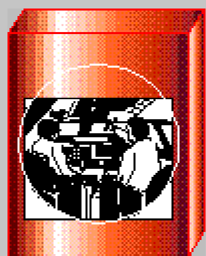
Chapter 7
TRAINING

7 Training



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Quote: "Training for aviation maintenance is driven by a unique combination of three factors: public safety, complex equipment, and very high workload."

INTRODUCTION

People who perform aviation maintenance are unique. While all maintenance technicians learn their job skills through a combination of education, formal training, and "hands on" experience, aviation maintenance training has a special focus and unique challenges. This is due to stringent safety and quality requirements, complex equipment with sophisticated systems, and a wide range of working conditions.

Airworthiness is dependent upon maintenance quality; it directly affects the flying public's safety. For this reason, the Federal Aviation Administration (FAA) sets standards for experience and training, establishes minimum curriculum requirements, and tests individuals for competence before they are awarded an Airframe and Powerplant (A&P) certificate. The title of Airframe and Powerplant Mechanic will soon be changed to Aviation Maintenance Technician (AMT), so we will use the title "AMT" in this *Guide*.

Aviation maintenance is becoming increasingly complex. New aircraft are becoming more sophisticated. They rely heavily on composite construction and integrated electronics. At the other extreme, aviation organizations are keeping older aircraft in service. As aircraft age, they require more, and more specialized, maintenance. Finally, the competitive and economic environment in which aviation organizations operate requires them to keep aircraft in the air as much as possible. These characteristics are reflected in the demand for improved performance from better-trained, more efficient maintenance workers.

As aviation maintenance tasks grow more complex, so does the training necessary to transfer the requisite knowledge and skills to **AMT**s. We include inspectors in the definition of AMT, since inspectors must also hold an Airframe and Powerplant (A&P) certificate. This chapter covers the most salient issues related to initial and recurrent AMT training. These include the changing nature of aviation maintenance, the declining size and perceived quality of the AMT labor pool, the changing demographics of the AMT population, and a new emphasis on Maintenance Resource Management (MRM).

The use of human factors methods directly affects the quality of aviation maintenance training. Using the systems approach to select and develop training programs will make them effective and efficient. Properly analyzing training needs will result in an appropriate tradeoff between learned and procedural knowledge. This is known as the *head-book* tradeoff, i.e., information that must be committed to memory versus information that can be supplied with written procedures, such as workcards.

This chapter presents basic concepts and guidelines needed to successfully implement a training program within the constraints of actual aviation maintenance organizations. We define an array of different types of training techniques and their most appropriate uses. Our focus in this chapter is on selecting and developing **AMT** training related to any topic, not training specifically aimed at teaching human factors methods or data. While the concepts and techniques we provide here can certainly be used to impart human factors information, that is not our sole, or even primary, intent.

BACKGROUND

Training for aviation maintenance is driven by a unique combination of three factors: public safety, complex equipment, and very high workload. Aviation Maintenance Technicians must combine in-depth knowledge, complex mental processing abilities, skillful use of reference information, and advanced manual skills. Because of the breadth and depth of knowledge and skills required for aviation maintenance tasks, a heavy demand is place upon **AMT** training.

Certification

To be granted an **AMT** license, an individual must be able to either prove he has a certain level of experience or successfully complete the curriculum of a certified AMT training school. The requires at least 18 months of work experience for an Airframe, Powerplant, or Repairer's certificate. For a combined **A&P** certificate, at least 30 months of experience working with both engines and airframes are required. [1]

While it is possible to obtain an **A&P** license without formal training, most **AMT**s learn their jobs in one of the schools certified under Part 147 of the **FAR**s.[2] The **FAA** has established a minimum of 1,900 actual class hours for the combined A&P certificate. The elapsed time to complete this number of class hours typically ranges from 14 months to 2 years. For an inspector's authorization, an AMT must be twenty-one years of age and have held an A&P certificate for at least 3 years. Applicants for any certificate or authorization must pass written and oral tests and demonstrate that they can do the work before they are issued a certificate.

Aviation maintenance work requires a high degree of mechanical aptitude. High-quality **AMT**s are self-motivated, hard-working, enthusiastic, and able to diagnose and solve complex technical problems. Agility and comfort with heights are also required for the job. In addition, recent technological advances in aircraft and test systems require a strong background in logic and electronics. Courses in mathematics, physics, chemistry, electronics, computer science and mechanical drawing are recommended for AMT candidates. Courses that develop writing skills are also important because of the significant amount of report writing required of AMTs.[3]

The **FAA** is currently considering a number of significant rule changes related to **AMT** training and certification. These are described fully in the **REGULATORY REQUIREMENTS** section.

Initial and Recurrent Training

Existing aviation training is categorized as either initial or recurrent. Initial training brings technicians to a level of proficiency that allows them to work on particular types of aircraft. Recurrent training is used to acquaint **AMT**s with new systems and equipment, or to keep rarely-used skills current.

Initial training consists of two parts. First, an individual acquires an **A&P** certificate through one of the certified **AMT** schools. In the best circumstances, new AMTs are hired by a commercial aircraft maintenance organization. These newly-certified AMTs undergo further training designed to bring them to a level of performance acceptable to the organization.

Once actively working as **AMT**s, individuals receive recurrent training to introduce them to new components and further develop their troubleshooting and repair skills.

In the workplace, **AMT**s must become productive on new equipment as quickly as possible. New aircraft technology is introduced frequently; aircraft are constantly modified; and aircraft routes change often to meet market demands. It is difficult for an organization to ensure that sufficient numbers of qualified AMTs will be available at the appropriate locations. Selecting the proper training methods and developing effective training materials assumes a heightened level of importance in today's aviation maintenance environment.

ISSUES AND PROBLEMS

There are a number of outstanding issues related to **AMT** training. Some of these relate to the changing nature of the AMT job. Others concern societal trends that are reflected in the AMT population. The aviation maintenance domain and the people who inhabit it do not exist in a vacuum. Rather, the aviation maintenance workplace is a microcosm of the general state of the social and business environments. In this section, we describe those issues with the most far-reaching consequences for AMTs and managers.

Changing Nature of Aviation Maintenance

There seem to be three major trends effecting changes in aviation maintenance.[4] First, new aircraft increasingly incorporate digital and bus-centered electronics to integrate and monitor aircraft systems. Second, more and more aircraft are remaining in operation for longer periods. Third, there is an increasing shift of maintenance activities to third-party providers.

The first trend dictates an increased demand for highly-skilled **AMT**s. The ability to work on newer aircraft demands less emphasis on mechanical aptitude and more diagnostic and troubleshooting ability. The second trend creates more demand for due diligence in performing the work and the retention of knowledge and skills pertaining to older aircraft. The third trend signals the need for increased accountability of third-party maintainers, a fact brought home forcefully with the ValuJet crash.[5]

What motivates operators to use third-party operations? Is it money only? If so, then what motivates a third-party operator to take the extra steps that are required to do an in-depth job? Highly-trained and experienced technicians cost money. What requires a third-party to hire these highly-trained **AMT**s? These types of questions must be addressed before logical arguments for increasing the quality of training can be made.[6]

Each of these trends entails an increased demand for teamwork and its associated skills -- communication, leadership, and situation awareness. See **Chapter 16**, Maintenance Resource Management (MRM), for a detailed discussion of these topics.

The combination of these trends places tremendous emphasis and stress on the training systems in place for **AMT**s. There is growing concern among both manufacturers and operators that existing AMT training must be enhanced to meet the new challenges posed by these trends.[4]

Decline in Quantity and Quality of AMT Labor Pool

Beginning in late1990 and lasting through 1994, the industry experienced a severe economic downturn. This caused a drop in demand for **AMT**s, which was followed by a reduction in students entering AMT training programs. This demand and enrollment reduction led to a 50% drop in the number of graduating students in the 1994-95 period.[4] Since 1995, the industry has been experiencing a moderate recovery.

As a result of the severe drop in enrollment, many vocational schools eliminated **AMT** training programs altogether. The number of AMT schools declined from 213 in 1991-92 to 193 in 1994.[4] Another 10 programs were discontinued in 1995, bringing the total to at least 30 fewer schools in a 5-year period. The steady elimination of AMT schools is seen as part of a nationwide trend toward a decline in high-quality vocational-technical programs within the educational system.

It has been estimated that approximately 171,000 **AMT** new-hires will be needed to satisfy aircraft demand between 1993 and 2004. To meet this demand, an average of 14,240 new AMTs must be hired each year.[4]

Compounding the projected shortage of qualified **AMT**s, competition for quality technicians has increased. Other industries, such as the automobile and electronic manufacturing industries, are drawing from the available pool of technically skilled people. Unless vocational-technical programs experience a resurgence, other industries will continue to compete for AMT school graduates.

Prior to entering an **AMT** school, students must complete a standard course of study at an accredited high school. However, many high school students are being passed through the educational system without being required to learn and demonstrate certain basic skills. This trend has led to a decline in the basic literacy skills of the current pool of new AMT applicants. Some candidates have the requisite mechanical aptitude, but are lacking basic skills in reading comprehension, writing, calculation, or problem solving.

There is a growing consensus within the aviation industry that applicants should be required to complete prerequisite courses before entering the **AMT** program. However, with the growing demand for "bodies" to fill the ranks there is also a reluctance to institutionalize such a requirement.

Changing Demographics

In 1990, African-Americans comprised 12.1% of the total U.S. population. However, this minority population is not evenly distributed. In some areas in the Mid-Atlantic and Southeastern states, African-Americans make up 50% or more of the population. Likewise, 9% of the total population of the U.S. is Hispanic. However, 50% or more of that total is concentrated in Texas and the Southwest. Foreign-born individuals comprise 7.9% of the total U.S. population with concentrations of 13% or more in New York, New Jersey, Southern Florida, Texas, and the Southwest.[7]

As of 1992, there were over 700,000 employees in the domestic air transport business. Concentrations of over 20,000 aviation employees are found in California, Florida, New York, and Texas. Concentrations of over 10,000 employees are found in Illinois, Kentucky, Ohio, and Utah.[7]

In 1993, 45.8% of the employed domestic population were women, 10.2% were African-American, and 7.8% were Hispanic. However, for workers employed in any mechanic or repair-related fields, only 3.5% were women, 7.3% were African-Americans, and 7.9 % were Hispanic. These figures have essentially remained unchanged since 1983.[8] As of 1995, women comprised only 1% of the total **A&P** certificate holders.[9]

These statistics describe a cultural distribution that challenges traditional notions of appropriate **AMT** training. First while African-American and Hispanic populations comprise 12 and 9 % of the total U.S. population, respectively, these groups are concentrated in high numbers in the Southeast, Southwest and Mid-Atlantic states. This distribution creates a non-homogeneous cultural distribution of workers. In other words, the workers in Los Angeles differ culturally from the workers in New York City and workers in either of these cities are culturally different than workers in Atlanta. Since the emergence of an international presence in aviation maintenance, particularly from the Pacific rim countries, awareness of cultural diversity has become even more pronounced.

In contrast to the increased cultural diversity within the ranks of the **AMT** at home and abroad, the representation of women in aviation maintenance continues to be abysmally small. The cultural climate in the training and work environment has been shown to adversely effect the recruitment and retention of women in the field.[9]

Training classes must embed the need for cultural awareness and sensitivity within each demographic region. Instructors and instructional materials must be adaptable to successfully interact with changing localized demographics.[10]

New Emphasis on Maintenance Resource Management

A series of accidents related to a breakdown of human communication and team work[11] prompted the aviation industry to institute Crew Resource Management (CRM) training to explicitly teach flight crews to work together as a team. The lessons learned in the cockpit and the positive effects of CRM training have not been ignored in the maintenance community. The maintenance side of the industry understands that communication, situation awareness, and teamwork are essential to reduce errors and increase efficiencies.

The maintenance equivalent of **CRM** is called Maintenance Resource Management (MRM). For many reasons, MRM is a more challenging training effort than CRM. The flight crew "team" is more readily identifiable than a team in a maintenance facility. Maintenance involves larger, more dissociated groups of people who must successfully coordinate with each other. Maintenance teams do not typically adopt the military command-hierarchy model prevalent in cockpit operations.

Because of these significant differences between **MRM** and **CRM**, the Office of Aviation Medicine has sponsored the development of MRM training courses and materials. For a complete description of MRM and recommendations for implementing an MRM training program, see **Chapter 16**.

The Need for Structured On-the-Job Training

Certain aviation maintenance training practices have been frequently criticized. Recurrent training tends to receive less emphasis than the constant technological changes in the industry demand. Mechanics sent to school for training on a specific aircraft may not receive formal training again on that aircraft type for 10 years or more.[12] Training related to technological changes tends to be done on the job, instead of in formal, structured settings. There is ample evidence that **OJT** is not the best training method for a variety of skills needed by today's **AMT**.[13]

Even when using **OJT** is appropriate, the current system has been criticized for its lax OJT training practices, which tend to be unstructured. Younger mechanics turn to more senior employees for *ad hoc* OJT, although there is no systematic way to ensure that the senior **AMT**s work or teaching skills are adequate to ensure the efficient transfer of skills and knowledge.[14]

The term "recurrent training" is used throughout the aviation industry and in Part 66 of the Federal Aviation Regulations (FARs). There is, however, no established definition of this term.[6] What are the standards? How should one measure hours or continuing education units? What are acceptable delivery methods? These are important issues for recurrent training to be successful. A universally-accepted standard that includes delivery, evaluation and measurement needs to be developed.

REGULATORY REQUIREMENTS

Training for **AMT**s is governed by two parts of Title 14 of the Code of Federal Regulations (CFR). All the parts of Title 14 are collectively known as the Federal Aviation Regulations (FARs). Part 147, originally implemented in 1962, specifies the procedures and curricula for AMTs.[2] Part 65 covers initial and recurrent training requirements.[15]

Regulations and policies governing **AMT** certification have lagged behind current technology and industry trends. A complete regulatory review has not been accomplished since 1962 when the Civil Air Regulations were re-codified into the **FAR**s. Since then, no significant revisions have been made to Part 65 - Certification, Airmen Other than Flight Crew Members, Subpart D - Mechanics[4].

Part 147 requirements are based on an **FAA**-sponsored study of aircraft maintenance jobs known as the Allen Study, conducted before 1962. The requirements remained relatively unchanged for years, despite rapid advances in aircraft structures, materials, and avionics. Until 1992, Part 147 required **AMT**s to be trained in wood, dope, and fabric structures.

In 1988, the **FAA** proposed several revisions to the Part 147 training requirements to reflect changes in the industry and in the state of the art.[16] These changes became effective in 1992. They decreased or eliminated training related to obsolete technology and increased training related to newer engines, structures, materials, systems, and diagnostic procedures and equipment. The changes also specifically encourage using innovative training methods such as computer-based training (CBT).

More recently, the **FAA** has sponsored a multi-year effort to conduct a new job and task analysis for aviation maintenance. This work is essentially re-doing the old Allen Study. The results of the new job and task analysis will form the basis for future changes to Part 147 training curricula.[17]

The **FAA** and the aviation maintenance industry are also exploring ways to restructure the regulatory process. The intent is to allow a more responsive system that better accommodates a rapidly-changing industry, as well as to provide international harmonization among different aviation regulatory agencies.[4] Efforts to revise the FAA **AMT** certification process have lead to the development of a proposed Part 66. This new (proposed) rule prescribes enhanced training and certification standards for technicians who work on transport aircraft certified under Parts 25 and 29.

The new certification is called the Aviation Maintenance Technician (Transport) AMT-T. If the rule making process remains on schedule, the new rule (consolidated as Part 66) will become effective in 1998. Below are listed the key points to the new rule[18,19]:

- Establish a new rule to prescribe training and certification for aircraft maintenance personnel.
- Change from Mechanic (**A&P**) to Aviation Maintenance Technician (AMT).
- Combine **A&P** to a single rating - Aircraft.
- Establish recurrent training requirements.
- Establish an Aviation Maintenance Instructor rating.
- Allow work to be performed on a wet compass.
- Permit **AMT** Programs (**FAR** 147) to test applicants for AMT certificate when doing business as Part 66 training providers.
- **IA** renewal on a 2-year period.
- Establish a new certificate for "transport" category maintenance technicians.
- Establish an **AMT** instructor rating for **AMT-T** programs.
- Increase training requirements for personnel returning transport aircraft to service.

The changes in the certificate structure implies that corresponding training requirements will be needed. A report sponsored by the **FAA** Office of Aviation Medicine outlining guidelines for an **AMT-T** program is being written and will be published as an advisory circular in 1998.[20]

In addition to the new **AMT-T** certificate the **FAA** has proposed to upgrade certain specialist qualifications with additional focused and specialized training. These will be aviation repair specialist certificates (ARS-I). The FAA is currently considering issuing these certificates with ratings based on proficiency in the areas of nondestructive inspection (NDI), composite structure repair, metal structure repair, and aircraft electronics (from Part 66 **NPRM** draft proposal).[4] These certificates will be granted to the individual not the repair station. However, the ARS-I holder must perform his specialty while employed by an FAA-certified repair station.[18]

CONCEPTS

Certain training concepts apply to all domains, including aviation maintenance. Understanding these concepts can help one evaluate the *need* for particular types of training, as well as training methods offered by different vendors. A more detailed discussion of these concepts can be found in the references.[21] In general, however, they relate to matching **AMT**'s needs with the content, format, and delivery method of the training they receive.

Efficiency

The efficiency of any type of training is determined by how closely the content, format, and delivery method match the learners' needs. Efficient training delivers the appropriate types of information in the correct amounts at the right time. Trainers must understand both the job tasks that they want learners to perform *and* the knowledge and skills learners bring with them to training. This is often called the ***systems approach*** to training. It is much more efficient than traditional approaches.[22]

Job Performance Aid

In the most general sense, a job performance aid, or JPA, is anything that helps a person perform a task. For aviation maintenance tasks, the most common JPAs are workcards, maintenance manuals, and other forms of written procedures. Technicians do not have to commit the task information contained in (or on) the JPA, to memory. Since the JPA information doesn't have to be memorized, there is less chance that parts will be forgotten or left out when the task is being performed.

The tradeoff between which information must be committed to memory and which information can be transmitted via a **JPA** is called the *head-book* tradeoff.

Management

There is a tendency to think of training as a distinct, well-bounded activity that is completely separate from other management and work tasks. However, thoughtful consideration of the two domains -- training and management -- reveals many parallels in their requisite skills and abilities.

Both good training and good management require the ability to assess employee needs, evaluate personality characteristics, develop performance requirements that are challenging while not beyond each person's capabilities, and assess performance. Training should be considered an integral part of good aviation maintenance management.

Motivation

Motivation is usually classified as either *extrinsic*, (e.g., pay scales, promotions, or penalties), or *intrinsic* (e.g., professionalism and the satisfaction of simply doing a good job). It would seem obvious that people learn more and more quickly when they are motivated. Research attempting to demonstrate this effect, however, has been largely unsuccessful.[23,24]

While most people would claim that highly-motivated employees perform better, research studies have failed to confirm this. Studies have found that employees with minimal motivation usually perform as well as those who are highly-motivated. From a training perspective, the chief benefit of high motivation is that it makes people practice more, which definitely aids the learning process.

Practice

Practice is the most important activity associated with learning, particularly for learning skilled tasks such as those comprising an **AMT**'s job. The concepts described below are related to practice.

Feedback

Feedback is often called *knowledge of results*, or KR. Feedback can take many forms from a simple *right* or *wrong* at the end of a practice task to constant verbal feedback from an instructor. For many tasks, the equipment indicates whether or not tasks are being performed correctly.

There is no clear agreement that a particular type of feedback is best for all tasks. However, there is agreement that learners need some form of feedback so they can adjust their task performance appropriately.

Timing

Practice can occur in concentrated (*massed*) groupings or over a period of time. The factor distinguishing concentrated and spaced practice is the amount of rest time given between practice sessions. There is no clear evidence that one type of practice timing is preferable. At least one study has shown that spaced practice improves long-term learning.[25] Fatigue is most often cited as the reason for not using concentrated practice; learning diminishes when fatigue sets in. The best guidance is that the nature of the task should dictate a reasonable practice schedule.

Part Practice

Some tasks are simply too complex to learn all at once, and some tasks contain components in common with other tasks. When feasible, it is good practice to subdivide such tasks and learn them in parts. Some tasks are difficult to subdivide. However, for those that can be broken down, part learning is usually superior to whole learning. Interestingly, the order in which the parts are learned seems to be unimportant.[26]

Adaptation

Adaptation is the process of changing the difficulty of practice tasks to match a learner's ability. In general, training providing adaptive practice is superior to that which provides practice with a fixed level of difficulty.[27] For individualized instruction, adaptation allows for more efficient learning because training is essentially tailored to each person.

Mental Practice

It appears, at least for certain types of tasks, that practice does not have to be overt to be beneficial. Mental practice, sometimes called *covert* practice, has been shown to increase performance for perceptual-motor skills such as bowling and piano playing.[28] Mental practice can be seen as *thinking through* all the actions necessary in the real-life task. While it is not clear that mental practice increases performance for all types of tasks, it can be an effective learning tool.

Tasks

The single most important factor affecting a training program's content is the nature and complexity of *tasks* learners must master. There are many ways of classifying tasks; one distinction is between *verbal* and *motor* tasks. In turn, each category can be divided more precisely. To evaluate any type of training program, ask for a detailed analysis of tasks for which the program is designed.

Transfer of Training

Except for **OJT**, learners rarely train on the exact equipment and in the same environment that their real job tasks require. The extent to which knowledge and skills acquired during training transfer to their real jobs is called *transfer of training*. In aviation maintenance, some training utilizes aids such as life-sized mockups and simulators to enhance transfer of training. The important factor for such training appears to be its operational (or psychological) similarity to the real task, rather than its physical similarity.[29]

METHODS

There are many methods available for defining training needs, developing and evaluating training programs or modules, and actually delivering training to **AMT**s. Certain training methods are more appropriate than others for teaching specific types of skill and knowledge. In this section, we describe two development methods and six categories of training techniques. In the **GUIDELINES** section, we will provide detailed criteria for choosing among these methods.

Training Development

Below, we briefly describe two methods for developing training. The first technique is a very general approach that can be applied to all (or any combination) of training delivery. The second method is used primarily to develop on-the-job training (OJT).

Instructional Systems Design

Instructional Systems Design (ISD) is the name given to a category of design techniques that systematically proceed, in a top-down manner, from the most general instructional requirements to the most detailed. The ISD process has been around for many years and is used extensively by government agencies and the Department of Defense.[30]

Because it is so general, **ISD** can be applied to any of the training delivery methods described later in this section. **Table 7-1** shows the ISD process used by Galaxy Scientific Corporation to develop computer-based training.[30] **Table 7-2** shows the ISD process for developing classroom instruction in the aviation maintenance setting.

The steps found in **Table 7-2** are taken from John Cotter's presentation to **ATEC** in 1997 entitled "Developing Instruction for the **AMT-T** Curriculum: A Systems Approach".[31] This paper is a good starting point for developing classroom training for using a formal systems approach. Note that all of the steps through Step 6 could easily be applied to nearly any of the training delivery methods described later in the section. See **WHERE TO GET HELP** and **FURTHER READING** for references to more information in this area.

The DAPPER Model for On-the-Job Training

The **DAPPER** model (an acronym composed of the names of the steps in the model) has been put forth by Rothwell and Kazanas as a reasonable way of developing structured **OJT**. It is presented in "Improving On-the-Job Training: How to establish and operate a comprehensive OJT program".[32] A brief description of each step in the model is given in **Table 7-3**.

Note the similarities among the **DAPPER** model and the **ISD** method described above. All models that follow the systems approach will have similar steps, albeit with different names. A more detailed presentation of the DAPPER model is given in the **GUIDELINES** section.

Table 7-1. Instructional systems design approach for computer based training.
1. Planning - the purpose of the planning phase is to lay out a comprehensive project plan. This phase includes a cost-benefit analysis and an inventory of resources in order to determine the feasibility of training.
2. Learning Analysis · **Conduct needs assessment** - Assess what training is needed. Focus on skills and procedures that are needed to competently perform a task but not being demonstrated. · **Develop instructional goals** - Turn identified needs into goal statements, i.e., What do we want the training to accomplish? · **Develop learner profile** - Identify the skills trainees must have prior to entering training. · **Conduct task analysis** - Break task up into component parts. What procedures are needed to complete the job?
3. Design Strategy · **Performance objectives** - Define what the learner will be able to do at the end of the training. · **Course mapping** - lay out the general sequence of events for the course and map it back to the instructional goals. · **Learning hierarchy** - Structure a hierarchy of learning objectives. Skills should build on one another from lower to higher levels in the hierarchy. · **Criterion testing** - Develop tests where the learners can demonstrate their mastery of the material relative to objective criteria.
4. Prototyping · **Scripting** - Write scripts for all text and auditory information. · **Storyboarding** - Draw diagrams of all major screens - capturing functional actions of the program. This includes mapping out navigation through the program. · **Media selection** - Decide what types of media will add value to communicating the information and skills to be taught. · **Graphics** - Create graphics. · **Programming** - Write code that will control the flow and functionality of the program.
5. Full-Course Development · **Match objectives** - Check to make sure all performance objectives are being met. · **Content revisions** - Rewrite text scripts as needed. Make sure this step is completed before doing audio recording. · **Performance criteria** - Establish the performance criteria that learners must meet in order to pass the course. · **Documentation** - Write the help file(s) for the program. Write the instructor's manual and course developer's manual. Document all code.

Table 7-2. Instructional systems design for classroom training.
1. **Identify Instructional Goals -** Instructional goals are clear, precise statements establishing the goal of the instruction. This is usually derived from a needs assessment.
2. **Conduct Instructional Analysis -** Instructional analysis produces a description of skills and behaviors that, when performed, meet the instructional goals.
3. **Identify Entry Behaviors -** This step identifies the skills that the learners must have to begin instruction.
4. **Write Performance Objectives** - Performance objectives guide the designer in selecting content and developing the instructional strategy. At least one objective should be defined for each skill.
5. **Develop Criterion-Referenced Test Items -** Criterion-referenced test items determine whether an individual has mastered a skill or knowledge area by comparing his or her performance to an established criterion behavior.
6. **Develop Instructional Strategy -** The instructional strategy identifies the materials and defines the procedures that will be used by instructors to teach students.
7. **Develop and Select Instructional Materials -** This phase of the instructional development process clarifies the role of the instructor and the delivery of the instruction.

Table 7-3. DAPPER model for on-the-job training.
1. **Discover needs** - Determine whether or not OJT is appropriate.
2. **Analyze work, worker, and workplace -** Develop a job description for the work, establish criteria for selecting employees for the training, and describe the environment that must be present for competent work to occur.
3. **Prepare** - Develop performance objectives, i.e., means to evaluate level of mastery, sequence training components into a schedule, and design materials.
4. **Present** - Conduct the training.
5. **Evaluate** - Evaluate the results of the training program.
6. **Review** - Review training outcomes and update the training accordingly.

Training Delivery

Training methods can be placed into one of the following general categories:

- Classroom
- On-the-Job.
- Computer-Based
- Distance Learning
- Internet/Intranet
- Just-in-Time/Embedded

Boundaries between these categories often become fuzzy, e.g., what if we use a computer-based system in a classroom? However, the categories provide a useful framework for discussing training alternatives.

Classroom Training

Classroom training requires a human instructor to stand before a group of students and provide information related to a particular topic or set of tasks. The distinguishing feature of this training category is the presence of a *human instructor* who can respond to learners' questions, spend more or less time on particular topics, relate workplace experiences, and provide a flexible learning environment.

Classroom training uses a variety of presentation media and can include both verbal and hands-on practice on job tasks. Classroom instruction is the most commonly used *traditional* training method. It is, or can be, highly interactive and is particularly efficient for transferring declarative knowledge about what things are or how they work. Classroom instruction is also time-consuming, expensive, and not easily adaptable to individual learner's needs. It relies on the availability of skilled instructors and classroom space.

On-the-Job Training (OJT)

On-the-job training (OJT) is the generic name describing a variety of training methods in which trainees work while they learn job skills. On-the-Job training follows the apprenticeship model of education where a new employee is mentored by a seasoned employee thought to be an expert in the field. This is sometimes called the "buddy" system. Demonstration and supervised practice with equipment and procedures within the work environment is what is normally considered OJT.

OJT has several positive aspects: trainees perform many job tasks while becoming more proficient; trainees observe highly skilled technicians perform the tasks they are learning; and the trainees have an opportunity to build one-to-one relationships with mentors.

Improperly used however, **OJT** can be inefficient from both the points-of-view of learning and cost. The results of OJT are highly dependent on the trainer's teaching and interpersonal skills. In most OJT situations, the trainer is an **AMT** whose primary job is maintenance, not training. At its worst, OJT is idiosyncratic, incomplete, haphazard, and time-consuming.[33,34]

OJT is unsuitable for teaching skills such as non-destructive inspection (NDI) techniques.[16]

Computer-Based Training

Computer-based training (CBT) has become a generic term referring to any electronically-based technology used to create and deliver learning technology. Computer-assisted instruction and technology-based instruction are similar terms used in this context.

Training methods in this category are sometimes called *interactive*. This means **CBT** responds to an individual's actions. Older computer-based methods, sometimes called page turners, can be monotonously non-interactive. In more sophisticated **CBT**, such as Intelligent Tutoring Systems (ITS), the program will model student input -- adapting the course presentation and testing to the knowledge and skill level of the student.

One type of computer-based training that is noteworthy is called simulation-oriented computer-based instruction (SOCBI). It is particularly interesting because it provides users with the opportunity to practice diagnostic and troubleshooting skills, which are notoriously difficult to learn and maintain (see **Chapter 8**).

Most computer-based training products include built-in testing, student management, administration, and record keeping functions. Many products run on a variety of hardware platforms, including networked systems. The cost of hardware, while certainly a factor, is almost incidental to the cost of custom developed software.

Computer-based training can be more expensive to develop than either classroom or **OJT**. **CBT** is cost-effective in circumstances where the curriculum will be used repeatedly over multiple years and where standardization of the presentation and testing of trainees is important. CBT is an efficient method for training since it can provide independent, self-paced practice.

Distance Learning

There are several new trends in training. One is the notion of distance learning. Distance learning is a term that is used for any training where the instructor and the students are not co-located. Traditionally, distance learning has consisted of mail-centered correspondence courses. There are many videotape-based correspondence courses being offered. In these courses, the student views the videotape, completes the corresponding work assignments, and mails the materials back to the granting institution.

More recently, corporations have invested in satellite video classes and conferencing. With such advances in technology, the human instructor can actually be located at some distance from the students. In fact, the students themselves can be dispersed over a wide geographic area -- the "virtual" classroom. The Monroney Aeronautical Center in Oklahoma City, for instance, has installed a one way video classroom to train safety inspectors.

The main advantage of distance learning is that it provides a mechanism for people to continue their professional development without expending the time and money to physically travel to a central location.

Internet/Intranet

Many people have heard of "surfing the Internet". The Internet is a network of computers that "serve" public information to individuals with a computer, modem and access to an Internet provider. The Internet (and its forerunner, ArpaNet) was originally created by the government, **DOD**, and universities. It was to be used primarily for communications related to research and development.

In recent years, the Internet has evolved into a commercial and entertainment delivery system. What makes the Internet unique is its ability to act as a public forum. Whether it is hobbies, products, news or the weather, it can be found on the Internet. It is not surprising, then, to find on-line courses being offered through the Internet as well.

Intranets are private electronic networks set up by individual corporations and institutions to support communication, collaborative work and administrative tasks. Intranets provide for central storage and dissemination of information. Intranets are accessible from remote locations, but access to them requires that users pass through a level of security that screens the system from the general public, i.e., those people using the Internet.

As network technology has become sophisticated, it has become possible to deliver **CBT** over the Internet or an intranet. Most forms of CBT can be ported to an Internet/intranet system with existing technology. The main inhibitor to Internet/intranet CBT is the bandwidth required between the delivery system and the student. Sophisticated graphics, animation, and interaction between systems stretch the available communication bandwidth.

The advantages of using Internet/intranet training are consistency, wider access, ease of maintaining a single version (and copy) of the training software, and new mechanisms for interaction between instructor and students. An example of Internet/intranet training in the aviation community is a demonstration program for training pilots sponsored by Flight Safety International Inc. and Interactive Learning International Corp.[35]

Another example is the SMART Center (Safe Maintenance in Aviation Resource and Training Center), a project sponsored by the **FAA** Office of Aviation Maintenance, Human Factors in Aviation Maintenance program.[36] The SMART Center is a forum, available on the Internet, for sharing information and discussing issues related to **MRM**. See the **FURTHER READING** section for information on how to reach this site.

Just-in-Time / Embedded

Just-in-time training allows the user to learn about a particular job task just before or during the task itself. The terms "embedded" and "just-in-time" are often used synonymously, since the training can be considered to be embedded in the equipment or software that the **AMT** is using to perform their job.

The simplest form of just-in-time training is making relevant reference material easily accessible. Embedded references are implemented in several electronic document management systems for aviation maintenance and inspection. One such system is the On-line Aviation Safety Inspection System (OASIS), which has been distributed to the **FAA** Aviation Safety Inspectors.[37]

A second type of embedded training is the sophisticated, context-sensitive "help" files that have become commonly available. In these applications, users can ask a specific question about a task and have that question answered. If the user needs more information or explicit instructions, then they can request that level of assistance as well. A third example is to have a coaching mechanism embedded in an electronic form to coach an employee through a procedure filling out the form.

All three of these examples are training aids associated with an electronic job aid. The non-electronic equivalent of just-in-time training is apprenticeship-based **OJT**.

READERS TASKS

This *Guide* is directed toward maintenance managers who will probably not have the time, training, or inclination to develop classroom or computer-based training. It is entirely within the scope of a manager's job, however, to evaluate and select training methods and products, to oversee and pay for training development, and to oversee the development or selection of on-the-job training.

Below, we describe three tasks that relate directly to selecting appropriate training methods, evaluating various computer-based training products, and developing structured **OJT**. Regardless of whether managers are directly involved in these tasks, they are ultimately responsible for the effectiveness of initial and recurrent **AMT** training.

Training Selection

There are a number of common job scenarios in which maintenance managers need to participate in the selection of training methods. Three such scenarios are listed below.

1. The airline is buying a new type of aircraft or adding a new system to existing aircraft. Aviation Maintenance Technicians must learn to troubleshoot and service the new systems.
2. Existing employees' skills must be upgraded to enable them to use new types of test equipment.
3. Novice technicians must be trained to support an increased maintenance workload. Such a demand is sometimes accompanied by a *per capita* reduction in the training budget.

In each of these scenarios, the maintenance supervisor must select one, or more, training methods or products from a large number of offerings. If your organization has a Training Department, it should have most of the responsibility for selecting training methods and materials. However, even if a Training department makes the final choice, maintenance managers are ultimately responsible for the training outcome and should understand the basis for their decisions.

In this chapter's **GUIDELINES** section, we provide a list of criteria that can be applied to select the most appropriate training method(s) to accommodate particular training objectives.

CBT Evaluation

While it is not a reasonable task for maintenance managers to develop **CBT**, it is certainly appropriate for managers to be involved in the decisions regarding which CBT products to purchase.

In the **GUIDELINES** section, we provide a number of criteria that can be used to evaluate the completeness and potential effectiveness of **CBT** products.

Training Development

Maintenance supervisors are occasionally asked to develop a training program for some specific purpose. In general, this *is not* a reasonable assignment if any classroom or computer-based training is involved. However, experienced supervisors are certainly capable of developing or directing **OJT** development. For help in developing OJT, we present a detailed description of the **DAPPER OJT** development process in the **GUIDELINES** section.

GUIDELINES

These guidelines are keyed to tasks listed in the previous section. There are no guidelines in this section for developing and implementing computer-based courseware: such an endeavor is beyond the scope of this *Guide*. Should readers be interested in this topic, there are at least two aviation industry groups actively involved in developing such guidance.[38,39]

Training as a Part of Management

Training, particularly **OJT**, is an integral part of good management. One of the most important skills for good management is observation. Being observant will let a manager know who an employee is and what his or her talents and weaknesses are. For each of their workers, good managers must be able to assess:

- their skills,
- their ability to learn new skills quickly,
- their ability to complete tasks without supervision,

- whether they pay attention to detail or are global thinkers,
- whether they are comfortable in solving ill-specified problems
- whether they are good at trouble shooting
- whether they are good at following directions,
- whether they have a positive attitude toward their work, their colleagues, and the organization,
- whether their fellow workers look to them for leadership and guidance, and
- whether or not their judgment can be trusted, and
- whether they are honest with you.

All of these factors are important to managers when deciding how to allocate tasks and choosing project leaders. In each case, astute observation and good listening skills are essential to making the right decisions.

Good observation and listening skills are also essential for training. The first step required for effective training is to realize that training is needed. Sometimes this step is easy. A new task needs to be done and someone needs to be trained to do the job; **AMT**s must be chosen to learn a particular new skill; one or more new employees have arrived and they need orientation.

In a case when people need to be chosen to learn a new task or skill, a manager's ability to match the individual to the task to be learned will largely determine the speed and success of the required training. Answers to the following questions help determine whom to train for which new task.

- How difficult is the task?
- Does the person have the right prerequisites for the skill or task?
- How long does it take the person to learn something?
- Does the person learn things at a deep or cursory level?

One candidate may take longer to learn something but the person's level of performance will be high once it is learned. Another candidate may learn tasks quickly but at a cursory level. If something "quick and dirty" is needed, where quality is less of a factor, then the latter candidate may be the appropriate choice. If quality and precision are needed then the former candidate may be the better choice.

Offering someone an opportunity to learn is typically perceived by the employee as a vote of confidence from management. It is an easy morale builder for an organization to use. Most people want to learn new things in their jobs. Otherwise they feel like they are not growing. Some people, actually many people, go through an initial anxiety period when they are asked to learn something new. They fear that they will not be able to master the designated task. With the right orientation from the manager, that fear quickly passes.

Don't give a learner a learning task for which he won't experience some immediate success. If it is a complex task, warn the learner that she probably won't master the whole task right away.

Help them break the task down into smaller tasks, so they don't feel they have to master everything all at once. Make sure they understand why they are learning the task. Show them how it fits into the grand scheme of things, and, if they are expected to interact with others, what they can expect from others and what others can expect from them.

Teaching should not be a belabored affair. Demonstrate the tools and steps for the task. Let the person try it under guidance and then give them an opportunity to practice. Allow a period of unsupervised practice. Check in later and see how things are going.

Some learners are hesitant about learning new processes. Don't mistake this for lack of motivation. For these individuals, check in several times to give them an opportunity to ask questions. Such individuals will always have questions, but the questions will begin to demonstrate their mastery of knowledge rather than their ignorance. When their questions begin to indicate mastery, congratulate them. This is an easy way to increase self esteem.

For learners who act too confident about their knowledge or their ability to learn, let them learn autonomously, but check their work carefully. Don't assume they have learned something just because they say they have learned it. An informal discussion about the steps they went through to learn the task will usually reveal their level of mastery.

Finally, there is a tendency to train the most competent people for every new task. After all, we know we can count on these people to learn quickly. Be sensitive to the fact that these people tend to overextend themselves. Information overload is a very real problem in the work environment. Whenever possible, make sure people have time to absorb knowledge and become competent with their new skills before they are asked to learn another new skill.

Training Selection

All maintenance training should be viewed in the context of an overall *training system* accounting for the knowledge and skills to be learned, the existing proficiency of the students, and the work environment in which training occurs. Certain training methods are appropriate for specific job tasks. These guidelines address the general issue of selecting training methods.

Classroom Training

Classroom training is most appropriate when face-to-face interaction is needed to convey concepts and skills. Hands-on demonstration and practice with a piece of equipment, role playing, and small group problem solving are best done in a classroom setting. Classroom training allows instructors to give a high-level, conceptual overview of a topic. Classroom instruction is also the method of choice for teaching soft skills, such as communication, where interaction among students is essential.

On-the-Job Training (OJT)

Structured **OJT** is an appropriate training choice for a wide variety of **AMT** tasks. **Table**

7-4 lists a number of situations in which OJT is appropriate and when it is not.

Computer-Based Training

There are many types of **CBT**. In general, CBT is very good for introducing basic concepts, for enhancing skills that require practice, such as troubleshooting and computational skills, and for the rote memorization of facts, such as specifications. The general selection criteria for various forms of CBT are given below.

Drill and practice

CBT is excellent in any situation where automation of skills is desirable. Computational skills, rote memorization of facts, recognition tasks, and timing all lend themselves to a drill and practice type of CBT. Drill and practice CBT is usually designed to be taken in small doses, about 20 minutes per module and allows individuals to practice on their own, during off-peak times.

Table 7-4. Guidelines for determining when OJT is appropriate.

OJT may be appropriate in the following situations:

- Trainees already have prerequisite knowledge and skills. They do not need long explanations and discussions.
- The target skills can only be learned, or learned best, in an actual work setting.
- The job environment cannot be reasonably simulated or replicated in the classroom or with computer-based training.
- The target skills involve specialized systems or equipment found in the workplace.
- When the training tasks closely match tasks in the workplace, e.g. performing the steps in a procedure.
- When line and staff organizations have a high level of financial and human resource commitment to training employees on the job.

OJT is probably inappropriate in the following situations:

- The work environment is too noisy, too stressful, or has conflicting or distracting background activity.
- The target skills require the detailed presentation of theory, knowledge, concepts, and principles.
- Delivering OJT results in significant decreases in workplace productivity.
- The target skills require extensive practice time.
- Large numbers of students must be trained in a short period of time.

Electronic book

CBT is good for introducing basic concepts. In this case, it can be thought of as an interactive book. The learner is usually given a pretest and then taken through conceptual material appropriate to their level. Each unit is often enhanced with graphics, audio commentary, and video in addition to the text. There are typically practice exercises interspersed through the unit. When learners are ready, they can take a post test.

Electronic books can be used as a stand-alone, self-paced course but are best used in combination with face-to-face classes. Instructing students to go through material in an electronic book prior to a class helps ensure that all the students have mastered the basic prerequisites for the class. Instructors are more confident that the entire class is operating at the same level. Concept-oriented **CBT** is also a good method for reinforcing concepts taught in a traditional class lecture. Remedial training is a good use for this type of CBT.

Simulation-oriented and intelligent tutoring

Simulation-oriented computer-based instruction (SOCBI) and Intelligent Tutoring Systems (ITS) are the most sophisticated forms of **CBT**. They are most appropriate when an individual must learn to use a piece of equipment or a task technique, but practicing on the equipment itself is dangerous or, from a standpoint of cost and time, impractical. Flight simulators are the best example of using computer simulation for training pilots. In the maintenance arena, troubleshooting simulators for hydraulic or avionics diagnostics are good training examples.

Distance Learning

Distance learning has many of the characteristics of classroom instruction and is usually appropriate in the same conditions. There is typically a live instructor, although he or she is not in the same location as the students. The instructor can be seen and heard by the students, as can the slides or notes generated by the instructor during a class period. A mechanism is usually in place to allow students to ask questions and, when the students are dispersed in various locations, to hear the dialog between other students and the instructor.

The choice between normal classroom instruction, in which the instructor and students are co-located, and distance learning is typically based on logistic and cost considerations.

Internet / Intranet Training

Internet/intranet training is a specific type of distance learning that has the potential to accommodate both live instruction and interactive courseware comparable to **CBT**. The biggest advantages of Internet/intranet training is its accessibility. Anyone with the proper computer and communications setup can participate.

The disadvantages of this type of training are technological. Without dedicated communication lines and servers, the response time of Internet/intranet training can vary from no noticeable delays to growing old waiting for the system to respond. As information transmission becomes faster and more reliable, you can expect to see Internet/intranet-based training become more popular and available.

Just-in-Time / Embedded Training

Just-in-time training is conceptually very popular among managers because the time required for training is hidden in the total time to perform a task. That is, there is no time set aside specifically for "training". Some of the most popular software applications and operating systems rely on embedded training in the form of sophisticated contextual "help" programs. Embedded training is appropriate when the following conditions apply:

- learners are not complete novices, but have some knowledge of the topic area
- the task to be learned is bounded and conceptually simple
- the media in which training is embedded are part of the task or equipment to be learned.

Table 7-5. Human factors criteria for evaluating computer-based training products.
STUDENT INTERFACE
Simplicity - The words and graphical elements should be easy to understand. Students should not have to memorize commands or action sequences.
Consistency - The interface should be consistent with other computer interfaces students use. Similar actions should always cause similar results.
Redundancy - The interface should allow students to respond using their choice of input devices.
Parsimony - The software should present only information needed to achieve its stated learning objectives. Extraneous information should be withheld.
Robustness - The software should handle foreseeable student errors without "crashing." It should recover gracefully, with no loss of student data.
Clarity - Any coding, such as color, should be minimal, consistent, and easy to interpret. Coding should use learned stereotypes whenever this is possible.
Media - The software should use media most appropriate for the task being taught. For example, audio output is useful for teaching the meaning of audio alarms and warnings.
INSTRUCTOR INTERFACE
The instructor interface should embody the basic human factors criteria listed for the student interface, as well as those listed below.
Consistency - The interface should be consistent with other computer-based training interfaces. It should respond consistently to similar instructor input.
Flexibility - The interface should allow instructors to tailor the instructional content and flow for individual students.
Record Keeping - The software should automatically retain whatever measures the instructor deems most appropriate. All records should be easily accessible by instructors.
Student Management - The interface should allow instructors to enter, edit, and retrieve student information.
Testing - The interface should allow instructors easily to test student proficiency. It should allow instructors to construct, retain, retrieve, and administer tests.

Evaluating CBT Products

All forms of computer-based instruction require some interface between the computer and the people who will interact with the **CBT**. One point that is commonly overlooked when considering CBT is that both students and instructors will use the program. When evaluating computer-based training products, consider the ease of administering the software, configuring tests, customizing the package for individual learners, hardware compatibility, cost, etc. Remember that easy-to-use products are used more frequently and effectively.

Table 7-5 lists the most important human factors criteria for evaluating computer-based training.[38] As with previous selection criteria, we do not intend these criteria as the final word. However, when these criteria are not met, the risk of the product failing to be used effectively increases. Criteria for selecting software for authoring computer-based training is beyond the scope of this G*uide*. However, if a maintenance organization intends to develop computer-based training, refer to the Aviation Industry Computer-Based Training Committee (AICC) Guidelines and Recommendations[39] for criteria to follow when choosing an authoring environment.

Developing Structured OJT

Structured **OJT** can be an effective training method, when developed and delivered properly. However, OJT does not exist in a vacuum. Rather, it is part of the overall work and training environment in which **AMT**s and managers function. **Table 7-6** lists some of general characteristics of structured OJT.

The following framework for **OJT** development is taken from Rothwell and Kazanas's "Improving On-the-Job Training: How to establish and operate a comprehensive OJT program".[32] This book is an excellent reference for anyone considering implementing an OJT program. The **DAPPER** model includes sample checklists and forms that are easily modified to fit specific job requirements. Below, we describe each step in the DAPPER process. Within certain steps, we provide information from other sources.

Discover Needs

Is **OJT** appropriate for a particular training need? Will it fit into your organizational culture? Rothwell and Kazanas suggest asking (and answering) the following questions:

- Is the learner new to the organization, division or department, work unit, job?
- Does the learner lack knowledge of the essential job function?
- Does the learner lack knowledge of when to perform specific job tasks?
- Have performance obstacles in the work environment been removed?
- Is **OJT** more cost effective than other solutions?
- Can workplace distractions be minimized?
- Can workplace health and safety hazards be minimized?
- Can adequate time, staff, and other resources be devoted to **OJT**?

A negative response to any of these questions should be cause for further consideration of whether **OJT** is the most appropriate training method for the job or tasks being evaluated. A positive response to all questions suggests that structured OJT might be appropriate. **Table 7-4** contains more specific criteria to determine when OJT is (and is not) the proper choice for an effective training method.

Table 7-6. General guidelines for structured OJT.

Structured OJT should have the following characteristics:

- Be developed as an integral component of the overall technical and skills training program.
- Be based on written, agreed-upon, and measurable performance standards.
- Be designed and delivered in a systems framework that includes information presentation, demonstrations, practice, and evaluation.
- Be designed to provide initial, recurrent, and remedial training.
- Be used to standardize procedures and to provide consistent training among workers.
- Be conducted by experienced employees who have
  - demonstrated exemplary performance and task mastery
  - strong interpersonal communication skills
  - been trained in structured **OJT** techniques and adult learning principles.
- Be delivered in segments that
  - are planned, scheduled, and frequent
  - include keeping complete, up-to-date trainee performance records.
- Be audited annually to identify
  - signs of obsolescence
  - new or emerging needs
  - opportunities to make existing OJT processes more efficient
  - organizational changes that might result in improved job performance.

Analyzing Work Elements

Once an appropriate **OJT** need has been identified, we must then define exactly what we want the OJT to accomplish in terms of transferring skills, knowledge, etc. In general, one must asses the work, the worker and the environment in which the work is being performed.

The analytical steps required to complete each type of analysis are listed below.

Work analysis

1. Collect background information about the job.
2. Develop a work plan to guide your analysis.
3. Conduct briefings to organizational stakeholders.
4. Select an information-gathering approach that will yield desired information within existing time, money and staffing constraints. Approaches include: observation, individual interviews, group interviews, written questionnaires, diaries, computerized conferences, audio teleconferences, and critical incident reporting.

5. Prepare a draft job description and have all stakeholders review it.
6. Prepare a final job description.

Worker analysis

1. Prepare an ideal job candidate profile (knowledge, skills and attitudes required for each essential job function).
2. Specify minimum entry-level criteria.
3. Develop assessment methods. Assess how well each job applicant matches up to the minimum entry-level criteria, based on applicant's education, training, and work experience.
4. Develop selection methods. Using checklists, worker profile, and applicant information, develop nondiscriminatory employment interview questions and written or performance-based examinations to compare applicants.
5. Select job candidates according to fair employment practices.

Workplace analysis

For the worker to perform competently on a specified task, the workplace must support the worker's needs for appropriate workspace characteristics, environmental conditions, tools, access to information, job aids, co-workers, communication channels, etc. A proper workplace analysis should, at a minimum, answer the following questions:

- What conditions must exist in the workplace?
- What tools or equipment must be supplied?
- What information must the worker have?
- How much interdependency exists among jobs in a work unit or team?
- What health and safety hazards are present in the workplace?

Training Plan

Rothwell and Kazanas recommend that trainees be oriented to the new work unit before **OJT** starts. Trainees will better understand how the results of their work contribute to the organization's ability to meet its goals if they are oriented to these goals and needs before training begins. To create a training plan Rothwell and Kazanas suggest:

1. Use the results of the work, worker, and workplace analysis to get a big-picture view of the essential job functions on which the learners need to be trained.
2. Assigning peer sponsors to the trainee before **OJT** begins to encourage the learners' socialization into the organization.
3. Prepare performance objectives. Develop performance objectives directly from the essential job functions listed on the job description.
4. Establish means to assess learner mastery (e.g., oral or written questions, homework, independent study, work assessment)
5. Sequence **OJT** segments. OJT should be sequenced and organized around trainee needs.

6. Prepare a plan and schedule (i.e., what will be taught and when).

Presenting structured **OJT** in the appropriate sequence is an important determinant of the overall effectiveness of the training. **Steps 5** and **6**, above, require that OJT be structured and scheduled - and that a formal plan be developed. **Table 7-7** provides a recommended sequence for structuring OJT. Note that this sequence provides for complete closure. That is, the results of training are objectively evaluated to determine their effectiveness.

Designing Instructional Materials

The next step is to develop instructional materials that will support **OJT**. Various types of instructional materials can work well in an OJT setting. In addition to workcards and the technical manuals and procedures that already exist in the **AMT** workplace, the following types of materials are useful:

Topical outline - summarizes the **OJT** content. It is based on the results of the work, worker, and workplace analyses. Topical outlines describe what and when not how, can be developed quickly, and ensure a logical, consistent training sequence.

Task training checklist - covers specific parts of tasks that students will learn, when training will occur, how it will occur, and how task competence or completion of training will be verified.

Lesson plan - summarizes who will conduct instruction, to whom instruction is directed, and what, where, when, why and how instruction will take place.

Learning contract - a binding agreement explicitly listing the results to be achieved through structured **OJT**. Includes learning objectives, learning resources and strategies, and target date(s) of accomplishments or completion. This is essentially an agreement among the teacher(s) and student(s) stating what will be taught and learned.

Learner interview guide - a list of questions about job functions or tasks. It is given to newcomers to guide them through a self-directed inquiry process. The lesson plan guides trainers in showing the ropes to a newcomer. The interview guide lists questions that guide newcomers to learn the ropes for themselves. Learners need to be able to take initiative to be successful in this approach.

Presenting training

When their level of responsibility has been clearly defined, on-the-job trainers and learners feel confident about what they are expected to do and how they will be held accountable. The role of the trainer is to provide guidance on the proper ways to perform work tasks, provide support so learners feel comfortable, and model effective role behavior.

Ultimately, the effectiveness of **OJT** depends on the ability of trainers to convey information. One of the major disadvantages of OJT is that its quality can vary significantly based on the trainers' qualifications and skill. **Table 7-8** lists some of the most important characteristics that define proficient OJT trainers.

Managers bear the responsibility for ensuring that workers receive **OJT**. It is up to them to juggle work schedules or staffing to make the time and people available for OJT. They are usually held accountable if things go wrong.

Table 7-7. Guidelines for delivering structured OJT.

Structured OJT should be delivered in the following sequence.

1. Orientation
   - Explain how OJT relates to the overall training program.
   - State the objectives of the OJT session.
   - Motivate the trainees by explaining why the OJT session is required and why the skills to be learned are important on the job.
   - Introduce trainees to the equipment to be used and review basic principles and procedures of operation.
2. Information Presentation
   - Put trainees at ease.
   - Involve trainees with OJT course materials.
   - Show and tell in small "bites."
   - Emphasize safety and quality issues.
   - Check often for trainee understanding, using both verbal and non-verbal cues.
3. Demonstration
   - Make sure trainees have a clear view of the equipment to be demonstrated.
   - Demonstrate procedures slowly, one step at a time.
   - Explain each step verbally, as it is being performed.
   - Explain what to do, how to do it, and why it is done.
   - Emphasize the equipment's safety aspects.
4. Practice
   - Allow ample time for practice.
   - Guide and prompt, but let trainees perform the procedures.
   - Provide corrective feedback only as required.
   - Reinforce correct behavior with praise.
   - Offer advice based on experience and emphasize safety.
   - Allow trainees to perform procedures with no guidance.
5. Evaluation and Closure
   - Evaluate trainee performance against procedures and written standards.
   - Review the procedures that trainees have learned.

- Reinforce learning with positive feedback (praise).
- Answer trainees' questions. Pose questions about key points.
- Identify areas where trainees need more practice.
- Discuss any planned performance evaluation.
- Remind trainees to use OJT materials as job performance aids following training.

Table 7-8. Guidelines for selecting on-the-job trainers.

OJT trainers should be selected based on the following characteristics and skills:

- Sufficient length of time on the job
- High level of motivation and a positive attitude toward the job
- Demonstrated mastery of the task(s) they will be training
- Well-developed interpersonal communication skills
- Overall willingness and desire to share their job knowledge and experience
- Ability to organize, plan, and solve problems
- Coaching skills and the ability to constructively question others' performance.

Table 7-9. Common categories of objective task performance criteria.

- **Time** - How long should it take a technician to perform this task?
- **Errors** - Which (and how many) errors are acceptable when performing a task?
- **Tolerances** - Within which range of adjustment or system function can acceptable performance reside?
- **Number of Steps** - How many steps should be required to perform this task?
- **Tools/equipment** - Which type of tools and test equipment should be used to perform this task?
- **Help and Advice** - Should this task be performed alone, or should the technician seek help or advice from others?

Presentation

Effective **OJT** is based on at least two presentation characteristics. First, learners must be in an environment and frame of mind that support attentive learning. Second, trainers must be willing to repeat a task or operation several times, usually at a pace that is considerably slower than the task might be performed by an experienced **AMT**.

According to Rothwell and Kazanas, **OJT** trainers should use the following basic presentation sequence:

1. Arrange work area
2. Set learner at ease
3. Show learner how to perform the task
4. Explain key points
5. Show learner how to perform the task again

Research on short-term memory suggests that people forget about 75 percent of what they learn within 48 hours.[40] By demonstrating a function again (and again and again, if necessary), trainers increase the odds that what they demonstrate will stick. Rothwell and Kazanas suggest the following as a good sequence for reinforcing a newly learned task:

1. Let the learner do simple parts of the job giving them constructive criticism after the performance. Constructive criticism focuses the learner on what should be done not on what should not be done.
2. Let the learner perform the whole job as the trainer watches.
3. Let the learner perform the whole job alone, with trainer feedback at the end of the task sequence.
4. Put the learner on his or her own with only periodic feedback.

Evaluating Results

With structured **OJT**, little or no time lag exists between instruction and application, and supervisors or co-workers typically act as trainers. During each cycle in which a learner performs the task that is being trained, the trainer should be evaluating the learner's work. These evaluations tend to be subjective, which is not to say they are ineffective. There are many objective evaluation criteria that can be used to quantify learners' task performance. **Table 7-9** lists some of the more common objective task performance criteria.

Review

A good **OJT** program should be reviewed on a regular basis. Usually the first couple of times a program is implemented it will not be perfect. Use your evaluation results and test outcomes to guide the improvements to the program. Once the course has been established review it periodically (at least once per year - **Table 7-6**) to keep the information and procedures current.

WHERE TO GET HELP

Aviation and Human Factors Specific Training

Air Transport Association of America
Engineering Department
1301 Pennsylvania Ave., NW
Washington, DC 20004
Phone: (202)626-4000
Fax: (202) 626-4081
E-mail: ata@air-transport.com
Web site: http://www.air-transport.org

American Society for Training and Development
1640 King St.
Alexandria, VA 22213
Phone: (703) 683-8100
Fax: (703) 683-1523

Human Factors and Ergonomics Society
PO Box 1369
Santa Monica, CA 90406
Phone: (310) 394-1811
Fax: (310) 394-2410
Web site: http://hfes.org
Email: hfes@compuserve.com

Classroom Training and AMT-T Curriculum Development

Charles W. White
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Rt. 1 Box 151C
Bridgeport, West Virginia 26330, USA
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Michael J. Kroes
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On-the-Job Training

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Computer-Based Training and Distance Learning

Terrell N. Chandler Ph.D.
Galaxy Scientific Corporation
2130 LaVista Executive Park Drive
Tucker, GA 30084
Phone: 770-491-1100
Fax: 770-491-0739
Email: terry.chandler@galaxyscientific.com

FURTHER READING

The documents listed below may or may not be specifically referenced in the chapter. They contain information of general and fundamental interest pertaining to training. These citations are grouped under general topics to make finding particular information easier.

General and Classroom Training

American Society for Training and Development (ASTD) (1989). *Training America: Learning to work for the 21st century*. Alexandria, VA: ASTD.

Carneville, A. P., Gainer, L. J., and Meltzer, A. S. *Workplace basics: The essential skills employers want.* San Francisco, CA: Jossey-Bass Publishers.

Carr, C. (1992). Performance support systems-The next step? *Performance and Instruction, 31* (2), 23-26.

Department of Labor (1988). *Workforce 2000: Work and workers for the 21st cenury* (**DOL** Report HI-3796-RR). Washington, DC: Department of Labor.

Federal Aviation Administration Academy (1990, June). *Training technology - present and future*. Federal Aviation Administration Training Technology Symposium. Oklahoma City, OK.

Federal Aviation Administration. (1997). *Developing and presenting effective training*. Videotape. Running time 39 minutes. Available in 1/2" VHS tape format. Accompanying handbook must be specifically requested.

For copies contact: Lee Norvell, **FAA** National Headquarters, AFS-340, 800 Independence Avenue S.W., Washington, DC 20591, (202) 267-8616.

Gordon, S. E., (1994). *Systematic training program design*. Englewood Cliffs, NJ: Prentice Hall.

Johnson, W. B. (1987). *Workforce 2000.* Indianapolis, IN: Hudson Institute.

Rossett, A. (1992). Analysis of human performance problems. In H.D. Slotovitch and E.J. Keeps (Eds.), *Handbook of human performance technology.* San Francisco, CA: Jossey-Bass Publishers.

Aviation-Specific Training

Boyce, J. (1992). The need for further training. *Aircraft Technician.* May/June.

Cotter, J. D., (1997). Developing instruction for the AMT-T curriculum: A systems approach. In *Proceedings of the Annual Conference of the Aviation Technician Education Council* (ATEC), April 14-15, Orlando, Florida.

Parker, J. F. (Ed.) *Human factors issues in aircraft maintenance and inspection, training issues.* Washington, DC: Federal Aviation Administration.

Instructional Design

Briggs, L., Gustafson, K. L., and Tillman, M. H. (1991). *Instructional design: Principles and applications* (Second Edition). Englewood Cliffs, NJ: Educational Technology Publications.

Greer, M. (1992). *ID project management: Tools and techniques for instructional designers and developers*. Englewood Cliffs, NJ: Educational Technology Publications.

Computer-Based Training

Aviation Industry Computer-Based Training Committee (AICC) (1992). *CBT courseware/hardware matrix.* Grand Forks, ND: AICC.

Baker, E. L., & O'Neil, Jr., H. F., Eds. (1994). *Technology assessment: In education and training*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Bergman, R. E., & Moore, T. V. (1990). *Managing interactive video/multimedia projects.* Englewood Cliffs, NJ: Educational Technology Publications.

Fletcher, J. D. (1990). *The effectiveness of interactive videodisc instruction in defense training and education* (IDA Paper P-2372 DRAFT). Alexandria, VA: Institute for Defense Analysis.

Gery, G. (1991). *Electronic performance support systems.* Boston, MA: Weingarten Publications.

Reynolds, A. (1992). The basics: High-tech training technologies. *Technical and Skills Training, 3* (4), 33-34.

Weingarten Publications, Inc. (1992). Comparing authoring systems: Where do you start? *CBT Directions, 4* (3), 15-29.

Distance Learning

Eurich, Nell P., (1990).. *The learning industry: Education for adult workers*. Princeton, NJ: The Carnegie Foundation for the Advancement of Teaching.

Mason, R., & Kaye, A., Eds. (1989). *Mindweave: communication, computers and distance education*. New York, NY: Pergamon Press.

Mood, T. A., (1995). *Distance education: An annotated bibliography*. Englewood, CO: Libraries Unlimited, Inc.

Newsletter: *The Lakewood report on technology for learning: Practical ideas for creating a wired, retooled, and networked learning organization*. Contact 1-800-328-4329 for subscription information. Subscriptions are $291/year. Group subscription rates are available at significant discounts. A general description of the publication can be found at http://www.trainingsupersite.com.

Percival, F., Land R., & Edgar-Nevill D., Eds. (1995). *Computer assisted and open access education: Aspects of educational and training technology XXVIII*. Brunswick, NJ: Nichols Publishing.

SMART Center (Safe Maintenance in Aviation Resources & Training Center). Sponsored by the **FAA** Office of Aviation Medicine Human Factors in Aviation Maintenance and Inspection (HFAMI) Program (DTFA01-94-Y-01013). The SMART Center can be accessed through Http://hfskyway.com. Click on the Training button once you have entered the HFAMI Web site.

On-the-Job Training

Broadwell, M. (1986). *The supervisor and on-the-job training*, Third Edition. Reading, MA: Addison-Wesley.

Department of Defense (DOD) (1990). *On-the-Job Training Handbook* (DI-ILSS-81101). *Military Training Programs* (MIL-STD-1379D). Washington, DC: Department of Defense.

Grace, P., and Straub, C. (1991). Managers as training assets. *Training and Development*, **45**(6), 49-54.

Jacobs, R.L. (1992). Structured on-the-job training. In H.D. Slotovitch and E.J. Keeps (Eds), *Handbook of Human Performance Technology*. San Francisco, CA: Jossey-Bass Publishers.

Marsh, P.J., & Pigott, D. (1992). Turning a new page in OJT. *Technology and Skills Training*, **3**(4), 13-16.

Navy Sea Systems Command (NAVSEA) (1986). *On-the-job training handbook, training materials development* (DOD-HDBK-292-1/2). Washington, DC: Department of the Navy, NAVSEA.

Rothwell, W.J., Kazanas, H. C. (1994). *Im-proving on-the-job training: How to establish and operate a comprehensive OJT program*. San Francisco, CA: Jossey-Bass Publishers.

Rothwell, W. (1996). *The self-directed on-the-job learning workshop*. Amherst, MA: Human Resource Development Press. (Phone: 1-800-822-2801)

Rothwell, W. (1990). *The structured on-the-job training workshop*. 2 vols. Amherst, MA: Human Resources Development Press. (Phone: 1-800-822-2801)

Rothwell, W. (1996). *The just-in-time training assessment instrument*. Amherst, MA: Human Resource Development Press. (Phone: 1-800-822-2801)

Wichman, M. A. (1989). On-the-job training: Formalizing informality or shouldn't supervisors do the training? *Performance and Instruction*, **28** (1), 31-32.

EXAMPLE SCENARIOS

The scenarios below represent some typical training-related tasks one can expect to encounter in the workplace. We include these scenarios in the *Guide* to demonstrate how the authors foresee the document being used. For each scenario, we describe how issues raised in the scenario can be resolved. There is usually more than one way to approach these issues, so responses below represent only one path users of the *Guide* might take.

As a general rule, always start to look for information by using the Search function. There will be instances that you already know where required information is located. However, unless you frequently use specific sections of the *Guide*, you might miss information pertaining to the same issue located in more than one chapter. The Search will allow you to quickly search all chapters simultaneously.

Scenario 1 - Training for a New System

You've been told that your organization will have to begin maintaining a new electro-hydraulic actuation system. This system combines some elements of hydraulic systems you presently maintain with very new electrical diaphragm pump technology. None of your technicians have ever seen or worked on this new system.

Issues

1. What type(s) of training is most likely to provide the knowledge and skills required to work on this system?
2. How do you select the first technicians that will be trained to maintain the new system?
3. What part, if any, will on-the-job training (**OJT**) play in your proposed training program?

Responses

1. A couple of components of this issue are important in determining the best type(s) of training. First, technicians have never seen or worked on this type of system, although it combines elements of systems they have seen. Second, we have to provide knowledge about the new system, as well as hands-on practice.

Training Delivery in the METHODS section and **Training Selection** in the GUIDELINES section provides much of the information we need to resolve this issue. We know that we need to teach declarative knowledge -- describe the new system's components and how they work together. We also need to teach specific cognitive skills -- show how to troubleshoot this system and allow for practice. Finally, we need to teach specific manual skills -- how to test, remove, and replace specific components within the system. Below is an outline for the sequence and types of training that might me used for a new system.

a) Introduce basic concepts of the new system through written materials, **CBT**, or an introductory video. These materials are likely to be supplied by the manufacturer of the system. Make inquiries to the manufacturer about such support material. If introductory materials are not available, draw introductory conceptual materials from the supplied manuals.

   In any case, make it clear to your employees that you expect them to go through the material prior to the orientation class. By taking this step, you are priming your employees to be receptive to the material you will be presenting in class. You will find their understanding and retention will be much higher if they prepare ahead of time.

b) Introduce the basic concepts of the system in one, or more, formal class sessions. If your employees have done their pre-class orientation, these sessions should progress quickly and smoothly. Questions from your audience will be focused and informed. Don't let your class session degenerate into a question and answer session, even though your **AMT**s have seen some of the material before.

   Reinforcing conceptual material is very important for long term retention. Questions should be encouraged but they should come at logical breaks in the presentation. If the students have done their homework, then you should be able to move the material quickly and efficiently.

In addition to manipulatives (practice components), manufacturers of new complex systems should offer troubleshooting **CBT** for practice as part of their total training package. Using an electronic white board or some other electronic projection device, instructors can set up trouble scenarios for group troubleshooting exercises during class. Instructors can then model correct troubleshooting procedures.

Instructor-led **CBT** is an economical approach to practicing maintenance and troubleshooting skills for electronic systems.

c) Test your students on concepts related to the new system. Testing, either during the class sessions or at the end of sessions, will help reinforce those concepts and emphasize the importance the material.

Follow up the classroom sessions with practice sessions. If manipulatives or troubleshooting **CBT** are available, set up a practice schedule. For general maintenance procedures, set up a concise check list to help them step through the process. Closely supervise work on the new system until students demonstrate their proficiency.

2. Since the new system combines elements of existing hydraulic systems, the simplest way to proceed is to select technicians experienced with these hydraulic systems. These individuals will already have mastered at least some of the subject matter required to work on the new system. Refer to **Training as Part of Management** in the GUIDELINES section for more guidance in selecting individuals for training.

3. **OJT** is best used to provide supervised practice in the job setting. **Table 7-4** describes factors we can use to determine first whether or not OJT is appropriate. The **GUIDELINES** section provides a thorough discussion of the sequence of tasks that should be followed to develop and implement a structured OJT program.

Scenario 2 - Appropriate Skills and Knowledge

Your floor supervisors have been complaining that some newer technicians seem to be making a lot of errors when working on particular components. All the technicians must pass the same written and hands-on test before they start working in the department. The supervisors think the test is not a very good measure of the technicians' ability actually to do the job.

Issues

1. How will you determine exactly what knowledge, skills, and aptitudes are required to do a competent job of fixing the components in question?
2. How will you determine whether or not the test content really measures the appropriate

knowledge and skills?

3. Does this sound like a task that you can pretty much do yourself, or do you need professional help?

Responses

1. The discussion of performance objectives in the **METHODS** and **GUIDELINES** sections points out that the first step in establishing performance criteria is to analyze the tasks in the job. In this scenario, we would first have to identify the tasks and steps required to perform the work in which errors are occurring. We will also have to establish performance criteria for acceptable job performance.

2. After we identify the component tasks and performance criteria, we can determine the knowledge and skills the training program should address. This issue is simple to address after performance criteria have been established. To evaluate the existing test, we need to compare its content to the performance criteria and note any discrepancies.

For example, suppose we said that an important performance criterion is that technicians should be able to change out a certain part in 5 minutes or less. If the current test doesn't measure this performance, then, by definition it doesn't measure all the appropriate knowledge and skills for this task.

3. This is another issue we can respond to with a resounding, "It depends." Maintenance supervisors can identify task elements and performance criteria they feel are the most important determinants of job performance. However, once these criteria are established, the precise knowledge and skills enabling such performance might not be so obvious. Professional trainers have the training and experience to identify such knowledge and skill elements.

Scenario 3 - Evaluating Computer-Based Training

The manufacturer of the new Electro-hydraulic action system provides both manipulative and interactive simulation-oriented computer-based instruction with the new system. Unfortunately, your organization can't afford to purchase both types of training aids. Since the **CBT** is less expensive you have been asked to evaluate whether or not the CBT will adequately training your employees.

Issues

1. What needs to be taught?
2. Is **CBT** the appropriate choice?
3. How can we determine the quality of the **CBT**?

Responses

1. Before you can decide whether or not a **CBT** program is appropriate for your training needs, you must have a clear idea of your training objectives. **Training Development** in the METHODS section and **Developing Structured OJT** in the GUIDELINES section provide guidance for determining those learning objectives. From the first scenario, we know that declarative knowledge, instruction in troubleshooting, as well as practice in manipulating the system are all required as part of the training.

2. **Training Selection** in the GUIDELINES section discusses the conditions under which **CBT** is most appropriate for training. **CBT** is good for automating skills, introducing basic concepts, and simulating equipment. Simulation-oriented CBT is excellent for practicing the steps related to operating and troubleshooting a system.

   CBT is not adequate for simulating manipulations where tactile perceptions and skills are required (e.g., learning to feel the proper torque of a wrench). In this scenario you would need to answer the question "Which is more important to properly maintain this system: diagnostic or manipulative skills?" The answer will help determine whether or not CBT is adequate for this training.

3. If the answer to the second question is that the most important tasks are primarily diagnostic rather than manipulative, then simulation-oriented **CBT** may be the best training aid for your money. Next, you need to determine whether or not this particular CBT is adequate for the job. **Table 7-5** provides a set of criteria with which to judge whether or not the CBT is designed well for your training needs.

Scenario 4 - On-the-Job Training

You've noticed that on a particular task related to the B-check on a specific type of aircraft certain newer technicians seem to do a much better job than others. All these technicians go through **OJT** with more experienced **AMT**s. You suspect that the difference in job performance might be related to their OJT.

Issues

1. How will you decide whether **OJT** is appropriate for the task in question?
2. How can you determine just what needs to be taught during the **OJT** period?
3. Assuming that **OJT** is a reasonable training method for this task, what elements would you like to see in the OJT program?
4. How often should you (or someone) review the **OJT** program for this task?

Responses

1. Determining whether **OJT** is appropriate for a given task or set of tasks requires an understanding of the task's components. We need to understand what knowledge and skills are required to perform the task in question. Task analysis can identify such knowledge and skills. This may be as simple as asking a task expert, i.e., a skilled technician, to list the required knowledge and skills. Refer to **Table 7-4** for a more in depth discussion of when OJT is appropriate.

2. Once the knowledge and skill components are known, refer to the **DAPPER Model in Developing Structured OJT** to determine which, if any, knowledge and skill components can be taught using structured **OJT**.

3. **The DAPPER Model** describes the steps to follow when developing structured **OJT**. The **Training Plan** step relates to developing OJT course objectives; **Designing Instructional Materials** gives guidance for structuring OJT content. We determine what is being taught with an existing OJT segment, i.e., one not developed using our process, by using task analysis. However, such analysis is tricky and requires help from a training professional.

4. **Table 7-6** lists elements that we would expect to find in a well-designed **OJT** program. **Table 7-7** describes a good OJT delivery. Together, the elements presented in the DAPPER Model and found in **Tables 7-4** through **7-9** adequately describe what we would like to see in a structured OJT program.

5. The last item in **Table 7-6** states that **OJT** programs should be audited at least annually.

REFERENCES

1. Code of Federal Regulations, Title 14 Part 121.378, Subpart L - Maintenance, Preventative Maintenance, and Alterations - Certificate Requirements -

2. Code of Federal Regulations, Title 14 Part 147 - Aviation Maintenance Technician Schools - Appendices A-D.

3. U.S. Department of Labor (1996-97). Aircraft mechanics, including engine specialists. *Occupational Outlook Handbook*. pp. 342-343. Washington, DC: US Department of Labor, Bureau of Labor Statistics.

4. Goldsby, R. (1995). *Training and certification in the aircraft maintenance industry: Specialist resources for the 21st century*. Final report prepared for U.S. Department of Transportation, Federal Aviation Administration, Flight Standards Division.

5. National Transportation Safety Board (1997), Aircraft accident report: ValuJet Flight 592, McDonnell Douglas DC-9-32, N904VJ, over the Everglades, Florida, May 11, 1996. Washington, DC: US Government Printing Office.

6. White, C. (November, 1997). Personal Correspondence.

7. Hall, G.E., & Gaquin, D.A. (Eds.). (1997). *Country and city extra: Annual metro, city, and county data book*, pp. xxxiii-xxxvi & p.16. Lanham, MD: Bernan Press.

8. Dorgan, C.A. (Ed.) (1995). *Statistical handbook of working America: Statistics on occupations, careers, employment, & the work environment*, p.44. New York, NY: Gale Research.

9. Eiff, M. A. (1997). *Women in aviation maintenance: Why the issue is important to your school and to industry. Successes in improving women's enrollment in Purdue's aviation technology department*. Paper presented at Aviation Technician Education Council (ATEC) 1997 Annual Conference. Orlando, FL.

10. Gindlesperger, B. (1997, June). Interview with Bruce Gindlesperger, Manager, Technical Operations Training, Delta Air Lines, Inc.

11. Lofaro, R.J. (1997). **MRM: It can't be CRM re-packaged.** In *Meeting Proceedings Eleventh Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection: Human error in aviation maintenance* (pp. 65-77). Washington, DC: Federal Aviation Administration/Office of Aviation Medicine.

12. Mc Kenna, J.T. (1996). Maintenance training undergoes review. *Aviation Week & Space Technology, September*, p. 158.

13. Spencer, F. W. & Schurman, D. L. (1995). *Reliability assessment at airline inspection facilities. Volume 3: Results of an eddy current inspection reliability experiment* (DOT-FAA-CT-92-12-V-3). Arlington, VA: National Technical Information Service.

14. Walter, D., & Kanki, B.G. (1996). **A human factors approach to aviation maintenance training: The task analytic training system.** In *Proceedings of the Tenth Meeting on Human Factors Issues in Aircraft Maintenance and Inspection*. Washington, DC: Federal Aviation Administration, Office of Aviation Medicine.

15. Code of Federal Regulations, Title 14 Part 65 - Certification: Airmen Other than Flight Crewmembers, Subpart D - Mechanics.

16. Vipond, L.K. (1990). **FAA**'s proposed revisions to Parts 147 and 65. In J. F. Parker, Jr. (Ed.), *Human Factors Issues in Aircraft Maintenance and Inspection, Training Issues*. Washington, DC: Federal Aviation Administration.

17. Adams, L.K., Czepiel, E.J., Henry, D.J., Krulee, G.K., Murray, G.C., & Williamson, B.M., (March, 1997*). Job task analysis of the aviation maintenance technician - Phase II report.* Final report prepared for U.S. Department of Transportation, Federal Aviation Administration, Technical Center.

18. Vipond, L. (1997). Personal correspondence with Leslie Vipond, Federal Aviation

Administration Aircraft Maintenance Division, AFS-300.

19. White, C. (1997). *Far 66: Implications for 147 schools*. Paper presentation in Aviation Technician Education Council (ATEC) 1997 Annual Conference, Orlando, FL.

20. Federal Aviation Administration (1997). *Human factors in aviation maintenance and inspection strategic program plan*. Prepared for the Aircraft Maintenance Division (AFS-300) of the Flight Standards Service in cooperation with the Office of Aviation Medicine (AAM-240). Washington, DC: **FAA**, Office of Aviation Medicine.

21. Professional Aviation Maintenance Association (PAMA) (1992). Required Recurrent Training. *PAMA News*. Volume 13, Number 7.

22. Salvendy, G., & Pilitsis, J. (1980). The development and validation of an analytical training program for medical suturing. *Human Factors, 22,* 153-170.

23. Crowder, R. G. (1976). *Principles of learning and memory.* Hillsdale, NJ: Lawrence Erlbaum & Associates.

24. Crocker, P. R. E., & Dickinson, J. (1984). Incidental psychomotor learning: the effects of number of movements, practice and rehearsal. *Journal of Motor Behavior, 16,* 61-75.

25. Baddeley, A. D., & Longman, D. J. A. (1978). The influence of length and frequency of training session on the rate of learning to type. *Ergonomics, 21*, 627-635.

26. Singer, R. N. (1968). Sequential skill learning and retention effects in volleyball. *Research Quarterly, 39,* 185-194.

27. Kelly, C. R. (1969). What is adaptive training? *Human Factors, 11,* 547-556.

28. Shick, J. (1970). Effects of mental practice on selected volleyball skills for college women. *Research Quarterly, 41,* 88-94.

29. Maddox, M. E., Johnson, W. B., & Frey, P. R. (1986, March). *Diagnostic training for nuclear plant personnel, Volume 2: Implementation and evaluation.* (EPRI NP-3829). Palo Alto, CA: Electric Power Research Institute.

30. Taber, R. (1997). *Instructional systems development guidelines*. Internal document. Tucker, GA: Galaxy Scientific Corporation.

31. Cotter, J. D. (1997). *Developing instruction for the **AMT-T** curriculum: A systems approach*. Paper presented at Aviation Technician Education Council (ATEC) 1997 Annual Conference. Orlando, FL.

32. Rothwell, W.J., & Kazanas, H. C. (1994). *Improving on-the-job training: How to establish and operate a comprehensive OJT program*. San Francisco, CA: Jossey-Bass Publishers.

33. Jacobs, R. L. (1992). Structured on-the-job training. In H.D. Slotovitch and E.J. Keeps (Eds.), *Handbook of Human Performance Technology*. San Francisco, CA: Jossey-Bass Publishers.

34. Lewick-Wallace, M., & Jask, R. C. (1988). Tips for effective on-the-job training. *Performance and Instruction, 27* (7), 17-18.

35. Fister, S. (Ed.) (November, 1997). Linking pilots to training during layovers will keep 'em flying later. The Lakewood Report on Technology for Learning. Minneapolis: Lakewood Publications Inc. 3(11), p. 6.

36. Chandler, T., & Earon, C. (October, 1997). SMART Center: A distance training approach for aviation maintenance personnel. Conference proceedings in *IEEE International Conference on Systems, Man, and Cybernetics*, Vol. II. Orlando, FL. pp. 1873-1877.

37. Galaxy Scientific Corporation. (1996). OASIS year one final report. Prepared for Mobile Computing Applications for the Flight Standards Service Project. Federal Aviation Administration Flight Standards Service.

38. Air Transport Association (ATA) (1989). *ATA Spec 104: Guidelines for Aircraft Maintenance Training.* Washington, DC: Air Transport Association.

39. Aviation Industry Computer-Based Training Committee (AICC) Guidelines and Recommendations:
    - *CBT Peripheral Devices* (AGR 005, Version 1.0), 11 Nov. 1992.
    - *Courseware Delivery Stations* (AGR 002, Version 4.0), 12 Mar 1993.
    - *CMI Guidelines for Interoperability* (CMI 001, Draft), 1993.
    - *Digital Audio* (AGR 003, Version 1.0), 24 Sept 1992.
    - *Glossary of Terms Related to Computer-Based Training* (Revision), 29 Feb 1992.
    - *Operating Systems and Networking* (AGR 004, Version 2.0), 1 Feb 1993.

40. Broadwell, M. (1986). *The supervisor and on-the-job-training.* (3rd Ed.). Reading, MA: Addison-Wesley.