

APPROVAL SHEET FOR SUSPENDED LOAD OPERATIONS

SLO-KSC-2002-002

TITLE Mars Exploration Rover (MER) Lifting Operations
in the PHSF High Bay

DOCUMENT NUMBER/TITLE MER420-S-46XX

PREPARED BY M. Glenn

DATE 10/25/02

REQUIRED APPROVAL

CONTRACTOR DESIGN R & QA OPERATIONS SAFETY
 NASA DESIGN R & QA OPERATIONS SAFETY

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1.0 OPERATION: Mars Exploration Rover (MER) lifting operations in the PHSF High Bay.

2.0 SUPPORTING DOCUMENTS: The associated System Assurance Analysis (SAA) and MER Procedures are:

SAA 01HS11-005 - 50-ton Bridge Crane PHSF

MER420-5-4656 Flight System: Handling and Transportation

MER420-5-4646 Flight System: Cruise Stage/Entry Vehicle Integration and Deintegration

MER420-5-4633 Entry Vehicle: Mars Lander Module Back-Shell Integration and Deintegration

MER420-5-4658 Spin Test Mechanical Preparation and Support

MER420-5-4650 S/C and 3rd Stage Integration

3.0 GENERAL DESCRIPTION: The following Mars Exploration Rover operations require three personnel to be directly under the lifting fixture, load cell and hydra-set or under the Flight Hardware. (Ref. attached figures)

Case 1-

1) Attaching/Detaching the MER S/C on & off the Turnover Fixture (Fig.1)

Case 2-

2) Attaching/Detaching the entry /descent and landing (EDL) Stage on & off the Turnover Fixture. (Fig. 2)

Case 3-

3) Attaching/Detaching the EDL from the MER Cruise Stage (Fig. 3)

Case 4-

4) Attaching the Lander to the Backshell (Fig. 4)

Case 5 and 6-

5) Attaching/Detaching the EDL or the MER S/C on & off the Spin Balance Machine (Figs. 5 and 6).

Case 7 -

6) Mounting the MER S/C onto the Delta 3rd stage.

These operations require three personnel to work below the Lift Fixture when suspended from the facility crane in the PHSF High Bay. These lift operations will be performed using approved procedures outlined in para.2.0 above. The test procedures will include warnings and precautions to minimize the exposure of personnel to suspended loads.

4.0 RATIONALE/ANALYSIS: The MER suspended load operations comply with the NASA Alternate Safety Standard for Suspended Load Operations because:

Alternate Standard Requirement 1 a: For cases 1 thru 4, The Flight System (F/S) components do not have lifting provisions to allow them to be inverted and suspended above the component to which they are mating. In cases 5, 6 and 7, the spacecraft mating/separation ring is smaller in diameter than the outer diameter of the spacecraft. It is necessary to position personnel beneath the flight hardware to ensure proper mating and de-mating in order to prevent damaging the flight separation surface.

Alternate Standard Requirement 1 b: For cases 1 thru 4, As shown in Figures 1 thru 4, the personnel are in the prone position during the assembly operation. As such, the height of the work platform handrail would absorb the impact of a falling lift fixture. The rails have been analyzed and are capable of withstanding 5 times the lift fixture weight before overall yielding occurs. However, if the fixture were to break loose from the crane hook, the hydra-set and load cell could swing below the handrail level and injure personnel on the platform.

In cases 5, 6 and 7, a secondary support system is not feasible because the separation interface represents the only primary structure interface for the spacecraft.

Alternate Standard Requirement 1 c: The handling procedures will limit the number of personnel beneath the suspended load to no more than three.

Alternate Standard Requirement 1 d: The MER Flight System personnel will accomplish the mating and separation tasks as quickly and safely as possible to minimize exposure. Procedures listed in para.2.0 will control these operations.

Alternate Standard Requirement 2: MER suspended load operations will be reviewed and approved on a case-by-case/specific need basis.

Alternate Standard Requirement 3: Only MER suspended load operations approved by the NASA Safety & Mission Assurance Division Chief will be permitted. The NASA Safety & Mission Assurance Division will maintain a list of these operations.

Alternate Standard Requirement 4: Operational requirements will be included in approved procedures (para.2.0). These procedures will be on site during MER operations for inspection.

Alternate Standard Requirement 5: Any new MER suspended load operation not covered by this SLOAA, deemed necessary due to unusual or unforeseen circumstances where real time action is required, shall be documented and approved by the NASA Safety & Mission Assurance Division Chief.

Alternate Standard Requirement 6: The PHSF 50-ton bridge crane is tested, inspected, maintained, and operated in accordance with the NASA Standard for Lifting Devices and Equipment, NASA-STD-8719.9.

The crane is load tested at 100 percent rated capacity annually and has a monthly, quarterly, semi-annual and annual preventative maintenance program to ensure proper operation. The crane is load tested to 125 percent rated capacity when new or following a major repair or modification.

The spacecraft lift fixture was designed with an ultimate factor of safety of 8.0 times rated load and proof tested to a factor of 2.0 times rated load annually. The lift fixtures were designed to handle the worst-case spacecraft weight and crane accelerations.

When lifting the Flight Hardware, the crane will be connected to a hydra-set, crane scale, lift fixtures, and spacecraft. Maximum weight of the spacecraft is approximately 2000 pounds.

Only certified crane operators will be allowed to operate the crane.

An individual will be stationed at the crane main circuit breaker during hoisting to immediately remove power, thus setting the brakes, should a failure occur with the crane controls.

The crane will be operated in a slow-speed mode when the Flight Hardware is in close proximity to its initial or final testing position.

Alternate Standard Requirement 7: System Assurance Analysis (SAA) has been performed on the PHSF crane that will be used to lift the spacecraft. Each SAA includes a Failure Modes and Effects Analysis/Critical Items list (FMEA/CIL) and a hazard analysis.

The SAA (SAA 01HS11-005) for the 50-ton Bridge Crane in PHSF 2 identifies no Category 1 Mechanical or Electrical Critical Items.

A hydra-set will be used for the initial 1 or 2 inches of travel during separation and the final 1 or 2 inches of travel during mating.

Pre-operational checks of the crane control system will be performed prior to each lift of the spacecraft.

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Alternate Standard Requirement 8: Pre-operational inspections will be performed. The spacecraft lift fixtures have been proof tested, dye-penetrant inspected, tagged and will be visually inspected prior to each spacecraft lift.

Alternate Standard Requirement 9: Trained and certified crane operators shall operate the crane controls at all times when personnel are beneath suspended loads.

Alternate Standard Requirement 10: Para 2.0 procedures establish appropriate hazard control areas before initiating operations. Only the minimal number of personnel (man-loaded in procedure) will be permitted in this area.

Alternate Standard Requirement 11: A pre-task briefing and a safety walk down of the hazard control area will be performed immediately prior to each operation to ensure personnel are ready to support.

Alternate Standard Requirement 12: Personnel beneath the suspended load will be in voice contact with the crane operator and test conductor throughout the operation. At any time during the operation anyone can call a safety hold. The crane operator will have full visual contact with the load throughout the operation.

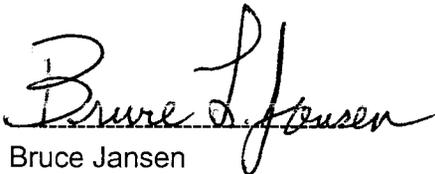
Alternate Standard Requirement 13: The test conductor, the crane operator, and the crane power cut-off switch operator will be in visual contact with the personnel beneath the suspended load throughout the operation.

Alternate Standard Requirement 14: The NASA Safety & Mission Assurance Division shall conduct periodic reviews to ensure the continued safety of MER suspended load procedures.

Alternate Standard Requirement 15: The NASA Safety & Mission Assurance Division will provide copies of approved SLOAA's; a list of approved MER suspended load operations, a list of cranes/hoists used for suspended load operations and copies of the associated FMEA/CIL and hazards analyses to NASA Headquarters.

APPROVAL:

DATE:



Bruce Jansen
Chief, ISS/Payload Processing Safety and Mission Assurance Division
Kennedy Space Center

10/2/02

Figure 1 Attaching/Detaching the MER S/C On & Off the Turnover Fixture

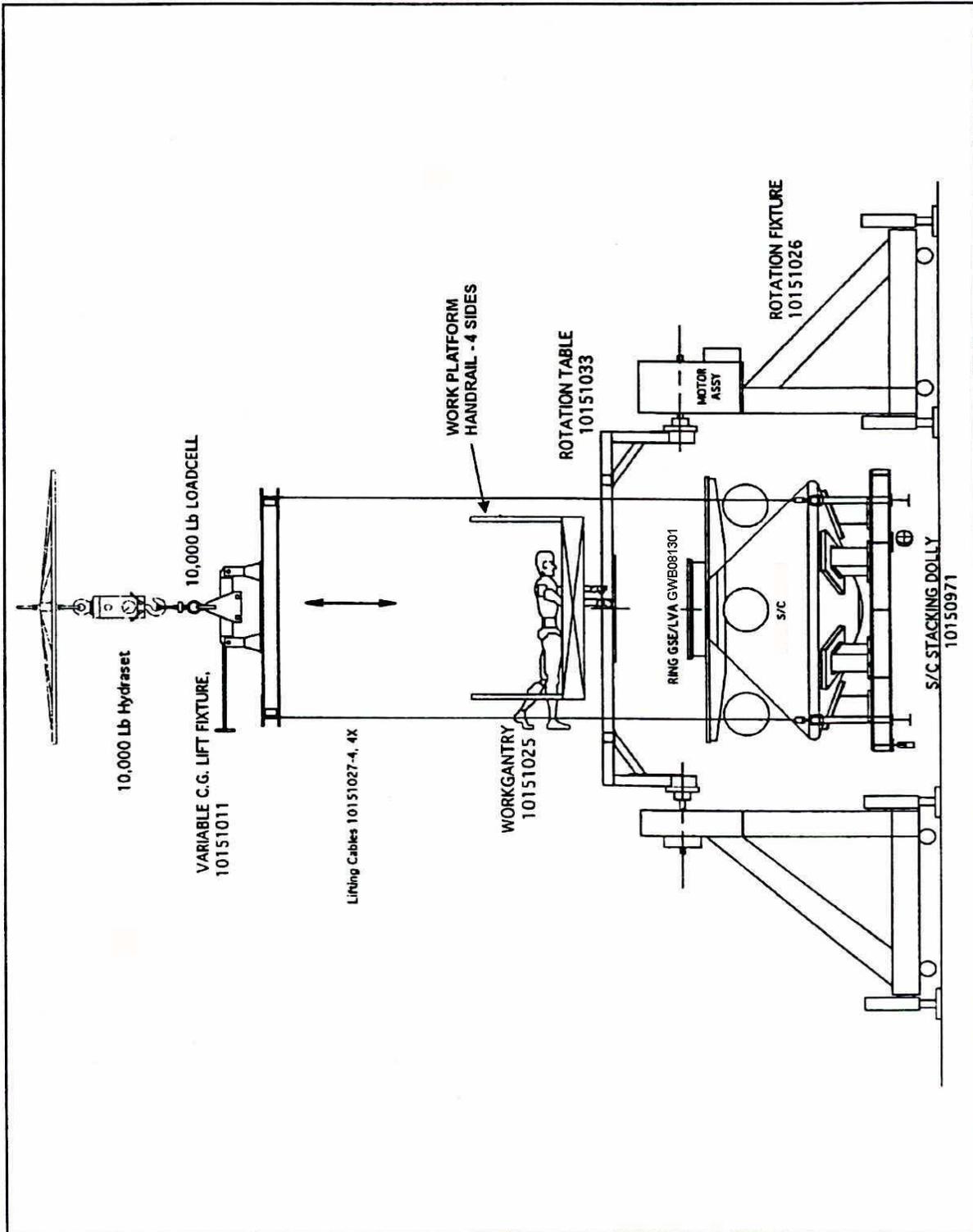


Figure 2 Attaching/Detaching the EDL On & Off the Turnover Fixture

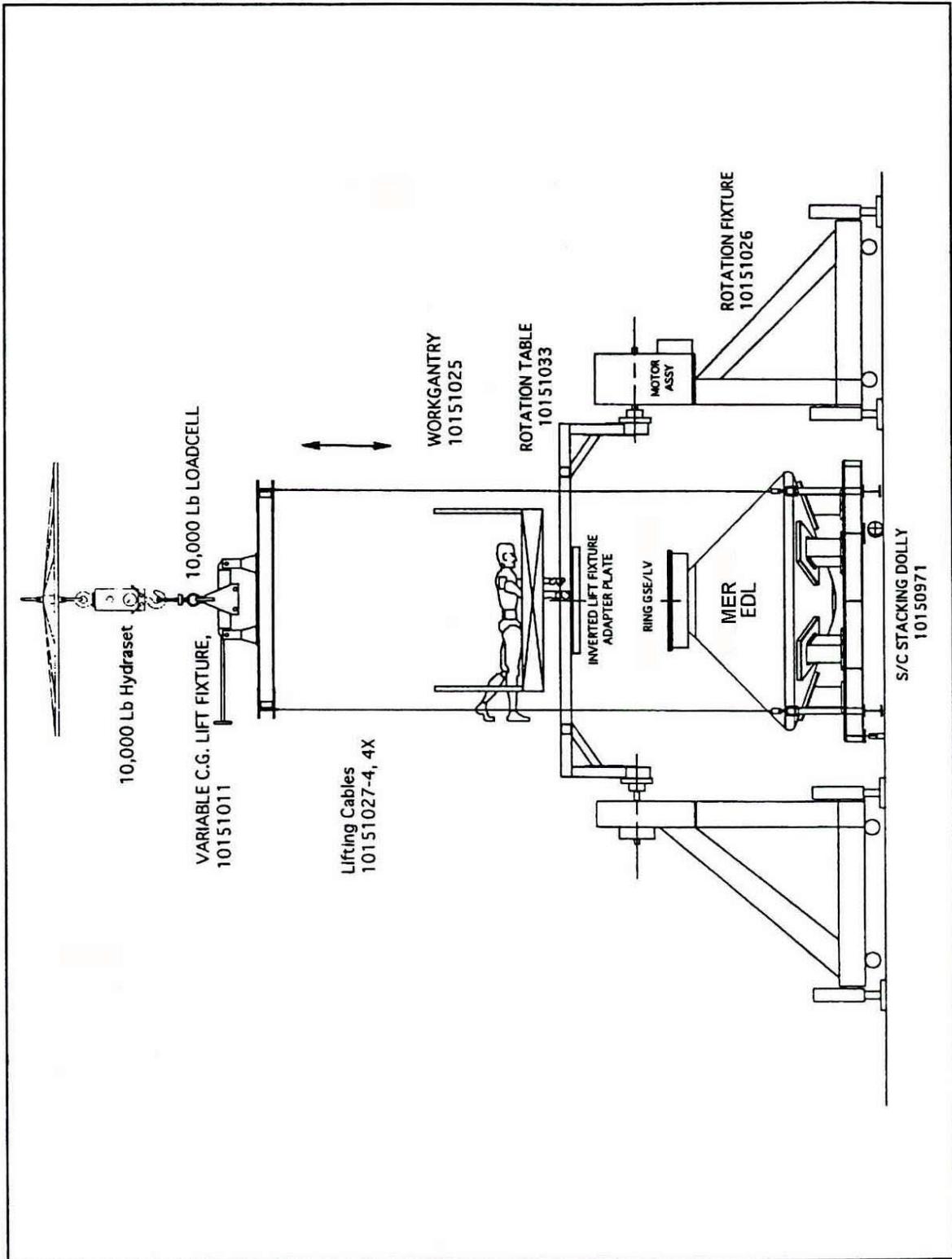


Figure 3 Attaching/Detaching the EDL from the MER Cruise Stage

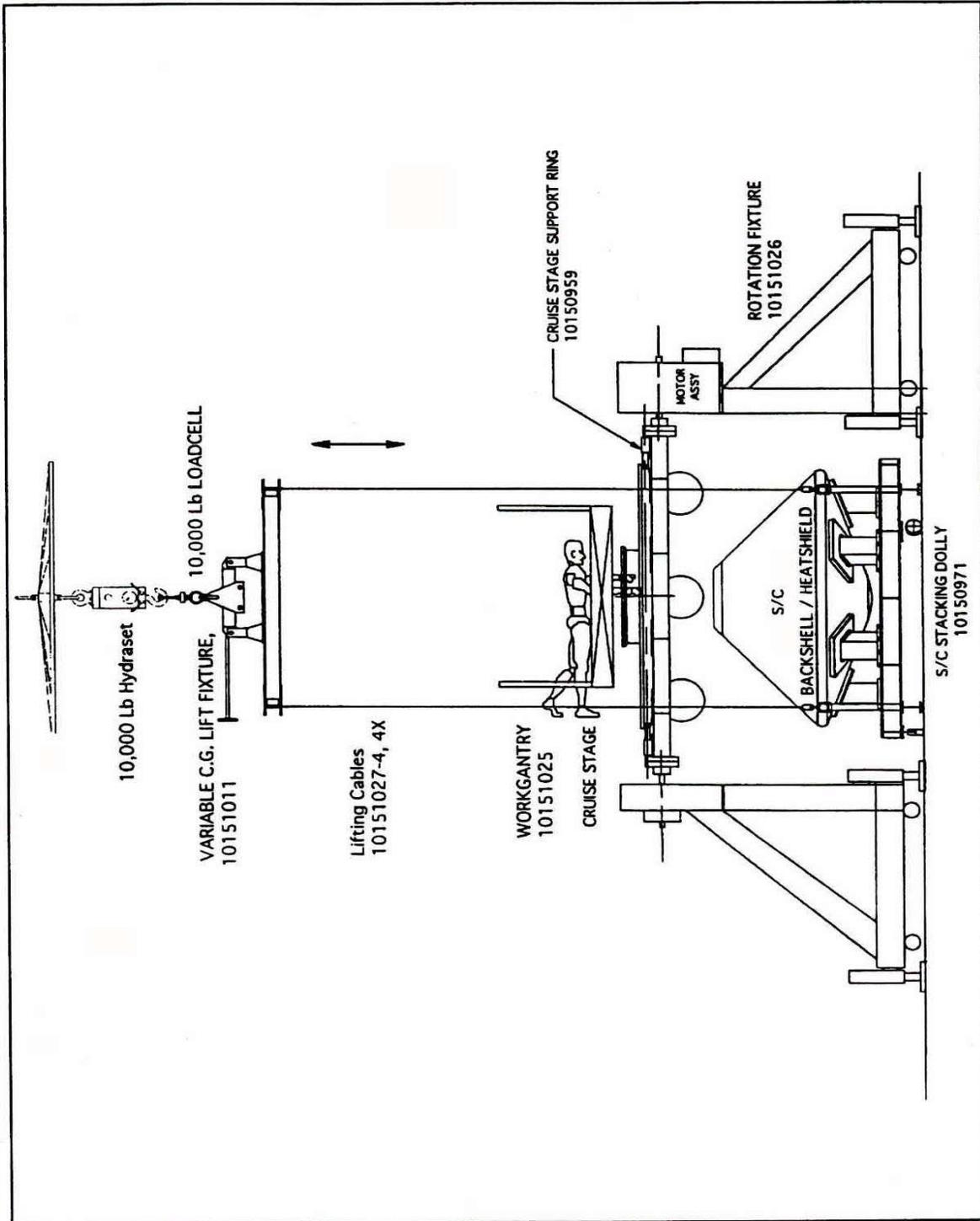


Figure 4 Attaching the Lander Into the Backshell

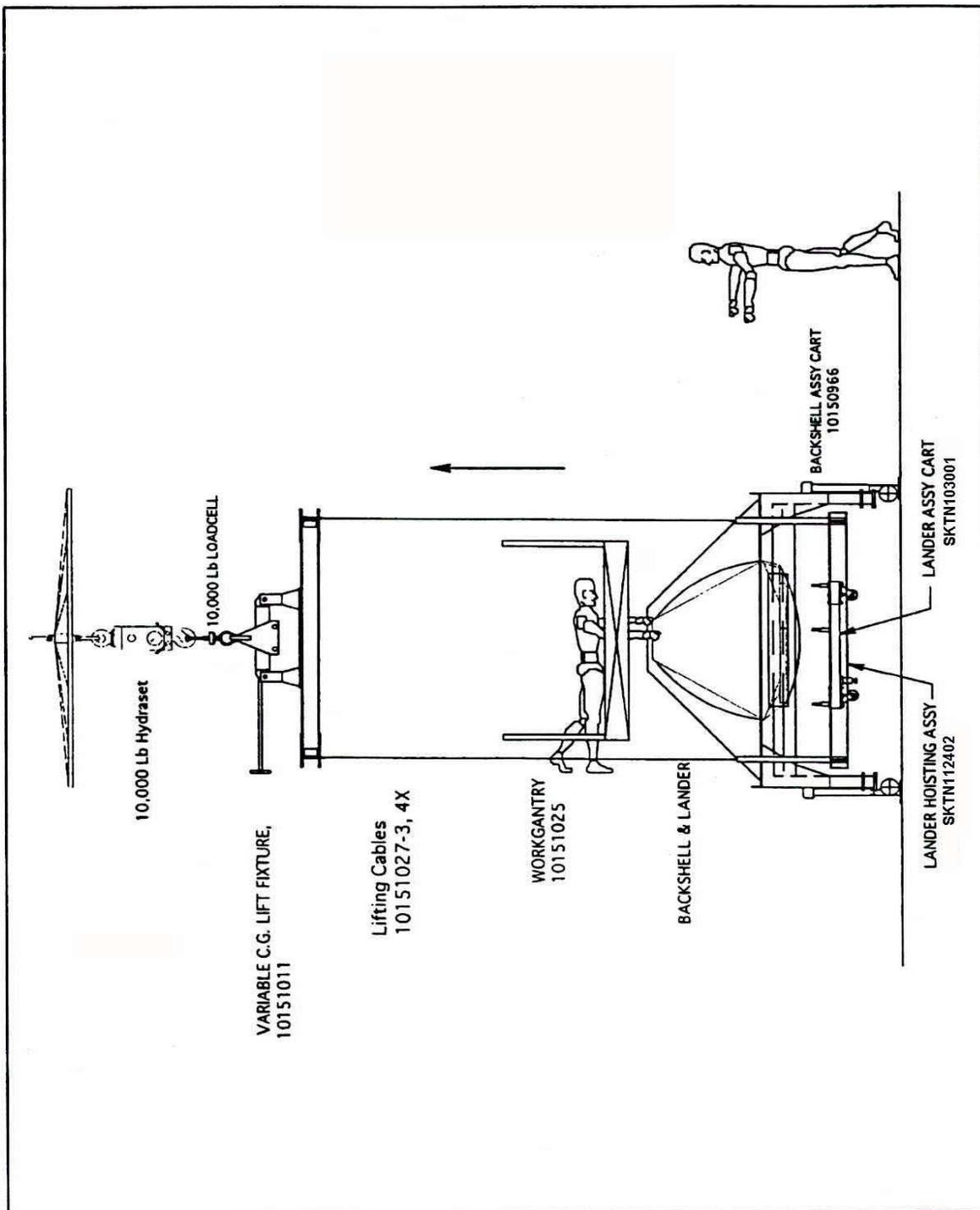


Figure 5 Attaching Detaching the EDL On & Off the KSC Spin Balance Machine

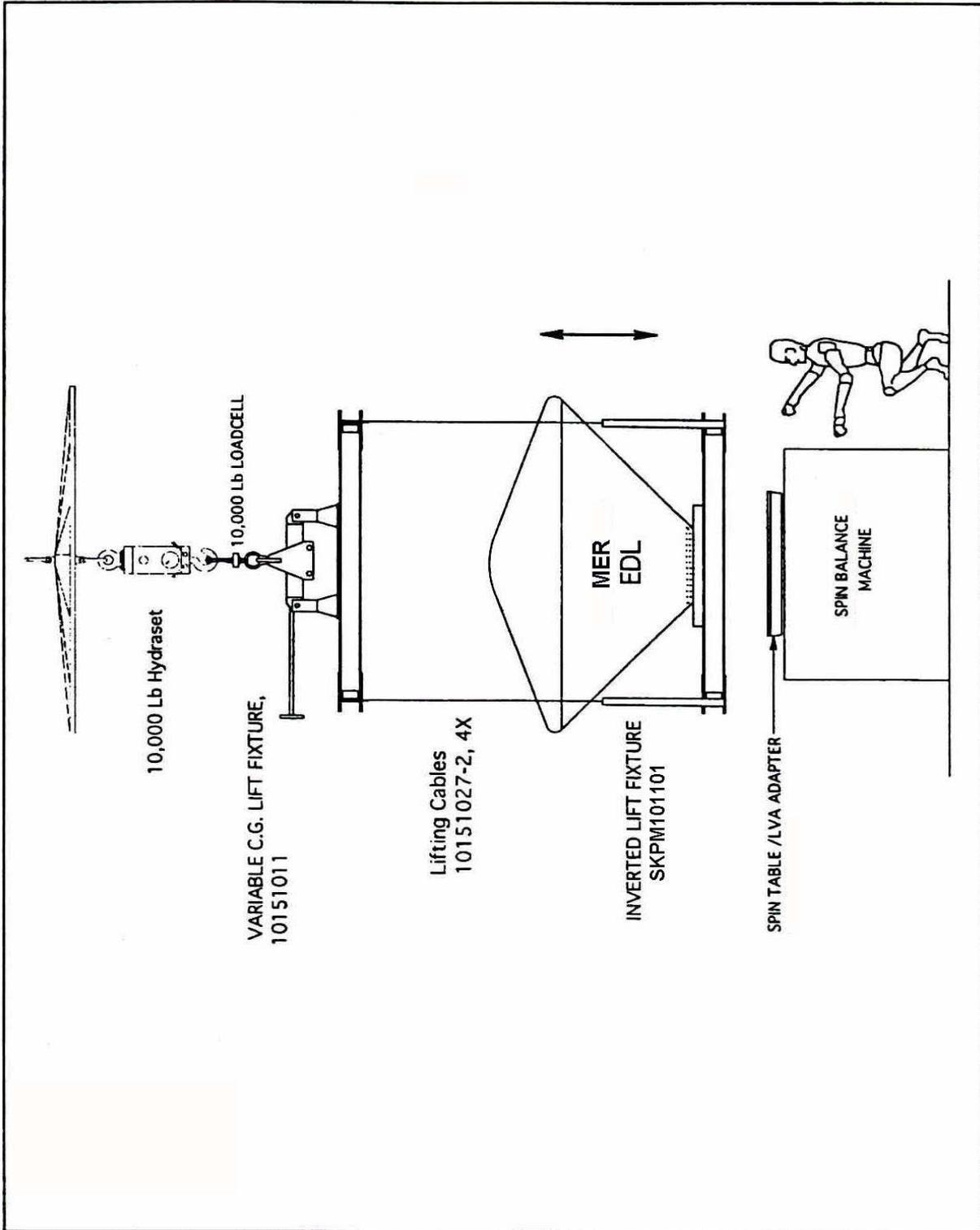


Figure 6 Mounting/Removing the MERS/C On & Off the KSC Spin Balance Machine

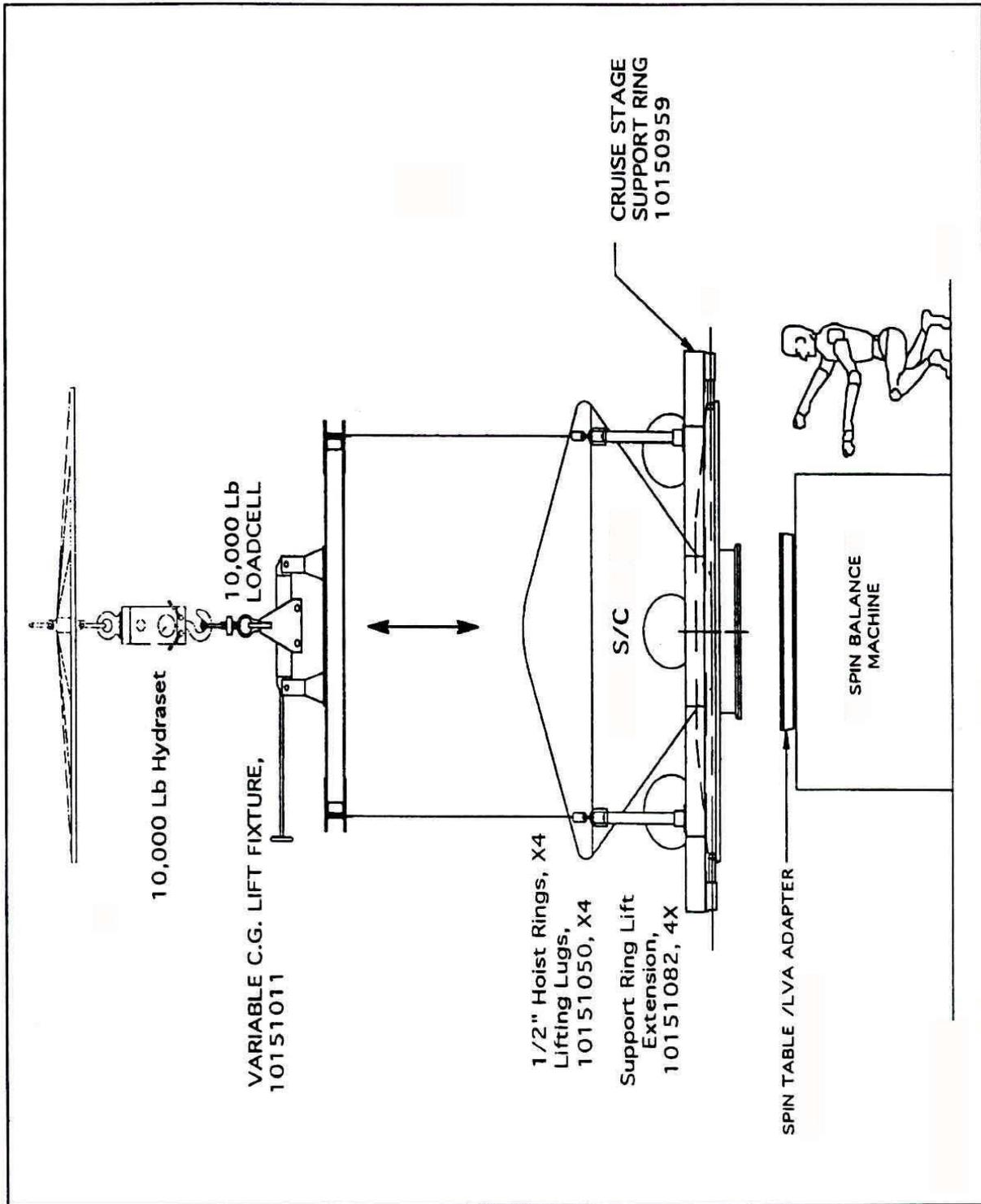


Figure 7 Mounting the MER S/C Into the Delta 3rd Stage

