• Requirements

Resupply (PMC)

ECLSS Fluids \( \sim 3200 \) lbs \( N_2 \) per year

LAB Fluids \( \sim 3500 \) lbs \( O_2 \) per year

Contingency

ECLSS Fluids

\( \sim 700 \) lbs \( N_2 \) on station

\( \sim 900 \) lbs \( O_2 \) on station
Space Station Fluid Resupply

Space Station Freedom

- Design Considerations:
  
  Resupply
  
  Resupply Frequency  ~ 180 days
  Transportation State  High pressure gas
  Contingency  Supercritical fluid
  Supply Frequency  On station @ PMC; as required thereafter
  Transportation State  High pressure gas (3000 psi)
  Supercritical fluid
Space Station Fluid Resupply

Space Station Freedom

Pressurized Logistics Module (PLM)
(3 required)
- Cargo:
- Crew Support:
  - Food
  - Personnel supplies
  - Housekeeping supplies
- Station Support:
  - Maintenance supplies
  - Spares
  - EVA support
- Customer Support:
  - USL Equipment & supplies
  - JEM Equipment & supplies
  - Columbus equipment & supplies
- GSE Roller Floor

- Unpressurized Logistics Carrier (ULC) (4 required)
- Carriers
  - Station spares
  - Platform and satellite supplies (refill and ORU's)
  - Attached payloads
  - Inflatable launch integrable fluid/propellant subcarriers
  - Direct mounting for a variety of non-conventional cargo configurations

- Subcarriers
  - Provides multiple combinations of subcarriers with the ULC
  - Efficient manifesting
  - Subcarriers are attached by automatic attachment and umbilical mechanisms

- High Pressure Gas subcarrier (HPSC) (6 required)
- Oxygen subcarrier (OSC) (3 required)
- Fluids subcarrier (FSC) (3 required)
- Dry Cargo subcarrier (DCSC) (8 required)
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)
- Mechanisms
  - Automated Umbilical Mechanism
  - Subcarrier Attachment Mechanisms

Characteristics
- Empty Weight: 2,251 lbs
- Cargo Accommodation capability
  - Combinations of Subcarriers (FSC, OSC, HPSC, DCSC)
  - Seat Track on Member Faces for Oversized Cargo
Space Station Fluid Resupply

Space Station Freedom

- Fluids Subcarrier (FSC)

Outfitting
- Cargo accommodations
  - 3 ECLSS Supercritical \( N_2 \) (SCN\(_2\)) tanks
  - 1 Lab SCN\(_2\) tank

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

Characteristics
- Total Dry Weight - 1940 lbs
- Cargo Accommodations Capability
  - ECLSS SCN\(_2\) - 1434 lbs
  - Lab SCN\(_2\) - 478 lbs
Space Station Fluid Resupply

- Oxygen Subcarrier (OSC)

Outfitting
- Cargo accommodations
- 3 ECLSS Supercritical O₂ (SCO₂) 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 SCO₂ - 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

Space Station Freedom

**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's 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

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
- 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)

Fluids States
(N_2 and O_2)

Timeline Hrs/Days

Operations

(1) Preliminary timeline estimate

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

Operations Flow - FSC and OSC (continued)

- Fluids State
  \(\text{N}_2\) and \(\text{O}_2\)

- Residual Gas

- Returned @ 120 psia and \(-130^\circ\text{F} (\text{N}_2\) and \(\text{O}_2)\)

Timeline

- Hrs/Days

Operations
- + TBD
- + TBD
- + TBD
- + 185.7 Days
- + 186.9 Days
- + 187 Days

- Emplace first subcarrier set into ULC
- Start Transfer of ULC from ITA to Orbiter
- Emplace ULC into Orbiter
- Unlock Orbiter from Station
- Close PLB doors
- Land

(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 O₂ and N₂ 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 (O₂ and N₂) 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