TEST AND EVALUATION OF IMPROVED AIRCREW RESTRAINT SYSTEMS

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US Army aviation accident data shows that a majority of all injuries in attack helicopters could have been avoided if these aircraft had been equipped with crashworthy seat and restraint systems. The compactness of the cockpit and the close proximity of mission equipment to the aircrew in attack and scout helicopters pose serious crash impact hazards. Although not desirable from a crashworthiness standpoint, operational considerations may dictate that mission equipment and structure be located within the occupant's crash impact motion envelope, particularly for his head. The cockpit can be de-lethalized further when the improved restraint is complemented by...

'Babbing potential strike surfaces in the cockpit; making contact surfaces frangible; and providing
weapon system sights with frangibility, telescoping, and/or swing-away features. This report
presents the results of an effort to test and compare the potential of several aircrew restraint
systems to reduce the crash impact motion envelope of helicopter aircrewmen.

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PREFACE

The work described in this report was the result of the participation and cooperation of individuals from several Government and industrial organizations. Participating contractors were:

- Thiokol Corporation, Wasatch Division, Brigham City, Utah — provided the Inflatable Body and Head Restraint System (IBAHRS) test specimens under the terms of Naval Air Development Center Contract N 6229-77-C-0025, jointly funded by ATL and NADC.

- Pacific Scientific Company, Anaheim, California — provided the MIL-S-58095, MIL-R-XXXX, and power haul-back restraint system test specimens under the terms of ATL Contract DAAJ02-79-C-0006.

- Simula, Inc., Tempe, Arizona — instrumented two restraint systems for use in the Civil Aeromedical Institute testing under the terms of ATL Contract DAAJ02-79-C-0016.

Appreciation is extended to the following organizations and individuals for their contributions to this effort:

- Federal Aviation Administration, Civil Aeromedical Institute, Oklahoma City, Oklahoma — Mr. R. F. Chandler provided guidance in furnishing the test sled facility, rigid seat apparatus, and anthropomorphic dummy; conducting the sled crash impact testing; acquiring and reducing all test data; and providing photographic records.

- Aircrew Systems Branch, Naval Air Development Center (NADC), Warminster, Pennsylvania — Mr. J. R. McElhenney, Project Engineer, provided the crash impact sensor and test support for all IBAHRS tests.

- Royal Air Force Institute of Aviation Medicine (IAM), Farnborough, England, United Kingdom — Squadron Leader D. C. Reader provided the rotary-motion, single-point attachment/release buckle manufactured by GQ Ltd.

- US Army Natick Research and Development Command (NARADCOM), Natick, Massachusetts — Mr. T. Judge provided the aircrewman clothing, survival vest, and armor vest.

- Applied Technology Laboratory, US Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia — Mr. J. Batista and Mr. M. Slye analyzed the high-speed motion picture test coverage and illustrated the occupant motion envelopes. Mr. Kent Smith of the Flight Safety Team of Safety and Survivability coordinated and prepared this report for publication upon the departure of the author from this laboratory.
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<td>ATL/CAMI/NADC restraint system test results (95th percentile survivable pulse)</td>
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INTRODUCTION

BACKGROUND

Accident data from the US Army Safety Center involving 4550 helicopter occupants during the period 1971 through 1976 documents the frequency and severity of head injuries. Head injuries are the leading cause of major and fatal injuries (see Table 1) and account for 31.5 percent of fatalities in all helicopters (see Table 2). Figure 1 summarizes the data in Tables 1 and 2.

Current trends toward cockpit space limitation, pilot night vision and target acquisition displays, and armor panels have increased the potential for helicopter crewmember injury. The proximity of the crewmember to cockpit structure instruments, controls, sights, and armor panels is compounded by structural deformation during the crash impact sequence. The potential for major or fatal crash injury is increased in helicopters equipped with weapon sight systems with an eyepiece that requires the copilot/gunner (CPG) to look into it. Under nap of the earth conditions, the CPG viewing through the sight eyepiece can expect little warning of any impending crash impact and a high likelihood of serious head/neck injury. The Army's "Crash Survival Design Guide" published in 1971 shows that the head of a crewmember restrained by a conventional aircrew restraint system (lap belt plus double strap shoulder harness) will displace approximately 10 inches forward during a forward crash pulse as little as 4g (see Figure 2).

The proximity of the upright crewmember's head to cockpit controls/sights/instruments (typically 15 inches or less), forward displacement of the occupant with respect to the seat in mild accidents, forward displacement of the seat, and cockpit structural deformation combine to pose a formidable challenge to the aircraft designer's attempts to provide the required level of crashworthiness.

MIL-STD-1290 is the Army's standard for the design and qualification of new light fixed- and rotary-wing aircraft crashworthiness. This standard requires that fatalities be prevented and injuries minimized in accidents as severe as the 95th percentile potentially survivable accident illustrated in Figure 3. The 95th percentile potentially survivable longitudinal velocity change of 50 feet per second can cause the seat occupant to experience peak longitudinal decelerations of 30g or higher. The latest edition of the "Aircraft Crash Survival Design Guide" presents analytical techniques, concepts, and design test criteria for satisfying MIL-STD-1290; it includes seat, restraint system, protective padding, cockpit controls, and equipment considerations.


   Volume III - Aircraft Structural Crashworthiness, August 1980, AD A089104.
   Volume IV - Aircraft Seats, Restraints, Litters, and Padding, June 1980, AD A088441.
PROGRAM OBJECTIVE

Although crewmember strike hazards can be reduced by methods such as removing the contact surface from the strike envelope or using frangible structure/sights/controls, telescoping or collapsing sights and controls, air bags, or padding, there are several restraint system options available that offer improved restraint and strike envelope reduction. These include inertia reel systems as well as an inflatable body and head restraint system (IBAHRS). Aircraft designers and program managers lacked data detailing the relative crashworthiness benefits of these available restraint systems, however. For this reason a program was conducted to compare by dynamic crash impact testing the potential of seven types of restraint systems to reduce the probability of injury to helicopter crewmembers resulting from striking the cockpit interior and/or controls.

TECHNICAL APPROACH

The abilities of the seven candidate restraint systems to limit occupant motion during typical helicopter crash pulses were compared by subjecting an anthropomorphic dummy in a stiff, nonstroking seat to a series of crash input pulses using a horizontal sled impact facility. The testing was designed to investigate the effect that the following key variables had on the occupant strike envelope: crash pulse peak deceleration, rise time, and velocity change; anthropomorphic dummy clothing and equipment; restraint system concept; and seat orientation. Accelerometer, load cell, and high-speed photographic data were analyzed to compare the performance of the systems.
TABLE 1. MAJOR AND FATAL INJURIES AS PERCENTAGES OF TOTAL (US ARMY AIRCRAFT, 1971-1976) (FROM REFERENCE 3)

<table>
<thead>
<tr>
<th>Body Part</th>
<th>UH (678)</th>
<th>OH (271)</th>
<th>CH (70)</th>
<th>AH (93)</th>
<th>All (1114)</th>
<th>FW (104)</th>
<th>All Aircraft (1218)</th>
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<tr>
<td>Head</td>
<td>19.6</td>
<td>18.5</td>
<td>22.9</td>
<td>21.5</td>
<td>19.7</td>
<td>19.2</td>
<td>19.6</td>
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<tr>
<td>Face</td>
<td>9.1</td>
<td>9.2</td>
<td>10.0</td>
<td>11.8</td>
<td>9.4</td>
<td>14.4</td>
<td>9.3</td>
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<tr>
<td>Neck</td>
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<td>3.0</td>
<td>1.4</td>
<td>3.2</td>
<td>2.6</td>
<td>0.0</td>
<td>2.4</td>
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<tr>
<td>Upper Extremity</td>
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<td>12.9</td>
<td>17.1</td>
<td>15.1</td>
<td>12.1</td>
<td>11.5</td>
<td>12.1</td>
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<tr>
<td>Thorax</td>
<td>13.7</td>
<td>12.2</td>
<td>7.1</td>
<td>8.6</td>
<td>12.5</td>
<td>19.2</td>
<td>13.0</td>
</tr>
<tr>
<td>Abdomen</td>
<td>7.8</td>
<td>5.9</td>
<td>10.0</td>
<td>3.2</td>
<td>7.1</td>
<td>5.8</td>
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<tr>
<td>Pelvis</td>
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<td>2.6</td>
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<td>1.1</td>
<td>3.0</td>
<td>1.9</td>
<td>2.9</td>
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<td>19.2</td>
<td>8.6</td>
<td>21.5</td>
<td>16.5</td>
<td>12.5</td>
<td>15.7</td>
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<tr>
<td>Lower Extremity</td>
<td>17.1</td>
<td>16.6</td>
<td>22.9</td>
<td>14.0</td>
<td>17.1</td>
<td>15.4</td>
<td>15.9</td>
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</tbody>
</table>

Legend: UH - Utility Helicopter
OH - Observation Helicopter
CH - Cargo Helicopter
AH - Attack Helicopter
FW - Fixed-Wing Aircraft

TABLE 2. FATAL INJURIES AS PERCENTAGES OF TOTAL (US ARMY AIRCRAFT, 1971-1976) (FROM REFERENCE 3)

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<tr>
<th>Body Part</th>
<th>UH (262)</th>
<th>OH (175)</th>
<th>CH (134)</th>
<th>AH (132)</th>
<th>All (403)</th>
<th>FW (153)</th>
<th>All Aircraft (456)</th>
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<td>25.3</td>
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<td>Face</td>
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<td>Neck</td>
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<tr>
<td>Lower Extremity</td>
<td>10.7</td>
<td>13.3</td>
<td>17.6</td>
<td>18.8</td>
<td>12.4</td>
<td>11.3</td>
<td>12.3</td>
</tr>
</tbody>
</table>

Legend: UH - Utility Helicopter
OH - Observation Helicopter
CH - Cargo Helicopter
AH - Attack Helicopter
FW - Fixed-Wing Aircraft
Figure 1. Frequency of injuries to body parts in US Army aircraft accidents, 1971-1976 (from Reference 3).

Figure 2. Double shoulder harness with lap belt restraint extremity strike envelope - side view (from Reference 1).
Figure 3. Design velocity change off-axis requirements.
TEST SPECIMENS

Seven types of pilot/copilot restraint systems were crash impact tested and evaluated:

Type 1 — MIL-S-58095\(^4\) restraint system (see Figure 4) with MIL-R-8236C\(^5\) inertia reel.

Type 2 — Type 1 with a single-strap power haul-back (PHB) reel instead of an inertia reel (see Figure 5).

Type 3 — Reflected strap shoulder harness restraint of the type proposed in USAAMRDL TR 75-2,\(^6\) defined in the draft specification MIL-R-XXXX,\(^7\) and shown in Figure 6.

Type 4 — Type 3 except with a dual-strap PHB reel in lieu of the two inertia reels (see Figure 7).

Type 5 — Experimental prototype inflatable body and head restraint system (IBAHRS) shown in Figures 8 and 9.

Type 6 — Type 5 except with a Type 3 restraint serving as the host restraint for the shoulder strap air bags (see Figure 10).

Type 7 — Type 1 except the single point attachment/release buckle was replaced with a rotary motion buckle (see Figure 11).

Webbing characteristics for all of the above restraint systems except Type 5 are presented in Table 3. The Type 5 host restraint system consisted of a MS1609-1\(^8\) shoulder harness, Y-type, and a MS22033-4\(^9\) aircraft safety lap belt.


\(^8\)Military Specification MS1609-1, Shoulder Harness, Y-Type, Department of Defense, Washington, DC.

\(^9\)Military Specification MS22033-4, Aircraft Safety Lap Belt, Department of Defense, Washington, DC.
Figure 4. MIL-S-58095 aircrew restraint system.

Figure 5. Type 2 restraint system.
Figure 6. MIL-R-XXXX restraint system, including reflected shoulder straps.

Figure 7. Type 4 restraint system.

a. Front view.  
b. Rear view.
Figure 8. Inflatable body and head restraint.
a. IBAHRS.

b. Pretest.

c. Posttest.

Figure 9. Type 5 restraint system - IBAHRS.
Figure 10. Type 6 restraint system - IBAHRS with MIL-R-XXXX
host restraint and air bags unstowed.
a. Back of buckle.

b. Restraint.

Figure 11. Type 7 restraint system - RAF, GQ Ltd system.
Pacific Scientific Company provided all the restraint systems except the following: Thiokol Corporation provided the Type 5 restraint system and added the inflatable feature to the Type 3 restraint to create the Type 6 restraint; the Royal Air Force Institute of Aviation Medicine provided the Type 7 buckle that was manufactured by GQ Ltd. of the United Kingdom.

The Type 1 restraint is the minimum acceptable required by MIL-S-58095 for US Army forward-facing crewmembers. Type 3 provides improved lateral restraint due to the reflected shoulder straps. Types 2 and 4 were tested to evaluate the potential for reducing the strike envelope by manually activating a ballistic PHB reel. Automatic retraction of the crewmember by a PHB reel activated by crash sensor was rejected. These PHB reels were designed for pre-positioning ejection seat crewmembers and have a retraction time of 0.3-0.4 second, considerably more than the 0.06-second retraction time required if the PHB reel is to be effective in most crashes. An investigation by the US Army Aeromedical Research Laboratory showed that to reduce this retraction time, the torso retraction velocity would have to significantly exceed the current 9-foot-per-second limit established by human tolerance considerations. The PHB reel’s potential for this application is that it will be a manually activated tightening device for the CPG in a head-up position and will offer little benefit when the crewmember is in the head-down mode viewing through a sight.

The use of an air bag(s) for the CPG station has potential; however, air bags deflate immediately after inflation, thereby being effective for a single pulse. Also, their application in the cockpit would require considerable research and development. The IBAHRS of Figure 9, however, has more near-term potential. Based on automotive air bag technology, the IBAHRS is being jointly developed by the US Naval Air Development Center and the US Army’s Applied Technology Laboratory. It provides increased crash protection when the air bag sewn on the underside of the shoulder strap by the crash impact sensor is inflated, thereby forcing the occupant against the seat back and reducing strike envelope, dynamic overshoot, concentration of strap
load on the body, and rotation and whiplash-induced trauma. Also, if the IBAHRS air bags malfunction, the crewmember still has the protection of the basic (or host) restraint system. One inflator is sewn into each bag and is wired to the crash impact sensor mounted to either the seat or the floor. The inflator is shown in Figure 12. The development of the IBAHRS concept is documented in Reference 10.

Figure 12. IBAHRS inflator.

CRASH IMPACT SLED TESTING

PROCEDURE

Thirty three crash impact sled tests were performed on the candidate restraint systems at the Federal Aviation Administration’s Civil Aeromedical Institute (CAMI). An Alderson Model VIP-95 95th percentile adult male anthropomorphic dummy was used for each test. Dummy clothing and equipment for all tests except numbers 27 and 34 of Table 4 included an APH-5 flight helmet, a flight suit, and boots. Tests 27 and 34 were performed with the addition of an armored vest. The rigid test seat, floor, and rudder pedal geometry is shown in Figure 13. This geometry and the seat pan and back cushions are representative of an attack helicopter. Test impact conditions are given in Table 4.

Data were obtained from accelerometers, webbing load cells, high-speed motion pictures, still photographs, and observation. Triaxial accelerometers were mounted on the head, chest, pelvis, and seat pan bottom surface. Accelerometers were also mounted along the longitudinal axis of the sled, and foot rest reaction loads were recorded. Prior to each test the dummy was positioned in the upright, design eye reference position. The dummy position and strap length were measured to ensure the same body position and restraint system slack prior to each test.

Figure 13. Pretest geometry.
Note: Seat back cushion, seat pad cushion, restraint system and usage geometry, and anthropomorphic dummy position are in accordance with the YA-64A armored crew seat.

Figure 13. Continued.
<table>
<thead>
<tr>
<th>CAMI Test No.</th>
<th>Restraint System Type</th>
<th>Description</th>
<th>%</th>
<th>ΔV</th>
<th>G&lt;sub&gt;PK&lt;/sub&gt;</th>
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</table>

- %: percentile survivable pulse
- ΔV: velocity change, ft/sec
- G<sub>PK</sub>: programmed pulse peak deceleration, g
RESULTS

Accelerometer and strap load cell data for selected tests are compared in Tables 5, 6, and 7 for the 50th, 85th, and 95th percentile potentially survivable impacts respectively. The significant reduction in occupant loading by the IBAHRS reported in Reference 10 and illustrated in Figures 14 and 15 was not noted in these tests and may be attributable to the snug fit of the restraint system used for the tests.

The main benefit of the IBAHRS demonstrated during these tests was the reduction in occupant upper torso, head, and neck motion compared to the other restraint systems (see Figures 16, 17, and 18). Although the occupant head strike envelope was only slightly better with the IBAHRS than with the MIL-R-XXXX/PHB restraint, the IBAHRS has the major advantage of being crash sensor activated. At the 95th percentile pulse level the difference in head strike envelopes of the different restraint systems was less than at the lower impact levels. The Type 7 restraint withstood the 95th percentile survivable pulse with the seat yawed 30 degrees (see test 047 of Table 4).

Malfunctions were experienced with some of the restraint system components. The rotary motion attachment/release buckle failed in a "cam-out" mode when subjected to the 95th percentile potentially survivable pulse when the seat was oriented with a 30-degree yaw. This buckle design had been qualified to MIL-S-58095 in production crashworthy armored crew seat static and dynamic tests and successfully withstood the 0-degree yaw testing. A typical failure is shown in Figure 19. The "cam-out" occurred in the 30-degree yaw tests because the fitting with a rectangular hole rotated both in and out of the plane of the buckle, creating a point load on the buckle dog which precipitated in local plastic deformation of the dog and fitting, permitting the lap belt fitting to slip up and over the dog. This was corrected by rounding the dog and fitting contact edge to allow rotation of the fitting in the plane of the buckle (see Figure 20).

Another problem experienced was the asymmetric deployment of the IBAHRS air bags shown in Figure 21. Although both bags inflated quickly, for the tests with the restraint worn with negligible slack, one of the bags inflated outboard of the strap instead of beneath the chin. In test 057 the IBAHRS was adjusted to allow for more slack, and both bags deployed correctly.

Complete time history plots of load cell and accelerometer data acquired for each test are presented in Appendix A. Dummy strike envelope plots are presented in Appendix B for all tests except -025, -038, and -054.
TABLE 5. ATL/CAMI/NADC RESTRAINT SYSTEM TEST RESULTS

50TH PERCENTILE SURVIVABLE PULSE
\( \Delta V = 28 \text{ fps} \quad G_{pk} = 5.4g \quad \text{Yaw} = 0^\circ \)
VIP-95 Dummy \quad 227 lb

<table>
<thead>
<tr>
<th>Restraint System</th>
<th>MIL-S-58095, Test -022</th>
<th>MIL-R-XXXX/PHB, Test -031</th>
<th>IBAMHS,*</th>
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<td>.74</td>
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<td>6.1</td>
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<td>Seat pan ( G_x )</td>
<td>5.8</td>
<td>5.7</td>
<td>6.0</td>
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<td>Pelvis: ( G_x )</td>
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<td>( G_z )</td>
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<td>0</td>
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<td>5.0</td>
<td>8.3</td>
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<tr>
<td>( G_z )</td>
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<td>0</td>
<td>3.4</td>
</tr>
<tr>
<td>Head: ( G_{x1} )</td>
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<td>7.0</td>
<td>7.5</td>
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<tr>
<td>( G_{z1} )</td>
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<td>5.5</td>
<td>5.0</td>
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<td>( G_{x2} )</td>
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<td>( PLL )</td>
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</table>

*Bags sewn

Legend: \( G_x \) = peak longitudinal deceleration, g
\( G_{x1} \) = first peak longitudinal deceleration, g
\( G_{x2} \) = second peak longitudinal deceleration, g
\( G_z \) = peak vertical deceleration, g
\( G_{z1} \) = first peak vertical deceleration, g
\( G_{z2} \) = second peak vertical deceleration, g
\( PLS \) = left shoulder strap peak load, lb
\( PRS \) = right shoulder strap peak load, lb
\( PLL \) = left lap belt strap peak load, lb
\( PLL \) = right lap belt strap peak load, lb
### TABLE 6. ATL/CAMI/NADC RESTRAINT SYSTEM TEST RESULTS

#### 85TH PERCENTILE SURVIVABLE PULSE

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<td>0°</td>
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VIP-95 Dummy 227 lb

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<th>Head:</th>
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<th>Head:</th>
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---

*Stack with bags stowed

**Bags sewn

Legend:

- $G_x$ = peak longitudinal deceleration, g
- $G_{x1}$ = first peak longitudinal deceleration, g
- $G_{x2}$ = second peak longitudinal deceleration, g
- $G_y$ = peak vertical deceleration, g
- $G_{y1}$ = first peak vertical deceleration, g
- $G_{y2}$ = second peak vertical deceleration, g
- PLS = left shoulder strap peak load, lb
- PRS = right shoulder strap peak load, lb
- PLL = left lap belt strap peak load, lb
- PRL = right lap belt strap peak load, lb

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## TABLE 7. ATL/CAMI/NAOC RESTRAINT SYSTEM TEST RESULTS

**96TH PERCENTILE SURVIVABLE PULSE**

\[ \Delta V = 60 \text{ fps} \quad G_{PK} = 30g \quad \text{Yaw} = 0^\circ \]

VIP-95 Dummy 227 lb

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<th>MIL-S-58095/PHB</th>
<th>MIL-R-XXXX</th>
<th>MIL-R-XXXX/PHB</th>
<th>IBAHRS</th>
<th>IBAHRS</th>
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<tr>
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<td>Test -028</td>
<td>Test -029</td>
<td>Test -030</td>
<td>Test -035</td>
<td>Test -061</td>
<td>Test -062</td>
</tr>
</tbody>
</table>

### Input pulse:
- **Sled**
- **Seat pan Gx**

### Pelvis:
- **Gx**
- **Gz**

### Chest:
- **Gx**
- **Gz**

### Head:
- **Gx1**
- **Gx2**
- **Gz1**
- **Gz2**

### Straps:
- **PRS**
- **PLS**
- **PRL**
- **PLL**
- **PS Loop**
- **PS Sum**

### Legend:
- \( G_x \) = peak longitudinal deceleration, g
- \( G_{x1} \) = first peak longitudinal deceleration, g
- \( G_{x2} \) = second peak longitudinal deceleration, g
- \( G_z \) = peak vertical deceleration, g
- \( G_{z1} \) = first peak vertical deceleration, g
- \( G_{z2} \) = second peak vertical deceleration, g
- \( PLS \) = left shoulder strap peak load, lb
- \( PRS \) = right shoulder strap peak load, lb
- \( PLL \) = left lap belt strap peak load, lb
- \( PRL \) = right lap belt strap peak load, lb

*Bags are pre-positioned and sewn*
Figure 14. Uninflated versus preinflated restraint with 2-inch shoulder and 1-inch lap belt slack at 15g.

Figure 15. Reduction of restraint loads with inflation for three slack conditions.
Figure 16. CPG strike envelope comparison (50th percentile survivable pulse).

Figure 17. CPG strike envelope comparison (85th percentile survivable pulse).
Figure 18. CPG strike envelope comparison (95th percentile survivable pulse).

Figure 19. Buckle failure.
Figure 20. Buckle modification.

Figure 21. IBAHRS asymmetric deployment.
CONCLUSIONS AND RECOMMENDATIONS

Both the IBAHRS and PHB reel features will decrease the occupant head motion envelope in crash impacts as severe as the 95th percentile potentially survivable helicopter accident pulse; however, because it is crash sensor activated, the IBAHRS is preferable. This level of protection is based on a rigid seat such as the one used in these tests. Seat forward displacement during a crash characteristic of crash force attenuating seats which stroke in the forward direction will compromise the potential protection of any restraint system.

The Army and Navy are continuing the development of the IBAHRS for potential application to attack and scout helicopters. Notwithstanding the benefits of the IBAHRS, future combat helicopters should be designed to remove the occupant strike hazard where operational considerations permit. In addition, any sights and/or cyclic sticks which must remain within the crew-member's strike envelope should be collapsible, crushable, or telescoping. The detailed cockpit delethalization design criteria of Volume IV of the "Aircraft Crash Survival Design Guide" should be followed.
REFERENCES


   Volume III — Aircraft Structural Crashworthiness, August 1980, AD 089104.


8. Military Specification MS1609-1, Shoulder Harness, Y-Type, Department of Defense, Washington, DC.


APPENDIX A
ATL/CAMI/NADC RESTRAINT SYSTEM TEST DATA

CAMI SLED TESTS
RUN A73-22A

CAMI SLED TESTS
RUN A79-22A

CAMI SLED TESTS
RUN A79-22A

CAMI SLED TESTS
RUN A79-22A
CAMI SLED TESTS
RUN A73-24A

CAMI SLED TESTS
RUN A73-24A

LEFT SHOULDER FORCE (LB)

RIGHT SHOULDER FORCE (LB)

SHOULDER FORCE (LB)

TIME MILLISECONDS

TIME MILLISECONDS

TIME MILLISECONDS

TIME MILLISECONDS
SLED TESTS
RUN A75-48A

CHEST X ACCELERATION (G)

TIME: MILLISECONDS

CHEST Z ACCELERATION (G)

TIME: MILLISECONDS
SLED TESTS
Chest Y Acceleration (g)

SLED TESTS
Chest Resultant (g)

SLED TESTS
Chest X Acceleration (g)

SLED TESTS
Chest Z Acceleration (g)
APPENDIX B
ANTHROPOMORPHIC DUMMY STRIKE ENVELOPES

PULSE: 50th PERCENTILE SURVIVABLE
$\Delta V = 28\text{FPS}$  $G_{\text{PEAK}} = 5.4G$
YAW = 0°
DUMMY: VIP-95, 227LBS

---

UP
NSRP
DOWN

MIL-S-58095(A79-022)
DESIGN EYE REF POSITION

SEAT ADJUSTMENT
POSITIONS:
UP
NSRP
DOWN
CPG STRIKE ENVELOPE

PULSE: 85th PERCENTILE SURVIVABLE
ΔV = 39 FPS    G_{PEAK} = 16G
YAW = 0°
DUMMY: VIP-95, 227 LBS

MIL-S-58095(A79-023)

DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
ΔV = 50FPS  G_{PEAK} = 30G
YAW = 0°
DUMMY: VIP-95, 227LBS

MIL-S-59065(A79-024)
DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\( \Delta V = 50 \text{FPS} \)  \( G_{\text{PEAK}} = 30G \)
\( \text{YAW} = 0^\circ \)
DUMMY: VIP-95, 244.25 LBS

MIL-S-58095(A79-027)
DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
ΔV = 50FPS  G_PEAK = 30G
YAW = 30°
DUMMY: VIP-95, 227LBS

MIL-S-58095(A79-028)
LAP BELT FITTING FAILED ("CAM-OUT")
- DESIGN EYE REF POSITION

RESTRAINT FAILED

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\( \Delta V = 50 \text{FPS} \quad G_{\text{PEAK}} = 30 \text{G} \)
YAW = 0°

DUMMY: VIP-95, 227LBS

MIL-S-59095/PHB/(A79-029)
DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
ΔV = 50 FPS  G_{PEAK} = 30 G
YAW = 0°
DUMMY: VIP-95, 227 LBS

MIL-R-XXX/PHB(A79-030)

DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
  - UP
  - NSRP
  - DOWN
CPG STRIKE ENVELOPE

PULSE: 50th PERCENTILE SURVIVABLE
\[ \Delta V = 28 \text{fps} \quad G_{\text{peak}} = 5.4 \text{G} \]
\[ \text{YAW} = 0^\circ \]
DUMMY: VIP-95, 227LBS

MIL-R-XXX/PHB(A79-031)

DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 85th PERCENTILE SURVIVABLE
\[ \Delta V = 39 \text{FPS} \quad G_{\text{PEAK}} = 16 \text{G} \]
YAW = 0°
DUMMY: VIP-95, 227LBS

- UP
- NSRP
- DOWN

MIL-R-XXX/PHB(A79-032)

DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 25th PERCENTILE SURVIVABLE
\[ \Delta V = 39 \text{ FPS} \quad G_{\text{PEAK}} = 16G \]
YAW = 0°
DUMMY: VIP-95, 227LBS

MIL-R-XXX/PHB(A79-033)
- DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE

$\Delta V = 50$FPS \quad G_{\text{PEAK}} = 30G

YAW = 0°

DUMMY: VIP-95, 227LBS

NSRP

UP

DOWN

MIL-R-XXX(A79-035)

DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:

UP

NSRP

DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
ΔV = 50FPS  \( G_{\text{PEAK}} = 30G \)
YAW = 30°
DUMMY: VIP-95, 227LBS

RESTRAINT FAILED

UP
NSRP
DOWN

MIL-S-58095(A79-036)
FAILED
DESIGN EYE REF POSITION

SEAT ADJUSTMENT
POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
ΔV = 50FPS  G PEAK = 30G
YAW = 30°
DUMMY: VIP-95, 227LBS

NSRP

-MIL-S-58095(A798-036)
FAILED
-DESIGN EYE REF POSITION
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50 \text{FPS} \quad G_{\text{PEAK}} = 30 \text{G} \]
YAW = 30°
DUMMY: VIP-95, 227'LBS

MIL-R-XXX/PHB(A79-037)
DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50 \text{FPS} \quad G_{\text{peak}} = 30 \text{G} \]
YAW = 30°

DUMMY: VIP-95, 227LBS

- NSRP

- MIL-R-XXX/PHB(A79-037)

- DESIGN EYE REF POSITION
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50\text{FPS} \quad G_{\text{PEAK}} = 30G \]
YAW = 30°
DUMMY: VIP-95, 227LBS

MIL-R-XXX(A79-039)
DESIGN EYE REF POSITION

SEAT ADJUSTMENT
POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50 \text{FPS} \quad G_{\text{PEAK}} = 30 \text{G} \]
YAW = 30°
DUMMY: VIP-95, 227LBS

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MIL-R-XXX(A79-039)

DESIGN EYE REF POSITION
CPG STRIKE ENVELOPE

Pulse: 95th percentile survivable
\[ \Delta V = 50 \text{ FPS} \]
\[ G_{\text{peak}} = 30 \text{G} \]
\[ \text{YAW} = 30^\circ \]

Dummy: VIP-95, 227lbs

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Diagram showing:
- Design eye ref position
- Seat adjustment positions: up, NSRP, down
- MIL-S-58095(A79-043)
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
ΔV = 50FPS  G_{PEAK} = 30G
YAW = 30°
DUMMY: VIP-95, 227LBS

- NSRP
- MIL-S-58095(A79-043)
- DESIGN EYE REF POSITION
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50\text{FPS} \quad G_{\text{PEAK}} = 30G \]
YAW = 30°

DUMMY: VIP-95, 227LBS

MIL-S-58095(A79-044)
DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
ΔV = 50FPS  G_{PEAK} = 30G
YAW = 30°
DUMMY: VIP-95, 227LBS

-- MIL-S-58095(A79-044) --

DESIGN EYE REF POSITION
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50 \text{fps} \quad G_{\text{peak}} = 30 \text{G} \]
YAW = 30°

DUMMY: VIP-95, 227LBS

- UP
- NSRP
- DOWN
- MIL-S-58095(A79-045)
- DESIGN EYE REF POSITION
- SEAT ADJUSTMENT POSITIONS:
  - UP
  - NSRP
  - DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50\text{FPS} \quad G_{\text{PEAK}} = 30\text{G} \]
YAW = 30°
DUMMY: VIP-95, 227LBS

NSRP

MIL-S-58095(A79-045)

DESIGN EYE REF POSITION
PULSE: 95th PERCENTILE SURVIVABLE
$\Delta V = 50 \text{ FPS}$  \hspace{1cm} $G_{\text{PEAK}} = 30 \text{G}$
$YAW = 30^\circ$

DUMMY: VIP-95, 227LBS

INERTIA REEL STRAP FAILED

MIL-S-58095(A79-046)
FAILED
DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\( \Delta V = 50 \text{FPS} \) \( G_{\text{PEAK}} = 30G \)
YAW = 30°
DUMMY: VIP-95, 227LBS

MIL-S-58095(A78-046)
FAILED
DESIGN EYE REF POSITION
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50 \text{FPS} \quad G_{\text{PEAK}} = 30G \]
\[ \text{YAW} = 30^\circ \]
DUMMY: VIP-95. 227LBS

MIL-S-58095/GQ(A79-047)
DESIGN EYE REF POSITION
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50 \text{FPS} \quad G_{\text{PEAK}} = 30 \text{G} \]
YAW = 30°

DUMMY: VIP-95, 227LBS

- UP
- NSRP
- DOWN

INERTIA REEL STRAP FAILED

IBAHRS(A79-048) FAILED
DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50 \text{FPS} \quad G_{\text{PEAK}} = 30 \text{G} \]
YAW = 30°
DUMMY: VIP-95, 227LBS

NSRP

IBAHRS(A78-048) FAILED
DESIGN EYE REF POSITION
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
△V = 50FPS  G_PEAK = 30G
YAW = 0°
DUMMY: VIP-95, 227LBS

-10-
10 1

IBAHR(A79-040)

DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50\text{FPS} \quad \text{G}_{\text{PEAK}} = 30\text{G} \]
YAW = 0°
DUMMY: VIP-95, 227LBS

INERTIA REEL FAILED

IBAHRS-PREPOSITIONED
(A79-050)
FAILED

DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
ΔV = 50 FPS  G_{PEAK} = 30G
YAW = 0°
DUMMY: VIP-95, 227LBS

IBAHR'S PREPOSITIONED (A79-051)

DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN

- 10 -
- 10 -
- 1 -
CPG STRIKE ENVELOPE

PULSE: 95th PERCENTILE SURVIVABLE
\[ \Delta V = 50 \text{FPS} \quad G_{\text{PEAK}} = 30 \text{G} \]
\[ \text{YAW} = 0^\circ \]
DUMMY: VIP-95, 227LBS

IBAHRS(A79-052)
DESIGN EYE REF POSITION
SEAT ADJUSTMENT POSITIONS
UP
NSRP
DOWN
CPG STRIKE ENVELOPE

PULSE: 85th PERCENTILE SURVivable
\[ \Delta V = 39 \text{FPS} \quad G_{ \text{PEAK}} = 16 \text{G} \]
YAW = 0°

DUMMY: VIP-95, 227 LBS

- IBAHRS-BAGS SEWN (A79-053)
- DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 50th PERCENTILE SURVIVABLE
ΔV = 28FPS  G_{PEAK} = 5.4G
YAW = 0°
DUMMY: VIP-95, 227LBS

IBAHRS-BAGS SEWN (A70-055)
DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN
CPG STRIKE ENVELOPE

PULSE: 85th PERCENTILE SURVIVABLE
\[ \Delta V = 39\text{FPS} \quad G_{\text{PEAK}} = 16G \]
YAW = 0°
DUMMY: VIP-95, 227LBS

MIL-R-XXX/IBAHRS-BAGS SEWN(A79-056)
DESIGN EYE REF POSITION

SEAT ADJUSTMENT POSITIONS:
- UP
- NSRP
- DOWN