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REVIEW OF MAJOR INJURIES AND FATALITIES IN USAF EJECTIONS, 1981-1995

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KEYWORDS

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ABSTRACT

Our laboratories are examining injuries and deaths resulting from mechanical forces applied to aircrew members in the course of Department of Defense aviation operations.

In this paper we report only on bodily injuries sustained during ejection from US Air force, aircraft for the fiscal years 1981-1996, that is, major injuries and fatalities resulting directly from seat acceleration forces, from aerodynamic forces applied to crew members during escape through the effects of windblast and parachute opening shock; from direct contact: and from parachute landing injuries.

Such injuries occur typically to the head, neck, cervical spine, thorax, thoracolumbar spine, ribs, pelvis, and the upper and lower extremities. Injuries are usually caused by anomalies in the ejection sequence or by delaying ejection until too close to the ground. Conversely, a planned ejection in a modern ejection seat in controlled, low speed flight imposes forces well below injury thresholds. In the USAF, 10-50 aircrew eject yearly, with a decline since 1991. We conclude that the risk of fatality is 0-11% and of major injury is 2-25%. Both are remarkably low and decreasing in the later years of this study period. The absolute number of head, neck, and spine injuries is 0-10 yearly and similarly decreasing. The results of this study are intended to provide a basis for estimating potential savings in deaths, injuries, and costs expected from the development of improved protective measures.

INTRODUCTION

Developed to prevent injuries sustained by striking the aircraft during manual bail-out from W.W.II fighters, the primary purpose of an ejection seat is to lift the ejectee clear of the rudder and tailplane. Early ejection seats, powered by powder cartridges, imposed severe rates of acceleration. Similarly, prompt parachute opening near the ground required forward velocity at ejection of 50-120 knots. Contemporary ejection seats use staged rocket propulsion to limit spinal loads, thrust vectoring and aerodynamics for stability, and automatic man-seat separation and parachute. Together, these improvements allow reliable ejection from ground level with no forward velocity - true “Zero-Zero” ejection - and avoid windblast or flail injuries below approximately 450 knots indicated air speed.

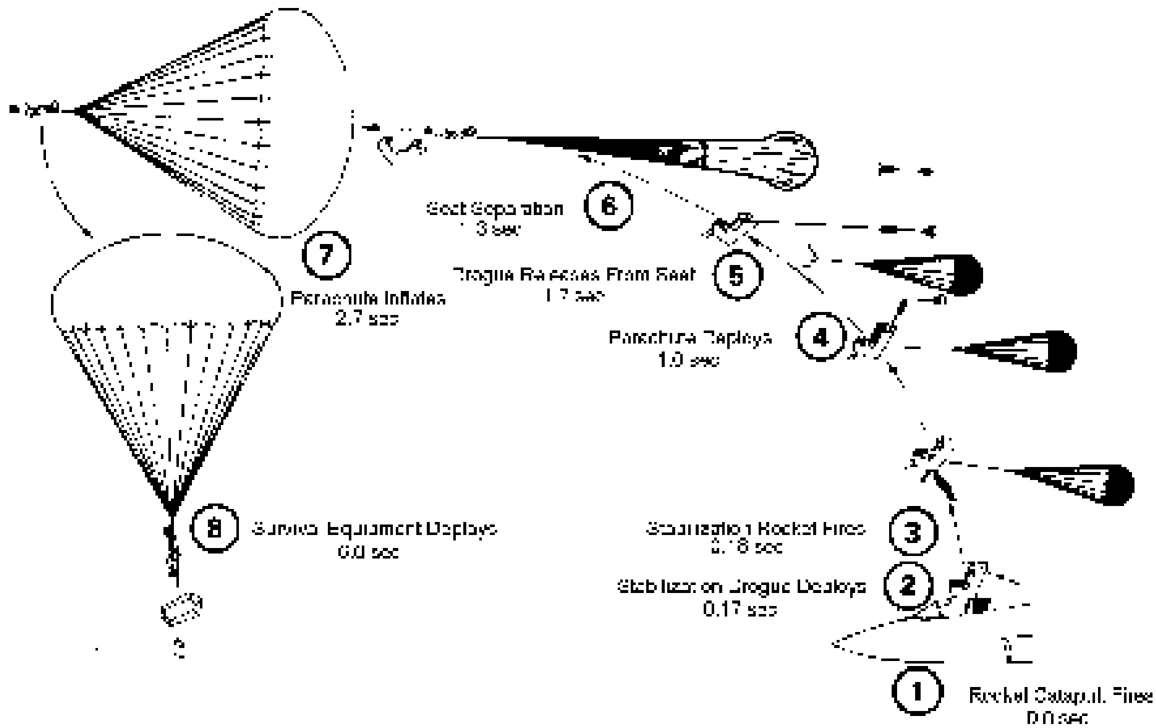

Fig. 1. Ejection Time-Sequence. The aircraft is flying from right to left. Ejection has been initiated by pulling up on a side or center handle, and the aircraft canopy has already been jettisoned as the first step in the sequence. Aircraft with multiple ejection seats have time delays and divergent rocket thrust to prevent rocket blast burns and seat-to-seat interference. Not shown are the magnitude of the $+G_z$ (vertical) acceleration of 12-25G, and the possibilities for injury from frontal windblast; from adverse pitch, roll, or yaw forces on the ejectee; or from contact with the aircraft, seat, or ground.

METHOD

Comprehensive data have been gathered on a continuous basis over the years by the three Department of Defense aviation safety centers for both fixed-wing and rotary-wing aircraft. We have compiled data from mishaps involving fatalities and major injuries, obtained from the USAF Safety Center into relational databases using Microsoft ACCESS. In this paper, only a limited analysis of Air Force data, for the time-frame 1981-1995, will be reported. We focus primarily on head, neck, and spinal injuries inflicted during emergency ejection from military aircraft during training or operational missions in peace-time.

RESULTS

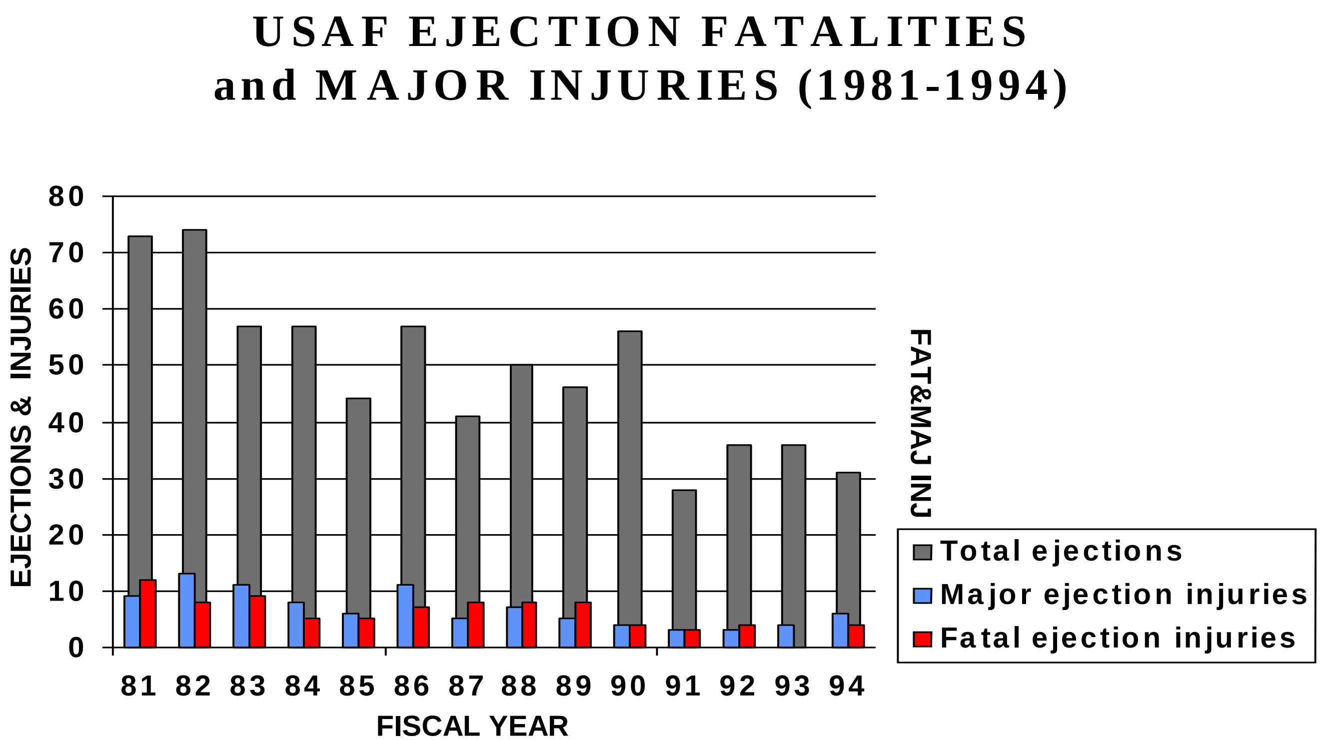

Fig. 2. USAF ejections with number of resulting fatalities and major injuries, 1981-1995.

This graph demonstrates the remarkable safety of emergency ejection from a high performance aircraft. The absolute numbers are too small for rigorous statistical analysis, but fatal injury appears highly unlikely. Major injuries, defined as those causing loss of work days, have historically occurred in about 16% of ejections. Similarly, the risk of fatal injuries is about 20%. [1,2] Our data for 1981-1995 indicate downward trends in both.

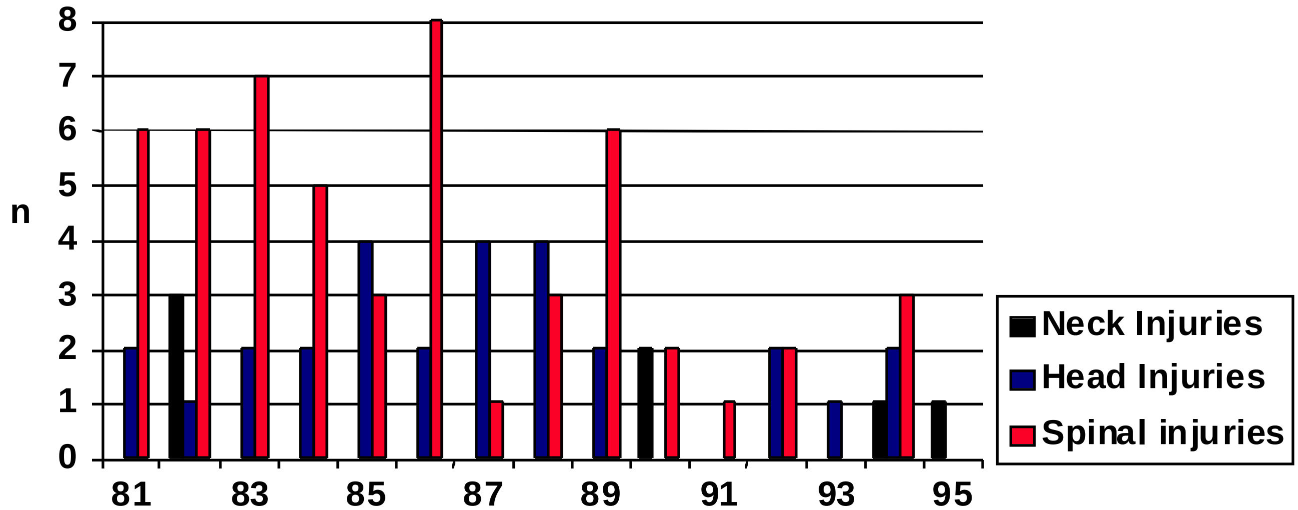

Fig. 3. Incidence of head, neck, spine injuries from USAF ejections, 1981-1995.

Of these injuries, the spine and head are involved more frequently than the neck. The decreases in head, neck, and spine injuries are parallel to the decrease in overall risk of injury or death.

DISCUSSION

Each year, very few of the thousands of aircrew in the USAF eject. Of these, a small proportion suffer major injuries or are killed during ejection. These reassuring statistics derive from decades of continuous technological improvements in all phases of the ejection sequence.

The smaller absolute numbers of ejections after 1991 may be attributed to two factors. The USAF has shrunk in size with a smaller population at risk, hence the lower numbers of ejections. Also, tactics have changed to emphasize medium and high altitude attack profiles. Thus, ejection altitudes are higher, and more time is available to the aircrew to slow the aircraft and make a controlled ejection. Many of the ejection fatalities are caused by “out of the envelope” ejection, i.e., too close to the ground or with an excess, downward aircraft vector.

In the time-frame 1981-1984, it appeared that spinal injuries were dominant. This pattern appears to have altered somewhat during the latter years to levels more comparable to those of head injuries as major factors in aircrew ejections. A possible explanation is the greater number of modern seats in use later in this analysis period. Current ejection seats are designed to avoid spinal compression fractures by moderating acceleration and jolt. Note also that the primary spinal injury is a thoraco-lumbar vertebral compression fracture; paralyzing injuries to the spinal cord are rare.

The head is well protected by the flying helmet, but at higher speeds, the helmet may be lifted off the head and lost, increasing the probability of head injury. As seen in Fig. 1, modern ejection seats have aerodynamic devices - a drogue parachute here- to increase seat stability and to increase seat-man separation when the restraining belt and personal parachute automatically open. These improvements have virtually eliminated man-seat contact as a cause of head injury.

The relative rarity of neck injuries may be attributed to design and training. Aircrew are taught to brace themselves, spine erect and head back against the seat’s headrest, before initiating ejection. Seat stability minimizes torsion and flexion loading of the neck.

Not reflected in this study, nor in the available data base, is the incidence of major injuries or fatalities in combat ejections. Ejection is known to occur at higher average speeds during combat; and the risk of injury may be higher in combat. Future studies using this data base will assess the effects of speed of ejection, differences among various seats and aircraft types, and potential cost savings.

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