DEPARTMENT OF THE AIR FORCE
AIR FORCE INSTITUTE FOR OPERATIONAL HEALTH (AFMC)
BROOKS CITY-BASE TEXAS

7 Sep 04

MEMORANDUM FOR AFMSA/SGZE

FROM: AFIOH/RSH
2513 Kennedy Circle
Brooks AFB TX 78235-5123

SUBJECT: Consultative Letter, IOH-RS-BR-CL-2004-0091, Follow On Effort to Consultative Letter IERA-RS-BR-CL-2001-0099, Ergonomic Assessment of HH60 Gunner/Flight Engineer Workstation.

1. INTRODUCTION

a. *Purpose*:

(1) This evaluation was performed on 19 Aug 04 at the 305th RQS, Davis-Monthan AFB, as a follow up to an ergonomic evaluation performed by Dr. Kathy Grant of AFIOH, Aug 2001, a subsequent meeting with 305 RQS to discuss the Martin Baker rotating/translating crashworthy seat, Sep 01; and a meeting at AFIOH to discuss weight, space and floor armor issues March 04.

(2) Westwind Technologies is under contract to Warner Robins Air Logistics Center, Special Operations Forces/Combat Search and Rescue System Program Office, to provide engineering and development for the integration of the Martin Baker crashworthy seat into the HH-60G PAVE HAWK helicopter gunner/flight engineer position.

(3) The purpose for this visit was to fit test the Martin Baker seat in the HH-60 PAVE HAWK. The role of the AFIOH representative was to determine if ergonomic risk factors were being controlled as best as possible, given the space limitations of the HH-60 aircraft.

b. *Personnel in Attendance:*

SSgt Carlos Delgado, Det 3, 18 FLTS/DOV
SMSgt Mike Flake, 305 RQS/DOE
CMSgt Laz Ibarra, 301 RQA/DOT
Maj Linda Schemm, AFIOH/RSH
Fred Cusick, WR-ALC/LUHH

Jim Sawinski, WR-ALC/LUHHE
Mark McUmber, AFRC/XPRC
Dane Weinberger, Westwind Technologies
Pete Yost, Martin-Baker

c. *Equipment Used:*

Tape Measure
Cannon Digital Camera

d. *Background Information:*

(1) Background information was obtained from the original ergonomic evaluation (CL; IERA-RS-BR-CL-2001-0099) performed by Dr. Kathy Grant of AFIOH in 2001. The two major deficiencies identified in that report were related to the (1) design of the crew seat backrest, and the (2) lack of space between the seat and the side of the aircraft for the legs and feet. The following are excerpts from Dr. Grant's report:

(a) During the flight phase of HH-60G operations, the flight engineer and gunner are seated in two side-facing jump seats, located in the rear of the helicopter (Figure 1). Both seats are identically constructed, and consist primarily of a canvas-covered, metal frame. Some features are provided in the seat design that will allow it to absorb energy in the event of a crash; supports underneath the seat will allow the seat pan to "stroke" or displace downward. However, the seat is not considered "crashworthy". The seat back forms a 90° angle with the seat pan.

Figure 1. HH-60G flight engineer/gunner current seat

The dimensions of the seat and surrounding work area are as follows:

- Total ceiling to floor height inside cabin: 54 in.
- Seat pan height above cabin floor: 16 in.
- Back rest height above cabin floor: 47.5 in.
- Seat length: 14 in.
- Seat width: 19.5 in.
- Knee clearance (edge of seat pan to window ledge): 12.5 in.

(b) The problem caused by this configuration is illustrated in Figure 2 below. The combination of the backrest angle, the location and thickness of the head rest, the helmet design, and the location of the battery pack makes it impossible for the crewmember to maintain the head and neck in an upright position when the torso is in contact with the seat back, rendering the backrest essentially useless.

Figure 2. Neck flexion with C1-C2 vertebral extension caused by seat back/head rest position

(c) Measurements gleaned from the original report are as follows:

- The total distance from the backrest to the inside wall of the aircraft was measured at 26.5 in.; of this, the seat pan depth takes up 14 in., leaving 12.5 in. from the front edge of the seat pan to the inside wall of the aircraft. Although this space can accommodate the buttock-knee length of 99% of AF flyers (mean of 23.8 in., standard deviation of 1.1 in.), no space is allotted for the placement of the feet. MIL-STD-1472F recommends a minimum of 4 in. be provided in front of the knees for foot/toe clearance. Because there is no room for the feet to extend beyond the knees, most flight engineers/gunners sit with their feet in a fixed position, tucked underneath the seat (Figure 3). To achieve the flexed knee position this posture requires, the flight engineer/gunner is generally required to sit forward in the seat, causing the body weight to be transferred to the seat pan over a smaller area of the buttocks or there is compression at the posterior thigh on the seat pan bar, and also forcing contact between the knees and the interior of

the aircraft (Figure 4). The flexion of the knees also produces bending at the hips and spine due to the backward rotation of the pelvis.

- The seat width (19.5 in) is sufficient to accommodate virtually all (> 99.9%) AF crewmembers, based on the hip breadth dimensions (mean of 14.9 in., standard deviation of 0.9 in.) of this population, even after clothing effects are considered.

Figure 3. Position of the feet while sitting in the current HH-60G crew seat.

Figure 4. Contact between the knees and the HH-60G window ledge.

(d) During tactical situations or missions that involve low-altitude flying maneuvers, the HH-60G flight engineer and gunner assist the pilot by visually "scanning" to detect hazardous terrain or obstacles in the flight path. Achieving the required visibility can require a variety of awkward postures; including some in which portions of the body are physically located outside the aircraft. However, the time spent in these positions appeared to be relatively limited in duration (i.e., a few minutes at a time).

(e) The recommendations that can most readily address posture and reduce musculoskeletal stress among HH-60G flight engineers and gunners were (1) seat back angle and (2) seat positioning. The following recommendations were gleaned from the initial evaluation and include:

(1) "The seat back must allow the occupant to rest the back against the seat without pushing the head forward into a position of neck flexion. The angle between the backrest and seat pan should be increased to a minimum of 110°, the headrest should be eliminated, and/or the top of the backrest should be lowered to a height of approximately 24 in. above the seat pan (midshoulder sitting height for 5th percentile AF crew member). Note that increasing the seat back angle to 110° would also provide additional 2.4 in. of clearance space between the occupant's head and the cabin ceiling. This added space would be sufficient to accommodate 90% of AF fliers without changing the height of the seat pan or assuming any "give" in the seat pan cushion.

(2) Although moving the seat away from the side of the aircraft to provide additional clearance space for the legs and feet is not a feasible option (due to the location of the GAU-2B mini-gun ammunition canisters), allowing the seat to rotate 90° (to a rear-facing position) would permit the gunner/flight engineer to extend the legs into space available in the rear of the cabin (sometimes used for equipment storage). The seat could be rotated back into a side-facing position when the flight engineer or gunner is operating the gun or performing scanning duties."

2. SURVEY PROCEDURES:

a. *Fit Test of Proposed Seat:*

(1) The proposed Martin-Baker seat can rotate about center in tracks that allow translation of the seat (Fig. 5). The seat also provides a cutter attenuation system that absorbs sufficient energy to decelerate the occupant within human tolerance levels, under crash loads specified in FAR/JAR part 27/29 (Fig. 6). Although the seat is not currently used in U.S. military aircraft, they are used in civilian emergency search and rescue and medical evacuation helicopters, including the Eurocopter EC-135 and the Boeing MD Explorer. This seat required modifications to fit in the HH-60G per Trip Report dated Sep 01.

(2) The crew seat location is constrained by the location of a large steel plate in the center of the crew compartment for the GAU-2B ammunition canister. Only 26.5 in. of floor space are available on either side of the plate for the crew seat. Although plans for an external ammunition storage system have been devised, modification of the airframe to incorporate this change is unlikely before FY 05. Therefore, other alternatives to accommodate an adjustable seat were required for more immediate implementation.

Figure 5. Martin-Baker seat in tracks of Plexiglas template.

(3) The pallet template was made of ½" thick Plexiglas to simulate the actual flooring (Fig 5). Longitudinal grooved tracks were machined into place prior to this fit test. The fit test was accomplished on an HH-60 aircraft with the typical flooring removed, and then again on another HH-60 aircraft with the typical flooring intact. It was determined that the seat placement would be moved approximately 3" (in the longitudinal tracks) towards the midline of the aircraft (without interfering with the ammunition canister) to achieve maximum leg room in the limited space of the aircraft in relation to the gunner/flight engineer position in the aircraft. Two flight engineers were observed in the proposed seat. One was 5'4" in stature, the other 6'3" in stature. This was a convenient way to assess the full range from the 5th percentile to the 95th percentile.

Figure 6. Cutter attenuation system

(4) The proposed seat back angle is reported to be 105º. It was difficult to measure the angle directly due to the seat padding contours, but it appeared to be approximately 100º, not a significant difference, but the original recommendation had been a minimum angle of 110º to allow the occupant to support the lumbar area of the back against the backrest without bending the head forward. The seat back height is 25”; with added cutout headrest the total height is 35”. The cutout headrest accommodates the NVG battery pack and because the seat angle is greater than 90º, the headrest did not force the flight engineer’s head into cervical flexion/C1-C2 extension. The recommendation had been for a back height of 20”, and 24” with a headrest. Because the combination of the seat angle and cutout headrest on the proposed seat appears to meet the general principle of the recommendations, there were no further concerns noted (Fig.7).

Figure 7. 95% male seated in proposed seat

(5) The proposed seat is also height adjustable from 13” (front of seat) to 16” (front of seat), which allows for adjustability for head clearance. The current seat was set at a height of 16.5” with no adjustability, so the proposed seat is an improvement. However, with flight engineers in the 95th percentile, to gain headroom they must lower the seat, thus forcing more flexion at the knees, hips and spine. This presents postural concerns at the knees, hips and back; however, given the limited cabin space, this may be the best that can be achieved. Also, the proposed seat allows re-positioning through seat rotation at 15º increments in an 180º arc. So the flight engineer/gunner can rotate the seat to face the rear of the aircraft to stretch the legs, when the flight engineer/gunner are not actively performing scanning or gun operations. The rotation towards the rear at 15º increments may actually improve their positioning for hoist operations out the side doors (Fig. 8). It should be noted, that to achieve crashworthy positioning, the seat should be in the side facing position during any in-flight emergencies.

Figure 8. Simulated position for hoist operations.

(6) Seat width on the proposed seat is 16", which is narrower than the original (19.5"). Based on anthropometrics data in the Military Standard 1472C, this would accommodate up to the 95th percentile. The seat pan length is 16" on the proposed seat and is cushioned and contoured in a downward slope. There are no sharp edges to it and it meets the needs of the 5th percentile, so will not impede the 95th percentile. The current seat pan length is 14" with the edge being a metal tube that presented a compression site to the posterior thigh.

3. CONCLUSIONS:

a. Although all the recommendations from the original consultative letter were not met exactly, it appears that the proposed seat meets the general principles of those recommendations through seat angle, headrest design, and seat rotation and height adjustability. It is likely impossible to eliminate entirely the risk factors for musculoskeletal discomfort from the activities performed by the HH-60 Flight Engineers/Gunners.

b. As expected, the proposed seat does not provide significant improvement in legroom; however, it does provide the operators with the option to rotate the seat to the rear to gain a resting posture when not actively involved in mission activities. Given the limited space within the HH-60G, the proposed Martin-Baker seat would present a significant improvement to the current seat for the 5th to 95th percentile male.

4. RECOMMENDATIONS:

a. It would be appropriate for AFIOH to perform a final follow up when the seating system is actually installed in the HH-60 PAVEHAWK and ready for fielding.

b. The results of this project could be beneficial in determining criteria for the development of the next generation system. Warner Robins Logistic Center should consider sharing this information with the appropriate agencies involved in future acquisitions of next generation HH-60s.

5. We greatly appreciate the cooperation of the 305th RQS during this study. Special thanks to TSgt Kyle Fagin, Det 3, 418 FLTS/H-60 CTF/OS, SSgt Carlos Delgado, AFSOC Det 3, FLTS/DOV and SMSgt Mike Flake, 305 RQS/DOE for all their efforts in coordinating this project. If there are additional concerns, please contact me at DSN 240-6116 or Commercial 210-536-6116, or at Linda.Schemm@Brooks.af.mil.

//Signed//

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Attachment:
References

Distribution:
Kyle Fagin, TSgt, USAF, 418 FLTS
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Mark McUmber, AFRC/XPRC

References

1. Grant, Kathy (2001). *Consultative Letter, IERA-RS-BR-CL-2001-0099, Ergonomic Assessment of HH-60 Gunner/Flight Engineer Workstation.* Air Force Institute for Operational Health.

2. Grant, Kathy (2001). *Trip Report (HH-60 Flight Engineer/Gunner's Seat Meeting, 26 Sep 01).* Air Force Institute for Operational Health.

3. Military Standard 1472C