Human Servicing Mission: Sun-Earth L2 Telescope

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Human Servicing Mission (HSM): Sun-Earth L2 Telescope

- Mission Description
- Mission Requirements
- Mission Systems
- Mission Mass Statements
- Launch Manifests

Hubble Servicing Capabilities Are Applicable to JWST and other SEL2 Telescopes

http://spaceflight.nasa.gov/gallery/images/shuttle/sts-125

http://www.jwst.nasa.gov/about.html
SEL2 HSM Description

- Launch
- LEO operations
- LEO departure
- Transit (14 - 40 d)
- SEL2 arrival
- Telescope servicing (14d)
- SEL2 departure
- Transit (14 - 40 d)
- Reentry preparation
- Direct entry, aerobrake capture, or propulsive capture
SEL2 HSM Requirements

- **Velocity changes**
  - LEO departure/capture: 3198 – 3236 m/s
  - SEL2 arrival/departure: 338 – 1000 m/s
  - Post-aerobrake circularization: 100 m/s

- **Personnel**: 6 (4 EVA; 1 pilot; 1 commander)

- **Duration**: 42 – 94 d
  - 14 – 40 d out; 14 d @ SEL2; 14 – 40 d back

- **Consumables**: Oxygen, nitrogen, water, food

- **Required capabilities**: habitation, manipulators, EVA
SEL2 Telescope HSM Systems

- Crew launch – Boeing Crew Vehicle or SpaceX Dragon
- Transit habitation module – Bigelow Sundancer
- Airlock – ISS or Shuttle Airlock
- EVA – Shuttle spacesuits
- EVA Tools – Hubble tool kit
- Manipulator – OE ARMS and ISS Dextre for robotic aid
- Telescope mechanical interface – Hubble FSS
Existing Hardware Elements Can Support HSM for SEL2 Telescope

- Quest Joint Airlock Module (NASA) or Shuttle Airlock
- Bigelow Sundancer
- Hubble Flight Support System
- Hubble Servicing Tool Kit
- ISS Dextre by MDA
- Shuttle EVA Suits
- Boeing Crew Vehicle
- Orbital Express ARMS by MDA

March 24-26, 2010

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Comparing Aerobrake with Direct Entry Shows Infrastructure Can Be Retained for 20 - 30 t IMLEO

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<th>Aerobrake Return to LEO</th>
<th>Direct Entry</th>
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<td>Crew vehicle 10.0</td>
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<tr>
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<td>Bigelow Sundancer 10.0</td>
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<tr>
<td>Bigelow Sundancer</td>
<td>Airlock (Shuttle – ISS) 1.8 – 6.1</td>
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<tr>
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<td>Crew (6) 0.8</td>
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<tr>
<td>Crew (6)</td>
<td>EVA suits (4) 0.5</td>
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<tr>
<td>EVA Suits (4)</td>
<td>Dextre 1.7</td>
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<tr>
<td>Dextre</td>
<td>Orbital Express ARMS 0.2</td>
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<tr>
<td>Orbital Express ARMS</td>
<td>Repair kit 5.0</td>
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<tr>
<td>Repair kit</td>
<td>Margin 7.0</td>
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<td>Propellant 75.6 – 156.9</td>
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<td>Propellant</td>
<td>Transfer stage inert 8.3 – 15.2</td>
</tr>
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<td>Transfer stage inert</td>
<td>129.5 – 223.8</td>
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| Direct Entry                            | 111.1 – 192.4               |
| Propellant                              | Transfer stage inert 7.1 – 14.8 |
| Margin                                  | 129.5 – 223.8               |

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SEL2 HSM Manifests
Need 11 – 160 t Launch Capability

### Aerobrake Return to LEO

<table>
<thead>
<tr>
<th>Manifest without Depot</th>
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<th>Manifest 2 with Depot</th>
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<tr>
<td>1. Aerobrake, Hab, Tools 43.3 – 50.1</td>
<td>1. A/B, hab, tools, stage 53.5 – 59.9</td>
<td>1. A/B, tools, stage 40.6 – 55.0</td>
</tr>
<tr>
<td>2. Transfer Vehicle 84.1 – 156.9</td>
<td>2. Crew Vehicle 10.8</td>
<td>2. Habitat 11.1 – 12.6</td>
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<td>3. Crew Vehicle 10.8</td>
<td>Depot Propellant 75.7 – 88.5</td>
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### Direct Entry

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<td>2. Transfer Vehicle 71.1 – 148.5</td>
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Depot propellant 75.7 – 88.5
LEO Propellant Depot Reduces SEL2 HSM HLV Requirement from 70 – 160 t to 25 – 60 t
Human Servicing of SEL2 Telescopes Requires Enhanced Capabilities

- Servicing capabilities from Hubble and Orbital Express

- Direct entry upon return requires...
  - Heavy Lift Vehicle (75 – 150 t) for transfer stage, or
  - LEO propellant transfer/depot, or
  - Assembly of multiple transfer stages in LEO

- Aerobrake for asset recovery in LEO