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CRASH INJURY INVESTIGATION

U. S. ARMY H-21C

SHAWNEE HELICOPTER ACCIDENT

Big Meadows, Virginia

2 December 1959

TREC Technical Report 60-14

FSF

AVIATION CRASH INJURY RESEARCH

A DIVISION OF

FLIGHT SAFETY FOUNDATION, Inc.

2713 EAST AIRLINE WAY • SKY HARBOR AIRPORT • PHOENIX, ARIZONA

U. S. ARMY H-21C VERTOL SHAWNEE HELICOPTER 56-8630

Big Meadows, Virginia
2 December 1959

Report of Crash Injury Investigation
AvCIR-11-PR-112
February 1960

U. S. Army
Transportation Research Command
Contract DA 44-177-TC-624

AVIATION CRASH INJURY RESEARCH
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Crash Injury Investigation

Harold F. Roegner

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Crash Injury Analysis

Harold F. Roegner

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Jack Carroll

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SUMMARY

A U. S. Army H21-C "Shawnee" helicopter crashed while ferrying combat troops from Shannon Airport in Fredericksburg to Big Meadows, Virginia, on 2 December 1959. The crash site was in a mountainous, heavily wooded area approximately six miles south of Luray, Virginia, near the Sky Line Drive.

At the time of the crash, there were three crew members and twelve passengers aboard the aircraft The copilot was fatally injured; the pilot and ten of the passengers received injuries ranging from minor to serious; three passengers were uninjured.

A crash injury investigation conducted by Aviation Crash Injury Research revealed that the predominant causes of injuries were failures of seats and seat belts. As a result of the investigation, it was concluded that if properly designed and installed seats and restraining devices, in both the cockpit and cabin, had been provided, this accident probably would have resulted in only minor injuries.

The investigation found, also, that relatively minor damage to the basic aircraft structure resulted from the crash and that the occupiable area of the aircraft (with the exception of the seats and restraining devices) was almost completely intact.

As a result of the above findings, the attention of responsible military authorities is called to the following recommendations:

1. Immediate steps be taken toward increasing the integrity of both cockpit and cabin seats in this aircraft.
2. Consideration be given to attachment of all restraining devices to the basic structure of of the aircraft.

BACKGROUND

On 2 December 1959 a U. S. Army H21-C "Shawnee" helicopter (Serial #56-8630) crashed in a mountainous, heavily wooded area near Big Meadows, Virginia.

The copilot* was fatally injured; the pilot and ten of the passengers received injuries ranging from minor to serious; three passengers were uninjured. (AvCIR Scale of Injuries is contained in this report as Appendix III.)

A crash injury investigation of the accident was conducted on 5-7 December 1959 by Aviation Crash Injury Research (AvCIR) under the provisions of U. S. Army Transportation Research Command Contract #DA44-177-TC-624.

The aircraft was examined at the crash site. Photographs of the wreckage and of the essential components and equipment were obtained during the course of the investigation.** Statements of the pilot and of the occupants assisted the investigation team in estimating the flight path, the impact conditions, and the principal vertical and horizontal forces during the crash.

This is the final report on the crash injury investigation.

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* The copilot seat was occupied by an instructor pilot who will be referred to throughout this report as the "copilot."

** Some of the photographs were taken after a light snow had covered the area.

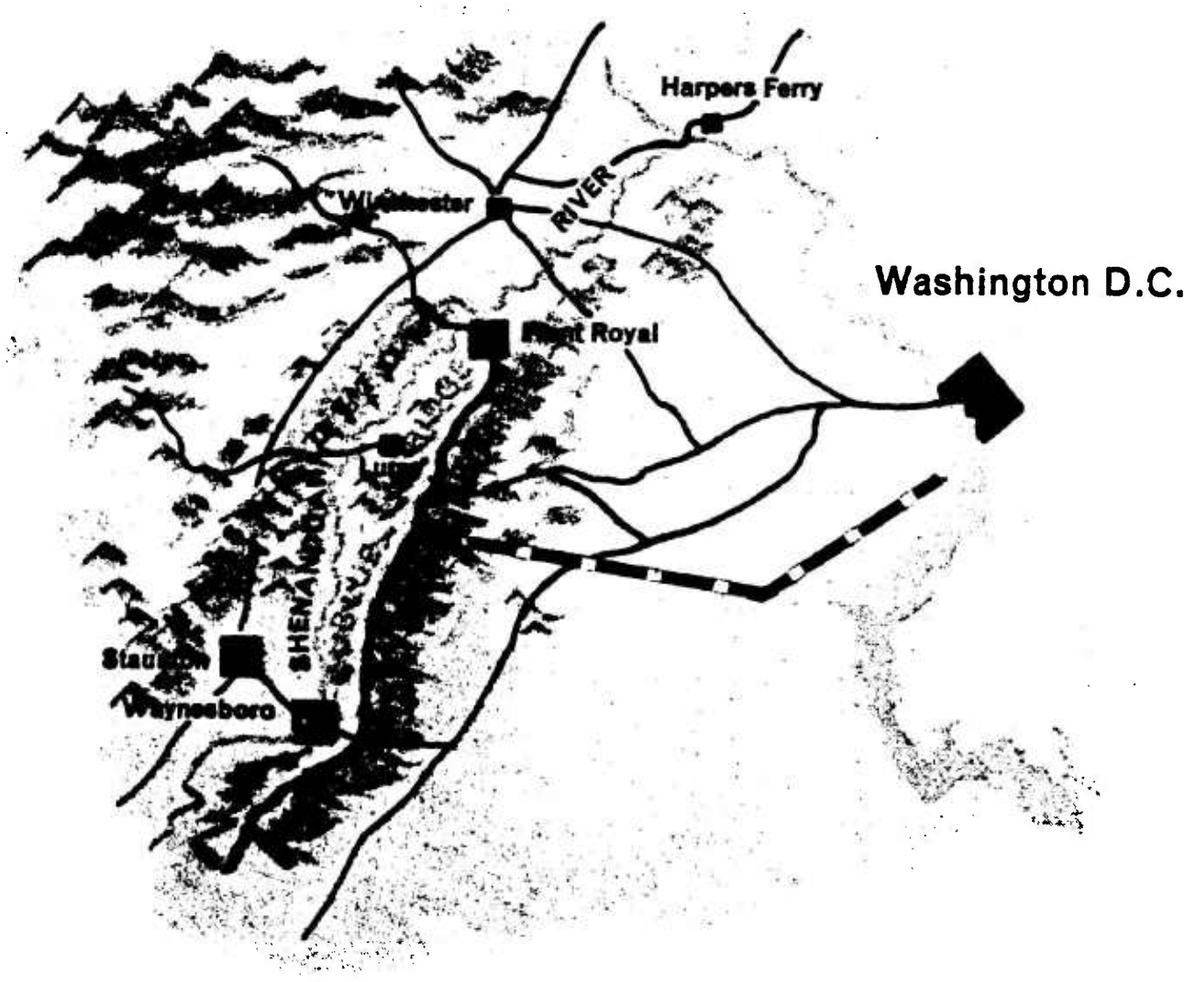


Figure 1. Area chart showing the route flown by the three H-21C helicopters. Crash site is marked with an X.

Figure 2. Side view of an intact H-21C "Shawnee" helicopter.

DESCRIPTION OF THE ACCIDENT

CRASH SEQUENCE

The aircraft involved in this accident (H21-C, S/N568639) was leading a flight of three aircraft ferrying combat-equipped troops from Shannon Airport in Fredericksburg, Virginia, to Big Meadows, Virginia. The intended landing site was situated at the top of a ridge (elevation 3800 ft. m. s. l.) approximately six miles from Luray, Virginia, near the Sky Line Drive. The route of the flight and the crash site are shown in Figure 1.

The approach to the intended landing site was up a steep, wooded ravine terminating at the ridge line. Approximately four miles from the intended landing site (at approximately 3400 ft. m. s. l.) the aircraft began to experience difficulty in maintaining air speed and altitude. To counteract the loss of air speed and altitude, the pilot continued to add power and pitch to maintain his climb up the ravine, until the throttle reached the stops. In spite of the application of maximum power, air speed and altitude continued to decrease.

With the other two aircraft in echelon on his left, the pilot decided to execute a right turn back down the ravine in an attempt to effect a recovery from the loss of speed and altitude condition. Figure 3 shows this maneuver. As he initiated the turn, however, he found there was insufficient room in the ravine to complete the maneuver and committed the aircraft to a forced landing; leveling the helicopter and executing a full flare (nose high) to dissipate the remaining air speed and applying collective pitch to decrease the rate of descent. During this maneuver, the rear rotor contacted the trees and disintegrated as the aircraft settled into the trees.

During the crash sequence, the aircraft rolled approximately 90 degrees to the left, scraping down the sides of trees approximately 40 feet in height. The aircraft impacted on its left side. Initial ground contact occurred on the left side of the pilot's compartment, forward of the copilot's seat, with the aircraft in a 3-5° nose-down attitude in relation to the ground. After initial impact, the rear section of the aircraft settled with the tail cone wedged between several trees. The kinematic behaviour of the aircraft during the crash is shown in Figure 4. Figures 5, 6, and 7 show the aircraft in its final position.

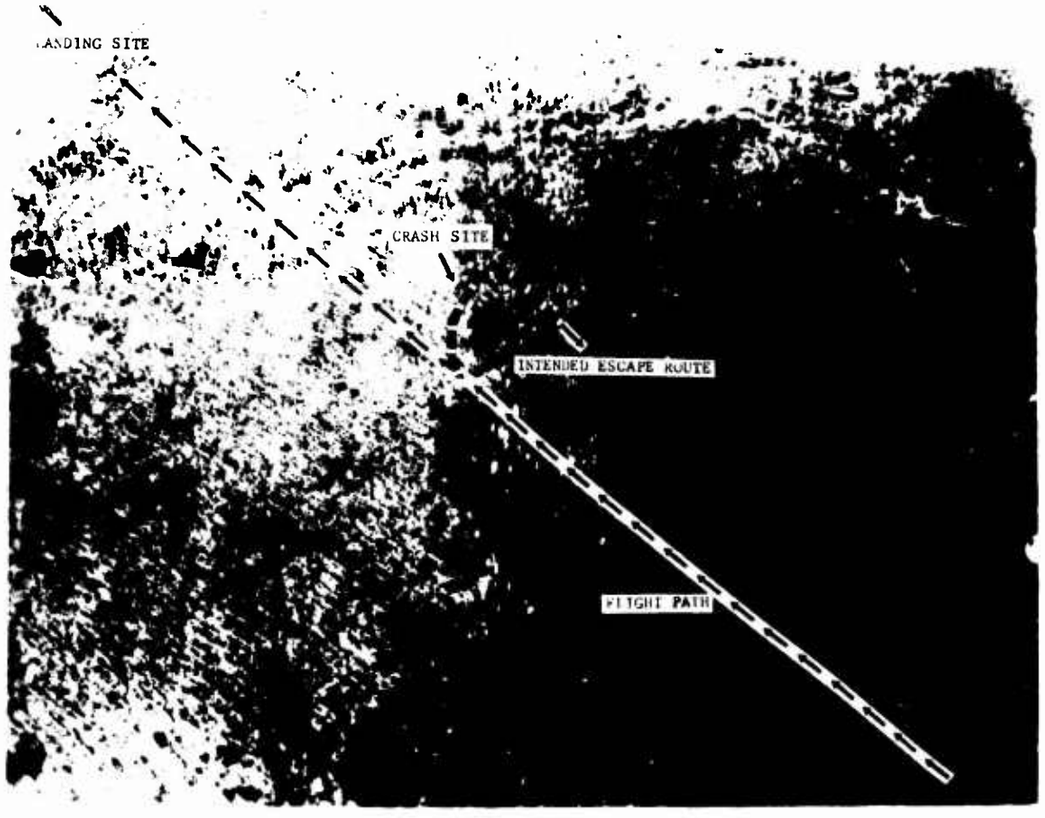


Figure 3. Aerial view showing the flight path, intended landing site, crash site and intended escape route.

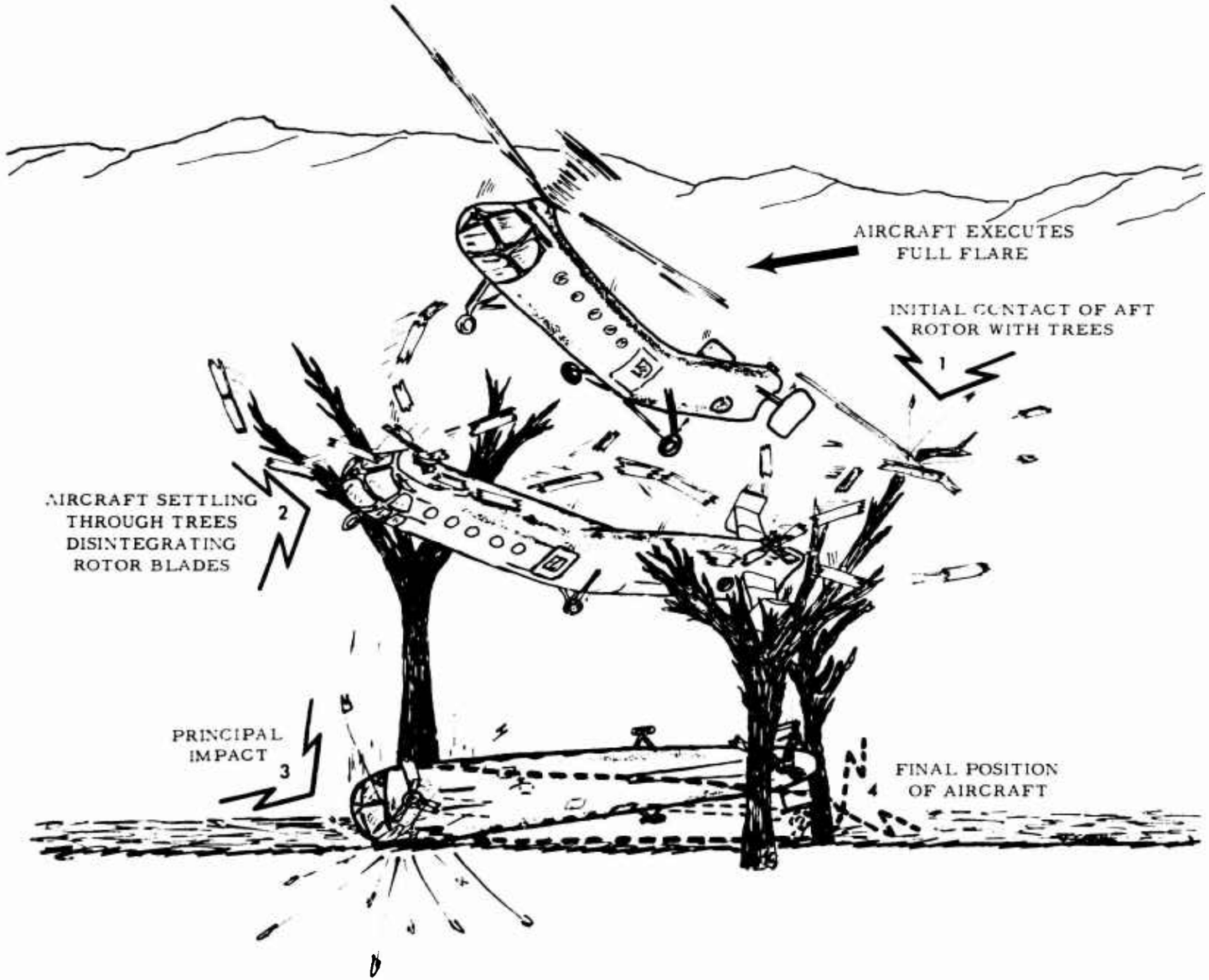


FIGURE 4. KINEMATICS DRAWING

Figure 5. A side view of subject aircraft as it came to rest on its left side. The engine covers were removed after the accident.

Figure 6. The nose-down attitude was caused by the aft end of the aircraft being wedged between several large trees as shown in the above photograph.

EVACUATION

When the aircraft came to rest, the pilot released himself from his seat (which was broken free) and evacuated the cockpit through the broken lower portion of the cockpit bubble on the copilot's side. From that position, he released the copilot from his seat (which had also broken free) and removed him from the aircraft. During this interval, two cabin occupants evacuated the main cabin and assisted the pilot in removing the copilot from the aircraft.

After removing the copilot, the pilot returned to the aircraft and assisted in the evacuation of the troops from the main cabin. The entire evacuation from the main cabin was accomplished through the right front cabin door, which was now located on the top side of the aircraft, which is visible in Figure 5. Some of the more seriously injured troops required assistance in evacuating the cabin.

Figure 7. Front view of the helicopter showing the broken nose bubble on the left side.

Although adequate emergency exits are provided in this aircraft, they were not utilized. Figures 9 and 10 show the location of two ceiling exits, which were operable but were not utilized, probably as a result of inadequate emergency evacuation briefing prior to the flight or the incapacitation of the crew chief.

The time required to evacuate all personnel from the aircraft including those requiring assistance indicates that more emphasis should be placed on briefing occupants of military aircraft on evacuation procedures and the location and use of emergency exits prior to the flight.

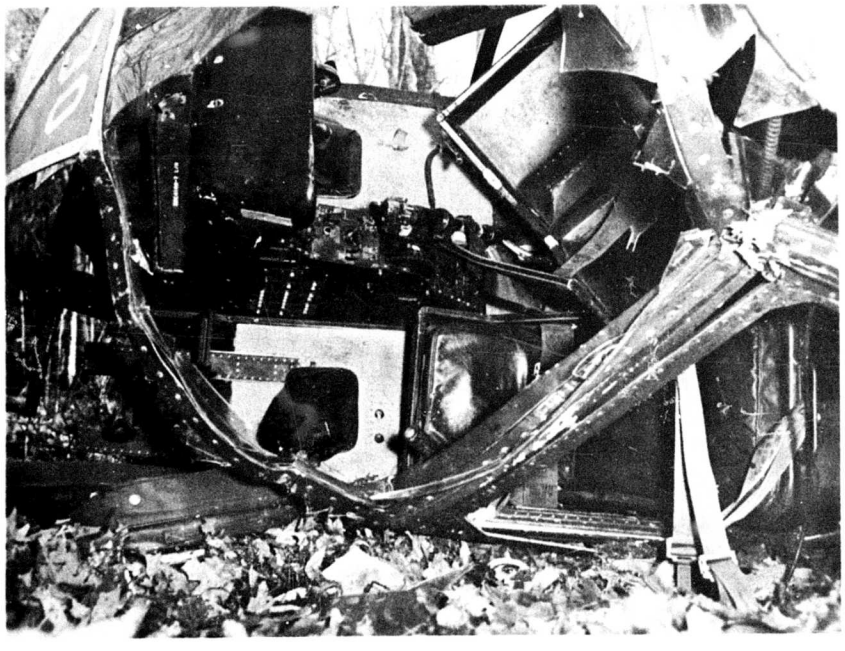


Figure 8. View looking down into the cockpit showing the final position of the two pilots' seats and the opening in the cockpit through which the pilot evacuated the aircraft.

Figure 9. A view of the aircraft looking toward the forward rotor. The arrows indicate the operable, but unused, ceiling emergency exits.

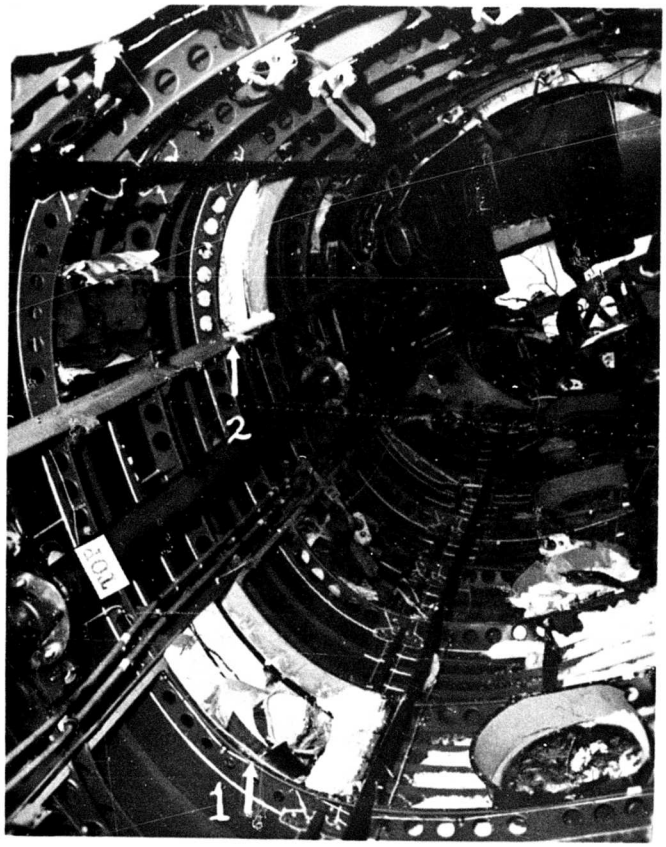


Figure 10. Interior view of the operable but unused ceiling emergency exits (arrows 1 and 2). Both exits were opened by the accident investigators.

DAMAGE TO THE AIRCRAFT

EXTERIOR

An analysis of the crash forces involved in this accident (Appendix I) reveals that the mean crash force resultant was relatively low. Based upon the information available, it is estimated that the forces were approximately 8 to 12G. The relatively moderate force is also evidenced by the fact that the fuselage was not damaged extensively. The fuselage structure sustained no significant damage, as shown in Figure 5; the floor remained completely intact, as shown in Figure 11; all doors and emergency exits (except the left cabin door, which was torn free) were intact and operable; there was no engine displacement, and radio units remained attached to the radio rack.

As the aircraft settled into the trees, the drive shaft to the forward rotor snapped a short distance aft of the forward bulkhead, putting the two rotor systems out of phase, which resulted in blade-to-blade contact. Rotor contact with the trees added to the damage, the final result being extensive damage to the rotors, rotor heads and rotor masts.

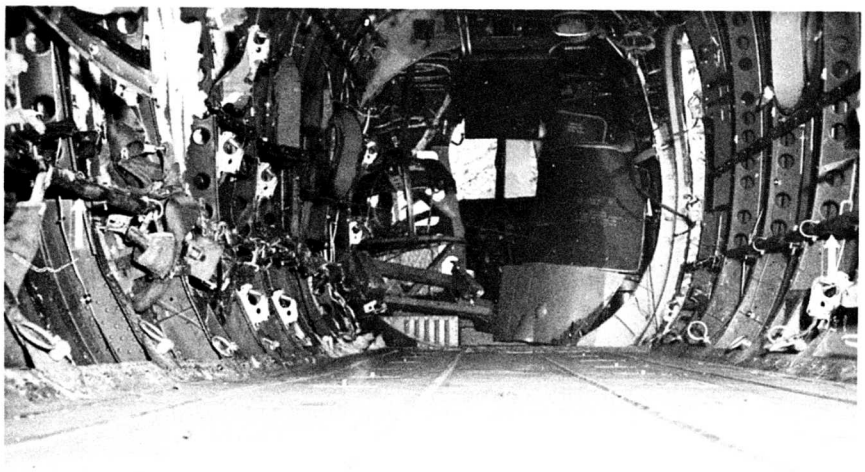


Figure 11. View looking forward to show intactness of the helicopter. The floor showed no distortion. Arrows denote the rear-seat supporting structure.

The nose-low attitude of the aircraft on impact concentrated the main impact force at the left side of the cockpit. (There was no evidence of any forward deceleration in this impact.) External damage in the cockpit area included disintegration of the left half of the nose bubble, broken left windshield, and partial collapse of the vertical structural member.

In addition, the left cabin door was torn free, the left rear landing gear was bent and the drag strut broken and pushed into the engine area. Some distortion occurred on the left side of the engine area and fire wall. The fuselage skin aft of the forward rotor along the left side was wrinkled as the nose struck the ground (Figure 9). The tail assembly was damaged by sliding down the 40 foot trees (Figure 6).

INTERIOR

1. COCKPIT—Minor damage was sustained by the supporting structures of the cockpit; however, there was insufficient distortion of any of these members to cause impingement upon or into the occupants.

The most significant damage in the entire cockpit area was the failure of both pilot and copilot's seats during the lateral deceleration. Both seat supporting structures failed, permitting the pilot and the copilot to be thrown violently to the left. This movement caused the copilot to strike the left vertical support member, as shown in posed photograph (Figure 12). Figures 13 and 14 show the seat supporting structures and the failure points.

The complete failure of the seats from their supporting assemblies rendered the shoulder harnesses and the seat belts of both the pilot and the copilot ineffective. Figures 15 and 16 show the inertia reels, which are of the impact type, mounted on the seat backs. The copilot's inertia reel did not lock during this crash, apparently as a result of predominant side loads. Had the inertia reels been anchored to primary structures of the aircraft, the occupants would have been partially restrained by the shoulder harnesses even though the seats failed. An additional item of interest is the excessive width of the shoulder harness guide at the top of the seat (Fig. 17). Under seat load conditions as experienced in this accident, the occupant is permitted to move laterally several inches before the harness becomes effective.

Figure 12. Posed photograph shows position of the copilot when the helicopter came to rest. Note the position of the copilot's head against the cockpit support member.

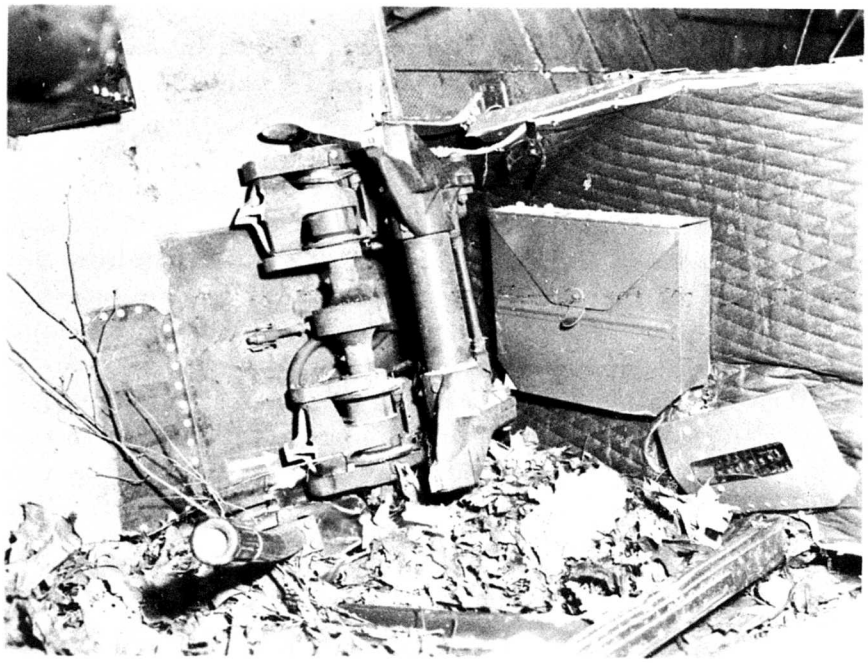


Figure 13. The four seat support members (arrows) of the copilot's seat failed due to side load.

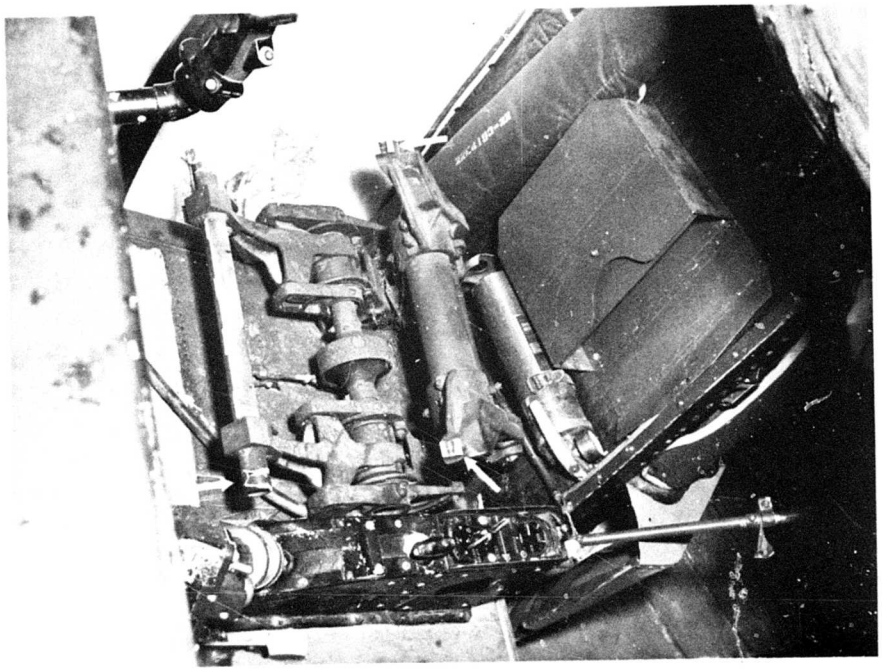


Figure 14. The four arrows in the photo depict points of failure of the seat support members on the pilot's seat. The failures are almost identical with those of the copilot's seat.

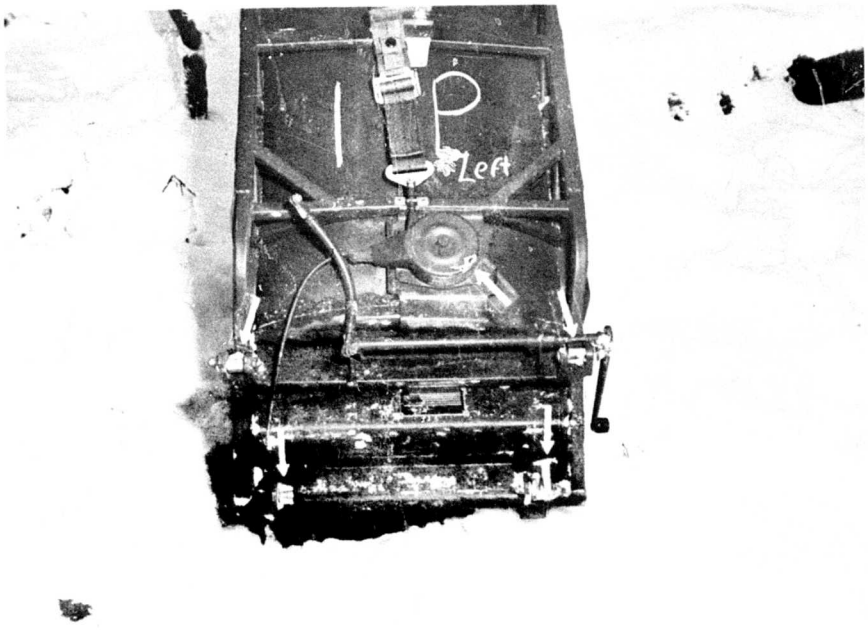


Figure 15. A rear view of the copilot's seat. Arrows depict points of failure of the support members. Location of inertia reel mounted on the seat back is also indicated.

Figure 16. The failures of the seat-support members are depicted by the arrows. The inertia reel locked but due to the seat failure the shoulder harness was ineffective. There are indications that the seat structure offered the pilot some protection when he struck the console.

Figure 17. The wide shoulder harness guide at the top of the seat permits considerable lateral movement under side load conditions.

In addition to the seat failures, the instructor's left pedal was pushed inward and rearward; the right pedal was distorted; the copilot's cyclic control stick was broken; his collective pitch control was bent inward against the stick, and the pilot's collective pitch control was broken to the left (Figures 18 and 19).

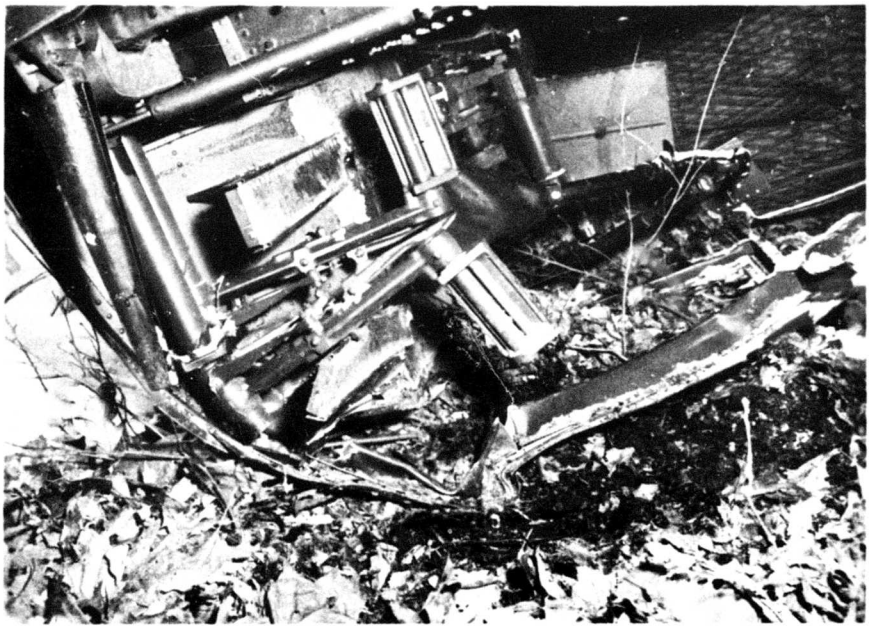


Figure 18. Front view of the left cockpit area after removal of the copilot's seat.

Figure 19. The arrow denotes the point where the copilot's helmet contacted the support member. The copilot's seat is visible in the lower right.

2. MAIN CABIN—The basic structure in the main cabin area remained completely intact, as illustrated in Figure 20. In spite of the intact condition of this basic structure (indicating moderate crash forces), a number of the seats and seat belts failed, resulting in numerous injuries to the occupants of the main cabin. Figure 21 is a chart showing the seating arrangement of all occupants at the time of the accident, seat and seat belt damage, and a summary of the injuries sustained by each occupant.

An examination of the chart reveals that six seats failed, two on the left, or low side, of the aircraft and four on the right, or high side. The two failures on the left side of the cabin consisted of failure of the vertical seat supports. These failures probably occurred when the occupants from the right side were thrown against them. The four seat failures on the right side resulted mainly from a number of breaks in the rear seat supporting structure. These failures occurred at the points where the seat supporting structure is drilled to accommodate either a seat belt

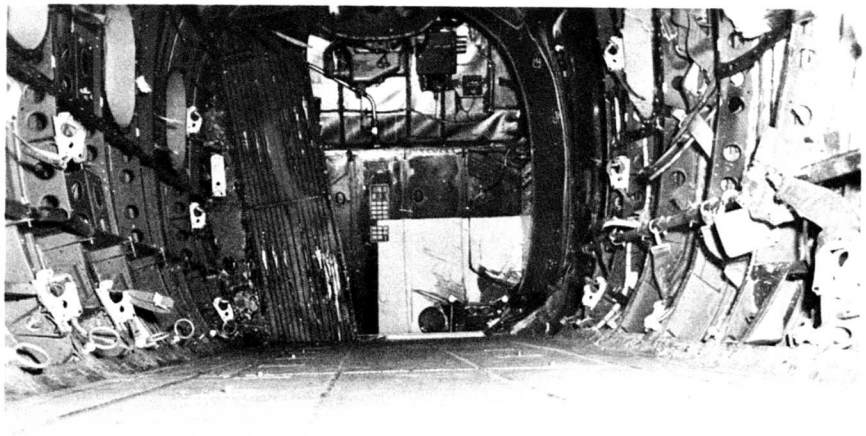


Figure 20. View looking aft at floor level. Note the tie-down rings (floor level) designed for cargo. Each ring is tied into primary structure and stressed for 2, 000 lb. Similar tie-downs for the safety belts would prevent some of the failures that occurred in this accident.

FIGURE 21. SEATING ARRANGEMENT - SEAT AND SEAT BELT
(OCCUPANTS' WEIGHTS NOTED ON THEIR

NON DANGEROUS

1. Abrasions and bruises left forehead
2. Fracture, simple, greater tuberosity of left humerus
3. Abrasions, left arm
4. Abrasions, right leg

MINOR

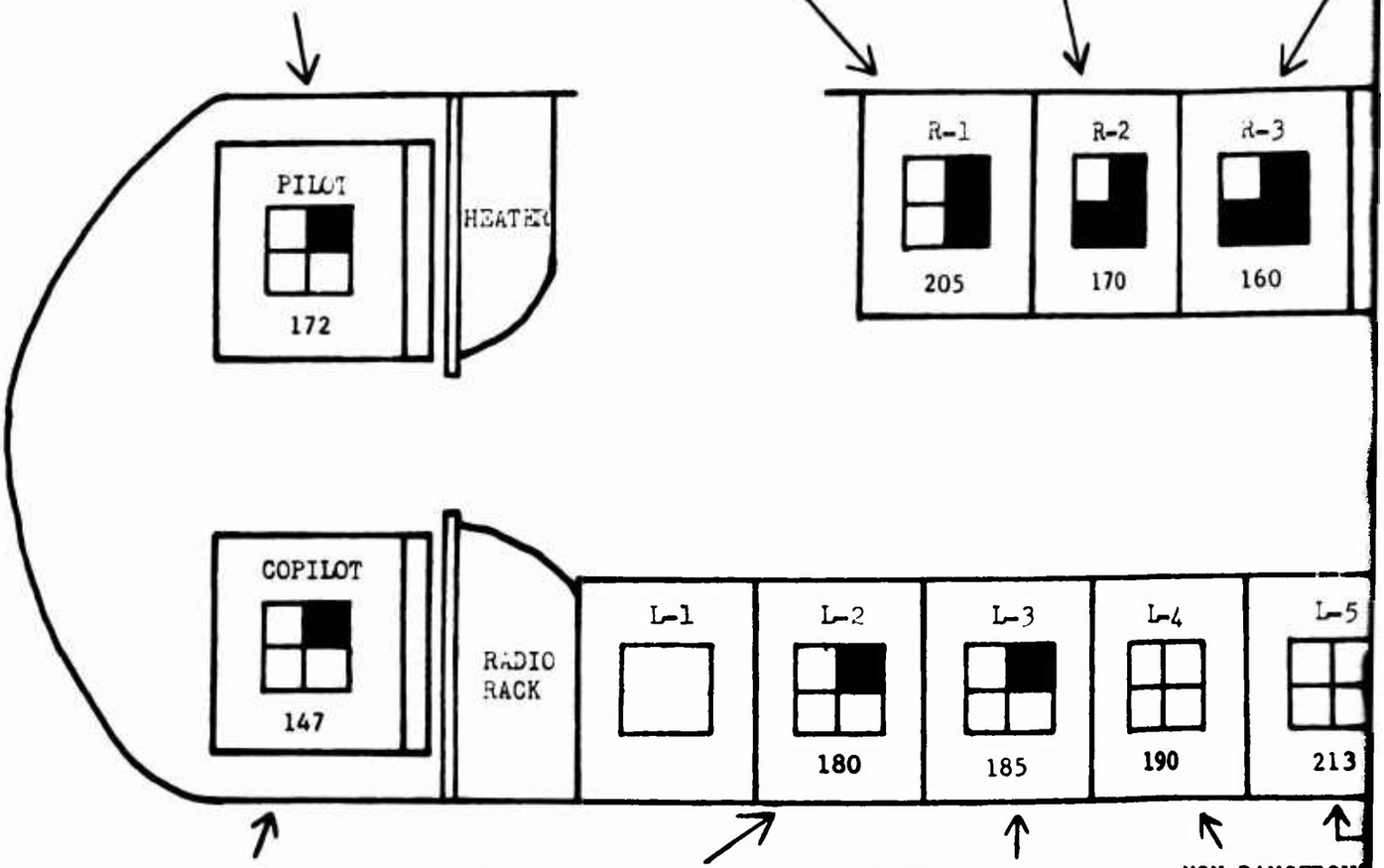
1. Bruised forehead
2. Bruises, right arm
3. Bruises, right leg

NON DANGEROUS

1. Concussion
2. Laceration, parietal scalp
3. Facial lacerations
4. Fracture, simple, mid shaft tibia, fibula left

NON DANGE

1. Concu moder about
2. Lacer scalp each



FATAL

1. Concussion
2. Intercranial hemorrhage right fronto-temporal region
3. Laceration left fronto-temporal scalp
4. Lacerations flexor-ulnar surface, left wrist.

MINOR

1. Laceration, irregular, left achilles area

NON DANGEROUS

1. Concussion
2. 3 simple fractures of mandible
3. Small lacerations, ½ inch each, scalp

NON DANGEROU

1. Concussi
2. Fracture nasal bo
3. Jagged l nose
4. Fracture
5. Bruises.

VACANT | OCCUPIED - NO FAILURE | SEAT FAILED | SEAT BELT

SEAT AND SEAT BELT DAMAGE - INJURY CHART
HTS NOTED ON THEIR RESPECTIVE SEATS)

NON DANGEROUS

parietal

rations
imple,
ibia,

1. Concussion, mild to moderate; amnesia about 30 minutes
2. Lacerations occipital scalp, 2 x $\frac{1}{4}$ inches each

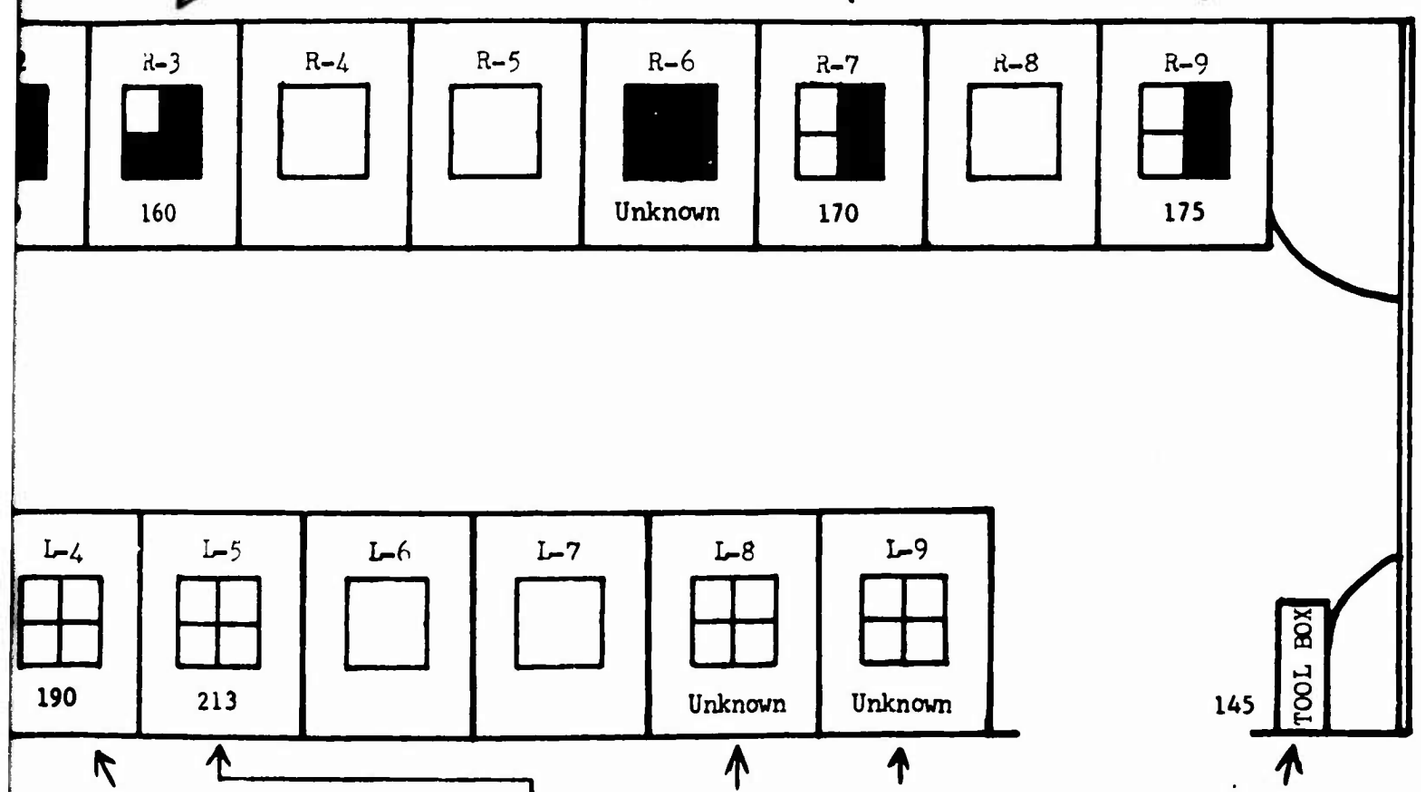
NO INJURY

MINOR

1. Laceration parietal scalp
2. Bruise, left gastrocnemius area (calf)

MINOR

1. Low back strain



NON DANGEROUS

1. Concussion
2. Fracture, compound, nasal bones
3. Jagged laceration, nose
4. Fractured tooth
5. Bruises, upper torso

NON DANGEROUS

1. Concussion

NO INJURY

NO INJURY

NON DANGEROUS

Crew chief seated on loose tool box. Safety belt and hard hat were not utilized.

1. Concussion
2. Fracture, simple, closed left humerus

SEAT FAILED
BELT ANCHORAGE FAILED

BELT WEBBING FAILED
BELT ANCHORAGE FAILED

SEAT FAILED
BELT WEBBING FAILED
BELT ANCHORAGE FAILED

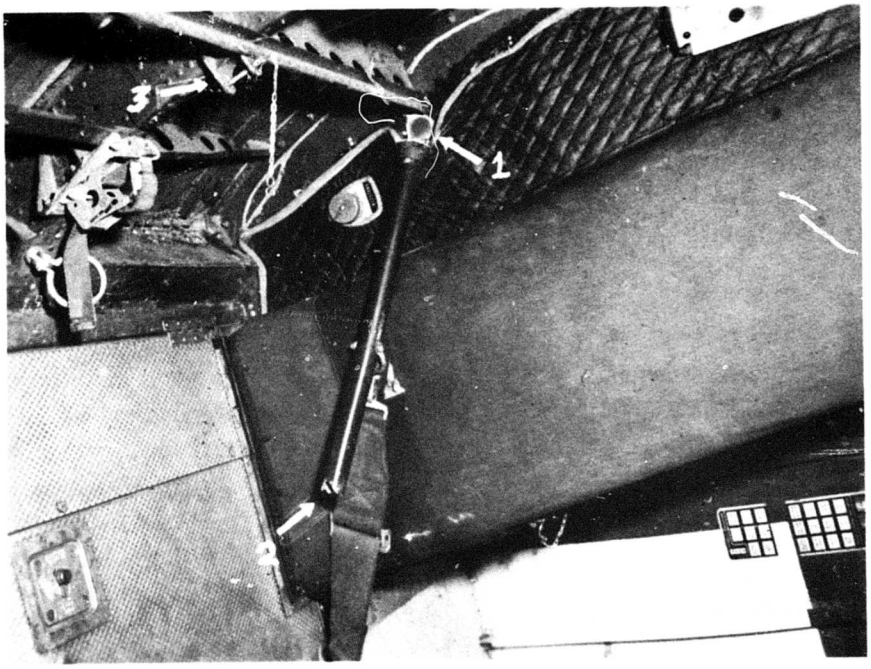


Figure 22. The rear support member, in addition to failing, was nearly torn free from the rear bulkhead (arrow 1). Arrow 2 shows a failure in the rear support member which is normally attached at arrow 3.

attachment (D-ring) or a wall anchorage. The drill holes are located approximately every 18 inches along the length of the support member. In addition to the rear seat support member failures, there were also numerous vertical and diagonal support member failures of the seats on the right, or high side. Illustrations of seat failures are contained in Figures 22 through 27.

Further examination of Figure 21 also reveals six seat belt anchorage failures on the right, or high side, of the cabin. These failures also resulted from failure of the rear seat supporting member. The safety belts are attached to this rear seat supporting member in the following manner: A D-ring is attached to the rear seat support member through one of the drill holes cited above. The safety belts are then snapped to this D-ring. Two safety belts are frequently attached on one D-ring; that is, the left safety belt of one occupant and the right safety belt for another occupant are both attached to the same ring. This is illustrated by Arrow 5 in Figure 27. A single failure, under such conditions, permits two occupants to be thrown free in the cabin area. Attachment of the seat belts in this manner, combined with the forces generated by the occupant in the seat, contributed to the numerous failures of the rear seat supporting structure in the accident.

Figure 21 also reveals that two seat belt webbing failures occurred during the accident (Seats R-2 and R-3.) These failures are illustrated in Figures 28 and 29. The failures were probably caused by the occupants wearing the seat belts loosely fastened, resulting in amplification of the impact forces or jolt loads on the belts.

In summary, the seat failures in the main cabin of the aircraft were caused by a combination of the triple seat arrangement carrying the weight of three persons; the attachment of seat belt anchorages to the rear longitudinal seat support member; attachment of two seat belts to one D-ring; and loosely worn seat belts. This situation is one which has resulted in numerous injuries to personnel involved in Army aircraft accidents in which this type seating arrangement has been utilized.

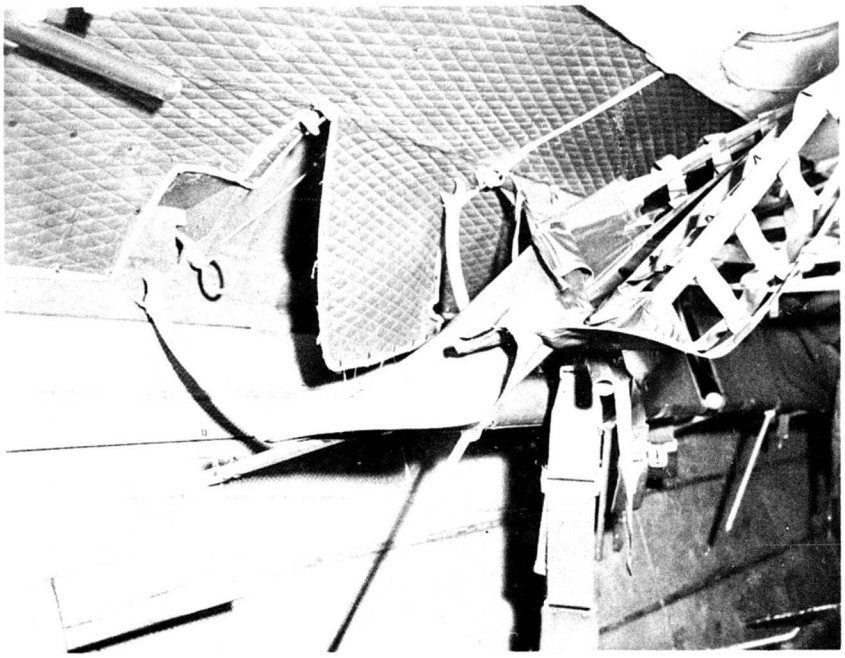


Figure 23. The first group of seats (forward) on the right or "high" side. The rear support failure plus belt and tie-down failures allowed the occupants to become projectiles.

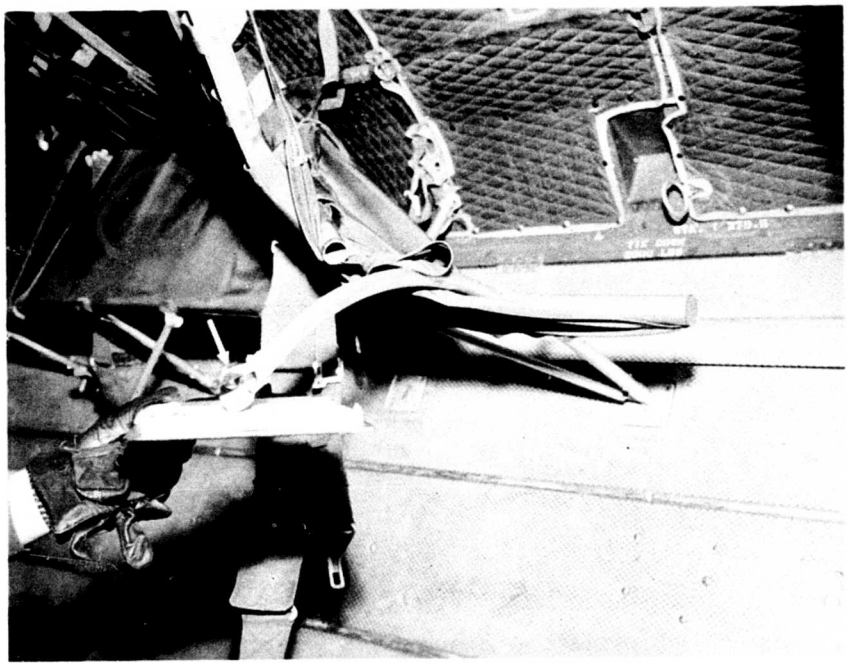


Figure 24. The seat spreader (arrow) was torn from the rear support member.

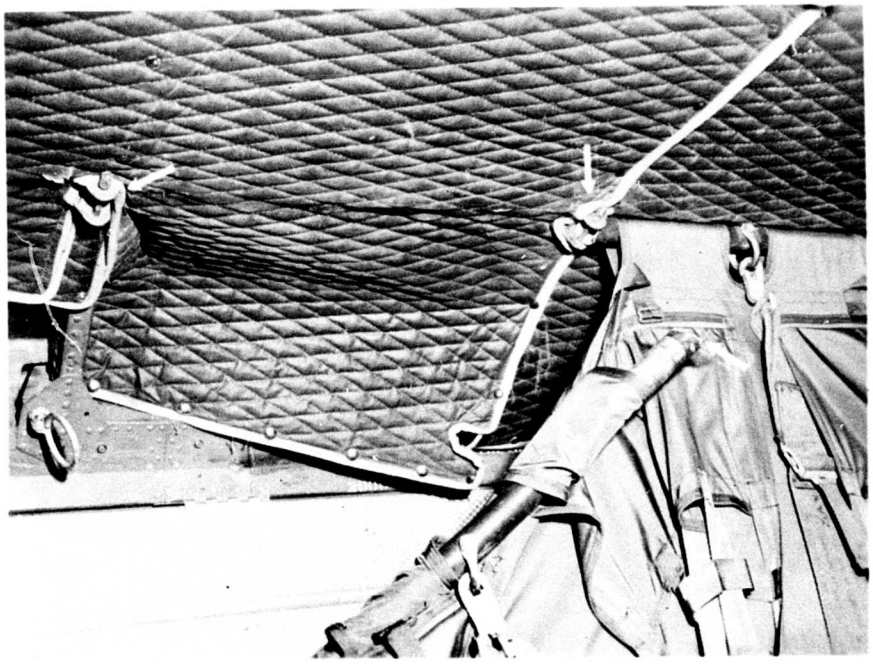


Figure 25. Rear longitudinal support failures (arrows). Snap load conditions frequently tear the support member from its attachment points.

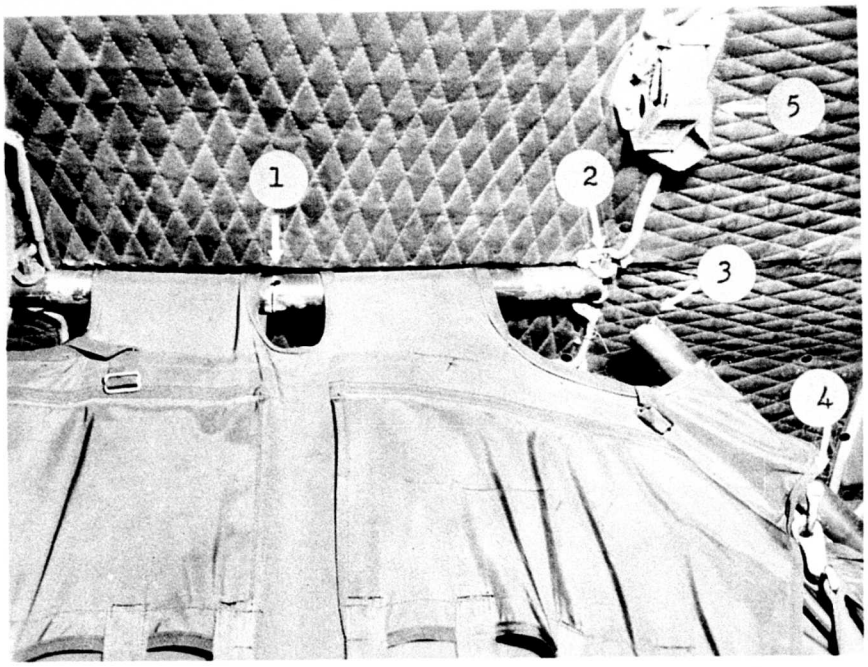


Figure 26. Arrow 1 depicts the manner in which some of the "D" rings failed. Arrows 2 and 3 depict typical seat support failures. This occupant's safety belt, arrow 4, became ineffective due to failure of the rear support member. A litter bracket, arrow 5, which is located directly behind an occupant's back, is a potential injury-producing item.

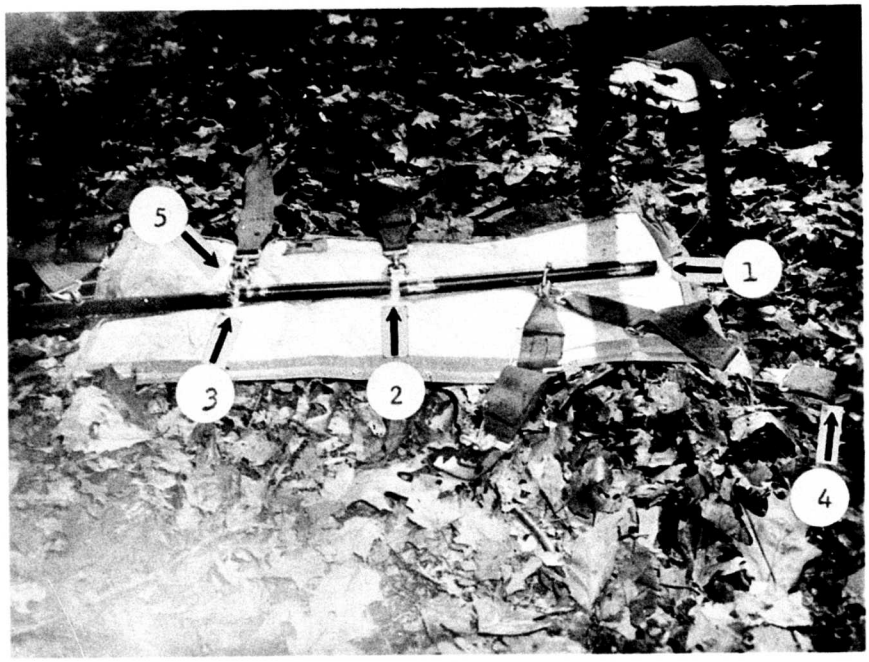


Figure 27. View showing the failures of the rear-seat supporting structure (arrows 1, 2 and 3) due to the seat belt anchorages' tearing free. Notice the failure of the seat belt webbing (arrow 4). Arrow 5 indicates the manner in which two belts are anchored to the same "D" ring.

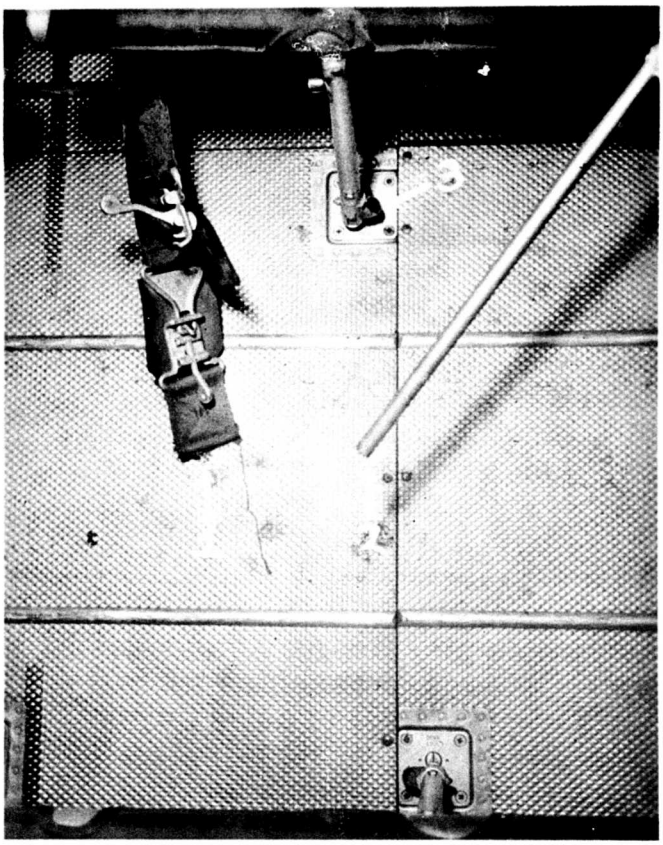


Figure 28. Seat belt webbing failed at the aft end of the overlap (arrow 1). The diagonal seat support (arrow 2) was pulled out of its attachment (arrow 3). It should also be noted that the vertical seat support is straddled by the occupant and usually fails under vertical loads leaving exposed jagged ends, which are a potential cause of injury.

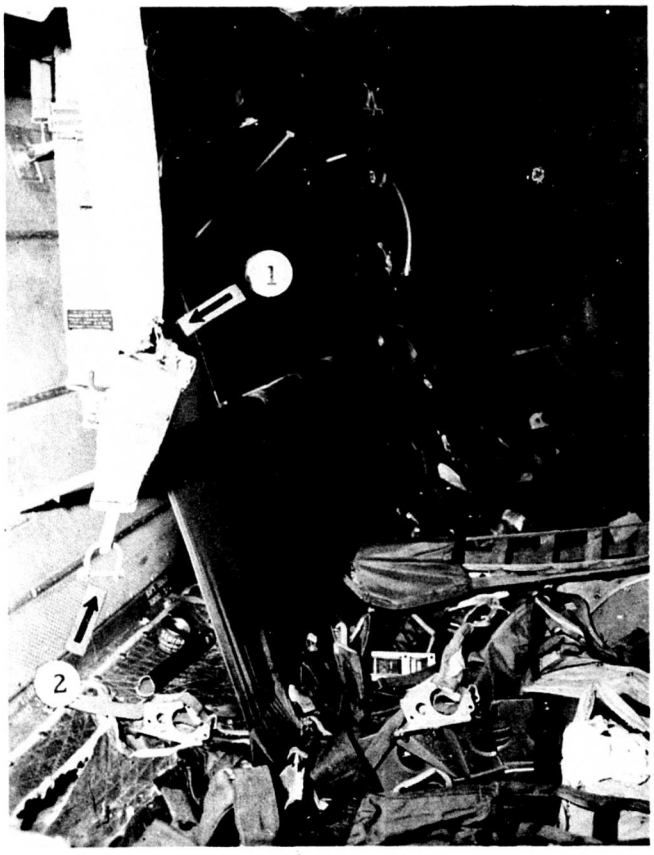


Figure 29. Particular attention should be paid to arrows 1 and 2. Arrow 1 indicates webbing failures. Arrow 2 shows the "D" ring that was pulled out of the rear-seat support structure. This was actually a double failure at a single restraint attachment point.

CRASH INJURY ANALYSIS

GENERAL

The direction of the principal crash force in this accident was from the left and parallel to the lateral axis of the aircraft. This imposed a side load on the cockpit occupants, who were facing forward, and a fore and aft load on the cabin occupants, who were facing the center aisle.

Although the crash force was relatively moderate (estimated at 8 to 12 Gs) as indicated by the intact condition of the fuselage, 12 of the 15 occupants received injuries ranging from fatal to minor. All severe injuries occurred in the cockpit and front half of the cabin, as indicated in Figure 21, with the exception of the crew chief, who was seated on a loose tool box in the rear of the cabin. This injury pattern is generally in accordance with the theory that the magnitude of the crash force transmitted to the occupants decreases with an increase in distance from the main impact area (in this case, the left side of the forward fuselage). It is also possible that the collapse of the left landing gear and the left hori-

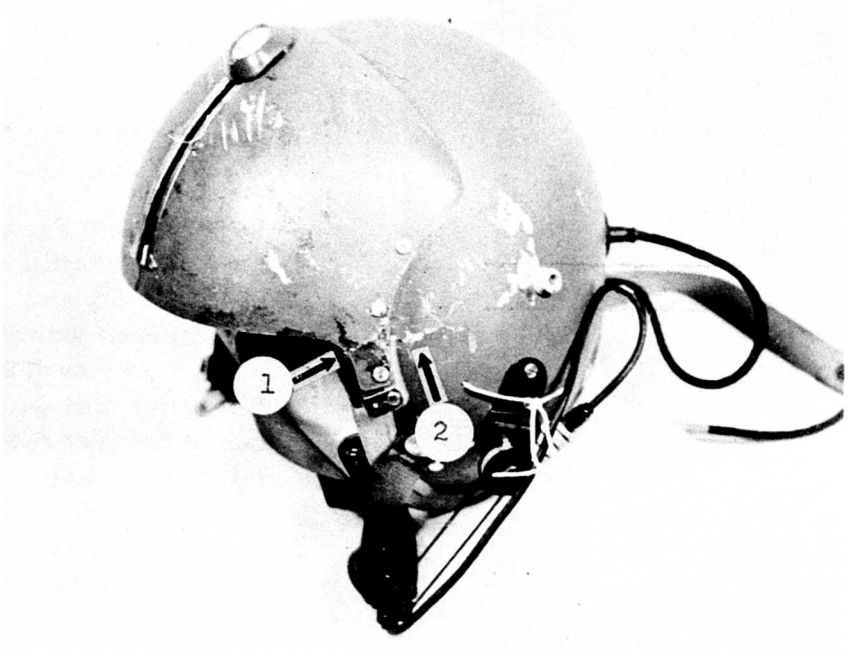


Figure 30. Impact marks were found on the left temple area and also on the visor housing. The arrows point out the area of impact.

zontal stabilizer provided a more gradual deceleration for the center and aft portion of the fuselage.

COCKPIT

1. COPILOT—At impact, both cockpit seats failed and permitted the seats and their occupants to be thrown violently to the left. The copilot, who occupied the left cockpit seat, nearest the point of impact, struck the left vertical cockpit support member with the left side of his helmet, just above the keeper on the eye shield housing. The impact marks on the helmet are indicated in Figures 30 and 31. A detailed examination of the helmet revealed that the blow was absorbed by the shield housing at the point indicated by Arrow 1 in Figure 30. The shield housing broke at this point, permitting inward bending of the outer shell, resulting in a fracture approximately one inch in length at the point indicated by Arrow 2. Removal and examination of the inner liner revealed that the total force was absorbed over an area of approximately 2 to 3 square inches.

The forces transmitted through the helmet produced a fatal

Figure 31. Front view of the copilot's helmet. The arrow denotes the impact area.

lesion (an inter-cerebral hematoma in the right fronto-temporal region). This brain injury was of the contrecoup type, the result of transmission of impact force from the point of impact to the opposite side of the brain. The copilot was hospitalized, underwent neuro-surgery, suffered a cardiac arrest and died about 20 hours after the accident. In addition to the brain injury, the copilot also sustained a laceration to the left wrist, apparently as his wrist struck the window handles.

The fatal injury suffered by the copilot resulted from a combination of the following factors: (1) failure of the seat-supporting structure; (2) attachment of his restraint system (seat belt and shoulder harness) to the seat itself, rendering them ineffective when the seat failed; (3) exposed vertical support member within striking range of his head; (4) concentration of the force of the blow in a very small area of the crash helmet. It is believed that elimination of any one of the above factors would have reduced the severity of the injury and, probably, prevented the fatality.

2. PILOT—The pilot occupied the right seat and was also thrown to the left when his seat support structure failed in a manner almost identical with that of the copilot's seat. In addition to general abrasions, he suffered a fracture of the upper left arm (greater tuberosity). This injury was probably sustained when the pilot struck the copilot's seat.

As in the case of the copilot, the injuries sustained by the pilot resulted from failure of the seat supporting structure and the ineffectiveness of his restraint system. Had his shoulder harness and seat belt been attached to basic airframe structure, the injuries would probably have been reduced to minor or none.

CABIN

The six passengers sitting on the right (high) side of the cabin all experienced seat and/or seat belt failure. This allowed them to come into forcible contact with their environment, including other passengers. The unpredictable kinematic behavior of the occupants under such circumstances makes it impossible to accurately correlate the injuries with their causative factors. The site and frequency

of injuries sustained by the 10 cabin occupants is as follows:

HEAD		UPPER EXTREMITY	
Concussion	6	Fractures	1
Facial fractures	2	Surface injuries	1
Surface injuries	6		
UPPER TORSO		**LOWER EXTREMITY**	
Surface injuries	1	Fractures	1
		Surface injuries	1
LOWER TORSO			
Back strain	1		

The predominance of head injuries (see table above) may be considered typical in aircraft accidents, since the head is the most vulnerable area of an unrestrained body. The two persons who sustained facial fractures (jaw and nose) were sitting on the left (low) side of the cabin. Since they were subject to aft deceleration, it is possible that the rifles which they held between their legs caused the injuries. It is also possible that these injuries are related to the missilelike behavior of the equipment and occupants on the right (high) side of the cabin.

The crew chief, who was seated on a loose tool box near the rear exit, facing forward, suffered a mild concussion and a fractured left upper arm.

Injury potential of the litter brackets—located directly behind the backs of seat occupants—was noted during the investigation. Although no injuries in this accident are traceable to such brackets, a moderate impact force which would throw a seat occupant against one of these litter brackets could cause dangerous back or upper torso injury. It is recommended that these brackets be hinged (as is presently done in the H-19) and stowed out of the way when not in use.

Summarizing, it can be stated that failure of the occupant tie-down chain was the predominant injury causation factor in this accident.

CONCLUSIONS

After a careful examination and analysis of the wreckage and injuries sustained by the occupants, it is concluded that:

1. The H-21 basic airframe structure is relatively crashworthy and provides a substantial shell or protective capsule for the occupants when subjected to moderate crash forces, as experienced in this accident.

2. The seats and restraint systems for the occupants of this aircraft are structurally inadequate when subjected to even moderate crash forces.

3. The injuries sustained by the occupants of the aircraft involved in this accident are attributable primarily to factors within the control of aircraft designers and users.

4. The fatal injury sustained by the copilot could have been moderated or prevented by a more effective crash helmet.

RECOMMENDATIONS

Based upon the foregoing conclusions, it is recommended that:

1. The seat supporting structure of the pilot and copilot seats in the H-21 be re-designed to prevent failures due to lateral forces under survivable conditions. A more ductile material, which will absorb energy through progressive collapse, is suggested.

2. Inertia reels and seat belts for pilot and copilot be attached to basic aircraft structure.

3. Shoulder harness guides on the pilot and copilot seats be designed for narrowest possible width to prevent excessive lateral movement when side loads are applied.

4. Cockpit support members within striking range of either the pilot or copilot be padded with high energy absorption material, such as ensolite.

5. The three-man troop seat used in this aircraft be re-signed or a new design be developed which will prevent structural failures under survivable conditions.

6. Seat belts used for passenger restraint in the main cabin be attached to basic airframe structure or to the cargo tie-down rings.

7. A study be conducted on more suitable methods or devices for stowing rifles during flight.

8. Litter brackets be hinged and stowed out of the way when not in use (as is presently done in the H-19).

9. All occupants be instructed in the proper procedure for evacuating the aircraft in event of an accident.

10. A thorough investigation of the APH-5 helmet and its protective features be conducted.

APPENDIX I

CRASH FORCE ANALYSIS

Because of regulations prohibiting the cutting of trees on a Federal Reservation, it was impossible to bring in the equipment necessary to right the aircraft or to salvage the fuselage. It was, therefore, not possible to obtain measurements of the gouge marks or to inspect the damage inflicted to the exterior of the left side of the fuselage.

The problem is further complicated by the fact that the crash force was partly absorbed by the trees and the soft terrain which was covered with approximately two inches of decomposed leaves and branches. Additional force was absorbed by the left main landing gear and the progressive collapse of the left horizontal stabilizer and the left vertical fin. The aforementioned factors preclude an accurate crash force analysis of this accident.

After reviewing the overall condition of the fuselage structure, the damage sustained by the seats and seat belts, plus previous experience with this type of accident, it is estimated that the crash forces in this accident may have been in the order of 8 to 12 Gs.

APPENDIX II

MEDICAL SUMMARIES

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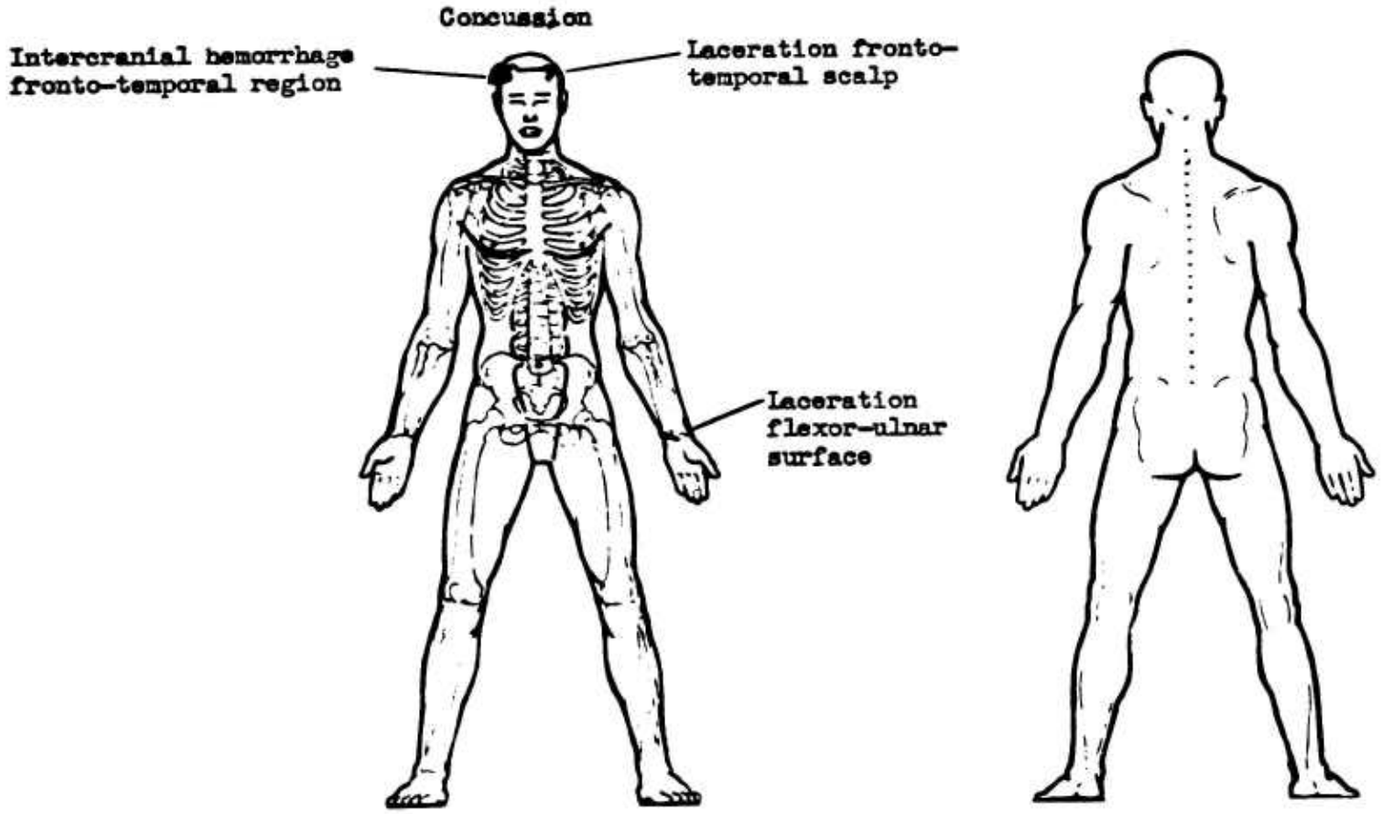
APPENDIX II - MEDICAL REPORT

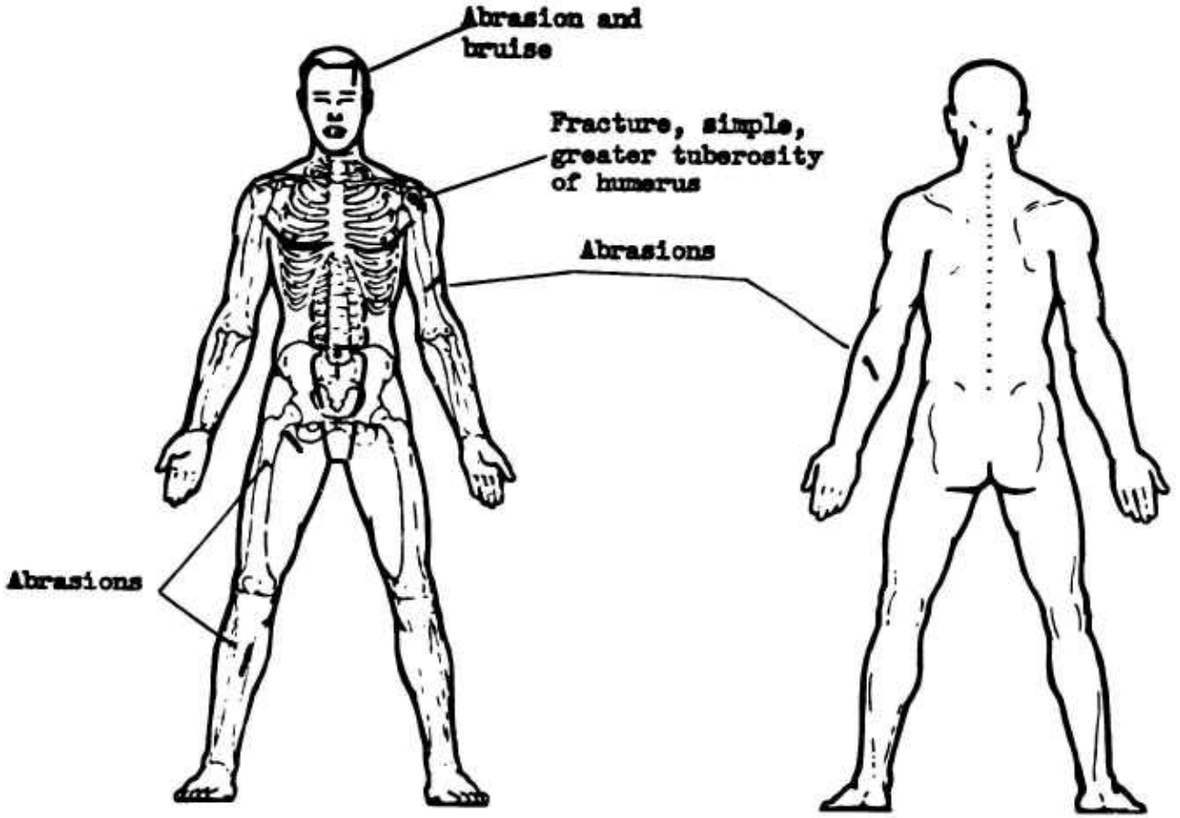
COPILOT



Age 29 Height 5' 9" Weight 147

APPENDIX II - MEDICAL REPORT

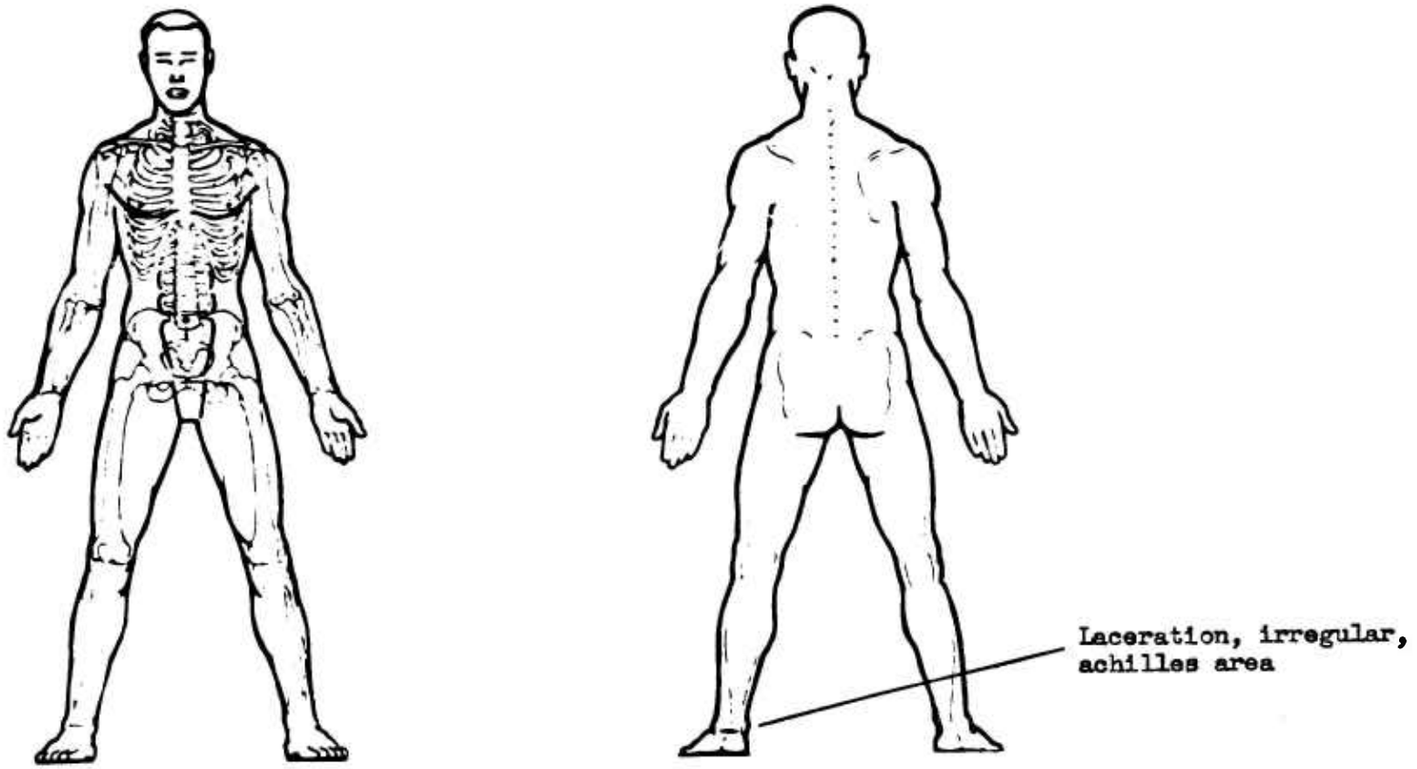
PILOT



Age 34 Height 6' 0" Weight 172

APPENDIX II - MEDICAL REPORT

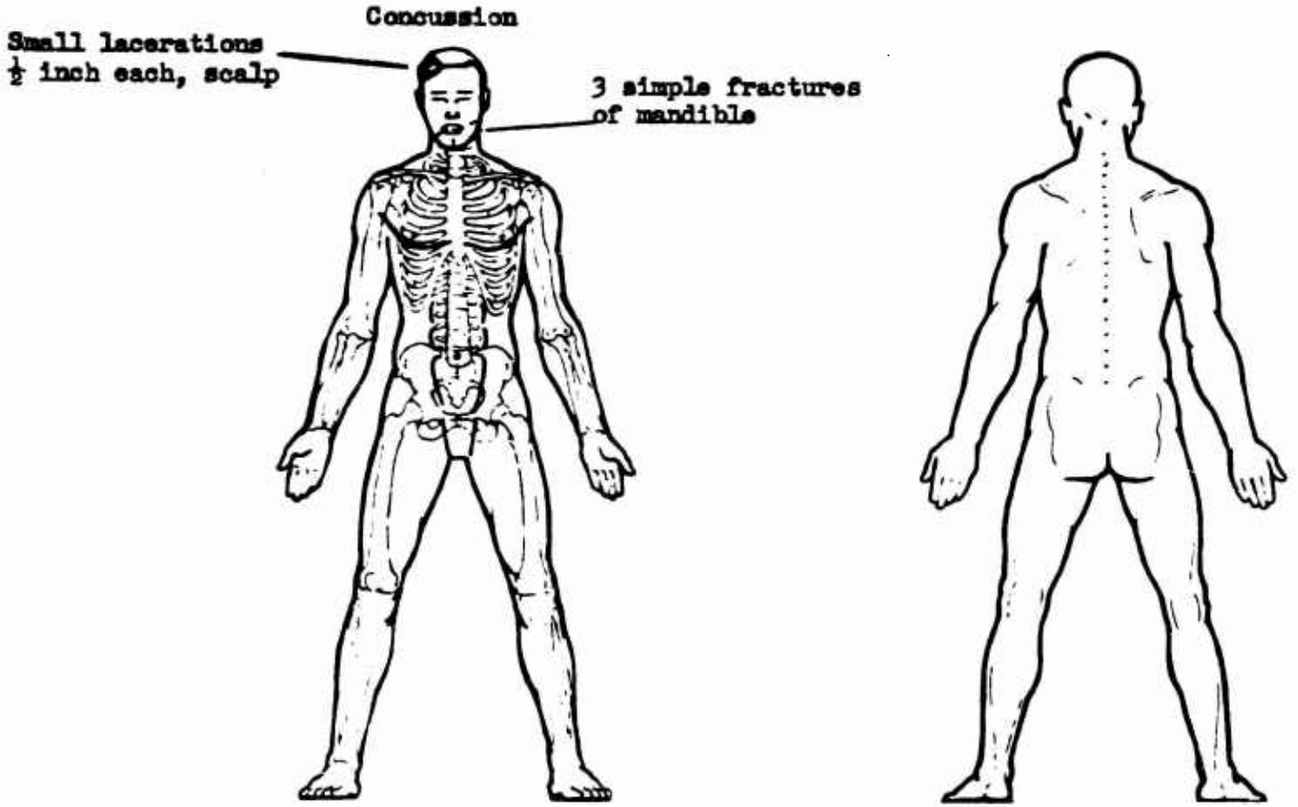
SEAT - L 2



Age 24 Height 5' 11" Weight 180

APPENDIX II - MEDICAL REPORT

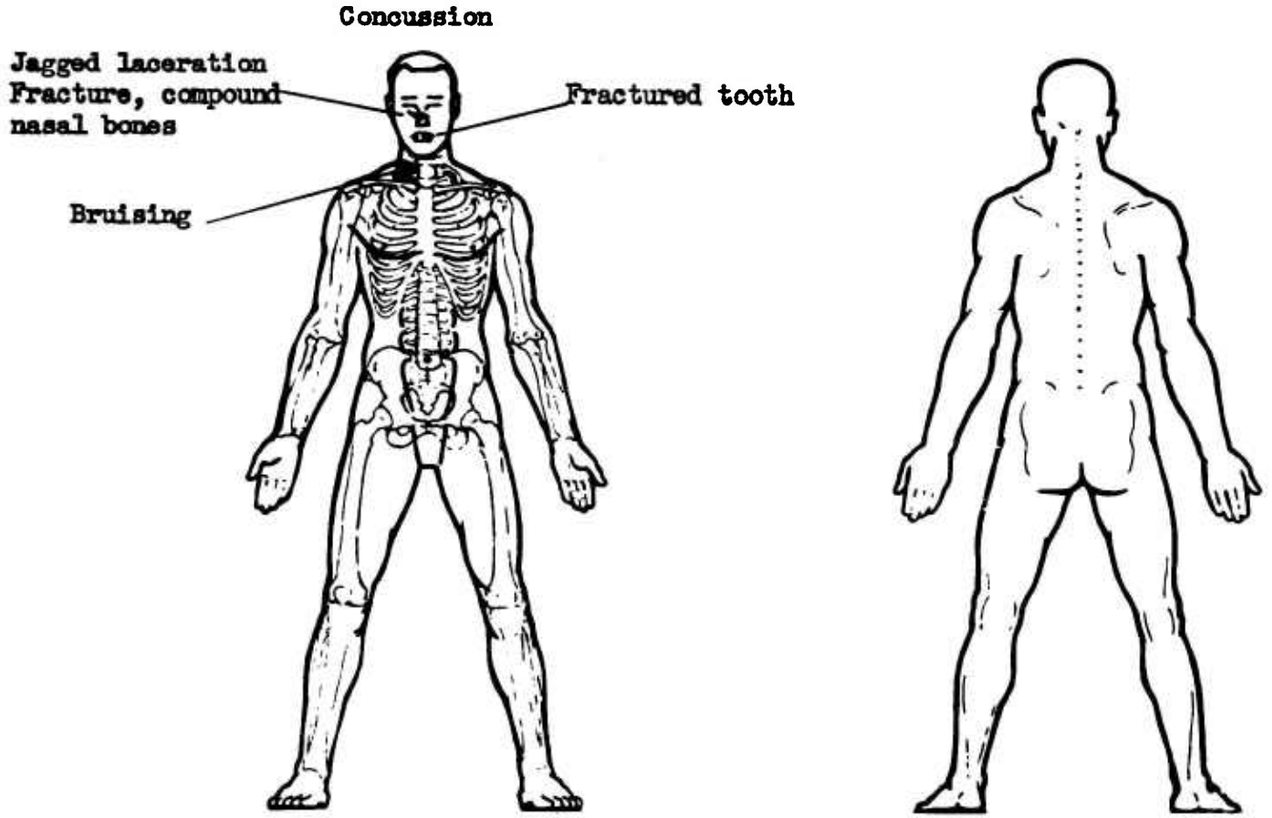
SEAT - L 3



Age 23 Height 5'6" Weight 185

APPENDIX II - MEDICAL REPORT

SEAT - L 4

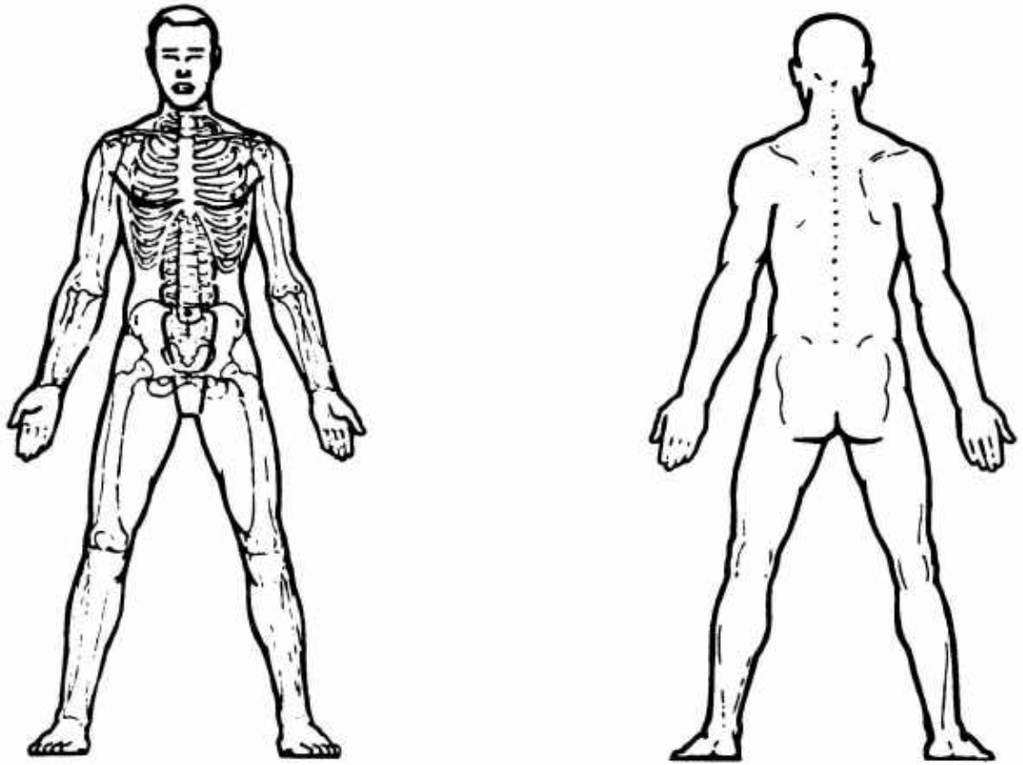


Age 19 Height 6'4" Weight 190

APPENDIX II - MEDICAL REPORT

SEAT - L 5

Concussion

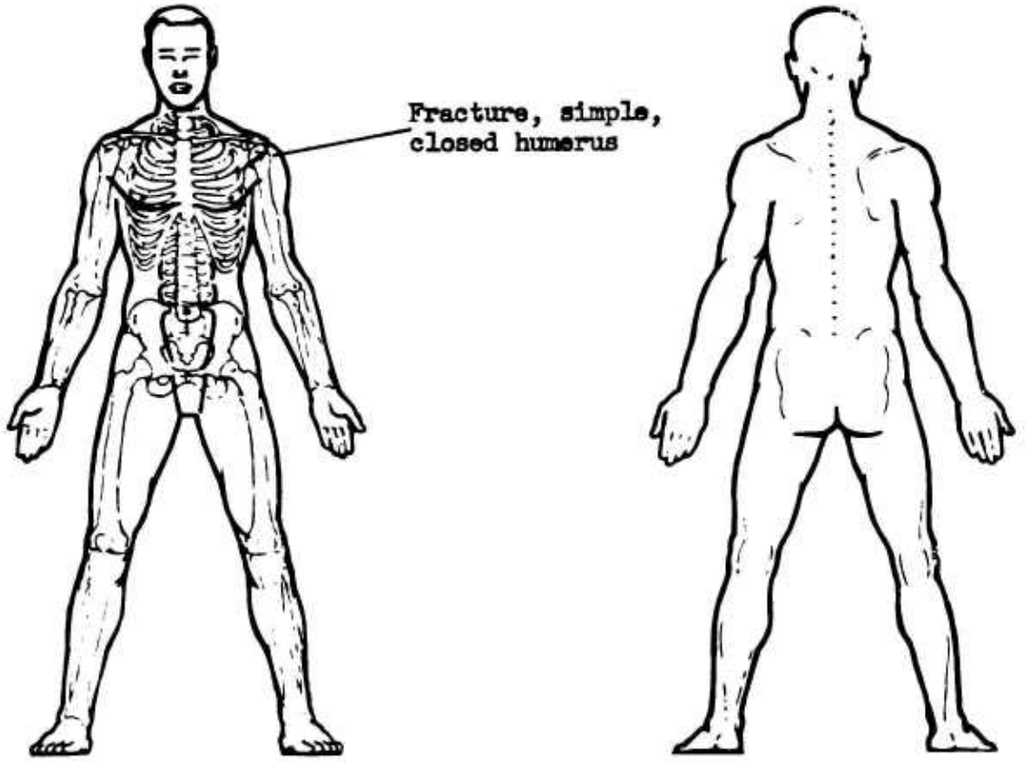


Age 30 Height 6' 2" Weight 213

APPENDIX II - MEDICAL REPORT

SEATED ON TOOL BOX

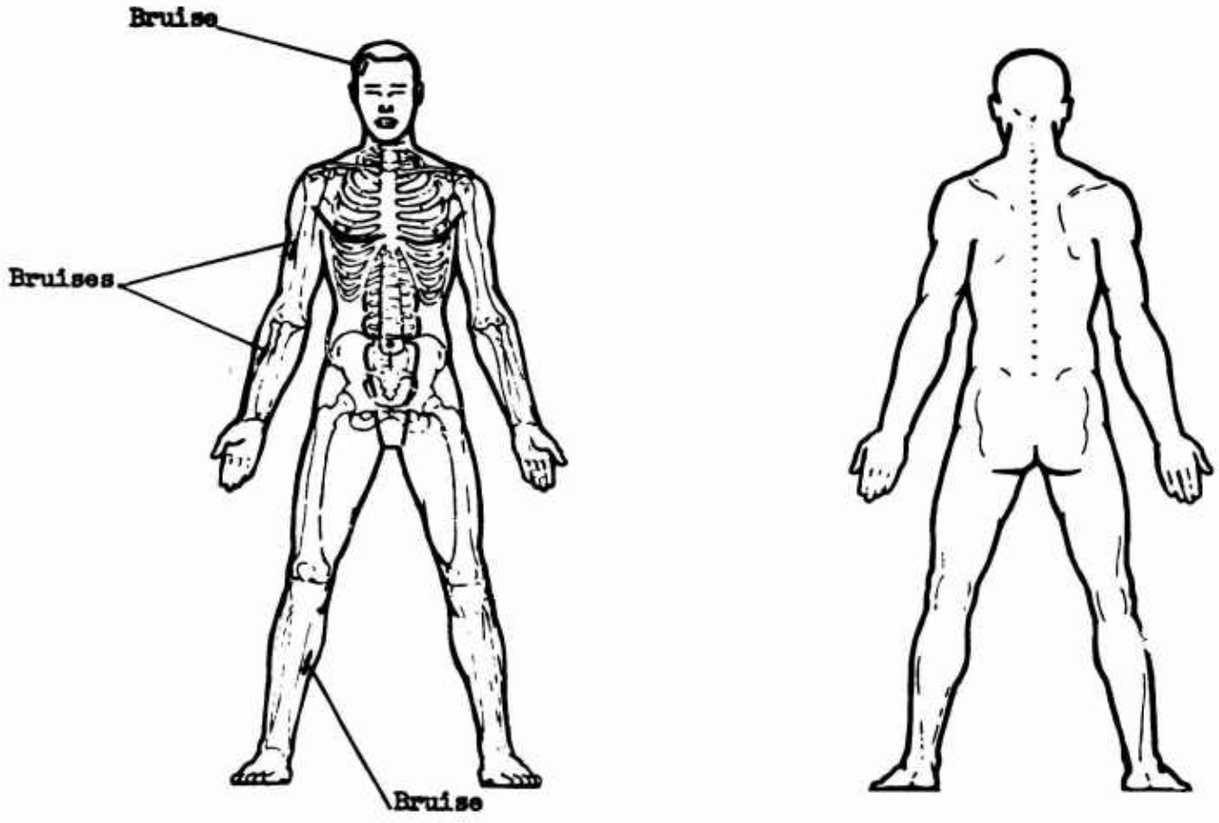
Concussion



Age 25 Height 5' 9" Weight 145

APPENDIX II - MEDICAL REPORT

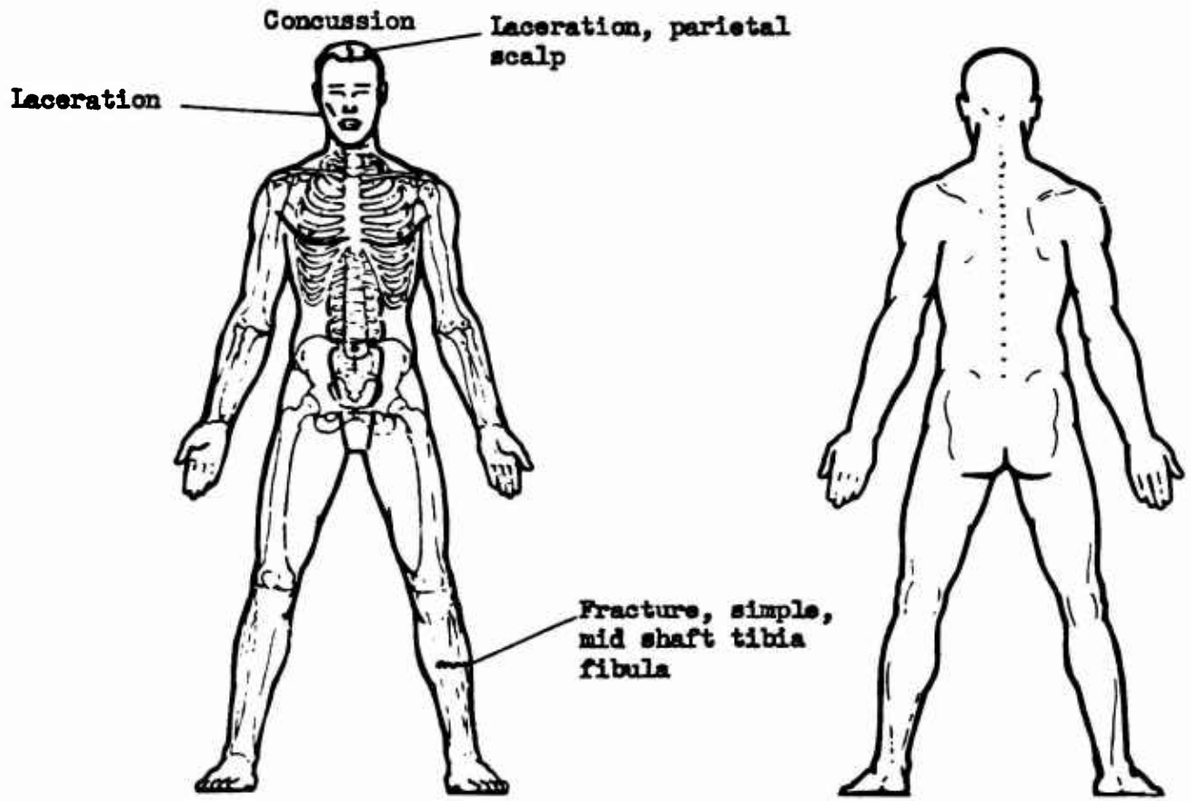
SEAT - R 1



Age 23 Height 6' 1" Weight 205

APPENDIX II - MEDICAL REPORT

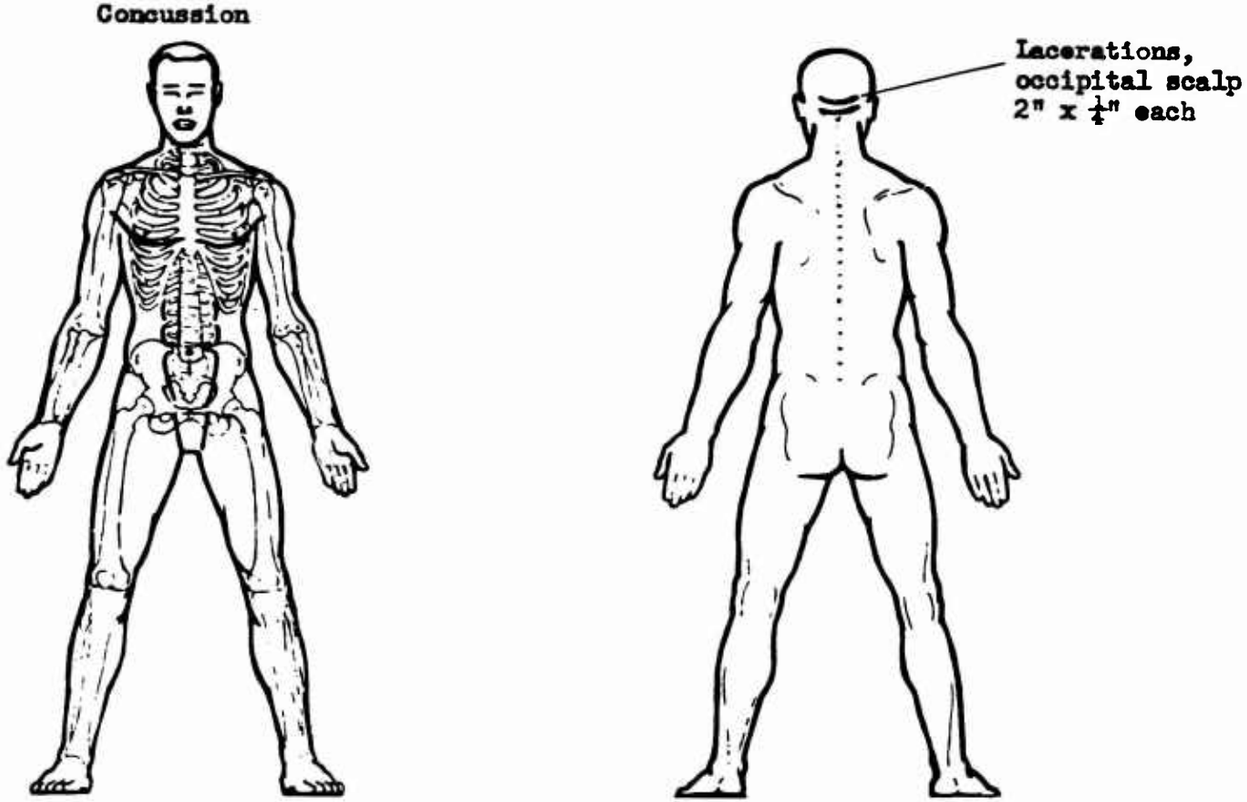
SEAT - R 2



Age 27 Height 6' 4" Weight 170

APPENDIX II - MEDICAL REPORT

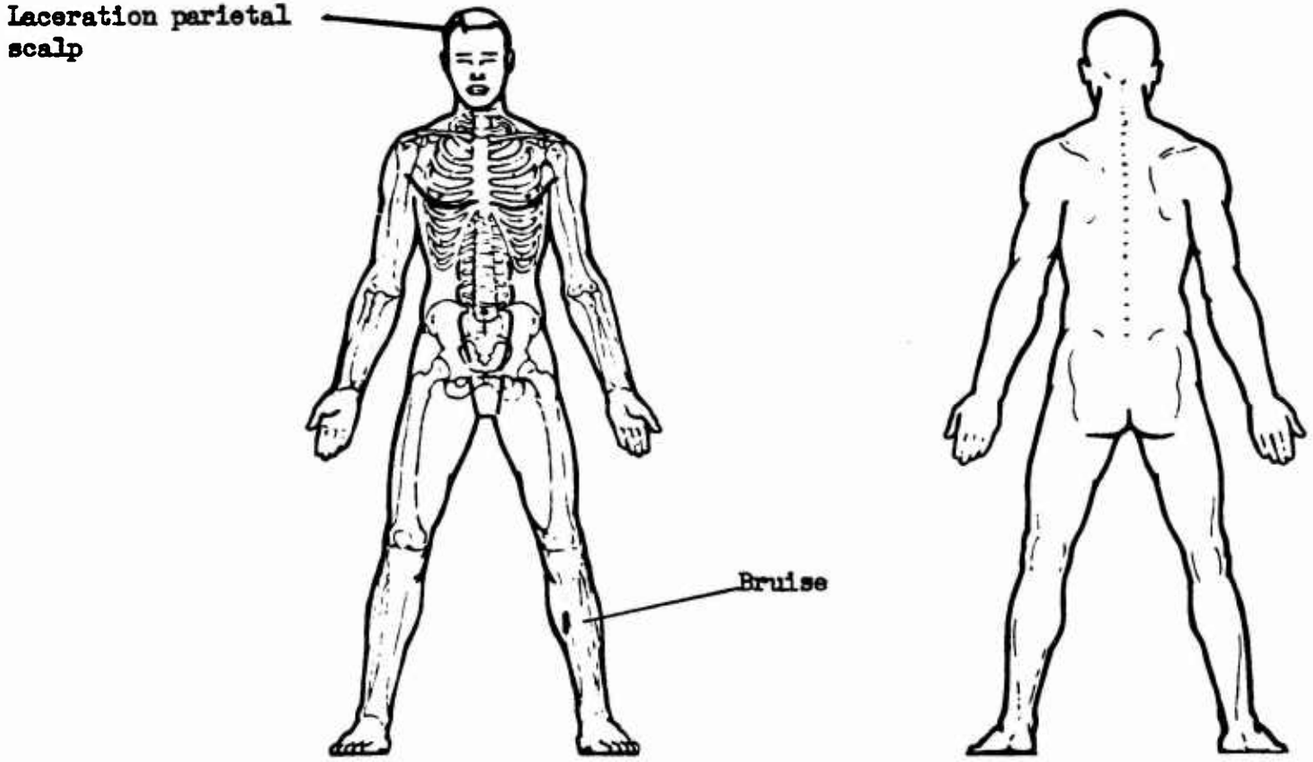
SEAT - R 3



Age 19 Height 5' 10" Weight 160

APPENDIX II - MEDICAL REPORT

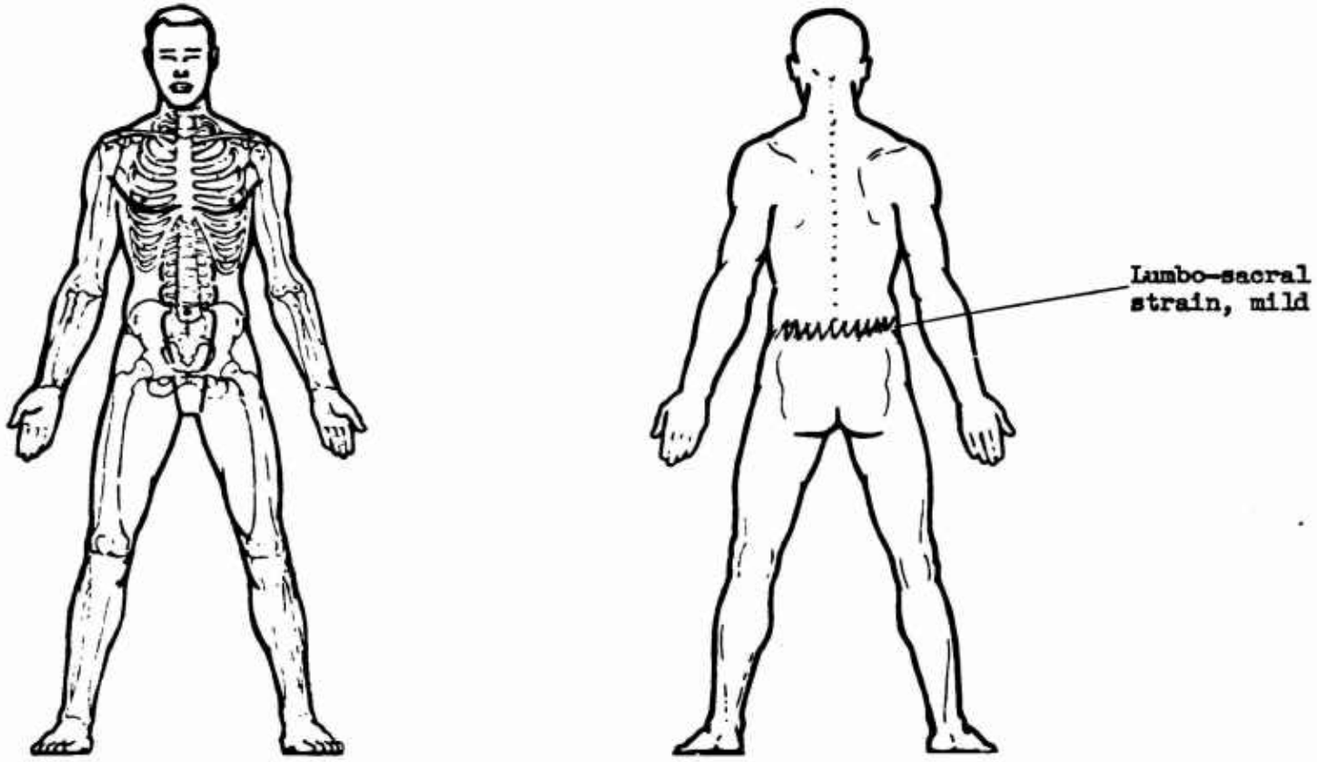
SEAT - R 7



Age 19 Height 5' 11" Weight 170

APPENDIX II - MEDICAL REPORT

SEAT - R 9



Age 21 Height 5'10" Weight 175

APPENDIX III

SCALE OF INJURY USED

BY AvCIR

SCALE OF INJURY* USED BY AvCIR

(Revised 4/60)

Degree of Injury	Classification and Description of Injury
Trivial or None	
Minor	"Minor" contusions, lacerations, abrasions in any area(s) of the body. Sprains, fractures, dislocations of fingers, toes, or nose. Dazed or slightly stunned. Mild concussion as evidenced by mild headache, with no loss of consciousness.
Moderate	"Moderate" contusions, lacerations, abrasions in any area(s) of the body. Sprains of the shoulders or principal articulations of the extremities. Uncomplicated, simple, or green-stick fractures of extremities, mandible and rib cage (excluding spine). Concussion as evidenced by loss of consciousness not exceeding 5 minutes, without evidence of other intracranial injury.
Severe (survival normally assured with prompt medical care and without complications)	Extensive lacerations without dangerous hemorrhage. Compound or comminuted fractures, or simple fractures with displacements. Dislocations of the arms, legs, shoulders or pelvisacral processes. Fractures of the facial bones excluding mandible. Severe sprains of the cervical spine. Fractures of transverse and/or spinous processes of the spine, without evidence of spinal cord damage. Fractures of vertebral bodies of the dorsal and/or lumbar spine, without evidence of spinal cord damage, or compression fractures of L-3-4-5 without evidence of damage to nervous system. Skull fracture without evidence of concussion or other intracranial injury. Concussion as evidenced by loss of consciousness of over 5 and up to 30 minutes, without evidence of other intracranial injury.
Serious (but survival probable)	Lacerations with dangerous hemorrhage. Fractures or dislocations of vertebral bodies of the cervical spine, without evidence of spinal cord damage. Compression fractures of vertebral bodies of dorsal spine and/or of L-1 and L-2 without evidence of spinal cord damage. Compression fractures of L-3-4-5 with

*Based on observations during first 48 hours after injury and previously normal life expectancy.

Degree of Injury	Classification and Description of Injury
Serious (cont'd)	evidence of damage to nervous system. Crushing or multiple fractures of the extremities and/or of the chest. Indication of moderate intrathoracic or intra-abdominal injury. Skull fracture with concussion as evidenced by loss of consciousness up to 30 minutes. Concussion as evidenced by loss of consciousness of over 30 minutes to 2 hours, without evidence of other intracranial injury.
Critical (survival uncertain or doubtful. Includes fatal termination beyond 24 hrs.)	Evidence of dangerous intrathoracic or intra-abdominal injury. Fractures or dislocations of vertebral bodies of cervical spine with evidence of cord damage. Compression fractures of vertebral bodies of dorsal spine, and/or L-1, L-2, with evidence of spinal cord damage. Skull fracture with concussion as evidenced by loss of consciousness beyond 30 minutes. Concussion as evidenced by loss of consciousness beyond 2 hours. Evidence of critical intracranial injury.
Fatal within 24 hrs. of accident	Fatal lesions in single region of the body, with or without other injuries classed as Severe.
Fatal within 24 hrs. of accident	Fatal lesions in single region of the body, with other injuries classed as Serious or Critical.
Fatal	Fatal lesions in two regions of the body, with or without other injuries elsewhere.
Fatal	Fatal lesions in three or more regions of the body - up to and including demolition of the body.

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