APPROVAL SHEET FOR SUSPENDED LOAD OPERATIONS

SLO-KSC 2008-005

TITLE: Installation/Removal of Express Logistics Carrier Into/From Express Logistics Carrier Rotation Stand in the SSPF

DOCUMENT NUMBER/TITLE: OMI L5166 Cargo Element Lifting Assembly

PREPARED BY: Ed McKnight DATE: 11/10/2008

REQUIRED APPROVAL

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

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NASA SUSPENDED LOAD OPERATION ANALYSIS/APPROVAL

OPERATIONS

Installation/removal of the Express Logistics Carrier (ELC) into/from the Express Logistics Carrier Rotation Stand (ELCRS) in the Space Station Processing Facility (SSPF)

SUPPORTING DOCUMENTS - The associated operational procedure and System Assurance Analysis (SAA) are as follows:

- OMI L5166, Cargo Element Lifting Assembly (CELA)
- SAA21HAS1-055, Express Logistics Carrier Rotation Stand (ELCRS)
- SAA21HAS1-001, Cargo Element Lifting Assembly
- SAA21CRS1-001, 30 Ton Highbay Bridge Cranes - (SSPF)

GENERAL DESCRIPTION

Installation/removal of the ELC into or from the ELCRS requires the use of the CELA and one of the highbay cranes. These operations require a maximum of four people under the suspended load (1 person per trunnion) to disconnect/connect the CELA drop links from the four trunnions during installation/removal operations. To do this, persons must be under the suspended CELA structure.

RATIONALE/ANALYSIS - The suspended load tasks comply with the NASA Alternate Safety Standard as follows:

Alternate Standard Requirement #1a

During installation/removal of the ELC into or from the ELCRS, the technicians must be directly beneath the suspended load to guide the trunnions into/out of the trunnion retention fittings and disconnect/connect the CELA downrods. There is no alternate access to the trunnion retention fittings located under the CELA structure. The rotation stand allows removal of the payload with either the top side up or bottom side up. This requires the payload retention fitting to be inboard of its support beam to allow access for a lifting device. It also defines the reach from the personnel work stand to the retention fitting. These physical limitations preclude any design, operational, or procedural changes that would eliminate exposure to a suspended load.

Alternate Standard Requirement #1b

The possible use of a secondary support system, to catch the load in the event of a crane failure was analyzed. It was determined that the use of a secondary support system was not feasible because of the position of the load over the ELCRS. Suitable alternative lifting devices for Space Shuttle payloads that eliminate exposure to a suspended load do not exist.

The Cargo Element Lifting Assembly (CELA) design is uniquely able to lift an ELC or similar payload. The ELC center of gravity can change as it is integrated. This requires a lifting device that is able to compensate for an offset center of gravity and maintain a level lift. The payload trunnions are defined per the payload's interface control document as the ground handling points for lifting. To lift from any other location would cause unacceptable loads into the flight hardware and likely cause interference with integrated ORUs. The payload trunnion interface requires a vertical lifting connection to prevent side loads into the flight hardware. The CELA drop-links provide the vertical structural connections to the flight hardware during lifting. Personnel must access these drop-links in order to connect or disconnect the lifting device. Tolerances on the drop-link interface are tightly controlled to prevent damage to the flight hardware's flight trunnion surface and a human interface is required to ensure proper location of the drop-links and precise attachment. The payload envelope for the ELC and other payloads require the lifting device to be over five-feet above the payload's trunnions (see figure 1). To ensure clearance with the payload envelope, the structural support for the drop-links must be directly above the trunnion which is also above the human interface. It is these requirements that create working under a suspended load. The only other lifting device capable of meeting all of these requirements is the Payload Strongback which requires two cranes. The Strongback drop-links and location of their structural connection (above the human interface) are similar to the CELA and also require working under the suspended load.

The CELA is certified as ISS Ground Support Equipment. The system's design went through Preliminary and Critical Design Reviews. The validation of the system was certified by a Design Certification Review. The system was certified as meeting all program requirements for GSE. It is designated a critical system and has a completed hazard analysis and system assurance analysis (SAA21HAS1-0501). There are no critical single failure points within the system's design.

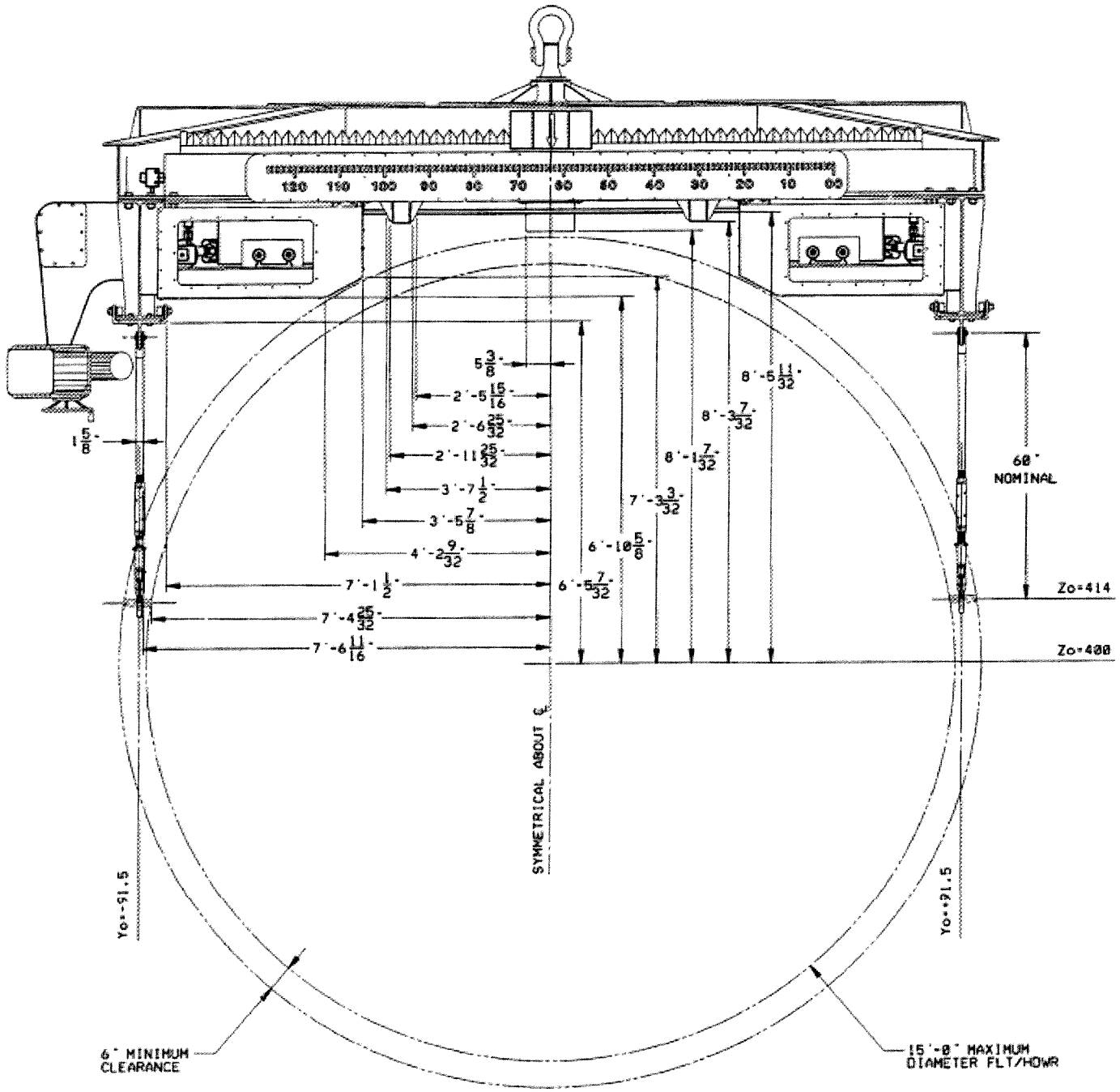

Figure 1: Flight Hardware Envelope and CELA
Ref: 82K00760

Design Alternatives Considered	Reason(s) Not Viable	Impacts/Risks
Lifting Flight H/W with alternative lift points	• Would not be compatible with program requirements defined in NSTS 21000-IDD-ISS, figure 3.3.2.1-1 • Lifting fixture would interfere with 90" payload envelope defined in NSTS 21000-IDD-ISS, figure 3.3.2.1-1 and limit the Program's ability to fly ORUs • Interior attach points would be >18-inches further inboard. This would require personnel to be on the ELC to make connections with lifting hardware	• Redesign of ELC • Risk of unproven operations • Could not meet ISS flight schedule • Requires redesign of flight hardware and partnering of new program requirements which could not be done in time to support the ISS flight schedule • Possibly requires development of new lifting equipment which could not be done in time to support ISS flight schedule
Use of alternative lifting device to CELA	• Would not provide clearance with the 90" payload envelope defined in NSTS 21000-IDD-ISS, figure 3.3.2.1-1 and limit the Program's ability to fly ORUs • Would not be compatible with program requirements defined in NSTS 21000-IDD-ISS, figure 3.3.2.1-1 • Payload Strongback also has working under suspended load issues	• Unlikely new design could meet program requirements, the payload envelope and operational requirements for adjustment and FOD prevention • Development could not be done in time to support ELC processing and the ISS flight schedule • Risk of unproven operations/design

Design Alternatives Considered	Reason(s) Not Viable	Impacts/Risks
Installation of support structure between the CELA and the ELCRS. Structure would be attached to the ELCRS.	• ELCRS Structure (rated at 14300-lb) cannot support impact loads of falling CELA/Payload assembly weighing >25000-lb o ELCRS Analysis 82K07773	• Structure would be obstruction during ORU installations • Installing/removing structure may create additional risks
Installation of a support structure between the CELA and the floor. Structure would be supported by the SSPF floor.	• If installed on port/std, added structure would interfere with ELCRS structure or be required to cantilever over the ELCRS Structure • A permanently installed cantilevered structure would interfere with payload/ORU installation and prevent rotation • A temporarily installed cantilevered structure would require conflicting crane operations due to payload interference • If installed on fwd/aft, the added structure would interfere with ORU operations and ELC rotation • Payload interference during raising/lowering crane ops would require installation of structure during the crane operation	• Structure would increase length of crane operations • Development could not be done in time to support ELC Processing • Cantilevered structures would require attachment of the base to the floor • Handling risks associated with the support structure sized to safely absorb the impact loading

Alternate Standard Requirement #1c

The maximum number of personnel allowed under the suspended load while guiding the trunnion into or out of the payload retention fitting is 1 person per trunnion.

Alternate Standard Requirement #1d

Guiding the ELC trunnions into the payload retention fitting and making the appropriate connections/disconnections will be accomplished as quickly and safely as possible to minimize exposure time. Guiding the ELC trunnions into or out of the retention fittings will take four persons (one per trunnion). Making the appropriate connections/disconnections will take four people (one per trunnion). It will take up to 60 minutes to ensure the payload is installed or removed properly.

Alternate Standard Requirement #2

Suspended load operations are reviewed and approved on a case-by-case/specific need basis.

Alternate Standard Requirement #3

Only those suspended load operations approved by the NASA Safety & Mission Assurance Division Chief will be permitted. The NASA Safety & Mission Assurance Division Chief will maintain a list of approved suspended load operations, which can be found at http://www-ph.ksc.nasa.gov/sma/KSC_LDE_files/slide0001.htm.

Alternate Standard Requirement #4

OMI L5166 will be revised to specify the necessary additional requirements identified by the hazard analysis discussed in paragraph A.4.1 (Ref. NASA-STD-8719.9, Appendix A). The OMI will be available on site for inspection during the operation.

Alternate Standard Requirement #5

A new 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 before operations continue. Safety will coordinate with Operations, Engineering, and other organizations as appropriate. If a new procedure is to be performed on a regular basis, a detailed hazards analysis and approval as outlined in NASA-STD-8719.9, Appendix A, paragraph A.4.1 are required.

Alternate Standard Requirement #6

The suspended load operations addressed in this analysis involve one of the 30 ton SSPF bridge cranes. The cranes are designed, tested, inspected, maintained, and operated in accordance with the Standard for Lifting Devices and Equipment, NASA-STD-8719.9.

The SSPF 30 ton crane hoists are equipped with two magnetic holding brakes, each capable of holding the load up to the crane's rated capacity. Each brake's ability to hold the rated load (30 tons) is verified annually. The cranes are designed to meet a 5 to 1 safety factor based on ultimate strength for the load bearing components. The 30 ton cranes are load tested annually at 100% of their rated capacities. Detailed preventive maintenance is performed monthly, quarterly, semiannually, and annually on the cranes to ensure proper operation. A detailed inspection of the lifting fixtures is performed annually. Nondestructive testing of the crane hooks is performed annually.

Alternate Standard Requirement #7

An SAA (SAA21CRS1-001) has been completed on the 30-ton bridge cranes in the SSPF. The SAA includes a Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL) and a hazard analysis. No critical single failure points were identified during this analysis. The total weight of the load will not exceed the crane's rated load.

Alternate Standard Requirement #8

Visual inspections for cracks or other signs of damage or anomalies are performed on the hoist hooks, hoist beams, hoist cables, hoist rod assemblies, and hoist fittings, and crane functional checks are performed before each operation per NASA-STD-8719.9.

Alternate Standard Requirement #9

Trained and licensed crane operators shall remain at the hoist controls while personnel are under the load.

Alternate Standard Requirement #10
Appropriate safety control areas are established before initiating operations. Only the minimum number of people (manloaded in the procedure) will be permitted in this area.

Alternate Standard Requirement #11

A pretask briefing and a safety walkdown of the area will be conducted prior to the lift to ensure that all systems and personnel are ready to support. All participants are instructed on their specific tasks and warned of potential hazards. Following any crew change, the new personnel are instructed by the task leader on their specific tasks and warned of any hazards involved.

Alternate Standard Requirement #12

The personnel beneath the suspended load will be in voice contact with the hoist operator and/or task leader. Upon loss of communication, the operation shall stop immediately, personnel shall clear the hazardous area, and the load shall be safed. Operations shall not continue until communications are restored.

Alternate Standard Requirement #13

The personnel working beneath the suspended load shall be in continuous sight of the hoist operator, signal person, and/or task leader.

Alternate Standard Requirement #14

NASA shall conduct periodic reviews to ensure the continued safety of the procedures. As a minimum, NASA shall annually evaluate the implementation of this procedure at each Center with operations on the suspended load list.

Alternate Standard Requirement #15

A list of approved suspended load operations, list of cranes/hoists used for suspended load operations, and copies of associated hazards analyses will be provided to the OSHA Office of Federal Agency Programs via NASA Headquarters for distribution to the appropriate regional and area OSHA offices. Quarterly updates to the documentation will be provided as needed.

Approval: Date:

Maynette E. Smith 11/14/08

Maynette Smith
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