NASA Conditioned Stowage Capability

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Susan Hutchison, ISS Payloads Office
Sharon Campana, Engineering
NASA Managed Cold Stowage Resources

• Cold Stowage Fleet
  – Mixed fleet of active and passive systems to maximize mission flexibility and redundancy
  – Temperature range available for Payloads is +48°C to -130°C.
  – All systems are compatible with Shuttle and ISS and some systems are compatible with Progress, HTV, SpaceX CRS and Orbital Cargo CEV (ascent only).

• Active Systems
  • Minus Eighty Laboratory Freezer for ISS (MELFI)
  • Glacier
  • Microgravity Experiment Research Locker/INcubator (MERLIN)

• Passive Systems
  • Cold Stowage Insulated Sample Bag (Double Coldbag)
  • Ice Bricks and Icepac Assemblies

IPs: Usage of NASA Cold Stowage hardware must be negotiated with the OZ Office under a separate barter agreement.

NOTE: ISS Payload Cold Stowage Info can also be found at: http://iss-www.jsc.nasa.gov/nwo/payload/oz2/web/ColdStow.shtml
Active Freezers/Refrigerators

Glacier (Double MDL)

MERLIN (Single MDL)

MELFI
MELFI Rack

MELFI – On-orbit cooling and low temperature science storage facility.

• MELFI complement
  – Three Flight Units on orbit
    – Flight Unit 1 (JEM) powered on
    – Flight Unit 2 (US Lab) powered on
    – Flight Unit 3 (JEM) not powered
  – One Training Unit, one Laboratory Ground Model, & one Engineering Unit
    ✤ Ground units are all located at JSC.

• Each MELFI has four identical dewars which can be controlled independently at certain set points (as long as Dewar 2 is at -95°C). The three set points for dewar temperatures are -95°C, -35°C, and +2°C. One MELFI can hold 175 liters.
  – Dewars are divided longitudinally into four quadrants, each of which holds a long tray. Trays contain ¼ and ½ box modules which hold individual science samples. Eventually all will have ½ box modules.

• MELFI Power off hold time: MELFI can maintain temperature below (-68°C) with power off duration of 8 hours
# MELFI Box Modules

## MELFI Exterior Dimensions *(approximate)*

<table>
<thead>
<tr>
<th>Code -&gt;</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>Max per tray</th>
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<tbody>
<tr>
<td>Internal Volume (L)</td>
<td>Max Width (cm)</td>
<td>Min Width (cm)</td>
<td>Max Width (cm)</td>
<td>Min Width (cm)</td>
<td>Length/Depth (cm)</td>
<td>Door Width (cm)</td>
<td>Door Length (cm)</td>
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<td>Tray</td>
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<td>10</td>
<td>57.5</td>
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<td>7.5</td>
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<tr>
<td>2.67</td>
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<td>7.5</td>
<td>14.3</td>
<td>10.5</td>
<td>13</td>
<td>18.5</td>
<td>11.9</td>
<td>4</td>
</tr>
</tbody>
</table>

* Wall is approximately 1 mm in thickness
Glacier – On-orbit low temperature science storage facility, as well as cold stowage transportation to and from orbit.

- Glacier complement
  - Six Flight Units
  - Two additional Flight Units to be built to support extension of ISS (2011)
  - One Engineering Unit
- Active ascent/descent in Shuttle Middeck, SpaceX CRS and Cargo CEV. Passive ascent in ATV, HTV and Shuttle MPLM.
- Glacier supports a selectable temperature range of +4°C to -130°C
  - Middeck (36 cfm) or EXPRESS (30 cfm) air cooling mode minimum temperature: -95°C
  - EXPRESS water cooling mode (50 lbs/hr) minimum temperature: -130°C
  - Maximum cooling rate 1°C/min to -130°C
- Glacier is a double Middeck locker equivalent in size
Glacier

- For Glacier in the forward Middeck position, Glacier can accommodate **6.22 kg** (13.72 lbs) of total payload mass.
- For Glacier in the aft Middeck position, Glacier can accommodate **4.82 kg** (10.62 lbs) of total payload mass.
- For Glacier in SpaceX Dragon, Glacier can accommodate a minimum if **6.22 kg** of total payload mass. The exact payload mass will be determined after the Dragon loads have been defined.
- Glacier can accommodate a payload as large as 23.1 cm x 16.6 cm x 7.4 cm. (2.84 liters)
  - This is the internal dimension of a GLACIER tray
  - There are four GLACIER trays (effective total volume of all trays is 11.35 liters)

- Power off hold time: Glacier can maintain samples below -68°C for ~ 20 hrs., if it has been operating at -160°C and is 75% full volume. If operating at -95°C, the samples will reach -68°C in ~6 hours, with 75% full volume in Glacier.
GLACIER

• Active Glacier – Ascent (Middeck, COTS vehicles)
  – Launched at cold temperatures with samples installed prior to turn over
  – Payload delivery for late installation at Pad is L-3 days (Middeck) if science is cold conditioned.
  – Payload delivery for late installation at Pad is L-4 days if science is NOT cold conditioned
  – Requires power during transport to pad (supplied by KSC provided ground battery unit)
  – Power interrupts needs to be limited to no more than 30 minutes during ground installation to prevent temperature warm up at or below + 6°C.
  – Turnover times for COTS vehicles is TBD, but could range from L-4 to L-1 days.

• Active Glacier – Descent (Middeck or Dragon)
  – Early destow (science specific – typically R+6 hours for Middeck operations)
  – Requires power during transport from landing strip to the lab (supplied by ground battery unit)
  – De-integration in off-line laboratory
  – Early destow for Dragon vehicle is TBD

▪ Two Glaciers are planned to be on ISS after the Shuttle Program has completed.
MERLIN

MERLIN – On-orbit low temperature and incubation science storage facility, as well as cold/incubation stowage transportation to/from orbit.

- MERLIN complement
  - Seven Flight Units owned by University of Alabama
  - One Qualification/Trainer unit

- Active ascent/descent in Shuttle Middeck. Passive ascent in ATV and Shuttle MPLM.

- MERLIN supports the following temperature ranges
  - Approximately +4°C to +48.5°C in air cooling mode (Middeck). (Air cooling operations may be colder based on payload configuration.)
  - Approximately -20°C to + 48.5°C in water cooling mode (EXPRESS).
  - Maximum heating rate 15°C/min to +48.5°C (MERLIN) (payload specific)

- MERLIN can support **10 kg** of experiment samples (13 kg if c.g. is ideal)

- MERLIN supports a maximum payload size of **7.62 cm x 17.53 cm x 31.24 cm (4.17 liters)**
  - Maximum dimensions based on payload inside of MERLIN pouch
  - Dimensions reflects 1” of foam on the inside walls of the pouch

- MERLIN is a Middeck Locker Replacement
  - 70 lb max weight for integrated configuration (includes internal items and 4.0 lb VPMP)
• **Active MERLIN - Shuttle Ascent** – (utilizes Middeck AAA interface via VPMP)
  – Launched at cold or warm temperatures with samples installed prior to turn over
  – **Payload delivery for late installation at Pad is L-3 days if science is cold conditioned**
  – **Payload delivery for late installation at Pad is L-4 days if science is NOT cold conditioned**
  – Requires power during transport to pad (supplied by ground battery unit)
  – Power interrupts need to be limited to no more than 5 minutes during ground installation when operating temperatures are above or below ambient temperatures by more than 10°C. This will prevent temperature drift away from the desired set point.

• **Active MERLIN - Shuttle descent** - (utilizes Middeck AAA interface via VPMP)
  – Early destow (science specific – typically R+6 hours for Middeck operations)
  – Requires power during transport from the pad (supplied by ground battery unit)
  – De-integration in off-line laboratory

• **MERLIN launched as a Shuttle sortie on 13A.1 supporting SPEGIS.**
• **MERLIN launched on flight 1J/A supporting the WAICO payload for descent.**
• **MERLIN was launched on ULF-2 where it serves as a refrigerator/freezer system for crew food and drink storage in the Galley.**
• **MERLIN launched on 19A supporting JAXA NeuroRad for ascent and other JAXA payloads for descent.**
Passive Cold Stowage Resources

Double Coldbag

Icepac assemblies

Ice Brick assembly
Coldbag

Coldbag – Passive low temperature science storage resource for transportation to/from orbit.

• Coldbag complement consists of
  – 14 Double Coldbags
  – Ice Bricks/Icepacs to provide cold conditioning for Coldbag contents.
• Temperature hold time depends on Ice Brick type & quantity, sample requirements, and environment. (For return - minimum 5.3 to 6 days).
• Double Coldbag
  – One Middeck locker insert in size and weighs 8.2 kg
  – Ice Brick Configuration
    • Supports samples up to **9.53 cm x 22.86 cm x 33.02 cm** in size. (cavity inside 14 Ice Brick configuration) – **7.2 liters**
    • Supports **5.0 kg** of contents including 14 (-32C) Ice Brick assemblies.
  – Max mass with phase change materials (PCMs) and samples – 24.4 kg.
  – Compatible with Shuttle Middeck, MPLM, ISS, Progress, and loaded tested for ATV, HTV and future vehicles.
• Coldbag - ascent
  – Coldbags need to be stowed in early retrieval locations. It can be stowed in a locker or soft stowed.
    If soft stowed, heavy items must not be stowed on top of the Coldbag.
  – Late loaded at the Pad if containing cold samples
  – Samples and Phase Change Material installed prior to turnover
• Coldbag - Descent
  – Early destow if returning cold samples
  – De-integration in off-line laboratory
Ice Brick Assemblies

Ice Brick – Solid-liquid phase change material in a hard plastic rectangular container compatible with the cold stowage systems

- Ice Bricks provide cold conditioning for Coldbag and are designed to be re-freezable on-orbit in active freezers (e.g. MELFI, Glacier, MERLIN).
- Ice Bricks are available in specific melting temperatures: +4°C, -26°C, -32°C, and other temperatures are under investigation.
  - Temperature hold time depends on Ice Brick type & quantity, sample requirements, and environment.
  - Each type is a different color.
  - ~14 Bricks required per Double Cold Bag
- Two Ice Bricks are incorporated into a sleeve which bends in the middle.
- Each Ice Brick assembly weighs between 0.71 – 0.80 kgs. and has a volume of 1.31 liters.
- Cold Stowage Team will determine the Ice Brick configuration based on mission requirements.
Icepac Assemblies

Icepac – Solid-liquid phase change material in a hard plastic capsule compatible with the cold stowage systems

- Icepacs are being phased out in favor of Ice Bricks
- Icepacs provide cold conditioning for Coldbag and are designed to be re-freezable on-orbit in active freezers (e.g. MELFI, Glacier, MERLIN).
- Icepacs are available in specific melting temperatures: +4°C, 0°C, -32°C and others.
  - Temperature hold time depends on Icepac type & quantity, sample requirements, and environment (typically 4 – 10 days). Each type is a different color.
- Icepacs are incorporated into a belt assembly of eight identical Icepac types.
- Each Icepac assembly weighs between 0.97 - 1.29 kgs. and has a volume of 1.9 liters.
- Engineering/EC2 will determine the Icepac configuration based on mission requirements.
Cold Stowage Team

• Cold Stowage (CS) Responsibilities
  • Provide Engineering oversight for hardware development and operations.
  • Deliver CS hardware to KSC for flight and perform off-line operations.
  • Support Cold Stowage hardware and cold stowage operations on-orbit.
  • Integrated Cold Stowage Performance analysis
  • Compatibility Analysis for Safety

• Cold Stowage Partners
  – NASA JSC
    • OZ Payloads Office
    • EC Thermal System and Engineering Support
  – Contractors
    • Jacobs Engineering (Engineering Science Contract)
    • University of Alabama Center for Biophysical Science and Engineering
Cold Stowage Services Available to Payloads

- On-orbit operation of MELFI, MERLIN, Glacier systems for contained payloads in full coordination with MSFC POIC.
- Cold sample launch is supported at the launch location.
- Cold sample return is supported at the landing location, including back-up landing sites.
- Testing in Cold Stowage Laboratory
  - Ability to conduct thermal cycle testing (i.e. acceptance thermal cycle, cryo-cycle, etc.) in the range of +93°C to -191°C.
  - Conduct thermal performance tests (e.g. determine how long will samples will stay cold in Double Coldbag or MELFI during a power off)
  - End-to-end/Science Verification testing duplicating planned on-orbit scenarios with CS Fleet
  - Load testing of samples in range +93°C to -150°C
- Crew Training
  - MELFI Cold Skills Training
  - Coldbag/Ice Brick Packing Training
  - MERLIN/Glacier Expert or User Training
- Engineering Evaluations
  - Full function Engineering Units of all systems including MELFI, Glacier, and MERLIN
  - Conduct fit checks and develop packing plans for Payloads utilizing Cold Stowage Fleet