6 Human Factors in Aviation Maintenance

6.1 INTRODUCTION

An efficient and safe air travel system depends basically on three elements: design, operation, and maintenance. Each year a vast sum of money is spent on aviation maintenance throughout the world. For example, according to the United States Air Transport Association, U.S. airlines spend around $9 billion on maintenance each year [1]. This represents roughly 12% of the total operating cost of an airline company.

Aviation maintenance has changed over the years because newer aircraft contain power plants, electronic subsystems, and materials that did not exist in earlier models [2, 3]. In turn, aircraft maintenance personnel are using increasingly sophisticated equipment and procedures. However, one important aspect of aviation maintenance that has not changed is that most maintenance tasks are still being performed by human inspectors and technicians.

Needless to say, although the aircraft on which these maintenance personnel work have evolved dramatically over the past 50 years, the maintenance personnel still exhibit all of the limitations, idiosyncrasies, and capabilities that are part of being human.

This chapter presents various important aspects of human factors in aviation maintenance.

6.2 THE NEED FOR HUMAN FACTORS IN AVIATION MAINTENANCE AND HOW HUMAN FACTORS IMPACT AIRCRAFT ENGINEERING AND MAINTENANCE

According to the Annual Report of the United States, scheduled Airline Industry, costs, passenger miles flown, and number of aircraft have all exceeded the overall growth of the aviation maintenance technician (AMT) workforce over a period of ten years (i.e., 1983–1993) [4]. It simply means that AMT must enhance efficiency to match the increasing workload demanded by the combination of new skill and knowledge requirements for advanced technology aircraft and increasing labor demand appropriate for providing continuing airworthiness to the existing fleet.

In order to achieve these goals effectively, individual technician's skills and responsibilities must increase to a significant level. Moreover, the airline industry and agencies such as the United States Federal Aviation Administration (FAA) must strive to ensure that maintenance personnel become better qualified and that maintenance works and procedures become more simplified.

Past experiences indicate that human factors can impact aircraft engineering and maintenance in many different ways [5]. For example, at the design and manufacturing stage, critical parts must be identified and manufactured according to the requisite standards. Subsequently, these parts must be subject to inspection and test requirements, as appropriate, in the aircraft maintenance schedule. If they are not in the schedule, then the planning engineer cannot be blamed for not calling a check. Similarly, the aircraft engineer cannot be blamed for overlooking to perform an inspection that was not called for, unless the fault is very obvious.

Nonetheless, engineering designers can take various steps to minimize the occurrence of certain maintenance errors. Two examples of these steps are making critical part areas readily inspectable and devising appropriate checkout procedures to cater for maintenance errors which could cause hazards.

Other human factors that can have a direct effect on aircraft engineering and maintenance include pressure and stress (i.e., either actual or perceived), environment (e.g., too dark, too cold), and circadian rhythm (i.e., natural body variations on shift work) [5].

6.3 HUMAN FACTORS CHALLENGES IN AVIATION MAINTENANCE

There are many human factors challenges in aviation maintenance. The primary challenges can be identified under five classifications as shown in Figure 6.1 [6].

The classification *the worker* is basically concerned with the availability of adequately qualified aviation maintenance personnel in the future. The classification *the workplace* is concerned with providing an effective workplace to aviation maintenance personnel with respect to factors such as safety, temperature, lighting, work access, and noise. The classification *training* is basically concerned with continuously providing proper training to aviation maintenance personnel with respect to changing aircraft-related technologies.

The classification *communication* is concerned with providing timely and accurate maintenance task performance information to aviation maintenance personnel with respect to factors such as "user-friendly" manuals, work cards, and other sources for obtaining inspection and repair-related information. Finally, the classification *aircraft systems* is concerned with, in addition to considering the traditional maintainability-related factors during aircraft systems design, the specific needs of aviation maintenance and inspection manpower at the initial stage of the aircraft systems design.

Additional information on these five classifications of human factors challenges is available in Ref. [6].

6.4 PRACTICAL HUMAN FACTORS GUIDE FOR THE AVIATION MAINTENANCE ENVIRONMENT

Aviation maintenance personnel work as one element within the framework of a large industrial system that contains elements such as the maintenance facility, aircraft, inspection equipment, repair equipment, and supervisory forces [7]. In order

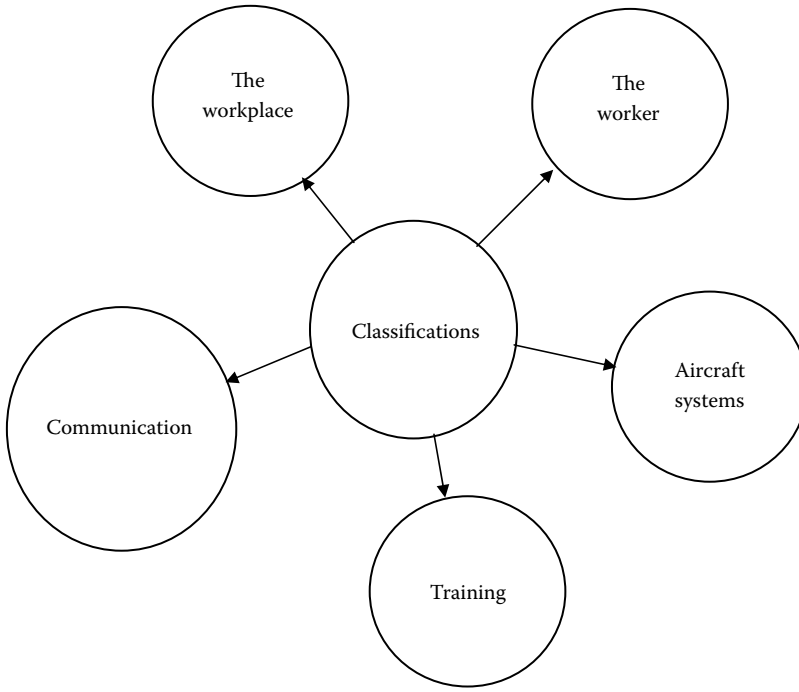

FIGURE 6.1 Classifications of human factors challenges in aviation maintenance.

to understand the performance of maintenance personnel working within the framework of this system, proper information is needed concerning the operating characteristics of this very element, that is, maintenance personnel. Two examples of the required information are the following:

- How do the maintenance personnel work?
- What features of the maintenance personnel and/or the environment tend to generate maintenance error?

Human factors is a discipline that seeks to provide appropriate answers to questions such as listed above through an understanding of factors such as the capabilities and limitations of humans, human behavior laws, and the possible effects of the environment on human performance. Thus, a goal of human factors is to draw on knowledge of these factors in developing guidelines for the optimum use of humans in operating systems.

In order to meet this objective the FAA has developed a guidebook titled *Human Factors in Aviation Maintenance* that presents human factors information oriented specifically towards their carrier maintenance personnel. The guidebook contains 12 chapters on 12 different topics, listed in Table 6.1 [3].

TABLE 6.1
Topics Covered in the Federal Aviation Administration Human Factors Guidebook

No.	Topic
1	Human factors
2	Facility design
3	Establishing human factors/ergonomics program
4	Workplace and job design
5	Workplace safety
6	Training
7	Testing and troubleshooting
8	Automation
9	Shift work and scheduling
10	Personal and job-related factors
11	Sexual harassment
12	Disabilities

The chapter "Human Factors" introduces the field of human factors/ergonomics and defines various concepts and terminology related to factoring human capabilities and limitations into the workplace environment. The chapter "Facility Design" describes the important human factors concepts concerning designing facilities by emphasizing the elements found in the aviation maintenance environment. Two examples of these elements are movable scaffolding and large open hanger areas.

The chapter "Establishing Human Factors/Ergonomics Program" discusses what an ergonomics program is and why an aviation organization should have one. The chapter also describes items such as the concept of a systematic framework for ensuring that human factors are properly considered in the maintenance organization, the regulatory requirements that relate to human factors programs, and the steps required to set up a human factors program. The chapter "Workplace and Job Design" describes the human factors concepts underlying the proper design of jobs and workplaces and the recent research efforts in the aviation maintenance environment that is part of the ongoing FAA emphasis.

The chapter "Workplace Safety" discusses items such as the major hazards associated with industrial workplaces, the steps maintenance supervisors and planners should take to mitigate the hazards, and the features unique to the aviation maintenance workplace.

The chapter "Training" describes various important items concerning training including the overall training requirements in the aviation maintenance environment, changes to training required from the regulatory perspective, and the training methods appropriate for teaching various types of knowledge and skills.

The chapter "Testing and Troubleshooting" discusses the human factors concepts and methods that relate, directly or indirectly, to aviation maintenance testing and troubleshooting. The chapter "Automation" describes the most useful concepts

concerning automation, that is, both in general and in the aviation maintenance environment. More specifically, it describes how to decide which maintenance functions are most amenable to automation, as well as various myths and potential automation pitfalls.

The chapter "Shift Work and Scheduling" discusses important research findings concerning various shift scheduling practices including the concepts of circadian rhythms, desynchronization, and the effects of sleep deprivation. The chapter "Personal and Job-Related Factors" discusses issues such as job-related stress, financial concerns, substance abuse, and family problems along with the proper use and potential misuse of employee assistance programs.

The chapter "Sexual Harassment" discusses various aspects of sexual harassment including the underlying social and legal concepts concerning sexual harassment, and the latest court decisions and regulatory requirements. Finally, the chapter "Disabilities" describes the requirements of the Americans with Disabilities Act (ADA) and its implications for the aviation maintenance environment, along with a human factors perspective on adjusting to the capabilities and limitations of people with disabilities.

Additional information on all of the above twelve topics is available in Ref. [3].

6.5 INTEGRATED MAINTENANCE HUMAN FACTORS MANAGEMENT SYSTEM (IMMS)

IMMS is the ongoing European effort toward the integrated management of human factors in aircraft maintenance. More specifically, it is the part of the HILAS (Human Integration into the Lifecycle of Aviation Systems) project divided into four parallel strands of work: the monitoring and assessment of maintenance operations, the integration and management of human factors knowledge, the evaluation of new flight deck technologies, and the flight operations environment and performance [8].

Some of the main objectives of the IMMS are to improve operational performance, improve safety performance, reduce human factors-related risks, and improve quality.

There are five main components (i.e., C_1, C_2, C_3, C_4, and C_5) of the IMMS divided into two categories: front applications and back applications. Thus, the front and back application components are C_1, C_2 and C_3, C_4 and C_5, respectively. Each of these five components is described below [8].

- **C_1:** This is for aircraft maintenance engineers and it will provide these engineers better task support, through a portable handheld device, employing modern technologies such as radio frequency identification (RFID) and virtual reality.
- **C_2:** This is for all the support functions. More specifically, it will both provide information to these support functions on how to manage the "softer" aspects of managing the checks and any difficulty experienced.
- **C_3:** This will collect data from the front applications (i.e., C_1 and C_2) in addition to collecting data from currently operating systems such as

planning, engineering, and quality systems, within the organization. Also, C_3 will allow all these systems to communicate with each other.

- **C_4:** This is the suite of Human Factor Tools and Methods that will manage the human component of the system. Directly or indirectly, the data from components C_1, C_2, and C_3 will continuously update this component (i.e., C_4).
- **C_5:** This deals with implementation on two levels. The first level is concerned with implementing the actual recommendations that come out of the system, whereas the second level is concerned with the implementation of the system itself. This component, i.e., C_5, will also address the wider issue of organizational support.

Additional information on IMMS is available in Ref. [8].

6.6 AVIATION MAINTENANCE HUMAN FACTORS TRAINING PROGRAM AND HUMAN FACTORS TRAINING AREAS FOR AVIATION MAINTENANCE PERSONNEL

One of the most challenging issues in aviation maintenance is designing and developing appropriate human factors training programs. A systematic method that can be used to design and develop human factors training programs is composed of five processes/steps as shown in Figure 6.2 [9–12]. This process includes items such as

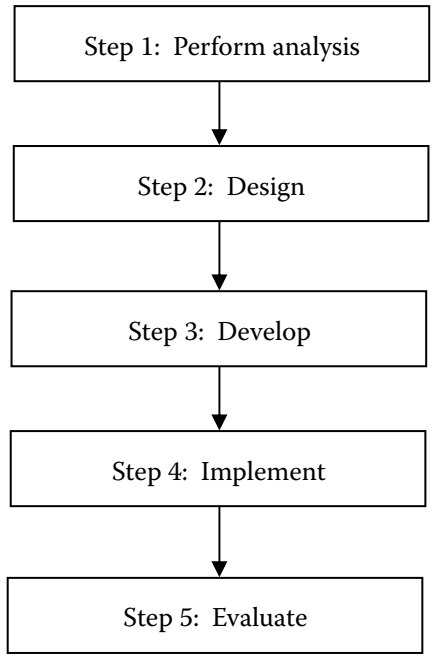

FIGURE 6.2 Steps of the method for designing and developing human factors training programs.

establishing goals and defining training objectives, developing and implementing the training program, involving end users and/or subject matter experts, measuring the training effects, and providing feedback to the training developers [9]. The steps shown in Figure 6.2 are described below [9].

- **Step 1: Perform analysis:** This is concerned with performing three types of analysis: organizational, task, and person. The purpose of these analyses is to determine the degree of training needs and performance gaps, develop hierarchical task analyses, and create an appropriate learning hierarchy which identifies the existing knowledge, skills, and ability levels of trainees under consideration.
- **Step 2: Design**: This is concerned with defining the instructional curriculum, goals, and objectives. This can be accomplished quite effectively by adopting a participatory design approach that includes the creation of a multidisciplinary team of experts, end users, in the areas of aviation maintenance, maintenance operations, inspections, FAA regulations, and human factors.
- **Step 3**: **Develop:** This is concerned with developing the training materials and media. The incorporation of "in-house" examples in such materials could be very useful.
- **Step 4**: **Implement:** This is concerned with implementing and delivering the training to trainees.
- **Step 5**: **Evaluate:** This is concerned with evaluating the training and it includes measuring the effectiveness of the training program on the trainees' performance, behaviors, and knowledge. There are a number of approaches used to evaluate training courses based on a five-level framework [11, 12, 13–15]. These five levels are baseline assessment prior to training, trainee reaction, learning, performance (i.e., behavioral changes), and organizational results [9].

There are many disciplines of human factors including educational psychology, organizational psychology, cognitive science, safety engineering, clinical psychology, experimental psychology, and anthropometric engineering [16]. Because of these many disciplines, aviation maintenance human factors courses can have many approaches with varying instructional goals. Nonetheless, some of the useful topics/areas as candidates for an aviation maintenance human factors course are as follows [16]:

- Safety and economic statistics
- Error and error reporting with respect to economics of error and corporate/regulatory discipline
- Maintenance crew resource management
- Stress
- Human factors fundamentals including analytic methods, human performance models, environmental factors, physical factors, medical factors and health, and cognitive factors
- Teamwork

- Workplace safety
- Behavioral analysis
- Psychological factors
- Situation awareness
- Communication in the workplace that includes items such as principles of communication, leadership, conflict resolution, decision making, planning meetings, and group dynamics/teamwork.

6.7 COMMON HUMAN FACTORS–RELATED AVIATION MAINTENANCE PROBLEMS

Past experiences indicate that there are many human factors–related aviation maintenance problems. Some of the common ones are as follows [17]:

- Coexistence of various types of new technology and old technology equipment
- Need for appropriate advanced technology job aids
- Availability of qualified manpower
- Need for effective technical training for troubleshooting
- Need for task analytic job performance-related data
- Suboptimal working conditions/environments
- Organization and effective usability of all technical documentation

Additional information on these common human factors–related aviation maintenance problems is available in Ref. [17].

6.8 PROBLEMS

1. Discuss the need for human factors in aviation maintenance.
2. List at least six common aviation maintenance problems with respect to human factors.
3. Describe the Integrated Maintenance Human Factors Management System (IMMS).
4. List at least ten topics covered in the Federal Aviation Administration (FAA) human factors guidebook for the aviation maintenance environment.
5. Discuss how human factors impact aircraft engineering and maintenance.
6. What are the major human factors challenges in aviation maintenance?
7. Describe the steps of the method for designing and developing human factors training programs.
8. List at least 10 topics/areas as prime candidates for an aviation maintenance human factors training course.
9. Write a short essay on human factors in aviation maintenance.
10. Discuss the need for having a practical human factors guide for the aviation maintenance environment.

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