Space Station Fluid Resupply

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Space Station Fluid Resupply

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Space Station Fluid Resupply

- Requirements

  Resupply (PMC)

  ECLSS Fluids
  \[ \sim 3200 \text{ lbs } N_2 \text{ per year} \]
  \[ \sim 3500 \text{ lbs } O_2 \text{ per year} \]

  LAB Fluids
  \[ \sim 1300 \text{ lbs } N_2 \text{ per year} \]

  Contingency

  ECLSS Fluids
  \[ \sim 700 \text{ lbs } N_2 \text{ on station} \]
  \[ \sim 900 \text{ lbs } O_2 \text{ on station} \]
## Space Station Fluid Resupply

**Space Station Freedom**

**Design Considerations:**

<table>
<thead>
<tr>
<th>Resupply</th>
<th>~ 180 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resupply Frequency</td>
<td>High pressure gas</td>
</tr>
<tr>
<td>Transportation State</td>
<td>Supercritical fluid</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contingency</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Frequency</td>
<td>On station @ PMC; as required thereafter</td>
</tr>
<tr>
<td>Transportation State</td>
<td>High pressure gas (3000 psi) Supercritical fluid</td>
</tr>
</tbody>
</table>
Space Station Fluid Resupply

Space Station Freedom

- Unpressurized Logistics Carrier

Outfitting
- Cargo Accommodations
  - Subcarrier Attach Mechanisms
  - Nor: Containerized Cargo Attachments

- Subsystems
  - EPS
  - DMS
  - TSS
  - MS
  - Passive Thermal Control System (PTCS)

Characteristics
- Empty Weight: 2,251 lbs

- Cargo Accommodation capability
  - Combinations of Subcarriers (ESC, OSC, HPSC, DCSC)
  - Seat Track on Member Faces for Oversized Cargo

- Automated Umbilical Mechanism
- Subcarrier Attachment Mechanisms
Space Station Fluid Resupply

Space Station Freedom

- Fluids Subcarrier (FSC)

Outfitting
- Cargo accommodations
  - 3 ECLSS Supercritical N₂ (SCN₂) tanks
  - 1 Lab SCN₂ tank

- Subsystems
  - MS
  - FPS
  - DMS
  - TSS
  - Passive Thermal Control System (PTCS)
  - Tanks and Plumbing
  - Mechanisms
    - Automated Umbilical Mechanism
    - U³C Attachment Mechanism
    - ITA Attachment Mechanism

Characteristics
- Total Dry Weight - 1940 lbs
- Cargo Accommodations Capability
  - ECLSS SCN₂ - 1434 lbs
  - Lab SCN₂ - 478 lbs
Space Station Fluid Resupply

- Oxygen Subcarrier (OSC)

![Diagram of oxygen subcarrier]

**Outfitting**
- Cargo accommodations
  - 3 ECLSS Supercritical O\(_2\) (SCO\(_2\)) tanks
- Subsystems
  - MS
  - EPS
  - DMS
  - TSS
  - Passive Thermal Control System (PTCS)
  - Tanks and Plumbing
  - Mechanisms
    - Automated Umbilical Mechanism
    - ULC Attachment Mechanism
    - ITA Attachment Mechanism

**Characteristics**
- Total Dry Weight - 1459 lbs
- Cargo Accommodations Capability
  - ECLSS SCO\(_2\) - 2.75 lbs
Space Station Fluid Resupply

- High Pressure Subcarrier (HPSC)

Outfitting
- Cargo accommodations
  - 3 High Pressure N₂ (HPN₂) tanks
  - 2 HP O₂ tanks

- Subsystems
  - MS
  - EPS
  - DMS
  - TSS
  - Passive Thermal Control System (PTCS)
  - Mechanisms
    - Automated Umbilical Mechanism
    - ULC Attachment Mechanism
    - ITA Attachment Mechanism

Characteristics
- Total Dry Weight – 3226 lbs
- Cargo Accommodations Capability
  - HPN₂ – 588 lbs
  - HPO₂ – 506 lbs
Space Station Fluid Resupply

- Transportation and Transfer Plan – Resupply
  - Prelaunch and post launch operations phases
    - Load fluids into supercritical tanks on the subcarriers
    - Transport fluids to the SS in a liquid state
  - On station operations phase
    - Change state of fluid from liquid to supercritical by turning on tank heaters
    - Transfer fluids from subcarriers to users
    - Complete unloading of subcarriers
  - Prelanding operations phase
    - Return subcarriers with residual gas
Space Station Fluid Resupply

* Operations Phase Definitions

- All LE's go through complete operations cycles consisting of 6 primary phases
- Hab and US Lab go through operations cycles 1, 2 and 3 TOTAL CYCLE

PHASE DEFINITIONS

1. **Pre Launch Phase**
   Begins at start of preparations and processing for launch and ends at launch.

2. **Post Launch Phase**
   Begins at launch and ends at completion of element installation on SS.

3. **On Station Operations Phase**
   Begins at completion of element installation on SS and ends at start of transfer of returning LE from SS to the orbiter.

4. **Prelanding Phase**
   Begins at start of transfer of returning LE from SS to the orbiter and ends at landing.

5. **Post Landing Phase**
   Begins at landing and ends at completion of LE offload operations.

6. **LE Turnaround**
   Begins at completion of LE unloading operations and ends at start of LE prelaunch operations.
Space Station Fluid Resupply

- Operations Flow - FSC and OSC

Fluids State (N₂ and O₂)

- Loaded @ ~ 20 psia and - 320°F (N₂) and TBD°F (O₂)
- Tank Pressure @ Launch ~ 31.5 psia

Liquid

Timeline Hrs/Days

- 568 Hrs (1)
- 560 Hrs (1)
- 544 Hrs (1)
- 400 Hrs (1)
- 72 Hrs (1)
- 0
- + 1.5 Hrs (2)
- + 31 Hrs (2)
- + 45 Hrs (2)

Operations

- Start Loading Fluids
- Complete Loading Fluids
- Emplace Subcarriers into ULC
- Emplace ULC into Orbiter
- Close PLB Doors
- Launch Orbiter
- Open PLB Doors
- Dock Orbiter on-Station
- Connect SSRMS to ULC

Note: While in the liquid state, pressure and temperature will slowly rise in the tanks

Note: 4 day contingency allowance included in this timeline

(1) Preliminary timeline estimate
(2) Preliminary timeline estimate from NSTS Integration and Operations Office
Space Station Fluid Resupply

- Operations Flow - FSC and OSC (continued)

Fluid States
(N₂ and O₂)

Timeline Hrs/Days

Operations

Connect ULC to ITA
Parking and C/O Complete for ULC on ITA
Parking and C/O Complete for sub-carriers on ITA
Start subcarrier heater duty cycle
Start transfer of fluids from subcarriers to User
Launch next Orbiter
Dock Orbiter On-Station
Parking and C/O Complete for second subcarrier set on ITA
Complete Unloading of first subcarrier set

N₂ Delivered @ 550 - 700 psia and ~ -300° F (start) to -130° F (start + 180 days)
O₂ Delivered @ 840 - 950 psia and temperature TBD

Critical Pressure
- 493 psia (N₂)
- 736 psia (O₂)

Note: Heater cycles to increase pressure and expell gas

(1) Preliminary timeline estimate
(2) Preliminary timeline estimate NSTS Integration and Operations Office
Space Station Fluid Resupply

- Operations Flow - FSC and OSC (continued)

Timeline:
- Fluids State (N\textsubscript{2} and O\textsubscript{2})
- Residual Gas
- Returned @ 120 psia and -130°F (N\textsubscript{2} and O\textsubscript{2})

Operations:
- + TBD: Emplace first subcarrier set into ULC
- + TBD: Start transfer of ULC from ITA to Orbiter
- + TBD: Emplace ULC into Orbiter
- + 186.9 Days: Unlock Orbiter from Station
- (2) + 187 Days: Close PLB doors

(1) Preliminary timeline estimate
(2) Preliminary timeline estimate from NSTS Integration and Operations Office
Space Station Fluid Resupply

- Transportation and Transfer Plan – Contingency
  - Prelaunch and post launch operations phases
    - Load fluids into high pressure tanks on the HPSC
    - Transport fluids to the SS in a gaseous state
  - On station operations phase
    - Transfer fluids as required
    - Replace HPSC as required
Space Station Fluid Resupply

- Summary
  - SSF is resupplied with supercritical \( O_2 \) and \( N_2 \) for the ECLSS and USL on a 180 day resupply cycle
  - Resupply fluids are stored in the subcarriers on station between resupply cycles and transferred to the users as required
  - ECLSS contingency fluids (\( O_2 \) and \( N_2 \)) are supplied and stored on station in a gaseous state
  - Efficiency and flexibility are major design considerations
  - Subcarrier approach allows multiple manifest combinations
  - Growth is achieved by adding modular subcarriers