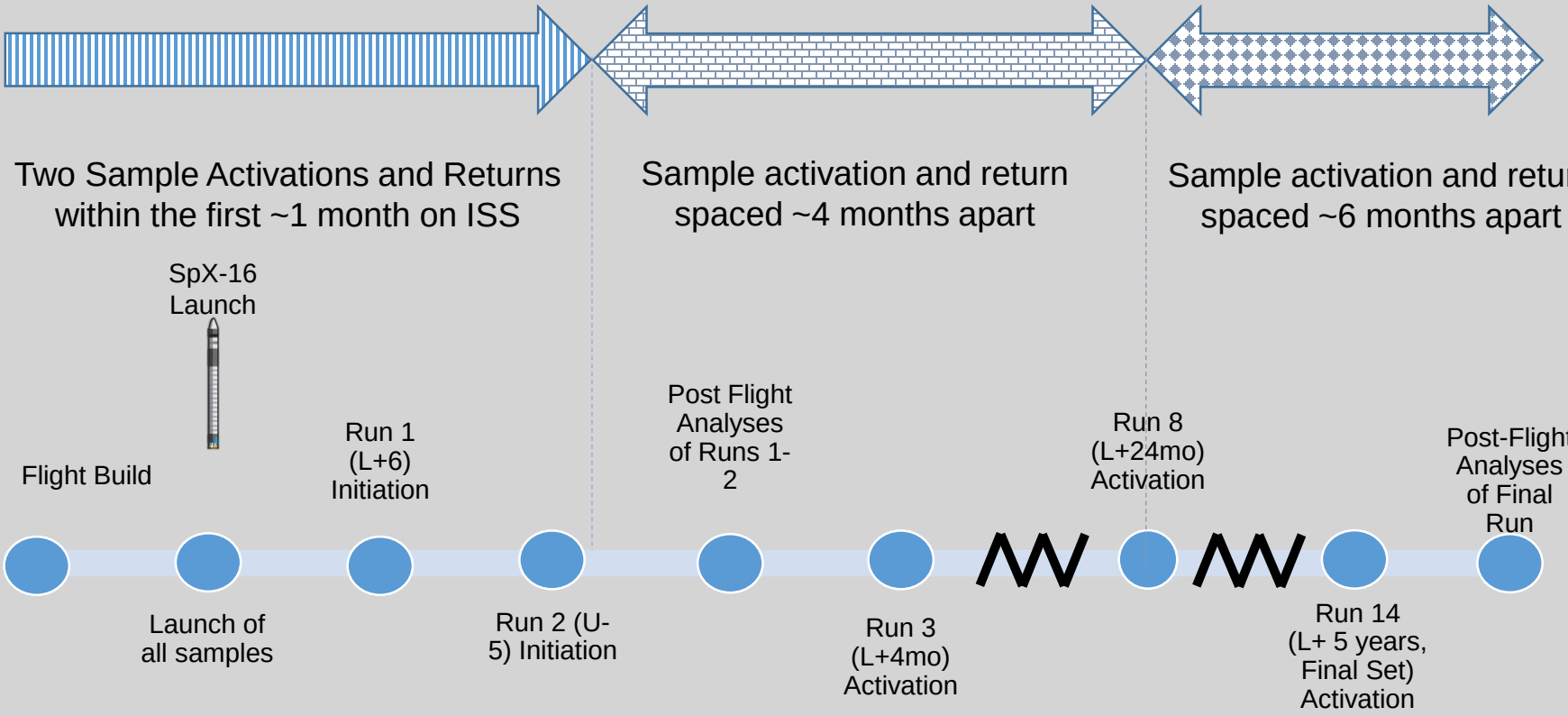
Concept of Operations

Assumptions and Constraints

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

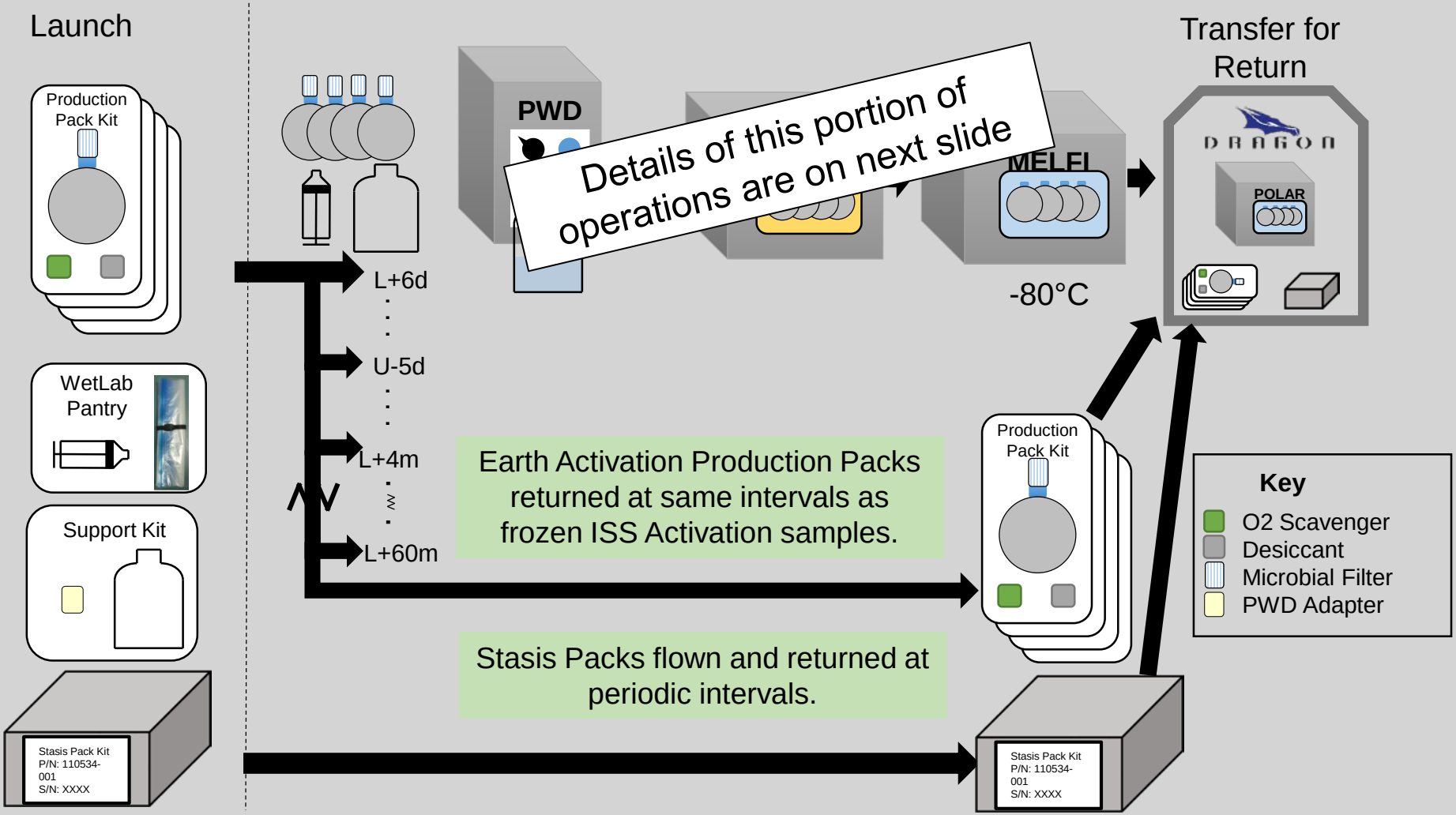
- Pre-flight sample and hardware prep occurs at ARC.
- All hardware launched in single launch event.
- Payload launched soft-stowed at ambient temperature.
- Payload launched to ISS in the SpaceX Dragon spacecraft or comparable vehicle
- ISS Activation Samples return in ≤-70°C cold stowage. Earth Activation 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.

Timeline Overview



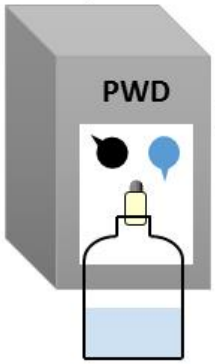
Note: Timeline not to scale.

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

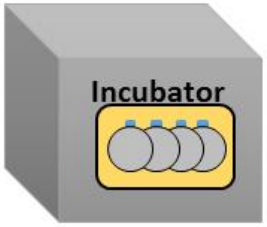
Hydration

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

Agitation #1

Repeat 4x per run

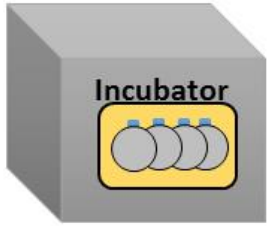
Incubation



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

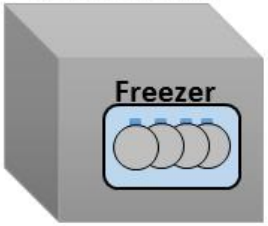
Agitation #2

Incubation



~42hrs @ specimen-specific temp

Preservation

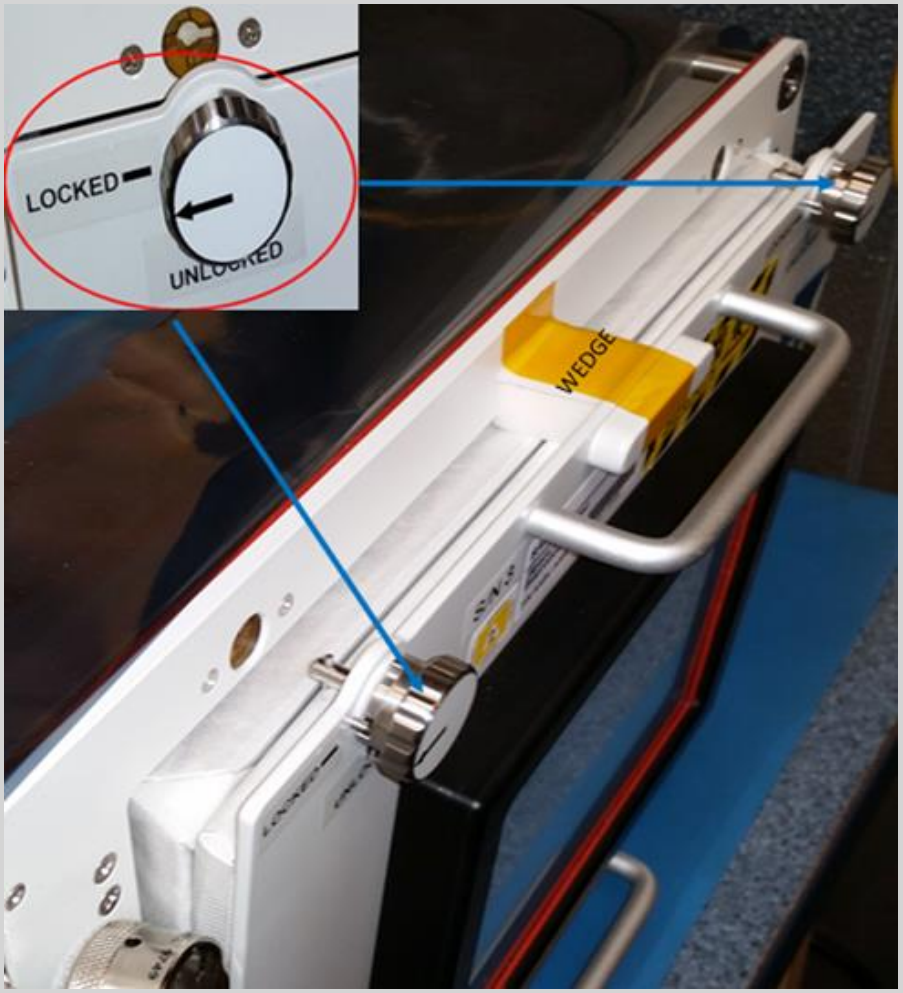


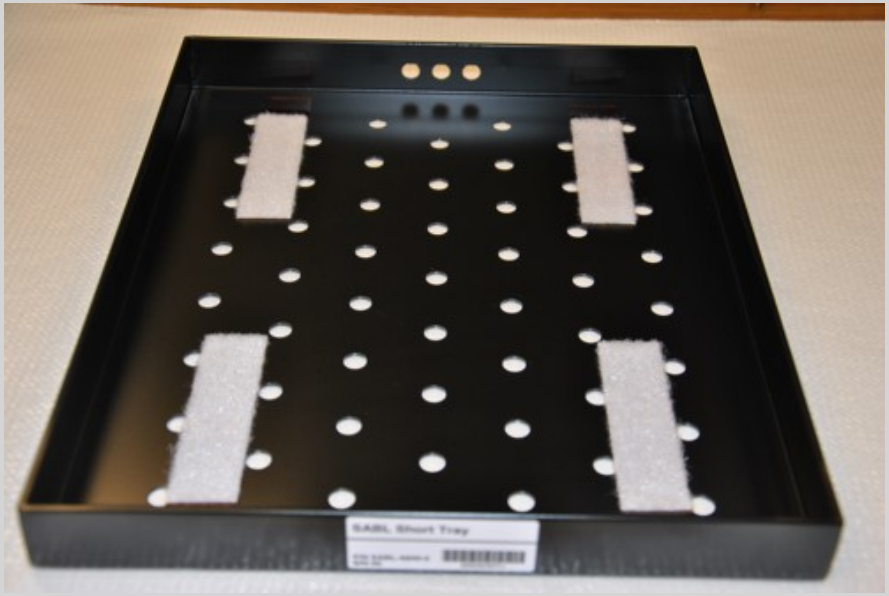
-80°C

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

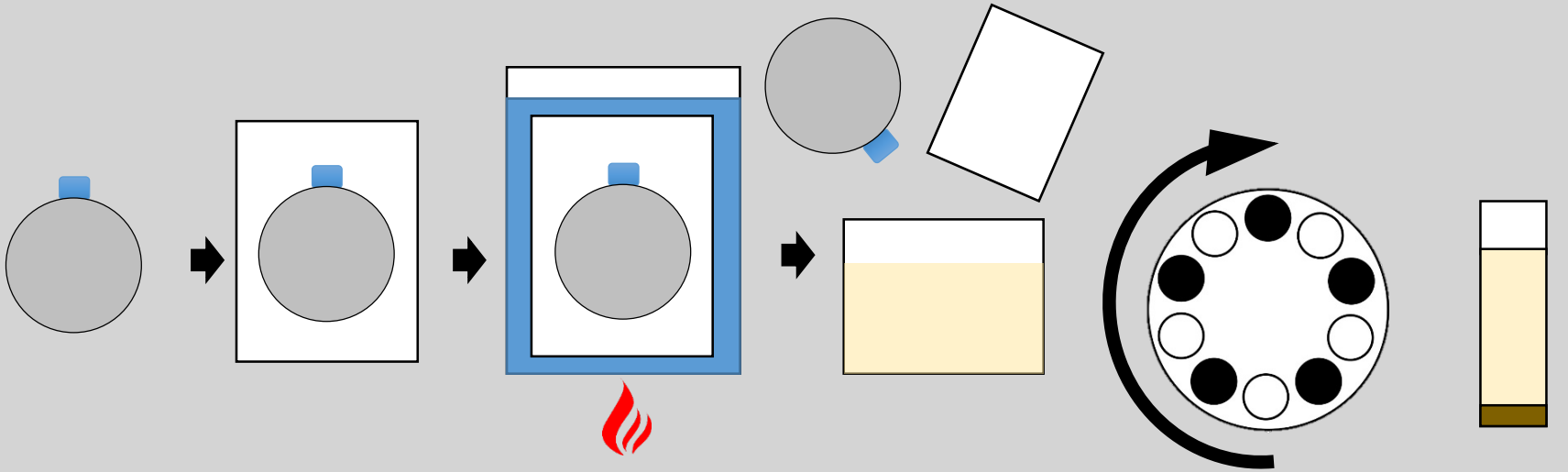
Syringe for hydration and bitran bag for freezer containment obtained from Wetlab Pantry

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 II Safety Review

- Phase II Safety Review was held on February 7, 2018
- All hazard reports were approved with minor modifications
- 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
- Project was given approval to proceed to Phase III
  - Current plan has Phase III in the May timeframe

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-16

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-17 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!