Cell Science-04 (CS-04) Payload Overview

POIWG #47

October 21, 2020

Kevin Sims

Ames Research Center (ARC)

Thank

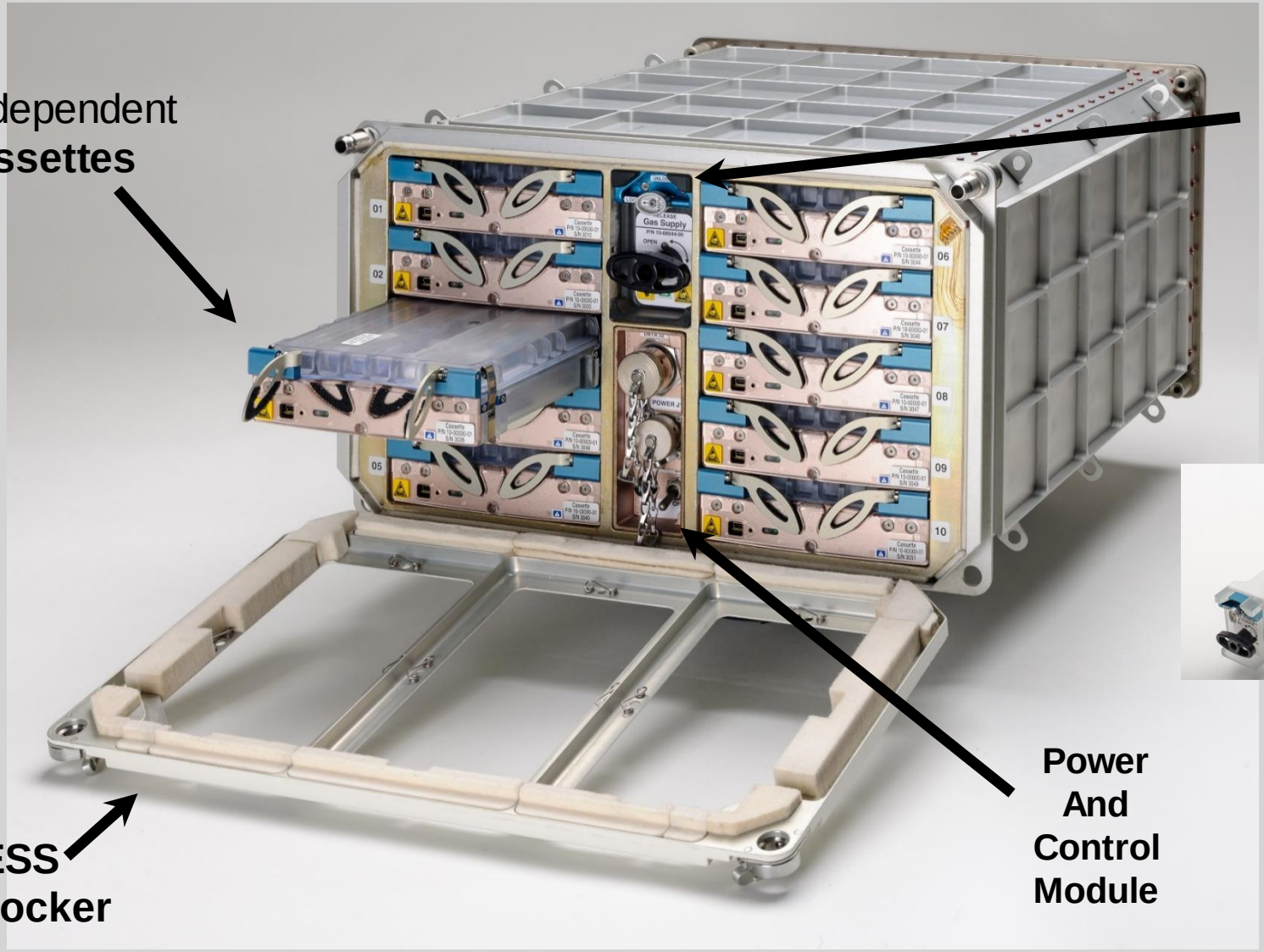
NASA SILICON VALLEY

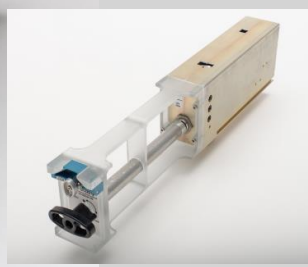
AMES RESEARCH CENTER

Bioculture System

- Automated cell biology system with 10 independent cassettes
- Programmable manipulations include:
  - Media Feeds (not used for CS-04)
  - Adjustable gas dosing (not used for CS-04)
  - Sample collection (not used for CS-04)
  - Fixative injection
- Cassettes are removed and opened in LSG to allow culture initiation, bag change-out, sample retrieval and preservation.

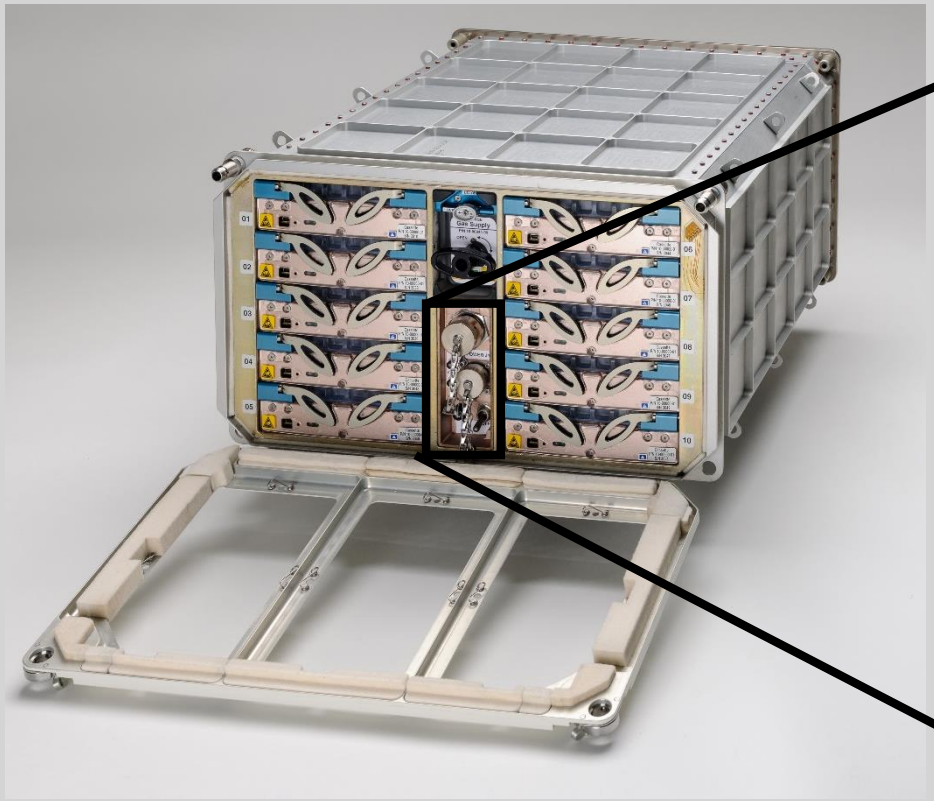
Bioculture System

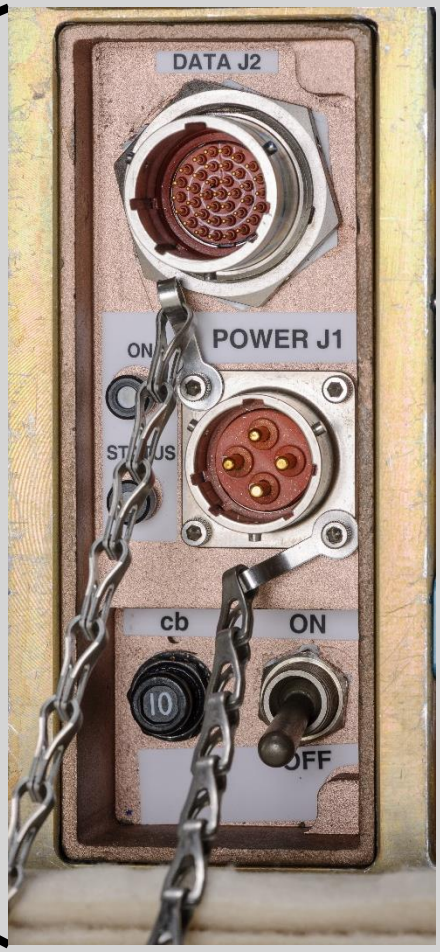




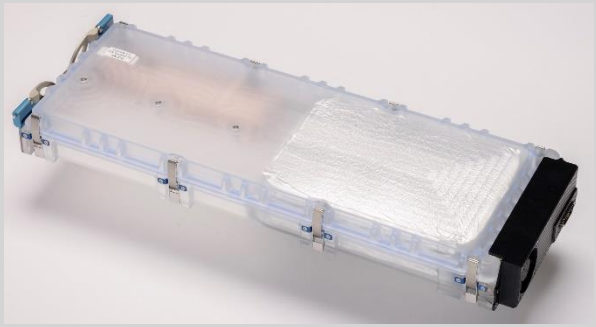
Power and Control Module

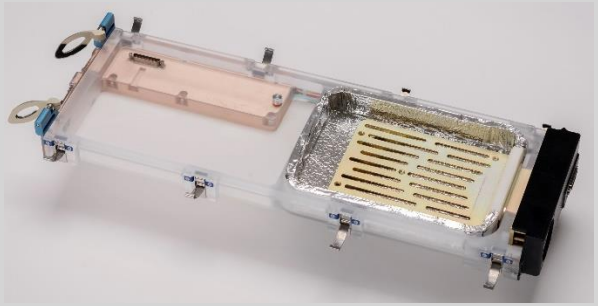
The Power and Control Module takes 28V Rack voltage, converts it to 12V, and uses standard interfaces for both power and data to the Rack. The Power and Control Module contains an On/Off toggle switch, a circuit breaker, Data Connector, Power Connector, and two LEDs for Power/Fault Status.

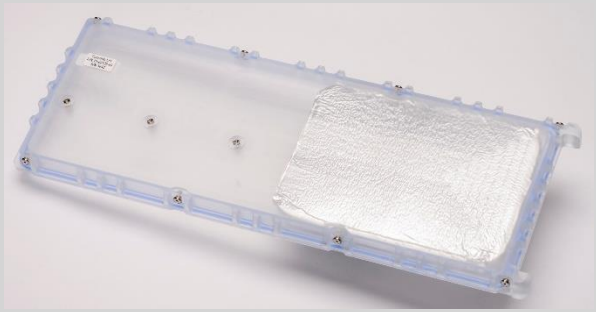


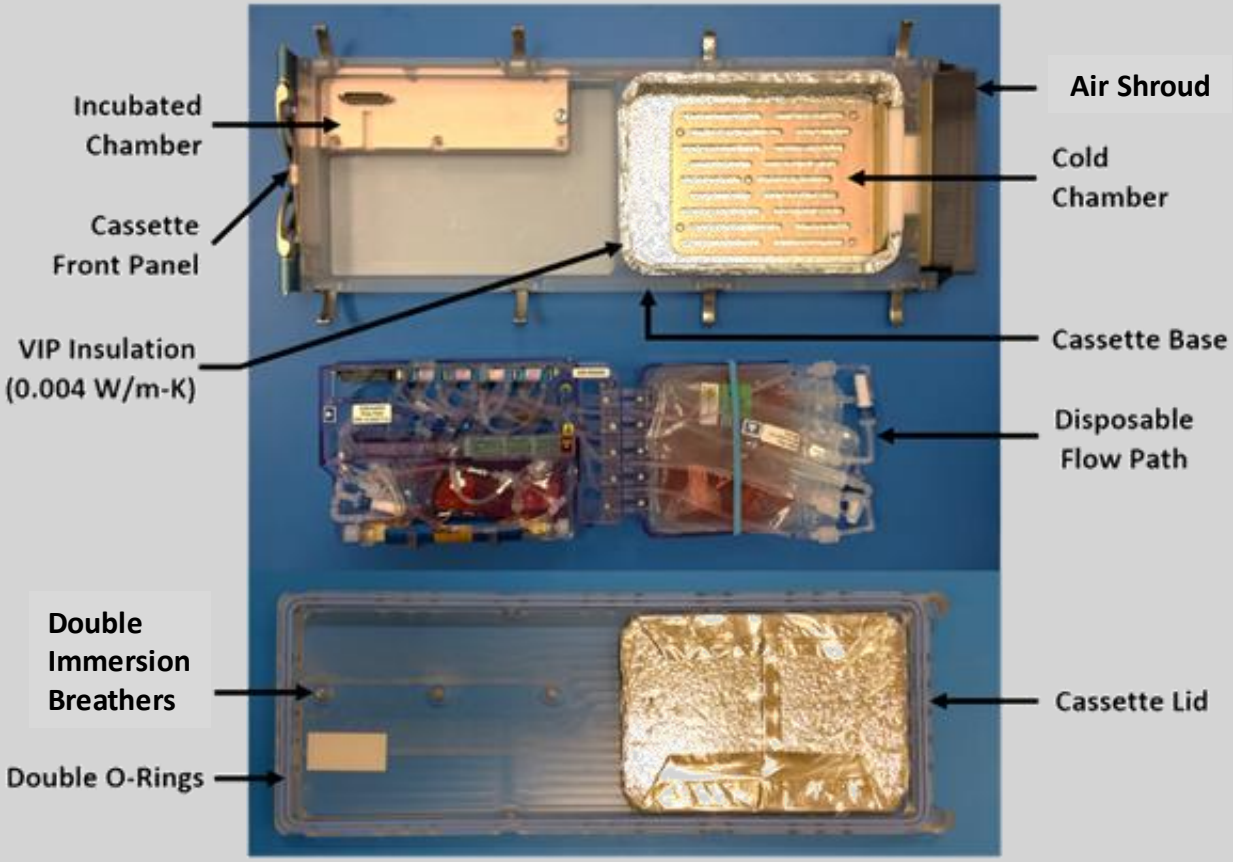


Durable Cassette with Disposable Flow Path

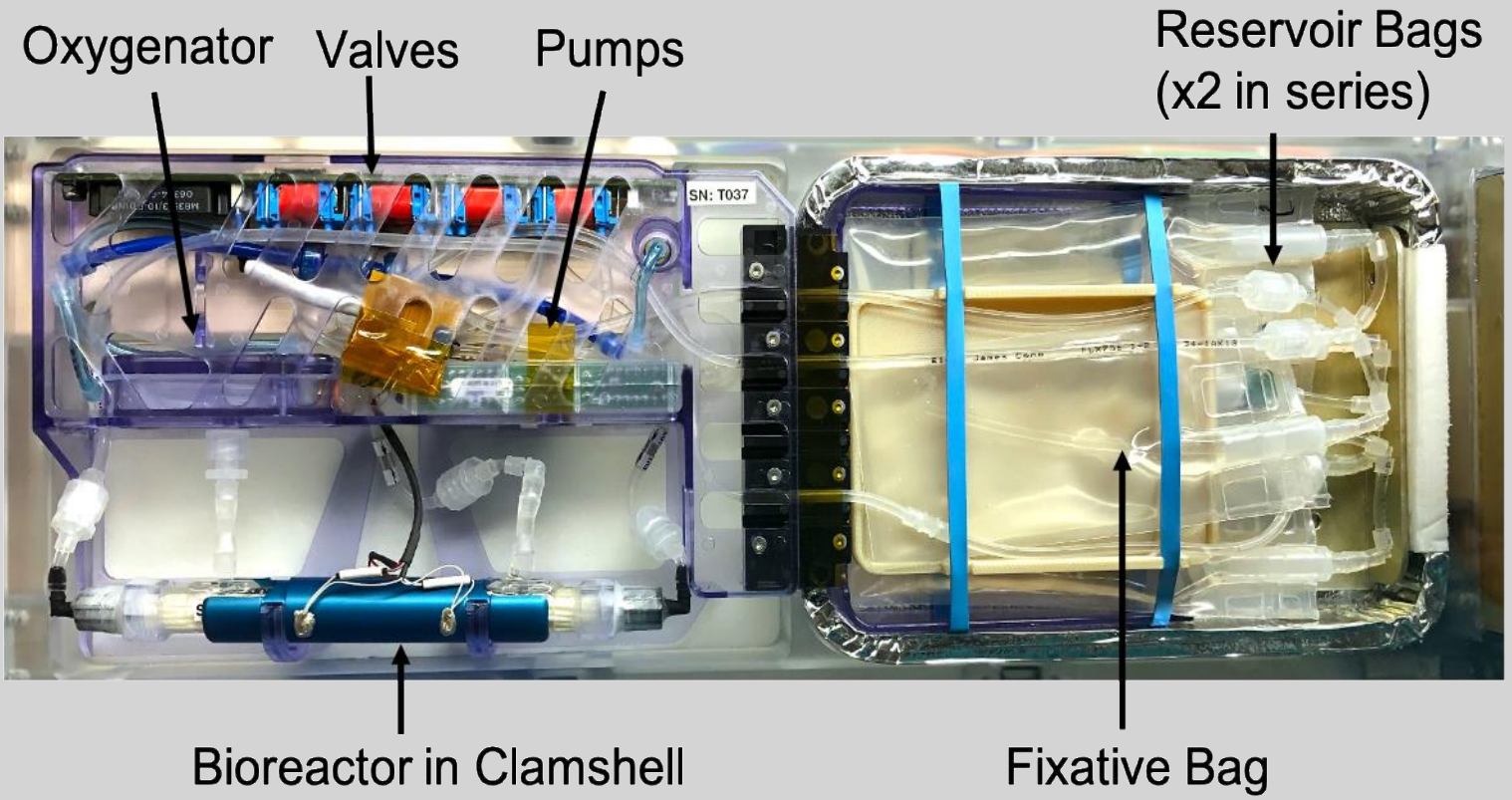






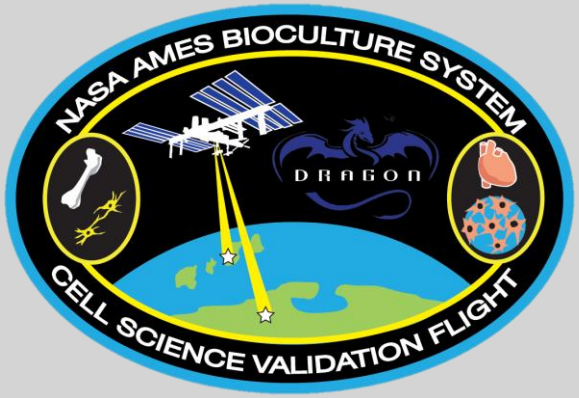


Disposable Flow Path
CS-04 Configuration



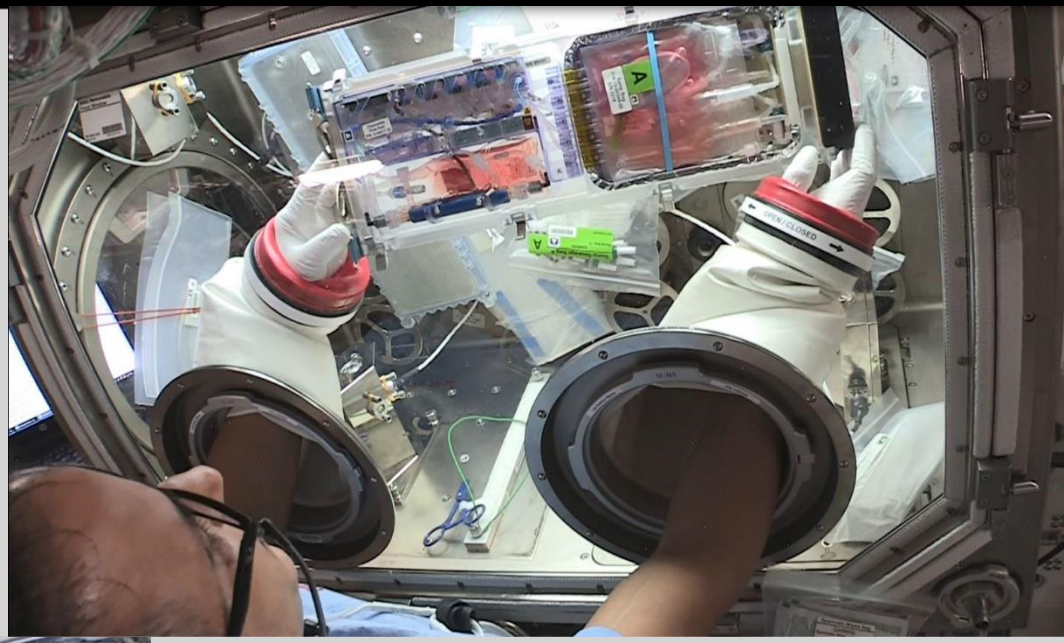
Cell Science Validation (CS-V)

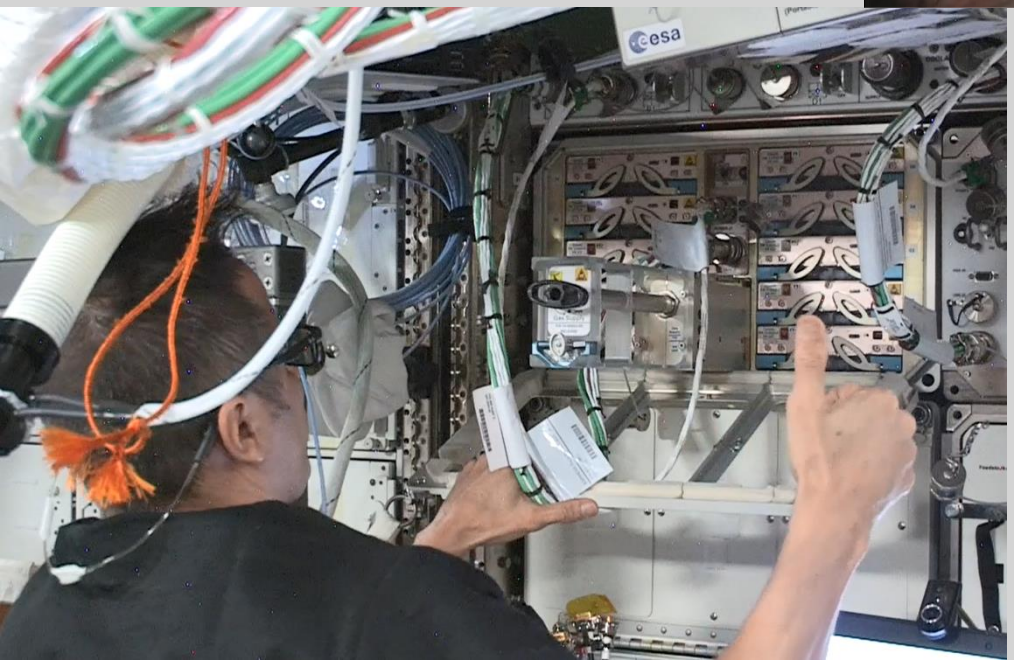
- **Vehicle**: SpX-13
- **Dates**: December 15th, 2017 – January 13th, 2018
- **Crew**:
  - Joe Acaba performed the majority of CS-V operations
  - Nemo (Norishige Kanai) performed transfer to ISS
  - Scott Tingle performed bioreactor removal
- **Results**:
  - 100% Science Return (8/8 Bioreactors and 4/4 Samples)
  - Bioculture System validated for PI Missions (CS-02 and beyond)
- Received positive feedback on hardware in crew debriefs



CS-V Imagery

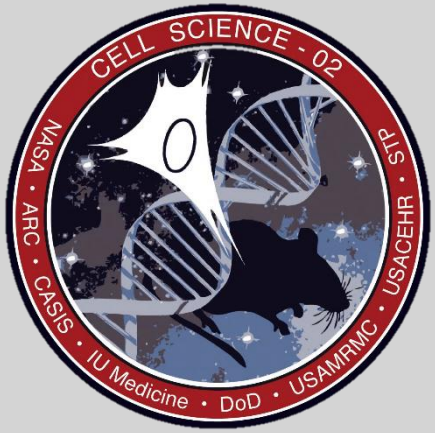
Bag Change Out in MSG





Gas Supply Change Out

Cell Science-02 (CS-02)



- **Vehicle**: SpX-18
- **Dates**: July 25 - August 6, 2019
- **Crew**:
  - Nick Hague performed the majority of CS-02 operations
  - Some assistance from Drew Morgan and Luca Parmitano
- **Results**:
  - All crew activities were successfully completed.
  - PI is in the process of analyzing returned samples
- **Anomalies:**
  - Upon initial installation to ER4 L1, experienced anomalously high inlet air temp. Crew transferred to Locker 6 which resolved the issue.

CS-02 Imagery

Nick Hague
holding cassette
in LSG

Drew Morgan and
Luca Parmitano
installing Bioculture
System in EXPRESS

CS-04 Experiment Summary

Principal Investigator	Thomas Boothby, Ph.D. University of Wyoming
Sponsor	Biological and Physical Sciences (BPS)
Funding Authority	ISS Technology and Science Research Office (NASA)
Experiment Duration	61 Days after initiation - initiated on ISS
Ground Control	Near Synchronous Ground Control (NSGC) initiated at ARC within 48hrs of the flight experiment initiation
Organism Type	Tardigrade (*Hypsibius exemplaris*) aka Water Bear
Independent Variable	Culture Duration – one cohort preserved after 7 days of on-orbit culture, second cohort preserved after 61 days.

What is a Tardigrade?

- *Hypsibius exemplaris* is a member of the phylum Tardigrada, a group of microscopic animals sometimes known as "water bears".
- It is found in moss and in freshwater habitats and has a cosmopolitan (world-wide) distribution.
- Conveniently, it can be cryopreserved for storage at -80°C and thawed months later with a fairly high survival rate.
- Like other tardigrades, *H. exemplaris* can shut down their metabolism almost entirely and survive long periods in an extremely desiccated state (anhydrobiosis).
- In this state, tardigrades are highly resistant to extremes of temperature, pressure, and radiation.
- Desiccated tardigrades sent into space survived exposure to space vacuum and cosmic radiation with no significant effect on survival; exposure to unfiltered solar radiation had a strong negative effect on survival, but some individuals survived even the combined effects of space vacuum and cosmic and solar radiation.
- For more, see CS-04 Science Highlight presented to RICB on 5/6/2020 or Dr. Boothby's TED Talk.

New Crew Operations

Tardigrade Injection:

- Crew injects a syringe containing tardigrades into the bioreactor to initiate the experiment.
- Will perform on all 10 cassettes in one session.
- Syringes are frozen at launch, and thawed prior to injection.

Algae Injection:

- Identical to tardigrade injection except for the syringe contents.
- Only performed on 61-day cohort, to replenish food for tardigrades
- Algae Syringes launch refrigerated at +4C

CS-04 Timeline

Turnover Unpowered Bioculture System (BCS) and soft stow to JSC CMC

NLT L-5w

Ship specimen syringes to launch site

NET L-1mo

Specimen syringes prepared by PI

NET L-1w

Launch

Set Up LSG Ancillary Hardware

Flexible

Transfer Kits to ISS stowage; Install BCS to EXPRESS

TBD

Thaw and Inject Frozen Tardigrades into Bioreactors

Will refer to this as "Initiation" day
NLT 4.5mo after Sample Prep

Group A Bioreactors Fixed and Removed

Initiation +7d (I+7d)

Algae Injection to Group B Bioreactors

I+15d

Algae Injection to Group B Bioreactors

I+30d

Algae Injection to Group B Bioreactors

I+45d

Tear Down LSG Ancillary Hardware

Group B Bioreactors Fixed and Removed

I+61d

Flexible

Transfer Bioculture System, cold and soft stow items to Dragon

TBD

Splashdown

Ship cold stow Samples from JSC to PI

NLT 48hrs after turnover to PD

Priority Return of Soft-stowed BCS to ARC

TBD

NSGC begins within 48 hours and maintains same time lag throughout

Purple Text indicates the activity occurs in the LSG
Red Line indicates time when the experiment is active

Integration Overview

- **Bioculture System unpowered for launch**
  - May be either hard-mounted or in soft stowage for return
- **Bioculture System Facility Payload Integration Agreement (PIA) Letter contains the following unique agreements applicable to Cell Science-04:**
  - Use of LSG for crew operations – coordinated with LSG via Utilization Memo (HP30 20-026) and with Glovebox SpOC team.
  - Priority return of unpowered Bioculture System to Ames after return to JSC (rationale: needed to support testing for future Cell Science missions)
  - Note: Many of the unique agreements in the PIA are not applicable for CS-04 since it is an unpowered launch with no SSPF work required.
- **CS-04 will be the first flight for Cell Science/Bioculture System under REMIS**

Integration Overview (Continued)

- Ambient Kits built at KBR Houston, delivered to CMC in September 2020
- Pre-flight processing of Bioculture System and Flow Paths to occur at ARC
- Sample syringes (Tardigrade and Algae) to be prepared by PI at his lab NET L-1mo
- **On-orbit operations**:
  - Bioculture System procedures already developed and executed on-orbit during CS-V and CS-02, require minor updates.
  - Procedures for new operations (Tardigrade and Algae Injection) are in work with SpOC
  - **Training Strategy**: OBT
  - **Real-time support**: Telemetry monitoring and commanding, both at ARC and remote
  - **Telemetry Monitoring**: Through PD-managed Payload Ground Software (PGS) as well as monitoring of key parameters by PRO
  - **Video:** Requesting over-the-shoulder JEM video during operations in LSG
  - **PD Enablement:** Coordinated for operations inside LSG through PEAT
- **Use of ISS facilities**:
  - EXPRESS Rack 4 Locker 5
  - Life Sciences Glovebox (LSG)
  - Cold Stowage (MELFI, Polar, etc.)

Stowage Overview: Ascent

Unpowered Locker

- Bioculture System
  - Containing 10 Cassettes with no biology

Cold Stowage

- Tardigrade Syringe Bag (x1)
  - -20°C or colder
  - Contains twelve Tardigrade Syringes
  - Thawed and used to initiate experiment
- Tardigrade Controls Bag (x1)
  - -20°C or colder
  - Contains three Tardigrade Syringes
  - Left frozen and returned to earth for analysis by PI.
- Algae Syringe Bag (x4)
  - +4°C
  - Each bag contains five Algae Syringes
  - Only three bags needed, fourth one is a spare and is trashed if unused

Soft Stowage

- Setup Kit (x1)
  - Contains consumables (gloves, wipes) and items for setting up LSG (O-rings)
- Injection Kit (x1)
  - Contains Hemostats, Wipes, and Waste Bags used during injection activities
  - One Kit contains supplies for all injection activities, kit is used a total of four times.
- Bioreactor Removal Kit (x2)
  - Contains Tube Cutter, one hard-sided Bioreactor Containers, and stowage bags
  - Used during Bioreactor Removal activities (two)

Stowage Overview: Descent

Cold Stowage

- Bioreactor Container (x2)
  - -20°C or colder
  - Each container will have five individually bagged Bioreactors
- Tardigrade Controls Bag (x1)
  - -20°C or colder
  - Contains three Tardigrade Syringes
  - Left frozen and returned to earth for analysis by PI.

Soft Stowage

- Bioculture System
  - Will be unpowered
  - Can either be hard-mounted, or in soft stowage (foam and oversize bag required) at discretion of ISS Program.
  - Requesting priority return to ARC

Thank You!