



NASA-STD-8719.9 - May 9, 2002

Appendix A NASA Alternate Standard for Suspended Load Operations
Re: Gulfstream engine removal / installation at DFRC & DAOF

PURPOSE: NASA HQ performed an Institutional/Facility/Operational (IFO) Audit of DFRC from March 8 – 12, 2010. The audit identified a Critical Nonconformance issue related to Gulfstream engine removal and installation procedures being a violation of OSHA and NASA safety regulations prohibiting people from being under a suspended load. This document is requesting approval and documentation that the Gulfstream engine removal and installation procedures, for G II, G III and C-20 aircraft maintained at the Dryden Flight Research Center (DFRC) and the Dryden Aircraft Operations Facility (DAOF), are in compliance with the NASA Alternate Standard for Suspended Load Operations.

RATIONALE: Interviews and discussions with DFRC staff knowledgeable of this operation and of critical lift planning did not identify any reasonable alternatives for this suspended load task. Attaching the engine to an additional overhead lift point could not be done due to the absence of other lifting attachment points on the engine. Supporting the engine from below could not be done because of potential engine/aircraft damage in the extremely limited access space for even a smaller sized forklift or hoist. Designing a “diversion device”, to deflect a falling engine away from the people, was also ruled out. Placing and securing a large diversion device in the extremely limited access space would restrict/limit the technicians’ access to the hard to see primary engine mount. Without a reasonable alternative, the consensus was to utilize the NASA Alternate Standard for Suspended Load Operations.

BACKGROUND: The NASA governing directive for this situation is the Standard for Lifting Devices and Equipment, NASA-STD-8719.9. NASA has acknowledged that due to its’ unique missions and equipment, compliance with the intent but not necessarily to the full letter of OSHA’s General Industry Safety Regulations is an issue. In response to this issue, NASA developed the NASA Alternate Standard for Suspended Load Operations. This “alternate standard” was submitted and approved by OSHA in 1991. This standard applies to specifically identified operations controlled by NASA involving both civil service and contractor employees. The standard is an alternate to Code of Federal Regulations 29 CFR 1910.179(n)(3)(vi), 29 CFR 1910.180(h)(3)(vi), and 29 CFR 1910.180(h)(4)(ii). NASA Safety is responsible for its implementation and enforcement.

As an alternative standard developed pursuant to Section 1-201(d) of Executive Order 12196 and 29 CFR 1960.17, it applies only to NASA employees. The Occupational Safety and Health Administration (OSHA) will inspect the working conditions of NASA employees performing these specified operations for compliance with these alternate standard requirements. Although OSHA cannot inspect private sector employees working in the same operation with NASA employees for compliance with the alternate standard, it will fully consider the equivalent safeguards specified in this standard for both NASA and contractor employees as the basis for a de minimis violation which is recorded, but not issued.

Due to the uniqueness of NASA activities and the limitations imposed when using present systems, hardware, equipment, and facilities, suspended load operations may be permitted only under specifically approved and controlled conditions. No suspended load operation shall be performed unless all (15) of the special requirements listed in Appendix A of NASA-STD-8719.9 are met.



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NASA Alternate Standard for Suspended Load Operations Special Requirements: This section will identify each of the fifteen (15) special requirements from Appendix A and then identifies how the Gulfstream engine removal and installation process fulfills each one.

- 1) Hazards analysis of the operation – to include justification why the operation cannot be conducted without personnel beneath the load / precautions taken to protect personnel should the load drop / maximum number of exposed personnel allowed / time of exposure.**

See Attachment 1 - Hazard Analysis. Gulfstream Aerospace has maintained the G II, G III and C-20 aircraft using these standard Maintenance Manual Procedures for engine work for over 40 years. The manual WARNING states that personnel will remain clear of the area, EXCEPT for those actively engaged in disconnecting or securing the engine mounts during the engine lift.

See Attachment 2 - Gulfstream Maintenance Manual. Two technicians are required to be under the suspended load. One person must be partially beneath the suspended engine in order to see, manipulate, align and install the primary (lower) engine mounting "trunnion". That person will be on a step ladder, which is placed as far under the engine pylon as possible; however, for short periods of time the person must move their head and arm up and into the suspended engine to attach the mounting hardware. A second technician must be under the suspended load to manually rotate/move/align the engine at the direction of the first technician trying to install the pin. The time for this exposure will vary from thirty (30) to sixty (60) minutes.

The one person who performs the primary (lower) engine mounting "trunnion" procedure must also remove their hardhat. Due to extremely close quarters and the numerous engine components obstructing a clear view of the engine mount, the person must be able to freely move their head without any obstructions to their field of view. Even the small bill of a "bump cap" would be an impediment to this difficult line of sight task. However, after the lower "trunnion" is installed a hardhat is required for the remainder of lift procedures involved with installation of the last two (upper) mounts.

- 2) Each operation reviewed on a case-by-case basis.**

Because this procedure meets the NASA definition of a Critical Lift, this procedure will be reviewed each time the Permit for the lift is requested.

- 3) Only those suspended load operations approved by the Center NASA Director of Safety will be permitted.**

This alternate standard approval is only for the Gulfstream engine removal and installation for all Gulfstream models G II, G III and the military model C-20.



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- 4) **The operational procedures revised to specify requirements identified by the hazard analysis.**

The Critical Lift review procedures will address all mitigations identified in the Hazard Analysis. See Attachment 3 – Draft Critical Lift Plan.

- 5) **During the operation if unusual or unforeseen circumstances require a new procedure not covered by the original analysis, the NASA Center Safety Office must approve and document the procedure before operations continue.**

During operations if unforeseen circumstances occur requiring variation from the procedure, concurrences between Safety, Operations, Engineering and other technical advisor as appropriate will be reached and recorded as redlines to the procedure. Operations may continue after briefing about the variation. Revisions of the procedure must be completed before any subsequent operations may be conducted. These requirements are built into the Critical Lift Plan.

- 6) **The crane shall be designed, tested, inspected, maintained, and operated in accordance with the NASA Standard for Lifting Devices and Equipment (NASA-STD-8719.9).**

The 15 Ton “large Broderson” crane, Number 51-91, is operated and maintained to the NASA Standard and has been approved for Critical Lift operations. Contact the DFRC LDEM to review the Broderson Critical Lift Certification package.

- 7) **The crane shall undergo a Failure Modes and Effects Analysis (FMEA) to determine Single Failure Points (SFP) - for cranes with no SFP the total weight of the suspended load shall not exceed the device’s rated load / for cranes with a SFP use must be approved by NASA Headquarters.**

During the Critical Lift certification process, a FMEA analysis was conducted as part of the System Assurance Analysis (SAA). The System Assurance Analysis of the 15 Ton Broderson Yardrunner, IC-180-1A, dated 04/09/2008, is located in DFRC LDEM’s office.

The SAA identified one critical category 1 and one category 2 SFP for the crane. The Category 1 SFP is a load could drop if there was structural failure of the gear or output shaft, at the point of torque transfer between the hoist hydraulic motor and the hoist drum. Although such a catastrophic failure is technically possible, the probability of such a failure is extremely unrealistic. Discussions with NASA Headquarters personnel covered the following consideration of using this specific mobile crane:

- A comprehensive SAA has been completed
- The crane is critical lift authorized
- The hoist, drum, and braking system has been rebuilt within the last 3 months
- The crane was tested and certified within the last 2 months



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- Lift is considered a critical lift due to personnel hazards = within this procedure limiting exposure time and personnel to the hazard is addressed
- Crane is being loaded to approximately 43% of rated net capacity
- A closer inspection of the hoist assembly will be conducted (in conjunction with the pre-use by the operator) by the ground support personnel who maintain the crane
- A load hold test will be complete before the actual suspended load lift

The Category 2 SFP is that a disengagement or failure of the gear or shaft that rotates the turret could allow loss of torque for moving or stopping horizontal movement of the upper structure. This is not identified within section A.4.7 as a stopping point; it is not a factor in which the load will drop; therefore, it is not a risk to people under the suspended load.

After reviewing the Critical Lift documentation package, the NASA Headquarters Safety personnel have concurred that the lift may proceed.

- 8) Before lifting the load, the crane 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).**

Prior to the operation, a visual inspection of the crane is conducted per NASA-STD-8719.9.

- 9) A trained / licensed operator shall remain at the crane/hoist controls while personnel are under the load.**

NASA and DFRC policies prohibit untrained/unqualified person from operating lifting equipment and NASA and OSHA safety regulation prohibit the operator from leaving a suspended load. QA, Safety, and/or LDEM audits and validates compliance with these requirements.

- 10) Safety controlled areas shall be established with appropriate barriers.**

It is standard operating procedure for all lifts to establish a Controlled Area to limit personnel movement in the lift area. For this operation a Restricted Area will also be established and only the two required technicians will be allowed under the suspended load.

- 11) Prior to the lift, a meeting with the crane 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.**

All Critical Lifts require an approved Lift Plan and this approved plan and procedures are reviewed during the pre-lift briefing.



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12) Communications between the operator(s), signal person(s), and the person(s) working under the load shall be constantly maintained.

It is standard operating procedure for all lifts and is emphasized for Critical Lifts. If communications between the signal person and the crane operator are compromised, operations will be immediately stopped until clear communications are reestablished.

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

It is standard operating procedure for all lifts and is emphasized for Critical Lifts. If the line of sight between the signal person and the crane operator are compromised, operations will be immediately stopped until a clear line of sight is reestablished.

14) NASA shall conduct periodic reviews, as a minimum annually, to ensure the continued safety of the procedures.

The DFRC NASA LDEM will participate in the Planning for all Critical Lifts and for periods where there are no alternate suspended load procedures conducted the LDEM will perform periodic evaluations.

15) A list of approved suspended load operations, list of cranes used and copies of the associated hazards analyses will be provided to the designated NASA officials for distribution to the appropriate regional and area OSHA offices.

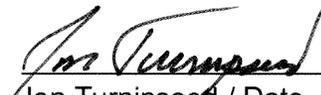
After final approval of this document, the LDEM will forward a copy to the applicable NASA personnel.

APPROVALS: Your signature below acknowledges that you have read, understand and agree that the Gulfstream engine removal & installation procedures are compliant with the NASA Alternate Standard for Suspended Load Operations.

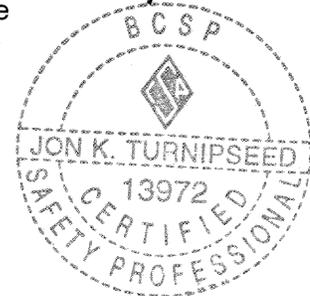
Computer Sciences Corporation (CSC)

 103/18/10

Ken MC Donald / Date
CSC Site Manager

 13/18/10

Jon Turnipseed / Date
CSC Safety Manager





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Appendix A NASA Alternate Standard for Suspended Load Operations
Re: Gulfstream engine removal / installation at DFRC & DAOF

DFRC/DAOF Code O

Tom Grindle / mar 19 2010
Tom Grindle
Chief of Maintenance

Lawrence Davis / 3/18/10
Lawrence Davis
Director of Flight Operations

DFRC/DAOF Safety & LDEM

Billy A. Bollinger / 3-18-10
Billy Bollinger
Lifting Device Equipment Manager / SH

Center Director of Safety

Vince Chacon / 3/19/10
Vince Chacon
Director of Safety & Mission Assurance



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Attachment 1 - Hazard Analysis



HAZARD REPORT – LIFTING EQUIPMENT ANALYSIS



PROJECT G II, G III, C-20	ORIGINATOR Jon Turnipseed	ORG / CODE OM	HAZARD TITLE Crushing	DATE 03 / 15 / 2010	HR # HR-02-PRS
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INFORMATION SOURCE <input type="checkbox"/> DESIGN REVIEW <input checked="" type="checkbox"/> HAZARD ANALYSIS <input type="checkbox"/> TEST READY REVIEW <input type="checkbox"/> TEST <input type="checkbox"/> DISCREPANCY REPORT <input type="checkbox"/> OTHER _____	SYSTEM / EQUIPMENT <input type="checkbox"/> TEST SET UP <input type="checkbox"/> TEST ARTICLE <input checked="" type="checkbox"/> AIRCRAFT <input type="checkbox"/> GROUND SUPPORT EQUIP <input type="checkbox"/> FACILITY EQUIPMENT <input type="checkbox"/> OTHER _____	ASSIGNED TO OM Maintenance Team	FINAL CATEGORY 1E
		SYSTEM NAME Lifting Operation	RELATED DRS N/A
		HAZARD ANALYSIS /STUDY NAME Lifting Operation Hazard	LOCATION DFRC

HAZARD DESCRIPTION & JUSTIFICATION FOR CATEGORY/PROBABILITY RATING
Crushing of personnel due to load movement.

CAUSE
Lack of communication, situational awareness and training.

EFFECT
Injury to or death of personnel; damage to aircraft.

INIT CAT/PROB Human – 1D	SIGNATURE 	DATE 03/15/2010
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CONTROL BOARD ACTION

<input type="checkbox"/> OPEN <input checked="" type="checkbox"/> ACCEPTED	RECOMMENDED ACTION Verify clear communications between signal person and crane operator. Verify procedures address personnel duties. Verify personnel are properly trained. Brief and follow procedures.
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SIGNATURE 	DATE 03/16/2010	SIGNATURE 	DATE / /
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HAZARD RISK REDUCTION ACTION

Verify clear communications between signal person, crane operator, and others in area are maintained. Stop operations if communications are interrupted for any reason. Brief and follow procedures ensuring roles and responsibilities are identified and adhered too. Verify personnel involved in the procedure are properly trained to the required disciplines.

SIGNATURE 	DATE 03/16/2010
---------------	---------------------------

Probability [Pr] Estimations					
Injury Severity Classifications	A: Expected to occur ($Pr > 10^{-1}$)	B: Probable to occur ($10^{-1} \geq Pr > 10^{-2}$)	C: Likely to occur ($10^{-2} \geq Pr > 10^{-3}$)	D: Unlikely to occur ($10^{-3} \geq Pr > 10^{-6}$)	E: Improbable to occur ($10^{-6} \geq Pr$)
I: Catastrophic*					HR-02-PRS
II: Critical*					
III: Minor*					
IV: Negligible*					



HAZARD REPORT – LIFTING EQUIPMENT ANALYSIS

PROJECT G II, G III, C-20	ORIGINATOR Jon Turnipseed	ORG / CODE OM	HAZARD TITLE Mobile Crane	DATE 03 / 15 / 2010	HR # HR-01-CRN
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INFORMATION SOURCE <input type="checkbox"/> DESIGN REVIEW <input checked="" type="checkbox"/> HAZARD ANALYSIS <input type="checkbox"/> TEST READY REVIEW <input type="checkbox"/> TEST <input type="checkbox"/> DISCREPANCY REPORT <input type="checkbox"/> OTHER _____	SYSTEM / EQUIPMENT <input type="checkbox"/> TEST SET UP <input type="checkbox"/> TEST ARTICLE <input checked="" type="checkbox"/> AIRCRAFT <input type="checkbox"/> GROUND SUPPORT EQUIP <input type="checkbox"/> FACILITY EQUIPMENT <input type="checkbox"/> OTHER _____	ASSIGNED TO OM Maintenance Team	FINAL CATEGORY 1E
		SYSTEM NAME Large Broderson Crane	RELATED DRS N/A
		HAZARD ANALYSIS /STUDY NAME Crane Hazards	LOCATION DFRC

HAZARD DESCRIPTION & JUSTIFICATION FOR CATEGORY/PROBABILITY RATING
Mechanical overload of the mobile crane due to improper usage.

CAUSE
Lack of training.

EFFECT
Injury to or death of personnel; damage to aircraft and equipment.

INIT CAT/PROB Human – 1D	SIGNATURE <i>Jon Turnipseed</i>	DATE 03/15/2010
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RECOMMENDED ACTION

<input type="checkbox"/> OPEN <input checked="" type="checkbox"/> ACCEPTED	Only trained personnel will operate the mobile crane. Verify crane capacity at given configuration.
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SIGNATURE <i>Scott A. [Signature]</i>	DATE 03/16/2010	SIGNATURE	DATE / /
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HAZARD RISK REDUCTION ACTION

Only trained personnel will operate the mobile crane and certifications will be verified before lifting operations. Verify crane capacity at given configuration is below 75% of crane's net capacity per manufacture's in-cab load chart.

SIGNATURE <i>Scott A. [Signature]</i>	DATE 03/16/2010
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Probability [Pr] Estimations					
Injury Severity Classifications	A: Expected to occur ($Pr > 10^{-1}$)	B: Probable to occur ($10^{-1} \geq Pr > 10^{-2}$)	C: Likely to occur ($10^{-2} \geq Pr > 10^{-3}$)	D: Unlikely to occur ($10^{-3} \geq Pr > 10^{-6}$)	E: Improbable to occur ($10^{-6} \geq Pr$)
I: Catastrophic*					HR-01-CRN
II: Critical*					
III: Minor*					
IV: Negligible*					



HAZARD REPORT – LIFTING EQUIPMENT ANALYSIS

PROJECT G II, G III, C-20	ORIGINATOR Jon Turnipseed	ORG / CODE OM	HAZARD TITLE Mechanical Overload	DATE 03 / 15 / 2010	HR # HR-03-HDW
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INFORMATION SOURCE <input type="checkbox"/> DESIGN REVIEW <input checked="" type="checkbox"/> HAZARD ANALYSIS <input type="checkbox"/> TEST READY REVIEW <input type="checkbox"/> TEST <input type="checkbox"/> DISCREPANCY REPORT <input type="checkbox"/> OTHER _____	SYSTEM / EQUIPMENT <input type="checkbox"/> TEST SET UP <input type="checkbox"/> TEST ARTICLE <input checked="" type="checkbox"/> AIRCRAFT <input type="checkbox"/> GROUND SUPPORT EQUIP <input type="checkbox"/> FACILITY EQUIPMENT <input type="checkbox"/> OTHER _____	ASSIGNED TO OM Maintenance Team SYSTEM NAME Structural Sling HAZARD ANALYSIS /STUDY NAME Lifting Sling Assembly Hazard	FINAL CATEGORY 1E RELATED DRS N/A LOCATION DFRC
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HAZARD DESCRIPTION & JUSTIFICATION FOR CATEGORY/PROBABILITY RATING
Crushing of personnel due to overloading and subsequent failure of the structural sling.

CAUSE
Use of improper lifting device and lack of proper training.

EFFECT
Injury to or death of personnel; damage to aircraft.

INIT CAT/PROB Human – 1D	SIGNATURE 	DATE 03/15/2010
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<input type="checkbox"/> OPEN <input checked="" type="checkbox"/> ACCEPTED	RECOMMENDED ACTION Ensure proper lifting device, per written procedure, is utilized. Verify lifting device is properly load tested and NDE'd. Verify personnel are properly trained. Brief and follow procedures.
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SIGNATURE 	DATE 03/16/2010	SIGNATURE 	DATE / /
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HAZARD RISK REDUCTION ACTION

Verify lifting hardware used is correct per the written procedure. Verify lifting hardware is properly tested, NDE'd and verification records are available. Verify personnel involved in the procedure are properly trained to the required disciplines. Stop operations if communications are interrupted for any reason. Brief and follow procedures ensuring roles and responsibilities are identified and adhered too.

SIGNATURE 	DATE 03/16/2010
---------------	---------------------------

Probability [Pr] Estimations					
Injury Severity Classifications	A: Expected to occur ($Pr > 10^{-1}$)	B: Probable to occur ($10^{-1} \geq Pr > 10^{-2}$)	C: Likely to occur ($10^{-2} \geq Pr > 10^{-3}$)	D: Unlikely to occur ($10^{-3} \geq Pr > 10^{-6}$)	E: Improbable to occur ($10^{-6} \geq Pr$)
I: Catastrophic*					HR-03-HDW
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Attachment 2 - Gulfstream Maintenance Manual



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Appendix A NASA Alternate Standard for Suspended Load Operations
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Attachment 3 – Draft Critical Lift Plan

DRAFT

AS RUN DATE: _____

W.O. NUMBER: _____



NASA Aircraft Maintenance



**Dryden Flight Research Center
(DFRC)**

**Dryden Aircraft Operations
Facility (DAOF)**

**G II / G III / C-20
Engine Lifts**

March 15, 2010

Hazardous Operation
The following procedure contains a
CRITICAL LIFT
Operation performed per
NASA Alternate Standard for Suspended
Load Operations

MISHAP/EMERGENCY RESPONSE

DFRC

***IN CASE OF
EMERGENCY***

CELL PHONES *MUST* DIAL:

661-276-3256

DAOF

***IN CASE OF
EMERGENCY***

CELL PHONES *MUST* DIAL:

661-276-5504

Emergency response phone numbers:

- | | <u>Land Line</u> | <u>Cell Phone</u> |
|---------|-------------------------|--------------------------|
| • DFRC: | 911 | 661-276-3256 |
| • DAOF: | 911 | 661-276-5504 |

Note: Cell Phone use is not allowed within 25 feet of an aircraft or 50 feet of an aircraft open fuel cell. Where allowed, participating personnel should have emergency numbers programmed into their cell phones prior to start of operations.

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1.0 OBJECTIVE

This procedure provides the safety guidelines and operational steps to perform engine removal and installation for G II, G III and C-20 aircraft, per the Gulfstream Maintenance Manual – Power Plant Removal / Installation Procedure.

1.1 SCOPE

This procedure is applicable to NASA and NASA contractors who operate and maintain G II, G III and C-20 aircraft at the NASA Dryden Flight Research Center (DFRC) and the Dryden Aircraft Operations Facility (DAOF).

2.0 REFERENCES

2.1 Applicable Documents

*All documents without a version should be considered Latest Issue (LI).

G II	Gulfstream Maintenance Manual – Power Plant Removal/Installation
G III	Gulfstream Maintenance Manual – Power Plant Removal/Installation
DCP-S-009	Dryden Centerwide Procedure, Chapter 6 Critical Lift
DCP-O-001	Dryden Centerwide Procedure, Aircraft Maintenance & Safety Manual
NASA STD 8719.9	Standard for Lifting Devices and Equipment
D-WK 230-8 (FORM)	Critical Lift Process Approval
D-WK 250-8 (FORM)	Lift Planning – Mobile Crane Critical and Non-Critical Lift Checklist
D-WK 251-8 (FORM)	Hazardous Operation Mobile Crane Lift Plan – Hydraulic – Boom Rubber-Tired Pre-Lift Worksheet
NPR 8621.1	NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping

2.2 Acronyms

CG	Center of Gravity
DCP	Dryden Centerwide Procedure
DFRC	Dryden Flight Research Center
DoD	Department of Defense
ESD	Electro Static Discharge
FT	Feet/Foot
FOD	Foreign Object Debris
GSE	Ground Support Equipment
HAZ	Hazardous
ID	Identification
IN.	Inch
Lbs.	Pounds
LDEM	Lifting Devices and Equipment Manager
MGSE	Mechanical Ground Support Equipment
NASA	National Aeronautics and Space Administration
NPR	NASA Procedural Requirements
OP(S)	Operation(s)
P/N	Part Number
POC	Point of Contact
PPE	Personnel Protective Equipment
QA	Quality Assurance
REV	Revision
TL	Task Leader

3.0 PERSONNEL AND EQUIPMENT

3.1 Essential Personnel

Operators:

- One (1) Task Leader / Lift Supervisor
- One (1) Certified Crane Operator
- Two (2) Certified Riggers / AFT Mechanics
- One (1) Quality Assurance Representative
- One (1) Safety Representative
- One (1) General Spotter

Casuals:

- Two (2) NASA Technical Advisors – are not essential to performing the procedure, but who are cleared to be called into the hazardous area on demand to provide technical support.

- One (1) Lifting Devices and Equipment Manager (LDEM) – may be essential to the operation, required to be directly involved in the hazardous operation, and be positioned inside the hazardous control area for the duration of the operation.

3.2 Support Equipment, PPE, and Tools Lists

Support Equipment required for this operation:

- 15 Ton (large) Broderson Crane
- Maintenance Stand
- Six foot step ladder

PPE as required for this operation:

- Hardhats
- Safety glasses
- Mechanics gloves
- Safety toed shoes/boots

Special Tools and Consumables required for the procedure are listed in The G II or G III Maintenance Manual, Power Plant - Removal Installation Procedures.

4.0 SAFETY AND SECURITY

4.1 Safety

These operations will be conducted under the applicable occupational safety and health regulations. All personnel are responsible for maintaining a safe work environment. The task leader shall assure that appropriate safe practices are implemented during pyrotechnics operations. The NASA Safety Representative/LDEM has the final authority over safety provisions.

4.2 Pre -Task Notifications and Safety Briefings

On the day of a Critical Lift, a Pre-Lift Safety Briefing must be held. A Safety Representative and any personnel who will be participating in, or in the operations area during, hazardous operations will attend this briefing.

Twenty four hours prior to the Critical Lift, site safety must be notified of the plan to perform the lift. Prior to the Critical Lift the following document must be completed:

- DFRC Critical Lift Process Approval (DFRC 230-8).
- Hazardous Operation Mobile Crane Lift Plan – Hydraulic Boom – Rubber-Tired Pre-Lift Worksheet (DFRC 251-8).
- Lift Planning – Mobile Crane Critical and Non-Critical Lift Checklist (DFRC 250-8).

The pre-task safety briefing will address the following topics:

- Hazards and associated mitigations provided in section 4.3.
- Emergency instructions, alarm initiation and responses to alarm initiations, and evacuation routes.
- Discuss any obstacles or inhibits, including environmental conditions and operations limitations if applicable.
- Address communication methods and identify the preferred method for stopping the task if the situation appears unsafe. Cell phones must be turned off and physically removed from the control area.
- Identification and inventory of the tools, equipment, and personal protective equipment (PPE).
- Verify that all relevant equipment/machinery has enough fuel prior to the operations.
- Review the procedure with the participating personnel and review the roles and responsibilities for executing the procedure.
- Review FOD Control Procedures for during and after the operation.

If there are any issues that arise during the operation immediately secure the area.

The safety debriefing will address the following topics:

- Review the as-run procedure to ensure that all steps have been executed properly.
- Review the as-run procedure to ensure that all signatures and buy-offs have been recorded properly in the procedure.
- Discuss and document the problems and lessons learned.

4.3 Safety Hazards and Mitigations

The following safety hazards exist when performing this procedure. **Failure to follow any of these mitigations may result in CATASTROPHIC DAMAGE TO THE AIRCRAFT, SERIOUS INJURY or DEATH**

The safety hazards and mitigations are as follows:

- A 24 Hour Notice prior to start of hazardous operations, the NASA Safety Representative/LDEM shall be notified of the Critical Lift and a Critical Lift Review Meeting will be held per DCP-S-009 Ch 6.
- The Critical Lift Plan will be followed as approved. If changes are made in real time, the NASA Safety Representative/LDEM, Quality Assurance Representative, and Operations Engineer will approve and sign these changes.
- Before operations, the crane and associated lifting hardware shall undergo a pre-operation checkout and a visual inspection per DCP-S-009 Ch 6.

- Ensure all lifting hardware meet Critical Lift design and/or proof testing requirements per DCP-S-009 Ch 6 and NASA STD 8719.9
- Ensure Fork Lift operators and riggers are trained per DCP-S-009 Ch 6 and NASA STD 8719.9. NASA Safety Representative/LDEM will verify the operator and rigger certifications
- Ensure Crane rated for Critical Lift per DCP-S-009 Ch 6 and NASA STD 8719.9. The NASA Safety Representative/LDEM will verify the crane certification.
- Ensure Crane operators and riggers are trained per DCP-S-009 Ch 6 and NASA STD 8719.9. The NASA Safety Representative/LDEM will verify the operator and rigger certifications
- Inside the designated operations zone, requisite Personal Protection Equipment (PPE) – Hardhats and steel toe footwear – shall be worn at all times. Gloves shall be worn when manning tag lines or where otherwise appropriate.
- Establish a Controlled Area around the crane and aircraft. Unauthorized persons shall not be permitted in the designated Controlled Area.
- Establish a Restricted Area immediately under the aircraft engine pylon. Only the two authorized technicians shall be allowed under a suspended.
- The Critical Lift object will have 2 tag lines as a minimum. As required in DCP-S-009 Ch 6.

4.4 Physical Security

All aspects of the operation are on secured US Government facilities and access to the aircraft and its GSE is restricted.

5.0 DETAILED OPERATIONS

Section 5.1 provides the steps to prepare for the engine lift operations.

Section 5.2 provides the steps to conclude the engine lift operations.

NOTE: During operations if unforeseen circumstances occur requiring variation from the procedure, concurrences between Safety, Operations, Engineering and other technical advisor as appropriate will be reached and recorded as redlines to the procedure. Operations may continue after briefing about the variation. Revisions of the procedure must be completed before any subsequent operations may be conducted.

5.1 Preparation for engine removal / installation operations

Step No.	Procedure	Initials		Date
		Crew	QA	
1.	<p>Notify NASA Safety Representative/LDEM or designee 24 hours prior to start of operation.</p> <p>Operations location / building no. _____</p> <p>Date/Time of Notification: _____</p> <p>Beginning Date/Time: _____</p>			
2.	<p>Record Date Location and Time:</p> <p>Date: _____</p> <p>Location: _____</p> <p>Start Time: _____</p>			
3.	<p>Verify Work area is free of FOD, hazards and defects.</p>			
4.	<p>Review the tools and equipment list. Verify all items are available.</p>			

5.

Record the names of personnel that will conduct this section of the procedure.

Task Leader / Lift Supervisor:

(print) _____ Aff: _____

(sign) _____

AFT Mechanic / Crane Operator

(print) _____ Aff: _____

(sign) _____

AFT Mechanic

(print) _____ Aff: _____

(sign) _____

	<p>Quality Assurance Representative: (print) _____ Aff: _____ (sign) _____</p> <p>NASA Safety Representative/LDEM (print) _____ Aff: _____ (sign) _____</p>			
6.	Verify Critical Lift Process Approval DFRC 230-8, Personnel Certifications per section 3.1 of this procedure, and Hazards Closed.			
7.	<p>NOTE: Task Leader and Crew Chief shall assess the crew's situational awareness to execute this section or break and regroup.</p> <p>Perform Pre-Task Briefing (Section 4.2). During this briefing, review the Emergency Procedures from Appendix A.</p>			
8.	<p>Perform crane pre-operation checkout and visual inspection. Verify crane and lifting hardware are certified, sufficient for desired lift and free of defects.</p> <p>Expected Load weights: One (1) Rolls-Royce engine and structural sling – 2,950 lbs.</p>			
9.	<p>NOTE: The Crane Operator shall fill out the worksheet. Ops Engineer and LDEM may provide assistance/info. This should be included in the as-run copy of the procedure.</p> <p>Complete Pre-Lift Plan Worksheet 251-8 for Hazardous Operation Mobile Crane Lifts.</p>			
10.	Verify all personnel have the proper PPE equipment in place for their assigned task(s).			
11.	Establish a hazardous Controlled Area around the lift operation.			

12.	Setup crane in a position near the aircraft such that it can be used for the intended lifting operations.			
13.	Clear non essential personnel and close control area. Task Team Leader: _____			

NOTE: List of Essential Personnel in Section 3.2. Additional personnel may be redlined in as required with concurrence from the Safety/LDEM.

	<u>Required</u>	<u>Actual</u>
Team Leader / Lift Supervisor	1	
Mechanics / Certified Riggers	2	
General Spotter	1	
Certified Crane Operator	1	
Quality Assurance Representative	1	
Safety Representative / LDEM	1	
	<u>Casuals</u>	
NASA Technical Advisors	2	
Project Management Representative	1	
Lifting Devices and Equipment Manager (LDEM)	1	

14.	Perform lift hold test. Lift load six inches and hold load for two minutes. Proceed only if hold test passes. Safety/LDEM: _____			
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WARNING: The following steps are HAZARDOUS – CRITICAL LIFT

Use appropriate lifting procedures per DCP-S-009 Ch 6 and NASA STD 8719.9. Personnel operating lifting equipment shall be trained and certified to perform this lift. PPE: Hardhats and steel toe footwear are required when inside operational control area. Mechanics gloves shall be worn when manning tag lines or when otherwise appropriate. Safety glasses shall be worn when appropriate.

Severe injury or death could result.

15.	Establish a Restricted Area around the suspended load operation.			
16.	Clear non essential personnel and close Restricted Area. Only the two required technicians are permitted to be in this area. Task Leader: _____			
17.	Proceed with engine operation per Gulfstream Maintenance Manual or TO.			
NOTE: During the primary (lower) engine mounting "trunnion" procedure, the technician performing this difficult task is permitted to work without a hardhat.				
18.	After suspended load operation is completed, remove Restricted Area but maintain Controlled Area until lifting operation is completed.			
NOTE: End of Hazardous Operations				

5.2 Conclusion of engine removal / installation operations

Step No.	Procedure	Initials		Date
1.	Obtain safety concurrence to open hazardous control area. Safety/LDEM signature: _____			
NOTE: End of procedure				

Revisions Log

Rev	Date	Description of Change	Page
Baseline	3-15-10	Initial Release	--
Rev. A			-

APPENDIX A EMERGENCY PROCEDURES

The following must be readily available during operations. Note that every emergency situation is unique and must be treated as such. It is at the discretion of the Task Team Leader to use his/her best judgment to address the situation.

EVACUATION EVENT

1.	Assess the situation.
WARNING: Only authorized personnel shall position themselves under the load at any time. Severe injury or death could result.	
2.	Secure the load by clearing it from personnel egress routes and lowering it to a supported position
3.	Secure and shut off crane
4.	Evacuate area

PARTIAL LOSS OF LOAD / LOSS OF LOAD CONTROL

WARNING: Do not shut off crane. This will prevent securing of load.	
1.	Stop operations.
WARNING: Only authorized personnel shall position themselves under the load at any time. Severe injury or death could result.	
2.	Assess security of load and determine best course of action.
3.	Assess medical needs
WARNING: Movement of load may result in further loss of load. Only authorized personnel shall position themselves under the load at any time. Severe injury or death could result.	
4.	Secure the load if possible. Some suggested courses of action: a) Lower load to supported position. b) Place cribbing below load to support it.
5.	Secure stored energy
6.	Secure area, preserving all evidence
7.	Activate mishap plan

LOSS OF LOAD

1.	Stop all operations.
2.	Assess medical needs
3.	Secure stored energy
4.	Secure and shut off crane
5.	Secure area, preserving all evidence
6.	Activate mishap plan

Attachment B – Hazardous Operation Mobile Crane Lift Plan

DRAFT

Hazardous Operation Mobile Crane Lift Plan

Hydraulic-Boom Rubber-Tired Pre-Lift Worksheet

SET-UP

Ground Compact And Stable

Type Of Surface: hangar floor Type of Material: concrete

Outrigger Support: hangar floor Size of Support Mats: N/A

Machine Level

Boom Configuration

A) Boom Length: 24 Ft. B) Boom Angle: 45 Degrees C) Load Radius: 22 Ft.

Rope Reeving

Number Parts: 4 Main Hoist Number Parts: _____ Aux. Hoist

Crane Gross Capacity: 7,600 Lbs.

LOAD INFORMATION

Load Weight Total: 2,650 Lbs. Load Rigging: — Size of Sling: — Type of Hitch: —

Number Shackles Required: —

Lifting Beam

Capacity of Beam: _____ Lbs. Weight of Beam/Sling: 300 Lbs. Length of Beam: 10 Ft.

Unused Reeving Parts: 3 Line @1.04 lbs ft. Weight: _____ Lbs.

Load C/G Known: Yes (If unknown, evaluate and pick with caution)

CRANE CONFIGURATION

Manufacturer: Broderick Model Number: IC180 Serial Number: 59374-01

On Outriggers: Yes No Fully Extended: _____ Mid-Point: _____ Retracted: _____

Counterweight Extended: _____ Retracted: _____ N/A: —

Area of Operation Over the Front: Over the Rear: _____ Over the Side: 360 Degrees

DEDUCTIONS

Hoisting From Main Boom: Jib: _____ Aux: _____

Boom Ext. Stowed: Erected: _____ Off Machine: Weight: 200 Lbs.

Jib Stowed: _____ Erected: _____ Off Machine: Weight: _____ Lbs.

Auxiliary Boom Nose (Rooster Sheave) Erected: _____ Off Machine: Weight: _____ Lbs.

Load Block (Main Boom) Capacity: 15 Tons Weight: 220 Lbs.

Load Block (Auxiliary) Capacity: _____ Tons Weight: _____ Lbs.

Headache Ball Capacity: _____ Tons Weight: _____ Lbs.

Unused Reeving: 75 Ft. (.096 LB @ FT) Weight: 72 Lbs.

Total Deductions: _____ Total Weight: 492 Lbs.

Below the Hook

Total of all used Rigging (slings, shackles, spreaders, equalizers, etc.) + Load Weight: 792 Lbs.

Gross Capacity 7,600 Lbs. - Total Deductions 792 Lbs. = Crane Net Capacity 6,808 Lbs.

Weight Below Hook 2,950 Lbs. % of Crane Net Capacity 43 % (Should not exceed 75%) For Critical Lift

Hazardous Operation Mobile Crane Lift Plan

Hydraulic-Boom Rubber-Tired Pre-Lift Worksheet

Critical Lift <input type="checkbox"/> Yes <input type="checkbox"/> No * Required only for Critical Lifts		CRITICAL LIFT CERTIFICATION	MEDICAL CERTIFICATION
MINIMUM LIFT CREW	NAME	VERIFY / STAMP	VERIFY / STAMP
Groundman/Signalman			
* LDEM / Safety			No Medical Required
Crane Operator			
Rigging Specialist			
* Safety Representative			No Medical Required
Lift Supervisor			No Medical Required
Pretask/lift Operations Checklist to be completed by Lift Supervisor or Quality Inspector/Assurance			VERIFY / STAMP
Crane Preoperational inspections and system checkout completed			
Setup: All controls, (RCI/LMI) in operational readiness, configured correctly			
Tag lines <u> 2 </u> #	Crane Boom Flag Deployed	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
Load Securing Requirements		<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
Personal Protection Equipment: Safety Shoes, Gloves, Hardhats, Eye Protection; as required			
Lightning Restrictions within _____ miles	Wind in Excess of MPH _____	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Cancel Lift Operations
Roof Top Lift Operation wind speed monitored	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Signal Person/Radio	<input type="checkbox"/> Yes <input type="checkbox"/> No
Hazardous Loads: <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Propellants _____ /ESD _____ /Pyros _____	Other _____	
Crane Stray Voltage and Grounding checks required		<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
High Voltage lines or Hangar Overhead Crane Grid Voltage identified or secured		<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
Crane Working area clear of obstructions, for upper deck rotation and Outrigger deployment		<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	
Ground density adequate for lift	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Cribbing used	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No Type: _____
Lift path of load clear of obstructions			
Adequate ceiling clearance for crane boom			
Area of Lift operations clear of nonessential personnel, and controlled			
Pretask/lift Operations briefing with lift crew complete			
Safety Representative OK to proceed with critical lift operations		Initials: _____	

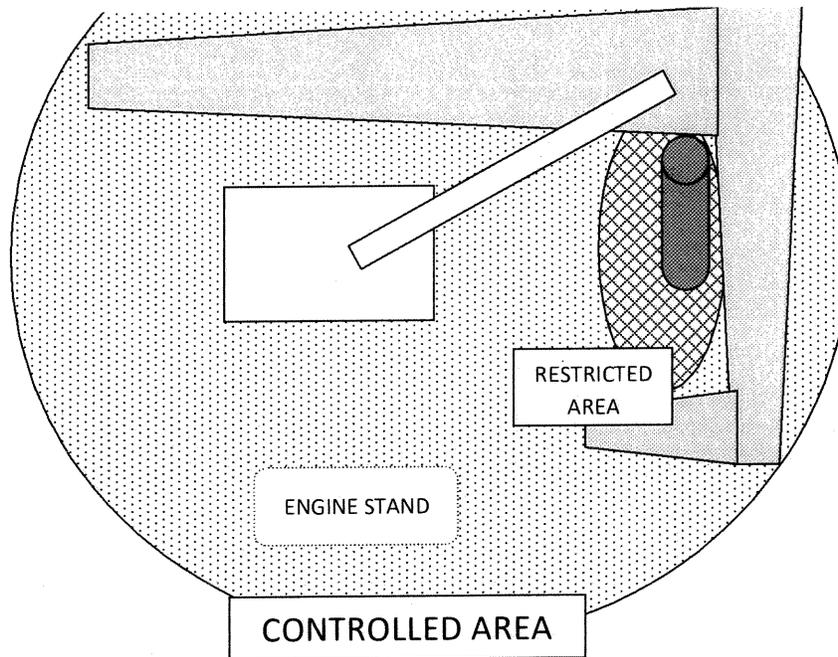
Hazardous Operation Mobile Crane Lift Plan

Hydraulic-Boom Rubber-Tired Pre-Lift Worksheet

RIGGING AND LIFTING HARDWARE CONFIGURATION DIAGRAM

LIFTING HARDWARE	CAPACITY RATING	NUMBER POINTS	WEIGHT	ANGLE AT LIFT POINTS
Spreader Beam	—————			
Shackles	—————			
Web Straps	—————			
Wire Rope	—————			
Chain Sling	—————			
	—————			

Draw Basic Lifting Fixture and Configuration Diagram. Include diagram of Crane setup and load pick and move, setdown / land. (Use additional blank pages if needed).



REVIEWED / APPROVED

SIGNATURES REQUIRED ONLY FOR CRITICAL LIFTS

INSTITUTIONAL SAFETY:	DATE:
LIFTING DEVICES EQUIPMENT MANAGER:	DATE:
LIFT SUPERVISOR:	DATE:
CRANE OPERATOR:	DATE:
CHIEF, FACILITIES ENGINEERING AND ASSET OFFICE (if applicable):	DATE:
CONTRACTOR/PROGRAM SAFETY REPRESENTATIVE:	DATE:
QUALITY ASSURANCE (if applicable):	DATE: