Lockheed D-6H: Preliminary Report

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LOCKHEED MARTIN D-6H HUMAN FACTORS ASSESSMENT

The assessment of the D-6H conducted at the Lockheed Martin facility was limited in its scope. The scope of the assessment was directed by the type of equipment being used and the amount of accessibility to the equipment. Due to severe time constraints - the assessment was conducted in one day - human factors interface activities were limited.

This report covers aspects of the technology that were available to the assessment team. Recommendations for future evaluation of this technology are also included.

Disabled Enterprise Extraction

Disabled Enterprise Extraction towing procedures are outlined in Chapter 4 of the Operations Manual provided by the developer of the technology. This refers to the caterpillar manual where towing procedures have been referenced. These procedures will require maintenance engineers to enter the exclusion zone and perform the following activities:

- Pumping off service brake
- Pulling of axle drive shafts
- Attaching towing cable
- Attaching of "A" frame or other rigid tow member
- Operation of secondary equipment that would effect towing operation.

Built In Safety

The developer has provided some safety considerations beyond those provided by the manufacturer of the heavy equipment:

- ◆ Safety Stops - Safety stops are override devices that will disable the heavy equipment from remote operation.

Safety stops are activated at the following locations:

- Remote operator console
- Remote supervisors console

- Software will automatically effect emergency stop in the event of loss of the radio frequency (RF) signal.

Failure Modes

There are several types of failure within the system that would cause immediate shutdown of the heavy equipment, including:

- loss of RF communication between local and remote site
- tripping of the key switch cut off fuse
- tripping actuator circuit breaker
- tripping of the platform controller circuit breaker
- system time outs
- failure of actuator to reach proper position at start up

Entry into the exclusion zone by maintenance engineers will require that special personal protective equipment be utilized. Additional stress is placed upon maintenance engineers in these situations, and must be considered as the overall mission is being planned. These stresses include:

- Heat
- Visual
- Auditory
- General Reflexes
- Perception
- Agility
- Size
- Range of motion

Manual Operation

Towing of the heavy equipment that has been interfaced with the technology may not always be feasible. It may be necessary to have maintenance engineers perform actual maintenance and repairs while such equipment remains in the exclusion zone. In the event of such a necessity, a procedure outline for the de-pinning of the actuator control arms and connectors is provided in the operations manual.

Although a procedure has been outlined in Chapter 4 of the Operations Manual under Miscellaneous Procedures, the following human factor interface considerations need to be integrated:

Actuator De-Pinning Operation

During the de-pinning operation evaluators made the following observations:

- Larger diameter pin rings would facilitate ease of removal. The operator in this interface was wearing two pairs of protective gloves to simulate realistic site conditions.
- Cables/lanyards attached to the small diameter pin rings would allow for pins to be retained at the proper location for later use and re-pinning.
- A pair of pliers and/or a specifically designed tool, similar to an engine hoof pick, would be useful in the removal of pins.
- Color coding of pins and/or cables/lanyards/actuators to facilitate re-pinning operations would be useful.
- Application of retaining devices to hold actuators in a specific location would prevent undue physical stress to lead wires used in the assembly. Application of such devices would also prevent the operator from stepping on the actuators during manual operation.
- Due care should be taken to assure that pins and rings are properly installed to prevent the possibility of interference with operation of other control devices.

Personal Protective Equipment Interfaces

During the human factors interface challenges the following observations were made with regard to integration of personal protective equipment:

- ◆ The opening of the access door of the operation cab posed potential problems for rapid egress in the event of an emergency. The door needs to be readjusted to allow for a greater swing radius
- ◆ The use of a back-pack mounted self-contained breathing apparatus (SCBA) impeded access to operator's cab door. Use of this type of SCBA also posed difficulties to the operator once seated in the equipment. This was apparent when the operator was positioned in the seat. The operator was placed approximately 8 inches (20.3 cm) forward of the normal operating position. This

placed undue ergonomic stress on the operator during manipulation of control levers, and interfered with the full utilization of safety devices such as mirrors.

- ◆ It is recommended that the backpack-mounted SCBA be replaced by an apparatus having an equivalent protection factor that would allow for a more reduced profile to be attained by the operator. Considering this, the backpack-mounted SCBA was replaced by a supplied airline respirator with emergency egress and escape capabilities.
- ◆ The supplied airline respirator with escape egress capabilities (SAR-E) was utilized in the interface and recommended for replacement of the back-pack mounted SCBA. An SAR-E with "Dual-Hook-UP" capabilities is recommended. This style is recommended as to allow the use of airlines from a stationary or semi-stationary source as well as a hand carried "carry-out" supply bottle.
- ◆ SAR-E units connected to a stationary source will allow the operator to sit properly against the seat back for safer and more effective integration/operation. SAR-E units utilized with a stationary air source would require the operator to utilize a low-profile harness assembly with regulator and egress/escape bottle. A primary air supply hose would then be trailed behind. It should be noted that the operator's "buddy" would need to keep track of the location of the hose to prevent snagging or other damage that would negate its effectiveness.
- ◆ The use of the SAR-E has the limitation that the distance of travel from the stationary air source is 300 feet or less.
- ◆ The use of semi-stationary air sources with the SAR-E would provide greater mobility while enhancing safety. This would entail the use of a hand-pulled cart with breathing air cylinders mounted on it. This could be moved whenever necessary. This could be enhanced by placing the above mentioned tanks on mobile equipment. Past experience has shown that skid-steer loaders have worked well as semi-stationary air stations. Due care should be maintained when using these units to prevent any harmful contact incidents involving it's use.
- ◆ The use of "carry-out" bottles to facilitate ingress to the exclusion zone may, depending on site conditions and other factors, be used as a source for exclusion zone operation and egress.
- ◆ In situations where a greater volume of air may be required for exclusion zone operations than that available through "carry-out" bottles, it is recommended that an air cylinder be mounted on heavy equipment. This would allow for the operator to ingress with and "carry-out" cylinders and then effect the dual hook-

up technology, provided by several respiratory protection manufacturers, and connect into the air cylinder mounted on the heavy equipment. Depending upon the size of the cylinder mounted on the equipment and the nature of the work to be performed, these cylinders may supply several hours of respirable air.

- ◆ Placement of any heavy equipment mounted cylinder should be carefully considered with respect to stability, protection from traumatic forces, obstruction of any view, heat stress, and practical distance for use.
- ◆ In situations where a "carry-out" cylinder is used for the primary air source, it is recommended that a bracket be mounted to safely hold the cylinder. This bracket must be positioned so that it will not impede safe operation of equipment or interfere directly with the operator. Care should also be taken that the cylinder does not obstruct operator's view or have any other deleterious effects upon health and safety concerns.