ORBITER LIFTING SLING DAMAGE PREVENTION
KSC ERB (Information only)

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Objective and Overview

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Objective: Discuss the probable cause of the recent ball screw jack breakage and possible solutions that will prevent future damage to the Orbiter lifting sling.

Current Orbiter Lifting Sling Move Configuration

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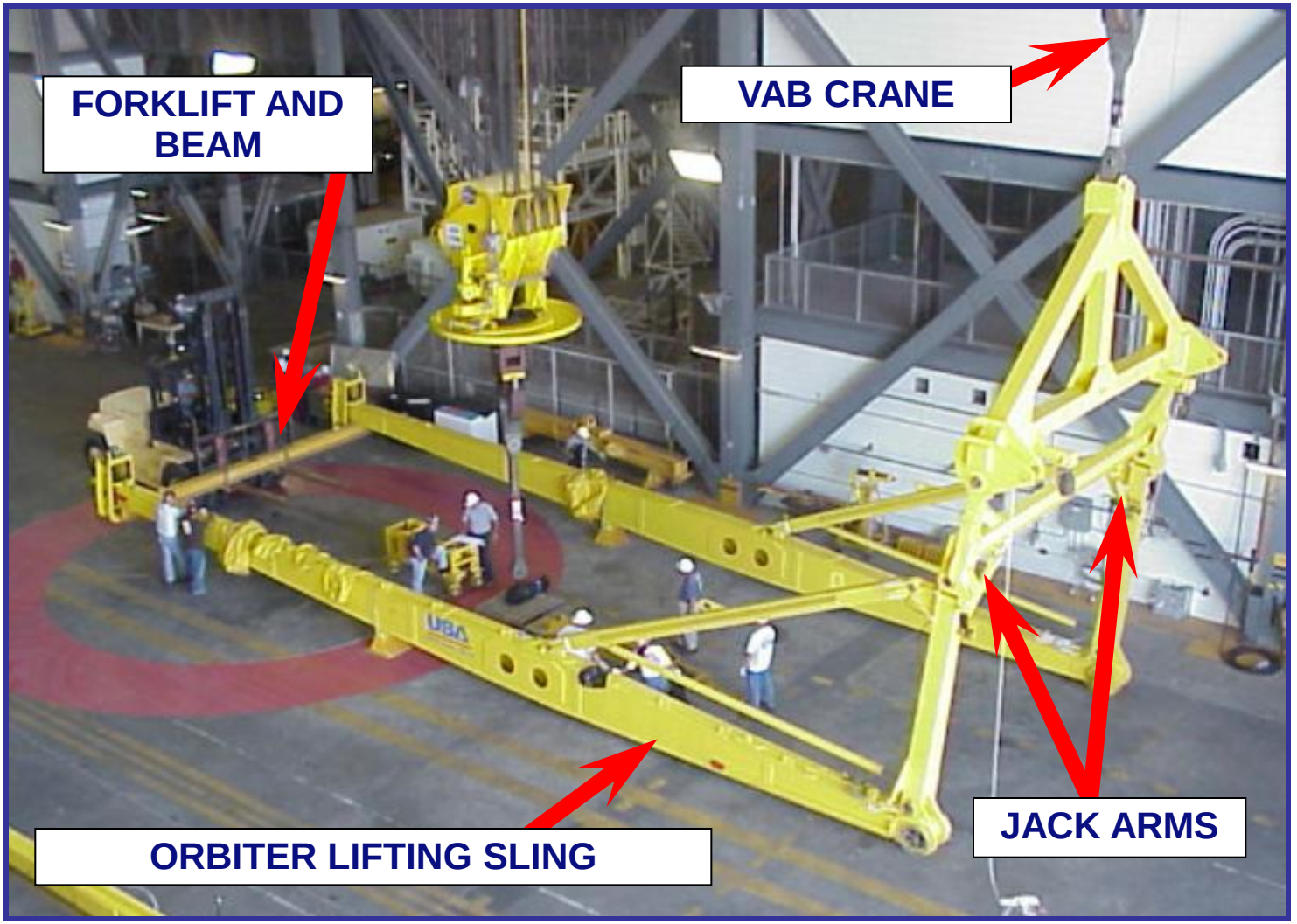

Failure During Sling Move Operation

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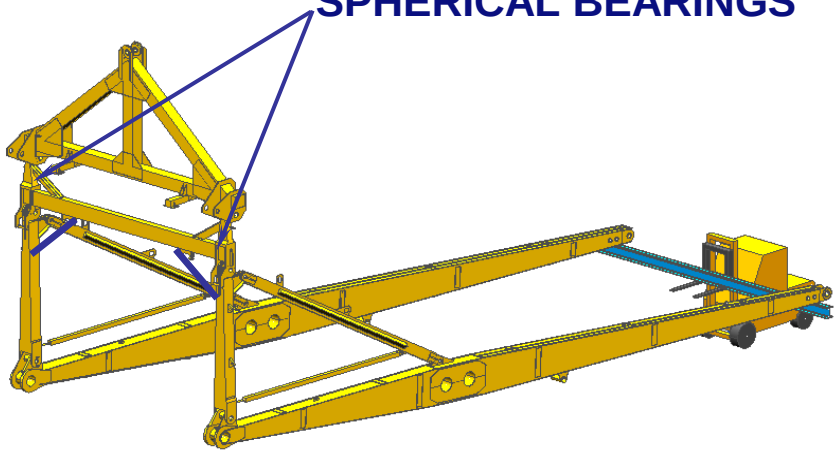
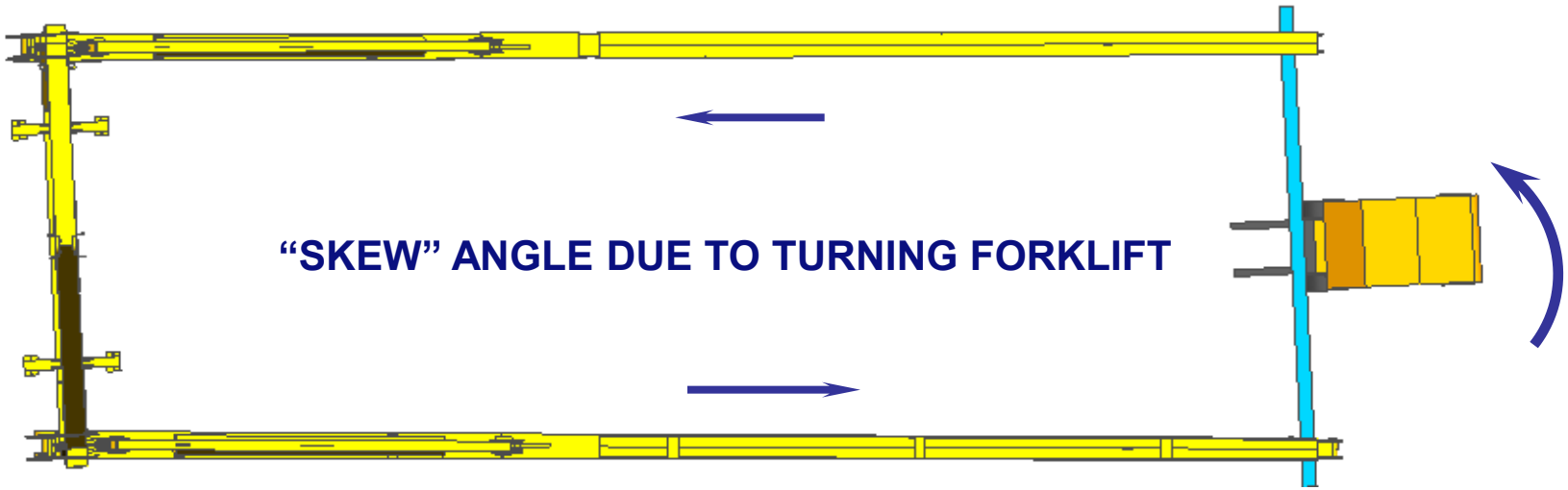
The forklift turned during the sling move operation from HB-1 to HB-3 prior to STS-121 mate, misaligning the sling sides (skew angle). This angle put the jack arms in bending, thus breaking one.





Orbiter Sling Failure Mode

Lower jack arm end connections have single axis pivots, with almost no tolerance for skew angle.

Failure analysis report BPT-006-06MP indicates a single bending failure.

Jack Strut Allowable Misalignment Test

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PR H70-0597-00-001-0143, Operation 91, Jack Arm Travel Limit Checks, performed on 5/30/2006.

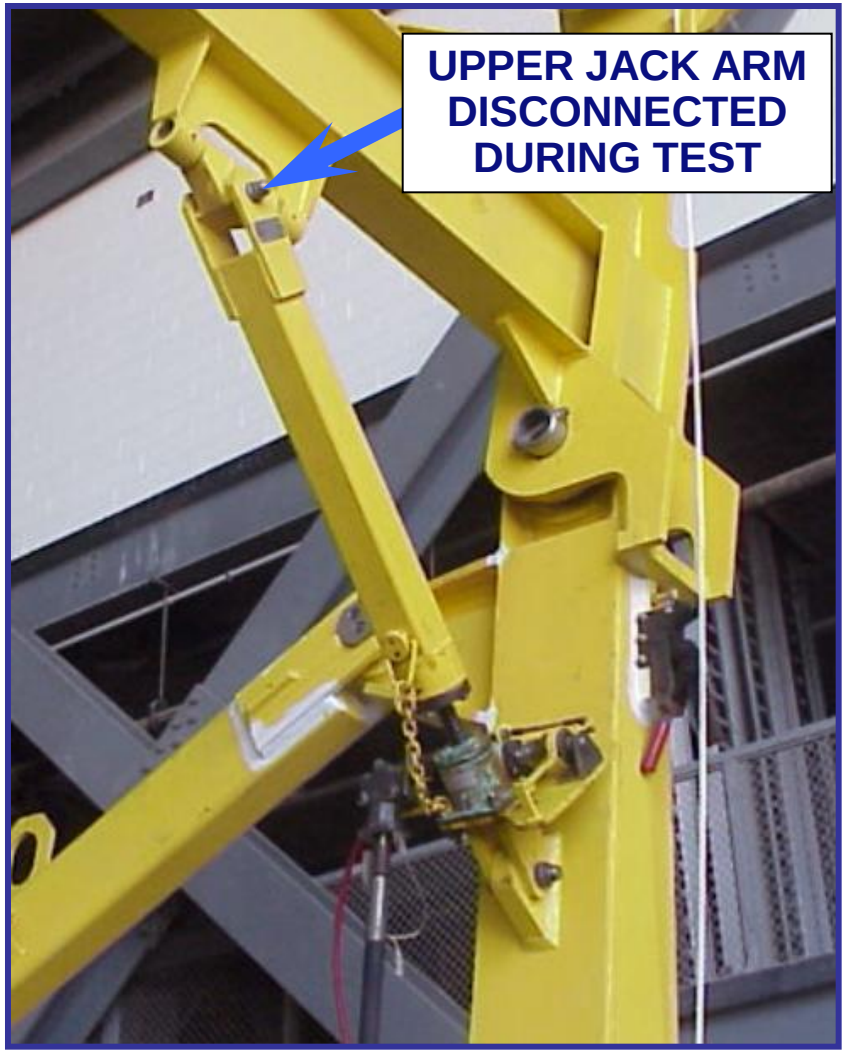
RH Forward Travel 1.0 in

RH Aft Travel: .5 in

LH forward travel .25 in

LH aft travel: 1.0 in

This confirms that the lower pivot connection has very little tolerance for misalignment.



Orbiter Sling Installation and Removal

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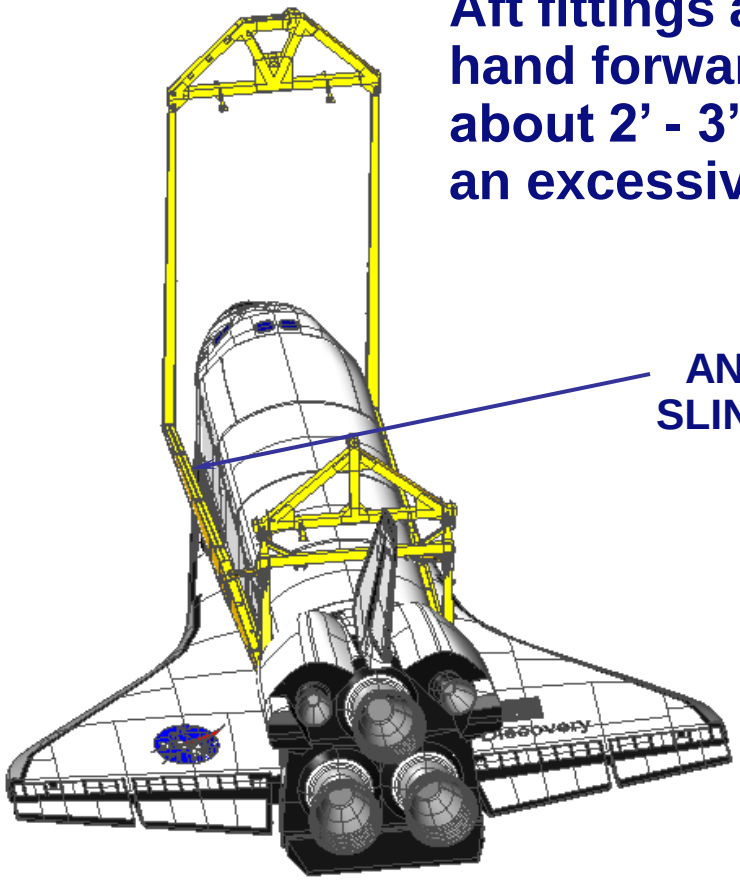
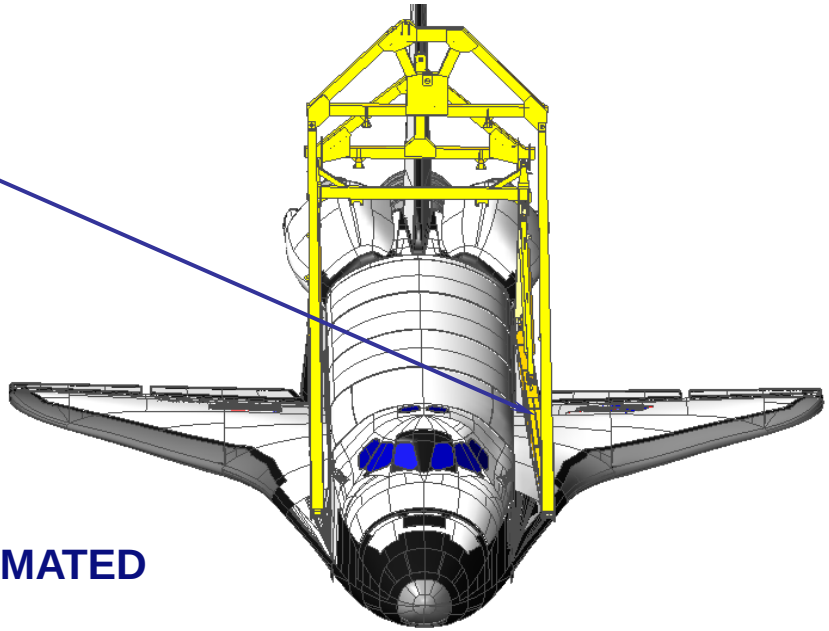
Sling installation and removal operations may exceed allowable jack arm angle.

Aft fittings are mated first. Prior to mating the left hand forward fitting, the end of the sling leg is about 2' - 3' from the mated position. This results in an excessive, >1.8 , angle at the jack arm.



ANGLED SLING ARM



3 FITTINGS MATED

Option 1 : Use Sling Trailer

Move the sling with the trailer originally designed to transport it at Vandenburg.

This option is recommended by Boeing GSE DE in SEPAR SFOC-2692.

The trailer is currently being used by the SRB group to transport segment rings.

The trailer has never been used to transport the Orbiter Sling at KSC.

Forward sling legs and spreader beam assembly is required to load and unload the trailer.

Option 1 (Continued): Trailer

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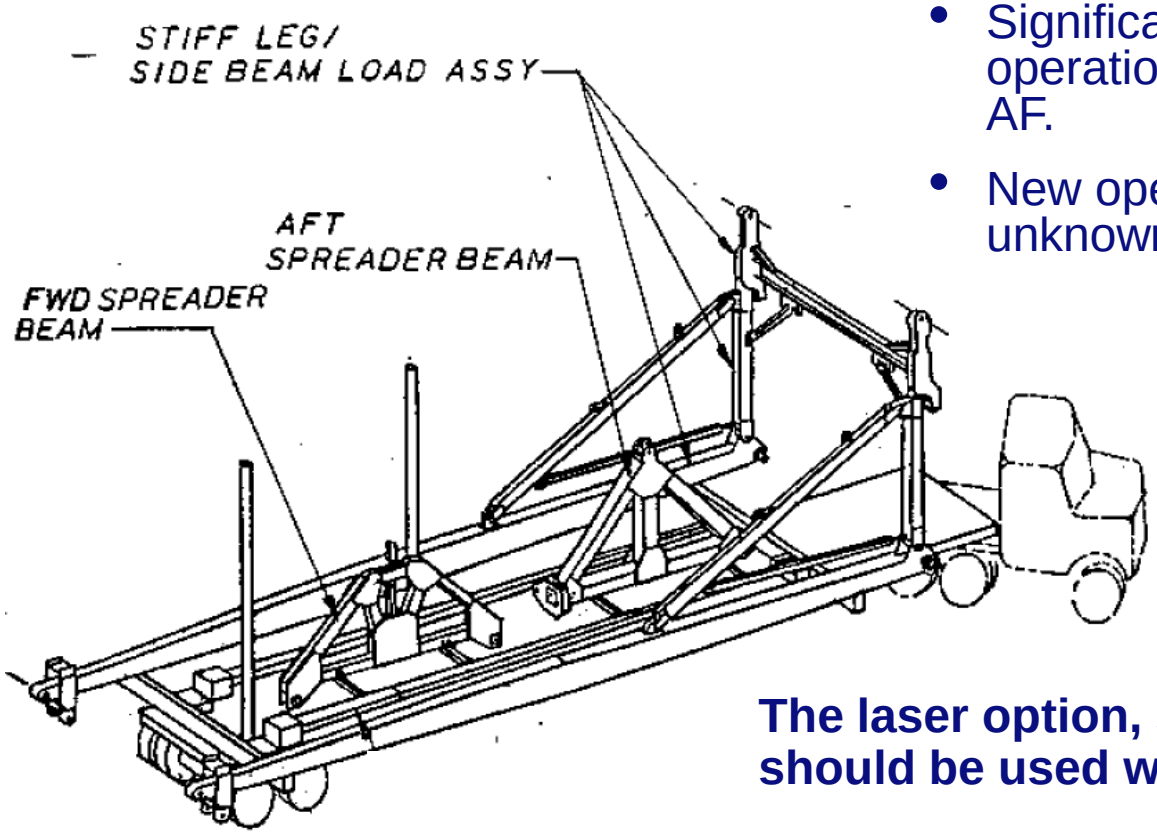
Pros:

- Sling can be moved without significant risk of damage.



Cons:

- Raises sling ~4', increasing difficulty of operations.
- Significant negative impact to SRB operations at the RPSF and Hangar AF.
- New operation, with potential unknown issues.

The laser option, shown on the next page, should be used with this option.

Option 2: Skew Angle Monitoring and Translating Forklift

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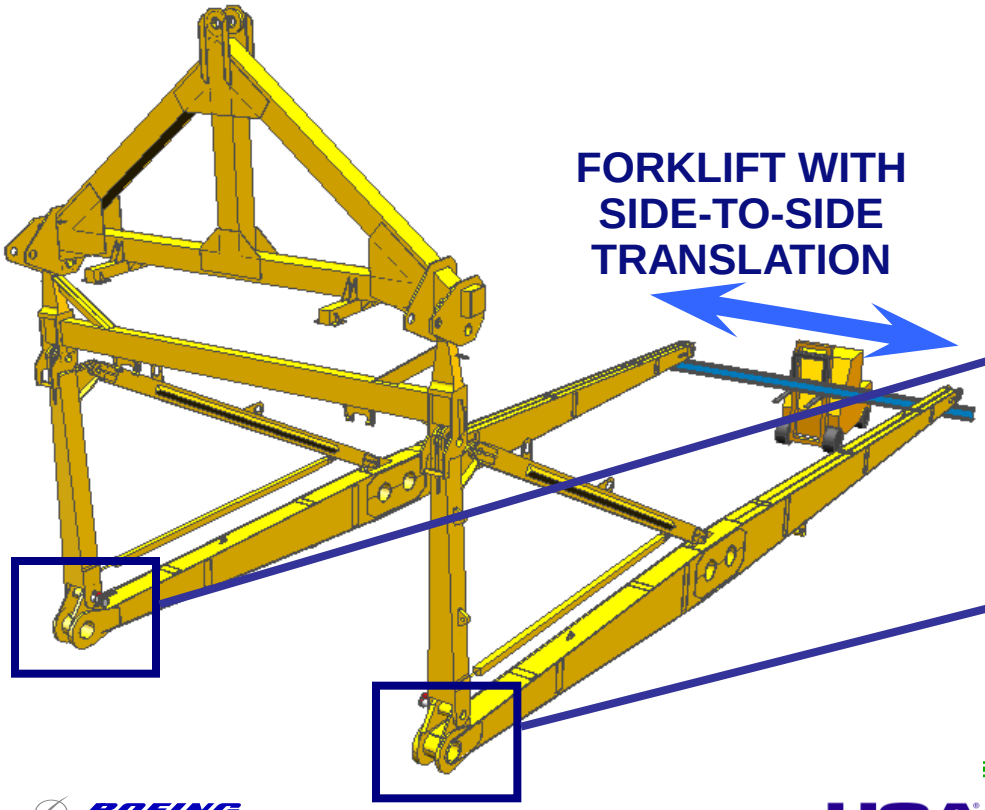
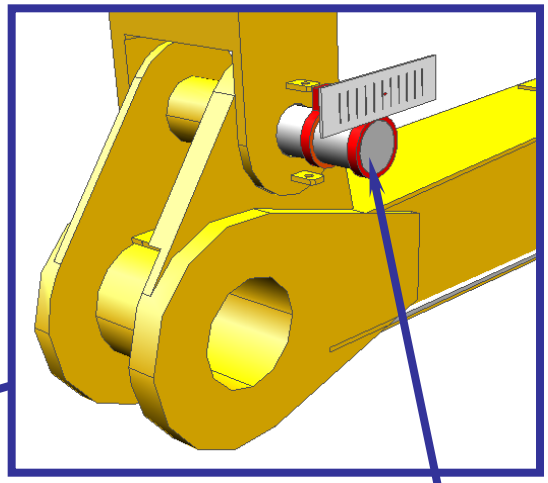
Monitor skew angle with a laser pointer and target. The laser monitoring system is already in-work by the NASA Applied Physics Lab.

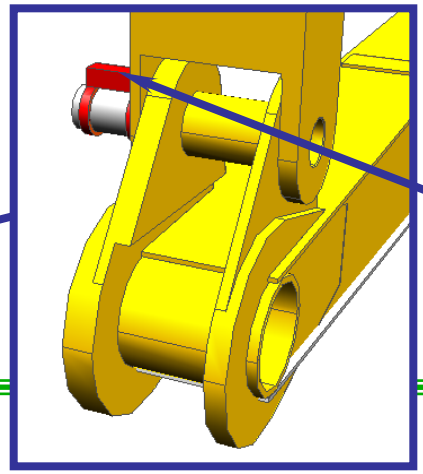
Use a different forklift with forks that translate side-to-side. This will allow sling to be moved East and West without turning the forklift.



FORKLIFT WITH SIDE-TO-SIDE TRANSLATION



LASER TARGET



LASER POINTER

BOEING

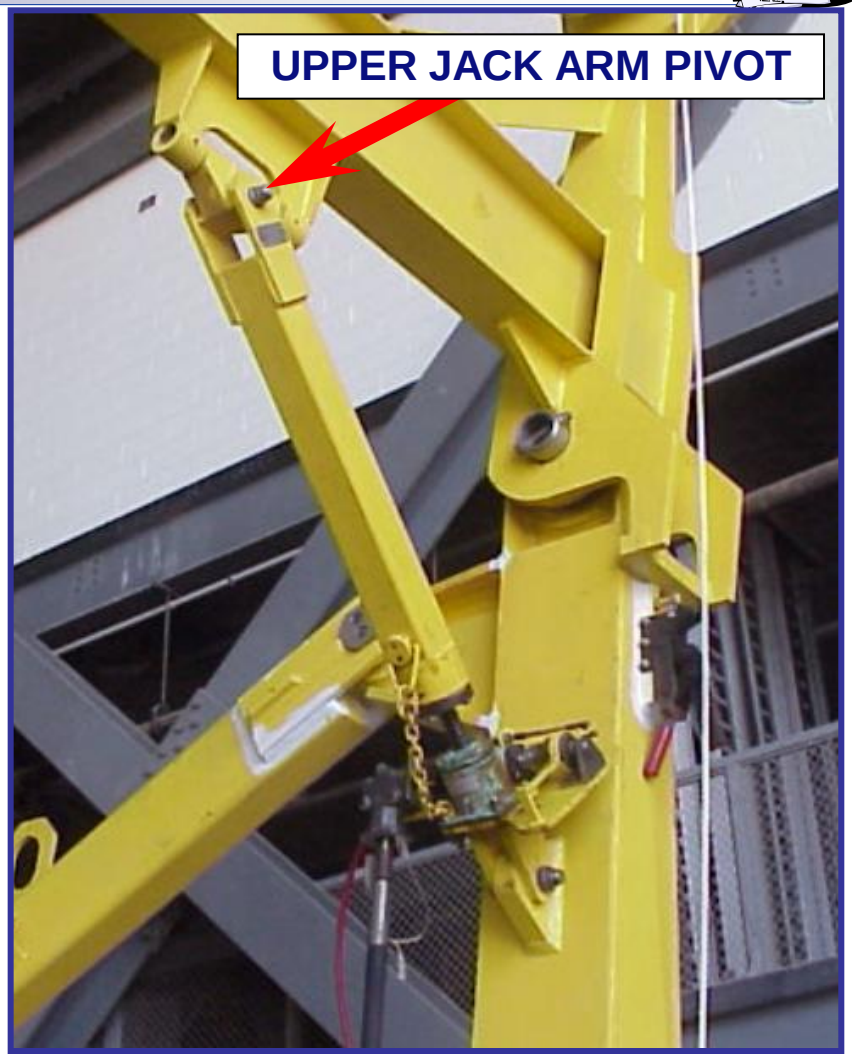
USA United Space Alliance

NASA

Option 3: Disconnect Jack Arm

Disconnect upper jack arm pivot after the VAB crane has assumed the load, prior to moving the sling.

Reconnect the jack arm prior to releasing crane load.

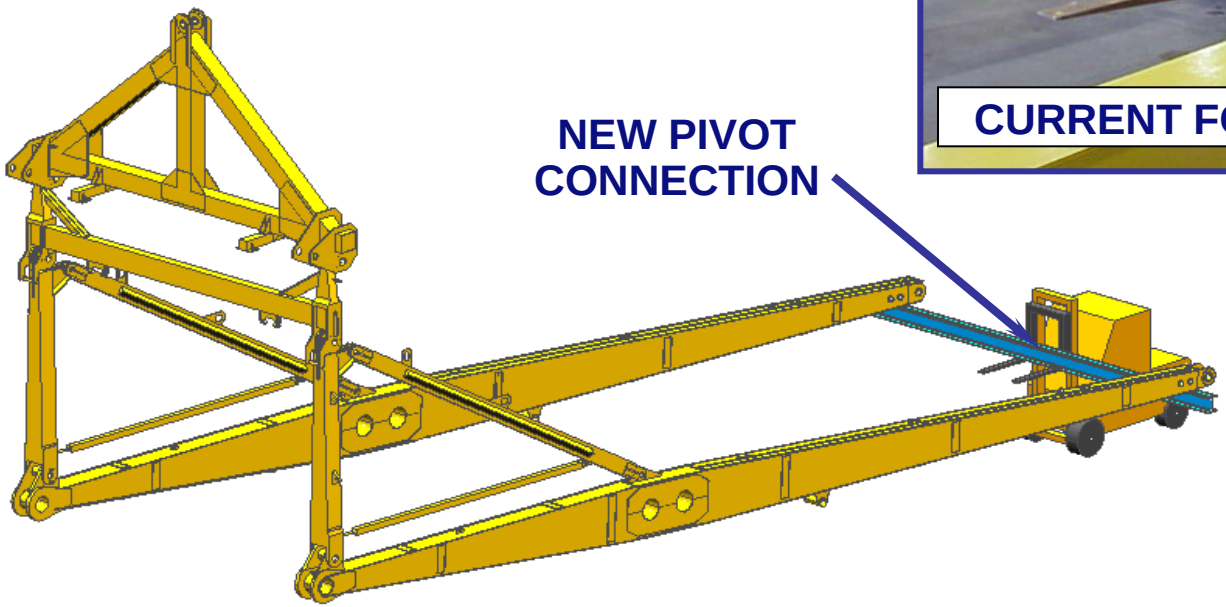


Option 4: Design Pivot Connection at Forklift

Design a pivot connection between the forklift and beam.

This will allow the forklift to turn without inducing a skew angle.

The laser system should also be used with this option.



Jack Arm Design Investigation

As designed, the aft stiff leg can rotate about a spherical bearing, ~3 each way.

The G070-543349 jack arm lower connection is limited to 1.25 per SEPAR SFOC-2692, and cannot comply with the potential leg rotation.

Boeing GSE DE is evaluating this problem.

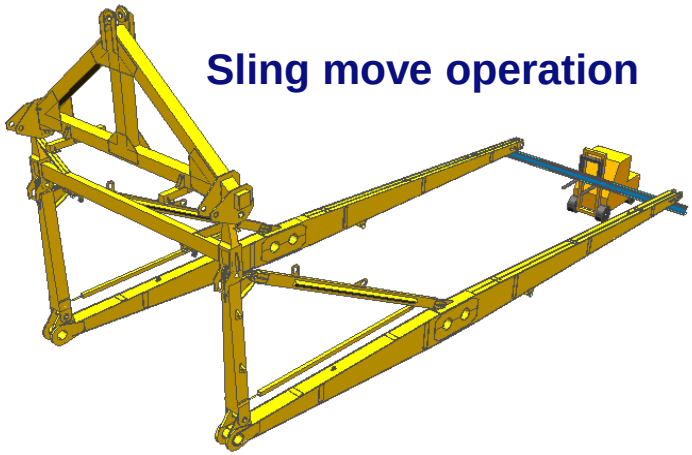
Summary

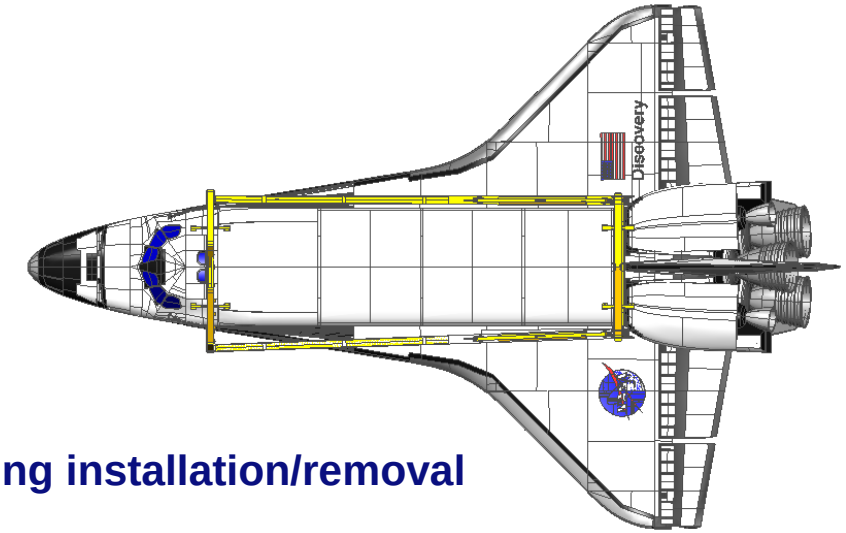
There are two separate operations that have the potential to improperly load the jack struts, the move operation, and the installation/removal operation.

For the move operation, USA launch Site Design Engineering (LSDE) recommends monitoring the skew angle (option 2) and disconnecting the ball screw jacks (option 3).

The installation/removal operation problem is being investigated by Boeing GSE DE.

Sling move operation





Sling installation/removal