ISS Payloads Office
Utilization / Research Cargo Familiarization
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Presented to
Commercial Cargo Service Industry Day

OZ3/ Mike Horkachuck
Manager, ISS Payload Engineering Integration

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center

Types of Cargo

- Refrigerators & Freezers
- Single, Double & Quad. Middeck Locker Payloads
- International Sub-rack Interface Standard Drawers- 4, 8, 12 Panel Units
- Small Experiments, Spares
- Animal Enclosure Modules
- Gas Bottles, Batteries
- External Payload Exposure samples
- Furnace, Material Samples, etc
- Hardware is certified for the STS launch environment.
  - It would certainly be of value to NASA, if we don't have a big job to recertify our hardware for return/launch on a commercial vehicle.

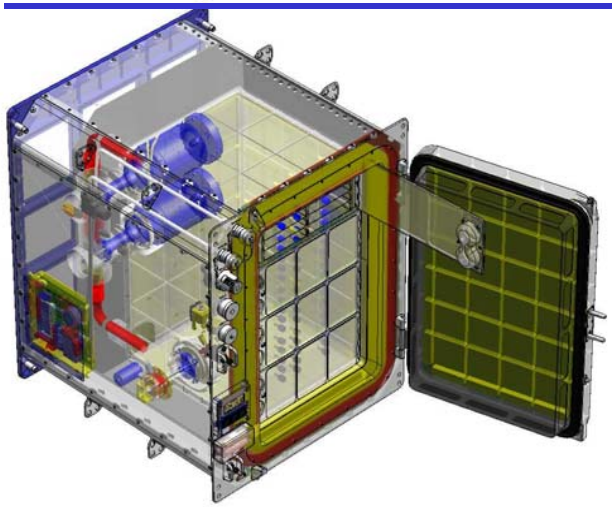
Interface Needs

Launch and Return system provide:

- **For Active Freezer:**
  - 28V DC Power
  - Air or Water Cooling system-
    - Water provides better performance than air cooled freezer
- **For Passive Freezer:**
  - Minimize the time from loading to recovery of samples post landing
  - Over board vent for Nitrogen or CO2 boil-off may be needed for colder temperature -80C or -180C
- **Both assume a standard cabin temperature (65-80F) and pressure (14.7psi)**
- **Early and Late Access to the Samples**
  - L-14 hrs and R+4 hrs assume continuous power to payload
- **Weight and Volume constraints for Early and Late Access**
  - Double Lockers at ~140lbs (Non-late access may be more)

Typical Freezers

Active – Power & Cooling



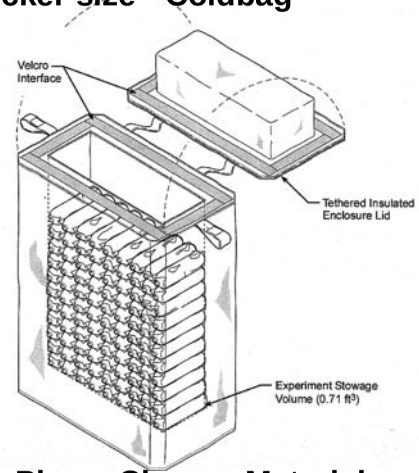
Double Middeck Locker size - Glacier
External Dimensions: 20.8” H X 18.125” W X 20.56” D

Single Middeck Locker size – MERLIN
External Dimensions: 10.75” H X 18.125” W X 20.56” D

Passive – No Power

½ & 1 Middeck Locker size - Coldbag

1/2 Middeck Locker size
Liquid Nitrogen Dewar



Phase Change Material inside
Aerogel Insulated Coldbag

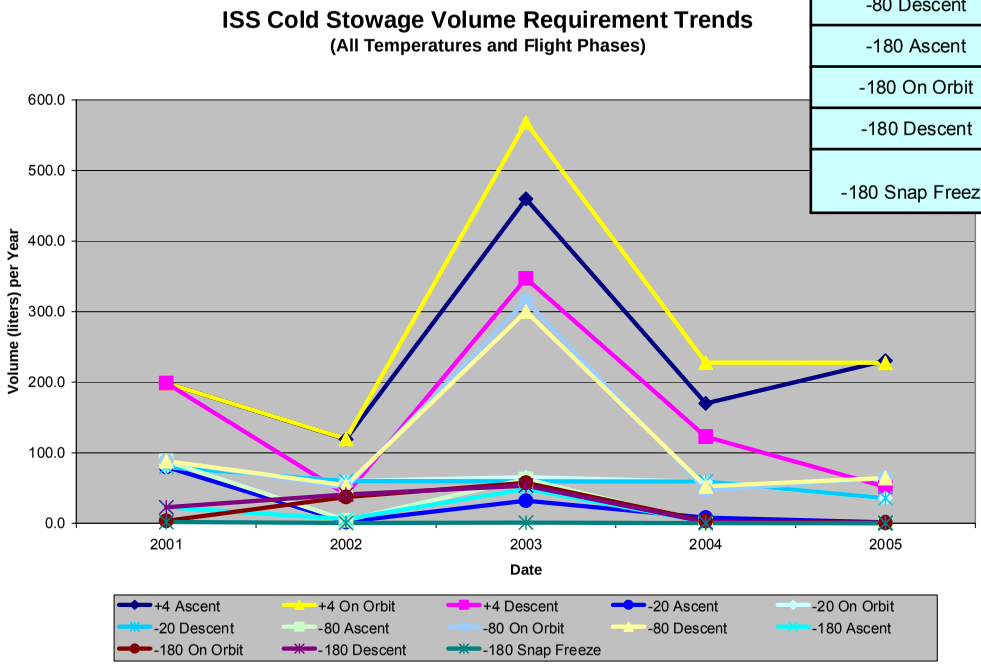
Freezer Trades – Launch & Return

- **Total volume of actual samples is 150 to 250 liters; approximate values per year**
  - This is a combination of all samples at +4C, -20C, -80C and –180C, based on today's plan.
- **Overhead using an Active (powered) freezer**
  - 3-4 times the sample volume would be needed
  - 2-3 times the sample mass (plus sample mass)
- **Overhead using a Passive (unpowered) freezer;**
  - 6-32 times the sample volume would be needed
  - 6-18 times the sample mass would be needed (including PCM)
  - Phase Change Material for colder temperatures (-80C, -180C) is not currently available (TOX level 3 or 4)
  - Liquid Nitrogen or Dry Ice not available on ISS for return system
- **However, the cost for passive systems make them very appealing, almost disposable**
  - On a per unit cost, passive systems can 10 times less expensive
- **Minimizing time from loading Passive Freezer on ISS, through undocking, re-entry, landing and recovery of samples to a ground freezer will effect the feasibility of a passive return system**
  - 8-12 hours might be possible without phase change; mass only
- **Science would prefer 6 months (or less) for the return interval**

ISS Cold Stowage Requirements

- Significant amounts of science requires Launch at +4C, but is returned at -80C
  - -20C samples can generally be returned colder (-80C or -180C)
  - Launching at +4C, but returning at -80C makes the mass and volume trades for passive systems less desirable

Sample Type	Predictions of Worst-case Assembly Complete Demand in Liters per Year (Including Packing Factor)				
	2001	2002	2003	2004	2005
+4 Ascent	198.8	119.1	459.7	169.9	230.4
+4 On Orbit	198.8	119.4	568.2	227.7	227.6
+4 Descent	198.8	40.8	347.0	122.9	51.6
-20 Ascent	80.0	2.1	32.0	8.0	1.6
-20 On Orbit	80.0	60.1	65.4	58.7	35.7
-20 Descent	80.0	60.1	59.6	59.2	35.7
-80 Ascent	88.3	4.2	62.9	0.0	0.0
-80 On Orbit	88.3	50.2	315.5	46.4	64.4
-80 Descent	88.3	53.6	300.4	52.5	64.4
-180 Ascent	22.8	6.1	48.6	1.8	0.4
-180 On Orbit	3.5	37.4	57.4	3.4	0.7
-180 Descent	22.8	40.8	53.4	1.8	0.7
-180 Snap Freeze	1.8	0.6	1.1	0.3	Not specified



- Cold stowage volume requirements predictions have changed greatly over the past 5 years
  - Needs will likely be bounded by these cases

Launch of Kits, ISIS Drawers & Misc. Shaped Equipment

HRF pre-packed Kit

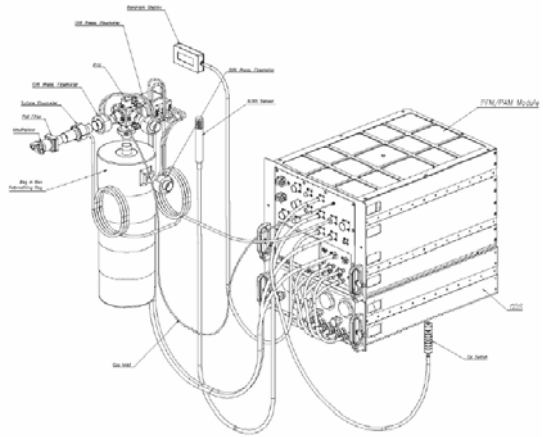
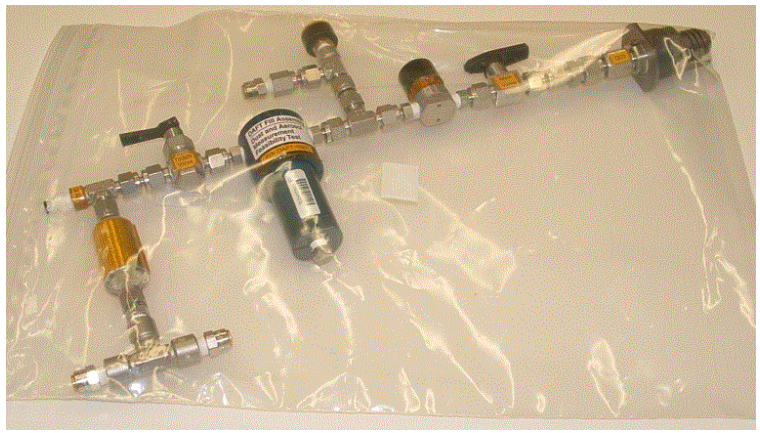


FIGURE 1.4.5–1 PHOTOACOUSTIC ANALYZER MODULE / PULMONARY FUNCTION MODULE

12 PU, ISIS Drawer & Equipment
External Dimensions: 20” H X 17” W X 24” D

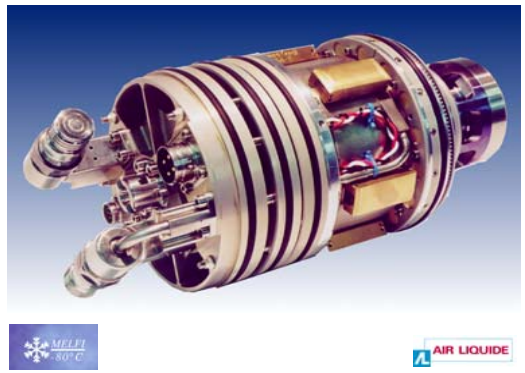
LN2 Dewar in Middeck Locker



DAFT Fill Assembly

Launch of New Experiment Hardware and Spares

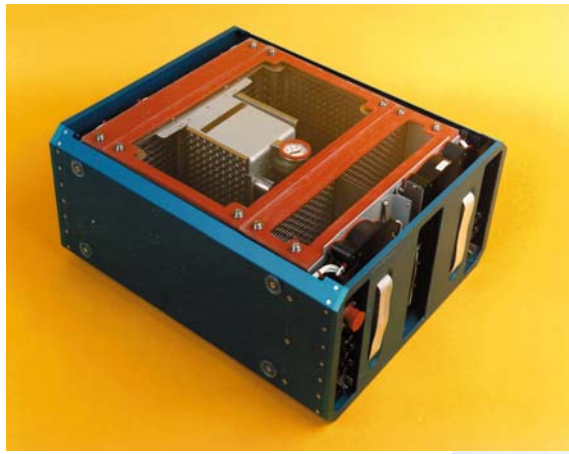
HRF SLEEP experiment



Brayton ORU

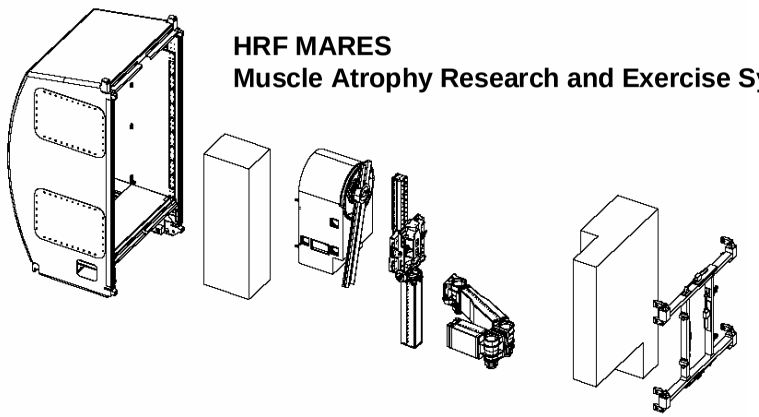
Launch of New Experiment Hardware & Launch of Animals

HRF Phantom Torso
Radiation Experiment



- **AEMs expect vehicle to provide shirt sleeve cabin air temperatures and pressures**
  - Oxygen for animal respiration
  - Carbon Dioxide removal

Rats in Animal Enclosure Module (AEM)



HRF MARES
Muscle Atrophy Research and Exercise System

Launch of Gas Supply Modules, Batteries

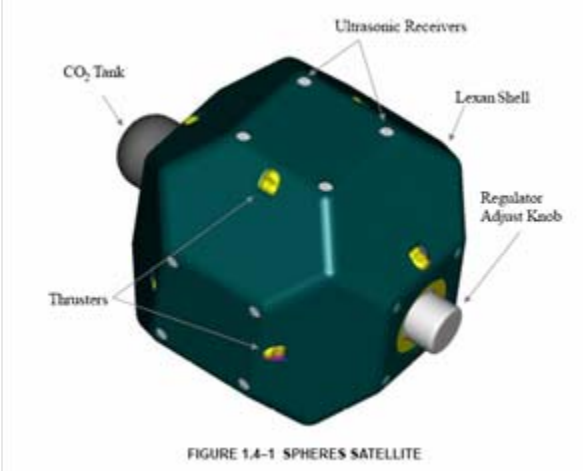


FIGURE 1.4-1 SPHERES SATELLITE

SPHERES with Gas Bottle

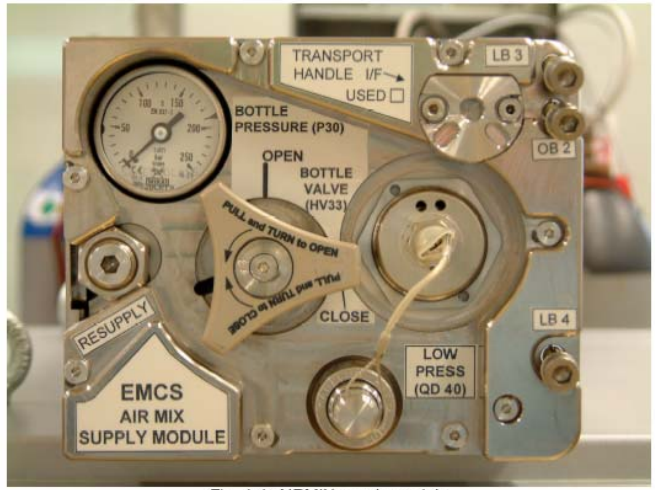
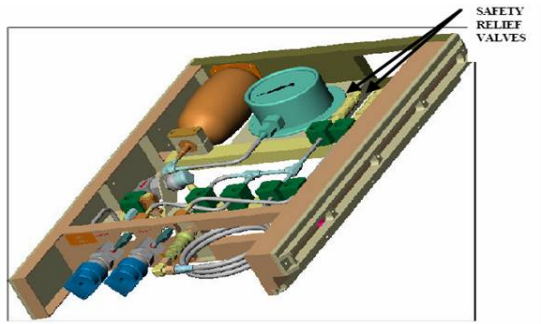


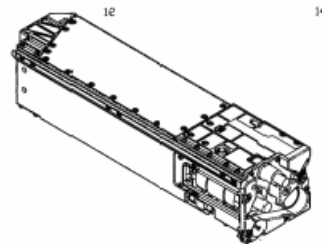
Fig. 4-4: AIRMIX supply module

Various Gas Bottles

Batteries

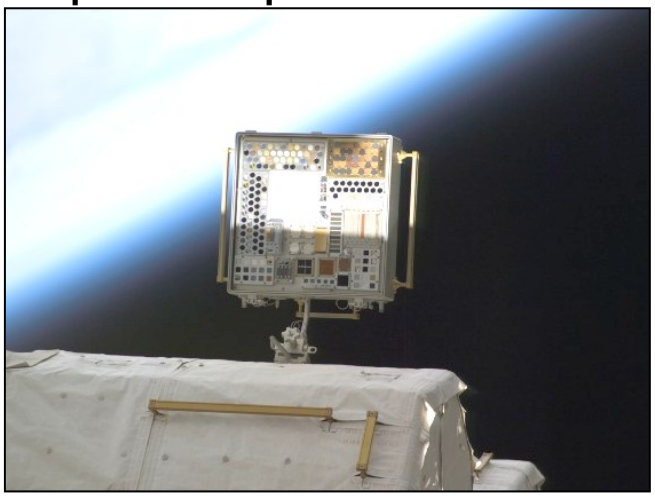
- Payload will also need various standard size batteries
- Typically from button cells to D-cell and rechargeable power tool batteries



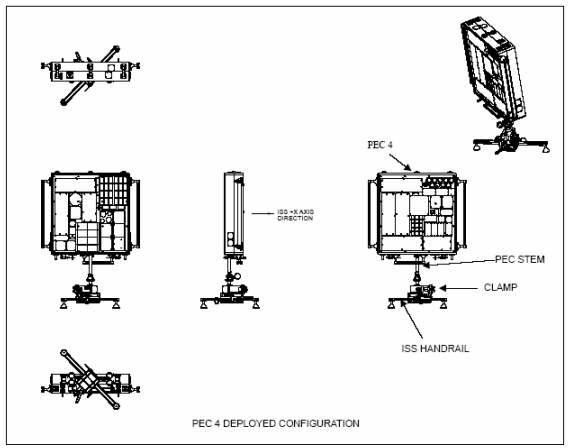


Launch & Return of External Exposure & Matl. Samples

- External Payload may need exposed samples returned



MISSE PEC



Launch and possible return of samples

SUBSA PI Aleksandar Ostrogorsky, Ph.D. holding a SUBSA ampuole in the MSG.

Fluids & Combustion Facility Equipment

Summary

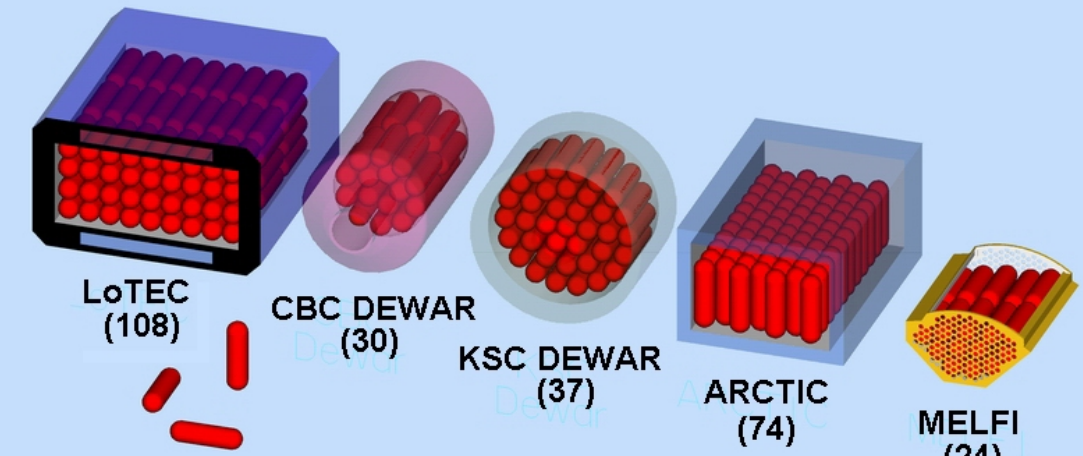
- **Launch**
  - Typically will be approximately single or double middeck locker size
    - New Experiments
    - ORUs, Spares
    - Occasionally larger sized items
- **Return**
  - The minimum return capability is to bring back frozen samples
  - Passive/Disposable systems become more appealing if the return time is less than a day
- **Environment and Recertification**
  - Hard-mounting of hardware will likely result in significant cost to NASA for recertification (vibration, shock)
  - Other environments- temperature, pressure, depress rate, etc. should be similar to STS

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center

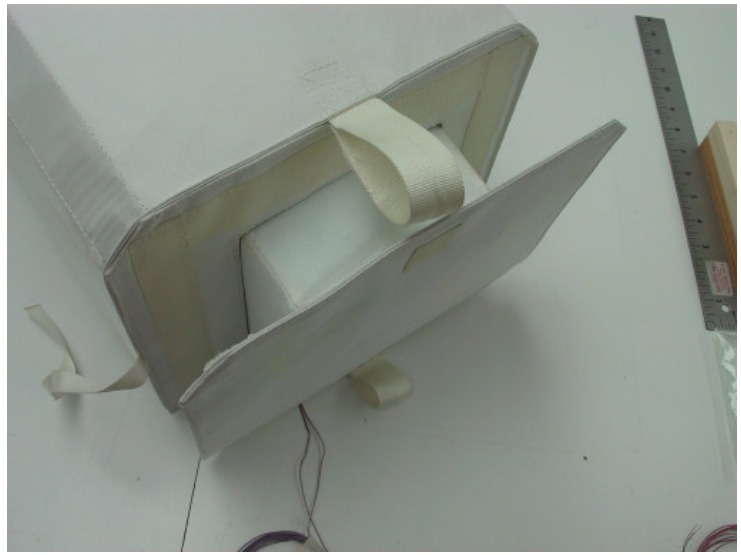
ISS Cold Stowage Fleet

ICEPAC Stowage Configurations

PCM cylindrical capsules optimized for joint use
in CBC and KSC dewars and LoTEC carrier



Coldbag



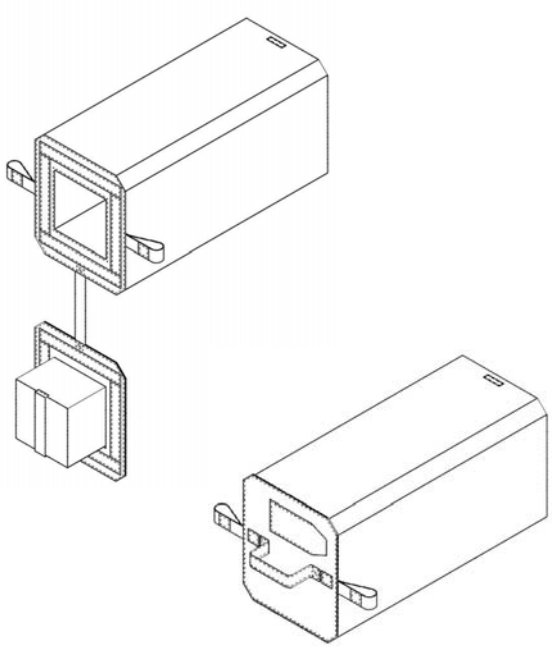
Single Coldbag Thermal Test

ISS Cold Stowage Fleet

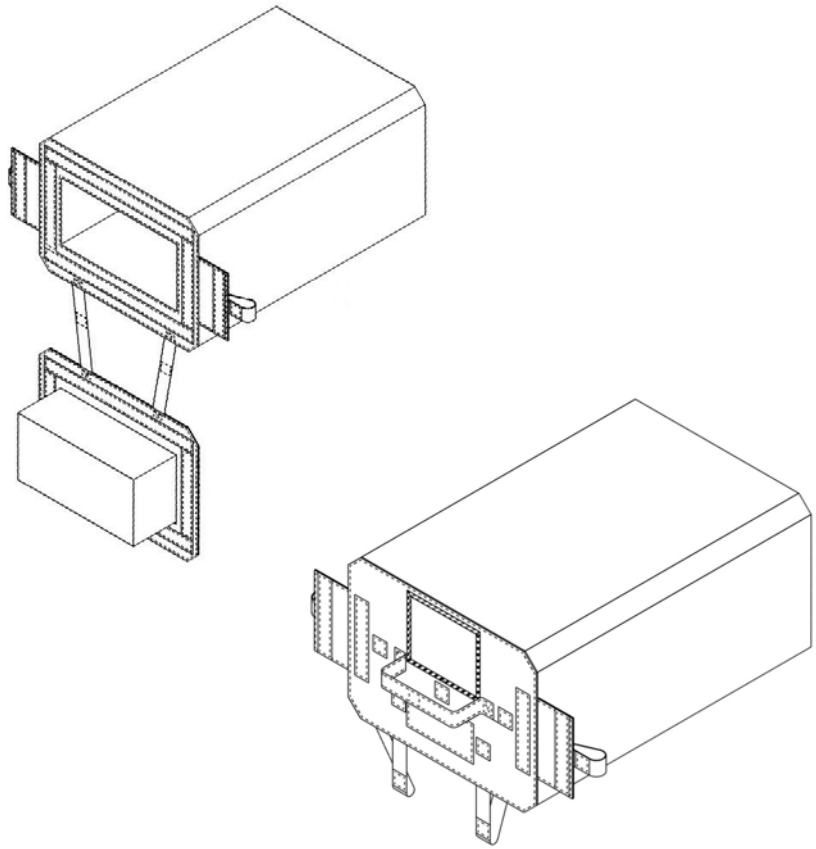
Cold Stowage Insulated Sample Bag (Coldbag)

- A passive thermal carrier for transport of samples to and from the International Space Station (ISS) without the need of external power
- Two sizes available: Coldbag and Double Coldbag
- Relies on a combination of high thermal resistance insulation (evacuated aerogel) and high energy density storage phase change materials. Nomex outer container.
- Acceptable Temperature Range:
  - +37ºC to -31ºC (or below)
- Coldbag empty mass:
  - Coldbag: 10 lbs (4.5 kg)
  - Double Coldbag: 18 lbs (8.2 kg)
- Coldbag capacity:
  - Coldbag:
    - ✓ Cold volume: 0.24 ft^3 (6.8 liters)
    - ✓ Payload Mass: 17 lbs (7.7 kg) including PCM
  - Double Coldbag:
    - ✓ Cold volume: 0.66 ft^3 (18.7 liters)
    - ✓ Payload Mass: 36 lbs (16.3 kg) including PCM

Coldbag Hardware



Single Coldbag



Double Coldbag

Cellular Biotechnology Cryodewar (CBC)

- Cold volume is 1.27L
- All specimens must pass through dewar neck which is 6.98 cm in diameter
- Can transport 1 CBC / MLE with space left over for extra stowage
- 4@ Flight and 2@ Ground CBCs for Cryogenic Transport using LN2 boil-off
- (2-CP100s delivered, 2-CX100s in cert)
- (Eng. Unit delivered and in testing)

Cold volume dimensions for CBC
Cold volume is 2.75" dia x 11.5" deep (6.98 cm dia x 29.2 cm deep). All specimens must pass through dewar neck which is 6.98 cm in diameter.

ISS Cold Stowage Fleet

KSC LN_2 Dewar

- Cold volume is 8.5 L 10.5” dia x 6” tall (26.67 cm dia x 15.25 cm tall).
- All specimens must pass through Dewar neck which is 3.5” (8.89 cm) in diameter.
- 4@ Additional KSC LN_2 Dewars

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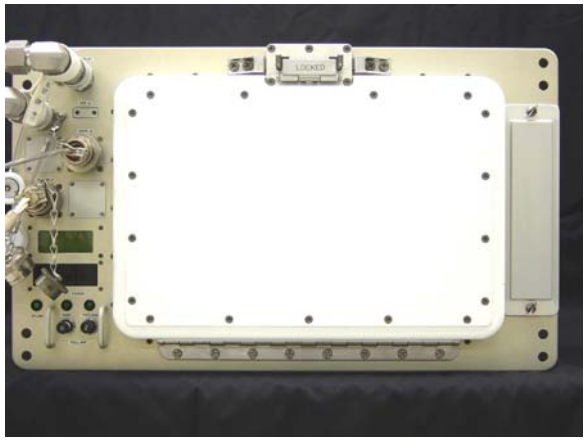
MERLIN

- Single Middeck Locker sized unit
  - Interfaces to Shuttle Middeck, SPACEHAB (with accommodations), and ISS ExPRESS rack
  - External Dimensions: 10.75” H X 18.125” W X 20.56” D
  - Mass 36.5 lbs (16.56 kg) empty
  - Accommodates up to 30 lb (13.61 kg) payload (with CG at the center of the cold volume)
  - Cold volume capacity: 0.66 ft^3 (19 liters)
- Dual Mode heat exchanger
  - Water or Air-cooled
- Active thermal control capability with passive Payload (selectable to 0.1 °C)
  - Water Cooled:(water @ 16 °C)
  - Air Cooled: air @ 22.5 °C
- Power Consumption
  - Input Voltage: 28 VDC ± 4 VDC
  - Minimum power draw: 0.4 A at 28 V (11 W)
  - Maximum power draw: 7.0 A at 28 V (196 W)

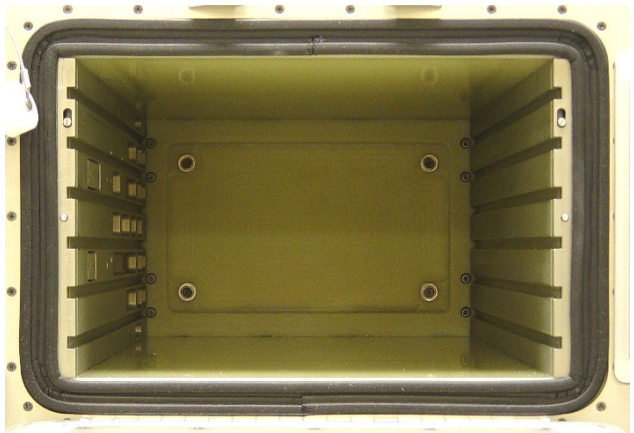
ISS Cold Stowage Fleet

MERLIN Hardware Views

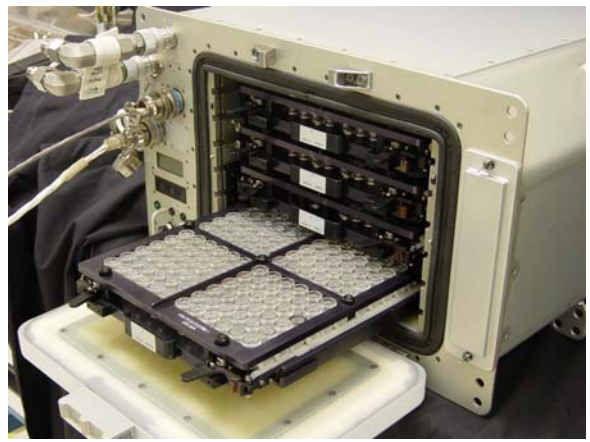


Data, Power, Fluid lines connected

Door Open



Empty Cold Volume

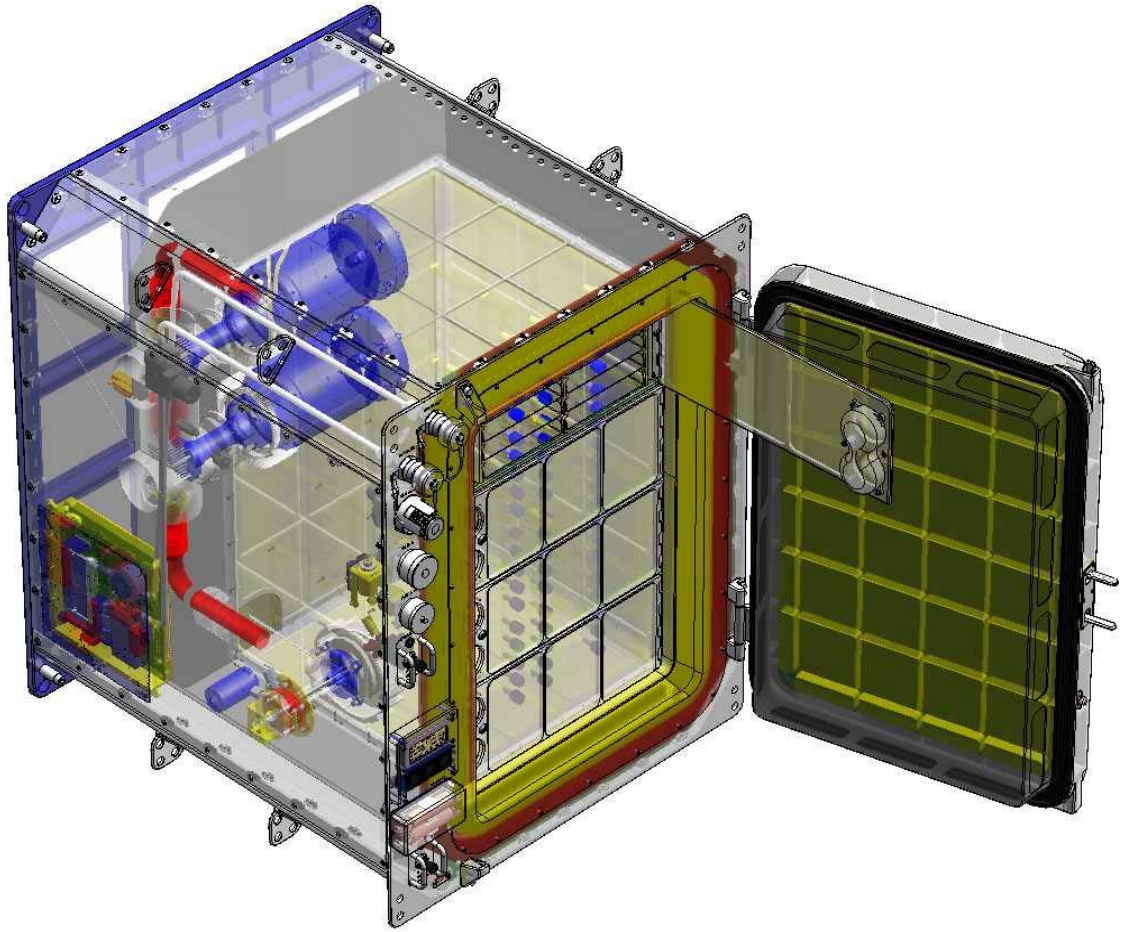


STES-compatible Payload Installed

ISS Cold Stowage Fleet

MERLIN Fleet (7 Flight Units)

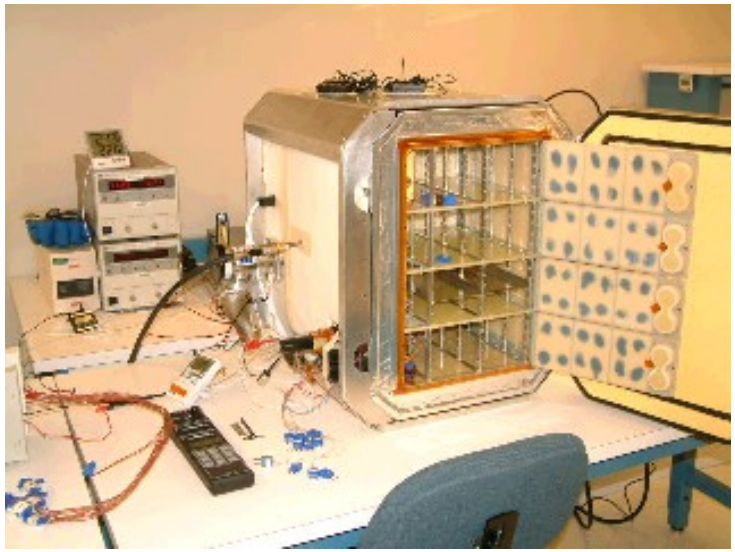
General Laboratory Active Cryogenic ISS Experiment Refrigerator (GLACIER)



ISS Cold Stowage Fleet

- **General Laboratory Active Cryogenic ISS Experiment Refrigerator (GLACIER)**
  - Double Middeck Locker sized unit
    - Interfaces to Shuttle Middeck, SPACEHAB (with accommodations), and ISS ExPRESS rack
    - External Dimensions: 20.8” H X 18.125” W X 20.56” D
    - Mass ≤81.4 lbs (36.9 kg) empty
  - Provides the on-orbit capability to quickly freeze samples to cryogenic temperature -185ºC (-301ºF)
  - Accommodates large variety of sample sizes
    - Cold volume capacity: 1.1 ft^3 (31 liters)
    - Can launch/land with 28.7lb (13kg) of samples aboard STS
  - Power Consumption
    - Input Voltage: 28 VDC ±4 VDC
    - Power draw: ≤ 280 W @ -185 ºC (water cooled)
≤ 225 W @ -160 ºC (air cooled)
≤ 80W @ -80 ºC (air cooled)
  - Active thermal control performance is better with water cooling
    - Water Cooled: -185 °C to + 4 °C (water @ 16 °C)
    - Air Cooled: <-80 °C to + 4°C (air @ 22.5 °C)
    - Dual Mode heat exchanger
      - ✓ Water or air-cooled in ISS ExPRESS Rack
      - ✓ Air-cooled in Shuttle Middeck
  - Can keep samples cold for up to 6 hr without power
    - Can hold ≤ -160 °C for 6 hour (power off, door closed)

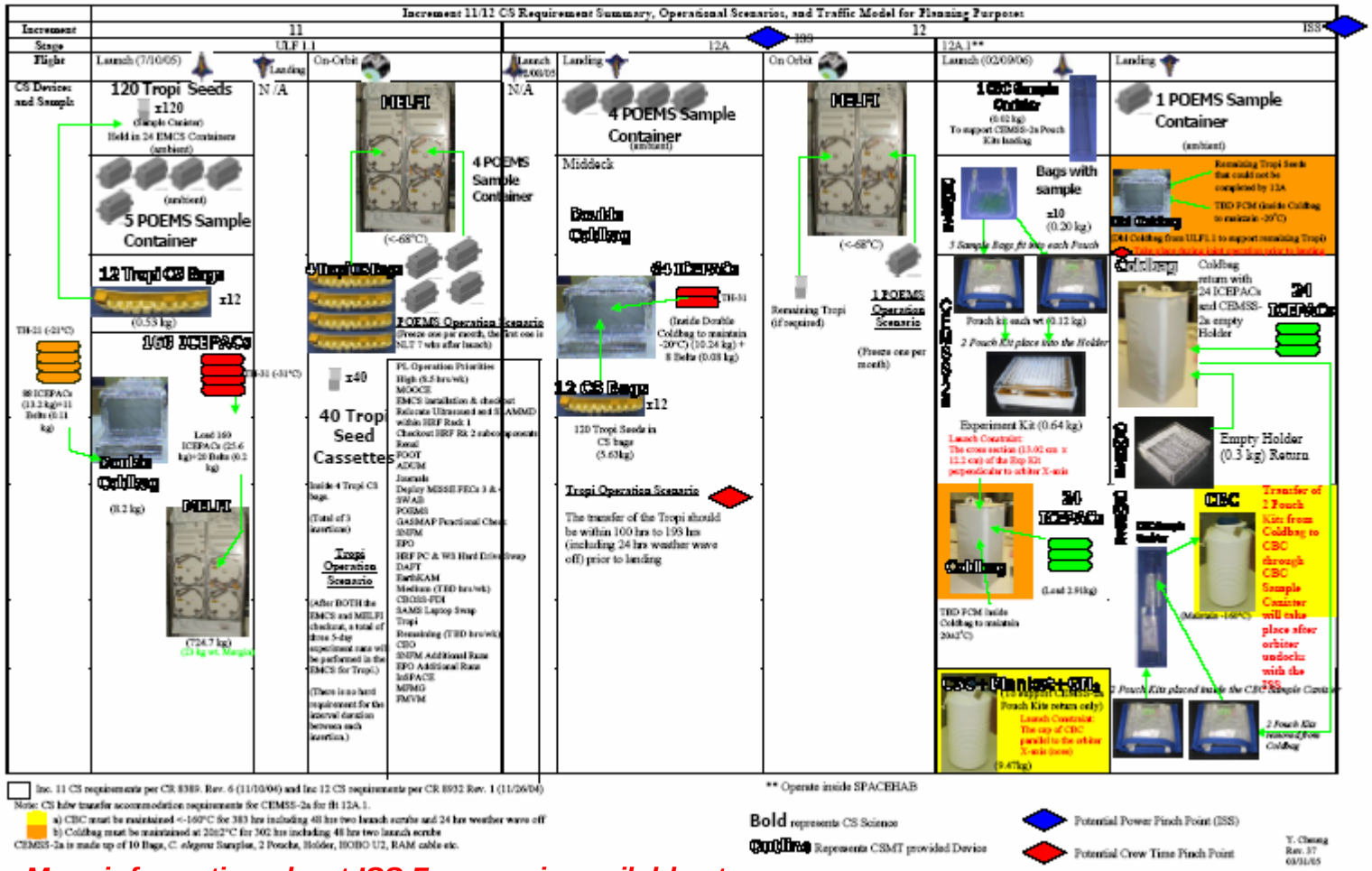
GLACIER Hardware Views



GLACIER Breadboard: -167ºC and 0.9ºC/min cool down demonstrated by test.

GLACIER Breadboard showing Sample Holding Grid

Traffic Model - Increments 11 and 12 only



More information about ISS Freezers is available at :

http://iss-www.jsc.nasa.gov/ss/issapt/payofc/OZ2/ColdStow.html

Minus Eighty Laboratory Freezer for ISS (MELFI)

ISS Cold Stowage Fleet

MELFI Hardware Views

Box modules/trays for one flight rack

1 Tray (of 4) removed from Dewar

MELFI installed in MPLM