APPROVAL SHEET FOR SUSPENDED LOAD OPERATIONS

TITLE: Orbiter Demate from SCA at Display Sites SLO-KSC-2012-003 Rev B

NUMBER/TITLE: SLO-KSC-2012-003 Rev B

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CHECK APPROPRIATE BOX:

☐ Single Occurrence Operation ☐ Multiple Occurrence Operation ☑ Revision to Existing SLOAA

IF REVISION TO EXISTING SLOAA SUMMARIZE CHANGES / RATIONALE:

This SLOAA was developed as a result of a request from the Intrepid Air and Space Museum and the California Science Center to place their respective Orbiters on ground transporters instead of on their landing gears, as was originally planned and documented in SLO-KSC-2012-002. Therefore, this SLOAA contains the steps necessary for mating an orbiter to a ground transporter as part of the Orbiter demate operations. These steps replace the steps for deploying the orbiter landing gear found in the SLO-KSC-2012-002. Additionally, the California Science Center requested the external tank (ET) ferry flight doors be removed from Orbiter Endeavour prior to delivery. Therefore, this revision incorporates an additional step to document removal of the ET ferry flight doors before orbiter mate to the ground transporter. The FMEAs developed and approved by NASA HQ OSMA for SLO-KSC-2012-002 remain valid and in full effect for the operations depicted in this SLOAA.

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Orbiter Mate and Demate to the Shuttle Carrier Aircraft (SCA) at Display Sites:

1.0 Background and Scope:

During the Shuttle Program, Orbiter mates and dematesto the NASA Shuttle Carrier Aircraft (SCA) occurred multiple times. Any time the orbiter landed at an End of Mission Site (EOM) other than KSC, it was necessary to mate it to the SCA and ferry it to KSC, where it would be demated from the SCA and towed to its hangar for processing for the next mission. The mate and demate operations at Dryden Flight Research Center (DFRC) and at KSC were conducted with the aid of Mate/Demate Devices (MDD), see Figures 1, permanent lifting structures installed at those locations. The MDD's at KSC and DFRC are a kind of gantry specially designed for the mate/demate of an orbiter to the SCA. Even with the aid of MDDs, all of the aforementioned operations involve suspended load operations, which are addressed in existing SLOAAs. Additional mate/demate operations occurred whenever the orbiters needed to be ferried to Palmdale, CA for Orbiter Maintenance Down Periods (OMDP). The mate/demate operations at Palmdale were conducted using the now-defunct Orbiter Lifting Frame (OLF), see Figure 2.

Orbiter transition and retirement involves relocation of Orbiters to museums/public viewing areas around the country. This involves loading of Orbiters on the Shuttle Carrier Aircraft (SCA), flight to an airport near the new location, and unloading of the Orbiters at that airport. Loading at KSC using the Mate Demate Device (MDD) (see Figure 1) is a long established operation covered by SLO-KSC-1991-006A, but any loading/unloading of Orbiters at display site airports is performed using two cranes because no MDD is available at those locations. Unloading of OV-103/Discovery and loading of OV-101/Enterprise at the Washington Dulles International Airport (for shipment to John F. Kennedy Airport (JFK)) was performed in April, 2012 under SLO-KSC-2012-002. The unloading operation for OV-103/Discovery involved placing the Orbiter on its landing gear. This SLOAA addresses demate operations for OV-101/Enterprise at JFK International Airport and OV-105/Endeavour at Los Angeles International Airport (LAX), and differs from SLO-KSC-2012-002 in that in these cases the Orbiters will be mated to ground transporters rather than being placed on their landing gear.

The required suspended load operations for demate operations utilizing mobile cranes will be essentially the same as the suspended load operations required for demate operations using the MDD, as documented in SLO-KSC-1991-005A. The major differences will be in the use of mobile cranes instead of the MDD's fixed hoists, a greater reliance on mobile aerial platforms for access instead of the structural platforms provided by the MDD, and in the placement of the Orbiters onto ground transporters instead of on their landing gear. Additionally, in order to compensate for the absence of stabilizing structure normally provided by the MDD, an arrangement of wire ropes, masts, and winches will be set up at the display site locations to provide stability for the suspended Orbiter/Sling combination.

There is precedent for demating an orbiter from the SCA using mobile cranes; these operations occurred multiple times early in the Shuttle program during the late seventies and mid eighties. The demate operations at the display sites will be analogous to those early operations, as depicted in Figures 3 and 4. There is also precedent in using cranes to mate orbiters to ground transporters. Orbiters have been mated to the Orbiter Transport System (OTS) using two overhead cranes in the Vehicle Assembly Building (VAB) multiple times in the past in support of Shuttle de-stack operations, as documented in SLOAA SLO-KSC-1993-006. Additionally, early in the Shuttle program Orbiters were mated to the Overland Transporter (OT) multiple times using mobile cranes or a mobile crane in combination with a stiff leg derrick.

The operations will be directed and conducted by experienced KSC personnel, utilizing leased cranes and operators. All crane operators will be certified for critical lifts in accordance with NASA-STD-8719.9. The cranes planned for the operation are a Liebherr LTM 1250-6.1 for the forward lift point and a Demag/Terex CC-2800-1 for the aft lift point. The SCA Demate operations have been planned to determine maximum lift radius and boom length for each of the cranes. The forward crane (250-Ton Liebherr) will have a maximum lift radius of approximately 40 ft. at a maximum boom length of approximately 119 ft. The aft crane (650-Ton Demag/Terex) will have a maximum lift radius of approximately 112 ft. at a maximum boom length of approximately 177 ft. Per NASA-STD-8719.9, the load on each crane will be kept under 75% of capacity.

If one or both of these crane models is not available at a particular display site and it becomes necessary to use different model cranes, the applicable fields in this SLOAA will be revised to reflect the actual cranes that will perform the operation. Approval for the updated SLOAA will be sought and obtained before the operation can take place.

Suspended Load Operations for Orbiter Demate from SCA using Mobile Cranes at Display Site Airport (JFK, LAX):

A summary of the Demate Operation is as follows: The SCA/Orbiter will arrive at the display site airport. The lifting sling will be hoisted by the two cranes, and the Orbiter/SCA will be spotted under the lifting sling. The sling will be lowered and connected to the orbiter by personnel on mobile aerial platforms. Personnel on mobile aerial platforms will then disconnect the SCA/Orbiter attach points. The cranes will then lift the orbiter from the SCA. The SCA will be towed away from under the suspended orbiter. The orbiter will then be lowered to a height above the ground and mated to a ground transporter. Once mated to the ground transporter, the lifting sling will be disconnected and raised clear of the orbiter. The transporter/orbiter will be towed/driven away from under the sling, and then the sling will be placed in a safe configuration. The necessary suspended load operations, exposed personnel, and exposure times are as follows:

NOTE: Orbiter/SCA demate activities are precise and deliberate operations that require careful planning, coordination, and communication. NASA Orbiter Handling

worked closely with NASA Safety and Mission Assurance to determine the maximum number of personnel and estimated exposure times that are representative of the number of personnel that are absolutely necessary to perform the work and the exposure times that are representative of time needed to perform the necessary tasks in a safe and successful manner. The number of exposed personnel and exposure times are comparable to analogous operations performed successfully throughout the lifecycle of the Shuttle Program.

1. Tow/spot SCA/Orbiter under the suspended H70-0743 Ferry Flight Lifting Sling (see Figure 5).
   - Total personnel under load: Three (Driver, Backup, and Spotter)
   - Exposure time: 10 minutes

2. Install the H70-0743 Ferry Flight Lifting Sling on the Orbiter at the four lifting attach points. There are two forward attach points and two aft attach points. Two personnel will be located at each attach point simultaneously. See Figures 6-10.
   - Total personnel under load: Eight
   - Exposure time: 240 minutes (4 hours)

3. As the orbiter is slowly lifted from the SCA, personnel located between the Orbiter and SCA on mobile aerial platforms monitor the aft Orbiter socket demate from the aft SCA ball while personnel located at the forward bipod either on the SCA itself or on a mobile aerial platform monitor the forward demate, until a 12 inch clearance is achieved. Two personnel will be located at each attach point (2 personnel at each aft attach point, and 2 personnel at the forward attach point). See Figures 11-15.
   - Total personnel under load: Six
   - Exposure time: 60 minutes

4. After lifting the orbiter clear of the SCA, tow the SCA out from under the suspended Orbiter. See Figures 16-19.
   - Total personnel under load: Three (Driver, Backup, and Spotter)
   - Exposure time: 10 minutes

5. After lowering the orbiter so that it's accessible from the ground, remove both orbiter external tank umbilical ferry doors. Four personnel located at each external tank umbilical door. This step will only be performed at the LAX offload site, per the request of the California Science Center. See Figure 20.
   - Total personnel under load: 8
   - Exposure Time: 60 minutes (1 hours)

6. Tow/spot the ground transporter under the suspended Orbiter. See Figure 21.
   - Total personnel under load: Two (Driver and Spotter)
   - Exposure Time: 10 minutes

7. The orbiter will be positioned approximately six inches above the ground transporter attach points before personnel go under the suspended load. As the aft of the orbiter is slowly lowered on to the ground transporter, personnel monitor the aft sockets mate to the aft transporter balls until the aft attach points are mated to the transporter. Once the aft attach points are mated to the transporter the personnel at the aft attach points are no longer under a suspended load. One person is located at each aft attach point for a total of two personnel under the load. See Figure 22.
   - Total personnel under load: Two
   - Exposure Time: 30 minutes

8. The orbiter will be positioned approximately six inches above the ground transporter attach points before personnel go under the suspended load. As the front of the orbiter is slowly lowered on to the ground transporter, personnel monitor the forward connection until the forward attach point is mated to the ground transporter. Once the forward attach point is mechanically connected to the ground transporter, the entire weight of the orbiter is supported by the transporter and it is no longer a suspended load. See Figure 23.
   - Total personnel under load: Two
   - Exposure Time: 15 minutes

9. After mating the Orbiter to the ground transporter, personnel remove the H70-0743 Orbiter Ferry Flight Lifting Sling from the Orbiter at the four lifting attach points. There are two forward attach points and two aft attach points. Two personnel will be located at each attach point simultaneously. See Figures 9-10.
   - Total personnel under load: Eight
   - Exposure time: 120 minutes (2 hours)

10. After hoisting the H70-0743 Ferry Flight Lifting Sling so it clears the Orbiter, personnel tow/drive the Transporter/Orbiter combination from under the suspended Ferry Flight Lifting Sling. See Figure 24.
    - Total personnel under load: Two (Driver and Spotter)
    - Exposure time: 10 minutes

2.0 Requirements

The following requirements are from the NASA Lifting Standard 8719.9, Appendix A and are addressed individually for the Orbiter Mate/Demate Procedure:

A.4.1 All suspended load operations will be approved by the Center/facility NASA Director of Safety based upon a detailed engineering hazards analysis of the operation. The hazards analysis will be prepared by the responsible safety organization and coordinated through appropriate engineering and design offices. The analysis documentation will include the following:

a. A justification why the operation cannot be conducted without personnel beneath the load. Feasible procedure/design options will be investigated to determine if the work can be accomplished without personnel working under a load suspended from a crane/hoist.

Orbiter/SCA demate operations involve heritage Shuttle Program hardware that was not designed to completely eliminate the need for personnel beneath the load during certain aspects of each mate/demate operation. There are no feasible procedure or design options that allow the necessary work to be accomplished without placing personnel under the load. Mate/Demate operations placing personnel under loads per this SLOAA will be performed by experienced personnel following time tested procedures. These operations are essentially the same as those performed successfully throughout the lifecycle of the Shuttle Program; the only differences are the locations and the specific cranes being used.

b. Details of the precautions taken to protect personnel should the load drop. Secondary support systems, i.e., equipment designed to assume support of (catch) the load preventing injury to personnel should the crane/hoist fail, shall be evaluated and used whenever feasible. Secondary support systems will be constructed with a minimum safety factor of 2 to yield.

There are no secondary support (fall arrest) systems that can be utilized during the exposure timeframe for these lift operations.

c. The maximum number of exposed personnel allowed. Steps shall be taken to limit the number of personnel working under a load suspended from a crane/hoist. Only those essential personnel absolutely necessary to perform the operation will be allowed to work in the safety controlled area.

Personnel will accomplish the required suspended load tasks as quickly and safely as possible to minimize time exposure. Only personnel absolutely essential to perform the operation will be allowed under the load. The maximum number of personnel under the load for each operation and the approximate exposure times are detailed in Section 1 –

Background and Scope.

d. The time of exposure. Steps shall be taken to ensure that personnel do not remain under the load any longer than necessary to complete the work.

Personnel will not remain under the suspended load any longer than necessary to complete the work safely. The estimated exposure times for each suspended load operation are detailed in Section 1 – Background and Scope. Personnel will place themselves underneath the suspended load only when it is necessary to do so in order to perform the required work, and will withdraw from underneath the load whenever practical, thereby minimizing exposure time.

A.4.2 Each operation will be reviewed on a case-by-case basis.

Suspended Load Operations are reviewed and approved on a case-by-case/specific need basis.

A.4.3 Only those suspended load operations approved by the Center/facility NASA Director of Safety will be permitted, subject to this standard. A list of approved suspended load operations will be maintained by NASA Safety and made available to OSHA personnel upon request.

This document satisfies the above requirement and will be filed with the KSC Safety Office and is available on-line at http://ksc-lde.ndc.nasa.gov/. The SLOAA will also be referenced in the text of the work plan for the mate/demate operations.

A.4.4 The operational procedures document (e.g., Operations and Maintenance Instruction, Technical Operating Procedure, Work Authorization Document) will be revised to specify the necessary additional requirements identified by the hazard analysis discussed in paragraph A.4.1. The procedures will be available on site for inspection during the operation.

The written procedure will be available for review prior to performing the operations in question as well as on the floor during the lift. The procedures will allow only required personnel under the suspended load. Pre-task briefings will be conducted as required in accordance with pre-task briefing Operating Procedure.

A.4.5 During a suspended load operation, if a new procedure not covered by the original analysis is deemed necessary due to unusual or unforeseen circumstances, the NASA Center/facility Safety Office will be consulted and must approve and document the procedure before operations continue. Safety will coordinate with Operations, Engineering, and other organizations as appropriate. If the new procedure is to be performed on a regular basis, a detailed hazards analysis and approval as outlined in paragraph A.4.1 are required.

Any 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 KSC LDEM present at the operation after consultation with lift team members as needed. A notification will be submitted to NASA Headquarters OSMA for review and forwarding to OSHA.

A.4.6 The crane/hoist shall be designed, tested, inspected, maintained, and operated in accordance with the NASA Standard for Lifting Devices and Equipment (NASA-STD-8719.9). Test, inspection, and maintenance procedures will be developed and approved by qualified, responsible NASA engineers. Qualified specialists will perform the procedures and resolve noted discrepancies. NASA Quality Assurance will perform an independent annual inspection of all cranes/hoists involved in suspended load operations. The results of the annual inspections will be maintained and made available to OSHA personnel upon request.

The two cranes that will be leased for this operation are: Liebherr LTM 1250-6.1 250-Ton Mobile crane and Demag/Terex CC-2800-1 650-Ton Crawler crane. In order to ensure that the cranes have been designed, maintained, inspected, and tested, in accordance with NASA-STD-8719.9 the maintenance documentation will be reviewed by KSC NASA Crane Engineering to verify that cranes have been properly maintained and that no modifications have been performed. A rated load test and an operational test will be performed per the requirements of the NASA-STD-8719. Additionally, NASA Crane Engineering and NASA Quality Assurance will conduct a thorough inspection of the each of the cranes prior to the operation. Any discrepancies or areas of concern will be addressed and resolved before the operation takes place. The configuration, reeving/parts of line, working radii and boom lengths of the cranes have been selected to ensure that the load on each crane does not exceed 75% of capacity.

NASA-STD-8719.9 requires compliance with OSHA regulations and the mechanical design criteria in ASME B30.5. The Liebherr and Demag/Terex cranes are European designed cranes and as such are designed to comply with European crane consensus standard DIN 13000, instead of ASME B30.5 that is used for American cranes. OSHA 29 CFR 1926 Subpart CC 1433(a) establishes the applicable DIN standards as an alternative to ASME B30.5 for cranes manufactured prior to November 8th, 2010. Therefore, the Liebherr and Demag/Terex cranes covered by this SLOAA, by way of being designed to meet DIN 13000 standards (alternative to ASME B30.5), are in compliance with OSHA and satisfy the intent of NASA-STD-8719.9.

In the event that different cranes from the ones listed above need to be used due to lack of availability, this SLOAA will be revised to reflect the actual cranes used for the operation. All of the above inspections and tests will be performed on whichever cranes are used in order to ensure that the cranes have been designed, maintained, inspected, and tested in accordance with NASA-STD-8719.9. In the event that a situation presents itself where a different crane must be brought in real-time to safe the load due to a malfunction of one the planned cranes, the KSC LDEM will work with the test team and the crane procurer to ensure that the replacement crane meets the requirements of NASA-STD-8719.9. After the load is placed in a safe configuration, the real-time

changes will be communicated to NASA Headquarters OSMA by the KSC LDEM.

A.4.7 Each crane/hoist involved in suspended load operations shall undergo a Failure Modes and Effects Analysis (FMEA) that shall be approved by the Center/facility NASA Director of Safety. The FMEA will determine Single Failure Points (SFP), assessing all critical mechanical functional components and support systems in the drive trains and critical electrical components.

Both cranes have been analyzed for Single Point Failure modes. Refer to FMEA-004 for the Liebherr LTM 1250-6.1 250-Ton Mobile crane and FMEA-001 for the Demag/Terex CC-2800-1 650-Ton Crawler Crane. Passive components such as rope, drum, wire rope and hook are verified through preventive maintenance.

Liebherr LTM 1250-6.1 250-Ton Mobile Crane

The FMEA for the 250-Ton Liebherr identified the Gearbox/motor as a SFP that may result in dropping the load. The use of high quality components and a comprehensive maintenance, inspection and test program including pre-operational checks ensure that the crane systems operate properly. The FMEA identified failure mode is gear disengagement due to structural failure of the gears. The maintenance history of the crane will be reviewed by USA and NASA Crane Engineering to verify no failure of the Gearbox/motor assembly. The hoist system will be load tested to 100% rated load within one year prior to its use for this operation.

Demag/Terex CC-2800-1 650-Ton Crawler Crane

The FMEA for the 650-Ton Demag/Terex identified the main hoist Gearbox/motor and the boom hoist Gearbox/motor as SFPs that may result in dropping the load. The use of high quality components and a comprehensive maintenance, inspection and test program including pre-operational checks ensure that the crane systems operate properly. The FMEA identified failure mode for the main hoist and boom hoist Gearbox/motor is gear disengagement due to structural failure of the gears. The maintenance history of the crane will be reviewed by USA and NASA Crane Engineering to verify no failure of the main hoist and boom hoist Gearboxes/motors. The crane will be load tested to 100% rated load within one year prior to its use for this operation.

A.4.8 Before lifting the load involved in a suspended load operation, the crane/hoist will undergo a visual inspection (without major disassembly) of components instrumental in assuring that the load will not be dropped (e.g., primary and secondary brake systems, hydraulics, mechanical linkages, and wire rope per NASA-STD-8719.9). Noted discrepancies will be resolved before the operation continues. This pre-lift inspection will be in addition to the inspections required in 29 CFR, 1910.179(j).

Prior to start of the operations, both mobile cranes will be inspected and run through all

motions to assure proper operation and functionality. Any noted discrepancies will be resolved before operations commence for the day. This pre-lift inspection will be in addition to the inspections required in 1910.179(j).

A.4.9 A trained and licensed operator (certified per NASA-STD-8719.9) shall remain at the crane/hoist controls while personnel are under the load.

The mobile crane operators will be trained and licensed in accordance with NASA-STD-8719.9. In addition, each operator will have undergone hands-on specific training on the two cranes. The crane operator will remain at the crane controls when personnel are under the suspended load. Operators will have been briefed on potential crane failure modes and appropriate responses, based on the FMEA for each crane in question.

A.4.10 Safety controlled areas shall be established with appropriate barriers (rope, cones, etc.). All nonessential personnel shall be required to remain behind the barriers.

Non-essential personnel will be kept clear of the lift operation as noted in the procedure. A controlled area will be established for all crane operations in the work plan. Appropriate barriers will be set-up prior to the start of the lift and removed only when the lift has been completed. A detailed discussion of the controlled area will be conducted at the pre-lift briefing to assure all participants are familiar with the defined boundary.

A.4.11 Prior to the suspended load operation, a meeting with the crane/hoist operator(s), signal person(s), person(s) who will work under the load, and the person responsible for the task shall be held to plan and review the approved operational procedures that will be followed, including procedures for entering and leaving the safety controlled area.

Multiple pre-task briefings with the test team will cover all risks and mitigating controls. A pre-task briefing will be held at the start of each shift and prior to all hazardous operations.

A.4.12 Communications (voice, radio, hard wired, or visual) between the operator(s), signal person(s), and the person(s) working under the load shall be maintained. Upon communication loss, operations shall stop immediately, personnel shall clear the hazardous area, and the load shall be safed. Operations shall not continue until communications are restored.

Communication and direct visual contact will be maintained at all times between the move director/signal person, crane operators, and the technicians under the suspended load. Upon visual or communication loss the lift will be halted immediately and persons under the suspended load will move to a safe area outside the envelope of the suspended load until the line of sight and/or communication can be re-established. All lifts during mate/demate operations, including the suspended load lifts in question, will be conducted with direct voice communication between the move director, crane operators and technicians using voice and/or hand signals. Primary communication

between the move director, crane operators and the technicians will be via radios, with hand signals as a supplement and/or backup.

A.4.13 Personnel working beneath the load shall remain in continuous sight of the operator(s) and/or the signal person(s).

Personnel working under the load will remain in continuous sight of the operators and/or signal persons/move director. See above response.

A.4.14 NASA shall conduct periodic reviews to ensure the continued safety of the procedures. As a minimum, NASA will annually evaluate the implementation of this procedure at each Center with operations on the suspended load list.

All hazardous procedures, including suspended load operations, will be reviewed in accordance with the standard TOPs review process as described in KNPR 8715.3. The appropriate NASA/KSC Safety organizations will review and approve all hazardous procedures well in advance of the commencement of the operation with at least seven days lead time after approval.

A.4.15 A list of approved suspended load operations, list of cranes/hoists used for suspended load operations, and copies of the 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. (NASA Headquarters, in conjunction with OSHA, will develop a format for transmittal of this information.) Quarterly updates to the documentation will be provided as needed.

Figures to Help Illustrate the Operations

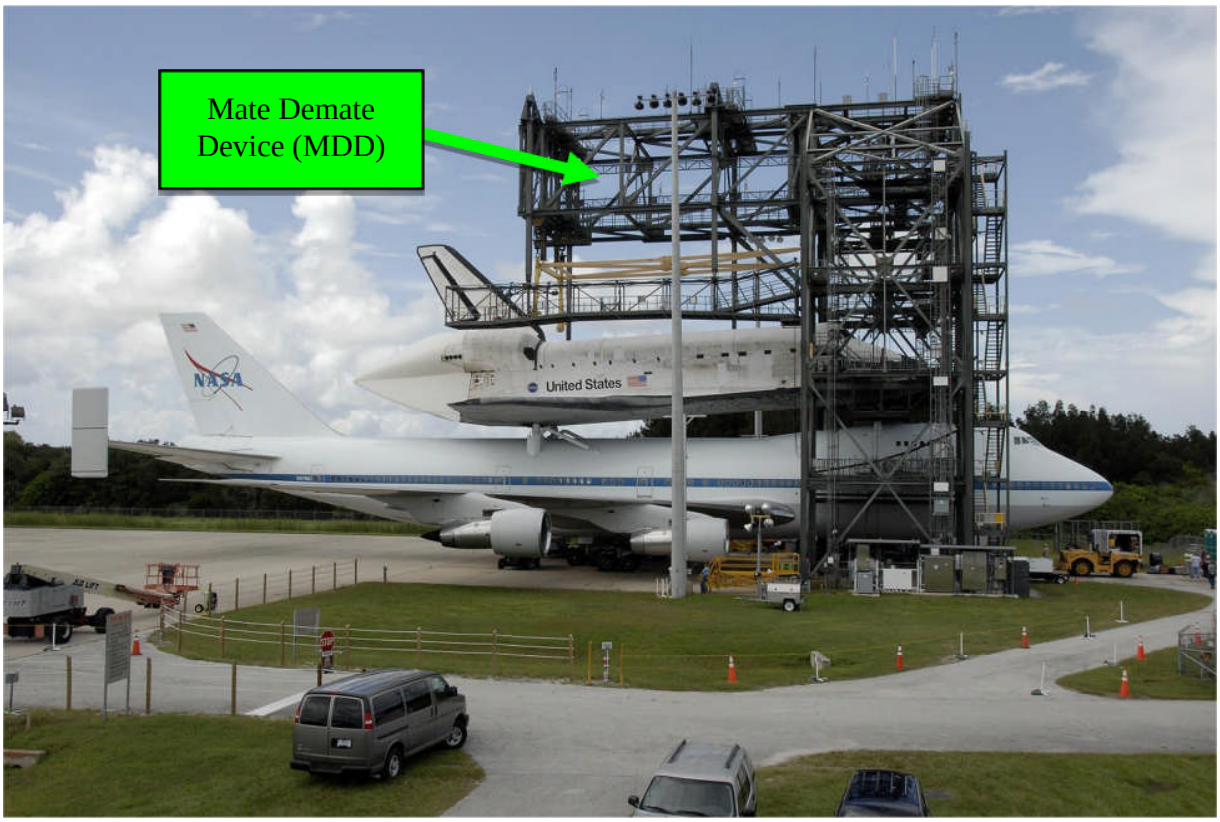

Figure 1 – Orbiter/SCA at the Kennedy Space Center Mate Demate Device
This photo shows the Mate Demate Device (MDD) used at Kennedy Space Center to conduct the Orbiter/SCA mate and demate operations. The MDD facilitates personnel access to the orbiter and SCA, but it does not eliminate the need for suspended load operations. Note that the Orbiter is attached to the SCA and the Ferry Flight Lifting Sling is suspended above the Orbiter/SCA.

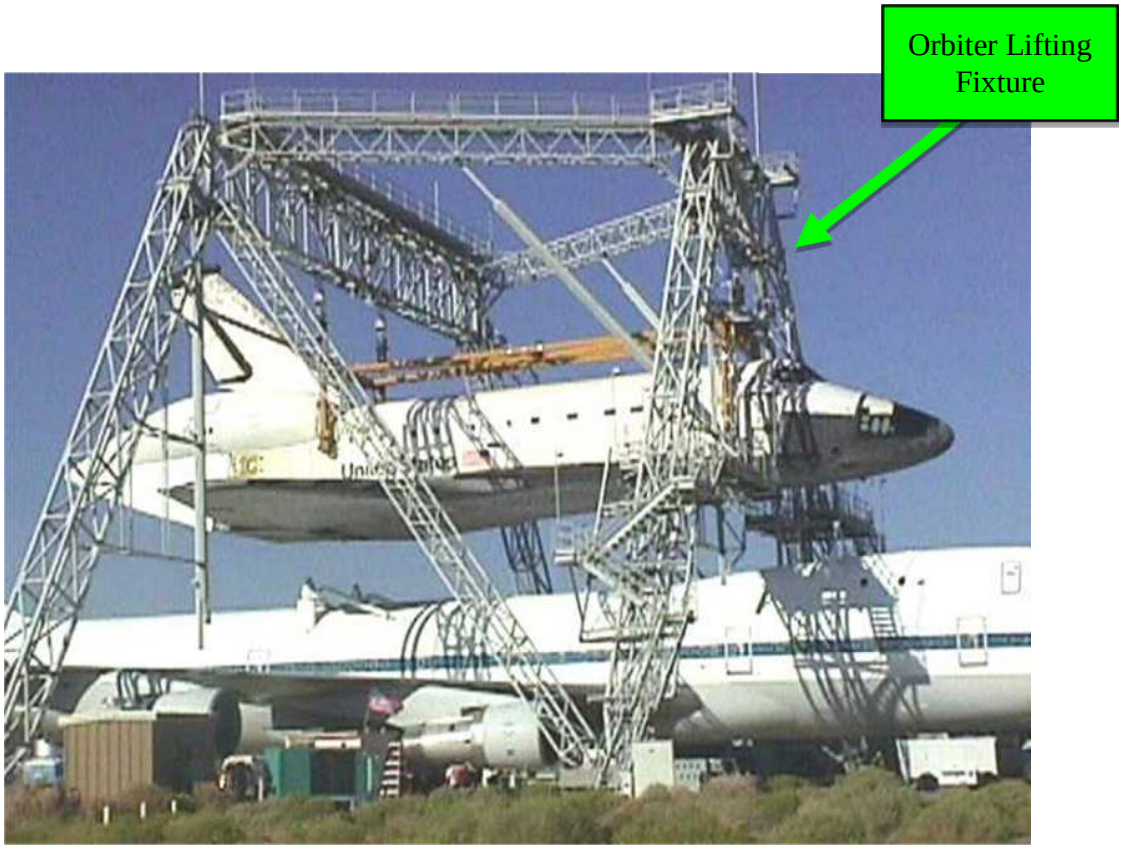

Figure 2 – OV-102/Columbia and SCA at the Palmdale, CA Orbiter Lifting Fixture (OLF)

The Orbiter Lifting Fixture in this photo was originally designed for mate/demate operations at Vandenberg Air Force Base. It was later moved to Palmdale, CA where it was used in support of OMDP for a number of years, until being demolished in 2008. Like the MDD, in spite of the specialized design with the sole purpose of mating and demating orbiters, suspended load operations were unavoidable. Note that the Orbiter is suspended above the SCA.

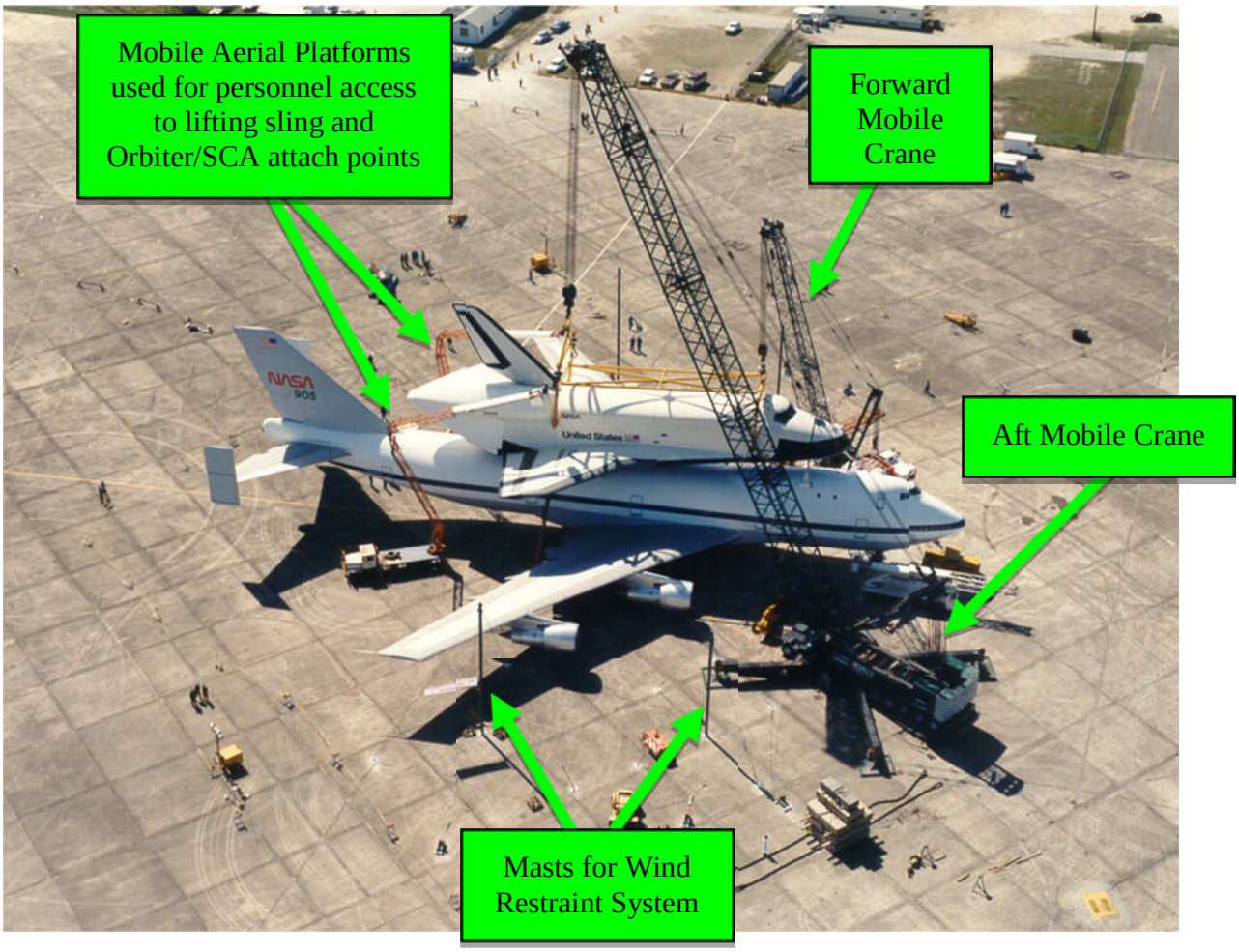

Figure 3 – OV-101/Enterprise being demated from SCA-905 in Mobile, AL in preparation for the 1984 Louisiana World Exposition

This photo shows an aerial layout of the Orbiter/SCA mate/demate operations using two mobile cranes. The operations at the display sites will be very similar to what is depicted in this photograph. Mobile aerial platforms will be used for personnel access to the lifting sling attach points on the Orbiters, and the SCA attach points. The masts form part of the Wind Restraint System, an arrangement of wire ropes, pulleys, masts, and winches that attach to the lifting sling and serve to stabilize the suspended Orbiter/Sling combination.

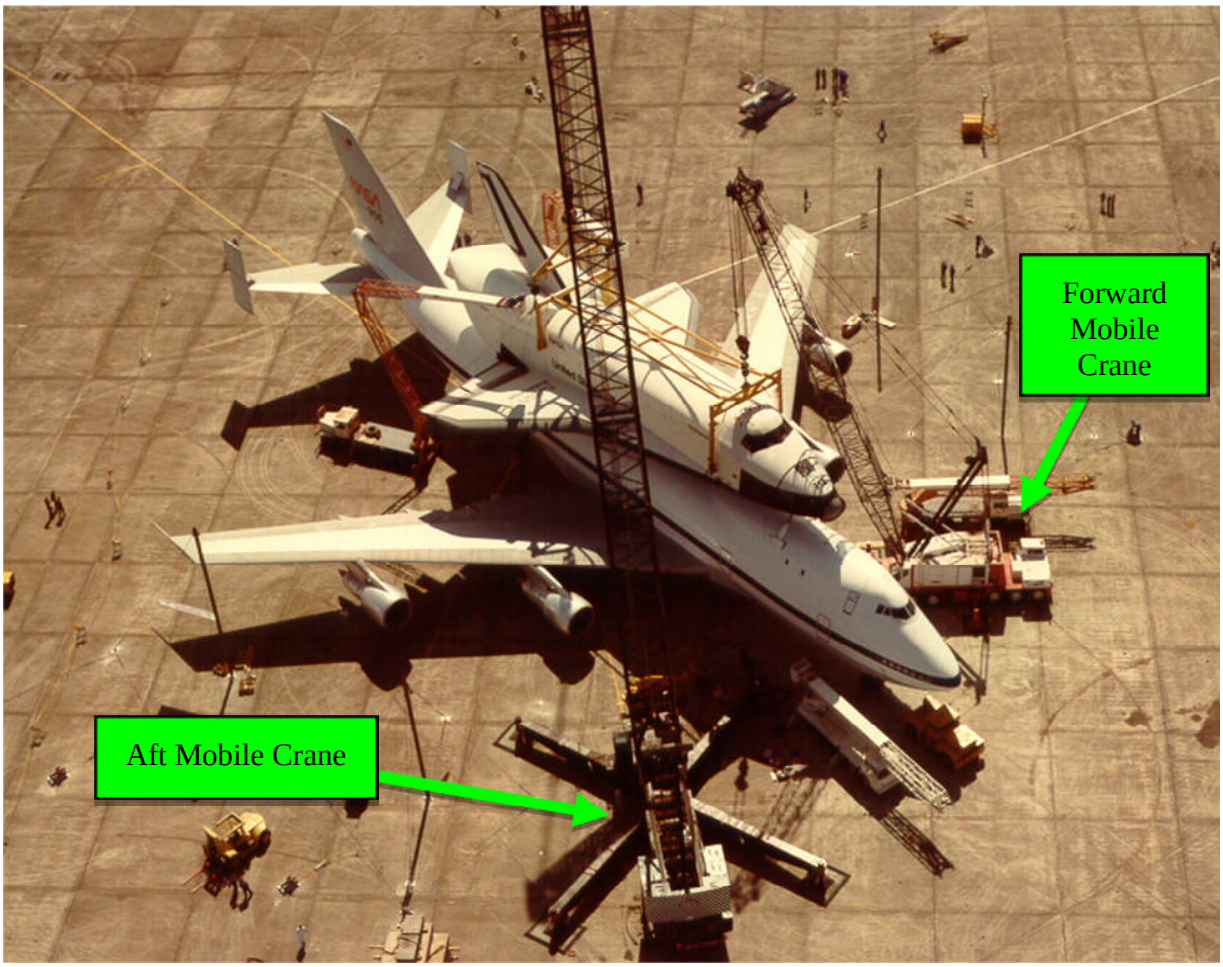

Figure 4 - OV-101/Enterprise being demated from SCA-905 in Mobile, AL in preparation for the 1984 Louisiana World Exposition

This photo shows an aerial layout of the Orbiter/SCA mate/demate operations using two mobile cranes. The operations at the display sites will be very similar to what is depicted in this photograph.

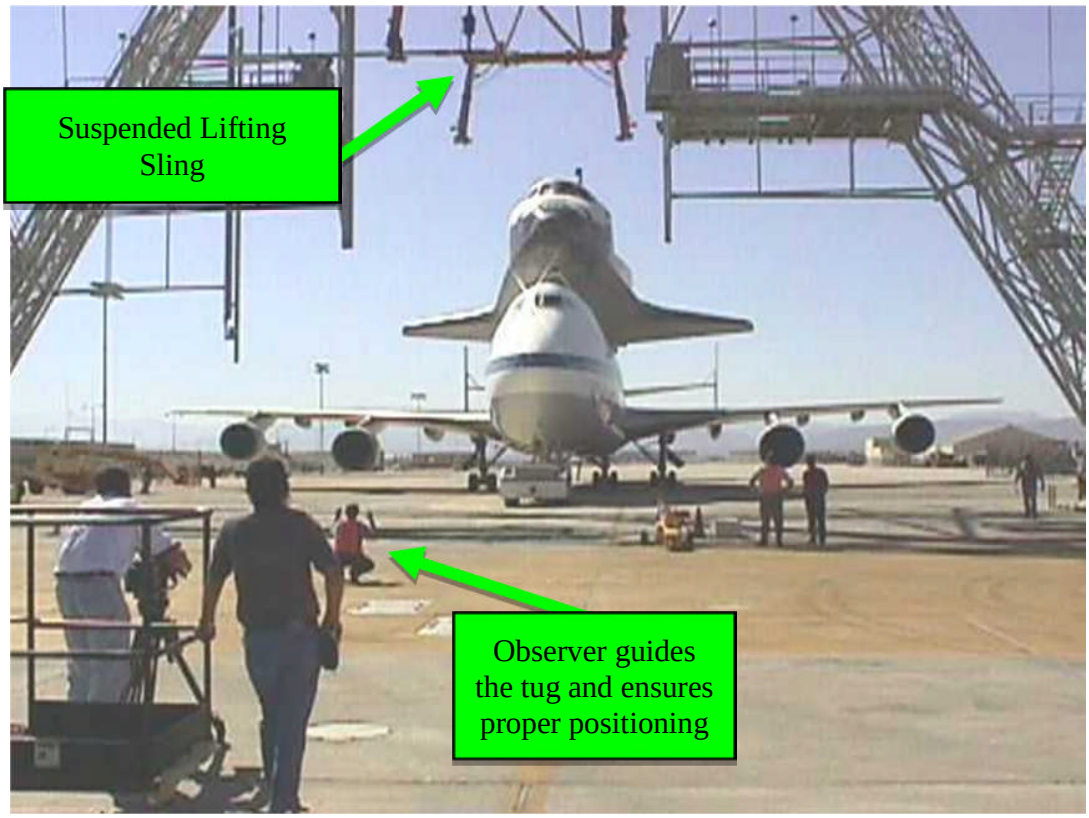

Figure 5 –OV-102/Columbia on SCA being towed under suspended sling

For Orbiter demate from SCA, the Orbiter/SCA combination will be positioned under the suspended sling in preparation for sling installation. For Orbiter mate to SCA, the tug tows the Orbiter/SCA out from underneath the suspended sling in preparation for ferry flight. The operation at the display sites will be similar to this, with the exception that the sling will be suspended from two mobile cranes, instead of the OLF as in this picture.

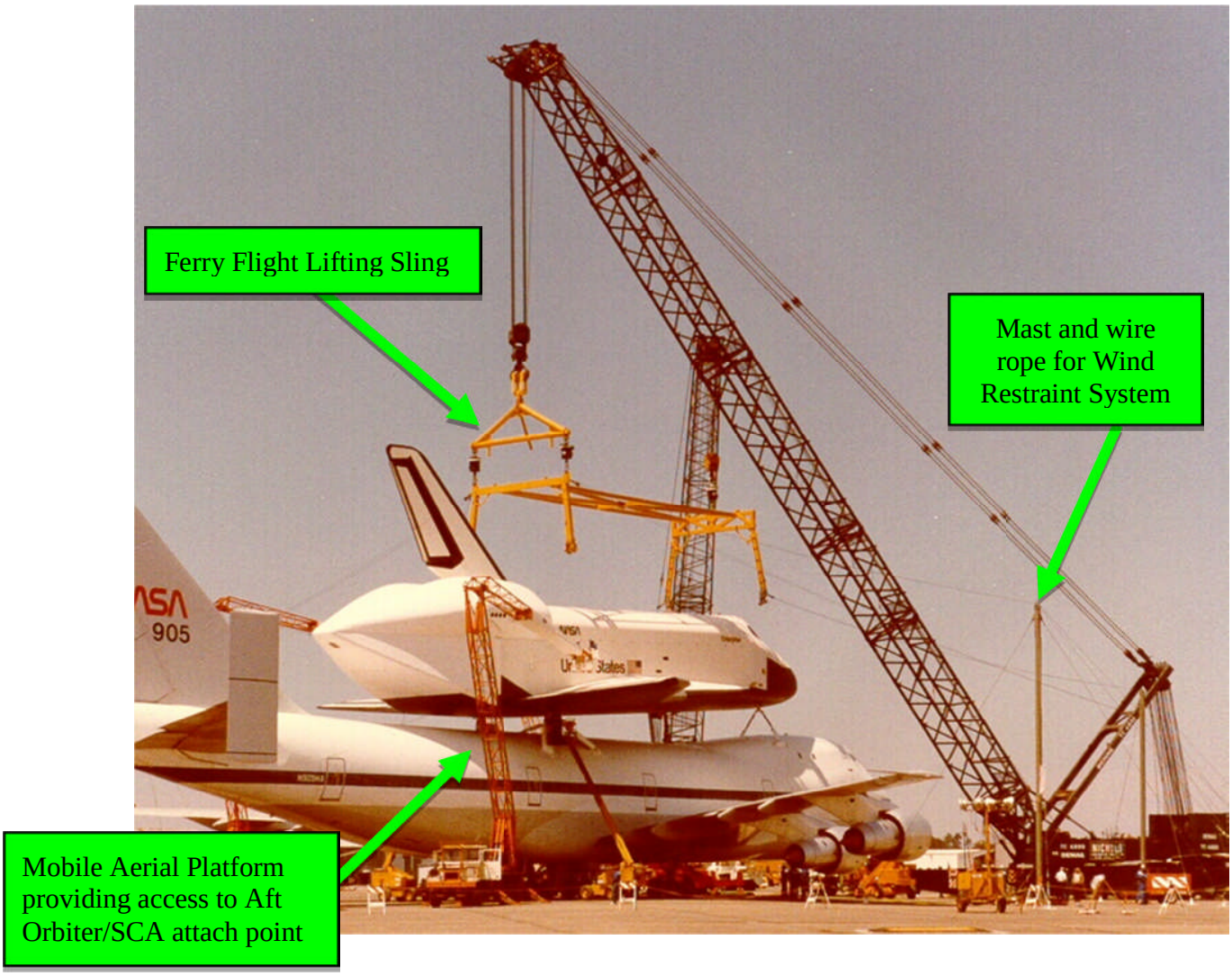

Figure 6 – Ferry Flight Lifting Sling suspended above OV-101/Enterprise

This photo shows the H70-0743 Ferry Flight Lifting Sling suspended above the Orbiter/SCA Combination. In order to attach and remove the lifting sling to/from the Orbiter, personnel will be under the suspended load of the sling (drop legs). Also note the wind restraint wire ropes attached to the lifting sling and the mobile aerial platform providing access to one of the aft Orbiter/SCA attach points. The personnel located at the aft Orbiter/SCA attach points are not under the suspended load of the sling as long as the Orbiter is structurally supported by SCA. The personnel in this picture are under a suspended load when the weight of the Orbiter is supported by the cranes.

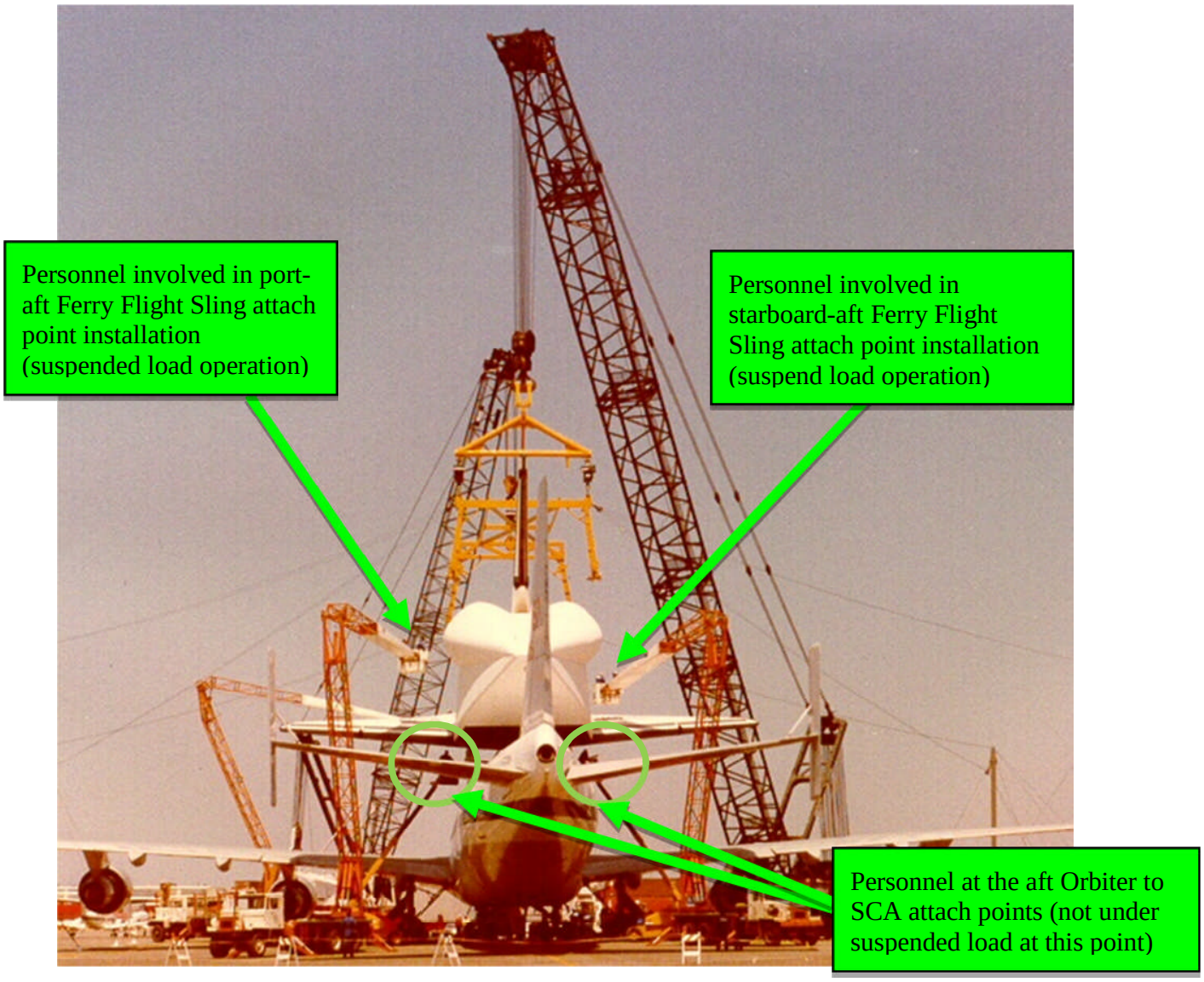

Figure 7 – Ferry Flight Lifting Sling suspended above OV-101/Enterprise

Note personnel on small mobile aerial platforms under the orbiter at the aft Orbiter/SCA attach points, and personnel on large mobile aerial platforms at Sling to Orbiter aft attach points. As long as the orbiter weight is supported by the SCA, as is the case in this photo, the personnel in the small mobile aerial platforms (under the Orbiter) are not under the suspended load of the Ferry Flight Lifting Sling because the Orbiter acts as a secondary support system. However, when the weight of the Orbiter is supported by the cranes, the personnel in this picture will be under the suspended load of the Orbiter/Sling combination. The personnel in the large mobile aerial platforms are under the suspended load of the Ferry Flight Sling during the Sling to Orbiter installation and removal processes.

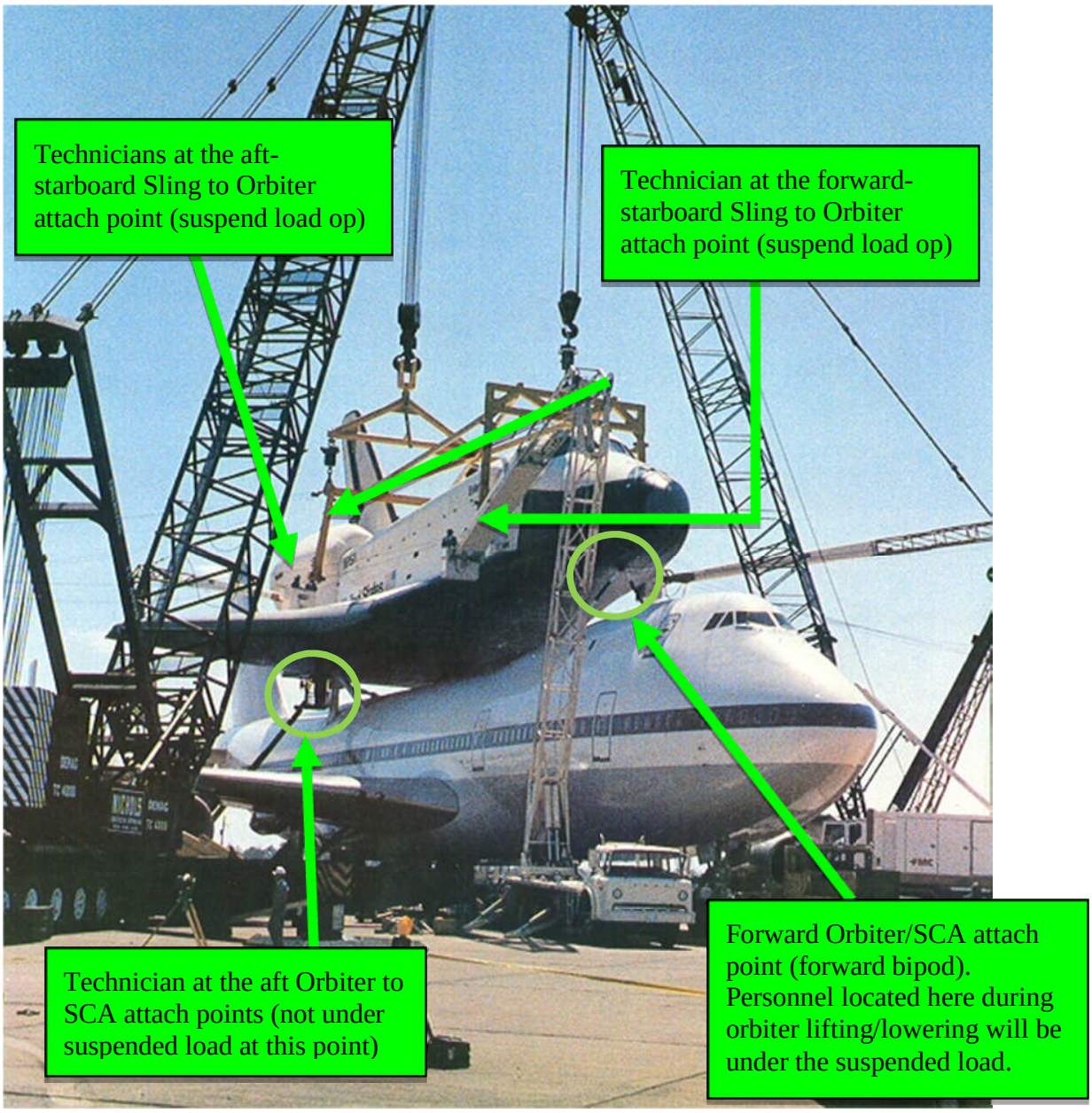

Figure 8 – Ferry Flight Sling installation on OV-101/Enterprise

The personnel in this photo at the forward and aft Sling to Orbiter attach points will be under the suspend load of the Ferry Flight Lifting Sling during the installation and removal processes associated with Orbiter to SCA mate/demate. The technician at the aft Orbiter to SCA attach point is protected from the suspended Ferry Flight Sling by the Orbiter, which is attached to the SCA in this picture. However, when the Orbiter is supported by the cranes during mate and

demate operations, personnel at this location and at the forward Orbiter to SCA attach points will be under the load of the Orbiter/Sling combination.

Figure 9 – Personnel at the forward-starboard Sling to Orbiter attach point

For Ferry Flight Sling installation and removal, personnel in the aerial lift will be under the suspended load of the Ferry Flight Lifting Sling. Two personnel are located at each of the four Sling to Orbiter attach points.

Figure 10 – Personnel at the aft-starboard Sling to Orbiter attach point

For Ferry Flight Sling installation and removal, personnel in the aerial lift will be under the suspended load of the Ferry Flight Lifting Sling. Two personnel are located at each of the four Sling to Orbiter attach points.

Figure 11 – Personnel at forward Orbiter to SCA attach point (forward bipod)

This photo shows personnel working at the forward bipod between the Orbiter and the SCA. The technicians in this picture are not under a suspended load as long as the weight of the Orbiter is supported by the SCA. The suspended load operation occurs when personnel are stationed at this point as the Orbiter is lifted (for demate) or lowered (for mate) by the cranes. For demating, two personnel are located under the load at the forward bipod and at each of the aft attach points.

Figure 12 – Personnel at forward Orbiter to SCA attach point (forward bipod)

This photo shows personnel working at the forward bipod between the Orbiter and the SCA. The technicians in this picture are not under a suspended load as long as the weight of the Orbiter is supported by the SCA. The suspended load operation occurs when personnel are stationed at this point as the Orbiter is lifted (for demate) or lowered (for mate) by the cranes. For demating, two personnel are located under the load at the forward bipod and at each of the aft attach points.

Figure 13 – Personnel monitoring forward attach point (forward bipod) separation

For demating, two personnel are located under the load at the forward bipod and at each of the aft attach points.

Figure 14 – Personnel at the aft-port attach point

This photo shows personnel working at the aft-port attach point between the Orbiter and the SCA. The technicians in this picture are not under a suspended load as long as the weight of the Orbiter is supported by the SCA. The suspended load operation occurs when personnel are stationed at this point as the Orbiter is lifted (for demate) or lowered (for mate) by the cranes. For demating, two personnel are located under the load at the forward bipod and at each of the aft attach points.

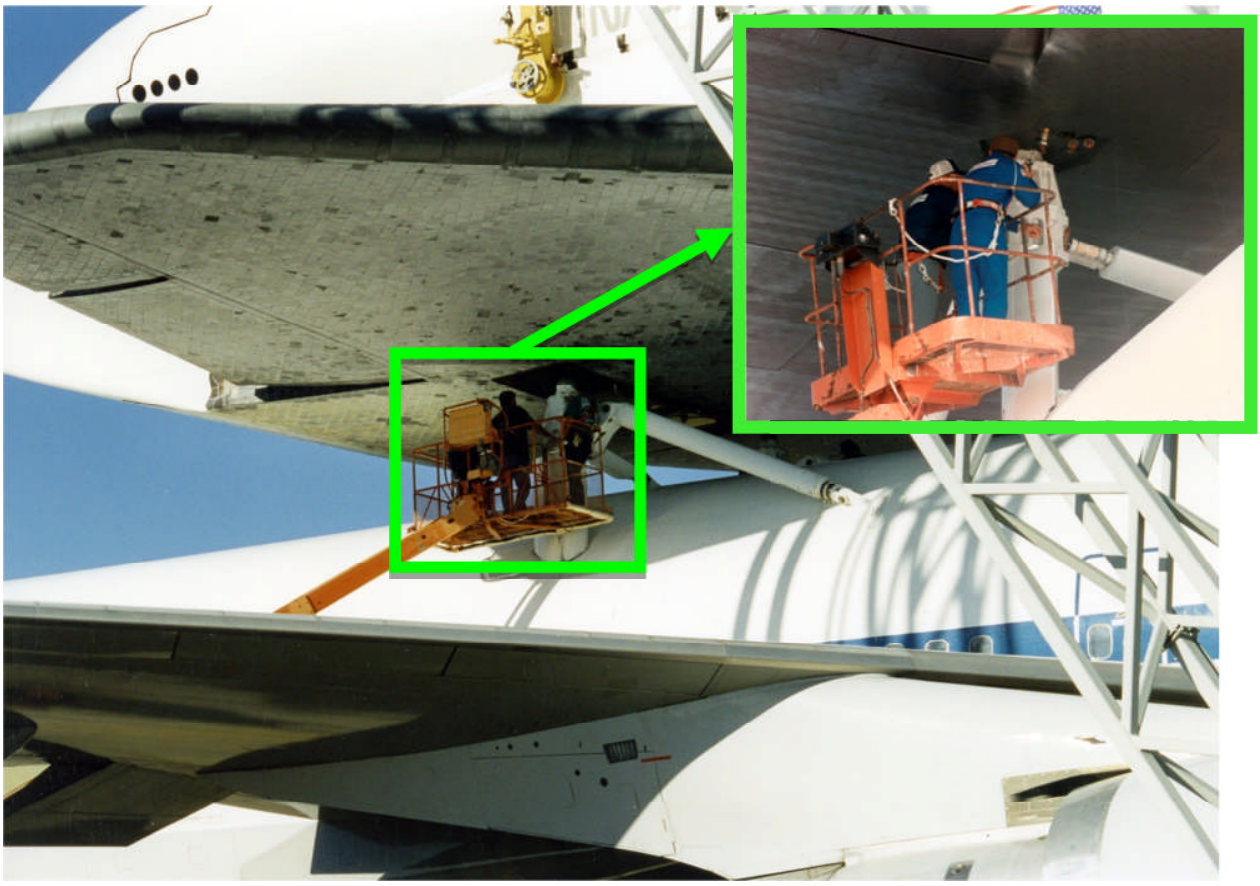

Figure 15 – Personnel at the aft-starboard attach point

This photo shows personnel working at the aft SCA/orbiter connection between the Orbiter and the SCA. The suspended load operation occurs when personnel are stationed at this point as the Orbiter is lifted (for demate) or lowered (for mate) by the cranes. The SCA aft attach point struts shown in this picture may require adjustment during the mate procedure so that they properly align with the attach points on the Orbiter side.

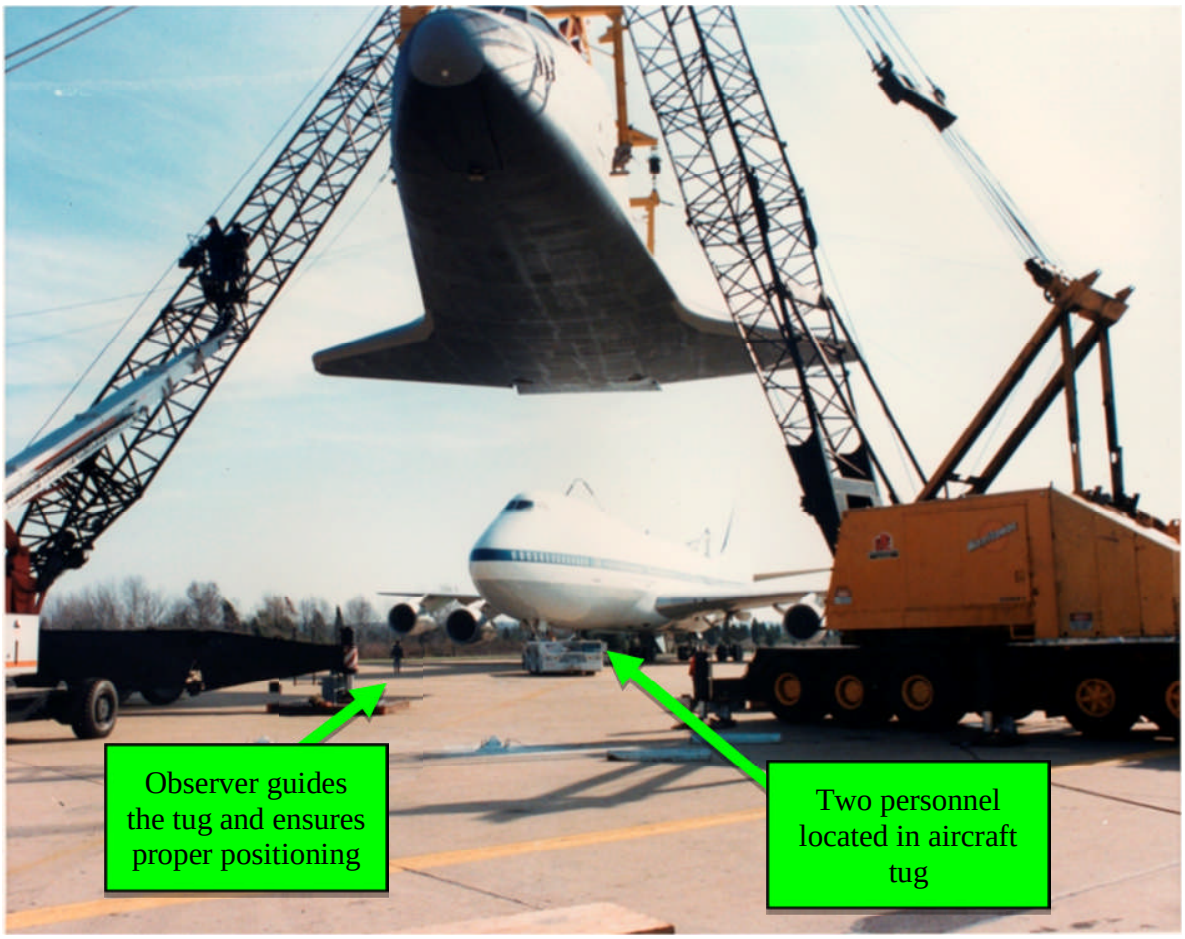

Figure 16 – OV-101/Enterprise suspended while tug tows the SCA

For Orbiter demate from SCA, the SCA is towed out from under the suspended Orbiter in preparation for lowering and landing gear deployment. For Orbiter to SCA mate operation, the SCA is towed under the suspend Orbiter in preparation for mate. The two personnel on the tug and the observer are under the suspended load of the Orbiter for parts of the operation.

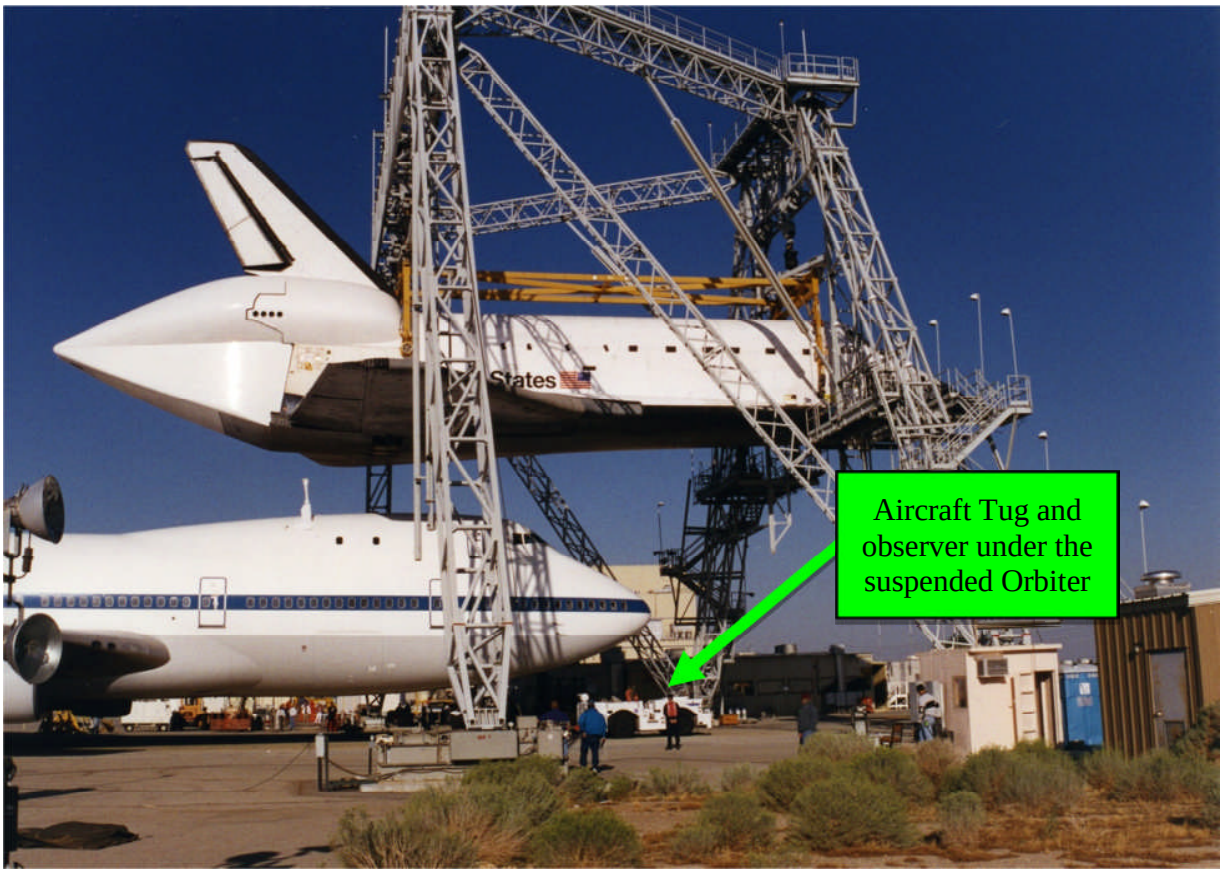

Figure 17 – OV-104/Enterprise suspended while SCA is towed underneath

For Orbiter demate from SCA, the tug tows the SCA out from under the suspended Orbiter in preparation for lowering and landing gear deployment. For Orbiter to SCA mate, the tug tows the SCA under the suspend Orbiter in preparation for mate. The two personnel on the tug and a guide/observer are under the suspended load of the Orbiter at times. The operation at the display sites will be similar to this, with the exception that the orbiter will be suspended from two mobile cranes, instead of the OLF as in this picture.

Figure 18 – SCA being towed under OV-102/Columbia after landing at White Sands, NM at the end of STS-3 in 1982

Figure 19 – OV-101/Enterprise suspended above the tarmac

This photo depicts the Orbiter suspended above the tarmac either after the SCA has been towed away after demate, or awaiting either the ground transporter or the SCA to tow under it in preparation for mate. The operation of towing the SCA or the ground transporter underneath the Orbiter exposes the personnel operating and guiding the tug/ground transporter under the suspended Orbiter/Sling combination.

Figure 20 – Personnel removing starboard ET umbilical ferry door

After lowering the orbiter so that it is accessible from the ground, personnel remove both ET umbilical ferry doors.

Figure 21 – OV-101/Enterprise suspended above ground transporter

Ground transporter is spotted underneath the suspended Orbiter in preparation for Orbiter to transporter mate. Once Orbiter is attached to the ground transporter, the Ferry Flight Lifting Sling is demated and lifted above the Orbiter; the transporter/Orbiter combination is then driven out from underneath the suspended sling.

Figure 22 –Personnel monitoring starboard-aft Orbiter to transporter attach point

Personnel monitor engagement of the aft balls into the Orbiter sockets. Once the aft balls are engaged in the sockets, the personnel under the Orbiter at the aft attach points are no longer under a suspended load. However, the front of the Orbiter is still suspended until the front attach point is connected.

Figure 23 – Personnel monitoring Orbiter to transporter front-end attach point

Personnel at the front end attach point monitor engagement as the forward crane rotates the Orbiter down about the aft attach points. Once the Orbiter is connected to the front end attach point, it is no longer a suspended load.

Figure 24 – Orbiter on Transporter being backed out from under suspended Ferry Flight Lifting Sling

3.0 Acronyms

ALDEM	Alternate Lifting Devices and Equipment Manager
ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
DFRC	Dryden Flight Research Center
DIN	Deutsches Institut für Normung (German Institute for Standardization)
EOM	End of Mission
ET	External Tank
KSC	Kennedy Space Center
SCA	Shuttle Carrier Aircraft
LDEM	Lifting Devices and Equipment Manager
MDD	Mate Demate Device
NASA	National Aeronautics and Space Administration
NLG	Nose Landing Gear
OLF	Orbiter Lifting Fixture
OMDP	Orbiter Maintenance Down Period
OSHA	Occupational Safety and Health Administration
OT	Overland Transporter
OTS	Orbiter Transport System
OV	Orbiter Vehicle
S&MA	Safety and Mission Assurance
SLO	Suspended Load Operation
SLOAA	Suspended Load Operation Analysis/Approval
USA	United Space Alliance
VAB	Vehicle Assembly Building

Jeffrey Alexander FOR BILL HIGGINS 6/25/12

William Higgins Date

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