Introduction

Aircraft maintenance human factors is one of the last "frontiers" that can have significant impact on aviation safety. This introduction first explains why there is a growing requirement for applied research in human factors for the aviation maintenance community. The section then defines human factors and how it can improve safety for the aviation maintenance community.

Growing Requirement for Maintenance Human Factors Research

Accidents and incidents are more likely to be caused by the actions of humans than by mechanical failure. Industry statistics show that human error contributes to nearly 80% of airline accidents and incidents, as illustrated below. This figure includes all aspects of human factors including operations, maintenance, and air traffic control. Because aviation systems are continually improving, the aircraft is seldom the cause of an accident and incident. Humans, rather than equipment, are more likely to be at the root cause of an accident or incident. Therefore, the best opportunity for safety improvement is to understand and manage the human factors that pose safety risks.

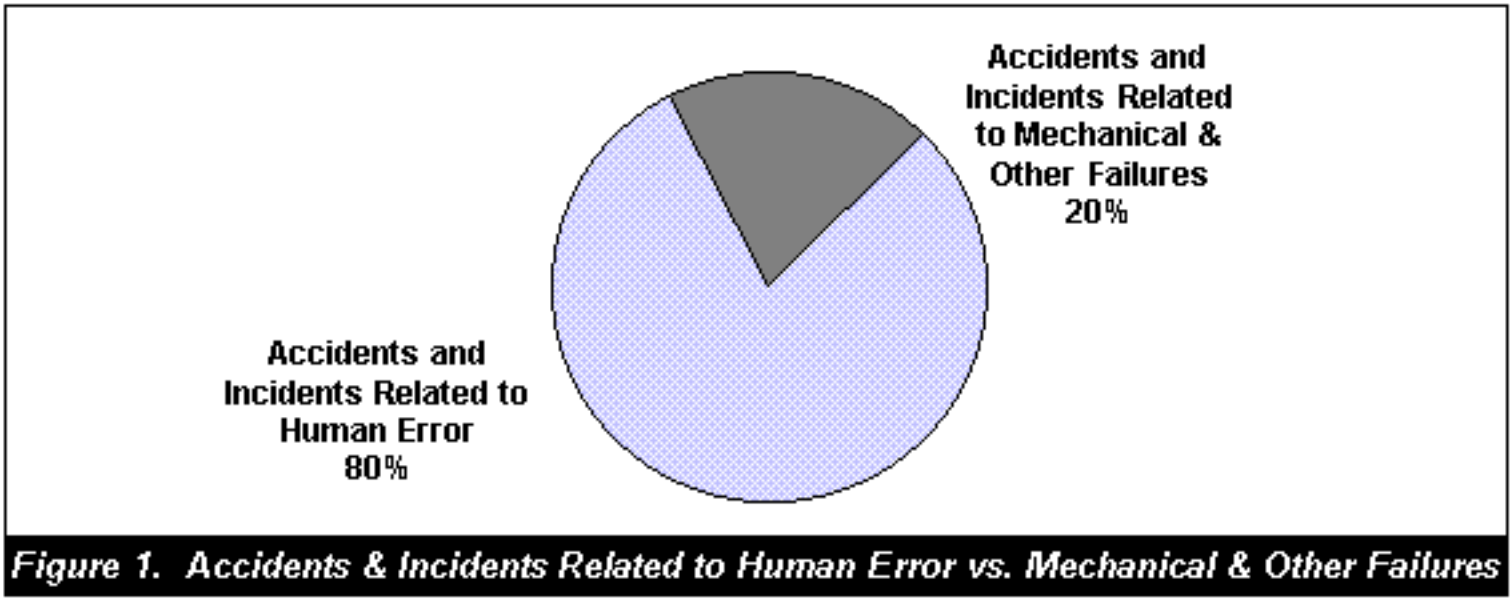

Figure 1. Accidents & Incidents Related to Human Error vs. Mechanical & Other Failures

Aircraft maintenance human factors research is particularly critical for improving aviation safety. Table 1 is a partial list of airline accidents where the probable cause is maintenance related (see Appendix A for a complete listing). In each of these cases, a mechanical failure was not the true culprit, but rather some aspect of the maintenance organization related to human performance was a casual factor of the accident.

Table 1. Examples of Airline Maintenance Errors

DATE	AIRLINE	LOCATION	CAUSE
5/25/79	American Airlines DC-10	Chicago	Engine separation
5/05/83	Eastern Airlines L-1011	Bahamas	O-rings
8/12/85	JAL B-747	Japan	Bulkhead
4/28/88	Aloha Airlines B-737	Hawaii	Fuselage failure
1/08/89	BM Airways B-737	Manchester	Burner can
7/19/89	United Airlines DC-10	Iowa	Fan blade failure
9/11/91	Continental Express Embraer	Texas	Deicing boot
3/01/94	Northwest Airlines B-747	Narita	Engine separation
6/08/95	ValuJet DC-9	Atlanta	Turbine Failure
5/11/96	ValuJet DC-9	Florida	Hazardous Materials
10/2/96	Aeroperu B-757	Peru	Blocked Pitot Ports

One example from Table 1 is an incident involving a "dragged engine on rollout" of a Northwest B-747 at the Tokyo Narita Airport in March 1994. The front of an engine fell from its mount causing its nose cowl to drag along the runway. The friction caused a small fire, which was extinguished by a ground crew. There were no injuries. The NTSB investigation showed a variety of maintenance actions that contributed to the incident, many of which were rooted in human factors.

The factors included the
following:

• inadequate training for the specific engine maintenance and inspection task

• poor tracking of maintenance responsibility

• inadequate lighting in the maintenance workplace

• improper use of job card instructions

• work environment conducive to error

• FAA inspectors failing to apply FAA-developed human factors guidelines for adequate work environments

There is good evidence to project that such accidents can be expected to continue to occur. Figure 2 shows that maintenance costs, passenger miles flown, and the number of aircraft have all exceeded the overall growth of the aviation maintenance technician (AMT) workforce (Air Transport Association, 1996) by substantial percentages. The obvious conclusion is that the AMT must raise efficiency to match the increasing work load.

The proportionately smaller workforce is also faced with other factors which compound the workload problem. Advanced technology aircraft with sophisticated composite structures, computers, and avionics add to the skills and knowledge required to perform maintenance today. In addition, aging fleets require increased labor efforts to keep older aircraft flying safely.

To meet these challenges without sacrificing safety, individual technician responsibilities and skill levels must increase. The industry must work together to ensure that workers become more qualified and that maintenance tasks and procedures are adapted to meet human capability. Attention to human factors in aircraft maintenance will ensure not only continuing performance enhancement of the technician workforce, but also continuing flight safety.

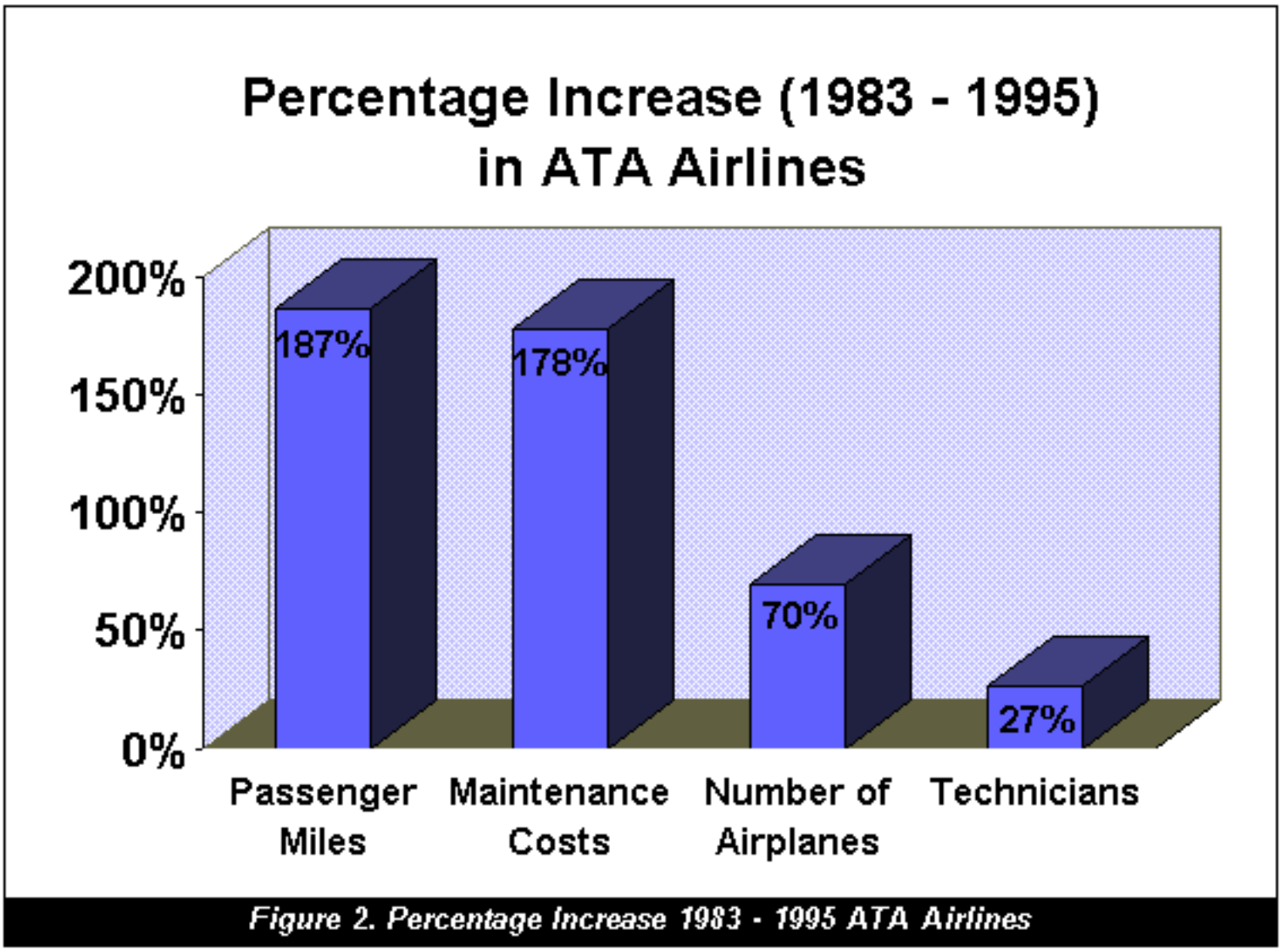

Figure 2. Percentage Increase 1983 - 1995 ATA Airlines

This strategic program plan details how the Aircraft Maintenance Division of Flight Standards Service (AFS-300) is responding to safety and human performance challenges via the Human Factors in Aviation Maintenance and Inspection research program.

How Human Factors Research Can Help

"Human Factors" refers to the study of human capabilities and limitations in the workplace. Human factors include, but are not limited to, such attributes as human physiology, psychology, work place design, environmental conditions, human-machine interface, and more. Human factors researchers study system performance. That is, they study the interaction of humans, the equipment they use, the written and verbal procedures and rules they follow, and the environmental conditions of any system.

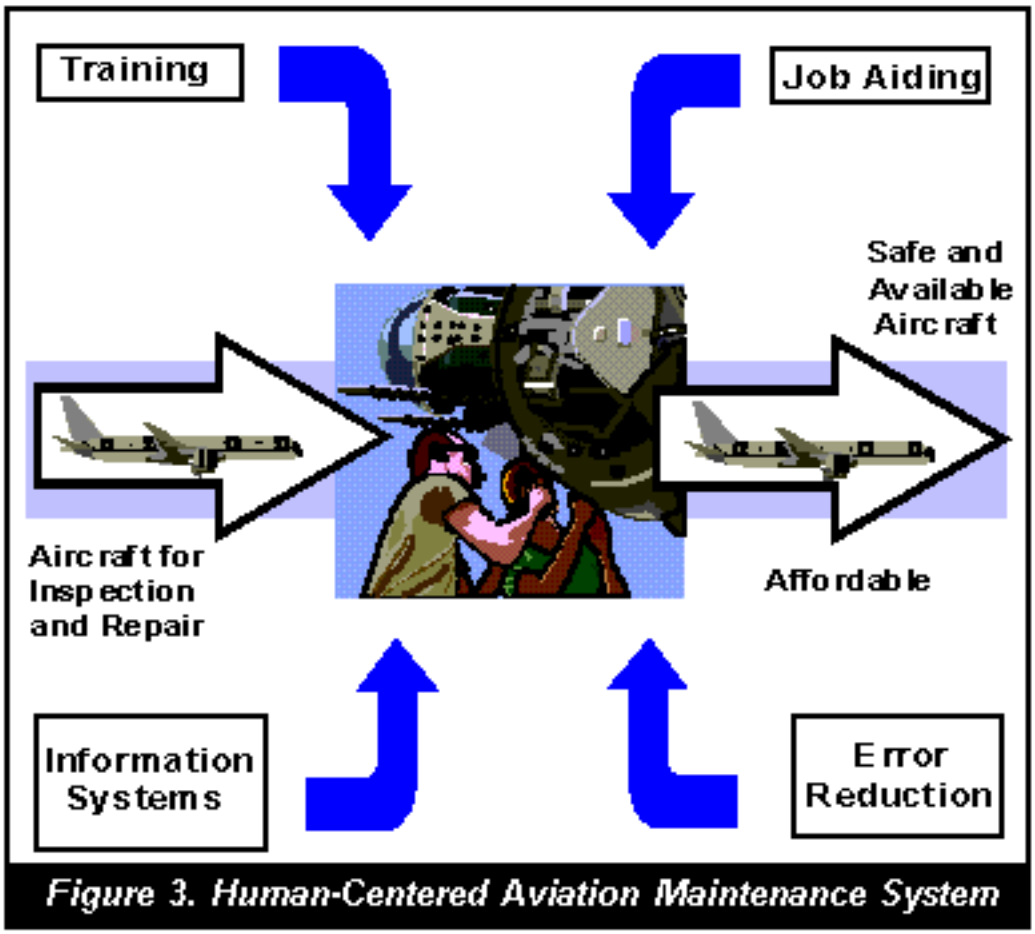

Figure 3. Human-Centered Aviation Maintenance System

Figure 3 illustrates the maintenance system, where the system starts with an aircraft ready for inspection and repair. Maintenance personnel, using tools and procedures within the maintenance environment, must maintain the aircraft. Figure 3 indicates four human factors that affect the human maintainer: training, job aiding, information systems, and error reduction practices. When the system is optimized, the result is an aircraft ready for dependable and safe use, such that the costs are affordable to travelers and the operation is profitable to the airline. As Figure 3 illustrates, in a complex system there are multiple approaches to optimizing system performance. The research program has identified seven primary research activities that address different aspects of the maintenance system:

• Maintenance Resource Management

• Maintenance Error Reduction

• Job Task Analysis in Aviation Maintenance Environments

• Maintenance and Inspection Training

• Job Aids for Maintenance and Inspection

• Information Dissemination

• Communication and Harmonization

Maintenance Resource Management

Maintenance Resource Management (MRM) has become an umbrella term that has yet to be clearly defined. Some current MRM programs may parallel the Crew Resource Management (CRM) programs used for improving team communication and performance in the cockpit. By defining resource management for maintenance and investigating related issues, this research will develop guidelines and related training and reference materials for MRM through extensive cooperation with the airline industry.

Maintenance Error Reduction

Error reduction is a key activity for the research program. The program seeks to develop methodologies or techniques to proactively minimize aircraft maintenance errors and enhance safety. General areas for research include error classification, identification, mitigation, and reduction.

Job Task Analysis

Job Task Analysis (JTA) is a technique used to determine the necessary knowledge, skills, and abilities required to perform the various tasks of a specified job. Job Task Analysis data is then used as the basis for developing curriculum.

A JTA is being conducted to gain an understanding of the current tasks that Aviation Maintenance Technicians perform. This project is an on-going grant that has been supervised by the FAA Technical Center through June 1997. The research project has cooperated with all sectors of the aviation maintenance community to update and upgrade the training standards for technicians performing maintenance in the current and future environment.

Maintenance and Inspection Training

Research activities in this category include studies for the improvement of maintenance training curriculum, delivery systems, and investigation of new technology for improved training methods. All prototype training products shall be pragmatic and aimed at affecting a measurable change in human performance in aviation maintenance and inspection. Related studies, such as investigations of personnel selection methods and workforce projections, are also included in this category.

Job Aids for Maintenance and Inspection

Job Aiding research acknowledges the requirements, capabilities, and limitations of human maintenance personnel. The research program identifies areas where human performance can benefit from improved or new support tools. The program develops prototype tools that support AMT performance. In addition, the program evaluates the feasibility and effectiveness of job aiding techniques and technologies, thereby improving safety through improved task performance.

Information Dissemination

Human factors research can only have an impact if the results and products of the research program are disseminated to the aviation maintenance community. The research program develops and distributes technical and scientific documentation via the FAA *Human Factors Guide for Aviation Maintenance and Inspection* and various research reports. Software prototypes for training or job aiding are provided to the industry via the internet and CD-ROMs.

Communication and Harmonization

Aviation safety is an international activity. For that reason the research program cooperates with a variety of international organizations, governments, and airlines. Examples of cooperative efforts include the joint working agreement among the Federal Aviation Administration (FAA), the Civil Aviation Authority (CAA) in the United Kingdom, and Transport Canada. Further, the research, engineering, and development team is active with the International Civil Aviation Organization (ICAO), International Air Transport Association (IATA), Air Transport Association (ATA), National Air Transport Association (NATA), and a variety of U.S. and international carriers. The work of the research program is presented at international conferences and showcased at annual conferences sponsored by the research program. In addition, the program supports harmonization of regulatory and guidance material with international bodies.