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**Technical Evaluation of the UH-60Q:
Litter Lift and Seating Plan**

By

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and

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January 1994

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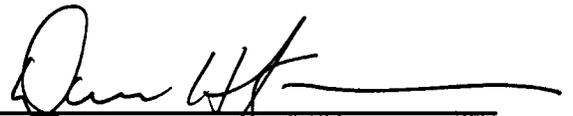


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<p>The UH-60Q prototype MEDEVAC Black Hawk is configured to provide day/night, adverse weather, emergency movement of patients. The objective of this report is to describe loading the litter lift system and discuss concepts for crew and passenger seating. The litter lift system in the aircraft consists of two mechanical lifts capable of accommodating a total of six litter or six ambulatory patients. The preferred loading order for the lifts is upper, middle, lower. The most seriously injured patient should be placed in the middle position and least serious in the upper position. The time required to load six litter patients varied from 230 to 268 seconds. The middle crew seat proved a significant encumbrance in loading litters. Inadequate vertical clearance is provided with the current lift mechanism. Redesign of the lift pans and elimination of the ambulatory seat backrests will improve vertical clearance. There should be a procedure to use the litter racks if the lift mechanism fails. The current restraint hardware is not durable and slowed loading operations.</p>			
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Introduction

The UH-60Q prototype MEDEVAC Black Hawk is configured to provide day/night, adverse weather, emergency movement of patients. The Materiel Need Statement for the UH-60Q directs that the UH-60Q be capable of performing medical evacuation in several mission profiles (Department of the Army, 1992). These include Southwest Asia, Europe, MAST, and Persian Gulf scenarios that are summarized in Appendix A. The U.S. Army Aeromedical Research Laboratory (USAARL) was tasked by the Utility Helicopter Program Manager to evaluate the prototype UH-60Q aircraft in flights that simulate the typical mission profiles. This information is needed to determine functional requirements for future operational and user tests of the UH-60Q. This report details the results of technical evaluations of the litter lift and seating systems of the UH-60Q prototype aircraft. An analysis of the crashworthy design and expected crash performance of the litter supports and seating will be described in another report.

The UH-60 aircraft, serial number 86-24560, is configured as the Proof of Principle Aircraft YUH-60A(Q). This helicopter is equipped with an enhanced medical interior, enhanced avionics and visual displays, and an externally-mounted rescue hoist.

The objective of this report is to describe the results of performance tests on loading the litter lift system and to discuss concepts for crew and passenger seating. This information will be useful to the Utility Helicopter Project Manager when evaluating how each component of the medical interior enhances or degrades the ability of typical flight medics to perform their duties.

Materials and methods

Litter lift system

The litter lift system is an electrically powered lift manufactured by Air Methods, Inc., Denver. It includes two litter pans that are raised and lowered by pressing a button to select height (patient, stow, seat, or floor) or manual override. The pans can be positioned flat or with head tilt up or down. Each litter pan is designed to accept a custom backboard style litter. Two pans on the prototype aircraft have been modified to accept a standard NATO litter. The litter pans are shown in Figure 1. They are located immediately above a patient on a NATO litter (placed on the floor).

The litter system also can be configured to provide six ambulatory patient seats (three on each side of the aircraft). This is accomplished by opening the hinged portion of the upper pan to reveal a cloth seat and padded back rest. Padded headrests with integral shoulder restraints can be lowered from the ceiling to complete the ambulatory seats. The opened ambulatory seats are shown in Figure 1.

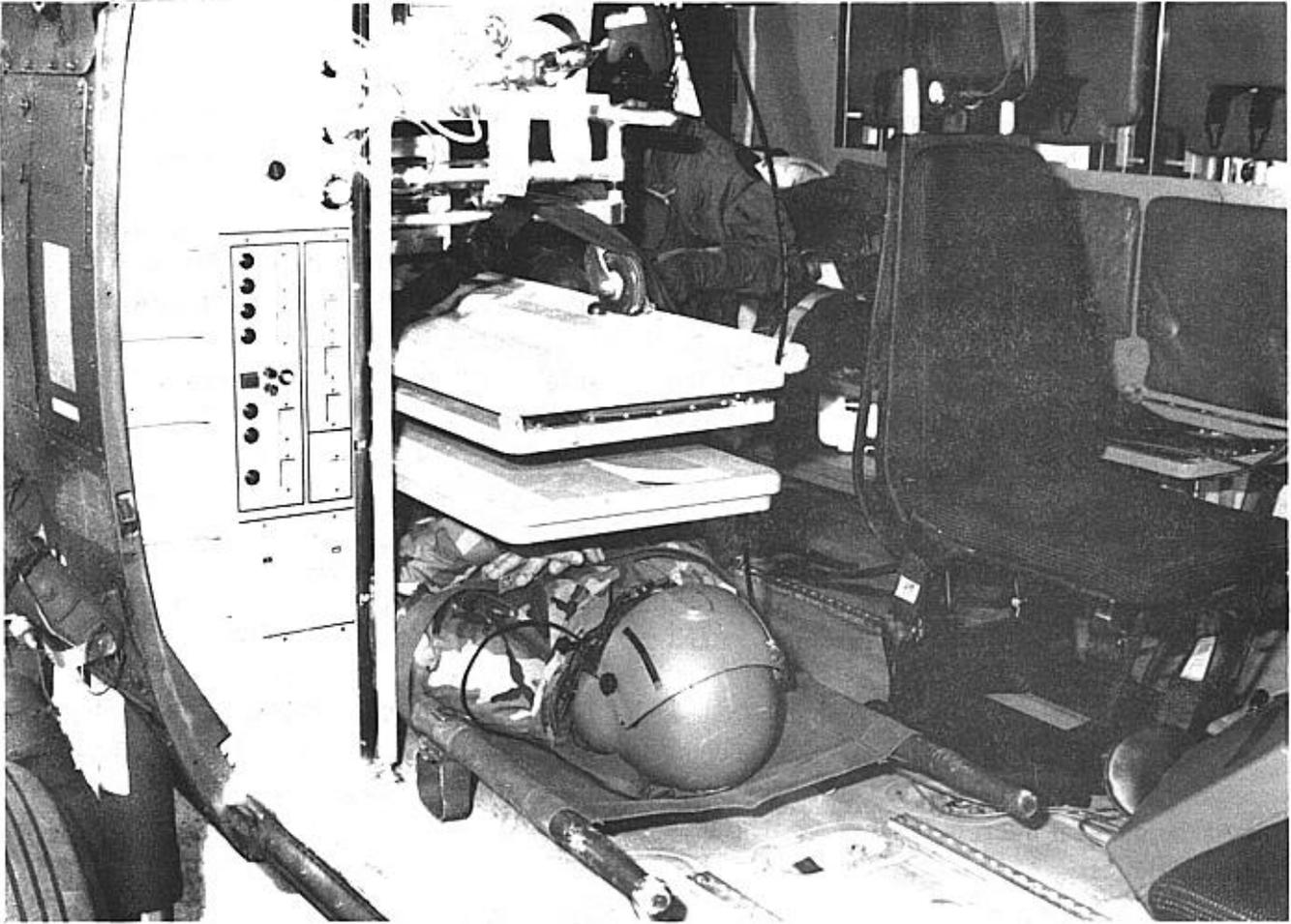


Figure 1. Overview of the aircraft interior with a single litter patient and infant transport incubator in place.

The controls for operating the litter lift and lighting system are on a panel located at the front edge of the sliding door. The control panel is shown in Figure 2. Fluorescent lights are located flush within the vertical face of the lift and in the space around the lift mechanism (Figure 3).

There are no formal procedures or training program for loading patients in the new aircraft or operating the lift mechanism. Operation of the lift system was determined by observation of the lift functions and hands-on practice. The most efficient aircraft loading procedures were determined by loading and unloading trials with 6 litter patients (approximately 20 trials). Final procedures were verified by a USAARL flight surgeon, safety engineer, and three flight medical aidman (91B "F") instructors from the U.S. Army School of Aviation Medicine.

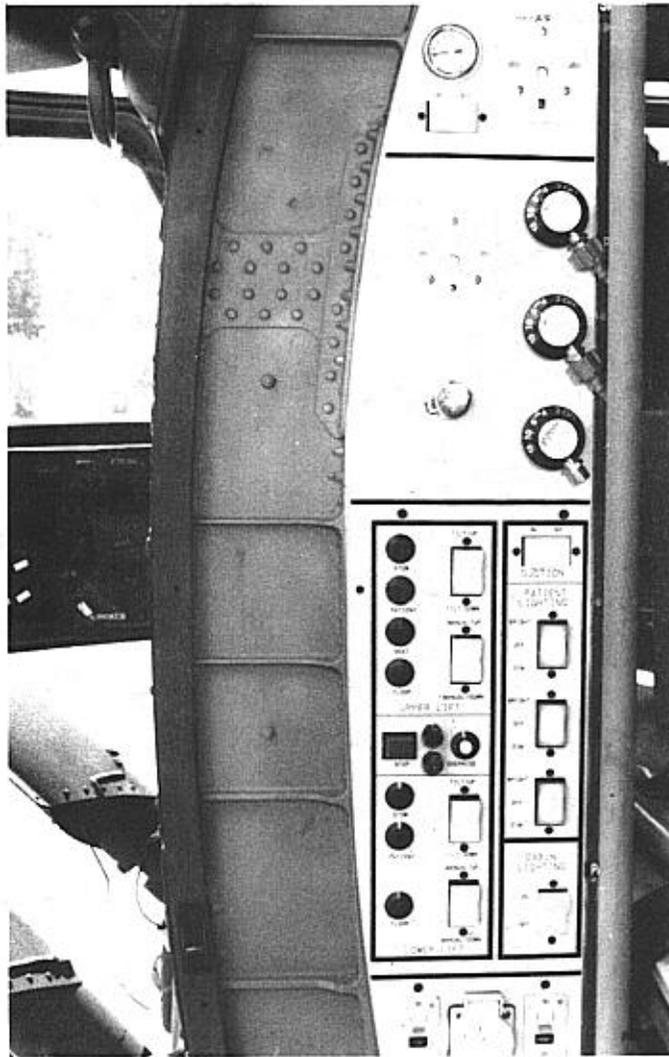


Figure 2. Control panel for lift mechanism, patient lighting, and oxygen outlets.

The time to load a litter was measured as the time for 4 litter bearers to lift the litter (with a 150 to 220 lb load), carry it 40 feet to the aircraft, load it aboard the helicopter (with 2-man crew), and return for the next litter. The time for loading each of six litters was averaged for two trials each when loading all litters from one side of the aircraft, for loading all six litters from one side with the center (crew) seat removed, and for loading three litters from each side with the center seat removed. The external stores system (ESSS) with two 230-gallon fuel tanks on the outer storage point was installed on the aircraft when the litter loading procedures were evaluated. Each loading trial was conducted with the aircraft main rotor turning at operating RPM.

The distance between litters was measured as the vertical distance above the litter pole to the first obstruction or the horizontal distance between the center litter poles at the floor position. The measurement was completed with six litters loaded on the aircraft. The litter lift on the left side of the aircraft was loaded with simulated patients on NATO standard litters.

The litter lift on the right side of the aircraft was loaded with simulated patients on a NATO litter for the floor, Stokes litter for the middle, and Skedco litter for the upper position.

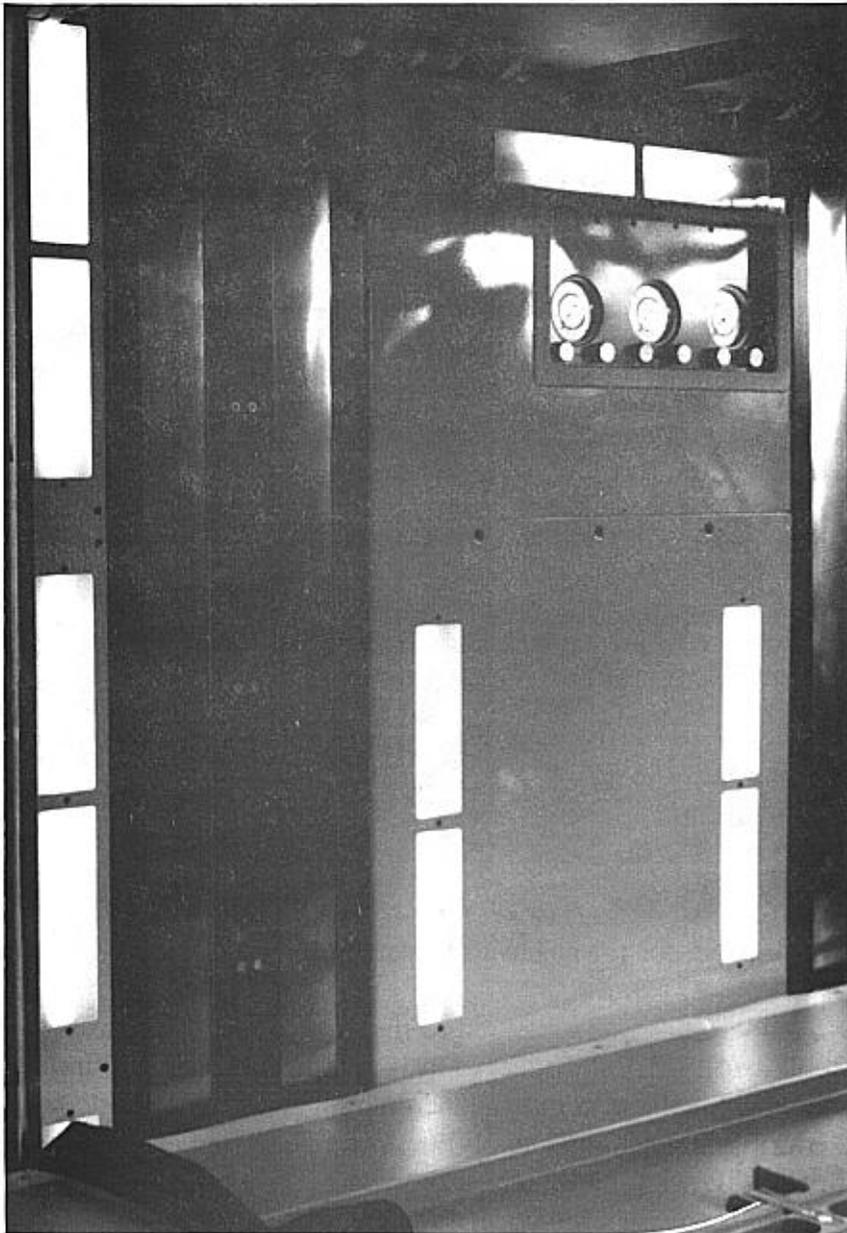


Figure 3. Flourescent lights mounted in the lift mechanism.

Crew seating

Crew seats in the aircraft are crashworthy seats manufactured by Simula, Inc. Each seat is mounted on rails that allow the seat to move forward and backward (approximately 4 feet) and swivel 360 degrees. One seat is placed in the middle of the aircraft, between the two litter lifts. It moves forward to the middle of the litter and aft to the cargo hook observation port. The other two seats are mounted by each door. The rails allow movement from the head of the patient to the aft bulkhead. The center seat and rails for the left rear seat are shown in Figure 1.

In the absence of procedures for crew seating locations, the ability to perform typical medical crew duties was evaluated for each seat location. These evaluations were completed by flight medical aidmen, flight surgeons, and safety engineers. The evaluated tasks included patient access, access to equipment, access to medical interior controls, access to the hoist, and ability to clear the aircraft. The ability to perform each task from a specific location was judged as satisfactory (+) or unsatisfactory (-). Comments on how to improve the ability to perform crew duties at each location were collected. The results of these evaluations were supplemented by in-flight evaluations with simulated patient care in the prototype aircraft. The mission scenarios for these in-flight evaluations followed the typical mission scenarios detailed in the materiel need statement (Department of the Army, 1979) and summarized in Appendix A. Specific information on medical procedures attempted and the results of questionnaires completed after these flights is contained in a separate report.

Results

Litter loading

The patients should be loaded on the litter lift in the order: upper, middle, lower to make use of the lift mechanism. If six patients are loaded from one side of the aircraft, then the far side litter stations must be loaded first. The average time to load the first through sixth litter is shown for three loading configurations in Figure 4. The time required to load six litter patients varied from 230 seconds (3:50) to 268 seconds (4:28). The fastest loading was possible when the patients were loaded from both sides of the aircraft with the center seat removed.

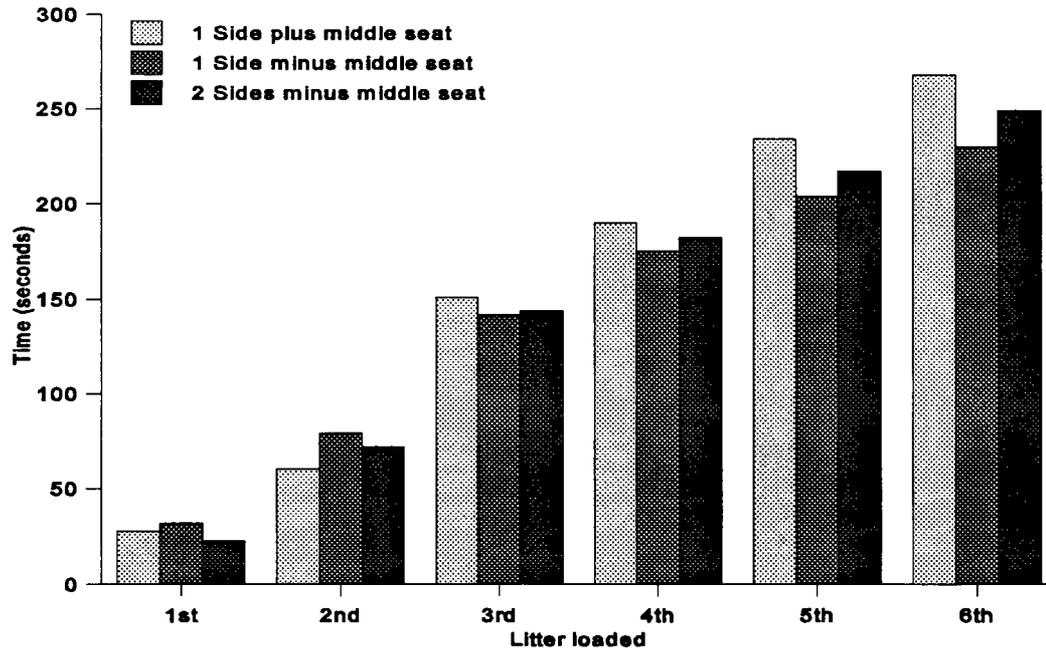


Figure 4. Comparison of time (seconds) required to load six litters with various loading and seat configurations.

The vertical distance between litters is 16 inches for a NATO litter placed on the floor, 17 inches for a NATO litter in the middle position, and 13 inches for a litter in the upper position. The horizontal distance between NATO litters on the floor is 21 inches.

Evaluations of task performance for each of the three available crew duty stations is shown in Table 1. Access to the head and body of the patients at each litter station required the medical aidman to leave his seat for some procedures. The rear seats (left and right) provide the best access to the heads of the patients while the center seat provides better access to the chest, abdomen, and lower extremities. However, the medical aidman must leave his seat to provide care to patients on the upper litter station or floor station (both sides).

Table 1.
Evaluation of ability to perform medical crew duties from each crew station.

Task	Right rear Seat	Left rear seat	Center seat
Patient access*	+	+	+
Access to litter lift controls	+	+	-
Access to medical oxygen	+	+	-
Access to hoist	+	-	-
Able to clear aircraft	+**	+**	-

(+) = satisfactory, (-) = unsatisfactory

* Access to head and body of medical patients requires medical aidman to leave seat for some procedures.

**Requires crewmember to loosen upper body restraint.

Discussion

After multiple trials, it was determined that the preferred loading order is the least serious injured in the highest berth, most serious in the middle berth, and intermediate severity on the floor. The more seriously injured individuals should be on the left side with the medical aidman. Patients should be loaded "feet first" to provide access to the patient's head for a medical aidman seated in a crew seat.

Mitchell and Wells (1986) reported that the following distances should be considered minimums for clearance between litter pole surfaces in military medical ambulance vehicles capable of carrying acutely ill, injured, or otherwise unstable patients: vertical separation = 20 inches, lateral separation = 21 inches. In the UH-60, there are only 57 inches available from the floor to the ceiling. It is unrealistic that any design using a stack of three litters will allow 20 inches of vertical separation between litters in the Black Hawk. Careful review of this report shows that the top litter position required significantly more space to accomplish medical procedures than the lower two litter positions. The vertical space in the UH-60Q would be allocated more effectively if the specification is changed to require 18 inches vertical separation for the middle and floor position and all remaining space (approximately 21 inches) for the top litter position. The lateral separation in the prototype aircraft exceeds the recommended minimum.

The vertical clearance to provide patient care in the prototype aircraft is unsatisfactory. Nine inches of available vertical space are lost due to the thickness of the litter pans and stowage of the ambulatory seat backrests on the ceiling. The litter pans in the UH-60Q should

be designed to allow optimum use of vertical space. For example, the lift arm could be integrated into the litter pan, the fold-open ambulatory seat can be eliminated by seating ambulatory patients on the litter pan, and the stirrups of the litter could be recessed to place the litter patient closer to the litter pan. Ambulatory seat backrests should not be stowed on the ceiling area above the lifts. It is unlikely that thickly padded backrests are required for ambulatory patient seating. If required, a thinner pad could be affixed to the front face of the lift mechanism.

The middle crew seat is a significant encumbrance in loading and unloading litters. The middle crew seat can not be "swiveled" when two NATO litters are loaded in the floor positions. The middle crew seat prevents the litters from approaching the litter pans at an angle. All litters, but particularly those loaded to the far-side litter rack and the bottom position litters, wedge between the middle and aft crew seats during loading. We attempted to move the seat along its track to minimize this effect, but found the middle seat is in the way for all loading operations. The middle seat also impedes the loader who must go to the front of the aircraft to pull the litters forward onto the litter pans.

All of the medical aidmen said that the middle seat crew position would be the least desirable location to perform all duties. They said that access to the head of the patient was superior in the left and right side seats. They can not clear the aircraft from the middle position because the seat does not move far enough aft to provide visibility from the side doors and forward visibility is severely restricted. They could not operate the lifts, medical oxygen system, or hoist from this location. They recommend this seat be replaced by a rear-facing, fixed seat located as far forward as possible. The replacement seat would be used primarily for ambulatory patient seating or rarely when a third medical attendant is on board.

If the mechanical lift mechanism on the prototype aircraft breaks, the litter rack may be unusable. The litter lift system should provide a backup means to position litters in the loaded position if the mechanical lift portion breaks.

Tracks are required on the floor of the aircraft to allow a litter in this position to slide forward. Litter loaders said that lifting the floor litter forward, under the middle position litter pan, will lead to frequent back strain and back injuries. Tracks on the floor will allow this litter to slide forward into the loaded position and will facilitate restraining the patient and litter.

NATO standard litters are not adequately restrained to fore / aft movement on the prototype litter pans. The litter poles are located a few inches behind the pilot seats and could strike the back of the pilot seats (Figure 5) or the litter stirrup can drop off the track on the litter rack with fore/aft movement (Figure 6). The litter pans must provide adequate provisions for restraining the litters.



Figure 5. Demonstrates close proximity of litter poles to pilot seat.

The current restraint hardware on the litter pans is not durable and significantly slowed the litter loading operations. The plastic covers on several restraint releases were broken (Figure 7). The half of the restraint located closest to the lift mechanism frequently fell behind the lift mechanism and was difficult to locate when loading. A superior design would use retractable belts that are quickly located when loading and retract when not in use.

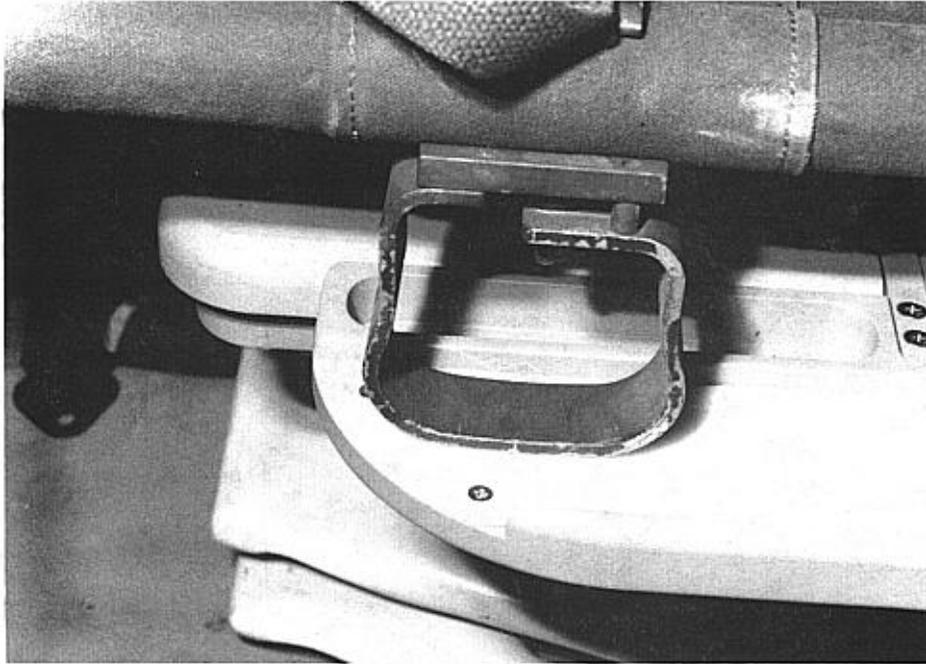


Figure 6. Demonstrates close proximity of litter stirrup to edge of litter pan track.

Summary

The preferred order for loading the litter racks is to load the top, middle, and finally, lower litter. The least serious patient should be placed in the top position and the most serious in the middle position. The medical aidman will be able to provide the best care if the patients are placed in the aircraft "feet-forward" and he is seated at the head of the patient. The middle crew seat is an encumbrance when loading patients and least desirable for performing crew duties.

The vertical clearance between litters in the prototype aircraft is significantly less than the minimum required for patient care. Recommend the litter lift design be optimized to allow at least 18 inches between litters for the middle and lower berth and all available remaining space (about 21 inches) should be provided for the top litter position.

NATO litters are inadequately restrained and some hardware on the prototype aircraft are not sufficiently durable for military use. Provisions to use the litter racks if the lift mechanism fails and improved litter restraints will improve the performance of these devices.

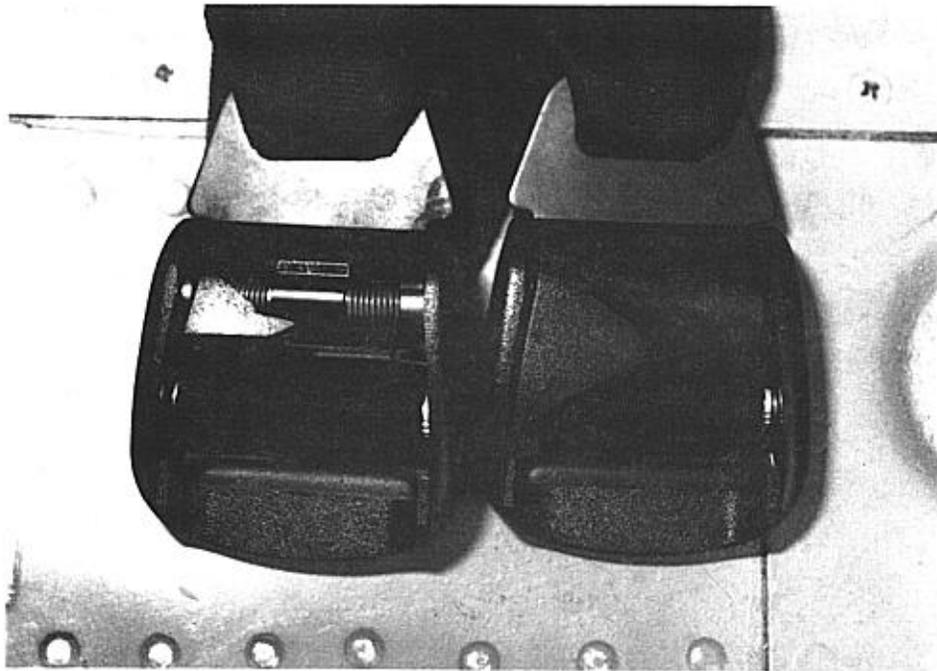


Figure 7. Example of broken plastic restraint releases.

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Appendix A.
Mission profile summaries.

A. AEROMEDICAL EVACUATION (SOUTHWEST ASIA). The UH-60Q, collocated with a forward support medical company in direct support to a maneuver brigade, receives a mission to transport a trauma treatment team from the forward support medical company forward to a battalion aid station and then evacuate six litter patients and one ambulatory patient from the battalion aid station to the division clearing station located in the brigade support area (BSA). The UH-60Q departs the BSA with the trauma treatment team and flies at an airspeed of 120 knots using contour flight technique for 67 nautical miles (nm) and then slows to an airspeed of 30 knots using NOE flight technique for the last three nm to the battalion aid station. The trauma treatment team is off-loaded and the patients are loaded into the aircraft. (20 minutes allocated for loading and unloading) The UH-60Q departs the battalion aid station using NOE for the first 3 nm and then transitions to contour flight for the remaining 67 nm to the BSA. The patients are off-loaded at division clearing station (10 minutes allocated) at which time the aircraft is ready for the next mission. Total time for the mission, to include patient loading and unloading times, is approximately 118 minutes.

Event	Distance (nm)	Speed (kts)	Flight mode	Time (min)
1 - 2	70	120/30	LL/NOE	44
Load patients			Landed	20
2-3	70	30/120	NOE/LL	44
Unload patients			Landed	10
TOTAL	140			118 (1.9 hr)

B. AEROMEDICAL EVACUATION (MAST). A UH-60Q located at a military installation receives a night MAST mission to transfer two patients involved in a traffic accident from a small community hospital to a medical center capable of providing life saving (definitive) medical treatment. The gaining hospital requests the mission and provides two nurses and a critical care physician to assist in the enroute care of the patients. The weather is marginal but acceptable. The small community does not have an airport or weather reporting capability and is not situated along the FAA enroute and terminal flight system. After pre-mission planning, the crew flies to the medical center (8 nm, 125 kts, low level) to pick up additional health care providers (5 minutes for loading). The crew uses onboard navigational equipment to locate and fly to the community hospital (80 nm, 120 to 145 kts, contour or low level). Unforecast weather was encountered at the pickup site. After landing, the health care team goes into the hospital to obtain patient briefings and execute transfer of patient responsibility (10 minutes for loading). The physician and the medic attend the adult patient while the

nurses attend the baby. Once loaded, the crew departs for the medical center. The patients require constant enroute treatment and monitoring on the return flight. The health care providers must use white light to provide appropriate care and must talk back and forth constantly. The female patient's condition deteriorates requiring the physician to contact the medical center to alert the operating room personnel of the requirement for immediate surgery upon arrival. Upon landing at the hospital helipad, the patients are off loaded (10 minutes) and moved into the hospital. The flight crew returns to the military installation (8 nm) and mission is complete. Total mission time is 2 hours.

Event	Distance (nm)	Speed (kts)	Flight mode	Time (min)
1 - 2	8	125	LL	5
Load personnel			Landed	5
2-3	80	120-145	LL	40
Load patients			Landed	10
3-4	80	145	LL	35
Offload patients			Landed	10
4-5	8	125	LL	5
TOTAL	176			120 (2 hr)

C. AEROMEDICAL EVACUATION (PERSIAN GULF). Low level flight for a distance of 200 nm with an airspeed of 110 to 120 kts. Hoist rescue from a hover of less than 70 feet (25 minutes allowed) followed by 170 nm low level flight at 110 to 120 nm. At this point the patients are offloaded and the aircraft flies 50 nm (low level) at an airspeed of 110 to 120 kts.

Event	Distance (nm)	Speed (kts)	Flight mode	Time (min)
1 - 2	200	110-120	LL	120
Rescue			Hover	25
2-3	170	110-120	LL	105
Unload patients			Landed	
3-4	50	110-120	LL	25
Offload patients			Landed	10
TOTAL	420+			275-305 (5.1 hr)

Adapted from Annex B, Appendix 1, UH-60A Black Hawk Materiel Need, Production, dated 1979 (MN) (P)