Space Station Fluid Resupply

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Space Station Fluid Resupply

Contents:

Requirements
Design Considerations
Configurations
Operations
Summary
Space Station Fluid Resupply

- **Requirements**

  Resupply (PMC)

  ECLSS Fluids
  ~ 3200 lbs N₂ per year
  ~ 3500 lbs O₂ per year

  LAB Fluids
  ~ 1300 lbs N₂ per year

  Contingency

  ECLSS Fluids
  ~ 700 lbs N₂ on station
  ~ 900 lbs O₂ on station
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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:
  - 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 (re-supply and ORUs)
    - Attached payload
    - Interchangeable launch integrable fluid/propellant subcarriers
    - Direct mounting for a variety of non-commercial 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)
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- Unpressurized Logistics Carrier

Outfitting
- Cargo Accommodations
  - Subcarrier Attach Mechanisms
  - No: 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 (FSC, OSC, HPSC, DCSC)
  - Seat Track on Member Faces for Oversized Cargo

- Automated Umbilical Mechanism
- Subcarrier Attachment Mechanisms
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- **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
  - UL-C Attachment Mechanism
  - ITA Attachment Mechanism

**Characteristics**
- Total Dry Weight - 1940 lbs
- Cargo Accommodations Capability
  - ECLSS SCN₂ - 1434 lbs
  - Lab SCN₂ - 478 lbs
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- 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
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• 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
• 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
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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 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.
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- 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 (N₂ and O₂)

Timeline Hrs/Days

Operations

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

Liquid to Supercritical Transformation

Critical Pressure
N₂ = 493 psia
O₂ = 736 psia

Note: Heater cycles to increase pressure and expell gas

(1) Preliminary timeline estimate
(2) Preliminary timeline estimate NSTS Integration and Operations Office

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

+ 46 Hrs (1)
+ 47 Hrs (1)
+ 49 Hrs (1)
+ 49.5 Hrs (1)
+ 73.5 Hrs (1)
+ 180 Days (2)
+ 181.3 Days (2)
+ 182 Days (2)
+ TBD
Space Station Fluid Resupply

- Operations Flow - FSC and OSC (continued)

Fluids State
\( (N_2 \text{ and } O_2) \)

Residual Gas

Returned @ 120 psia and - 130°F \((N_2 \text{ and } O_2)\)

Timeline Hrs/Days

\[ + \text{TBD} \quad + \text{TBD} \quad + \text{TBD} \quad + 185.7 \text{ Days} + 186.9 \text{ Days} + 187 \text{ Days} \]

Operations

- 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 \( O_2 \) 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