# Crash survivability & Safety Devices

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**Abstract- In recent times there have been increased focus on Innovative Aircraft designs which are addressed at fuel efficiency and operational efficiency. Alternate materials, systems are designed to meet growing customer requirements. However low probable incidents and accidents are posing threat to occupant safety. Aircraft crash is one of the major problems which have very less probability of saving human lives, although the technology has risen infinite in making the individual sector for designing, analyzing, weight reduction, and cost reduction etc., of parts by using composites or by means of any mode. Every sector has its uniqueness but when uniting all these together the final result when any abnormal crash happen to the aircraft there is very less probability of saving human. This paper studies, focuses on recent aircraft crash accident and effects of these accidents in terms of loss of lives and property. The statistics available on loss ratio of human lives, crash severity, safety devices is surveyed. Interestingly a majority of these occupants are survivable provided an efficient designed safety device is built to protect critical injury locations, Head and neck support devices are popular for safety still the design and scope for making it widely usable in aircraft needs to be studied further. The better protection system needs to be based on crash simulation studies and experimental tests on huge no. of safety devices. There is need to generate large experimental data base of crash protecting devices exists. New generation rapid prototyping technique may be tried towards fabricating of safety and protection devices. The survivability can be improved by using protection devices majorly for head and neck (HANS) and also other critical injury locations.**

**Keywords: Survivability, Crash severity, Safety devices, Rapid prototyping techniques, HANS Device**

## I. Introduction

Various regulations have been introduced over at least 100 years or so with the aim of saving human lives as the protection that an aircraft provides its occupants when involved in an accident, whereas primary safety refers to the features such as oxygen masks, seat belts etc., are being provided to the occupants as safety devices which are helpful to some extent when crash happens. This paper examines crash data of major aircrafts from which at least 100 human lives have been lost and the relative safety devices that might have helped at least 1 to 10 percent of lives survivable, the manufacturing of these safety devices by means of Rapid prototyping technique (Fused deposition modeling) makes the customized devices with ease and will meet the necessary standards.

## II. Motivation & Need

In over one hundred years of implementation, aviation safety has improved considerably. In modern times, few major manufacturers still produce heavy passenger aircraft for the civilian market. Both plays huge emphasis on the use of aviation safety equipment, now a billion-dollar industry in its own right; for each, safety is a major selling point—realizing that a poor safety record in the aviation industry is a threat to corporate survival. Some major safety devices now required in commercial aircraft involve: Evacuation slides — aid rapid passenger exit from an aircraft in an emergency situation, Advanced avionics – Computerized auto-recovery and alert systems, Turbine – durability and failure containment improvements, Landing – that can be lowered even after loss of power and hydraulics, Measured on a passenger-distance calculation. Air travel is the safest form of transportation available today and airline operations are among the safest anywhere. When compared to all other modes of transport, on a "fatality per mile basis", air transport is the safest — six times safer than traveling by car; twice as safe as rail. However, when measured by fatalities per person transported, buses are the safest form of transportation. The number of air travel fatalities per person is surpassed only by bicycles and motorcycles. This statistic is used by the insurance industry when calculating insurance rates for air travel. Per every billion kilometers traveled, trains have a fatality rate 12 times over air travel; by comparison, fatality rates for automobiles are 62 times greater than air travel. By contrast, for every billion journeys, buses are the safest form of transportation. By the last measure, air transportation is three times more dangerous than car transportation, and almost 30 times more dangerous than bus.

A 2007 study by Popular Mechanics found passengers sitting at the back of a plane are 40% more likely to survive a crash than those sitting in the front. Over 95% of people in U.S. plane crashes, between 1983 and 2000, were not survived. The Aviation Safety Reporting System (ASRS) [1], Collects voluntarily submitted aviation safety incident/situation reports from pilots, controllers and others. The ASRS uses reports to identify system deficiencies, issue alert messages, and produce two publications, CALLBACK, and ASRS Direct line. The collected information is made available to the public, and is used by the FAA, NASA and other organizations working in research and flight safety. Some of the data available in open literature is presented here for a glance at crash effects.

## III. Aircraft crash Data

| **Year** | **Airlines** | **Place** | **Deaths** | **Remarks** |
|---|---|---|---|---|
| 08-Mar-14 | Malaysia Airlines Flight 370 | Pacific Ocean | 239 passengers and crew | Flight crashed into the Pacific Ocean |
| 1-Jun-09 | Air France Flight 447 | Atlantic Ocean | 216 passengers and 12 aircrew | Flight crashed into the Atlantic Ocean |
| 12-Nov-01 | American Airlines Flight 587, an Airbus A300 | New York | 260 passengers on board, five people on ground | The first officer's overuse of the rudder |
| 25-Jul-00 | Air France Flight 4590 | | 260 passengers on board, five people on ground | The official finding traced the cause of the fuel tank rupture |
| 31-Oct-99 | Egypt Air Flight 990 (MSR990) | Atlantic Ocean | 217 passengers and crew | Officer intentionally dove the aircraft into the ocean |
| 02-Sep-98 | Swissair Flight 111 | Halifax, Nova Scotia | 229 passengers and crew | Fire had broken out in the cockpit, the plane disintegrated upon impact with the water |
| 12-Nov-96 | Chakra Dari collision involving Saudi Flight 763 and Air Kazakhstan Flight 1907 | Haryana, India | 349 passengers and crew | Terrorist bomb over the town of Lockerbie, Scotland |
| 17-Jul-96 | TWA Flight 800 | Atlantic Ocean near East Moriches, New | 230 passengers and crew | 243 passengers and 16 crew, and 11 on the ground |

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|---|---|---|---|---|
| | | York | | |
| 26-May-91 | Boeing 767 | Thailand | 223 passengers | The un-commanded deployment |
| 21-Dec-88 | Boeing 747–121 | Scotland | 243 passengers and 16 crew | Terrorist bomb over the town of Lockerbie, Scotland |
| 03-Jul-88 | Iran Air Flight 655 | Iran | 290 passengers and crew aboard | |
| 23-Jun-85 | Air India Flight 182 Boeing 747-237B | Ireland | 307 passengers and 22 crew | Bomb exploded in the cargo hold |
| 12-Dec-85 | Douglas DC-8, Arrow Air Flight 1285 | Newfoundland | 248 passengers and 8 crew | |
| 01-Sep-83 | Sukhoi Su-15 shot down Korean Air Lines Flight 007, a Boeing 747-230B | Soviet | 269 passengers and crew | |
| 19-Aug-80 | Saudi Arabian Airlines Flight 163, a Lockheed L-1011 | | 301 passengers and crew | The crew performed a successful emergency landing after a fire broke out in the rear cargo hold |
| 25-May-79 | American Airlines Flight 191 | Illinois | 271 passengers and crew | |
| 03-Mar-74 | Turkish Airlines Flight 981 | a forest northeast of Paris, France | 346 passengers on board | Cargo door detached |

Table 1: Aircraft Crash Accident data

## IV. AIRCRAFT CRASH SCENARIO

Aircraft and motor vehicle crashes will continue to occur in spite of all human efforts to prevent them. However, serious injury and death are not inevitable consequences of these crashes. It has been estimated that approximately 85 percent of all aircraft crashes are potentially survivable without serious injury for the occupants of these aircraft (1, 2). This estimate is based upon the determination that 85 percent of all crashes met two basic criteria. First, the forces involved in the crash were within the limits of human tolerance without serious injury to abrupt acceleration (1). Second, the structure within the occupant's immediate environment remained substantially intact, providing a livable volume throughout the crash sequence (2). In other words, contrary to popular belief, most aircraft crashes are not "Smoking holes". Nevertheless, many deaths and serious injuries occur in crashes that were classified as "survivable" by crash investigators. This is because the protective systems within the aircraft such as cabin strength, seats, and restraint systems were inadequate to protect the occupants in a crash that would have otherwise been no injurious.

This is why the definition of survivability of a crash is based solely on aircraft and impact related factors and not upon the outcome for the occupants of the crashed aircraft. A mismatch between the survivability of the crash and the outcome for the occupants suggests an inadequacy of protective systems design or utilization.

## V. Safety devices

It has been observed from the crash data that most often when an air craft crashes the human lives can be saved if a safety device for head and neck regions in the aircraft is incorporated makes the occupant safer, which will increase the rate of survivability.

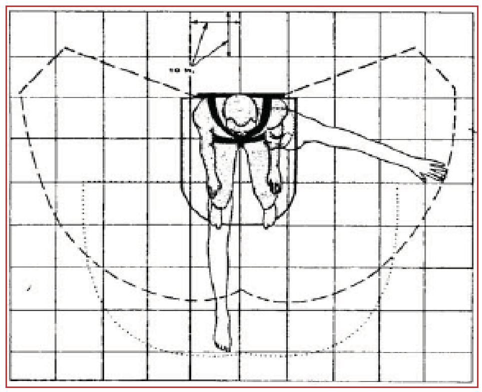

Figure 1. Max. stretch of occupant

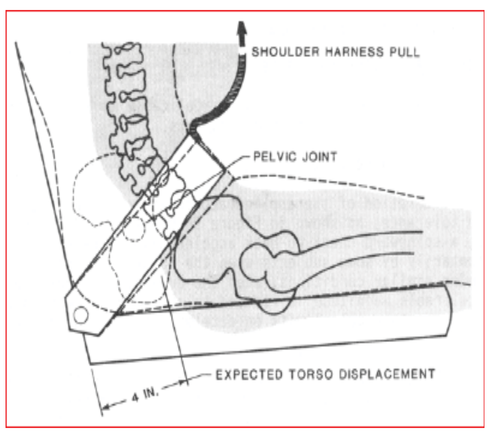


Figure 2. Head and Neck restrainment

Head and neck support system is provided for an occupant, air crew of an aircraft which restrains the forward, downward and lateral movement of the passenger's head when subjected to large deceleration or other impact forces. The system includes a helmet for receiving the human head and a neck suit adapted to be worn by the body having left, right and rear straps for easily connecting and disconnecting the helmet The protective helmet restraint and head and neck support system restrains the movement of a helmet upon impact, stabilizes the posture of the head and neck of the operator during high speed maneuvers, and yet is simple and economical to fabricate and use. The fabrication of head and neck safety device by means of 3D printing increases the flexibility and also for the customization of the occupant which was restricted in conventional method of making.

## VI. THE HANS DEVICE

The Head and Neck restraint system (HANS) safety device which was already been used in Formula-one racing was one of the major safety device is the reference which this paper refers for the aircraft occupant.

Of the various head-and-neck restraint systems that have emerged in recent years, one of the more popular is the Head and Neck Support or "HANS" device, produced by Hubbard-Downing, Inc. of Atlanta, Ga. The HANS [3] device which consists essentially of a rigid collar-shaped carbon fiber shell that is held onto the passenger's upper body by seat belts and fastened to the helmet with flexible nylon tethers attached to both sides of the passenger's helmet—is an example of a head and neck support device that makes use of a yoke and collar arrangement. HANS's apparatus consisting of a head and neck support device with tethers that are attached between the helmet and the collar of the head and neck support apparatus of the passenger. The head and neck support apparatus has a yoke integral with the collar that fits around the back of the passenger's shoulders, adjacent the neck, and on the front of the passenger's chest. The yoke has an opening so that the passenger can mount the head and neck support apparatus by placing his head through the opening. An alternate embodiment is described wherein the yoke is provided with a slot in the front so that the passenger can put on the apparatus from behind by sliding the apparatus around his neck. The need of fabricating these head and neck safety devices to the required standards can be achieved with ease by stepping into Rapid prototyping techniques such as additive manufacturing techniques. The iconic crash-test devices are anything but dumb. It's a high-tech safety device with innumerable physical and electronic configurations to satisfy the unique needs of each customer, whether auto maker, airline, space agency or the military. The demand for sophisticated new safety permutations is relentless. During the second Iraq war, for example, the US Department of Defense urgently needed a sophisticated head model to test a new generation of goggles and face shields. The model needed to incorporate a dozen segments representing facial bones, each having its own impact data collection sensors. The job of producing this innovative head model went to a leader in the design, development and manufacturing of crash-test safety devices – properly called anthropomorphic test devices (ATDs) [2]. The technology evolved in the early 1960s into automotive crash test dummies and crash devices. Since then, technological advances have contributed to constant improvements in the capabilities, quality and accuracy of crash test safety devices and dummies.

## VII. FUSED DEPOSITION TECHNIQUE

Manufacturing of human dummy devices by using Fused deposition technique was implemented and continues study process were already in progress, below image shows the manufacturing of human skull layer by layer formed which was replicated by means of reverse engineering process through cloud points [4].

By implementing the above process in making safety devices such as HANS can increase the required manufacturing conditions and thus increase the survivability rate when crash occurs.

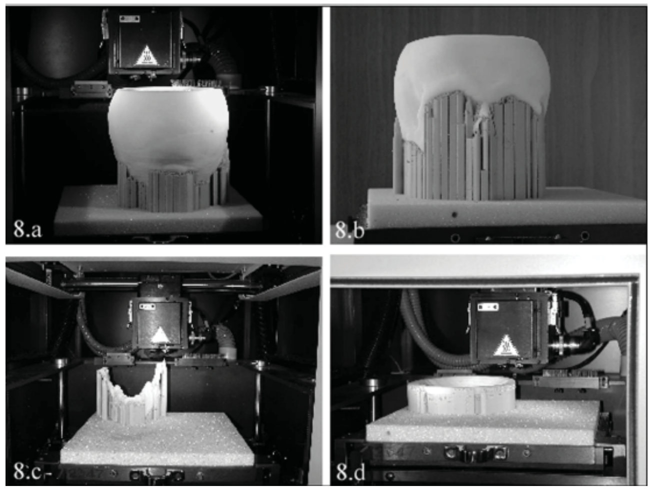


Figure 3. DWT Decomposition model

## VII. CONCLUSION

Occupant safety needs to be relooked at keeping in view the recent aircraft accidents. Even though enough innovation has been going on towards new aircraft design but the safety of occupant is still a challenge. Current paper summarized recent crash accident to the exclusive of other kind of accidents. An extensive literature survey of aircraft crash accident is carried out from the database of ASRS, where large portion of survivability can be achieved if these occupants' safety devices are incorporated. The usage of properly designed protection could possible safe guard few lives in case of crash landings. There is a better thinking required on protective device design and usage in aircraft which must be addressed for occupant specific human body parameters. There is a better proactive requirement to cover head and neck protection which can be easily wearable. Large amount of test data and occupant specific protective devices needs to be tested to be implementing them into air travel especially overseas travels.

## REFERENCES

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