

**Meeting 3: Training Issues (1990)**

**Proceedings of the Third  
Meeting on Human Factors  
Issues in Aircraft Maintenance  
and Inspection**

Report of a Meeting

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## FOREWORD

The job proficiency of airline mechanics and inspectors is in large measure a function of the training these technicians receive. The "training establishment" responsible for providing a fully qualified maintenance workforce involves a variety of institutions and activities, ranging from structured technical training schools to less structured on-the-job airline training programs. Each of these institutions and activities has a responsibility and must make its particular contribution to industry training objectives.

The changing nature of the air carrier industry is well recognized. Aircraft being added to the growing air carrier fleet have high technology flight decks, use advanced types of control systems, and incorporate a variety of new structural materials. Sophisticated technology is the order of the day for the air carrier fleet of the 1990's. And yet, at the same time, we still must face the aging aircraft issue. The burden on those responsible for training technicians to support the maintenance demands of this fleet will be heavy.

The Federal Aviation Administration (FAA) is conducting a series of meetings to address human factors in aircraft maintenance and inspection, with the present meeting focusing on "Training Issues." The purpose of this meeting was to review the status of maintenance training for the air carrier industry, to consider problems facing those responsible for this training, and to learn of new training technologies under development. Representatives of all segments of the maintenance community were in attendance, attesting to an industry-wide recognition of the importance to industry success of a well-trained workforce.

I would like to thank everyone who attended the meeting for your participation and would like especially to thank those who gave presentations. Your contributions toward the difficult problems facing maintenance training are greatly appreciated.

*William T. Shepherd, Ph.D.  
Federal Aviation Administration*

## EXECUTIVE SUMMARY

The Federal Aviation Administration (FAA) sponsored a two-day meeting in June 1990 as part of a series of meetings to address Human Factors in Aircraft Maintenance and Inspection. At this meeting, particular attention was given to "Training Issues" in maintenance operations. Presentations were given by 15 individuals covering the full spectrum of interests in maintenance training. Representatives of all segments of the aviation maintenance community were in attendance. Their participation reflects recognition that changes taking place in the air carrier industry, with the introduction of high-technology systems and new structural materials, present real challenges for maintenance training. Changing dynamics of the workforce also must be addressed. Careful planning and work will be necessary to ensure a fully qualified work force in the coming decade.

The objectives of the meeting were to (1) review the range of training activities now in place to support airline operations, (2) describe the effect of current and planned regulatory oversight, (3) identify specific problems in training, and (4) learn of new technologies that might aid training in the future. Based on presentations given and ensuing discussions, the following recommendations are presented:

### The Training Requirement

#### Recommendations

1. In light of strong support for the train-to-proficiency principle, the FAA should examine ways to move in that direction, possibly through use of the greater internal curricula flexibility to be provided in the revision of FAR Part 147.

### Trainee Characteristics

#### Recommendations

1. The FAA should establish a minimum performance level for communication (reading and writing) skills and for math skills as a prerequisite for all A&P programs. If a sufficient number of applicants can be maintained using these standards, consideration should be given to elimination of math and physics as required subjects in the A&P curriculum.

### Training Curricula

#### Recommendations

1. Airline operators should consider adding to their training efforts formal programs concerning proper use of the general aircraft manual and proper procedures for completion of paperwork required by the FAA. This course should be given very early in the work history of a maintenance technician.
2. The introduction of resource management training into maintenance training programs offers promise as a positive factor for improved productivity. Resource management training should be encouraged by the FAA and should be considered by airline operators.

## Training Delivery Systems

### Recommendations

1. The FAA should develop a short handbook on training to provide guidance for those planning and conducting in-house maintenance training programs. This handbook should present principles of training, describe proper instructor-student relationships, and discuss informal means of assessing training effectiveness. The handbook should be done completely in maintenance terms and should be structured as a "How To" book.

## Measurement of Proficiency

### Recommendations

1. The FAA and industry should be sensitive to the need for more systematic procedures for measuring the proficiency of trainee and technician performance in maintenance. The task analysis effort now being undertaken as part of the work of the FAA Human Factors Team in Aircraft Maintenance and Inspection will provide an excellent starting point for a proficiency measurement effort.

## Training Feedback/Follow-Up

### Recommendations

1. The FAA should conduct a national survey on the current placement and competency of A&P mechanics. This survey should produce sufficient information to allow meaningful feedback to the training system.

## INTRODUCTION

The Federal Aviation Administration (FAA) sponsored a two-day meeting in June 1990 as part of a series of meetings to address Human Factors in Aircraft Maintenance and Inspection. At this meeting, particular attention was given to "Training Issues" in maintenance operations. Presentations were given by 15 individuals covering the full spectrum of interests in maintenance training. These presentations covered regulatory issues, current practices by airline operators, problems and practices of training schools, and new technologies in training.

The broad objectives of the meeting were to (1) review the range of training activities now in place to support airline operations, (2) describe the effect of current and planned regulatory oversight, (3) identify specific problems in training, and (4) learn of new technologies that might aid training in the future. The objectives of the Federal Aviation Administration in sponsoring a meeting such as this are described in the two presentations immediately following.

Each presentation at the meeting, as well as the following question-and-answer period, was recorded for transcription and study. Using these materials, the ideas and opinions of presenters and attendees were reviewed and summarized in a "[Conclusions and Recommendations](#)" section, which appears after the [FAA Welcome/Meeting Objectives](#) and [Keynote Address](#). The [Conclusions and Recommendations](#) are organized to present the general feelings of attendees concerning the major elements found in a large industrial training system.

An edited version of each presentation, taken in most instances from the tape transcript, is presented as [Appendix A](#).

## WELCOME AND MEETING OBJECTIVES

*William T. Shepherd, Ph.D.  
Office of Aviation Medicine  
Federal Aviation Administration*

At this third meeting on Human Factors in Aircraft Maintenance and Inspection, I am pleased that I see a number of familiar faces from our previous two meetings. As you recall, our first meeting was general in nature and attempted to identify key issues to be addressed in greater depth. The meeting several months ago addressed one of these topics, that of Communications and Information Exchange.

The purpose of these human factors meetings is to facilitate an exchange of information among those in industry and Government concerned with maintenance and inspection in aviation. These individuals include maintenance managers in the air carrier industry, manufacturers responsible for detailing maintenance requirements, those who establish maintenance training programs, and others with similar responsibilities. We plan to continue holding these human factors-oriented conferences for the foreseeable future. As I have noted at previous meetings, we in the FAA are interested in your ideas for the content of these meetings and will be soliciting your input concerning worthwhile topics for the next meeting.

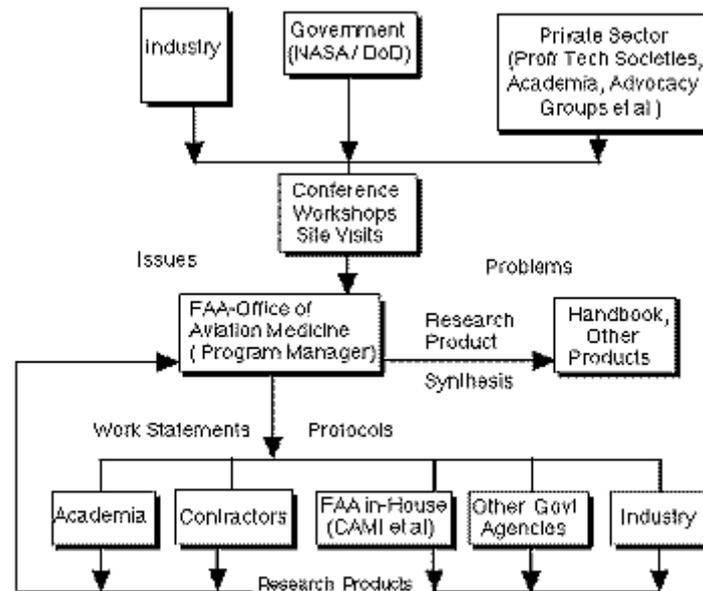
The theme of today's meeting is training. It is my personal feeling that training may prove to be one of the most important methods for dealing with future problems in aviation maintenance. One of these problems is the shortage of maintenance technicians, which is very real and will become crucial. My sense is that many people are not aware of the looming problem concerning the availability of personnel with the required skills. These people are not going to be there in the future.

At this time, we already are seeing a shortage both of experienced and inexperienced workers in maintenance. As the overall level of experience of the entry maintenance workforce diminishes, it will be up to the training industry and training institutions to bring maintenance technicians up to speed rapidly. The latest statistics from the industry support this. Hiring in the air carrier industry has risen steadily from 5,600 people in 1985 to 12,500 in 1989. The Air Transport Association estimates that there is already a shortfall of about 4,000 workers, with a projected need for 50,000 additional mechanics over the next ten years. Also, compounding this situation is the fact that we have an aging workforce. The present workforce totals 63,000 maintenance technicians. Of these, fully 60 percent may retire within the next ten years.

The changing world scene represents another issue to be taken into account. In previous years, the military has proven to be a relatively dependable source of experienced technicians for the airline industry. All of this may change. At this time, the Air Force regularly contracts about 40 percent of its maintenance work, costing approximately \$1.2 billion per year. Many of the airlines are no longer willing or able to do this work. One airline, for example, is planning to phase out \$150 million in contract maintenance for the Air Force because they need these people for their own work. Their fleet is growing, and it is the same across the industry.

The framework which we in the Office of Aviation Medicine of the Federal Aviation Administration are using to address these issues and some of the accomplishments we hope to achieve are shown in [Figure 1](#), which describes our R&D program. We are seeking input to our program from many sources, not the least of which is industry. We need to learn from industry the kinds of human factors problems that can be addressed through research. We also are looking for input from Government agencies, primarily DoD and NASA, as well as the private sector. We are seeking this input through avenues such as this conference as well as through workshops and site visits. Some of you are quite familiar with this process and have been very cooperative by allowing our people into your facilities for site visits. This has been most helpful for us in understanding how maintenance is accomplished and what the problems are. The information we obtain through such visits is being fed into our program management office in the Office of Aviation Medicine, where it is used in the

development of work statements and research protocols.



**Figure 1 FAA Office of Aviation Medicine R&D Program Supporting Human Factors in Aircraft Maintenance and Inspection**

The lower portion of [Figure 1](#) shows the key participants who are accomplishing our research work. The emphasis in our research is on information. Products of the research will include a human factors handbook, or perhaps a series of handbooks, directed toward identified maintenance issues. We also may produce video tape instructional materials. The role of the FAA here will not be to develop regulations. Instead, we wish to provide as much information as possible to the maintenance industry and to our own FAA inspectors to help both sides address current human factors problems and those likely to appear in the future.

[Figure 1](#) presents the thrust of our R&D program. However, we are open to any suggestions or inputs that any of you might like to provide, since you know what the real world problems are. We welcome your ideas and suggestions so that we can structure a research program that will provide most benefit for all parties.

Since we plan to continue holding these human factors-oriented conferences for the foreseeable future, we would like for you to include among your suggestions any ideas concerning appropriate topics to be covered during our next meeting. Planning for this meeting will begin shortly and your suggestions will be used as guidance for us.

During our meeting over the next two days, you will hear from a number of speakers who are familiar with the maintenance industry, its training problems, and its training initiatives. You also will hear from three members of the FAA Human Factors Team who are working at this time on the research program I described. [Dr. William Johnson](#), whom many of you know, will speak to us tomorrow about his findings on the status of computer-based training in the aviation industry. He will also provide some details on a prototype intelligent tutoring system under development. This system is representative of the new technologies being brought to bear on maintenance training.

The meeting also will be addressed by [Dr. James Taylor](#), who is developing unique insights into the effects of organizational variables on maintenance productivity, and [Dr. Colin Drury](#), who is using a task analytic approach to develop basic information concerning the performance of maintenance technicians. Such data will be invaluable as we proceed toward specific end products in our research activities.

Again, the theme of this meeting is "Training." We in the FAA consider this to be a very important topic and are looking forward to the presentations and to your discussions as a significant step toward the development of improved training procedures and technologies and, as a consequence, a more productive maintenance workforce. I welcome you to the third FAA Human Factors Meeting.

## KEYNOTE ADDRESS

*Colonel Robert R. McMeekin, MC, USA  
Federal Air Surgeon  
Federal Aviation Administration*

I am pleased to be invited to address today's meeting. In my mind, training has been a second-class citizen. It falls right behind safety in the attention it receives, and yet it is a key element to making the entire aviation system work. Unfortunately, we have focused on the more glamorous aspects of aviation. We are finally beginning to think more in terms of the complete system, but we have not traditionally thought in terms of the system as a whole, especially when it comes to training.

Many things about maintenance training are simple when you stop to think about them. On a day-to-day basis, however, we often forget how we are going to apply the lessons we learn in training. Now this lack is beginning to catch up with us. It is beginning to catch up with us because of several dramatic events which have attracted the public's notice. First, the well-known Aloha incident several years ago demonstrated the difficulties of inspecting for corrosion and metal fatigue. More recently, a British Airways plane had a cockpit window pop out and the two flight attendants had to hold the captain who was trying to keep from going out the window. What has happened all of a sudden? Are airplanes just beginning to come unglued? Airplanes are being flown much longer periods of time. Think about it. We are now flying airframes longer than we would have dreamed of 40 years ago. Take the good old workhorse DC-3. If you told someone at the outset that you were going to fly that airframe 80,000 or 100,000 hours, they would have laughed, but we have lots of airframes approaching these numbers. It should not be too surprising, then, that we are beginning to see some major mechanical problems that need to be addressed. Catastrophic events are not the only problem. Less disastrous problems are day-to-day facts of operational life affecting reliability for dispatch. Bottom line -- if you can't put the airplane in the air, you can't make money with it.

Technology also drives training requirements. Problems with evaluating technology are tremendous. How are we going to select people and train them to deal with all of this new technology? Are we, you and I, the kind of people who are prepared to deal with young students coming through the schools? How many of you are involved with training schools? Some very smart graduates are coming out of these schools. Part of the problem may be that we have a "make them like me" mentality. "I am the best maintenance instructor." and "I will design a curriculum for these students and put it into place and we will run them through that training curriculum. Then we will put them on the job, give them on-the-job training (OJT) for the fine details. Then we'll haze them the rest of the way so they look like me." With the new technologies, we cannot afford to do this. The "make them like me" philosophy will obstruct the productivity of these creative, smart young people.

Technology will determine where we go next. We must see that young students are raised in an environment using that new technology. We also must cope with the older people who have lots of experience but cannot figure out the new technology. We are going to have to grow into the new technology, learning as we go. There will be many new airplanes with the "glass cockpit" technology and, at the same time, there will be many old airframes flying as well. With this situation, we may have to make a choice, because there will be a limited amount of time in the training curriculum. Can we, in fact, train maintenance people all the way from Jenneys to jets, from fabric to aluminum to high tech alloys and digital electronics? Is this going to be a learn-from-your-mistakes training program? Can you really afford to make mistakes with the kinds of airframes we are flying now? If you lost a small airplane or an airliner with 20 to 25 people on it 40 years ago, it would get some notice. But if you lose an airplane now with 300 to 400 people on it, it will get a lot of notice.

How are we going to recruit people into the maintenance field? Is tightening the bolts as glamorous as flying the airplane? I overheard an interesting discussion earlier this morning about salaries. The salaries of maintenance workers can easily be competitive with other salaries in aviation, yet the

maintenance business has not been as alluring. I believe there are ways we can make it more attractive.

What types of skills will the new technicians need? Do they have to be the mechanical, hands-on types of skills, or will they have to be the problem-solving, conceptual, electronic skills? Will they be people who can read and absorb large amounts of technical information? If you look at the amount of data and the technical specs for just about any airplane these days, they fill entire shelves.

How are we going to accelerate people through the current technology so they can move on to being supervisors and instructors? How are we going to select supervisors? Perhaps supervisors are the real key to dealing with our maintenance issues. They are the ones who, after the student finishes his/her schooling and training, really determine how that mechanic is going to perform virtually for the rest of his/her career. A maintenance worker's exposure to his first supervisor is going to have a major impact on his performance for the rest of his career. What are these supervisor's going to be like? Will they be receptive to new ideas? Will they be patient? A lot of thought needs to go into the procedures for selecting and training supervisors.

There are two other issues that have potential impact for maintenance. One is the issue of medical standards. There really are no medical standards for maintenance people. Is good color vision important for a mechanic? Does it make a difference where the red wire goes or where the green wire goes? As we began recruiting Federal Air Marshals, we recognized the need to develop medical standards for them. Very strict color vision standards were required for the Federal Air Marshals. Why would that be? The answer is that if, for example, there is an electronically-detonated bomb device onboard an airplane, it makes a big difference where the red wire goes and the green wire goes. With that in mind, can we trust alignment of the digital cockpit and all its color displays to someone who does not have adequate color vision?

Another issue which your industry faces now is the aviation industry drug abatement program. It is a reality. We did not begin drug testing because of drug usage in maintenance, or because anyone demonstrated that there was a big drug problem in the aviation industry. Frankly, we have an industry drug abatement program because the public was scared. We looked around for drug-related incidents in the aviation industry, and they were hard to come by. I, for one, was not terribly enthusiastic about having another drug program to administer. Like many other people, I did not think there was a big problem in the aviation industry. However, when the mandated random testing program was started, we found a higher rate than anticipated. A detection and deterrence program is necessary and we, as part of the Administration, now are committed to the drug-free workplace.

In summary, we face many challenges as we move forward to foster our maintenance industry. How are we going to select mechanics and inspectors? How are we going to train them? What kind of people do they need to be? What type of background do they need to have? What type of culture are we going to establish for them? The culture we establish is going to be the principal influence on career and performance. Supervisors are the key. If you cannot pick good supervisors who will be receptive and patient and nurturing, your training program will fail.

I want to do all I can to support your programs. We at the Federal Aviation Administration will work hand-in-hand with you to foster aviation maintenance programs to meet the needs of the aviation industry and to assure the safety of the traveling public.

## CONCLUSIONS AND RECOMMENDATIONS

The U.S. air carrier fleet requires a well-trained maintenance workforce to ensure its goal of flight operations that are safe and on time. Demands on this workforce will only increase in the next decade as newer technology aircraft, such as the Boeing 747-400, are introduced and as passenger travel experiences its projected 50 percent growth. The training of maintenance technicians must be carefully planned and conducted so that the training is efficient and those trained are fully qualified.

Maintenance training consists of a number of different paths, with the Federal Aviation Administration providing a measure of oversight for each. Initial training generally is given by an FAA-certified technical training school. Through this training, one acquires the Airframe and Powerplant (A&P) license. Specialized training is given to those who work in component shops covering systems such as hydraulics and avionics. Company courses and on-the-job training bring a new technician to the desired level of proficiency to work on particular aircraft. Finally, those choosing to become maintenance inspectors undergo additional training. Each of these training activities is an element within a total training system and each has a number of issues and problems.

The purpose of this two-day meeting was to examine maintenance training support provided for air carrier operations. Attendees gave especial attention to issues of technical training schools, recognizing that these schools provide a foundation for the entire training effort.

Attendees at this two-day meeting represent all segments within the air carrier industry, including regulators, manufacturers, airline operators, members of the training establishment, and others. The formal presentations given during the two days covered a variety of topics related to training and training effectiveness. Recommendations for improvement in the training system were offered during formal presentations, during ensuing discussions, and during a final "summing up" period. The following recommendations represent a grouping and synthesis of attendee suggestions according to broad topics, with specific recommendations included within each topic.

This Conclusions and Recommendations section is organized around the principal elements in the training process, as follows:

- The Training Requirement
- Trainee Characteristics
- Training Curricula
- Training Delivery Systems
- Measurement of Proficiency
- Training Feedback/Follow-Up

Each of the above elements is discussed individually. To the extent possible, these discussions represent a status review for each training element, as viewed by meeting attendees. Following the discussion of each training element, one or more recommendations is presented as warranted.

### The Training Requirement

The first step in establishing a maintenance training program is to determine the training requirement. To do this, one should look at the entire maintenance system, specify the job functions required within the system, identify the person responsible for each job function, and, by examining individual elements within the job, determine his job training requirements. Then, by careful grouping of individual training requirements, a significant step toward the development of a broad maintenance training program is possible.

No comprehensive and systematic review of the training requirement for the entire aviation maintenance industry has been made, although many parts have been studied. However,

considerable work in that direction is being done at this time. The Federal Aviation Administration is planning a Job Task Analysis (JTA) of the occupation of "Aviation Maintenance Technician." This analysis will describe the frequency with which a mechanic performs certain activities, the knowledge and skills required, the manipulative capabilities necessary, and the training required for a mechanic both before and after FAA certification. These results will be of great value for the revision of Part 65 and, if made available on an industry-wide basis, for industry efforts to improve maintenance training.

Industry also is beginning systematic efforts to determine training requirements. For example, the Boeing Commercial Airplane Group has developed a Task Analytic Training System to address training needs of inspectors working in non-destructive testing (NDT). In this system, a design team consisting of three to five content experts performs a job task analysis of a specific maintenance occupation and prepares training modules for the identified tasks. The objective is to establish written, agreed upon performance standards that are measurable and observable. Employees then can be trained to these standards.

As training requirements are determined, it is important to remember that these training requirements differ from one carrier operation to another. The training requirements for a mechanic or an inspector differ depending on the extent of the responsibilities of that individual within the air carrier operations. For example, a small carrier with a small number of airplanes might not have an engineering department. Maintenance personnel then might be responsible for reviewing Service Bulletins, Service Letters, designing structural repairs, interpreting Airworthiness Directives, and generally providing the continuing analysis and surveillance required by Part 121. For an airline without an engineering department, maintenance personnel may have responsibilities far beyond that of simply being an A&P mechanic or an inspector. His job responsibilities will expand to ensure the continuing airworthiness of his carrier's aircraft. His training requirements will expand in proportion.

**Train to Proficiency.** Closely allied to the determination of the training requirement itself is a determination of the extent of the training requirement. The key issue here is whether one is required, or should, train to a demonstrable level of proficiency or whether one is required to provide a fixed amount of training, with proficiency measured in some manner at the completion of training. At this time, FAA-certified technical training schools are required to offer a minimum of 1900 hours of instruction in their A&P program. At the present meeting, strong voices were heard for a change to a "train to proficiency" philosophy, with technical training schools being given the freedom to adjust their programs accordingly. One attendee noted that, in his belief, the current training requirements of Part 147 are based on the following erroneous assumptions:

1. All students have the same native ability or capacity to learn.
2. All students will progress at the same rate during the same period of time.
3. Time spent in training is an effective way to measure student progress.

This attendee recommended the elimination of hours as any measure for the shop/lab portion of the A&P curriculum and that training to proficiency be conducted instead. Proficiency would be measured through use of tests based on criterion-referenced performance standards for each key competency area. One suggested value of this approach would be that, as some students complete their work early each day, instructors would have additional free time to provide more one-to-one interaction with those students proceeding more slowly.

The arguments in favor of a train-to-proficiency program are balanced by several counterarguments. A major argument is based on administrative grounds. Since test questions for the A&P licensing exam are public knowledge, and have been deemed to be so by court action, the simple passing of a test may not be an adequate indication of proficiency. It is the belief of some in the FAA that the best way to ensure the competency of an individual is to require that he be at least exposed to a training course of a fixed number of hours and with certain curricula items required by regulation. This, of course, should be supplemented by proficiency testing. This program will prevent short-cuts to a measured proficiency rating, with the actual proficiency being less than desired.

Another counterargument is purely practical. In order to do reasonable planning, students entering a training program need to know the duration of the program. They would like to know that they are entering a two-year program, not one perhaps one and one-half or two and one-half years long. There also is the matter of pricing. The schools need to know how long a student will be in attendance in order to provide realistic pricing for the training program.

Any consideration of the advantages and disadvantages of training to proficiency may become moot in light of the forthcoming revision of Part 147 of the Federal Aviation Regulations. The FAA and industry have been working together over the past several years to develop a new A&P school curriculum. While it is anticipated that the 1900 hours of required training will be retained, more latitude will be given to schools to adjust their training curricula within this fixed training time.

## Recommendations

1. In light of strong support for the train-to-proficiency principle, the FAA should examine ways to move in that direction, possibly through use of the greater internal curricula flexibility to be provided in the revision of FAR Part 147.

## Trainee Characteristics

Training programs must be prepared to be compatible with the learning capabilities of those being trained. Innate capacities, educational background, prior work experience, general motivational state, and other factors are important and set limits on both speed of learning and the potential success of the training effort.

Those persons entering A&P programs at technical training schools form an interesting dichotomy. At one school, more than 25 percent of a recent enrolling class already had a bachelor's degree. Most of these degrees had been taken in industrial technology or industrial management programs. These applicants should have been well-qualified to seek the A&P certificate.

In contrast to the above, many new students in technical training schools are found to have real deficiencies in basic reading, writing, and math skills. Several years ago, at least one school was experiencing approximately a 30 percent drop-out rate among new students because of these deficiencies. Some schools now have established academic entrance standards and require applicants to take placement tests in mathematics, reading, and English prior to acceptance. This has improved the drop-out rate considerably. With the establishment of appropriate entrance standards, some educators have proposed the elimination of math and physics as required subjects in the A&P curriculum. They feel these subjects should be mastered sufficiently prior to A&P school, thereby freeing more time within the two-year program for more applied topics.

## Recommendations

1. The FAA should establish a minimum performance level for communication (reading and writing) skills and for math skills as a prerequisite for all A&P programs. If a sufficient number of applicants can be maintained using these standards, consideration should be given to elimination of math and physics as required subjects in the A&P curriculum.

## Training Curricula

The curriculum content for technical training schools was noted in a number of discussions as being completely out-of-step with the requirements imposed by today's advanced jet fleet. This content includes many topics, such as propeller maintenance and fabric repair, that have no call in the maintenance bay of a large air carrier. Other issues, such as the maintenance of turbine engines,

repair of composite materials, and troubleshooting of complex avionics systems, are of great importance. For this reason, there is pressure to allow each school to tailor its curriculum to more closely match the needs of those employers taking most of the graduates of that school.

The FAA is aware of the concern over current curriculum requirements and apparently will allow technical training schools more latitude in establishing their curricula in the forthcoming revision of FAR Part 147. However, some questions will remain. Will the freedom to adjust curricula within the 1900 hours limit be sufficient to provide the requisite avionics skills, for example? If not, must schools offer advanced training beyond the current two-year limit?

Training given by airline operators also was considered. One attendee, with much experience, recommended the introduction of formal training for all maintenance employees concerning proper use of the general aircraft maintenance manual and procedures for incorporating such use into day-to-day maintenance. This training should include instruction in proper completion of required paperwork for different maintenance activities. This attendee felt that a formal training course on these topics, given at the beginning of employment, would produce a notable increase in job productivity.

A recommendation also was made that the curricula for training classes provided by employers be developed in some way so that the 20-year experience of supervisors, lead mechanics, and skilled inspectors can be captured and reflected in these training classes. This knowledge base also should be made available in some manner on the maintenance floor so that an inexperienced mechanic working the night shift can gain access freely and thereby answer his questions on the spot.

**Resource Management.** The continuing quest for avenues to improvement in aviation maintenance has led some to consider adopting the concepts of cockpit resource management (CRM) training, a program used with flight crews to ensure that crew teamwork and coordination are optimal and that best use is made of all cockpit resources. CRM training now is provided by most of the major airlines and reports are that flight deck performance has benefitted from this training. This positive experience with flight crews implies that the same principles might be used beneficially in training maintenance personnel who also must function effectively as crews.

Pan American World Airways, Inc. in 1989 started an exploratory program using flight-crew CRM concepts with a group of management and senior maintenance personnel. Those who participated in the experimental training program found the concepts to be relevant to maintenance operations. They also judged the information to be useful and felt that participation in this training program would affect their behavior on the job. Pan Am plans to extend this program to include all of its managers and supervisors. Ultimately, of course, evidence must be obtained concerning program impact on actual maintenance performance.

## Recommendations

1. Airline operators should consider adding to their training efforts formal programs concerning proper use of the general aircraft manual and proper procedures for completion of paperwork required by the FAA. This course should be given very early in the work history of a maintenance technician.
2. The introduction of resource management training into maintenance training programs offers promise as a positive factor for improved productivity. Resource management training should be encouraged by the FAA and should be considered by airline operators.

## Training Delivery Systems

The movement toward use of computer-based training (CBT) in maintenance training is growing and will be a dominant theme in the decade of the 1990's. CBT has many advantages as a training delivery system and apparently is being well received by maintenance technicians. CBT provides one-on-one training and also allows a student to proceed somewhat at his own pace. These are good

qualities in the eyes of trainees.

Work is being done with CBT and other training delivery systems to take advantage of the latest computer and display technology to bring maintenance training into the world of "high tech." One program described at the meeting is using interactive video plus expert systems to present a realistic maintenance scenario which then can be reviewed with a critique of the student's performance. Another effort is using 3-dimensional display technology to present maintenance items more realistically. A third effort is a computer-based intelligent tutoring system which incorporates models for a content expert, the instructor, and the student.

The work now being done on advanced training delivery systems is impressive and should have considerable impact in years to come. However, these systems are expensive and may well remain beyond the means of smaller maintenance operations for some time. As feasible, studies will be required to determine the ultimate impact of these training delivery systems on maintenance productivity so that cost-benefit analyses can be made.

Before computer-based testing and expert systems technology become common place, most training still will be delivered by the individual instructor and by the mechanic or inspector who is guiding on-the-job training. While such individuals may be quite knowledgeable concerning maintenance, they are not necessarily trained instructors. The suggestion was made that training materials be developed and training be given to part-time instructors concerning accepted principles of instruction and ways of assessing training effectiveness. A short training program or a brief handbook on training principles were mentioned.

## Recommendations

1. The FAA should develop a short handbook on training to provide guidance for those planning and conducting in-house maintenance training programs. This handbook should present principles of training, describe proper instructor-student relationships, and discuss informal means of assessing training effectiveness. The handbook should be done completely in maintenance terms and should be structured as a "How To" book.

## Measurement of Proficiency

An essential part of any training system is the ability to measure the proficiency of a student at any point during training and certainly at the completion of training. One presentation at the meeting made the point that "We must be able to assess the proficiency of a graduate in doing the kind of work he will be expected to do as a mechanic. Logging the time a student spends working on a training aid, or watching someone else work with a training aid, is not sufficient."

There are compelling reasons to consider the problem of proficiency measurement. Without valid methods for the measurement of proficiency, no real way exists to determine the true value of new training technologies, for example. There is no way to determine the effectiveness of technical training schools. Realistic training periods for company training programs cannot be established.

The methods used to measure proficiency today, i.e., paper and pencil subject matter tests, etc., undoubtedly measure proficiency to some extent. However, better measurement can be achieved.

Most training programs now being developed for the Department of Defense use a formal process known as Instructional System Development (ISD). One function within the ISD process is the construction of Job Performance Measures (JPMs) for each task. These JPMs are used for a number of purposes with one of the most important being the design and evaluation of training. Some process akin to the development of job performance measures would be very useful for maintenance training. In keeping with the ISD model, such measures or tests must be developed directly from training objectives, rather than from the content of training lessons.

## Recommendations

1. The FAA and industry should be sensitive to the need for more systematic procedures for measuring the proficiency of trainee and technician performance in maintenance. The task analysis effort now being undertaken as part of the work of the FAA Human Factors Team in Aircraft Maintenance and Inspection will provide an excellent starting point for a proficiency measurement effort.

## Training Feedback/Follow-Up

Continuing improvement in training requires a follow-up effort, some means of tracking the success or failure of the program and its components. As students graduate from A&P technical training schools, they move on to the airline industry or to other sources of employment. There is no way at this time to follow these students, to document their career paths, and to determine their on-the-job success. Such information would be of considerable value in reviewing the effectiveness of the technical training system and of its individual schools and parts.

## Recommendations

1. The FAA should conduct a national survey on the current placement and competency of A&P mechanics. This survey should produce sufficient information to allow meaningful feedback to the training system.

## Appendix A: Meeting Presentations

### FAA'S PROPOSED REVISIONS TO PARTS 147 AND 65

*Leslie K. Vipond  
Office of Flight Standards  
Federal Aviation Administration*

Part 147 of the Federal Aviation Regulations governs the procedures and curricula of technical schools which teach aircraft maintenance. Part 65 of the FARs covers the certification of mechanics and repairmen.

Part 147 was included in the FARs in 1962, almost three decades ago. At that time, the FAA commissioned a study of the aircraft maintenance occupation in order to develop definitive information about the job functions of a maintenance technician. This study was primarily a Job Task Analysis of the aviation technician position. The study, often called the Allen Study after its principal investigator, Dr. David Allen of the University of California, was used primarily to develop curricula for airframe and powerplant (A&P) schools.

The maintenance training curricula presented in Part 147 were based on the needs of the 1960's. Obviously, major changes have taken place in the aviation industry since that time. But, with the exception of some minor changes mostly to clarify language, the regulatory intent of the curricula has remained unchanged since about 1970. The FAA, however, recognizes that the regulation needs change and has initiated a number of actions to do so. In February 1988, the FAA proposed to revise specific parts of the regulation to upgrade educational requirements. I was assigned to this effort as a full-time Project Officer. Since then, we have held three public listening sessions at which members of industry and technical schools were invited to present their ideas.

The FAA now has a Notice of Proposed Rulemaking (NPRM) to effect changes in Part 147. The current schedule for the NPRM calls for completion during the fall of 1990. The purpose of the revised rule will be to produce a better trained technician, someone who can function more easily and capably in today's aviation environment.

The proposed revisions to Part 147 will produce a number of changes in the training of the Aviation Maintenance Technician (AMT). Instruction in the use of non-destructive diagnostic systems will increase, as well as instruction in electronics and avionics. Avionics will include training in use of built-in test equipment and in the maintenance of electronic flight information display systems. All schools will teach maintenance and repair of composite structures and turbine engines to a new level of proficiency. In contrast, requirements for instruction in wood, dope and fabric structures, welding, radial engines, and propellers will be decreased or eliminated.

Another change will be to allow a technical school to direct its curriculum toward its market. For example, if one school were in an area in which extensive crop dusting operations were conducted, its curriculum could be developed toward that market. The school would probably increase instruction covering radial engines, propellers, and welding. In contrast, a school in an urban market training technicians exclusively for the airlines might wish to change their curriculum to emphasize electronics, turbine engines, and repair of composite structures.

The FAA has evaluated some of the operating rules used by technical schools and hopes to eliminate some inefficient constraints of the past. We recognize that these schools are competing with other industries for students, for example the computer industry. In light of this, we were reluctant to raise the number of training hours. We feel that by intensifying the training requirements and not increasing the training time beyond 1900 hours, the curriculum would still fit within a two year program. By not increasing the training time beyond the two-year level, we hope to retain the attractiveness of these schools and let them be consistent with other two-year programs given at the junior college or the community college level. In short, the new regulation should mean the

development of a more streamlined curriculum. It will encourage the use of more innovative teaching methods, such as use of interactive computer-based training. Students will be able to use more advanced training aids and also will be trained on newer technology. The revision therefore is expected to promote the development of new AMT schools and to attract more students to this discipline.

The handbook for FAA inspectors responsible for the inspection of AMT schools also has been revised. As many of you know, each AMT school is inspected at least once a year by the FAA, and often more frequently than this. There also is a new FAA Advisory Circular directed toward interested parties who might want to start a technical school for Aviation Maintenance Technicians. Within the past year, we have had 13 new applications for schools. This is a considerably higher number of applications than we have received annually in past years. The publicity concerning curriculum revision may have contributed to this increased interest.

At this time, the FAA also has a proposed evaluation of FAR Part 65, the regulation which deals with the certification of mechanics and repairmen. Subparts D and E of Part 65 specify the requirements for mechanics and repairmen. This includes the training, experience, privileges, ratings, recordkeeping, and currency requirements for these aviation maintenance personnel. Since Part 65 has not been revised for 23 years, the FAA believes that a complete evaluation of this regulation is in order. Our regulatory evaluation will include, but not be limited to, the training requirements, certification standards, the rating system, mechanic and repairmen currency requirements, their limitations, experience requirements, the inspection authorization, aviation maintenance technician school integration and accompanying standards, impact of the changes on related FAR sections, and impact on bilateral and international agreements, including ICAO standards.

In the development of revisions for Part 65, we will rely heavily on human factors criteria. How can human factors studies provide input? Such studies are based on issues arising in the aftermath of deregulation of the airlines. We all recognize that this includes problems with the aging aircraft fleet. This has demonstrated a need for revision to Part 65, particularly as it should deal with non-destructive testing and corrosion control. Human factors studies will show us the best way to adapt certification standards to ensure that the maintenance workforce is best able to apply the new testing and diagnostic technologies.

To provide a sound basis for the revision of Part 65, we are planning to develop a Job Task Analysis (JTA) of the occupation of "Aviation Maintenance Technician." This JTA will assist us with the following:

**Certification Standards.** Can these standards be improved? Will any improvement at the same time increase the quantity and quality of applicants?

**Rating System.** Should this system be changed? Currently there are two ratings, airframe and powerplant. We have had many suggestions for adding another rating, so this issue needs study.

**Technician Currency Requirements.** Are these adequate? At the present time we do not believe they are adequate, but we need more information before any decision can be made.

**Certificate Limitations.** Are these limitations appropriate in the highly technical environment of today's aviation?

**Training Requirements.** Here we are concerned with training both before and after FAA certification. In particular, are appropriate training courses available after the certification and are they accomplishing their objectives?

**Inspection Authorization.** This is the authorization given by the FAA to an individual holding an A&P certificate for at least three years and who meets certain other criteria. These persons are authorized by the FAA to release an aircraft to service after major repair or alterations and to perform an annual inspection. Are the current limitations, duration, and renewal criteria for the inspection authorization appropriate?

The job task analysis will provide a detailed examination of the mechanic position. It will tell us how often a mechanic performs certain activities, the knowledge and skills that are required, what manipulative capabilities are necessary, and the training required for a mechanic after FAA certification. In short, the job task analysis will help us define the criteria needed for a complete revision of Part 65.

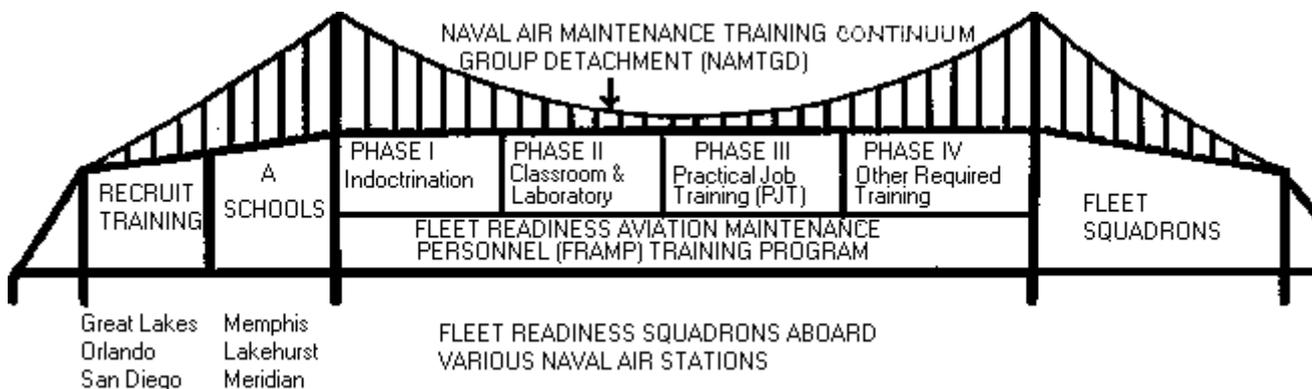
In addition to the job task analysis, the FAA is planning to hold about three public hearings across the nation to allow people from the aviation industry to discuss the proposed Part 65 revision and to provide any inputs they would like. We would like for the revised Part 65 to be the result of our best collective efforts. For this to occur we need the comments and recommendations of all interested parties in the aviation maintenance community.

## U.S. NAVY TRAINING FOR AIRCRAFT MAINTENANCE

*Captain James Qurollo, USN  
Naval Air Maintenance Training Group*

The Naval Air Maintenance Training Group provides formal maintenance training for each specific type of aircraft used by the Navy. Maintenance training is given across the United States, but primarily on both coasts at major Naval Air Stations and at Marine Corps Air Stations. Our training program employs about 1,600 instructors, 300 support personnel, and approximately 100 civilians. We have 1,100 trainers, use approximately one and one-half million square feet of floor space, and train between 50,000 and 60,000 students a year.

When a young man or woman enters the Navy, normally just out of high school, he or she generally follows the training path shown in [Figure 1](#). The inductee first goes to recruit training for about six weeks of Navy indoctrination and basic seamanship. Depending on expressed interest, qualifications, and test scores, the recruit might next be assigned to an Aviation A School. A School training can be anywhere from six to fourteen weeks and covers basic electronics, basic airframes, and basic hydraulics. Most of the Aviation A School training is done at Memphis facilities.



**Figure 1**

After Memphis, a maintenance trainee goes to one of the Naval Air Stations on either coast and begins Phase 1 through Phase 4 training as part of the Fleet Readiness Aviation Maintenance Personnel Training Program. In this program, Phase 1 is indoctrination. Phase 2 is the formal classroom training, conducted both in the classroom and in laboratories. Phase 3 is the practical job training in which the training is directed entirely toward accomplishing maintenance tasks. In Phase 4, we cover miscellaneous topics such as the maintenance of ground support and aviation support equipment. Finally, trainees are sent to fleet squadrons where they continue to be trained, with training directed toward the specific aircraft flown. This training is primarily on-the-job training (OJT) but may include some classroom work.

Aircraft-specific training takes place during Phase 2 and Phase 3. Depending on the particular aircraft and the particular specialty of the individual, Phase 2 might last from 3 to 19 weeks and Phase 3 from 2 to 6 weeks. The fact that Phase 2 can in some cases last for 19 weeks has caused us to examine one part of the process. When the student moves into OJT in Phase 3, we found that in some cases it was necessary to do a measure of retraining or to have some classroom refresher training on some of the material the student had learned during the early part of Phase 2. In order to eliminate this retraining, we developed a new program in which the Practical Job Training (PJT) of Phase 3 and the formal classroom/laboratory training of Phase 2 were broken into logical sections and combined into one training effort. We currently are using this new training procedure with F-14 aircraft training at NAS Oceana, the F-18 aircraft training at NAS Cecil Field, and two other facilities. We are finding that with this combined procedure we are able to reduce training time by over 20 percent which, considering the number of students we are training, represents a considerable cost savings for the U.S. Navy.

## Trainee Issues

The first issues to be faced in the development of a training program are who to train and how much training to give. In the Navy effort, a new recruit will go through the entire training curriculum. However, if the trainee is a mechanic or technician who is changing from one type of aircraft to another, he will go through Phase 2 and Phase 3 only in order to learn the new airplane. He learns to be a mechanic on the new airplane but he does not relearn electronics or engine systems. If he is current on a given airplane, he still may need additional training through his tour of working on that airplane. We handle this through a program called Maintenance Training Improvement Program (MTIP) that we use periodically to test technicians and mechanics and to look for specific weaknesses. Following this, we tailor a short period of training to address these specific problems.

The student-to-instructor ratio is adjusted throughout Navy maintenance training as appears appropriate. In A School training we have a student-to-instructor ratio of ten to one in some instances and even as high as twenty-five to one in others. The class size is relatively large and is taught as would be any course in a college. In Phase 2 and 3 training, the student-to-instructor ratio typically is two to one, with a typical class size of four to six students. When instruction is given in the classroom, this ratio is often two instructors and four students and at times two instructors and two students. One reason for this low ratio is safety. Some of these trainers are dangerous and we want to have an instructor right with the student to ensure that nothing dangerous is done inadvertently.

As opposed to the training of civilian aviation maintenance technicians, the Navy does not have a fixed number of training hours. If a technician is learning to maintain a P-3 airplane, which is a relatively complicated avionics aircraft, he may go through 19 weeks of Phase 2 on an eight hour per day, five days per week basis. For someone going to an airplane which is less avionics oriented, the Phase 2 training might only be six weeks in length. And we also have two different levels. There is the organizational level, in which a trainee would learn how to change an aircraft engine for example, and the intermediate level, where the trainee learns to tear down the engine. These training courses are of different lengths.

If an individual in Phase 2 or Phase 3 training is having any difficulty, the instructor or a subject matter expert will provide additional training. For instance, an instructor might take a student for two hours of individualized training after the normal classroom training. This means that we are training to proficiency rather than providing a training effort of fixed length. The expense of bringing an individual all the way to Phase 2 or Phase 3 training is such that we will go to considerable lengths, in terms of additional training hours, to ensure the success of the training and that the student leaves with the requisite proficiency. To the fullest extent, we train to proficiency.

## Training Practices

An on-going question is "How do you train?" Usually the decision is one of deciding the mix of training practices and procedures you will use. After World War II, the original Naval Air Maintenance Training Group worked with mobile training teams. Trainers on flatbed trucks or tractor trailers were taken across the country to provide formal maintenance training courses. Then, after the Navy developed the base loading concept in which each type of aircraft was located at a particular base, we changed to the school house concept for maintenance training. For a number of years now, this has been our primary mode for providing this training. Now, however, we are moving back toward a measure of mobile training, since this concept appears to offer advantages in particular situations.

We also have learned that we need a mixture of formal classroom training and on-the-job training. The two practices can be used to supplement each other or to cover independent aspects of our training curriculum.

Navy maintenance training may be supported by the use of actual hardware trainers, simulators, or may require no trainer. The decision concerning the route to follow here is influenced very much by cost. Hardware trainers initially are very expensive. The initial cost of simulators, by comparison, is less expensive. Nonetheless, for a variety of reasons, maintenance trainers in the Navy are almost always hardware trainers, although we do have some limited experience with simulators. This experience has told us that simulators are more expensive to maintain than hardware trainers and therefore can be more expensive in terms of life-cycle costs.

In selecting training equipment, we always consider the requirement for fidelity. If we are teaching hands-on procedures, remove and replace, we may require a hardware trainer or a simulator. On the other hand, if we are teaching theory only, standard classroom training, using no equipment, may be most appropriate.

Another variable we encounter is "frequency of change." As an example, the P-3 Orion aircraft has been in use by the Navy for about 30 years. During this time, there have been over 1,100 engineering changes, or close to 400 a year. We also have some 87 maintenance trainers associated with the P-3. When it becomes necessary to change the maintenance trainers because the aircraft has changed, one must look closely at the life cycle cost of these changes. As we have found, changing simulators to match aircraft changes can be quite expensive. For this reason, we have a number of simulators that have not been changed. These simulators now are sitting in the back of a classroom with a canvas cover over them because they don't look like the airplane anymore. We can't use them to train and they are too expensive to update. In many instances, it would cost more to update a simulator than simply to buy a new one.

Another variable influencing our decision regarding use of trainers is the type of students we have. Maintenance trainees in the Navy have a wide range of educational background and learning ability. Most, but not all, of our students are high school graduates. Some, but not all, read at the tenth grade level. We must choose our equipment so that it is capable of being used by students through the full array of ability.

At one training site where we teach maintenance for the AV-8B Harrier aircraft, we use a lot of simulation in maintenance trainers. With these simulators, we have large training panels which can be plugged into the simulator to demonstrate theory of operation and different troubleshooting procedures. These training aids are quite useful. One graduate of this program was interviewed at a later time when working at the squadron level. He said he thought his training was good but he did not understand why, when he got to the squadron, he no longer had the fancy troubleshooting devices but, instead, only had a small multi-meter. He did not understand that what he was seeing in the classroom was a trainer. This had not been pointed out to him and wasn't considered necessary, although apparently it was.

## **New Directions**

One new direction for Navy maintenance training is in an increased use of simulators. While

hardware trainers may be best for maintenance training, their high initial cost is turning us more and more to simulators. This being the case, we are trying to make our simulators as good as we can. Depending on our assessment of the fidelity requirement, the simulator should look, feel, and act like the hardware. We are also attempting, to the extent feasible, to ensure that our simulators can be changed in a timely manner and without great cost, in order that the simulators can stay abreast of changes in the aircraft. We do not want to have obsolete trainers on our hands.

**Computer-Based Training.** The Navy is also moving toward increased use of computer-based training systems, particularly for training topics involving theory of operation, interpretation of flow diagrams, and similar issues. For these topics, computer-based training can be quite useful and also can be changed quickly when a change becomes necessary. However, we are being quite careful not to use our computer-based training systems to replace hands-on maintenance training that we give in laboratories. For instance, a trainee cannot safety-wire a system on the computer. Hands-on training is required to learn this kind of activity.

**Imbedded Training.** The Navy is using imbedded training increasingly to meet many training requirements, particularly in operator training with pilots and other aircrew members. However, imbedded training now is moving into maintenance. As an example, our latest intermediate level test bench will provide considerable imbedded training. An individual working with this test system can have on-going training in which the system will teach him both new techniques and refresh him on certain procedures with its own training programming.

A key advantage for imbedded training in the Navy concerns space requirements. Floor space and deck space both are limited. In the intermediate maintenance area on a ship, there are many test benches and just about every square inch of space is taken. If some of that deck space must be used for trainers, many conflicts can occur. However, if the test bench is computer operated and can be used to provide its own training, there is a considerable savings in deck space. This is an important reason for our movement toward imbedded training.

**Early Involvement in Trainer/Course Procurement.** We have found that the Navy can save considerable costs in maintenance training by having an early involvement of the subject matter expert. The person who is responsible for the training content should have early involvement in the training equipment procurement process, including involvement in developing the request for proposal (RFP), evaluating the proposal, writing the contract, conducting design course and curriculum reviews, and in general following the trainer until it arrives at the training site. In the past, we have had experiences where we received trainers that were not what we needed to train as well as courses that we had to rewrite before we could use them. This early involvement program should be very cost-effective for the Navy.

The "New Directions" I have just described illustrate some of the changes now taking place in Navy maintenance. We are always receptive to other ideas and procedures in a continuing program to ensure that Navy maintenance is as good as it can be. The aviation resources of the Navy must be maintained in a maximum state of readiness to meet our nation's world-wide commitments.

## TRAINING WITHIN THE INDUSTRY

*David S. Wadsworth  
Professional Aviation Maintenance Association*

The Professional Aviation Maintenance Association (PAMA) is a non-profit, non-union, 20-year old association of aviation maintenance technicians dedicated to promoting safety and professionalism in the field of aviation maintenance. Support and improvement of technician education and training at all levels are a large part of PAMA's mandate. I am here today as a representative of PAMA to share some ideas and, hopefully, to help find answers to some of our problems in aviation maintenance training today. In equal measure, I am here to learn. I want to thank our hosts for this opportunity to do both. I will be touching on several of the topics we have already heard about this morning, and I hope I can shed a bit more light on some of them.

We probably all agree that the most talked about facet of aviation maintenance today is adequate training of technicians in today's technology in numbers sufficient to fill today's and future needs. I would like to share with you some observations we at PAMA have made about our profession and its needs, and offer some suggested approaches to make it better.

For at least three years, predictions of a shortage of technicians have been trumpeted throughout the industry. As a result of the recent aging aircraft issue, the advancing of our veteran technicians to retirement age, and the rapidly advancing technology in the field, we are now face-to-face with that shortage. We in the industry have grappled with the problem long enough to know that it is a problem of singular complexity, and that it will not go away of its own accord. To solve it, we must have a realistic picture of the situation in the aviation maintenance field as well as in the training field.

I would suggest that this shortage, as it is called, is composed of at least two major facets. First, there is the lack of pure numbers of technicians coming into the market today. Second, those graduate technicians who are entering today's market possess an overall lower experience level than did the group entering the field ten or fifteen years ago.

Let's look at the lack of pure numbers. PAMA's research shows that only about 50 percent of A&P graduates in this country enter the field of aviation maintenance. This is a mixed blessing. Other technical fields have recognized that A&P certificates are golden. It also means, however, that we are losing valuable, highly trained individuals to professions that offer better pay, better benefits, and possibly a better perceived image. The lack of pure numbers can be seen further by looking at some facts from Mike Murrell, publisher of FBO Magazine. Following are some of Mike's comments from the June 1990 issue of that magazine:

- The U.S. labor force will grow only 1.2 percent a year from 1986 to 2000, down from the annual rate of 2.2 percent from 1972 to 1986.
- The number of people from 16 to 24 years old has been declining by around half a million a year, and will continue to do so until at least 1995.
- In 1980 there were roughly 26 million people from this age group in the civilian labor force; by 1995, that will drop to 20 million.

These numbers indicate that "while in 1973, 13 of every 100 males were between the ages of 16 and 24 ... the 1990 and 1995 estimates are 9 and 8, respectively." The baby-boom supply of people traditionally targeted for entry-level jobs is rapidly running out.

The concept of less overall experience is, by necessity, a bit less quantitative in its discussion. It has to do with the traditional supply of aviation-experienced veterans who have come into our technician schools and into our industry with some years of experience in certain facets of aviation maintenance. From World War II through the Korean conflict to the Vietnam era veterans, this industry has reaped the benefit of A&P technicians with a basic practical experience level sometimes equaling several years before even beginning their A&P training. This flow is obviously no longer anywhere near previous levels, and the technicians who do benefit from military training find their areas of expertise have become highly specialized. Broad spectrum experience is no longer there.

In PAMA's own in-house referral service, we continue to see a demand for technicians with three to five years of experience while tendering a vast majority of applicants who are fresh out of A&P school. This would indicate that there is a disparity in the various concepts of what entry level really means. The indication here is a general failure to recognize that the basic A&P certificate is a license to learn, an opportunity to polish and specialize, and a certain lack of willingness in our industry to enter into the training process at this most crucial point.

The technology in today's corporate and commercial aircraft calls for training and techniques never before demanded in this profession. Again and again we have all heard about the need to supply specially trained technicians to handle state-of-the-art structural materials known as composites, glass cockpit technology, fly-by-wire, and fly-by-light systems. It is safe to say that the

sophistication of this technology will continue to increase in the coming years,

Who is not familiar with our industry's most recent crisis, that of aircraft structural failures attributable to our aging fleet? This problem has touched literally every sector of the U.S. registered fleet and most areas of commercial and private aviation around the world. Caring for the aging fleet has taken top priority in the aviation maintenance world for the past two years, and will hold this position until suitable methods for tracking, inspection, maintenance, and repair are identified and implemented. Extensive training and education is playing, and will continue to play, a major role in conquering the problems of the aging fleet.

In this regard I will quote our FAA administrator, Admiral James Busey, from a message he delivered at the PAMA Awards Banquet in Houston this spring. Admiral Busey said, "The Aloha Airlines accident of 1988 focused public attention on the important role maintenance plays in aviation safety." He went on to say, "Aging aircraft are creating problems for both airlines and general aviation." In summary of this point, he said, "Aviation maintenance technicians have a double-barreled challenge -- they need to maintain older aircraft and get ready for the new technology that's coming."

Much of the view I have just shared with you is not new, and I am sure that many of you have been party to hashing and rehashing various parts of it. You should know, then, that there are some other educational factors to be reckoned with in our profession which are not as obvious and which require training and education on a more far-reaching and subtle level. Some of these factors have to do not only with training of technicians, but also with educating various parts of the public.

One of these is the public awareness, or lack thereof, about our profession. Knowledge of the aviation maintenance field, the training required, and the career opportunities available is poorly distributed. Most references to aviation careers available to young people today are about pilots and air traffic controllers. Little, if any, mention is made of maintenance and its varied possibilities. Sometimes knowledge of our profession has limited scope even among our own ranks. When speaking to classes of A&P students, I have noted with disturbing regularity a lack of understanding of the opportunities and career choices available to them. It seems that we may be training a generation of technicians whose future is, in large degree, a mystery to them. How can we expect them to understand the scope of their professions when parents, grade and high school officials, teachers, and even guidance counselors have little idea of what it's all about?

The area of recurrent training for technicians in the field is of utmost importance in considering the problems we are facing. I would suggest that there is ample opportunity among factory schools and the private enterprise training facilities such as Flight Safety International or SimuFlight for keeping up with needed training demands today. What is lacking is acknowledgement by management of the need for this recurrent training. I can personally testify to a managerial attitude, especially in the FBO, private and corporate sectors, that formal recurrent training is a waste of time and money for the company. A common argument is, "We need our technicians here on the hangar floor maintaining our aircraft," or "Anything we need to know about our equipment is in our manuals."

This lack of understanding helps to create and maintain another factor requiring education outside of our ranks. From the beginning days of our profession, the aviation maintenance technician and the profession in which we work have suffered from a misconception about what we do, the knowledge and expertise needed to do it, and the safety and reliability levels involved with our responsibilities. Because the image of the cigar-chewing, grease-stained, semi-literate mechanic remains with us today, there is a need for education and training that is directly related to the advancement of our field other than that normally associated with training technicians.

Lest you think my object here is to paint a bleak picture of our lot today, I want to talk about what is being done right. I said earlier that we need to have a realistic picture of the situation in the aviation maintenance field as well as in the training field. There are many indications of that picture coming together, and steps have been and are being taken to accommodate the problems that we know are there. As you heard in this morning's session, FAA and the industry (notably the Aviation Technician Education Council) have worked successfully on a review and revision of FAR Part 147,

which addresses our A&P school curriculum. This revision has provided a much-needed adjustment in areas of emphasis to more closely align training with current technology. (There are people here who can more readily answer questions about Part 147 and its new form.) Another area of progress is the FAA's current review of FAR Part 65, Certification: Airmen Other Than Flight Crewmembers. The concept used here is, again, to use industry expertise and experience from as broad a spectrum of our field as possible to analyze and suggest adjustments to our certification process. I am proud to say that PAMA has been instrumental in organizing our industry talent in this effort, and working groups are currently doing just that -- working on Part 65.

In recent years the airlines have been spreading the word that they want specialized training in their technicians -- training more fitting to the airlines' needs and methods of maintenance in the airline structure. At least two major airlines in the United States today have plans to start and run technician training schools. In this case, the basic A&P certificates will be enhanced by more specialized exposure to subjects addressing specific airline needs. I expect that [Dr. Ken Govaerts](#) will address this subject during his session tomorrow.

One of the most encouraging trends in aviation maintenance training today is evident in our forward-looking A&P schools. Institutions that see the current shortcomings and future needs in aviation maintenance are offering training in specialty areas such as avionics and composites. Technicians in training can choose to extend their education, abilities, and worth to the industry and increase their earning power by taking advantage of these programs.

A good example of this concept can be seen in the Pittsburgh Institute of Aeronautics' Avionics Technician Training Program, or AVT. I would like to draw from a recent article in this institution's news magazine. The article announces the addition of a sixth semester to the school's avionics program, the objective being to provide PIA students with training in aircraft instrument repair and familiarization with commercial aircraft systems. The article goes on to explain, and I quote:

"The decision to add this new training came after many months of research into ways which would make our AVT graduates even more successful as they enter the industry. The research included substantial input from major air carriers, instrument manufacturers, and instrument overhaul facilities. The research indicated that, while modern aircraft design trends feature fully electronic components and systems . . . there is (and will continue to be) a substantial number of aircraft equipped with electromechanical instrumentation. Many of the cockpit displays and indicators in even the newest aircraft are electromechanical in nature; designed, built, and maintained with time-proven technology. There is thus a need for an avionics technician to have a working knowledge of the proper operation and care of both electronic and electromechanical instruments."

The article goes on to describe the equipment and facilities that will be and are being committed to this expansion. This is one example of progressive thinking and planning that will help meet the needs of our industry, and I imagine that [Mr. Jack Moore](#), who is next on today's agenda, may enlighten us further in this area.

I am proud and excited to announce that PAMA is embarking on a traveling program of two-day seminars designed to help fill the training gap, not only in the technical area, but also in promoting better understanding of FARs and the safety and legal aspects of our profession.

Contrary to the gloom and doom of our training status today there seems to be a great deal being done to meet the challenges. Industry and the FAA are cooperating to review and revise our training and certification guidelines. Modern, progressive A&P schools are coming to the fore with advanced programs in specialty areas, and airlines are attempting to address their own special needs by producing technicians specialized for their own demands.

Even with such progress, there are still many changes to be made and much planning work to be done in order to catch up with industry's needs and to ensure the replenishment of our dwindling supply of competent technicians. One of the first problems I mentioned was the shortage in pure numbers of technicians. Time and again, FAA and PAMA have said that there is no sure, accurate

method to count our active A&P technicians. Washington's list of A&P technicians was begun in the 1950s, and has accumulated names of all certificate-holders since that time. No method of tracking those names or of purging the list is currently available. There is no way to determine even how many of these people are deceased. Consequently, determination of how severe our technician shortage really is has become a problem in itself. PAMA suggests, therefore, that a major step in helping to solve our industry's technician shortage problem is to implement a technician re-registration program on a basis adequate to developing and keeping quantitative records about A&Ps, repairmen, and authorized inspectors. This proposal does not suggest or promote retesting of technicians. It supports a common-sense method of statistical tracking of our industry's resources. This is a system used throughout the United States to track nurses, real estate agents, and hairdressers. Reasonable fees to carry out such a program should be borne by the individual technicians.

Additional training of basic A&P certificate-holders in such areas as avionics, exotic structural materials, and non-destructive inspection must continue to be encouraged. Progressive A&P schools are taking the lead. Industry can encourage those by recognizing various levels of expertise through higher positions and better pay. We must also ask if FAA should recognize these levels by the establishment of federally recognized standard specialties other than airframe and powerplant; for instance, an A&P technician with a specialty certificate called non-destructive inspector or avionics technician. Possibly, authorized inspectors should carry these added designations.

Standard interpretation of FARs across the board is essential to training and education in aviation maintenance. Schools in each region need to have one standard upon which to base curricula and policy. PAMA and, I think it is safe to say, the industry as a whole supports regional standardization by FAA.

Finally, in order to assure a continuing supply of qualified technicians for the years ahead, we must educate the public about this profession. In particular, we must get into our grade schools and high schools -- we must create the opportunities to do so -- and tell young people about the real world of aviation maintenance. How it is structured, and what the opportunities really are. They need to know that aviation maintenance is a profession that stands on its own, and not a stepping-stone to becoming a pilot. In our own way, PAMA is attempting to get this message out by creating career brochures and acting as a clearinghouse of career information for all who call us. Additionally, PAMA is proactive in seeking new ways to distribute this information through our company members and chapters.

I sense in this industry today a new awakening to the problems and shortcomings we face and to the responsibility we have to clean our own back yard and to keep it that way. In National Transportation Safety Board surveys going back 20 years, aviation maintenance has an admirable safety record. It reflects an accident rate attributable to maintenance at no more than 3 percent. On behalf of PAMA and our industry, I call for cooperation and assistance from all of you in an effort to not just maintain but improve that record. With intelligent approaches to our system of training and education in aviation maintenance, we can ensure a renewable supply of highly qualified technicians for today's needs and for future needs throughout all sectors of the industry while raising the image of the aviation maintenance technician both in the eyes of the public and within our own ranks.

## TECHNICAL TRAINING SCHOOLS

*Jack Moore*

*President, Aviation Technician Educational Council and  
Professor, Clayton State College*

Technical training schools are responsible for providing a good measure of today's input of maintenance technicians to the air carrier industry. While I feel that these schools generally are doing a good job, they are being buffeted by a number of forces which are worthy of mention. To the extent that we understand these forces and can develop programs to address them, we will be able to improve the product we deliver to the industry.

Budget considerations and regulatory oversight are two of the most important forces acting on technical training schools today. Cost constraints dictate the highest student/instructor ratio and the minimum time to do the job. Regulatory constraints impose rules for operation that have not changed in keeping with the changing characteristics of aviation. Both of these forces must be dealt with if training schools are to meet the demands of the coming decade, both for quantity and quality of aviation maintenance technicians.

A major issue today, and one that will be addressed to some extent through the coming revision of Part 147 of the Federal Aviation Regulations, is that of determining the best curriculum to be followed by technical training schools. Training curricula should reflect the needs of the particular part of aviation which technicians will enter. For instance, the Navy has emphasized corrosion control as part of its curriculum ever since they began taking airplanes on aircraft carriers. They know what they want their maintenance technicians to do and this in turn causes them to decide the appropriate curriculum mix. At the Aviation Technician Educational Council we feel that each technical training school, just as in the Navy, should have some latitude in making the final determination of an appropriate curriculum. There are those who feel that oxyacetylene welding is important in aviation maintenance. Frankly, I feel that it has little relevance for the occupation of airline mechanic. I do not like being forced to deal with it to any great extent. In fact, at one time I asked all airlines in my area how important they considered welding. Their response was that "We don't hire A&P mechanics to do welding. We hire welders to do welding." I share their sentiments entirely.

There are many more examples of skills not appropriate or out-dated for the aviation maintenance crew of tomorrow. One certainly is the ability to prop an aircraft. In this day of high bypass ratio fan jet engines, there certainly is little call for an individual who knows how to prop an aircraft. As an example of a skill not appropriate for initial maintenance training, consider the ability to taxi an aircraft. How many airline operators will take a fresh A&P school graduate and let him taxi a 757? These skills are better learned on the job.

Many skills, such as welding and taxiing an aircraft, are important but do they belong in the curriculum of a technical training school? In such curricula, we must make room for more important issues such as the maintenance of turbine engines and the repair of composite materials. We indeed need to be doing more work with the latter topics but are faced with the issue of how to fit such additional training into our currently allotted training time. As we add new subjects, what will we give up?

The curriculum coverage in technical training schools directly affects the amount of time a student must spend in school. At Clayton State College, the age of our students is between 22 and 26 years. It may be surprising to find that the average student is over 22 years old. In fact, in most A&P programs in this country, there are few people going directly from high school into an aviation maintenance training program. When these people do decide to consider a career in aviation maintenance, it makes a big difference whether they are facing a two-year or a three-year commitment. If they look at a three year program of seven hours a day, five days a week and compare that to a four-year baccalaureate program or training for a profession such as medicine or law, they may well decline the maintenance challenge. A three-year commitment to obtain entry-level qualification into an occupation which may involve working in drizzling rain on an airport ramp to change an aircraft generator may not be that attractive.

The reasons for remaining with a two-year technical training program are strong. I have always chosen to stay within the 1900 hour curriculum and feel that it is appropriate not to have a proliferation of hours. However, this 1900 hour limit does bring its own set of problems. As an example, consider the 750 hours allocated to airframe and the 750 hours allocated to the power plant. Within each of these, there are a number of subcategories to cover topics of obvious importance. One not covered is basic electronic troubleshooting, which every major airline operator has reported to ATEC for the last ten years to be the most significant need. Most delays at the gate occur because of electrical or electronic/avionics interface problems. Mechanics need

troubleshooting skills for electrical systems so that they can approach the airplane secure in the knowledge that they will be able to troubleshoot the system and identify the problem. However, if we were to put in an additional 150 hours for basic electronics, how would we adjust the other parts of the curriculum?

As we review issues in the operation of a technical training school, let us examine use of other resources. At one time I considered having students take math and physics courses in on-campus departments since I felt that the instruction there would be quite good. Certainly a qualified teacher in mathematics at a college will do a better job in presenting this information than will a mechanic. However, I found that I could not use the campus resources unless I listed all instructors, all facilities, all equipment, and everything else associated with these courses and then obtained FAA approval for such use. Obviously this was more than I was willing to do, so I developed an alternative system in which students take these as regular on-campus courses and then do merely a review on math and physics. This review is very brief and concerns aircraft applications. So, in effect, I am reducing the 1900 hours of instruction by 50 hours for math and 50 hours for physics. However, I feel this system is designed to provide a better basis in conceptual physics and allow them to better understand the relationships of temperature, of pressure, and so on in air masses, all of which is part of our curriculum by requirement.

Improving instruction in math and physics is only one of many issues we must face if our schools are to turn out a product that the airline industry finds completely acceptable. And industry needs and standards are changing rapidly. Twenty years ago, who would have known that airliners today would have the integrated cockpits, glass cockpits, flat displays, fly-by-wire systems, and other high technologies? Could we have begun to prepare for these aircraft 20 years ago? How many of us would have had the money in restrained budgets and the available equipment to seriously prepare for today's aircraft? Yet perhaps we should have known because this technology was common 20 years ago in military fighter aircraft. The glass cockpit, the fly-by-wire, and all the rest were there at some level in the military in 1970. We must learn to anticipate trends and certainly the trend of movement of aircraft technology from military systems into commercial aircraft has been well established.

As we look at today's aircraft, the Boeing 747-400 represents the full advent of new technology. This aircraft has five cathode ray tube (CRT) displays and three computers. If we are to provide maintenance support for these aircraft, it is obvious we must move more toward computer training. How else will a mechanic troubleshoot Boeing 757 and 767 cockpits, which have an array of built-in test equipment, unless the mechanic has experience in interfacing with computer-based systems?

The transition to training for maintenance of higher technology aircraft may not be as difficult as we might think. Interestingly, the qualifications of some of our entering students are higher than one might expect. Last year more than 25 percent of my students enrolling for the A&P certificate already had a bachelor's degree. In fact, 20 percent of them had bachelor's degrees from Georgia Tech University, where they had taken industrial technology or industrial management programs. After graduation, they found they could make possibly \$17,000 per year employed in those fields. Then, when they learned of the shortage of mechanics and the kinds of skills required in aviation maintenance, they became interested in our program. The glass cockpit airplanes and use of new composite materials represent challenging matters for students with mechanical aptitude. Apparently these students decided it would be worthwhile to spend an additional two years to enter an occupation with these challenges.

As we move into a new era of aviation and attempt to train people to meet the maintenance requirements of high technology aircraft, we must confront the issue of proficiency measurement. We must be able to assess the proficiency of a graduate in doing the kind of work he will be expected to do as a mechanic. Logging the time a student spends working on a training aid, or watching someone else work with a training aid, is not sufficient.

I recently heard a Navy Commander in a television show discuss carrier operations and make the comment that "We are flying aircraft designed by Ph.D.'s, the production of which is overseen by people with master's degrees. They are flown by pilots with at least a bachelor's degree and are

maintained by high school dropouts who came into the military to get away from something worse." While the comments of the Commander may be a bit overstated, he does make a point. We should recognize that, in aviation, we ask a lot of aircraft designers, manufacturers, pilots, and others at visible positions in the industry. I feel that we expect the least of people in the maintenance area and that we have the poorest measures of how they achieve their goals. We must be able to do a better job of measuring proficiency at many points during training and certainly at the time of graduation.

To conclude, our focus in the training establishment must be always on ways to improve instruction and the quality of our product, the trained Aviation Maintenance Technician. One way to improve our product is to train to proficiency, not to train by hours. A second way is to integrate the training to the fullest extent possible. The theoretical and the practical must be integrated. When a student has had an explanation of the theory of operation of some system, he then should immediately be able to disassemble, inspect, and reassemble the system even if it is not something he would be expected to do as a mechanic. This is how students learn how a system works and how they learn to do effective troubleshooting.

The final point I would like to make concerns ways in which individuals are considered eligible for certification as mechanics. At this time, we will accept without question the ex-military individual with experience in military aviation maintenance. We feel that this experience provides capabilities equal to those of an individual who has covered the same subjects in an approved school. Yet, at this time we will not do the same for a student who may have acquired his skills in any system other than the military. In this case, the individual must be approved by the FAA as being qualified for all general subjects and all A&P requirements. The maintenance industry and the training establishment should apply standards of qualification evenly to all applicants, regardless of the particular situation in which they might have acquired their capabilities.

I have outlined a number of issues which we in the training establishment feel must be addressed if we are to provide qualified maintenance personnel to meet the needs of the air carrier industry in the future. I hope that we can work together toward solutions for these problems.

## AN INNOVATIVE APPROACH TO NDT INSPECTOR TRAINING AT BOEING

*Diane Walter  
Boeing Commercial Airplane Group*

### Introduction

The Task Analytic Training System model was developed to address training needs in the NDT areas of the Boeing Commercial Airplane Group. Specifically, to address on-the-job training. New and experienced inspectors need a comprehensive, structured training system designed to continuously improve the quality and reliability of inspections. They need a system that will provide first-time, remedial and recurrent training.

Any type of training must take into account three factors: skill, knowledge, and attitude. In order to blend these factors, the Task Analytic Training System is composed of three interacting components: job task analysis; job instruction training; and social psychology theory. These components are not new. The packaging, however, is unique. The job task analysis and job instruction training methods (which have been modified to meet the training needs of client divisions at Boeing) first appeared during World War II and earlier. The social psychology theory is based on the philosophy and psychological theory of Alfred Adler, a contemporary of Sigmund Freud and Carl Jung.

Skill and knowledge alone are not sufficient to ensure a well-trained and productive employee. An attitude that values work is critical to the success of any training program. Productivity relates directly to both ability and willingness to do work. Knowledgeable, skilled employees produce little when they dislike the job, have no personal goals for the work, and see limited personal reward for the effort. Attitude must be designed into the training system. One of the salient features of the

Task Analytic Training System is the positive effect it has on employee attitude and morale.

The discussion today will follow this agenda:

1. Problems with traditional training methods and common pitfalls that can result in industrial training program failures.
2. The WHAT, WHY, HOW, WHERE, and WHEN of the Task Analytic Training System.
3. The five basic assumptions of social psychology theory.
4. A description of the training system - the working elements of what you can expect from the system once implemented.
5. The Task Analytic Training System process.
6. Benefits of the training program to both employees and the company.

## **Problems with Traditional Training Methods**

There are several drawbacks with traditional industrial training methods. First, the training staff normally write the program. Typically, they have either little hands-on experience or none at all. The result is that the training material has little resemblance to what actually occurs on the job.

Second, the terminology is often unfamiliar to the staff. Training, to be effective, must be in the same "language" the worker uses.

Third, and extremely important, there is generally no employee ownership of the training program because of little or no participation from the workforce. Worker participation is crucial to the success of any training program. A basic assumption in the Task Analytic Training System is that people deserve the right-to-know what is going on around them, especially when it influences their jobs. A fourth problem with traditional training programs is that frequently they get put on the shelf and are forgotten. There is no follow-up or evaluation of the programs.

Fifth, the training system can become a "degenerating buddy system" subject to the following pitfalls:

1. Experienced workers are not always knowledgeable.
2. Without an outline to follow, valuable skills get left out.
3. Mistakes are perpetuated.
4. There is no consistency from employee to employee.
5. Shortcuts develop due to lack of understanding.

## **What, Why, How, Where, When**

### *WHAT is the Task Analytic Training System?*

It is a generic process, applicable to any job. It provides comprehensive, structured on-the-job training. The system incorporates proven training techniques/methodologies and is a performance based, hands-on approach. Training is accomplished through practice.

### *WHY was the training system developed?*

1. To provide new employees with structured on-the-job training.
2. To provide recurrent and remedial training to experienced employees.
3. To establish standardized procedures.
4. To positively affect attitude and morale.
5. To provide consistency between workers.

6. To incorporate changes in materials, equipment, and processes.

### *HOW was the system developed?*

The first step in the development of any training program is to obtain management commitment. Management has to agree that training is important and be willing to dedicate the necessary time and resources; otherwise, the program is already doomed to failure. The Task Analytic Training System is based on full workforce participation. Everyone is encouraged to participate in some way. During the development stage of the program, key personnel are a design team, an approval team, and a team facilitator.

The design team consists of three to five content experts(knowledgeable workers). Their primary task is to perform a job task analysis and write training modules on the identified tasks. The modules are short step-by-step procedures required to perform specific tasks. Criteria used in selecting employees to serve on the design team are:

1. Credibility with peers, supervision, and staff.
2. Willing and able to communicate what they believe.
3. Experts on most of the job being analyzed.
4. Willing to go along with the group even if they don't completely agree.

The approval team is made up of other knowledgeable workers, key supervisors, and technical experts. They review and approve all modules for accuracy and completeness.

The facilitator, a third party consultant, functions as a process expert and is present at all design team meetings to keep the team on track, help handle disagreements, and coordinate all activities.

### *WHERE can the training be applied?*

This training system can be used with new operations or with those already in existence. The program can be effectively applied in areas of high turnover or in any situation that requires workers to be retrained. A primary advantage of having a structured, comprehensive on-the-job training program is that employees are very quickly trained in new skills with minimum disruption of the day-to-day work schedule.

The design team may decide to apply the system to critical elements only or the entire job. The team has ownership of the system and directs its development to answer the needs of the workforce. Critical tasks may be addressed right away, if necessary, since modules may be written in any order.

The system can exist alone as a new training program or can be easily integrated into an existing program. The design team is encouraged to use material from sources already available and not to reinvent the wheel.

### *WHEN can the training system be applied?*

Training can begin early in the development process. It is not necessary to wait until all modules are written to begin training.

The training can be remedial, recurrent, or first-time training. The system (or process) is ongoing. Modules are written and used as needs arise - new materials, new equipment, changes in processes, etc. The flexibility of the modules (short procedures) allows for individual training plans. Due to prior experience, everyone will not need training in all areas.

## **Social Psychology Components of the Task Analytic Training System**

A fundamental component of the Task Analytic Training System is the social psychology theory of Alfred Adler. Adler is the founding father of social psychology which is at the very heart of present day management and organizational theories. There are five basic assumptions to the theory, and each is reflected in the training system.

The first assumption is that **all human behavior is goal-directed**. Each person's primary goal is to belong and feel significant. This striving for belonging and significance is the basis for motivation. People can only feel significant if they contribute. When employees are not given the chance to contribute, they become counterproductive, rebellious, avoid tasks, try to sabotage the system, etc. When given the chance to contribute, they become productive, task-oriented employees.

The second assumption is that **people are creative decision makers**. They are active problem solvers. Having an active role in solving problems is a hallmark of job satisfaction. People who are encouraged to be creative and active feel that they can make a difference and have an impact on the work environment. The Task Analytic Training System uses work teams to generate solutions by having them ask questions like, "What is the best way to do this job?"

The third assumption is that **humanity is socially imbedded**. People do not operate in isolation - everything we do, as individuals or in groups, relates in some way to other people. Problems cannot be solved by one person in isolation. Cooperation and contribution solve problems.

Fourth, **use is more important than possession**. The knowledge and skills a person has do not count unless they are put to use. The Task Analytic Training System is structured to develop and use people resources. In order to put skills and knowledge to use, employees must have attitudes that value work. Without attitudes that value work and see personal fulfillment in its accomplishment, it is doubtful whether employees would ever attain the classification as skilled, knowledgeable workers.

The fifth assumption is that **people (and organizations) function holistically**. The whole is greater than the sum of the individual parts. The Task Analytic Training System is based on teamwork. The quality and quantity of a group effort is greater than that of the same individuals working independently.

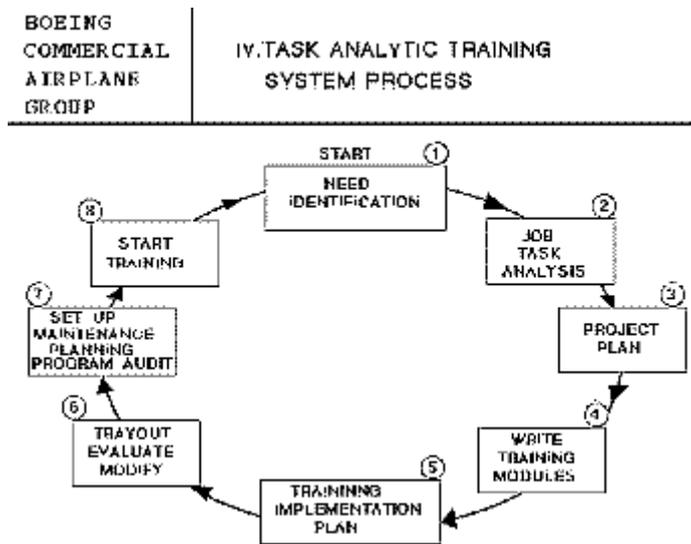
## Description of the Task Analytic Training System

The working elements of the Task Analytic Training System consist of: needs analysis; outlining targeted jobs; writing and verifying procedures (modules); an approval system; sequencing training; implementing; debugging; evaluating; and establishing a maintenance/audit plan. The system, when in operation, will do the following:

1. Establish written, agreed-upon performance standards which are measurable and observable.
2. Train and verify that employees are working to established standards.
3. Audit, on a regular basis, to assure sustained performance and to initiate appropriate corrective action.
4. Provide a plan to continue using the system with a trained facilitator.

## The Task Analytic Training System Process

Figure 1 shows a typical process for installing the Task Analytic Training System in a work area.



**Figure 1**

### *Need Identification - Step 1*

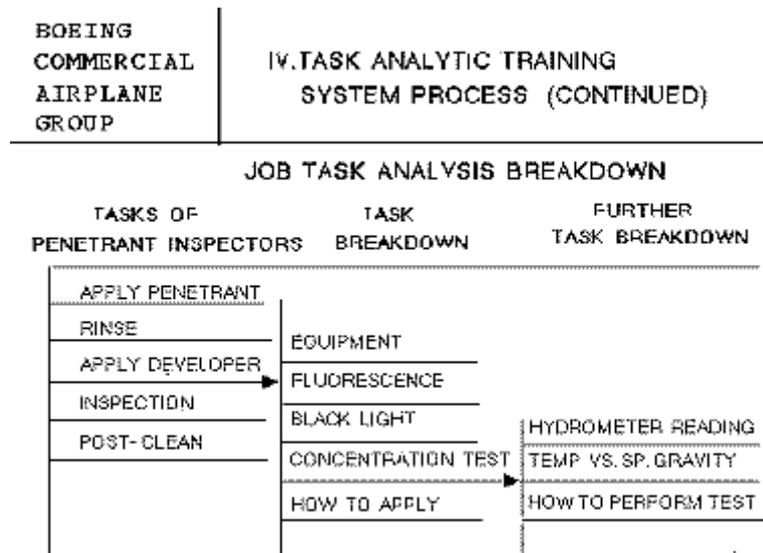
Identification of the problem as a training concern is the first step. If workers are able to do the job but are prevented from doing so because of organizational constraints, there is not a training problem. Once the need is established and a job is identified, the facilitator discusses the training system process with the workforce. Together they evaluate the usefulness of the system in that area. The facilitator then gains their commitment to continue.

### *Job Task Analysis - Step 2*

In breaking the targeted job down into task segments, the design team asks the following two questions:

1. What do you need to know or be able to do to be a qualified (Job title)?
2. Can you teach and can someone learn that in one-half hour?

Answers to question 1 are written on wall charts. Question 2 results in further breakdown of the major tasks into smaller segments. Repeated use of the two questions ends when the job experts agree that the branch of the "tree" takes no more than one-half hour to teach/learn. The left column in [Figure 2](#) shows a sample of the tasks associated with the job of liquid penetrant inspectors (resulting from applying question 1). The next two columns of Figure 2 show the task breakdown which continues until the tasks take no more than one-half hour to teach and learn. One-half hour segments:



**Figure 2**

1. Fit the attention span of average learners.
2. Provide manageable blocks of material for ease of instruction and learning.
3. Allow flexibility in situations where operating conditions require short periods of training away from the job.
4. May be modified as specifications change.
5. Give trainees a sense of accomplishment as they build a solid skill base.

### *Project Plan - Step 3*

After the job breakdown is complete, the design team creates a plan to keep the rest of the project on schedule. Identified tasks are ranked according to frequency, criticality, difficulty, degree of danger, etc. Some modules may need to be completed first in order to begin training on those tasks right away. A benefit of putting the project plan together as a group is the assurance of buy-in or group ownership. People tend to support their own ideas. Upon completion of the plan, the team obtains supervisory approval. This helps to strengthen management involvement and commitment.

### *Write the Training Module - Step 4*

Initially, two or three modules are selected in order for the team to learn the writing format. The level of complexity written into a module is critical. Too little detail means the module is unusable because of insufficient information. Too much detail results in a standard operating procedure that is cumbersome and difficult to modify. Generally, writers include enough material to serve as memory joggers for an instructor experienced doing the job. During the writing phase, the team engages in varying activities: meeting other teams in different areas; discussing forms and formats; providing periodic reviews to management; and verifying modules on-site. Each module is verified on-site at least twice: (1) by a trainee with an instructor, and (2) by at least one member of the approval team. Also, during the writing phase the team conducts workforce overviews to review modules with workers not on the design or approval teams. All members of the workforce are encouraged to contribute.

Figure 3 shows a typical learning module cover sheet. The cover sheet prepares the instructor and trainee to try out the tasks written in the module. Figures 4, 5, and 6 provide examples of the training modules. The easy-to-read-and-use format promotes workforce acceptance and increases the likelihood of the modules being used for quick task references.

BOEING COMMERCIAL AIRPLANE GROUP	IV. TASK ANALYTIC TRAINING SYSTEM PROCESS (CONTINUED)
<b>TRAINING MODULE COVER SHEET</b>	
MODULE NO. <u>24</u>	
MODULE NAME: <u>HOW TO PERFORM DEVELOPER CONCENTRATION TEST</u>	
TYPE : <input checked="" type="checkbox"/> SKILL <input type="checkbox"/> KNOWLEDGE	
OBJECTIVE : _____ _____	
INSTRUCTOR PREPARATION : _____	
SPECIAL REQUIREMENTS: _____	
PREREQUISITE MODULES : <u>24 A AND 24 B</u>	
PROCEDURES : <u>1. INSTRUCTORS DOES AND EXPLAINS</u> <u>2. TRAINEE DOES AS INSTRUCTOR CUES/PROMPTS</u> <u>3. TRAINEE DOES AS INSTRUCTOR OBSERVES AND DISCUSSES</u>	
NOTES : _____	

**Figure 3**

BOEING COMMERCIAL AIRPLANE GROUP	IV. TASK ANALYTIC TRAINING SYSTEM PROCESS (CONTINUED)
TRAINING MODULE NO. <u>24</u> TITLE: <u>HOW TO PERFORM DEVELOPER CONCENTRATION TEST</u>	
COLUMN 1. WHAT	COLUMN 2. WHY, WHEN, WHERE, HOW
1. LOCATE EQUIPMENT 2. CLEAN EQUIPMENT IF REQUIRED 3. PERFORM TEST	1. SHORTAGE CABINET NO. 2 2. WATER RINSE AND DRY 3 A. FILL CYLINDER WITH DEVELOPER B. INSERT HYDROMETER C. TAKE READING OF SPECIFIC GRAVITY (SEE MODULE 24.a.) D. LOCATE TEMPERATURE VS. SP. GRAVITY CHART AND FIND SP. GRAVITY ON CHART (SEE MODULE 24. b)

**Figure 4**

**BOEING  
COMMERCIAL  
AIRPLANE  
GROUP**

**IV. TASK ANALYTIC TRAINING  
SYSTEM PROCESS (CONTINUED)**

TRAINING MODULE NO. <u>24.b</u>	
TITLE: <u>HOW TO READ TEMPERATURE VS. SPECIFIC GRAVITY CHART</u>	
COLUMN 1 WHAT	COLUMN 2 WHY, WHEN, WHERE, HOW
1. LOCATE CHART FOR APPROPRIATE DEVELOPER	1. RECORD BOOK
2. LOCATE TEMPERATURE AND SPECIFIC GRAVITY ON CHART	2. SEE DIAGRAM
3. DETERMINE IF WITHIN ACCEPTABLE LIMITS OF $\pm 10$ PERCENT	3. SEE DIAGRAM

Figure 5

**BOEING  
COMMERCIAL  
AIRPLANE  
GROUP**

**IV. TASK ANALYTIC TRAINING  
SYSTEM PROCESS**

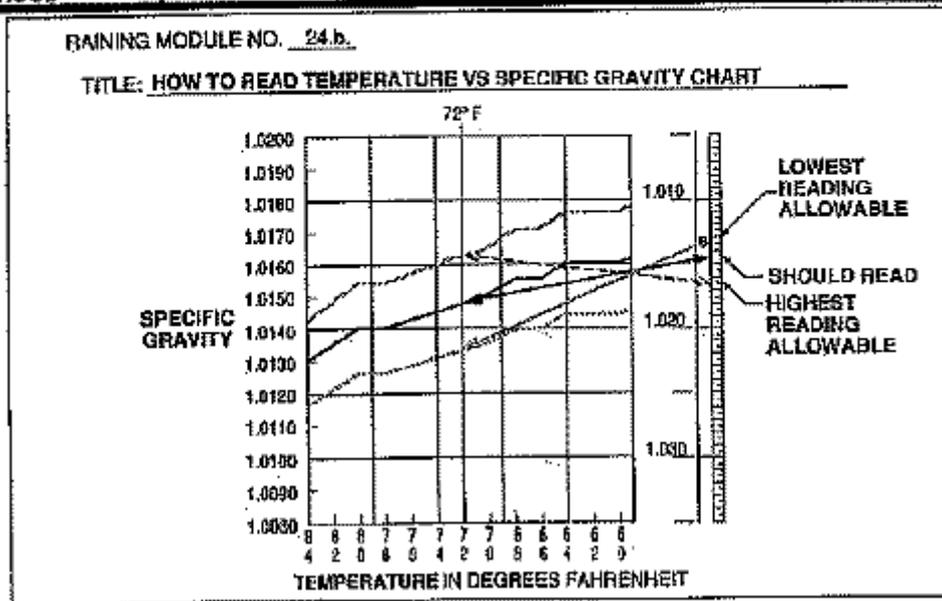


Figure 6

*Training Implementation Plan - Step 5*

Near the completion of module writing, the team, together with supervision, prepares a preliminary implementation plan. They conduct workforce evaluations to determine:

1. Who needs training in which modules and by what dates.
2. Who will do the training.
3. How results of training will be measured.

A person is assigned to prepare individual plans, taking into consideration:

1. Prior skills and knowledge brought to the job by trainees.

2. A logical sequence for presenting the modules.

### *Tryout, Evaluate, and Modify - Step 6*

Important with the first and subsequent use(s) of the training module is the attention paid to the "fitness for use" of the documents. This term refers to how closely the training materials meet the needs of the workers. The Task Analytic Training System encourages any additions, deletions, or corrections. Anyone may suggest changes, including the trainees.

### *Set-Up Maintenance Plan and Audit - Step 7*

Teams distribute manuals in work centers for use as resource guides. All personnel, from line managers to operating staff, have some ownership of the system. To keep the manuals up-to-date, each manual includes copies of change sheets. Change sheets are simple forms for identifying modules and the changes required. One member of the workforce is assigned to serve as an administrative coordinator to handle the records, forms, manual updates, etc.

The facilitator schedules annual audits to assess the status of the Task Analytic Training System in the particular work area. The audit is a checklist evaluation of critical areas of the process. During this evaluation, the facilitator looks for:

1. Signs of program obsolescence.
2. Identification of new training needs.
3. Opportunities to streamline the process to make it more cost-effective.
4. Organizational changes that impact training.

### *Start Training - Step 8*

The on-site training in the Task Analytic Training System incorporates traditional job instructional training (JIT) techniques. First, an instructor demonstrates the skills to the trainee. Next, the instructor coaches the trainee through the elements of the task while the trainee performs them. Finally, the trainee does the task without coaching. Both instructor and trainee discuss results afterwards. Trainees are then encouraged to practice the new skills until they feel comfortable with them. At the conclusion of training, evaluation questionnaires are given to both trainees and instructors. The questions are open-ended to solicit as much spontaneous information as possible.

## **Benefits of the Training System to Employees and the Company**

The numerous benefits of this system to employees include:

- Job satisfaction
- Improved attitude and morale
- Boosts to self-esteem
- Ownership of the system
- Improved communication with management
- Training directly related to the job
- Immediate and specific feedback
- Flexibility.

The results for the company are:

- Better trained workforce
- Reduced process variation
- Employees interested in doing the job

- Increased productivity
- Lower turnover
- Decrease in time to learn a new job/task
- Higher quality work
- A program where results of training are observable and measurable.

## Summary

The Task Analytic Training System is uniquely based on three interacting components:

1. job task analysis;
2. job instruction training; and
3. social psychology theory.

All three components interact to tie in skill, knowledge and attitude. Attitude is the key and must be designed into the program. The training system is a generic process applicable to any job. It provides a program that is ongoing. By the nature of its design, it addresses remedial, recurrent, and first-time training. The Task Analytic Training System produces a trained workforce whose performance can be observed and measured against carefully identified standards.

The critical role of teamwork and full worker participation in the training program development is key to the success of the program. It is a system that develops the people resources of the company by encouraging the contribution of all and stressing cooperation with others as the solution to problems.

Currently, the Task Analytic Training System is evaluated subjectively by the recipients of the program. Future research may yield data to support the system's claims of higher output in terms of productivity and quality.

## DEVELOPMENT OF MAINTENANCE TRAINING FOR A NEW AIRCRAFT COMMERCIAL TILT ROTOR PROGRAM

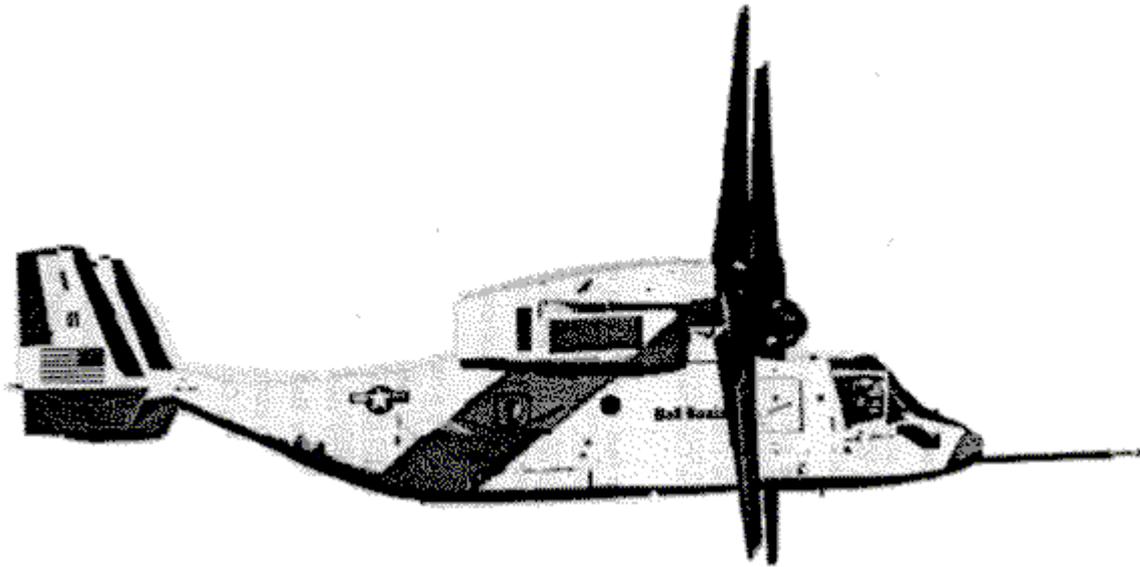
*Thomas Cooper  
Bell Helicopter Textron*

I am very pleased to represent Bell Helicopter Textron here this afternoon. I would like to talk about some initial considerations for development of maintenance training for a new aircraft.

First I would like to present the aircraft; then I will identify some of the challenges to be met in developing a maintenance training program and some of the resources available at this time that will facilitate the development of a maintenance training program for the Commercial Tilt Rotor Airplane.

We at Bell Helicopter Textron feel that training is the major variable in aviation safety and accident prevention. We also feel that training plays a major role in direct maintenance cost reduction, and that it is a significant key to business success.

Tilt rotors are coming and will bring a new era in aerial flight. Actually, tilt rotors are already here. The first patent for a tilt rotor was issued to George Lehburger in the United States in September of 1930. Some 25 years later, the Bell XV-3 flew for the first time. Twenty-two years after this, the Bell XV-15 made its first flight. Then, in 1989, the Bell-Boeing V-22 Osprey, shown in [Figure 1](#), had its maiden flight. Finally, to complete this development program, by the end of the century, the Bell-Boeing Commercial Tilt Rotor airplane will fly for the first time.



**Figure 1 The Bell-Boeing V-22 Osprey aircraft,  
a predecessor of the Civil Tilt Rotor Airplane**

A tilt rotor is a turbo-prop airplane that does not need a runway and is not bothered by airfield obstructions. It is a turbo-prop airplane that requires a verti-port for operations of about four and one-half acres. This is just over half the grazing area required by one Texas cow, 4.5 versus 7 acres. The Civil Tilt Rotor will find use in three major areas. First in air transportation; and in air cargo operations; and in public service.

In air transportation, a tilt rotor airplane will relieve airport congestion. It will operate at feeder hubs and provide portal-to-portal service. It also will be capable of operating from both skyports and verti-ports, offering transportation both for corporate and private users. Verti-ports, airports designed for vertical takeoff and landing aircraft, add to the advantage of tilt rotors because they are easy to locate and relatively cheap to build when one considers the cost of airports. Also, verti-ports can be located at waterfront space not being used today.

In air cargo service, a tilt rotor is capable of carrying internal cargo to unimproved areas where construction might be ongoing or where other work is being done. The airplane also can handle package services to inner-cities, such as provided by overnight delivery companies today. The tilt rotor also can support offshore oil production activities located as far as 600 miles off shore.

The tilt rotor aircraft also can work in public service and provide emergency medical services. One good feature of the tilt rotor for search and rescue is that, when hovering over a person in open water, the water remains calm. The tilt rotor does not create the turbulence that comes from the rotor wash of a helicopter. Tilt rotors also can be used in disaster relief, such as for floods or hurricanes, by reaching areas inaccessible to fixed-wing aircraft.

Design objectives for the Civil Tilt Rotor include normal operating route segments in the range of 600 to 800 nautical miles. The aircraft will offer a pressurized cabin, all-weather operation capability, and noise levels that meet both cabin interior requirements and community noise requirements. Utilization objectives include 2,000 to 3,000 hours per year with dispatch and completion rates of 99.5 percent or better. The tilt rotor will work as a turbo-prop airplane 90 to 99 percent of the time while in the air carrier business operating as a regional airline. It will operate as a helicopter from one to ten percent of the time. Speed range of the aircraft will be from -45 knots to +316 knots. It will have an altitude service ceiling of over 26,000 feet, with an endurance of over five hours, and a range in normal configuration of 1,100 miles. In ferry configuration, range will be 2,100 miles.

The envisioned economic impact of the Civil Tilt Rotor is impressive. The Tilt Rotor Program will mean a several billion dollar increase in national economic activity during the first decade of the 21st century. This will have a considerable net effect on balance of trade and will create over 100,000 jobs. The Civil Tilt Rotor will retain a unique technology in the United States.

## Maintenance and Training Challenges

Challenges for maintenance and training associated with the Civil Tilt Rotor airplane derive principally from the fact that this is truly a new aircraft. First, the fuselage is made of composite materials, including graphite, fiberglass, kevlar and other materials, with the greatest percentage being graphite. The aircraft uses a prop rotor rather than either a propeller or rotor. Rotor blades are independently removable and work as a fail/operate system. If an engine fails on one side, the other engine carries both prop rotors. The same with the tilt axis. If one fails on one side, the other will tilt the other side. The fly-by-wire flight control system will incorporate considerable software, with all the maintenance and training considerations that go with such software use. The plane has a 5,000 lb. psi hydraulic system, primarily for weight and convenience, because this permits hydraulic actuators to be smaller and hydraulic lines to be smaller. The plane will include an advanced cockpit display and avionics systems. It will also offer an advanced health monitoring system, providing information to the pilot on current functioning of the aircraft, and utilization monitoring system, being information taken for evaluation at a later time.

The development of training resources to provide a maintenance capability for an aircraft such as the Civil Tilt Rotor represents a challenge. Management, facility, curricula, and utilities all are important and must be considered at this time even though the aircraft itself is some years in the future. We must identify the skill levels required for mechanics and the future availability of these skills. Building an efficient maintenance workforce will not be a simple matter. I have talked with repair station operators in the Dallas area who tell me they must hire about five people before they get one who stays on the payroll and who provides a return on their investment.

The Bell Training Academy is looking toward the 21st century maintenance and inspection environment. We can see there will be a tremendous change in that environment over the one existing today. Our training resources must begin even today to gear for this future period, and we think the Bell Training Academy is doing that. Our academy is an FAA-approved flight school with an FAA- approved maintenance or manufacturer's maintenance facility. We train mechanics but they only receive a Certificate of Training. They are already qualified mechanics when they arrive at the Bell Training Academy. As a rule, these mechanics have been in the field for at least two years and are usually sent by their company. Since we provide advanced training and deal with a rather select group of trainees, we do not see some of the problems others of you have with those persons initially entering a training school.

One of the variables an advanced training school does have to deal with is the diversity of background in its students. In 1989 we trained some 2,399 people in our flight and maintenance training programs. These students represented 48 different countries, representing nationalities as far apart as Tahiti and Norway.

One of our more significant accomplishments concerns the provision of training for organizations using helicopter transportation to provide emergency medical service. [Table 1](#) shows the accident rate for emergency medical service (EMS) operations, beginning in 1984 with a rate of 14.2 per 100,000 patients transported. This high accident rate was attributed both to those persons who were dispatching EMS missions and to pilots who would accept any mission as given to them. In 1986, Bell Helicopter, in concert with other manufacturers, established a training program and delivered this program to field operations. We taught dispatchers how to dispatch and pilots how to determine whether they should say yes or no. The resulting dramatic drop in the accident rate, a value of 3.8 per 100,000 missions in 1987, surprised everyone.

Table 1

**EMS Accident Rate History**  
*(Accidents per 100,000 patients transported)*

<u>YEAR</u>	<u>RATE</u>
1984	14.2
1985	15.3
1986	15.4
1987	3.8
1988	4.8
1989	6.6

The training program we are building now for the V-22 Osprey aircraft is positioning us for the Civil Tilt Rotor Program. This is true both for flight training and for maintenance training. For flight training, we have developed our training and training equipment plan, have held eight training conferences, have conducted initial pilot training, and are well on our way toward development of the Operational Flight Trainer. We also are proceeding with the development of a maintenance trainer for the aircraft. Specifications for the maintenance trainer have been approved and competition for its development and production is completed.

We are developing maintenance training facilities at the Academy to be as modern and efficient as we can make them. Our maintenance training staff includes a number of instructors with advanced degrees, as well as others who are multi-lingual. Our classrooms are structured to make training as efficient as possible. In the shop area, we have a number of systems trainers in order to provide hands-on experience in assembly and disassembly for trainees. We also use the latest training aids developed for the aircraft we support.

The key ingredients for the development of a maintenance training program for a new aircraft are the aircraft itself, the development of knowledge of its systems and their operation, and the prudent use of existing training resources. A good maintenance training program is essential; first for safety and second for reducing direct maintenance costs. The data we have collected at Bell show us that the more a mechanic knows about the piece of equipment he is maintaining, the less it costs to operate it. Since it is good business to keep one's costs down, it follows that it is good business to develop an efficient training program. Maintenance and inspection training must have high priority. The attitude of management, pilots, and mechanics toward training must be positive. Nothing must compete with training requirements, and nothing must have priority over the best maintenance and inspection practices. Recurrent training and constant management are essential parts of the maintenance process. New aircraft, such as the Civil Tilt Rotor Airplane, will be very sophisticated vehicles. In order to ensure that the maintenance process is as effective as it can be, we at the Bell Training Academy are working today on the development of this process. Through proper training and support, an effective maintenance program will offer benefits in terms of workforce efficiency, improved safety, and cost reductions.

## MAINTENANCE TRAINING -- A VIEW FROM THE FLOOR

*John Goglia*

*International Association of Machinists and Aerospace Workers*

I am a mechanic with USAir and, since 1972, have been either lead mechanic or an inspector on the midnight shift where a considerable amount of aircraft maintenance is accomplished. The years that I've spent as an inspector required that I be qualified in non-destructive testing (NDT) methods and the use of radiographic, eddy current, and ultrasonic test equipment. Additionally, since the early 1970's, I have been the mechanic representative to a number of on-site crash investigations and subsequent follow-up investigations. It is from this background that my comments flow.

I am sure that everyone here would like to find a source of mechanics with an A&P license, five years experience, good troubleshooting ability, and some electronics background. Well, that person

is just not out there looking for work. As a result, airlines are now selecting new hire mechanics with little or no experience. Since today's training for an A&P license is geared toward general aviation, with the main objective being to pass the test, it is imperative that a new hire mechanic receive formal training on the type of aircraft he is working on, plus training on the policy and paperwork procedures of that airline. This should be required by regulation. A serious effort should also be made to provide meaningful on-the-job training and skill transfer from the more experienced mechanics. This does not occur as much as it should when one considers the number of new mechanics in today's airline maintenance activity.

Although there is hope that Part 147 will be revised in such a way that airlines are provided more qualified graduates, many in the air transport industry fear that the Federal Aviation Administration (FAA) will simply "shoot themselves in the foot" once more. In fairness to the FAA, it would be much easier to prepare a regulation that would accomplish these goals if it were possible to eliminate the requirement for input from politicians, political appointees, and special interest groups.

Although it is just another factor in our work life, new, low-experience mechanics will be with us for a long time. I can tell you from first-hand experience that you haven't lived until you've tried to accomplish a "full plate" of RON work with a low-experience crew, and still make schedule in the morning. It is an experience that I wish we could share with the Vice Presidents of Maintenance and others in management.

During the last 10 years my employer, USAir, has experienced tremendous expansion of both its fleet size and its maintenance staff to support this fleet. As a result of several mergers, the fleet mix has become quite different. In fact, it is not uncommon to have five or six 737-type aircraft in on RON maintenance and not have two of the same type. This problem is not unique to USAir. It is experienced by most, if not all, air carriers today.

As a result of this fleet mix, the proper use of the aircraft maintenance manuals becomes critical. During many years of observing maintenance work, I noticed that mechanics who mastered the use of maintenance manuals were better performers. The spotty use of the maintenance manual crossed experience lines. It didn't matter whether the mechanic had 25 years of experience. Some would use the manuals, while others would not. And some new hires would use the manuals very well while others would not look at them. I don't know why some mechanics think that going to the manual means that they are not knowledgeable, but we must take steps now to put our people back into the manuals.

The first training a new mechanic receives should be on the use of the aircraft manuals. This training should be conducted on the mechanic's first day on the floor. Mechanics already working on the floor should receive recurrent training on use of maintenance manuals.

In addition to maintenance manual training, a thorough explanation of required paperwork is essential. The largest single problem I as a Union representative face today in dealing with enforcement action taken by the FAA is incomplete or incorrect paperwork. Therefore, we believe that training in both the use of maintenance manuals and completion of required paperwork should be provided at the beginning. We also support a program of requiring this training by regulation.

Another issue that bears discussion is that of regularly scheduled recurrent classroom training. This type of training is essential in order to stay current with today's complicated integrated aircraft systems. The IAM&AW advocates a minimum of 40 hours of classroom training per year for all mechanics working in the line maintenance areas. Another recommendation is that aircraft manufacturers provide pocket size guides to component locations with access panels and station numbers identified. Basic system operation and normal indications should also be observed. This would do much to assist the mechanic and would lessen the tendency to rely on one's memory when checking out a system.

Another important matter is communication. The ability to communicate is a basic tenet of modern society, and yet poor communication is cited repeatedly as the cause of many workplace problems. We have the good fortune to work with some of the most sophisticated pieces of machinery that

technology can produce, and yet we continue to have miscommunications between departments, within departments, and between companies. Maintenance information systems can go a long way in helping with this problem, but they must be maintained, and they must have the support of everyone.

My last point of discussion concerns interpersonal skills. I believe we need to train our supervisors more in people skills. Supervisors today are chosen for a number of reasons, but usually not for people skills. Yet people skills are an important part of a supervisor's job. He has to motivate, to communicate, and generally see that his workers are working to their best. Supervisors should receive some training in people skills -- in the ability to work with and to motivate others.

I thank you for your time and attention. It has been a pleasure working with all of you.

## **AIRLINE MAINTENANCE TRAINING - EXPERIMENTAL TRAINING SYSTEM THE HUMAN FACTORS OF ADVANCED TECHNOLOGY MAINTENANCE TRAINING SYSTEMS**

*Kenneth Govaerts, Ph.D.  
AMR Technical Training  
and  
Andrew Gibbons, Ph.D.  
WICAT Systems, Inc.*

*"Aviation in itself is not inherently dangerous, but, to an even greater extent than the sea, it is terribly unforgiving of any carelessness, incapacity, or neglect."*

### **Introduction**

This unreferenced quotation, although credited to an aviator of a generation long past, is still applicable to modern conditions. The human factor in aviation has always been and will continue to be of critical importance. Even with the vast technological advances that have occurred in aviation, it is still the experienced vigilant pilot and mechanic along with a host of competent support staff who keep the industry functioning. Aviation is definitely a labor intensive industry. With the unprecedented development and growth of aviation during the last decade and projected into the 21st century, there is reason for all of us to be concerned about training the people who will become responsible for operating and maintaining the large fleets on which the world's commerce increasingly depends.

Many dramatic occupational changes have occurred in aviation in the past decade with the introduction of the advanced technology aircraft. It will no longer be the "mechanic" who works on the aircraft, it will be the "aviation maintenance technician." The job now requires much more than a mechanical aptitude and a box of tools. The change in title is only an indicator of real changes in the job caused by advances in technology. Obviously, there are implications for training resulting from these changes. Those of us responsible for training must, at the very least, examine our old philosophies, curricula, and methods. If the curriculum is inadequate, and if educational methods are outmoded, they can, and should, be revised. Just as technology has radically changed the way aircraft are operated and maintained, there is an equal opportunity for innovative approaches to training that will keep pace with the sophisticated job requirements of the modern aviation work environment.

Our purpose today is to discuss an instructional concept that is intended to advance the use of the computer as a tool for aviation maintenance training. We will demonstrate a prototype segment of competency-based instruction through the use of a device called an evaluator. This concept of CBT will show how the computer can be used to a much greater advantage through practice of real job applications with immediate feedback. The prototype will form the basis for a much larger curriculum design and development effort over the next four to five years.

## The Computer in Aviation Training

It is no longer doubted, as it once was, that the computer can function effectively as an instructional tool. The mass of evidence from both education and training is sufficient now to convince even the strongest skeptic that computer-based instruction can equal the best instruction delivered by traditional means in most content areas and for most types of outcome. Though none would maintain that a computer can replace an instructor, it is now clear that the computer can act very effectively as a supplement to the instructor by performing mundane, repetitive tasks, and leaving the instructor more freedom to consult, guide, and motivate. However, even this time tested use of CBT is less than ideal. There is a more sophisticated role for the computer in education that will more effectively utilize its power and capacity. This new role is the subject of our discussion and demonstration.

As is the case with other instructional innovations, CBT has tended to follow traditional lines rather than those defined by its unique instructional abilities. It is the "new wine, old bottle" syndrome that has plagued most instructional innovations of this century. Just as early video productions consisted of talking heads on the screen in imitation of the classroom instructors, the computer too often is assigned the mundane task of conveying information and asking verbal quiz and test questions. The result is the equivalent to using a sledge hammer to drive a ten-penny nail.

In computer-based instruction, the early use of computers tended to be in two major areas. One was the creation of tutorials, which can be mass produced at a relatively low cost and which take over a certain amount of the telling function of the instructor and a small portion of practice. The second was in simulation, for example, electrical control panels and indicators related to the operation of systems. Behind the control panel is a schematic of the electrical system which is alive to our manipulations. The computer-based simulator constitutes a live model of the electrical system which allows one to operate it from the panel. All the switches, controls, and indicators are operative and will give a realistic manifestation of what would normally happen if any switch or control is operated.

The computer-based simulator exceeds the functions normally performed by a portable mock-up maintenance training device. The instructor is capable of demonstrating panel controls and indicators as well as their relationships to the schematic and what is actually happening inside the system. It provides a cause/effect illustration and allows introduction of faults into this system. Once this is done the system operates faithfully to the faulted version of the system. This becomes a very effective instructional tool, particularly for use by instructors. It gives them the power of display that they need and yet the flexibility of control that they want. If this was as far as computer-based instruction had progressed, it would be a very useful tool, but we believe that one gap has developed in application of computers for instruction.

Even with sophisticated simulations, what very often gets left behind is trainee feedback. Feedback is an important part of the instructional process for two reasons. First, it gives students knowledge of results so they can understand whether their answer was correct. Second, it helps students to establish a self-monitoring capability which is essential for real-world performance. This is one of the aspects of feedback that is often overlooked. It is the very thing that allows the student to become an independent agent in the field. This self-monitoring capability is very important in a person. For this reason we have begun exploring a concept which we call the Maintenance Evaluator.

## The Concept of an Evaluator

A more appropriate way to use computers in training is to use them as actual instructional devices. Designers of CBT lessons may argue that this is precisely how computers have been used in the past. Admittedly, tutorials and equipment simulators are being used effectively in the context of the traditional learning environment. But instruction consists of much more than the temptingly simple processes of conveying information and simulating equipment. Instructing is a multi-functional

process that includes among others, setting problem scenarios, providing feedback and prescribing remediation.

An example of this use of the computer is the concept of the evaluator. Evaluators are simulations to which have been added: (1) a specific scenario or problem to be solved by the student, (2) an action environment in which the student is to solve the problem (3) an extended feedback mechanism capable of reviewing student performance in detail during problem-solving. Because the evaluator is based on a situation simulation, the student may take actions in any order and observe realistic results. Feedback is given after the conclusion of the problem or at the student's request.

The use of simulation exercises for higher levels of learning is common today in some areas of training. Airline pilots both train and certify using costly but realistic aircraft simulators. These simulation exercises and others like them which are used in other fields for training fill the first two criteria listed above for evaluators; scenario-basing and the use of simulation in a problem-solving environment. However, they do not satisfy the third, which is critiquing or providing feedback to the student.

The uncommon feature of the evaluator, the one that distinguishes it from the standard simulators, is the extended and detailed feedback provided following practice. Though trainers generally recognize the desirability of this type of feedback, the tools for providing it have not been easy to use or easily accessible. Moreover, the principles to guide this extended feedback process have not been identified and tested by instructional theorists.

The feedback given by an evaluator should be modeled after that which would be given by the most expert, patient, and painstaking of live instructors. This does not suggest that an evaluator should or even could be used to replace a live instructor, but it does mean that the evaluator should be capable of providing a more detailed level of feedback than most instructors have the time or ability (due to the extreme pressure it would place on memory) to provide. Moreover, it should do so under the control of the student, allowing repeated replays, restarts, and rehearsals of problematic sequences of action and offering appropriate remediation or review experiences to bolster areas of need.

The Evaluator focuses on higher level skills rather than on basic skills that are more appropriate to tutorials. It emphasizes the integration of skills rather than fragmentation of skills which is typical of traditional training methods. Finally, it frees instructors from a more subtle problem, which we call the lexical-loop, which has hampered a good deal of our training.

The lexical-loop is the emphasis on training at a verbal level for skills which are not verbal in nature. An example of the lexical-loop can be found in sports. A football coach or a soccer coach is caught in the lexical-loop if his training consists of chalk talks, followed by a verbal test. We would not be satisfied with a coach who only gave lectures. We would say that the coach is caught in the lexical-loop, and so much of training unfortunately also is caught in the lexical-loop. There is an example of an Electronics Maintenance Training Course given by the Army for radar technicians. The course had 26 weeks of classroom training with perhaps a total of five days of hands-on equipment experience. For the five days of hands-on work, most of the equipment was broken. There was a 75 percent performance rate on that equipment. This means the students had 75 percent of five days of experience, and since that experience was conducted in groups one can imagine how much actual learning took place.

Training programs are not the only systems caught in the lexical-loop. The education system also suffers. At one time, research was conducted to determine how much of each day a student actually spends in interactive learning; that is, in individual practice with feedback. The answer we found in the literature was six minutes or less per six-hour day. The educational system has fallen into the lexical-loop. Teachers are doing a tremendous amount of telling; they are not doing much interacting; and are doing even less feedback. The presentation that follows will describe an evaluator created for use in ab-initio maintenance training. This is a scenario-based simulation and is representative of the type of maintenance problems that can be dealt with by the Maintenance Evaluator. The essence of this problem, in the manner in which it is presented to the trainee, is as follows:

The trainee is notified, by computer printout, of a problem on an incoming flight. The problem says that at flight level 320, in cruise, the left air conditioning pack light illuminated, and the maintenance alert system showed a temperature message. As the aircraft now is shown to have arrived at the gate, the trainee has thirty minutes in which to deal with the problem before the plane must be released. In this computer simulation, the trainee finds himself in a maintenance shop. Through use of control icons, he has manuals, a parts room, a telephone that can be used to call various service organizations, a computer containing a maintenance data base for this aircraft, a microfilm reader for the maintenance manual, a printer which can be used to print out data base-records, and the aircraft itself.

The trainee first goes to the manuals. Here he can find the minimum equipment list and can learn that he is dealing with a normal complement of two air conditioning packs. The manuals provide descriptive information concerning these packs and could offer initial guidance as to the problem.

The trainee also can turn to the computerized data-base for this particular aircraft. Here he can get a thirty-day history of all systems, a five-day history of all systems, a thirty-day history of the aircraft itself, and a five-day aircraft history of this problem. If the trainee wishes, he can request a printout of these histories which he then will be able to carry with him on his clipboard.

The trainee also can go into the parts room, where he might decide to look at control modules for the air conditioning system. He can also determine which parts for the air conditioning pack are on the shelf. In the simulation, when the trainee orders a part, it disappears from the control room shelf and now is listed as being carried by the trainee.

Next the trainee may wish to go to the aircraft. The simulation allows him to leave the maintenance shop and proceed to the aircraft cockpit, where he may speak to the Captain concerning the aircraft status. He may also want to look into the aircraft logbook or proceed directly to the control panels to examine the air conditioning panel. Here, he can activate the air conditioning system and test it as appropriate. In this particular scenario, a lamp test indicates the left pack compressor outlet sensor is at fault. However, the trainee proceeds with replacement of the part he brought, the left pack controller.

Finally, having made an incorrect repair, the trainee returns to the shop to make an entry into the aircraft logbook. As he is doing his evaluation and repair, he is reminded by way of "Announcements" that so much of his allotted repair time has been taken. When the trainee feels the problem is resolved, the problem scenario is closed and the critique can begin.

At this point, The Maintenance Evaluator, a computer program designed to critique maintenance simulation problems, is used. The Maintenance Evaluator works from a student's event file which has a record of every action and information request made by the student. The Evaluator uses an expert system program for assessing the actions of the student.

The Evaluator works on the basis of three priorities, in this order. First, actions must ensure inflight passenger safety. Next, actions must ensure safety of airline personnel and integrity of equipment. Finally, actions must maintain the airline flight schedule. The expert system will use these criteria to judge the actions of the trainee in solving this particular problem. A detailed assessment of performance is provided. This assessment lists actions which were not done, those done improperly, and reviews the proper route to a solution. In this scenario, it tells the student he replaced equipment but did not review the repair procedures. It notices that he bypassed the maintenance manual and made a repair without proper reason to do so. It also notes that he did not carry all items needed for the replacement as prescribed in the maintenance manual. He replaced equipment but did not test such equipment following the repair. In all, The Evaluator reviews each action taken by the student,

describes its appropriateness, and presents proper actions toward a solution.

The Maintenance Evaluator just described is a prototype version. Designers are in the process of improving the variety and kinds of feedback that can be provided to trainees. In the course of building this system, it was discovered that principles for providing feedback following extended exercises of this sort are almost non-existent. Such information resides in the experience of expert instructors. For this reason, there is an attempt to identify rules used by excellent instructors and to build a model of the feedback process. This will provide a basis not only for improving the computer program but also should provide information for improved training of actual instructors.

## Conclusion

The unprecedented technological advances and the growth that has occurred in the past decade in commercial aviation are expected to continue unimpeded into the future. An educational system that supports progress in any technological field also must advance in order to accommodate the changing role of qualified professionals in these fields. In aviation maintenance the educational system has not kept pace and there is an urgency worldwide among training professionals to re-design the curriculum content and instructional methodologies to accomplish this goal.

Although technology-based training methods have been used extensively in aviation for a decade, the costly full-flight simulators used for training pilots have provided the first success in keeping pace with the greater demands for training. Aviation maintenance remains essentially entrenched in conventional classroom, instructor-led training methods.

The concept of the evaluator with its scenario-based problem solving, practice and feedback may be the breakthrough for maintenance training equivalent to the full-flight simulator.

The new system is capable of bringing students from entry-level through a training experience to real world capabilities. These attributes, along with performance orientation it fosters in training design and development, make it a valuable step forward in improving the relevance and completeness of training systems to meet the challenges of aviation in the future.

## INTRODUCING CRM INTO MAINTENANCE TRAINING

*William R. Taggart  
Resource Management Associates/  
Pan American World Airways, Inc.*

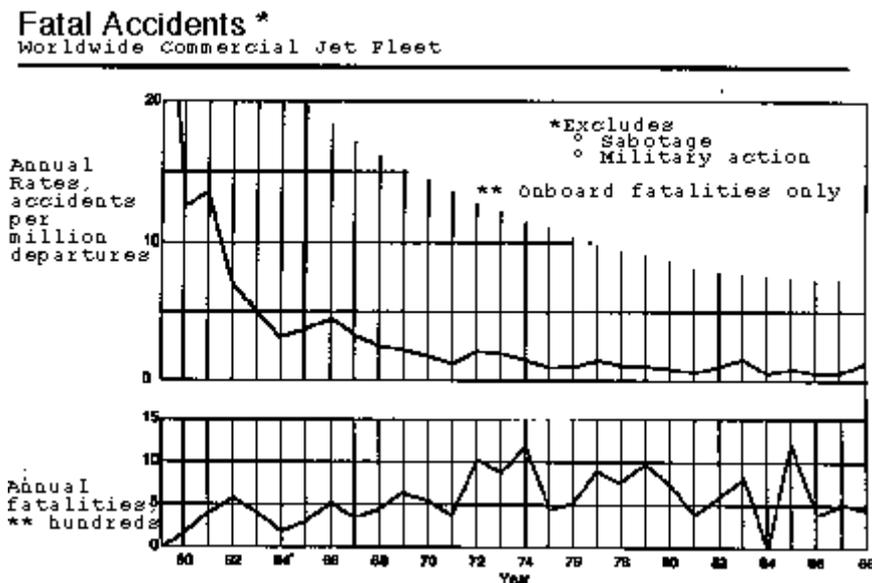
Cockpit resource management (CRM) training is a program to ensure that flight crew teamwork and coordination are optimal and that best use is made of all cockpit resources, including people, information, and equipment. Over the past ten years, most of the major airlines have adopted some form of CRM training and the Federal Aviation Administration (FAA) is preparing to make CRM training mandatory. Use of this training is based on the recognition that most airline accidents have resulted from failure of crews to interact properly or to use effectively all available information as conditions deteriorated. By all accounts, including NASA-sponsored research, CRM has been accepted by airline management and by flight crews and flight deck performance has benefitted. With this experience to draw on, the operations management of Pan Am felt that the type of training being provided for flight crews might also be useful for maintenance managers.

The maintenance CRM program at Pan Am began in November 1989 when a group of maintenance management personnel attended one of the flight crew CRM training programs. As a result of their positive response, a Steering Committee was formed to review the flight crew program and to tailor it for use with maintenance managers. These managers range from maintenance supervisors to the Vice President of Maintenance and Engineering.

The Pan Am CRM program for maintenance is called MELD, an acronym standing for Maintenance, Engineering, and Logistics Development. The purpose is to improve performance within these three

areas through improved teamwork and coordinated use of available resources. Several test programs have been run in recent months and initial results are available. I would like now to describe the foundations of the Pan Am program, and review the initial results.

The basis for CRM programs, as with all activities directed toward flight safety, can be found in the track record of aircraft accidents. Boeing has been studying accident trends, and [Figure 1](#) shows the trends in accidents and fatalities for the commercial jet fleet over the past 30 years. The initial drop in the accident rate in the early 1960's, of course, can be attributed to increased experience with jet airliners and the introduction of second generation jets. Since about 1970, the rate has been relatively constant, with fatalities showing fluctuations up and down roughly each year. However, the most recent chart, just completed in 1989, shows a sharp increase. Airplanes are bigger and the number of departures continues to grow.

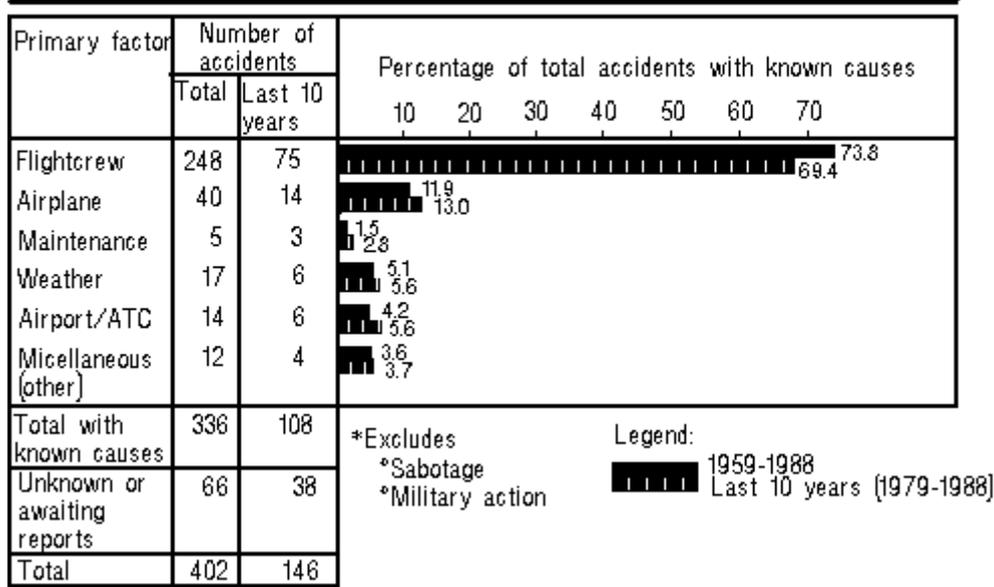


**Figure 1 Fatal Accidents**

The traditional response to this accident footprint is to strive for improved safety through greater use of technology. Increased use of computers, better automatic test systems, introduction of composite structures and fly-by-wire control systems, and greater reliance on system redundancy all have been employed. These technological advances are used primarily to improve the flight vehicle but also are intended to enhance flight safety. To some extent, they succeed. However, accidents and major incidents continue.

Investigations of accidents in the commercial jet fleet generally attribute from 60 to 80 percent of them to flight crew factors, as shown in [Figure 2](#). Studies also show that a large percentage of accidents occur during initial and final approach phases, just prior to landing. The response to both the flight crew involvement and the phases of flight in which accidents occur has been to initiate programs to improve operating procedures. These involve better policies, better checklists, and, in short, more and better paperwork. When the focus moves to the pilot, correction often involves additional technical training or supervision, or possibly more regulation. Again, accidents continue to occur world wide at an undesirable rate.

**Primary Cause Factors -- Hull Loss Accidents\***  
Worldwide Commercial Jet Fleet



**Figure 2 Primary Cause Factors**

Traditional training of flight crews and safety improvement has concentrated on three main areas: Improving technology and reliability; better procedures, and higher quality pilot training. But in the case of pilot training, the historical focus has been on the individual, not on the crews and the resources available to them. The FAA has now recognized that flight crews should be both trained and evaluated as a team as well as concentrating on individual proficiency. The premise that the MELD program is built on is that these same concepts apply to maintenance. In spite of improved technology, better procedures, computer-based training, etc., the frequency of human factors-related incidents is simply too high.

In our MELD effort, we borrowed concepts from the CRM program that have been shown to improve crew teamwork and effectiveness. We deal with issues such as assertion and advocacy. In our first effort to develop a CRM context, we drew on the chain of events in the Air Florida PALM 90 accident at Washington National Airport. Here, the copilot did recognize that something was wrong and he spoke up, but he did it in such a diplomatic, indirect, and oblique manner that the message never got through to the Captain. Other similar accidents of this type include Pan Am/KLM at Tenerife, United 173 at Portland, Oregon, and Avianca at Long Island. We were interested in whether information on flight crew related accidents, with good documentation from cockpit voice recorders and the NTSB investigation, would be seen as relevant to situations paced by supervisors and managers from maintenance, engineering, and logistics.

We were surprised to find that the supervisors and managers did indeed find the flight crew information to be relevant. Furthermore, they could relate information concerning a First Officer who did not do an effective job in communicating his position to actual events in maintenance. The participants were able to reflect on times when they felt an item should be voided or where they had a different proposal concerning a particular engineering change, yet allowed themselves to be overruled. They were able to develop a better appreciation of the importance of teamwork in maintenance operations just as in flight crew activities. In addition, new skills and attitudes about teamwork were developed for use in future job situations.

As we began structuring the MELD program, we developed a list of seven key resource management principles. In large measure, these were taken from similar principles used in flight crew CRM programs. These principles represent topics to be dealt with in detail in the MELD program. The seven principles include:

1. Delegating tasks and assigning responsibilities.

2. Establishing a logical order of priorities.
3. Monitoring and cross checking resources.
4. Assessing problems carefully, avoiding preoccupation.
5. Using all available data to conduct an operation.
6. Communicating clearly plans and intentions.
7. Assuring sound leadership by the person in charge.

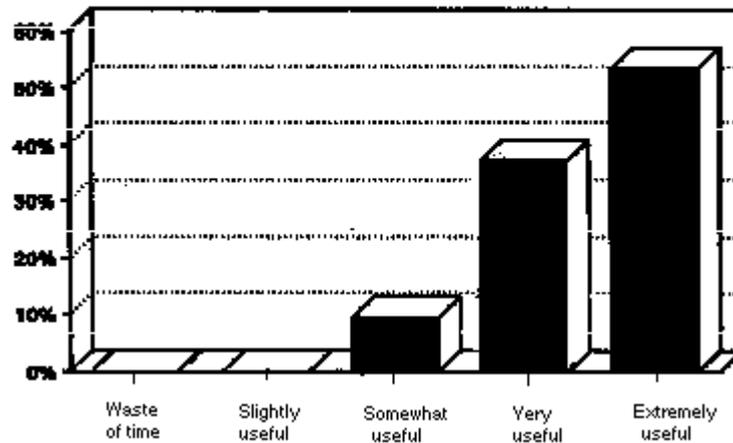
Using the above principles, several seminars were conducted for supervisors and managers. The instruction in these seminars was done through use of eight course modules, each using material relating to one aspect of resource management considered to be of particular importance. The topics for these eight course modules were:

1. Interpersonal communication and skills
2. Assertion and conflict
3. Stress
4. Critique skills
5. Value of briefings
6. Situation awareness
7. Leadership behavior
8. Case studies

It is also important to note that the method of training used in the seminars is different from traditional techniques. Participants are grouped into five or six person teams and there is very little in the way of traditional "lecture" style teaching. Instead, line maintenance managers and supervisors work as a pair to administer the seminar, introduce concepts, and manage the various team experiments, case studies, and learning activities. This learning method is interactive and involves the participants in a way that stimulates them to explore new ways of managing and using resources.

Upon completion of the seminars, several measures were taken in an attempt to judge the effectiveness of MELD training. A NASA-validated questionnaire on attitudes is used on a pre/post basis. This survey is included as [Appendix I](#) of this paper. Results of a question concerning the perceived usefulness of the MELD training are shown in [Figure 3](#), based on responses from about 75 to 80 participants. Note that none of these supervisors and managers found the training to be waste of time. This is particularly encouraging since many of the participants were attending the training against their better judgment since there were a host of continuing problems at Pan Am they felt more deserving of their time and attention. Also, many of the participants had been at work since 5:00 a.m. before attending the training program at 8:00 a.m. Many considered this to be a serious imposition on their schedules. However, as seen in [Figure 3](#), over 80 percent of the respondents found the training to be "extremely useful" or "very useful." These responses were quite encouraging.

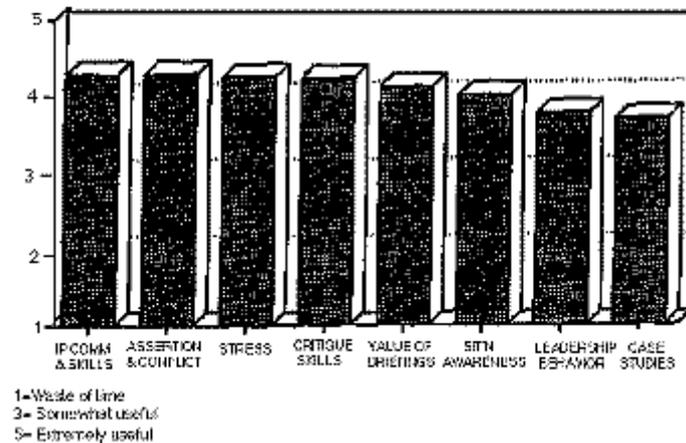
**Pan Am MELD Seminars:  
Overall, How Useful  
Did You Find The Training ?**



**Figure 3**

Participants also were asked to rate the usefulness of each of the eight course modules used in the MELD program. Results are presented in [Figure 4](#). The module dealing with "interpersonal communications and skills" was considered to be most useful by the respondents although not a great difference is found among all modules. In fact, each module was considered to be somewhere between "somewhat useful" and "extremely useful." It is interesting to note, however, that the top three modules in this evaluation dealt with classic CRM topics concerning the value of communications training and skills, developing assertion skills and conflict management, and recognizing the influence of stress on job performance and how such stress can affect the day-to-day problem solving process.

**Pan Am MELD Seminars  
Average Ratings of Each  
Course Module**



**Figure 4**

The course module judged to be least useful by comparison was that covering case study analyses. Perhaps one of the reasons why the case study section is lower is that all of the studies used dealt with flight crew cases. One issue on our agenda, therefore, is to develop a better list of case studies and examples that will deal with events strictly in the maintenance and engineering area.

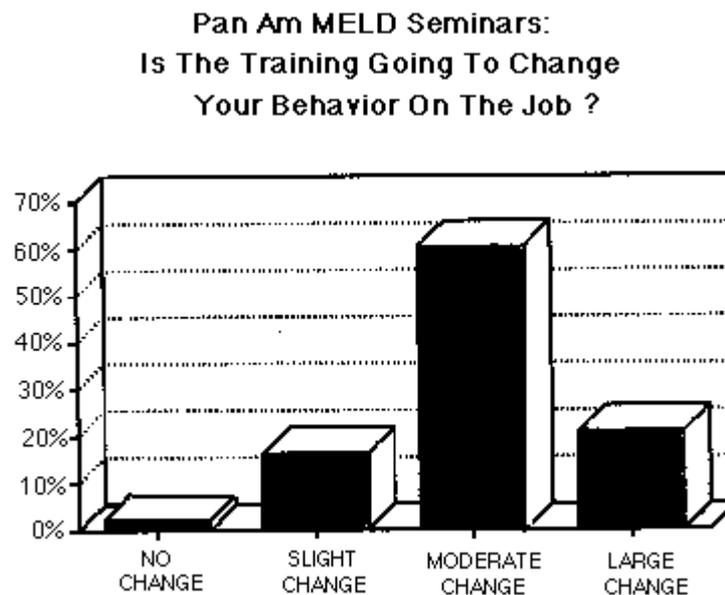
In one of the flight-related case studies presented in the MELD seminar, we used the scenario of the

Northwest Airlines Flight 255 in which the flight crew took off without flap extension. In this event, there were a number of distractions ranging from concern about the weather, interruptions from others, use of out-of-date information, a missed radio frequency, a missed taxiway, and computers not set properly. This accident is a good example of the impact of distractions coupled with a lack of situational awareness.

Based on the Northwest experience, we attempted to develop a set of warning signals to which any crew, whether in flight operations or in maintenance, should be sensitive as possible indicators of imminent trouble. The list of warning signals developed from the case studies include:

1. Deviation from standard operating procedures
2. Inadequate cross check
3. Not using available resources
4. Preoccupation
5. Violating established limits
6. Not minding the store
7. Not communicating
8. Not addressing discrepancies

One of our final, and possibly one of our most important, evaluations of the MELD program was in the question concerning the extent to which a participant felt that this training would change his behavior on the job. Participants were asked the question "As a result of being exposed to some of these concepts, are you going to do anything differently when you go back to work?" The results, shown in [Figure 5](#), indicate that most of the participants felt that there would be at least a moderate change in their on-the-job behavior as a result of attending the MELD seminar.



**Figure 5**

The MELD participants also were asked the extent to which they felt resource management training would benefit others. The response was favorable, with most indicating that all groups working in aviation should benefit from this type of training. This response is consistent with our concept of synergy in which all parts of aviation will have to work together closely to solve problems as the aviation environment grows more complex, including the introduction of advanced technology aircraft and the problems of dealing with aging aircraft. The world is no longer simple enough that problems can be solved by one person working on a job on a one-on-one basis. New concepts in team-work training are required. Such training should aid all groups trying to develop effective

solutions using incomplete and ambiguous information to resolve unforeseen problems.

We plan as a next step to extend the MELD program to cover roughly 750 managers and supervisors at Pan Am. Our objective is to systematically introduce self-managed, high-performance, self-directed work teams in maintenance.

## Appendix 1

### *PAN AMERICAN WORLD AIRWAYS MAINTENANCE/ENGINEERING/LOGISTICS NASA RESOURCE MANAGEMENT SURVEY*

**SEMINAR DATE** \_\_\_\_\_

#### **PART I**

As part of NASA sponsored research, we are collecting data on attitudes about Maintenance, Engineering, and Logistics (M/E/L) resource management at Pan Am. You will greatly assist our research if you complete the survey. Please do not put your name on this form. Your data are strictly confidential. However, we would like to link your responses on this survey to later questions. To do this, please enter a four digit Personal Identification Number below and record it where you can find it at a later date.

Identification Code \_\_\_\_\_

Please answer by writing beside each item the letter that best reflects your personal attitude. Choose the letter from the scale below.

#### **\*\*\* Scale \*\*\***

**A B C D E**

Disagree Disagree Neutral Agree Agree

Strongly Slightly Slightly Strongly

\_\_\_\_1. M/E/L team members should avoid disagreeing with others because conflicts create tension and reduce team effectiveness.

\_\_\_\_2. M/E/L team members should feel obligated to mention their own psychological stress or physical problems to other M/E/L personnel before or during a shift or assignment.

\_\_\_\_3. It is important to avoid negative comments about the procedures and techniques of other team members.

\_\_\_\_4. Managers should not dictate technique to their subordinates.

\_\_\_\_5. Casual, social conversation on the job during periods of low workload can improve M/E/L team coordination.

\_\_\_\_6. Each M/E/L team member should monitor others for signs of stress or fatigue and should discuss the situation with the individual.

\_\_\_\_7. Good communications and team coordination are as important as technical proficiency for aircraft safety and operational effectiveness.

\_\_\_\_8. We should be aware of and sensitive to the personal problems of other M/E/L team members.

\_\_\_\_9. The manager in charge should take hands-on control and make all decisions in emergency and non-standard situations.

**\*\*\* Scale \*\*\*****A B C D E**

Disagree Disagree Neutral Agree Agree

Strongly Slightly Slightly Strongly

\_\_\_\_10. The manager or supervisor in charge should verbalize plans for procedures or actions and should be sure that the information is understood and acknowledged by the other M/E/L team members.

\_\_\_\_11. M/E/L team members should not question the decisions or actions of the manager except when they threaten the safety of the operation.

\_\_\_\_12. M/E/L team members should alert others to their actual or potential work overloads.

\_\_\_\_13. Even when fatigued, I perform effectively during critical phases of work.

\_\_\_\_14. Managers should encourage questions during normal operations and in special situations.

\_\_\_\_15. There are no circumstances where the subordinate should assume control of a project.

\_\_\_\_16. A debriefing and critique of procedures and decisions after each job assignment is an important part of developing and maintaining effective team coordination.

\_\_\_\_17. My performance is not adversely affected by working with an inexperienced or less capable co-workers.

\_\_\_\_18. Overall, successful M/E/L management is primarily a function of the manager's technical proficiency.

\_\_\_\_19. Training is one of the manager's most important responsibilities.

\_\_\_\_20. Because individuals function less effectively under high stress, good team coordination is more important in emergency or abnormal situations.

\_\_\_\_21. The pre-assignment team briefing is important for safety and for effective team management.

\_\_\_\_22. Effective team coordination requires each person to take into account the personalities of other team members.

\_\_\_\_23. The manager's responsibilities include coordination between his or her work team and other support areas.

\_\_\_\_24. A truly professional manager/supervisor can leave personal problems behind.

\_\_\_\_25. My decision making ability is as good in abnormal situations as in routine daily operations.

Page 2

**PART II: BACKGROUND INFORMATION**

Year of birth \_\_\_\_\_

Total Years at Pan Am \_\_\_\_\_

Sex (M or F) \_\_\_\_\_

**Current Department**

\_\_\_\_ Maintenance

- \_\_\_ Engineering
- \_\_\_ Quality Control
- \_\_\_ Planning
- \_\_\_ Logistics
- \_\_\_ Shop

Job Title: \_\_\_\_\_

Years in present position: \_\_\_\_\_

Past Experience/Training (No. Years):

- Military \_\_\_\_\_
- Trade School \_\_\_\_\_
- College \_\_\_\_\_
- Other Airline \_\_\_\_\_

*PAN AMERICAN WORLD AIRWAYS MAINTENANCE/ENGINEERING/LOGISTICS NASA RESOURCE MANAGEMENT SURVEY*

**SEMINAR DATE**\_\_\_\_\_

**PART II**

Please enter the four digit Personal Identification Number that you selected at the beginning of the seminar.

Identification Code \_\_\_\_\_

Please answer by writing beside each item the letter that best reflects you personnel attitude. Choose the letter from the scale below. All data are strictly confidential.

**\*\*\* Scale \*\*\***

- |          |          |          |          |          |
|----------|----------|----------|----------|----------|
| <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> | <b>E</b> |
| Disagree | Disagree | Neutral  | Agree    | Agree    |
| Strongly | Slightly |          | Slightly | Strongly |

\_\_\_1. M/E/L team members should avoid disagreeing with others because conflicts create tension and reduce team effectiveness.

\_\_\_2. M/E/L team members should feel obligated to mention their own psychological stress or physical problems to other M/E/L personnel before or during a shift or assignment.

\_\_\_3. It is important to avoid negative comments about the procedures and techniques of other team members.

\_\_\_4. Managers should not dictate technique to their subordinates.

\_\_\_5. Casual, social conversation on the job during periods of low workload can improve M/E/L team coordination.

\_\_\_\_\_6. Each M/E/L team member should monitor others for signs of stress or fatigue and should discuss the situation with the individual.

\_\_\_\_\_7. Good communications and team coordination are as important as technical proficiency for aircraft safety and operational effectiveness.

\_\_\_\_\_8. We should be aware of and sensitive to the personal problems of other M/E/L team members.

\_\_\_\_\_9. The manager in charge should take hands-on control and make all decisions in emergency and non-standard situations.

\_\_\_\_\_10. The manager or supervisor in charge should verbalize plans for procedures or actions and should be sure that the information is understood and acknowledged by the other M/E/L team members.

\_\_\_\_\_11. M/E/L team members should not question the decisions or actions of the manager except when they threaten the safety of the operation.

\_\_\_\_\_12. M/E/L team members should alert others to their actual or potential work overloads.

**\*\*\* Scale \*\*\***

**A B C D E**

Disagree Disagree Neutral Agree Agree

Strongly Slightly Slightly Strongly

\_\_\_\_\_13. Even when fatigued, I perform effectively during critical phases of work.

\_\_\_\_\_14. Managers should encourage questions during normal operations and in special situations.

\_\_\_\_\_15. There are no circumstances where the subordinate should assume control of a project.

\_\_\_\_\_16. A debriefing and critique of procedures and decisions after each job assignment is an important part of developing and maintaining effective team coordination.

\_\_\_\_\_17. My performance is not adversely affected by working with an inexperienced or less capable co-workers.

\_\_\_\_\_18. Overall, successful M/E/L management is primarily a function of the manager's technical proficiency.

\_\_\_\_\_19. Training is one of the manager's most important responsibilities.

\_\_\_\_\_20. Because individuals function less effectively under high stress, good team coordination is more important in emergency or abnormal situations.

\_\_\_\_\_21. The pre-assignment team briefing is important for safety and for effective team management.

\_\_\_\_\_22. Effective team coordination requires each person to take into account the personalities of other team members.

\_\_\_\_\_23. The manager's responsibilities include coordination between his or her work team and other support areas.

\_\_\_\_\_24. A truly professional manager/supervisor can leave personal problems behind.

\_\_\_\_\_25. My decision making ability is as good in abnormal situations as in routine daily operations.

**II. TRAINING EXPERIENCE AND EVALUATION**

1. For each of the topic areas or training techniques listed below, please rate the value of this aspect of the training to you. Rate each item by choosing the letter on the scale below which best describes your personnel opinion and then write the letter beside the item. If the topic was not included in your training, please put "NA" in the blank.

A B C D E

Waste Slightly Somewhat Very Extremely  
of time Useful Useful Useful Useful

\_\_\_\_ Training In Interpersonal Communications And Skills

\_\_\_\_ Assertiveness, And Conflict Resolution

\_\_\_\_ Value Of Effective Team Briefings

\_\_\_\_ Stress Effects And Stress Management

Page 2

A B C D E

Waste Slightly Somewhat Very Extremely  
of time Useful Useful Useful Useful

\_\_\_\_ Analysis Of Personal Styles And Dimensions Of Team Crew Leadership

\_\_\_\_ Situational Awareness And Impact of Distractions

\_\_\_\_ Training in Critique Skills Using Dilemma Situations

\_\_\_\_ Case Studies Of Aircraft Accidents And Incidents

\_\_\_\_ Overall, How Useful Did You Find The Training?

2. MELD Resource Management training has the potential to increase aviation safety and teamwork effectiveness.(circle one)

**A B C D E**

Disagree Disagree Neutral Agree Agree  
Strongly Slightly Slightly Strongly

3. Is the training going to change your behavior on the job? (circle one)

No Change A Slight A Moderate A Large  
Change Change Change

4. How useful will such training be for others? (circle one)

A Waste Slightly Somewhat Very Extremely  
of time Useful Useful Useful Useful

5. What aspects of the training were particularly good?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

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6. What do you think could be done to improve the training?

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**THIS COMPLETES THE QUESTIONNAIRE  
THANKS FOR YOUR HELP !**

Page 3

## **TRAINING AT THE REPAIR STATION**

*Michael Rose  
Lockheed Aeromod Center, Inc.*

I would like to take this opportunity to explain some of the issues faced today by repair stations such as Lockheed Aeromod today. In order to set the stage, I would like to tell you first a bit about Lockheed Aeromod itself. Repair stations represent a rapidly growing industry. Since our beginning in 1985, we have grown at an average rate of 400 people a year to our present size of 1800 employees. We work in facilities which are set over approximately 144 acres. Our size and our rate of growth have presented us with training problems and with recordkeeping problems as we attempt to manage our personnel expansion and our turnover. Today I will discuss some of these problems, solutions that we have developed, and will describe some innovations that we are considering.

A major problem we face is that of maintaining a fully-qualified workforce. Much of this comes from the number of different kinds of aircraft on which we work. We do maintenance for all the major carriers, including Federal Express, UPS, Delta Airlines, and numerous others. We also work for the U.S. Government and for foreign governments. The different customer contract requirements present problems. One customer will want his work done in one specific way, while another will want it done in quite a different manner. Thus, when we are training employees to work on aircraft for both companies, in effect we are working to dual standards which creates problems for us. On top of this, our recent expansion has brought with it problems in employee turnover. Each time we lose qualified personnel, our training load increases correspondingly.

To help us maintain a fully qualified workforce, we recently have implemented an exclusive training program involving both academic courses and on-the-job training (OJT). To develop a sound basis for this training program, we assembled a team which went through our operation and identified all tasks being accomplished by different members of our workforce. This included the General Aircraft Mechanic, the Electrician/Avionics Technician, the Structures Technician, and even included aircraft painters. With painters we identified tasks ranging from the aircraft going into the hangar, to the stripping, and to the final painting and aircraft release. Now, under our OJT program, we can maintain a detailed record of training accomplished for each task for each individual.

We also have a program to identify the various skills of employees so that they can be properly assigned. When an individual comes to Lockheed, we review all training records to identify the training that has been accomplished on different types of aircraft. We take certificates from any previous trainings, such as for the 727 aircraft or the JT-8 engine, and enter this into our computer database. By so doing, we now have an excellent tool for personnel management and tracking. For example, if a customer inquires as to the number of technicians employed by Lockheed who are

qualified and trained on A-300's, we can get an immediate computer print-out which will tell us the number of people, where they work, and the and the experience level of these individuals.

Another program of interest we have developed is one with the local high schools and middle schools, specifically to support our work in aircraft structures. For the past two years, I have visited middle schools and talked to younger students, explaining to them the opportunities and advantages of work as an aviation maintenance technician. At the same time, representatives of Lockheed go to local high schools on "career days" and talk to those students. We have implemented a program through local career centers, which now is in its second year, in which they teach a two-year Metal Fabrication and Aircraft Structures Training Program, which is presented quite in-depth. Once students graduate from these programs, we take the individuals that have been selected as the highest student and give them a scholarship to a local A&P school or to a local college A&P school. After that, they go to an 11 week Advanced Structures Program, which is sponsored and completely funded by the Special Schools Division of the State of South Carolina. This program has given us a good working relationship with the state. One reason for the above program is the aging aircraft problem, which brings with it a lot of aircraft structures work. We have identified all of these structures tasks and all such tasks have been incorporated into the training program for these students. The shop we have set up in the local career center offers realistic training. The metal used in shop is the same as that in the aircraft. We also use the same curvature on the panels, so in reality we provide almost an actual situation. For the student, it is just like working on the aircraft.

Another in-house program at Lockheed was started as a way to improve communications. In this program, we attempted to capture our in-house expertise to support our on-the-job training efforts. In this program we began with the Avionics Department, which has probably the hardest subject to teach because you do not teach it that often. In any familiarization course at Lockheed, avionics may receive only four or five hours, or perhaps a day at most. In avionics, we selected an individual and then went through the procedures as to how to prepare a lesson plan. Then, for presentation of the lesson plan we used that individual. We asked him simply to come in and to explain the component location for the avionics and a bit about the operation of the systems. During this training, employees started asking a number of questions because they could relate to this person. The first class he conducted was to have been one hour as a short familiarization course. It ended up being six hours in length. Now we have progressed until it is a two-day course where this individual actually does the training for us.

Finally, I would like to describe what I consider one of our major efforts to improve our overall effectiveness. The Technical Training Department at Lockheed Aeromod is being reorganized to develop a closer tie between training activities and day-to-day operations. Since we feel that our problems are not in the classrooms but are on the floor where the work is being conducted, we are putting a number of instructors on the floor to identify problem areas that we have and then to develop appropriate training measures to address these problems. In the course of doing this, we are indeed getting a better handle on some of our training issues. For example, we recently were requested to provide a two week Advanced Structures Program to include blueprint reading. When we went on the floor and talked to technicians, we found that the need for training in blueprint reading was only one person's opinion. What they actually needed was training in reading the Structural Repair Manual. So instead of providing a two week program, we taught a three day Structural Repair Manual course, which dealt with the actual problem.

The different programs at Lockheed Aeromod that I have just described all are directed toward maintaining a fully-qualified and effective workforce. We are always working to improve our training programs as well as our management-employee communications. Both are essential to a quality maintenance effort.

## **ADVANCED TECHNOLOGY TRAINING FOR AVIATION MAINTENANCE**

*William B. Johnson, Ph.D.  
Galaxy Scientific Corporation*

## Introduction

The human is an important component in the commercial aviation system that provides safe and affordable public air transportation. Much attention to the "human factor" in the aviation industry has focused on the cockpit crew. However, the FAA and the airlines recognize that aircraft maintenance technicians (AMTs) are equal partners with pilots to ensure reliable safe dispatch. The job of the AMT is becoming increasingly difficult. This is a result of the fact that there are increasing maintenance tasks for the ever-aging aircraft fleet while, at the same time, new technology aircraft are presenting complex digital systems that must be understood and maintained. Sheet metal and mechanical instruments have given way to composite materials and glass cockpits. These new technologies have placed an increased training burden on the mechanic and the airline training organizations.

The FAA Office of Aviation Medicine, as part of the National Aging Aircraft Research Program, is studying a number of human factors-related issues that affect aviation maintenance. Examples of the projects under investigation include the following: a study of job aiding for maintenance tasks ([Berninger, 1990](#)); design and development of a handbook of human factors principles related to maintenance; a task analysis of aviation inspection practices ([Drury, 1989](#) and 1990); a study of maintenance organizations (Taylor, 1989 and [1990](#)); and the assessment and specification/demonstration of advanced technology for maintenance training. The advanced technology training research, reported here, is exploring alternatives for the effective and efficient delivery of a variety of aircraft maintenance training.

## Research Phases

The training technology research is divided into three phases that will be conducted over a three-year period. Work began in January of 1990.

In the first six months we have assessed the status of training technology for maintenance technicians. This was done with a series of telephone interviews and site visits to manufacturers, airlines, and schools operating under Federal Aviation Regulation Part 147 (FAR 147). Currently, the research team is designing and building a prototype intelligent tutoring system (ITS) that can be used as a demonstration of the application of expert system technology to maintenance training. ITSs are described later in this paper. The prototype will also be used to help finalize the specifications for a fully operational, intelligent tutoring system that will be finalized in the second year.

The operational intelligent tutoring system will be built in conjunction with a school and airline that were identified during the first six months of the project. The intelligent tutoring software will be designed so that it is generic and can be modified for a variety of aircraft maintenance training applications. The product will be a turn-key training system for maintenance. The important by-product will be a field-tested approach to develop, efficiently, subsequent ITSs for aircraft maintenance training.

The third phase will be dedicated to evaluation of the intelligent tutoring system for maintenance training. The system will be integrated into a training program at a school or airline. We will assess the user acceptance and training effectiveness of the intelligent tutoring system for maintenance training. In addition, we will conduct an analysis of the cost effectiveness of such training technology. [Table 1](#) is a summary of the three phases.

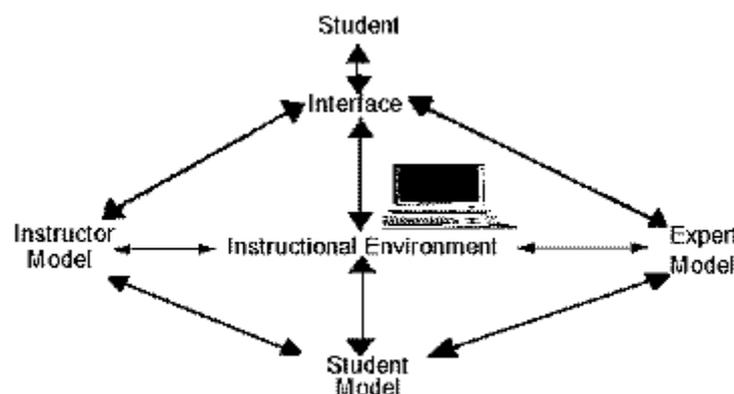
**Table 1 Phases of Research Plan**

Phase 1	1990	Technology Assessment and Prototype
Phase 2	1991	Build Complete Intelligent Tutoring System
Phase 3	1992	Conduct System Evaluation

## Definitions of Advanced Technology and ITS

Over the past decade, instructional technologists have offered numerous technology-based training devices with the promise of "improved efficiency and effectiveness." These training devices are applied to a variety of technical training applications. Examples of such technology include computer-based simulation, interactive videodisc, and other derivatives of computer-based instruction. Compact Disc Read Only Memory (CD-ROM) and Digital Video Interactive (DVI) are two additional technologies that will offer the "multi-media" training systems of the future.

The application of artificial intelligence (AI) to training has captivated the instructional technology literature of the 1980's (Sleeman and Brown, 1983; Wenger, 1987; Kearsley, 1987). The AI-based training systems are called intelligent tutoring systems (Polson and Richardson, 1988; Psotka et al, 1988). This section will define the ITS technology as it exists today. The section will show examples of systems that are currently in use and/or development. The examples are those for which the author has responsibility. There are many other excellent ITSs in development today. Intelligent tutoring systems are usually described with some version of the diagram in [Figure 1](#) (Johnson et al, 1989; Mitchell and Govindaraj, 1989; Yazdano, 1987).



**Figure 1 An Intelligent Tutoring System**

At the center of the diagram is the instructional environment. It can include any of the techniques that have been available with conventional computer-based instruction (CBI). This could include the following: simple tutorials, drill and practice, problem solving, simulation, and others. It can be argued that the design of the instructional environment is the most critical element in a training system. However, an ITS is only as strong as its weakest module.

Between the instructional environment and the student is the user interface. The interface permits the student to communicate with the instructional environment. The interface can be as simple as text with a keyboard. However, today's interfaces are more likely to include sophisticated color graphics, animation, audio and video disc. Example input devices are keyboards, touch screens, mice, trackballs, voice, and other such hardware.

The software that differentiates ITSs from conventional [CBI](#) are the models of the expert, student, and instructor. The expert model contains an understanding of the technical domain represented in the instructional environment. There are numerous ways to encode this expert understanding. The most common is with production rules. When the instructional environment is a simulation, a portion of the expert model is often embedded in the simulation. This is true with microcomputer Intelligence for Technical Training (MITT) (Johnson et al, 1988 and 1989) and with the Intelligent Maintenance Training System (IMTS) (Towne and Munro, 1989).

The student model is a dynamic accounting of student performance within a given problem. Most student models also contain a historical record of previous student performance. The final model, the instructor, compares the student model to the expert model to assess student performance. The

instructor model, sometimes called the pedagogical expert, offers appropriate feedback and/or suggestions for remediation. The instructor model also sequences subsequent instruction based on a perceived level of competence of the student. The instructor model is an expert system with production rules about training and feedback. This model does not necessarily know anything about the content matter within the instructional domain.

## Example Systems

Research on artificial intelligence in training has been going on for quite some time (Carbonell and Collins, 1973). However, few systems have made a successful transition from the laboratory to real training environments (Polson, 1989; Johnson, 1988b). Johnson has offered a number of reasons why the transition has been difficult. He also described how to build ITSs for real application (Johnson, 1988a, 1988b, 1988c).

Flowcharts and diagrams, like the one in [Figure 1](#), are helpful to gain a broad understanding of the ITS concept. Examples of operational ITS are a better way to understand and appreciate their potential for technical training. This section will briefly describe three systems that have been developed by the author and his colleagues. These systems represent many of the features that are emerging in the ITS development community.

### *Microcomputer Intelligence for Technical Training*

The Air Force recognizes that intelligent tutoring systems must be developed and delivered on computers that are available today and are affordable to training organizations. Therefore, the Microcomputer Intelligence for Technical Training (MITT) research and development had the goal of building intelligent tutoring systems on small microcomputers, like the IBM-AT or a compatible. Nests (1989) has described the trials and tribulations of developing robust systems within the constraints of the microcomputer environment.

MITT was developed with the cooperation of the NASA Johnson Space Center Operations Training Department. The student audience for MITT is comprised of astronauts and flight controllers. The domain for the first MITT tutor was the electric power distribution system for the Space Shuttle. A second domain in development is for training electronic technicians on United States Air Force missile systems.

The MITT system has evolved from over a decade of research, beginning in the late 1970's at the University of Illinois, related to training humans for troubleshooting (Johnson, 1987). This includes research with the development and evaluation of computer-based instruction for diagnostic training in nuclear power plants (Johnson et al, 1986; Maddox and Johnson, 1986; Johnson, 1986).

MITT has all of the modules shown in [Figure 1](#). At the heart of MITT is a simulation-oriented diagnostic training program called Framework for Aiding the Understanding of Logical Troubleshooting (FAULT) (Johnson, 1987). FAULT permits the ITS to have a model of the functional connectivity of each component in the system. For example, a functional connectivity matrix for the fuel cell would show that the oxygen and hydrogen valves must be functioning properly in order for the cell to operate. The functional connectivity matrix forms a framework for such data as component descriptions or how to perform tests. In addition, FAULT provides MITT with advice about the quality of any diagnostic action in regard to information gain per action. This is called the functional expert. The functional expert uses logical actions, almost common sense, to provide advice. It uses such techniques as splitting the system in half for troubleshooting actions or testing the parts with the highest history of failure. FAULT provides only generic logical advice - it does not know anything about the technical subject other than connectivity.

The common sense approach offered by the functional expert is necessary for safe operation and diagnosis of any system. However, it is not sufficient. Therefore, the functional expert is supplemented by the procedural expert that has system-specific information. This expert is

comprised of production rules (e.g., if gauge reading is above 200 degrees Fahrenheit, then check gauge Y) generated from the system's operating and diagnostic procedures. For the MITT fuel cell tutor the astronaut's flight data file malfunction procedures were directly translated to production rules for the procedural expert. The same approach is being used to develop the ITS for the missile domain.

The student model of MITT keeps an accounting of all student actions. Specifically, the model keeps a count of number of actions, number of displays accessed, number of errors committed, number of problems solved, kind of advice sought by the student, and other such information. This information is used by the instructor model to provide feedback and to structure the subsequent instruction. For example, the instructor model might notice that the student has made numerous mistakes related to one portion of a system. The instructor model can direct the student to specific sources of additional information or offer additional problems applicable to the remediation needed. More extensive descriptions of the MIT&T fuel cell tutor are offered elsewhere (Johnson et al, 1988).

### *MITT Writer: An Authoring System*

MITT was designed to be developed and delivered on computer systems that already exist in training departments. It's most important characteristic is that production of the necessary database, rulebase, and graphic files is a clearly defined and manageable task that can be accomplished in a reasonable time for reasonable dollars. This attractive characteristic of MITT will be amplified with MITT Writer.

MITT Writer, scheduled for completion during 1990, will permit technical training personnel to develop MITT Tutors for new technical domains. Therefore, technical training personnel will be able to build MITT intelligent tutoring systems without using computer programming languages. Like the tutor, MITT Writer runs on a microcomputer that is readily available to training departments.

### *Advanced Learning for Mobile Subscriber Equipment*

Another example of a new microcomputer-based technical training system is Advanced Learning for Mobile Subscriber Equipment (ALM) (see [Figure 2](#)). ALM trains operators and maintainers of the U.S. Army's newest tactical communications equipment. Like MITT, ALM has the constrained computing environment limited to 640k of memory. Since the Army has thousands of such computers, called the Electronic Information Delivery System (EIDS), new training systems must be developed for such hardware environments.

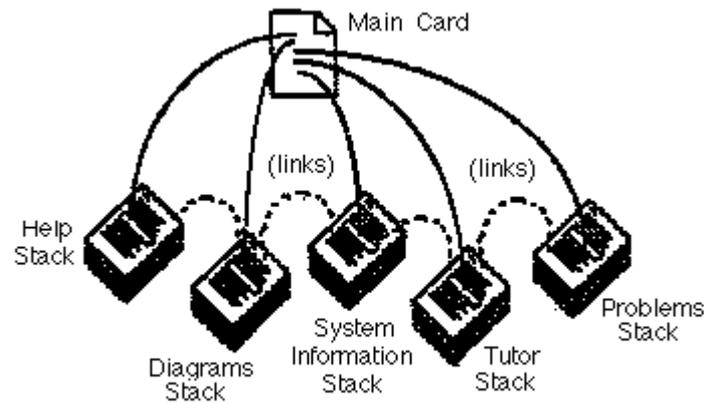


Figure 2. ALM Title Screen

ALM permits the Army student to learn about and operate the MSE. The student can build an MSE network, learn about MSE, and solve MSE system problems.

ALM uses an approach to software development different than that used by MITT or other intelligent tutoring systems. ALM uses a hypermedia approach where the various submodules are

arranged in "stacks" of cards (Coonan et al, 1990). In order to complete problems or add more problems, the developer simply completes the data for each new card in the stack. [Figure 3](#) shows the stack-like layout of ALM. Stacks can be dedicated to features like help, diagrams, problems, tutor, and any number of additional attributes. As with more traditional approaches to ITS, the hypermedia must contain an expert approach to training as well as to system operation and repair. This expertise is encoded with production rules, written in C or generated with an expert system shell. The combination of production rules and hypermedia software ensures that ALM is readily modifiable by the end user with some programming experience.



**Figure 3 ALM 'Stack of Cards' Architecture**

### Summary of Examples

MITT, MITT Writer, and ALM are but few examples of ITSs that have transitioned from the laboratory to the operational training environment. This transition was possible because the systems were designed to meet the hardware, software, and budget constraints associated with real training. These systems operate on hardware that is available, in place, today. If intelligent tutoring systems are to become a part of technical training, they must be sensitive to these constraints. Each will be briefly discussed here.

Hardware is the first constraint. Most of the early ITSs were developed on dedicated artificial intelligence workstations. Such hardware is considered to be obsolete and impractical by most developers. However, the early ITS development on the Xerox and Symbolics workstations permitted the initial design principles for today's systems.

The hardware problem is history. Today's computers, the IBM-AT, compatibles, and the MacIntosh, have the capability for ITS. The faster 80386 and 80486 processors are providing significant capability to deliver intelligent training. Such hardware is becoming increasingly affordable and reasonable for training applications.

Software has also evolved to become more suitable for ITS. The new operating systems, with new hardware, permit parallel processing and direct access to unlimited memory. These two changes, by themselves, will have a major impact on new training software. In addition to these advances are a variety of software tools that facilitate the development of interactive graphics, as an example.

Budget considerations are a third constraint to the development and implementation of ITS in technical training environments. The advent of ITSs on available microcomputers is driving down such costs. The development of authoring systems, like MITT Writer, will also bring down the cost of ITSs.

### Advanced Technology for Aircraft Maintenance Training

With definitions and demonstrations of advanced technology in hand, we proceeded to assess the status of such applications for aircraft maintenance training. To accomplish this goal, we visited or spoke with a sample of the population of airlines, schools, and manufacturers. The organizations visited are shown in [Table 2](#).

We began the interviews with a discussion of the situation as we perceived it. [Table 3](#) summarizes the preconceptions that served as a basis for initial discussions.

**Table 2**

**Sources of Information for Technology Survey**

**AIRLINES:**

American Airlines Maintenance Academy  
Continental  
Delta  
Northwest  
United  
ATA Maintenance Training Committee  
British Airways

**SCHOOLS:**

Clayton State College  
Embry-Riddle Aeronautical University  
The University of Illinois  
West Los Angeles College

**MANUFACTURERS:**

Boeing Commercial Airplanes  
Douglas Aircraft  
ATA Maintenance Training Committee

**Table 3**

**The Perceived Situation for Discussion Purposes**

- Maintenance training is traditional.
- Training personnel do not have time to develop advanced technology training systems.
- FAA has not encouraged the use of advanced technology as a substitute for laboratory practice.
- Advanced technology is an effective maintenance training alternative.
- There are few vendors of advanced technology for maintenance training.
- Most [CBI](#) systems require proprietary hardware.
- Training personnel want advanced technology training systems.

The interviews confirmed that our initial perceptions were accurate. However, there were noteworthy exceptions. Perhaps the most significant of the incorrect assumptions was the FAA position on advanced technology for maintenance training. Our discussions with FAA personnel and training personnel through the industry confirmed that advanced technology training systems have the potential to substitute for real equipment in certain laboratory tasks. For example, an AMT trainee

can learn to start and troubleshoot a turbine engine using a simulation rather than the real engine. Advanced technology cannot substitute for many psychomotor activities but is especially useful where students must practice the integration of knowledge and skill for problem solving, decision making, and other such diagnostic activities. It appears, therefore, that simulators and other advanced technology are becoming an important component of maintenance training

## A Discussion of Hardware for Advanced Technology Training

All of the interviews resulted in a discussion about the appropriate hardware systems for advanced technology training. While there is not unanimous agreement, the current favorite is the 80286 or 80386 operating in the DOS environment. VGA seems to be the acceptable video hardware standard. Many airlines managers were outspoken about their dissatisfaction with the lack of standards among the various [CBI](#) vendors. The Air Transport Association (ATA) Maintenance Training Committee (ATA, 1989) has strongly recommended that all manufacturer-produced courseware be designed for a common non-proprietary system like the IBM-AT and compatible computers. That is not currently the case, although the trends are in that direction. Software developers who meet the ATA standards are more likely to succeed in the new marketplace.

The two largest producers of [CBI](#) for aviation maintenance are Aero Information (for the Air Bus) and Boeing Commercial Airplane Company. Both systems require some proprietary hardware but are somewhat compatible within the 80286/386 family. Douglas Aircraft is developing CBI that will be compatible with the ATA standard. Another committee that is promoting standards is the Aviation Industry Computing Committee (AICC). They have published hardware guidelines and a catalog of current and planned CBI developments by its members (AICC, 1990).

Among the major airlines there is some hardware variance. Delta Air Lines, one of the few to have a significant [CBI](#) development staff, is using a large number of 80386 processors with advanced graphical displays. The Delta systems are also DOS-compatible in order to maximize applications.

The majority of Boeing training software is for the 747-400. Developed under contract to a large [CBI](#) company, the training requires proprietary equipment. The advanced technology training development group at Boeing are cooperating with United Airlines and Apple Computer Company to explore the concept of "Instructor-led CBT." Using MacIntosh computers and a variety of color graphics and hypermedia tools, they have created a variety of dynamic displays to be used for group training. Eventually this approach should find its way to individualized CBI.

## The Prototype Specifications

The prototype will be developed on hardware that is aligned with the ATA recommended standards. The specifications are listed in Table 4. This hardware will ensure that the prototype will be of value, for demonstration, to the most people. It will not require special hardware.

**Table 4**

### **Hardware and software for Prototype**

- 80286 or 80386 Processor
- 640 Kb of Memory
- VGA Display
- Hard Disk Storage
- Mouse
- MS-DOS
- Off-the-shelf software for graphics and windows
- C Programming Language

The instructional and pedagogical design is a more important consideration than hardware. While the design is hardware and software dependent, it must be emphasized that robust and expensive hardware will not make up for poor design of the instruction. An incomplete listing of the instructional specifications is shown in Table 5. These specifications will evolve with the software.

**Table 5**

**Instructional Specifications for Prototype.**

- Extensive Freeplay and Interaction
- Problem Solving and Simulation
- Explanation, Advice, and Coaching
- Orientation Towards Maintenance Tasks
- Adaptable to Student Skill Level

### **The Instructional Domain**

The primary criteria for selection of the instructional domain for the prototype was that the finished ITS be of immediate value to the airlines and to the FAR 147 schools. In order to accomplish this goal, the domain had to be a complex system that is prone to failure. Candidate systems included the following: hydraulics, auxiliary power unit (APU), engine information and crew alerting system (EICAS), electric power distribution, fuel distribution, and environment control system (ECS).

The current choice is ECS. This system is ideal for many reasons. On the ECS, diagnostic information and maintenance checks occur throughout the aircraft. The system is integrated with the APU and the main engines. The ECS is critical to passenger safety and comfort. Further, the ECS principles can be generalized to many aircraft. Therefore, currently the ECS will be the prototype domain.

### **Prototype Development Partners**

As the prototype development proceeds, we anticipate participation from at least one FAR 147 school and at least one major air carrier. A large number of schools and airlines have offered to participate. That is encouraging to the research team and to the FAA sponsor.

At this time, the most likely partners are Clayton State College and Delta Air Lines, both in Atlanta, Georgia. The combination of a major airline and an approved FAR 147 school will ensure that the ITSs will meet the instructional needs across a wide spectrum of AMT personnel. The combination will ensure that the training system is technically correct and instructionally sound. Further, the airline/school combination will be ideal to conduct evaluations of training effectiveness and cost efficiency.

### **Summary**

This paper has described the ongoing research and development related to the application of advanced technology to aircraft maintenance training. The research has characterized current use of advanced technology for maintenance personnel. Subsequent phases of the research will design, develop, and evaluate an intelligent tutoring system for aircraft maintenance training.

Training humans to learn new skills and to maintain current skills and knowledge is critical to the safe operation and maintenance of manufacturing, power production, and transportation systems. As the U.S. labor force changes, the criticality of such training becomes even more eminent. Intelligent tutoring systems, combined with human technical instructors, offer a cost-effective, reasonable alternative that can impact training immediately and into the future.

## Acknowledgements

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## USE OF 3-D PRESENTATIONS IN MAINTENANCE TRAINING

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My topic today is three-dimensional presentations in maintenance training.

Since we started in the A&P school business nearly 20 years ago, there has been dramatic improvement in teaching aids. I came to the school industry back in the 1970s, after ten years with Lockheed where professional visual aids for presentation were standard procedure. I remember my initial look for visual aids for A&P training. About all that was available were some slides on oxy-

acetylene welding that had been developed for non-aviation high school vocational courses.

The textbook situation at that time was equally meager. Most of the schools were using the Northrup series of textbooks. The AC65-9, 12, and 15 series had been written and printed, but the Government Printing Office (GPO) could not find them. They had been stored in a Washington, D.C., warehouse, but GPO could not identify which warehouse.

During the late 1970s and 1980s there were significant developments in the teaching aids field. When I refer to teaching aids, I include both software and hardware. I consider the textbooks, computer programs, slides, and videos the software. The mockups, actual aircraft, computers, projectors, etc., are hardware.

International Aviation Publishers has a series of textbooks and videos that constituted a significant step forward in the 1970s. During the 1980s, computer-based training (CBT) with laser disks and interactive capabilities have become popular. The evolution to having the material displayed on computer screens is with us now. Training schools are working with computer simulations such as engine starts on a King Air. This is a typical example of CBT. The simulated engine start is portrayed on the computer screen. This is a preliminary to an actual engine start later in the training cycle.

In this coming decade of the 1990s, we at Advanced Educational Concepts see the display moving from the computer screen to three-dimensional imagery in the classroom. We call this concept SEE -- Special Effects Education. In this approach, imagery will "wrap around" the student and immerse him in the material being presented. The entire classroom will become like a "simulator." It is multimedia, using three-dimensional simulation, computer-based techniques, dynamic sounds, interactive interfaces, and all available sensory stimuli. It is education in its most interesting, motivating, and captivating form. The student is captured by programmed audio, visual, and graphics presentations. This technique improves retention. Difficult material is grasped more readily. Lightning flashes, stereo sound, strobes, lasers, and smells such as jet fuel, lubricants, and burned insulation will be part of the presentation. The student will "live" the experience.

The engine start on the computer, for example, can be the base program for a darkened classroom with three-dimensional stereoscopic projection of the cockpit, actual engine instrument display, and audio of the engine noise. This type of training will give the feel of a simulator. It won't be a \$5 to \$10 million piece of equipment with motion, but it will hopefully "trigger" all of the senses, making the material more "live," and provide a total learning experience. All of education is "simulation." This is where we are headed as we approach the end of the century. As we become more sophisticated with imaging and the use of computer technology, we will improve the delivery system in the classroom.

A recent article in *Forbes* magazine typifies what I am talking about. The article is about a dual eyepiece miniature television screen and a glove that fits on your hand. The glove has electronic sensors on it. The article starts out saying:

"Why settle for the real thing if you can live in a dream world that is safer, cheaper, and easier to manipulate? Computers will soon make such a world possible."

The author relates his experience further:

"Five minutes into cyberspace and I'm submerged into a pool of computerized water, looking at a computerized fish finning in the far corner. 'Try to go inside the fish,' suggests my handler in the physical world. I make a fist - the cyberspace command to grab objects - the computer gets the message via electronic sensors in a glove in my hand. My eyes see a disembodied, computerized hand pass through the fish's body. The fish sticks to my hand without putting up a fight. I pull my fist down, towards my face and the fish pops over my head. I'm inside a hollow fish with two eyes at the far end. This is autodesk's whimsical world of three-dimensional computer images."

The system described in the *Forbes* article is still a year or more away from production. Its cost (for

one student) would exceed \$40,000 to \$50,000 for the hardware alone. It will not be cost effective for the educational environment, but some form of imaging will.

For the past year and a half, we at Advanced Educational Concepts have researched imaging techniques in the classroom. We started with an examination of the holographic approach and did some initial work with the University of Dayton. They do a lot of optics for the Air Force at Wright-Patterson Air Force Base. Our conclusion on holograms was that they are presently too expensive for use in the classroom. (One hologram of a Pratt-Whitney Engine about 3x4 feet costs \$18,000.) We have focused on stereoscopic interactive video and stereoscopic 35mm slides. These require polarizing glasses, where holograms do not. The costs, however, are much more realistic.

I have brought a couple of projectors and a few slides to give you an idea of what I am talking about. We can forward-project objects so they appear to be floating in front of the screen. We did not bring any audio, lighting, strobes, or special effects, but I thought you could still get a feel for the approach with these slides. We have a trademark on this approach to educational delivery. It is called "SEE" -- Special Effects Education. We are convinced that this is the educational wave of the future. The fact that the current generation is so graphically oriented points to this as the way to go. It is our job to make it economically feasible.

*The audience now dons 3-D polarizing glasses to view a series of slides that illustrate the extent to which this process can provide a three-dimensional view of objects under study.*

These 3-D slides by themselves involve the student more than 2-D does. The darkened room with the colorful visuals, stereo sound, explosions, thunder claps, strobe lights, and simulated lightning holds their attention. These effects keep the students involved. They unconsciously forget their resistance to the material. They stay interested and, most importantly, they retain the material.

In summary, during the 1990s we need to upgrade our approach to maintenance training to make it as real as possible. We must develop and make use of simulation as we have done in the flight area. We can no longer be satisfied with the technique of passing a "show and tell" general aviation item around the classroom. The schools cannot typically afford a current transport category aircraft as a training aid, but we can afford to provide simulated transport category imagery that will build more rapidly the real-time experience level we need. We must explore this type of technique to make up for the shortfall of knowledge and experience that faces us in the human resource area today and in the coming decades.

## HOW THE BRAIN PROCESSES INFORMATION

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The training process is a matter of continuous learning. A trainee must learn initially to do something. Then, as the task changes, he must learn new aspects of the task. All of this obviously involves the brain and we now are beginning to understand how specific parts of the brain are used in different kinds of learning activities. These insights into the manner in which the brain processes information can be applied profitably in programs to improve education and training.

There is a prevailing belief that everyone learns the same way. Certainly, this is the general belief within the public school system. However, we now recognize that there are several different ways in which humans learn. In fact, some individuals simply do not learn materials presented in the traditional manner. The manner in which these persons process information is not consistent with standard educational approaches.

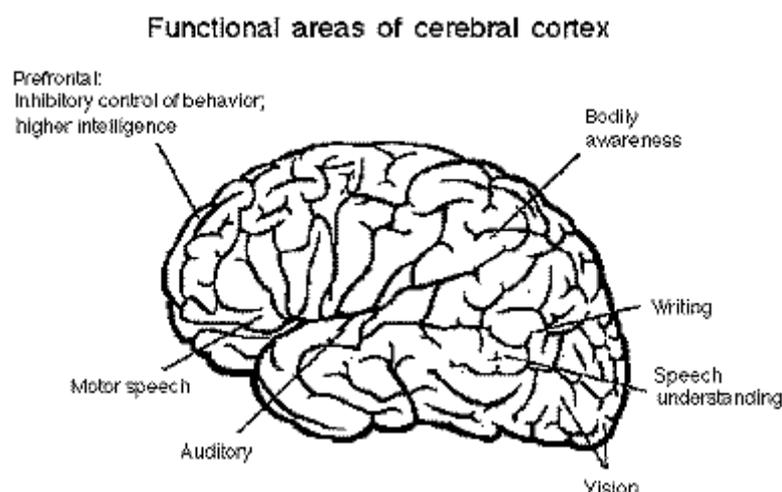
In today's elementary school system, 20 or 25 children usually are placed in a single classroom with a single teacher who presents materials to every child in the same way. Teacher-student interaction at an individual level is low. The result is that those students who do not learn in the way they are being taught become conduct problems. They don't learn the material even though the school tries as

much as it can to see that they do learn. Also, if the student has a troubled home life, he may not have anyone to go to the school and insist that the school teach them in some different way. The result is a student who is by no means achieving his potential and who may well become a problem rather than an asset for society.

In terms of our understanding of brain functioning, we have missed the boat in some parts of our educational system. We are not paying proper attention to how the brain processes information. We also are not making full use of the clues that a student's personality may give us concerning the best way in which he should be taught.

A student's personality can be considered a pathway between brain functioning and the real world. Personality concepts can be used in education and in the development of educational procedures. For instance, the impulsiveness of a student may tell you much about how that student should be taught. I have worked for almost 40 years studying impulsiveness. Recently my research has been with members of our prison population. Impulsiveness is characteristic of a large percentage of prisoners. These are people who act without thinking, make up their mind quickly, and do not plan ahead. This trait of impulsiveness offers one clue concerning the manner in which these persons process information.

Figure 1 shows the general structure of the cerebral cortex of the brain and points out in a very general way some of the areas which control specific human activities. Note that the frontal portion of the brain is responsible for selected forms of higher intelligence and also helps provide inhibitory control of behavior. The impulsive characteristics of aggressive and violent individuals are believed to be in part a function of the type of control actions of this part of the brain. The important thing to note, however, is that specific parts of the brain support specific human activities.



**Figure 1**

The specificity of brain function extends to the left and right hemispheres. The left and right cerebral hemispheres clearly support different activities, with one hemisphere or the other being dominant in its action for most people. In a general way, the left side of the brain is more disposed toward detailed activities whereas the right side is more disposed toward a "holistic" look at the world. [Table 1](#) shows a brief listing of functions which different investigators have ascribed to either the left or right hemisphere.

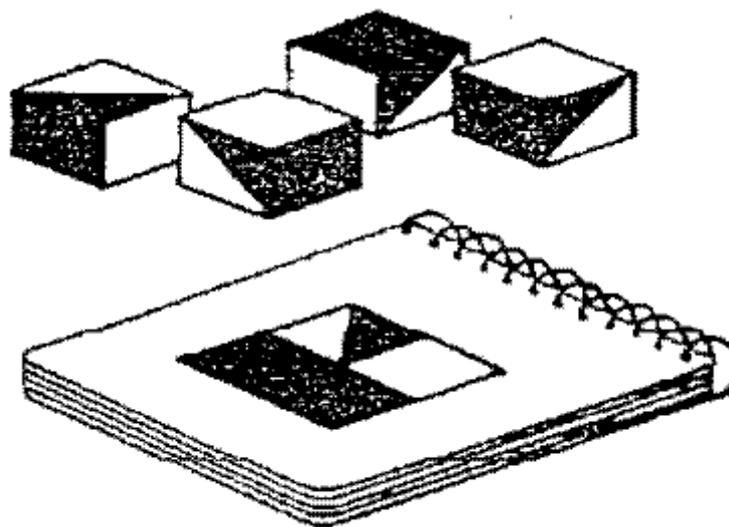
**TABLE 1**

Various Functions Ascribed to the Left and Right Cerebral Hemisphere

<b>Left Hemisphere</b>	<b>Right Hemisphere</b>
SPEECH	SPATIAL ORIENTATION
LANGUAGE	SPATIAL INTEGRATION
COMPLEX MOTOR FUNCTIONS	CREATIVE ASSOCIATIVE THINKING
LIASON TO CONSCIOUSNESS	NONVERBAL IDEATION
WRITING	FACIAL IDENTIFICATION

As noted earlier, our educational system is not set up to deal appropriately with all students. The school system favors those students who are left-side dominant. Schools are set up for students who use words. If a student is more comfortable in seeing the holistic view of something, he may have difficulty right away. A prime example of this is the story of Albert Einstein, who had great difficulty with words. In fact he did not speak until he was three years old. According to his sister, up to the age of 7, if someone said something to him, he would repeat it to himself so that he could try to understand it. In later life, Einstein was asked what was the most difficult thing for him and he repeated; putting his thoughts into words. It surprises those of us who use words with ease to learn that people can think without using words.

Those persons who think, i.e., who process information, without heavy reliance on word structures are usually right-side dominant. The right hemisphere of their brain is used more in visuo-spatial information processing than is the left. While handedness is related to which side of the brain has which functions, the relationship is not one-hundred percent. Therefore, other procedures are used to identify hemispheric dominance. In some instances, the corpus callosum of the brain has been cut for medical reasons; the two sides of the brain cannot communicate. Another approach is to use drugs to block a cranial artery and therefore interfere with the functioning of one side of the brain so that we can study it. In studies of hemispheric dominance, tests such as the block-design task show in [Figure 2](#) are used. In this test, the subject uses either the right hand or the left hand to arrange the four cubes to match the sample pattern. The performance of each hand is timed separately. Depending on which brain hemisphere is used, the reaction times of the left hand or the right hand will be significantly better.

**Figure 2 Block Design Task**

In studying information processing, it is important not only to think in terms of structural and location differences, but also to consider the bio-chemical and neuro-chemical properties of the brain. An important biochemical reaction in the brain involves the activity of serotonin, a neurotransmitter which operates at the junction between nerve cells. There appear to be at least five kinds of serotonin receptors in the brain, one of which is serotonin 2, which is found in good supply in the frontal lobe. The activity of serotonin 2 appears to relate to behavioral inhibition in the frontal lobe. If one is low in serotonin 2 activity, this person generally lacks behavioral inhibition. This person would be more inclined to impulsive behavior.

Use of "personality theories" to categorize human behavior also has given us insight into impulsiveness. Those who study personality believe that there are possibly five broad personality profiles that can be used to describe different people. These profiles include such items as extrovert versus introvert, neuroticism, social skills, intelligence, and other factors. Within each of the broad or higher-order personality profiles, there are more specific first order traits. One of the first-order factors is impulsiveness.

Impulsiveness appears to consist of at least three sub-parts; acting without thinking, non-planning, and cognitive impulsiveness. Impulsiveness does not necessarily indicate an abnormal personality. All of us have these traits to some extent. However, those persons with high levels of impulsiveness will often show certain problems with adjusting in a variety of situations. In the laboratory, we have used fifteen to twenty different tests to assess the behavior of those with high impulsiveness. For example, one task is paced tapping or the ability to mark time cognitively. Here there are consistent differences in high versus low impulsiveness with high impulsive subjects being much less accurate in pacing their taps.

Some studies have attempted to identify the extent to which personality traits such as impulsiveness are genetically determined. One such study, conducted recently in Sweden, used monozygotic twins (identical twins), dizygotic twins (fraternal twins), and siblings as subjects. The data from this study clearly showed a genetic predisposition for impulsiveness with the relationship strongest in the monozygotic twins.

Studies such as the above, which show a genetic influence on impulsiveness, and other studies, which indicate a biochemical basis, are providing a more clear picture concerning the basis for behavior and, in turn, the way individuals process information in the world around them. In order to pursue these lines of investigation into impulsiveness, I have been involved for the past three years in studies of members of our prison population as I noted earlier. Certainly, in this population one can find many persons for whom impulsiveness is a key personality trait. In the use of prisoners, all of whom are volunteers, we obtain cognitive psychophysiological data. Twenty-one electrodes are attached to the skull to obtain measures of brain activity. Subjects are then run through a number of laboratory-information processing tasks. As they perform each task, measures of brain activity can be related to the specific demands of the task.

One task used with prisoners is a choice-reaction time test in which the subject watches a screen for a particular stimulus. For example, if the letter "A" appears, the subject pushes with the right hand. If the letter "B" appears, the subject pushes with the left hand. Then we reverse the two letters and the two hands. Then, at random intervals and without the subject's knowledge, other letters appear. On these trials, the subject is not supposed to respond at all and most don't. The objective here is to add an additional feature of uncertainty and to make the task more challenging.

As prisoners accomplish the choice-reaction task, the electrical activity of the brain is recorded through electrodes placed at various sites over the skull. This gives us a very nice topographical map of electrical activity and clearly shows which locations within the cortex are activated and are principally involved in solving the task. We can also see, and this is very important, the correlation of activity between different parts of the brain for different kinds of information processing demands. This information allows us to relate functioning at different parts of the brain to each other.

In our recent research, studies of brain function have been conducted using prisoners, medical students, and controls matched with prisoners for race, socio-economic level, educational level, and other relevant variables. We find that in prisoners the correlation between the simultaneous functioning of frontal brain areas and posterior areas is high. When the frontal areas are working, other areas of the brain are supporting this activity. By contrast, other groups show lower relationships for the same tasks. With these other subjects, the frontal areas appear to operate more independently and do not require support from other brain elements. Prisoners appear to be less efficient in information processing in general because their frontal functions are not functioning independently.

The study of brain functioning in prisoners also has involved the extent to which certain drugs might improve information processing. Phenytoin, a drug used for many years for epilepsy, was chosen because it is generally safe and has the potential for controlling brain activity that we think relates to certain kinds of aggression or violence. The effect of phenytoin on prisoners was to reduce the correlations between anterior and posterior sections of the brain during the performance of tasks. In effect, this drug makes these brain areas function more independently. On the behavioral side, we obtained a significant reduction in the number of aggressive acts committed by prisoners while they were using this particular medication. What we have, then, is a pharmaceutical intervention which can be demonstrated to change the manner in which some individuals process information and also to control undesirable tendencies toward impulsive aggression.

In other studies in which we have worked with children, particularly those who have been classified as hyperactive, we found that drug therapy was useful in reducing tendencies toward impulsiveness. However, we also found that to achieve any lasting benefit, behavioral cognitive therapy had to be used in conjunction with the drug therapy. Now we plan to use the same approach with prisoners. Here we need to identify the proper teaching technique to use with each prisoner as we seek to improve his behavioral problems and to change his methods of information processing.

In summary, the work being done today in clinical neurophysiology, coupled with advances in behavior therapy and training technology, ultimately should allow us to select personnel with cognitive styles and learning skills more consistent with task demands. We also should be able to use our knowledge of the manner in which the brain processes information to develop individualized training programs which will do a better job of bringing young people into the work force. For instance, if we find an individual who scores high on the block design test but low on a verbal comprehension test, we will know that chances are he is more right than left hemisphere dominant. Then we can tailor training materials which provide information more in a spatial and holistic form than through strict reliance on the printed word. Under these circumstances, this individual, rather than being an immediate reject, might develop into a productive member of the work force. There is much to be done before these studies can be put into practical use and the result will never be absolute. Individual differences in cortical structure and in learning styles will make the prediction of success a function of probability. However, a better understanding of the manner in which the brain processes information does offer potential benefits for better training and, in the end, success on the job.

## TRAINING FOR VISUAL INSPECTION

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### **The Human Role in Inspection**

To evaluate and improve visual inspection training, we must first understand the inspection job

itself. Classic learning texts and practical training practitioners (Goldstein, 1974) agree that a detailed task analysis is the first step in training. Only when we understand the task can we evaluate the person to be trained, to determine what training is needed to bring the person to a high level of performance. Because there are large individual differences in inspection abilities (Wang and Drury, 1989), some form of training is indeed required to produce consistent inspection performance.

A task description of aircraft inspection (Drury, 1989) is shown in [Table 1](#), which gives examples from both visual and NDI tasks. This can form the basis of the task analysis required for training. Tasks 1 through 5 represent the basic inspection process and can be classified into two categories:

Manual Tasks: Initiate, Access, Respond

Cognitive Tasks: Search, Decision Making.

**Table 1**  
Generic Task Description of Incoming Inspection,  
with Examples from Visual and NDT Inspection

<b>Task Description</b>	<b>Visual Example</b>	<b>NDT Example</b>
1. Initiate	Get workcard, read and understand area to be covered	Get workcard and eddy current equipment, calibrate
2. Access	Locate area on aircraft, get into correct position	Locate area on aircraft, position self and equipment
3. Search	Move eyes across area systematically. Stop if any indication.	Move probe over each rivet head. Stop if any indication.
4. Decision Making	Examine indication against remembered standards; e.g. for dishing and corrosion.	Re-probe while closely watching eddy current trace.
5. Respond	Mark defect, write up repair sheet or if no defect, return to search.	Mark defect, write up repair sheet, or if no defect, return to search.
6. Repair	Drill out and replace rivet.	Drill out rivet, NDT on rivet hole, drill, out for oversize rivet.
7. Buy-back Inspect	Visually inspect marked area.	Visually inspect marked area.

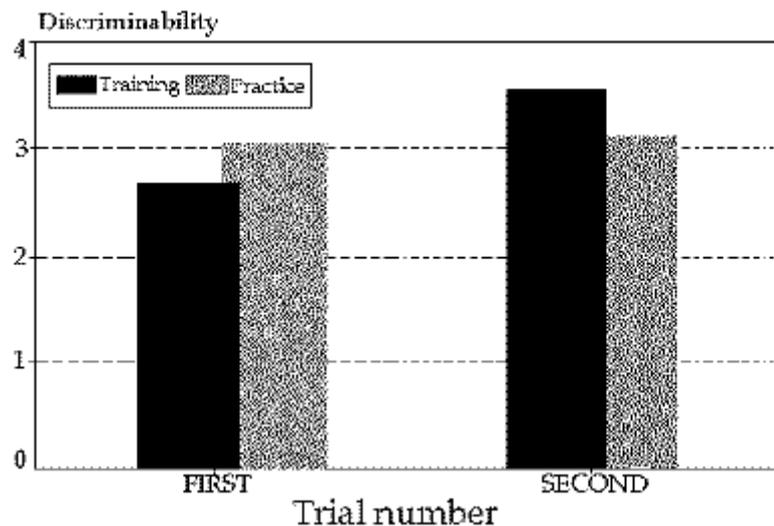
Training for manual or procedural tasks is relatively straightforward (e.g., Johnson, 1981), but training for cognitive tasks is less well known and so will be treated in more detail in this paper.

The current state of training is that much emphasis is placed on both procedural aspects of the task (e.g., how to set up for an X-ray inspection of an aileron), and on diagnosis of the causes of problems

from symptoms (e.g., troubleshooting an elevator control circuit). However, the inspectors we have studied in our task analysis work have been less well trained in the cognitive aspects of visual inspection itself. How do you search an array of rivets -- by columns, by rows, by blocks? How do you judge whether corrosion is severe enough to be reported?

Most inspectors receive their training in these cognitive aspects on the job by working with an experienced inspector. This is highly realistic, but uncontrolled. Our experience in training inspectors in the manufacturing industry (Kleiner, 1983) has shown that a more controlled training environment produces better inspectors. If training is entirely on-the-job, then two of the main determinants of the training program -- what the trainee sees and what feedback is given -- are a matter of chance; i.e., of which particular defects are present in the particular aircraft inspected.

There is a large difference between training and practice. [Figure 1](#) (Parker and Perry, 1982) shows how the effective discriminability of a target changed between two periods of practice compared with periods before and after training. There was a highly significant improvement with training but not with practice. The challenge is to apply what is known about human learning of cognitive tasks so as to maximize the effectiveness of training for the aviation inspector.



**Figure 1 Training vs. Practice**

## Training Principles

A basic principle of training is to determine whether the activity is indeed trainable. Studies of visual search (Parkes, 1967; Bloomfield, 1975) have shown that both speed and accuracy improve with controlled practice. Embrey (1979) has shown that for decision making, discriminability can be trained. Thus, both of our cognitive factors (Task 3, Task 4) can be trained.

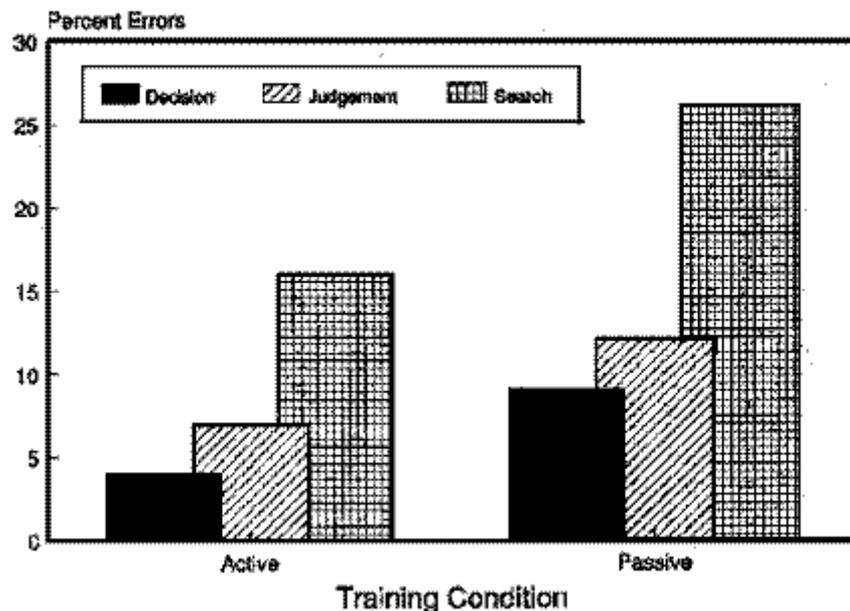
The principles on which training should be based are relatively well known, and can be summarized (Goldstein, 1974):

1. Develop and maintain attention; i.e., focus the trainee.
2. Present expected outcomes; i.e., present objectives.
3. Stimulate recall or prerequisites; i.e., get ready to learn.
4. Present underlying stimuli; i.e., form prototype patterns.
5. Guide the trainee; i.e., build up skills progressively.
6. Give knowledge of results; i.e., rapid feedback.
7. Appraise performance; i.e., test against objectives.

8. Aim for transfer; i.e., help trainee generalize.
9. Aim for retention; i.e., provide regular practice after training.

Control is important. Items 4, 5, and 6 above all require the trainee to receive a carefully tailored experience to obtain maximum benefit. Some particular ways in which these principles have been applied are:

1. **Cueing.** It is often necessary to cue the trainee as to what to perceive. When a novice first tries to find defective vanes in an engine, the indications are not obvious. The trainee must know what to look for in each X-ray. Many organizations have files of X-ray films with known indications for just this purpose. Specific techniques within cueing include match-to-sample and delayed-match-to-sample.
2. **Feedback.** The trainee needs rapid, accurate feedback in order to correctly classify a defect or to know whether a search pattern was effective. However, when training is completed, feedback is rare. The training program should start with rapid, frequent feedback and gradually delay this until the "working" level is reached. More feedback beyond the end of the training program will help to keep the inspector calibrated (Drury, 1989).
3. **Active Training.** In order to keep the trainee involved and aid in internalizing the material, an active approach is preferred (Belbin and Downes, 1964). In this method, the trainee makes an active response after each new piece of material is presented; e.g., naming a fault, weighting a discrepancy card. Czaja and Drury (1981) showed that an active training program was much more effective than the equipment passive program ([Figure 2](#)) for a complex inspection task.



**Figure 2 Active vs. Passive Training**

4. **Progressive Part.** A standard methodology in industrial skill training (Salvendy and Seymour, 1973) is to teach parts of the job to criterion, and then successively larger sequences of parts. Thus, if four task elements were E1, E2, E3, and E4, we have:

- Train E1, E2, E3, E4 separately to criterion.
- Train E1 and E2, E3 and E4 to criterion.
- Train E1 and E2 and E3, E2, and E3 and E4 to criterion.
- Train whole task E1 and E2 and E3 and E4 to criterion.

This technique enables the trainee to understand task elements separately and also the

links between them which represent a higher level of skill. Czaja and Drury (1981) and Kleiner (1981) use progressive part training very effectively.

5. Develop Schema. The trainee must eventually be able to generalize the training experience to new situations. For example, to train for every possible site and extent of corrosion is clearly impossible, so the trainee must be able to detect and classify corrosion wherever it occurs. Here, the trainee will have developed a "schema" for corrosion which will allow the correct response to be made in novel situations which are recognizable instances of the schema. The key to development of schema is to expose the trainee to controlled variability in training (Kleiner and Catalano, 1983).

Not all of these techniques are appropriate to all aspects of training aircraft inspectors. The next section provides some industrial examples of their use, leading to recommendations for aircraft inspection training.

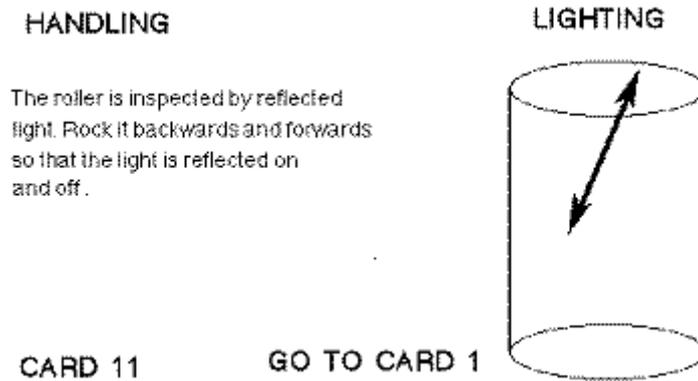
### **Examples of Inspection Training in Manufacturing**

Table 2, modified from Czaja and Drury (1981), shows the results achieved by industrial users of the training principles given above. In each case the inspectors were experienced, but the results from new training programs were dramatic. To provide a flavor of one of these successful programs, the final one by Kleiner will be illustrated.

**Table 2. Summary Table of Practical Applications of Inspector Training Programs.**

<u>Investigator(s)</u>	<u>Training Technique</u>	<u>Type of Task</u>	<u>Results</u>
Tiffin, J. and Rodgers, H.B. (1941)	Knowledge of results and training sessions which included lectures	Inspection of tin plates	General improvements in inspection performance; greater detection of faults
Evans (1951)	30 min. class instruction; 11 tests with K of R over 2 weeks	Micrometer inspection of gage blocks	50% reduction in average error, but no effect on retention
Martineck, H., & Sadacca, R. (1965)	Knowledge of results using an error key	Photointerpretation	Decrease in errors of commission
Chaney, F.B., & Teel, K.S. (1967)	Four 1-hr. sessions included lectures, demonstrations, and K of R from a Q&A period	Inspection of machine parts	Training resulted in a 32% increase in defects detected
Cockrell, J.T., & Sadacca, R. (1971)	Knowledge of results and group discussion	Photointerpretation	Significant improvement in inspection performance and a decrease in false alarms
Parker, C.G., & Perry, G. (1972)	Demonstrations, use of photographs simulating items and faults, examples of faulty items, practice with K of R	Inspection of glass bowls	50% increase in faulty detection, 50% increase in false rejections
Duncan, K.D., & Gray, M.J. (1975)	Gradual approach to the task (diagnosis of faults then verification) using programmed instruction	Fault detection in a petroleum refinery process	Training resulted in an increase in faults detected, decrease in detection time, and decrease in false rejections
Houghton, S. (1982)	Product knowledge, standards, search training, practice with K of R, progressive part	Solder joint, inspection	Efficiency up from 33-67% to 89-97%
Kleiner (1983)	Progressive part, cueing K of R, active	Aircraft bearing inspection	Rest errors reduced to zero, 50% scrap reduction

The company manufactured precision roller bearings for aircraft, and the training scheme was aimed at improving the performance of the inspection function for the rollers. All inspectors were experienced, from 2 to 14 years, but measurements of performance (Drury and Sinclair, 1983) showed much room for improvement. Based on a detailed task analysis, a two-day training program was developed. Inspectors were taught using a task card-based system ([Figure 3](#)). Each card had a color-coded task section.



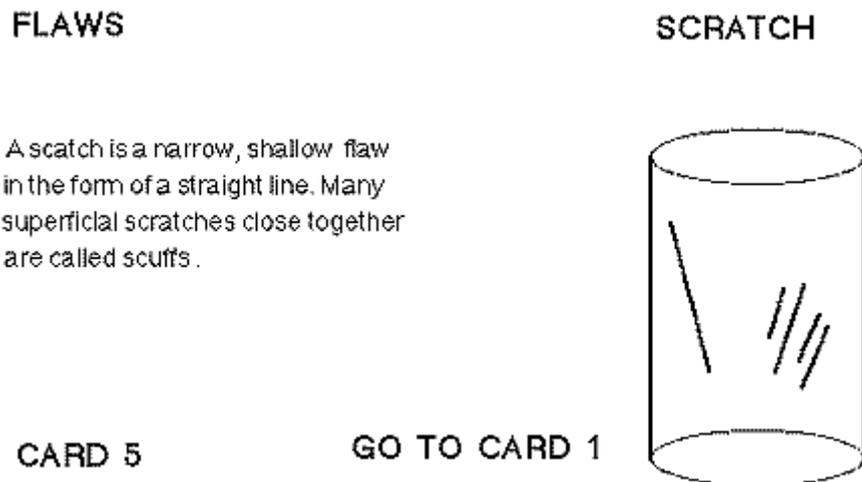
**Figure 3**

Naming of parts (surfaces)    Naming of defects (flaws)

Handling methods (handling)    Visual search (search)

Decision making (standards, decision making)    Process interface.

For each section, there was a progressive set of cards with information, possible physical examples or test procedures, and a sequence indication. Each card required an active response. [Figures 3, 4, and 5](#) show examples of Handling, Search, and Decision. Note that in each case the next action is to go to the first card in the section to preserve the progressive part structure.

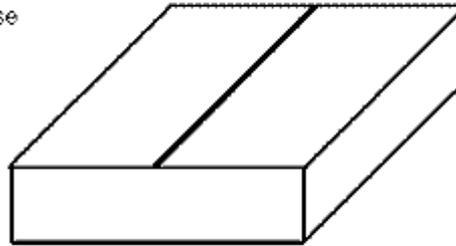


**Figure 4**

**DECISION**

Each of the blocks has a gap of a certain size, even though some cannot be felt. As I touch each one, please use the scribe to feel the gap. Use the following responses:

- (1) Definitely do not feel a crack
- (2) Probably do not feel a crack
- (3) Probably do feel a crack
- (4) Definitely do feel a crack

**SENSITIVITY****CARD 2****GO TO CARD 3****Figure 5**

This training program was evaluated in two ways. First, two new recruits were able to achieve perfect scores on the test batch at the completion of the program. Second, the quality of feedback from inspection to manufacturing increased so much that scrap was halved between the six months before the training and the six months after. The whole program was replicated for the inner and outer races of the bearings, entirely by company personnel using the roller training program as an example. Incidentally, subsequent university involvement with turning this company into an acknowledged world-class manufacturer was based on the results achieved in this inspection training program.

### Application to Aircraft Inspection

How can these principles and manufacturing examples be applied to aircraft inspection? Obviously, in such a short paper it is not possible to provide more than isolated examples, so the search and decision aspects of visually detecting defective turbine vanes on film will be used as an example. Specifically, this refers to an observed gamma ray inspection of a nozzle guide vane area of a JT9D. The current job card and [NDT](#) manual lists and illustrates six defects:

1. Trailing edge burning
2. Trailing edge bowing
3. Airfoil bulging
4. Missing vane inner rear foot
5. Broken vane mounting bolt
6. Incorrect vane tilt.

For defects 2, 3, and 6, standards are given, but for others, they are not. There are also defects in the [NDT](#) manual which are not on the workcard, and differences in terminology between the manual and the workcard. Given that these task design problems can be cured, a training scheme for these defects would proceed as follows:

1. Part naming -- Cueing and active response to the name of each part (inner lug, mounting bolt, trailing edge, etc.). A physical model should be easily visible and accessible away from the engine. Knowledge of results is given after each response in each step.
2. Transfer to film -- Repeat the part naming on the film to ensure that the three-dimensional concepts have formed a schema which generalizes to a two-dimensional view.
3. Defect naming -- Present large examples of each defect, clearly cued (marked) on a model.
4. Transfer to film -- Repeat the defect naming on film.

5. Search training -- Search for one defect (e.g. bulging airfoil) on different films until the defect can be located accurately. The different films provide the variety needed to develop schema.
6. Search training -- Repeat step 5 for each defect type. Repeat for combinations of defects until complete set can be searched for accurately.
7. Decision training -- Provide the standards for each fault with the measurement procedure. For example, measuring the width of the trailing edge for trailing edge bowing and comparison to standards. Use pre-marked defects to remove any search component. Repeat step for each fault and for combination.
8. Whole task -- Practice both search and decision aspects for each fault separately and for whole set.

Such a training procedure uses the techniques discussed earlier. It is mainly performed off-line in a controlled manner, but the results of the studies quoted in the previous section show that such training successfully transfers to the more complex on-the-job environment. What has really been done is to prepare the trainee carefully to make maximum use of what he/she sees on the job, rather than leaving the learning process to trial and error in an uncontrolled environment. Because the training experience is so controlled, it is concentrated. Trainees can progress to the same level as experienced inspectors (and usually beyond) in days rather than months.

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## **ORGANIZATIONAL CONTEXT IN AVIATION MAINTENANCE: SOME PRELIMINARY FINDINGS AND TRAINING IMPLICATIONS**

### **Progress of the Human Factors Team National Aging Aircraft Research Program**

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## **Introduction**

What I will present today is the report of initial findings from preliminary research on a complex subject. This report describes research on the organizational context of airline hangar maintenance. In line with the topic of this conference, I will draw some implications for maintenance training from those initial findings.

First I must insert a caution that what follows should not be interpreted as criticism of maintenance people or their dedication to air safety. Throughout the course of this study I continue to find well-meaning people everywhere I have visited. These are people who want to do their best for flight safety. In my remarks today I intend to be fair in reporting from my limited sample, but for the purposes of this conference I also intend to emphasize the training needs I have discovered from my interviews.

## **Background and Purpose of the Study**

This study was undertaken to begin the process of obtaining information about human relations and communication in aircraft maintenance work. There is no current public information on the behavior of typical maintenance organizations in the U.S. commercial air transport system. Such information needs to be available from an industry-wide perspective to form a baseline measure. Such a baseline

would facilitate developing guidelines for improving error management, improvement of other aspects of maintenance effectiveness (e.g., the speed, flexibility, and cost of maintenance), and improving the quality of working life of all members of the maintenance system. This present study is less ambitious in its scope, but no less so in its intention. It is a rapid observation and diagnostic tool, intended to provide some baseline information quickly to the industry in order to demonstrate the utility of organizational variables in improving maintainer performance, attitudes, and error management.

The full results of this preliminary study will be available to the industry by the Autumn of 1990 to permit a decision on the form and timing of a more extensive, quantified survey study of the organizational context for maintenance.

**Design of the Research.** A narrow slice of aviation maintenance is investigated in the present study. I have proposed to visit and have discussions with people in ten maintenance facilities in U.S. commercial transport aviation between January and August 1990. These visits involve discussions with aviation maintenance technicians (AMTs), their supervisors and managers. Where possible, the setting is the C-level maintenance check of aging aircraft. All work shifts engaged in the maintenance check are visited, and between 20 and 30 interviews/discussions have been completed at each site.

**Progress to Date.** Five sites of the ten proposed have been visited. These include Part 121 carriers and Part 145 repair stations. Regional air carriers will be included in the sample, but have not been visited yet. The visits to date have ranged between two and four days and have focused on the activity around a single aircraft.

## General Findings

Figure 1 shows what I have seen and heard in the typical evolution of today's maintenance organization. In the late 1960s and early 1970s, the organization of hangar maintenance was guided by the skill and experience of general foremen. To them reported shift foremen and specialist mechanics prepared mainly by their duty tours in military aviation. Also included at that time were schedulers to monitor job assignment documents and instructors to improve and broaden the mechanics' performance and skills.

### THE MAINTENANCE ORGANIZATION

#### *1970: The General Foreman*

Foremen and specialist mechanics

Schedulers

Instructors

#### *1980: Proven work cards*

Experienced foremen and mechanics

Shift foremen and mechanics

Planners

#### *1990: Withdrawal of experienced mechanics*

Reduced parts inventories

Older airplanes

Planners/computer experts

Shift Foremen

Instructors

Newer, sheet metal Mechanics

### Figure 1

By the late 1970s, the mechanics and their supervisors had reached a high level of competence. Job cards for work assignment had been proven effective and the process of standardizing the work flow in hangar maintenance necessitated the new role of "maintenance planner" to create and manage a work flow system.

Today, in 1990, we find a reduction in the numbers of experienced mechanics and inspectors. This represents, first, the still-lingering effects of AMT layoffs during the dark days of the PATCO strike and our U.S. oil crisis of the early 1980s. A second reason for this reduction in experienced AMTs is the exodus prompted by AMT retirements, promotions, and interdepartment transfers to maintenance shops. Following the general economic recession and airline deregulation, what we find are many indicators of a cost-conscious industry - a most obvious sign of which for the maintenance system is reduced parts inventories. Finally, as we well know now, the fleet of new transport aircraft in 1970 has become "aging aircraft." Together these changes result in the typical hangar maintenance organization guided by shift foremen and/or planners. The latter are increasingly computer-literate and tasked with digitizing the job card and work planning/tracking system. After a decade of absence, maintenance training departments and their instructors are reappearing.

**AMT Experience.** This current hangar maintenance organization typically has a bimodal experience distribution of 30-plus years and 3 or fewer years. With the increase of aging fuselages, and Airworthiness Directives to attend to them, most demand for new mechanics has been in sheet metal repair. Thus, most sheet metal mechanics are new, and most of these are young. They typically hold an A&P license, but did not enter aviation training directly out of high school. In most cases these new AMTs do not have military experience, and if they do, they are not necessarily immediately qualified for A&P work in a Part 121 carrier or Part 145 repair shop. For instance, experience as a military crew chief provides deep experience in weight and balance but little else, while repair in helicopters provides no understanding of repair on pressure cabins. There are also some AMTs who come into maintenance work after spending time in defense-related and/or aircraft manufacturing. This is also of limited benefit.

**Organizational Structure.** Structure differed among the sites I visited. The atypical characteristics range from unified systems to separate fiefdoms. The latter are often organized with Maintenance, Materials, Inspection, and Planning/Scheduling Departments, all reporting to separate vice presidents.

In some companies, Scheduling and Maintenance report together at a lower organizational level. In yet others, a materials group reports to the maintenance organization. These differences are usually reflected in the degree of cooperation among the departments and the degree of shared purpose. Several companies I visited had sheet metal departments in heavy maintenance units, separate from and in addition to sheet metal shops.

Different structures can act to vest authority in some departments (e.g., Planning), consequently eliminating or reducing authority in another department (e.g., Maintenance). In these cases, Planning usually reports up a separate chain of command from Maintenance.

For instance, in one company, high control of repair by Planning through restricting access to job card racks diminished the sense of control that mechanics, inspectors and their supervisors felt. Lower control and pride of "ownership" often led to lower care/attention to work performed.

Differences in norms between departments, or less developed norms in an inexperienced workforce, lead to decisions to control work which have widespread effect. In one instance, Inspection took control of routine job cards "opening up" access for preliminary inspection, based on a mistrust of inexperienced mechanics "closing up" access before inspection had been completed. They did this

by issuing a "non-routine" job to open-up, and another to close the job after inspection. The resulting lack of control of initial work planning by maintenance foremen and scheduling supervisors created confusion and frustration.

**Expectations.** I often heard reports of errors involving miscommunication. A new employee and an experienced boss usually means deference of the former to the latter - the former is expected to be learning the ropes, after all. Such subordinates will not often voice uncertainty or their lack of experience when assigned to a job. There may also be a failure to report problems if they occur. Relatively inexperienced employees are thus assigned to work beyond their abilities with ensuing repair errors. In those companies where there are strong sanctions (expectations) against remaining quiet and no punishment for speaking up, these errors are reported much less frequently.

**Attitudes and Opinions.** Despite these differences among companies, there were similarities in how AMTs saw things and felt about them. [Figure 2](#) lists the common categories of current attitudes.

**Organizational Purpose and Mission.** In all sites, a typical statement was, "everybody wants quick turnaround." Whether this was cause for AMT's pride or frustration or stoicism depended on the degree to which they saw this as realistic and relevant. AMTs consciously accepting safe, fast turnaround as realistic and relevant is an operational definition of purpose or mission. Most C-check sites I visited, however, had no apparent mission, either espoused or enacted. In these places, AMTs were willing to do their best in what seemed to them to be impossible circumstances. Only one of the sites visited revealed a strategy of maintenance which was both acknowledged and successfully pursued by AMTs. This site took pride in airworthy repairs and fast turnaround of the aircraft. In this site, foremen routinely held meetings with AMTs at the beginning of shifts to emphasize the joint purpose and their performance in its pursuit. In the other sites, confusion and crisis were the trend, typically with a willingness of AMTs to respond if they were led.

## THE MAINTENANCE ORGANIZATION

### *Typical Experiences in C-Check*

- "Everybody wants quick turnaround."
- "Folks are uncertain about what a flaw is, or what to do about it."
- "Those (new/young) folks don't love airplanes like we do, they aren't loyal to the company, and they don't have that old hustle."
- "Computers are coming in, and we're not certain who's in charge -- maintenance, or planning, or the computer?"

### Figure 2

Work assignment was seen as disorganized in two sites, with mechanics milling around at first of shift at the card racks until jobs were passed out. Once in receipt of job assignments, AMTs go to the job location and begin work or wait to get advice from leads and supervisors. In another case, Planning controls the job cards and passes them through the window to mechanics and inspectors without comment.

**AMT Experience.** Inexperience typically elicits similar reactions throughout the maintenance organization. Inspectors are expected (by themselves and others) to be confident of their decisions. These decisions often go beyond the identification of a flaw and include the required repair as well. Often relatively inexperienced inspectors (or inspectors with experience limited to systems, engines, and flight surfaces) will prescribe sheet metal repairs which are at variance with mechanics and their supervisors. These frequent differences are usually resolved between inspection supervisors and their counterparts in Maintenance.

Thus, AMTs are wary of one another's abilities and this includes feelings of mechanics for inspectors as well as vice versa.

**Organizational Culture.** In the past, the aviation industry could aptly be called "boys' own airplane club," because the people who chose it loved airplanes and flying. It was and still is a **boys'** club, in maintenance at least, because I saw very few women AMTs or managers. The passion, however, has largely gone the way of dope and fabric wings - held by the long-time employees and a few of the newcomers. From the top to the bottom jobs, people today join airlines for many reasons beyond the love of planes. This clear shift, plus changes in the labor force, confounds the long-service employee. Older AMTs are often discouraged with what their companies have become, and they resent the newer mechanics' lack of skills, their laissez faire attitude, and their high turnover. The new mechanics seem to like the work, but are not "excited" about it. The company's reputation is of little concern to younger workers because they are/will move on to other companies or other industries.

Whether or not an organization has a mission or conscious purpose, it can have a clear locus of control. This is sometimes structural combined with behavioral norms, and sometimes the norms themselves, over time, can wrest control in one group over the others. Usually the struggle for control over maintenance work is between Maintenance and Planning - and as computerized planning becomes more common, it can take on a life of its own, seeming to rise above both the Maintenance and Planning people in its rigidity and singular focus.

## Training

Figure 3 lists the results to date which bear on training issues.

### THE MAINTENANCE ORGANIZATION

#### Technical Training

- Pre-employment preparation

- Ab initio training

- Recurrent training

- On-the-job training (OJT)

#### Other Training

- Safety training

- Team building, leadership

#### Attitudes toward training

### Figure 3

## Technical Training

**Pre-employment Preparation.** There is little sheet metal training in A&P schools. Previous aircraft manufacturing experience is usually good for riveting skills.

**Ab initio Training.** With new mechanics' typical inexperience with Part 121 aircraft and maintenance practices, some vestibule training is provided in most sites observed. This training is intended to provide introduction to Part 121 aircraft through reviewing the AA Chapter categories.

**Recurrent Training.** Inspectors are faulted for not having much previous sheet metal experience and no training in sheet metal after becoming inspectors.

**On-the-Job Training (OJT).** On-the-job training (OJT) is performed by young, relatively inexperienced AMTs as often as by the seniors. Despite descriptions of elaborate OJT programs in several companies, little beyond "sit by Joe" was observed.

**Attitudes.** Younger workers' attitudes toward recurrent training are mixed. In companies where some training is provided they want more, and in those that don't provide much training, AMTs don't complain but they may not realize what it can add.

### *Other Training*

**Safety.** *Ab initio* orientation training usually covers personal safety. Many companies require periodic (often monthly) safety meetings.

**Team Building, Leadership.** One company provided shift foremen with training on how to conduct meetings. This company also required them to hold a crew meeting at the start of shift. Some of these foremen used their training well, and others did not. Even when the meetings were less skillfully led, the crews acted with less disorganization than in sites where foremen were neither encouraged nor trained to lead meetings.

## Implications for Training

Figure 4 lists implications of these results and the recommendations which follow from them.

### IMPLICATIONS FOR TRAINING

#### *Some preliminary thoughts*

- Increase and improve OJT
- Improve and expand sheet metal training
- Emphasize and expand teamwork training

#### Figure 4

**Increase and Improve OJT.** When OJT is offered it should be conducted by experienced employees, trained in teaching/learning techniques. It should be planned and frequent, with records kept complete and up to date. OJT records should include time spent on the training as well as an evaluation of the learner's knowledge and performance for a complete system or mechanical/electrical module. Ensure that faulty knowledge is not perpetuated from instructor to learner.

**Improve and Expand Sheet Metal Training.** A&P schools should extend their practical sheet metal repair module and minimize theory. Recurrent training for sheet metal repairmen should include theory as well as technique. Damage tolerance principles as well as the origins of SSIDs and on-condition monitoring should be covered. Sheet metal courses would be an effective addition in the inspectors' recurrent training program as well.

**Emphasize and Expand Teamwork Training.** Other industries outside aviation have established the effectiveness of brief, frequent and focused meetings between supervisor and subordinates. Where these are very brief but daily start-of-shift safety meetings, lost time accidents and injuries decrease. In the present study, those cases where foremen were observed leading daily, focused shift briefings, their groups were effective in achieving high performance. Where principles learned in leadership and team training were applied by foremen in these briefings, their results were even more positive.

## Appendix B: Meeting Agenda

### Third Federal Aviation Administration Meeting on Human Factors in Aircraft Maintenance and Inspection "Training Issues" 12 - 13 June 1990

*Tuesday Morning - Marlborough Rooms A/B/C*

7:30 a.m. Registration

8:30 a.m. Welcome/Meeting Objectives *William Shepherd, Ph.D. Federal Aviation Administration*

9:00 a.m. Keynote Address *Col. Robert R. McMeekin, MC, USA Federal Air Surgeon Federal Aviation Administration*

#### REGULATION AND OVERSIGHT OF MAINTENANCE TRAINING BY THE FAA

9:30 a.m. FAA's Proposed Revisions to Parts 147 and 65 *Leslie K. Vipond Office of Flight Standards Federal Aviation Administration*

10:15 a.m. Break

#### TECHNICAL TRAINING (A&P SCHOOLS, MILITARY, ETC.)

10:30 a.m. U.S. Navy Training for Aircraft Maintenance *Captain James Qurollo, USN Naval Air Maintenance Training Group*

11:15 a.m. Training Within the Industry *David Wadsworth President, Professional Aviation Maintenance Association*

12:00 noon Lunch

*Tuesday Afternoon - Marlborough Rooms A/B/C*

#### TECHNICAL TRAINING (A&P SCHOOLS, MILITARY, ETC.) - Cont'd.

1:00 p.m. Technical Training Schools *Jack Moore President, Aviation Technician Education Council and Professor, Clayton State College*

#### INDUSTRY TRAINING PROGRAMS-THRUSTS

1:45 p.m. An Innovative Approach to Training NDT Inspectors at Boeing *Diane Walter Boeing Commercial Airplanes*

2:30 p.m. Break

2:45 p.m. Development of Maintenance Training for a New Aircraft - Commercial Tilt Rotor Program *Thomas Cooper Bell Helicopter*

3:30 p.m. Maintenance Training - A View from the Floor *John Goglia International Association of Machinists and Aerospace Workers (IAM&AW)*

4:15 p.m. Adjourn

*Wednesday Morning - Marlborough Rooms A/B/C*

#### INDUSTRY TRAINING PROGRAMS-THRUSTS - Cont'd.

8:30 a.m. Airline Maintenance Training - Experimental Training Systems *Kenneth Govaerts, Ph.D. AMR Technical Training and Andrew Gibbons, Ph.D. WICAT*

9:15 a.m. Introducing CRM into Maintenance Training *William R. Taggart* **Resource Management Associates/Pan Am**

10:00 a.m. Break

10:15 a.m. Training at the Repair Station *Michael Rose* **Lockheed Aeromod**

#### **ADVANCE TRAINING TECHNOLOGY**

11:00 a.m. New Training Technology for Maintenance *William Johnson, Ph.D.* **Galaxy Scientific Corporation**

11:45 a.m. Lunch

*Wednesday Afternoon - Marlborough Rooms A/B/C*

#### **ADVANCE TRAINING TECHNOLOGY - Cont'd.**

12:45 p.m. Use of 3-D Presentations in Maintenance Training *James Rice, Ed.D.* **Rice Aviation**

1:30 p.m. How the Brain Processes Information *Ernest S. Barratt, Ph.D.* **University of Texas, Galveston**

#### **PANEL PRESENTATION**

2:15 p.m. Progress of FAA Human Factors Team *Colin G. Drury, Ph.D.* **SUNY Buffalo** and *James C. Taylor, Ph.D.* **University of Southern California**

#### **MEETING RECOMMENDATIONS AND CONCLUSIONS**

3:00 p.m. *William T. Shepherd, Ph.D.* **Federal Aviation Administration** and *James F. Parker, Jr., Ph.D.* **BioTechnology, Inc.**

3:30 p.m. Adjourn

## Appendix C: Meeting Attendees

### Third Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection 12 - 13 June 1990

#### TRAINING ISSUES

#### MEETING ATTENDEES

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**Meeting 4: The Aviation Maintenance  
Technician (1990)**

**Proceedings of the Fourth  
Meeting on Human Factors  
Issues in Aircraft Maintenance  
and Inspection**

Report of Meeting

12 - 13 December 1990

Alexandria, Virginia

Prepared by:

James F. Parker, Jr., Ph.D.

**BioTechnology, Inc.**

Falls Church, Virginia

under subcontract to

**Galaxy Scientific Corporation**

Mays Landing, New Jersey

## FOREWORD

This meeting recognizes the vital importance of the Aviation Maintenance Technician (AMT) as a support element for the entire air carrier industry. The Aviation Maintenance Technician is our first line of defense as we strive to ensure maximum safety and efficiency for a growing air carrier fleet which includes new advanced-technology aircraft as well as a growing number of older aircraft. It is most important that we understand the aviation maintenance workforce and that we take all necessary steps to provide an adequate and fully qualified workforce in the coming years. Issues that affect technician productivity and workforce stability must be identified and addressed.

There is evidence that the contributions and importance of maintenance technicians are not appreciated by the general public and, interestingly, within the aviation industry itself as fully as they should be. For these and other reasons, a measure of workforce instability exists. Workers, both present and future, are being lost to other industries. However, this meeting attests to the commitment of the Federal Aviation Administration, airline operators, and aircraft manufacturers to increasing support for the aviation maintenance technician and for continuing improvement in the "image" of this segment of our industry.

We were fortunate in having a number of industry maintenance managers in attendance. Their expertise and insights were invaluable. Also, those professionals with skills in personnel and administrative sciences made important contributions. I would like to thank everyone who attended the meeting and especially those who gave presentations. Your efforts provide an essential input into a program dedicated to continuing improvement in aviation maintenance.

*William T. Shepherd, Ph.D.*

*Office of Aviation Medicine Federal Aviation Administration*

## EXECUTIVE SUMMARY

The Federal Aviation Administration (FAA) sponsored a two-day meeting in December 1990 as part of a series of meetings to address Human Factors in Aircraft Maintenance and Inspection. At this meeting, primary attention was given to "The Aviation Maintenance Technician." The vital cog in the air carrier maintenance industry is the Aviation Maintenance Technician (AMT). Quality performance by the AMT is essential both for aviation safety and for industry efficiency. The growing air carrier fleet, with its mix of new advanced-technology aircraft and a continuing number of older aircraft, places heavy demands on the maintenance workforce. Problems confronting the workforce must be understood and all necessary steps taken to ensure excellent workforce performance in the coming years.

The objective of this meeting was to review human factors issues of importance for the performance of Aviation Maintenance Technicians. The meeting was attended by representatives of the airline industry, aircraft manufacturers, the training establishment, human factors scientists, and others. Based on presentations given and ensuing discussions, the following recommendations are presented:

### Availability of Qualified Entry-Level Personnel

1. The likelihood of a shortage of qualified entry-level personnel for air carrier maintenance in the next decade needs better definition. Some organizations such as the Professional Aviation Maintenance Association (PAMA) or the Future Aviation Professionals of America (FAPA) should undertake, with blessings from the FAA and financial support from the airline industry, a detailed manpower modeling study of the Aviation Maintenance Technician occupation as it is likely to change over the next decade. Factors which cause or which might serve to mitigate such changes should be documented.
2. The airline industry must begin a sustained program to draw women and minorities into maintenance. Problems, such as language, physical strength, etc., which might accompany greater use of these people should be identified early and corrective action taken before the numbers of these workers grow.
3. Efforts started by some airlines to increase the understanding of aviation maintenance by students in elementary and secondary schools are worthwhile and should be expanded. These programs should aid in improving the image of the Aviation Maintenance Technician and should encourage young students to consider airline maintenance as a career.

### Applicant Qualifications

1. Lack of basic skills in reading, math, and physics on the part of applicants for maintenance training has been noted on a number of occasions and obviously is of real concern. A meeting should be convened to address this problem exclusively. Representatives of the Federal Aviation Administration, the Department of Education, the technical training schools, and the airlines should attend. Objectives of the meeting should be to describe the extent of the problem more clearly and to consider paths leading to improvement.

### Role of the Aviation Maintenance Technician

1. Airline managers should review carefully the report of the U.S. Air Force Tactical Air Command (TAC) experiment in changing organizational factors to enhance aviation maintenance. While this military model certainly could not be adapted directly to a

commercial organization, many features of it might be employed to advantage in airline maintenance operations.

2. Each airline should look to itself to determine if its working corps of maintenance technicians is given proper respect, opportunities, and management support. Enhancing the "image" of the Aviation Maintenance Technician certainly starts within the organization.

3. Under FAA auspices, a meeting should be convened to consider the working environment of the Aviation Maintenance Technician. This meeting should attempt to identify variables which enhance or detract from maintenance productivity. Recommendations for improvements in the working environment should be generated.

## INTRODUCTION

The Federal Aviation Administration (FAA) sponsored a two-day meeting in December 1990 to address issues of human factors and personnel performance in aviation maintenance and inspection. At this meeting, particular attention was given to issues concerning "The Aviation Maintenance Technician." Presentations were given by some 16 individuals representing the full spectrum of interests in commercial aviation, air carrier maintenance, recruiting and training, and personnel administration and management specialties. Each presentation, as well as the following question and answer period, was recorded for transcription and study.

The broad objectives of the meeting were to (1) understand the changing dynamics of the national labor force in terms of impact on technician availability; (2) review factors that affect current recruiting and retention statistics; (3) describe initiatives for working with local educational systems; and (4) discuss procedures to enhance technician productivity and improve workforce stability. An elaboration of the objectives of the Federal Aviation Administration in sponsoring a meeting such as this is described in presentations immediately following.

"Conclusions and Recommendations" of the meeting are presented just after the "Meeting Welcome" and "Meeting Objectives" presentations. These conclusions and recommendations are based on a panel session held at the end of the meeting plus a review of the transcripts of each presentation and the ensuing discussions.

An edited version of each presentation, taken for the most part from tape transcripts, is presented as Appendix A.

## MEETING WELCOME

*John S. Kern  
Deputy Associate Administrator for Regulation and Certification  
Federal Aviation Administration*

I would like to welcome you to the Fourth FAA Meeting on Human Factors Issues in Aircraft Maintenance and Inspection.

As in previous meetings, today's topic reflects the concerns and recommendations of the group that participated in earlier meetings. I thank you for this contribution and I thank you for coming. I know you all have many other commitments and that you do not take this amount of time away from your usual schedule easily. Your presence here today demonstrates the importance you place on utilizing a "human factors" perspective in your work. The value of your attending this meeting, which allows you to informally discuss these issues, cannot be overemphasized. Your recommendations and insights will make real contributions to the nature and development of aviation and to the other attendees here as well.

These meetings are structured in a way unlike other meetings you might have attended. They are more than an audience listening to speakers. They are a forum for dialogue among all the participants.

Typically, people come to a meeting like this with some issue, concern, or question they would like to know more about. You might be one of these people. You might hold this issue like a question in your mind and, as you listen to the speakers, you decide whether their message has something to help you answer that question. It's a good way of making an informal meeting like this useful and for obtaining intended results because it leaves a great deal of room for thinking.

You may notice that the exact nature of this question changes or sharpens over time. The question you have now is not quite the same one you had at the last meeting. If this is a productive meeting for you, the question you have in your mind now will be replaced by other questions. You may also have some solutions by the time you return to your home organization.

I sense that the conferences themselves are changing. With each meeting, the quality of discussion that exists here has been deepening. We no longer speak of human factors in vague descriptive terms about each segment of the workplace. Now we can delve more fully into what it is that makes a difference there. We have left the day-to-day type of discussion and entered the realm of vision and determination that is needed if that vision is to become real.

Today, we begin a meeting on the Aviation Maintenance Technician. During the meeting, you can expect to hear discussions ranging from innovations in the recruitment and development of people to the professionalism of aviation maintenance technicians. You may also expect to hear about ways that change can take place on the maintenance floor and the ways that the effectiveness of such a change can be measured. You'll hear about ways a work crew can be supported in particular situations. The important thing here, of course, is not the situation but the innovations we might bring to bear in other, similar, situations.

Since this series of meetings began, the way we do business on a day-to-day basis has changed. We have already expressed concern about the number of people we need and where they will come from. Now, we are seeing and experiencing a real drain from the existing work force as employees become eligible for retirement. The industry will have to look hard to find the people they need. We must be concerned about maintaining employee skill levels and finding and training new employees.

I am certain that there is not an organization represented here today that has not considered strategies for augmenting the productivity level of the aviation maintenance work force. Changing organizations, mergers, new routes, aging aircraft, acquisition of new aircraft, changing products and services -- these are all concerns that affect the maintenance tasks of air carriers. There are also the continuing problems of literacy, longevity, job satisfaction, personnel shortages, and pressure to

make gate times.

One of the common themes discussed in the last meeting was the importance of worker participation in many of the functions that had traditionally been closely held by management. It was reported that worker attitude, as measured in participation and absenteeism among other factors, improved as workers took an active role in deciding their own futures. The workforce seems happier and more stable because of it.

These days this can lead to something of a dilemma. How can a manager sustain workforce enthusiasm at the same time he is looking at ways to increase the performance of the work force -- possibly through some less than desirable personnel changes? When times are tight, one of the first things we do is batten down the hatches and reduce expenditures. The task of maintaining workforce performance during anticipated lean economic conditions ahead will test management skills to the fullest. I hope you all learn something here that will help those of you confronting this task deal with it.

So, I invite you to take an active part in this conference. Consider the thoughts and experiences of those here who represent international and non-U.S. carriers. Listen to the ideas and suggestions of people who are not directly involved in aircraft maintenance.

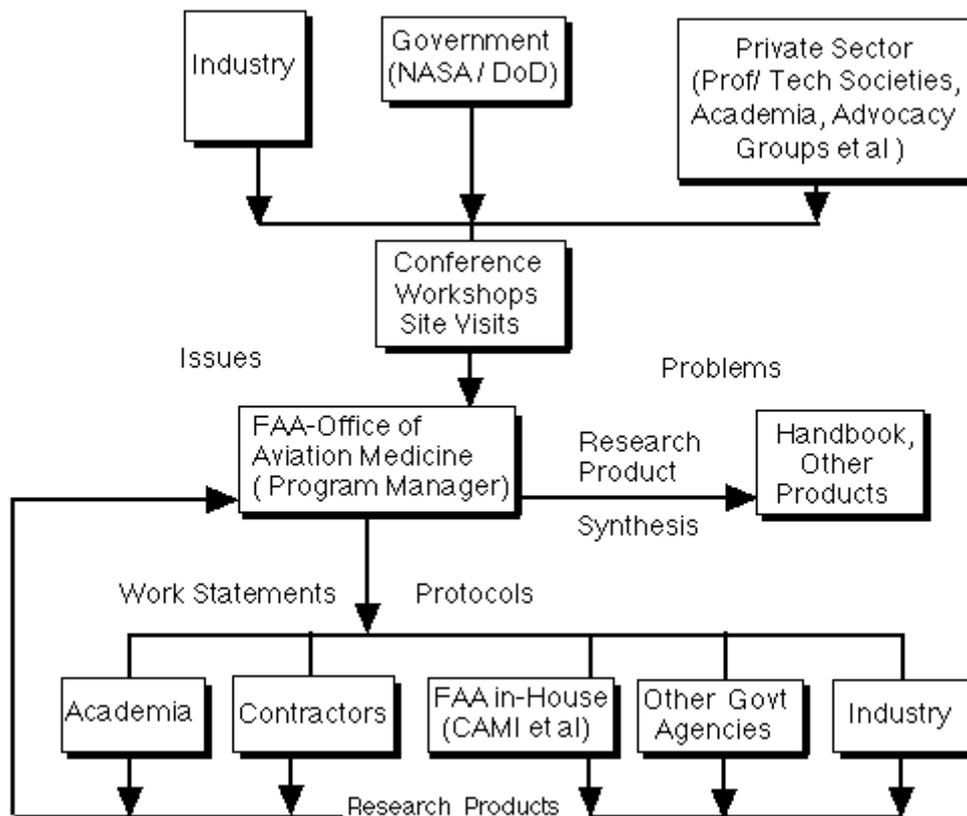
You will be exposed to new ideas here that may be the start in solving one of your current problems. We ask your participation and assistance as we strive for an aviation maintenance system to meet the challenges of the 21st century -- which will surely include times like these, too.

## MEETING OBJECTIVES

*William T. Shepherd, Ph.D.  
Office of Aviation Medicine  
Federal Aviation Administration*

I would like to welcome everyone again on behalf of the FAA Office of Aviation Medicine. As you know, this meeting is one in a series to address specific issues in Human Factors in Aircraft Maintenance and Inspection. Today's meeting addresses topics concerning "The Aviation Maintenance Technician." We all recognize that the aviation maintenance technician is our first line of defense as we strive to ensure maximum safety and efficiency for a growing air carrier fleet which includes new advanced technology aircraft as well as a growing number of older aircraft. It is most important that we understand the aviation maintenance workforce and that we take all necessary steps to provide an adequate and fully qualified workforce in the coming years.

The FAA Office of Aviation Medicine supports a comprehensive research program on human factors in aviation maintenance. The structure of this program is shown in [Figure 1](#). As you can see, we seek input from three principal sources which include industry, Government research programs, and contributions from all elements within the private sector. A major route for us to obtain and synthesize these inputs is through conferences such as the one you are attending today. We then use the information and recommendations provided through these conferences to develop a series of work statements and protocols for the research we support. Our ultimate goal is to develop research products, principally in the form of information items, which can be returned to the maintenance industry and to our own FAA employees concerned with maintenance oversight.



**Figure 1**

Progress has been made in aviation maintenance. There is good understanding of metal-oriented matters. We know what corrosion is and we are developing a better understanding of metal fatigue.

These are matters we can address. More and more, however, we are realizing that human factors issues -- problems related to visual inspection, recruiting and training, ensuring an adequate supply of qualified workers -- represent the pressing issues today. These are the kinds of issues we would like to cover in our research program and then provide appropriate feedback to our industry audience. Hopefully, industry then will be better equipped to deal in the future with topics concerning the maintenance workforce.

The theme today is the aviation maintenance workforce and the coming decade of change. Looking to the 1990's, we see that the forces driving change are population dynamics, industry dynamics, and technology dynamics. In terms of population dynamics, we see definite changes. The number of young people in the 19-25 year old age group, the group from which maintenance technicians are drawn, is getting smaller. The declining supply of potential male workers will be competed for by other occupations. This will be particularly true for high tech and computer-oriented industries. Increasing employment of women and minorities will be mandatory. There also is a need to understand geographical shifts in the population. For example, states in the sunbelt, from Florida across through the southwestern states, are showing significant increases in population. These shifts will bear on the location of maintenance facilities. Finally, as we consider population characteristics, we must take note of the decreasing number serving in the Armed Forces. This pool of potential maintenance technicians will no longer be as large.

Industry dynamics also will affect aviation maintenance. [Table 1](#) shows a 52 percent growth forecast for domestic and international passenger enplanements for the next decade. By the year 2000, these forecasts see 715 million passengers being carried. To accommodate this growth, the number of large jet aircraft will grow. The 19 percent increase may be somewhat conservative since it considers the retirement of a large number of the current narrow-bodied fleet. This retirement may or may not happen as scheduled. Certainly, a great deal of money is being spent today on repair and refurbishing of these older aircraft. As long as safety permits, most will remain in service.

Table 1  
Industry dynamics- Airline Growth

Passenger enplanements (domestic and international )

Year	Number
1990	471 million
2000	715 million

( 52% growth forecast )

Number of large jet aircraft

Year	Number
1990	4,055
2000	4,835

( 19% growth forecast )

Another important feature of aviation maintenance is its rising cost. [Table 2](#) shows that, through the years 1983-1988, the cost of aviation maintenance effectively doubled. However, a more critical aspect is that this cost increased by about two and one-half percent as a percentage of aircraft operating expenses. Undoubtedly, this increase reflects in part the additional maintenance requirements of aircraft growing older during this period. In future years, there also may be

increased maintenance requirements due to the introduction of high technology aircraft.

Table 2  
Industry Dynamics - Maintenance costs  
(Percent of aircraft operating expenses)

1983	9.2%	\$2.9 billion
1984	9.4%	\$3.2 billion
1985	9.8%	\$3.6 billion
1986	11.2%	\$4.5 billion
1987	11.3%	\$5.0 billion
1988	11.8%	\$5.6 billion

Source: FAA, 1988

Aircraft introduced in recent years, such as the Airbus A-300 series and the Boeing 757-67 planes, represent a new generation of technology. Other aircraft planned for the next decade will push the bounds of technology even farther. The glass cockpit will become standard; control systems will employ fly-by-wire and fly-by-light technology; aircraft structures will employ composites and other materials not now in use. Taking all of this into account, the skills and knowledges required of the maintenance workforce in the coming decade will be different from those of today. The demands on the training establishment necessarily will increase.

All of the above variables point to a major situation confronting the aviation industry in the next ten years. Many forces will impact the maintenance workforce. The objectives of this meeting are to examine these forces, as we now understand them, and to work toward recommendations for appropriate actions both by industry and by the FAA. I look forward to the contributions of each of you to our meeting objectives. These contributions will be of value as we all work toward a 1990's workforce that is adequate in number, works productively and efficiently, and strives for error-free operations. Thank you.

## CONCLUSIONS AND RECOMMENDATIONS

Maintenance operations to support the U.S. air carrier fleet are demanding and costly. Newer aircraft are becoming increasingly complex; older aircraft are showing the effects of delayed retirement from the air carrier fleet. These changes place the aviation maintenance technician (AMT) very much in the spotlight. The AMT must do his/her job well if aviation safety standards are to be maintained or improved. The performance of the AMT is critical for the success of the air carrier maintenance industry, now an \$8 billion per year enterprise.

The proficiency of maintenance technicians and the entire maintenance workforce is impacted by many factors. Maintenance technicians must work within an organization that offers proper support. An appropriate supply of technicians must be available and they must be well trained and motivated. Necessary maintenance documentation must be at hand and in usable form. Physical facilities and maintenance equipment must be suitable for the demands of air carrier maintenance. The list goes on.

The purpose of this two-day meeting was to examine the aviation maintenance technician, to consider steps necessary to ensure a continuing workforce of high quality, and to review all variable that might have a positive or negative impact on technician performance. Phrased differently, the questions posed to meeting attendees were:

*What do we in the air carrier industry have to do to properly support the aviation maintenance technician?*

*How can we ensure that the industry has a well qualified and motivated workforce to meet air carrier maintenance demands in the 1990's?*

Attendees at this meeting represent all segments within the air carrier industry, including airline operators, manufacturers, members of the training establishment, regulators, manpower specialists, and others. Formal presentations given during the two days covered a variety of topics related to manpower planning and workforce support. Recommendations for maintenance management during the coming decade were offered during formal presentations, during ensuing discussions, and during a final panel session in which four attendees agreed to lead a discussion of the group recommendations. Members who graciously agreed to serve on the Discussion Panel include:

*John Goglia*

**USAir/IAM&AW**

*Rod Peters*

**Northwest Airlines**

*Richard Ulm*

**Embry-Riddle Aeronautical University**

*Richard Yeatter*

**USAir**

The following recommendations represent a grouping and synthesis of broad topics considered important by attendees, with specific recommendations included within each topic.

### **Availability of Qualified Entry-Level Personnel**

Many indicators point to a basic problem likely to confront air carrier maintenance in the 1990's and beyond. There simply may not be a sufficient number of qualified AMTs entering the maintenance workforce to meet growing industry demands. Growth projections, both for the air carrier industry and for the national labor force, support this concern. There is little doubt that the industry itself will continue to grow. FAA forecasts predict over a 50 percent increase in the number of passengers to be carried by U.S. airlines by the end of this decade. The size of the air carrier fleet also will grow, although not at the same rate due to increasing use of wide-body jet aircraft. By the year 2000, almost 5,000 large jet aircraft are forecast to be in use, about a 20 percent increase over the size of today's fleet. Maintenance demands will increase accordingly.

A troubling fact is that, while the air carrier fleet grows robustly, the national labor force will grow modestly. Some sectors, in fact, may show a decline. Forecasts made by the Bureau of Labor Statistics, U.S. Department of Labor, show a slowing rate of growth for the total labor force. The 27 percent growth seen between 1976 and 1988 will drop to 16 percent between 1988 and the year 2000. Most troubling, however, is that both the 16 to 24 and the 25 to 34 year age groups are projected to show a decline in actual numbers by the year 2000. These are the age groups that provide entry-level technicians for air carrier maintenance.

The forecast of the Bureau of Labor Statistics also show changes in the makeup of the national labor force in the coming decade. The percentage of women in the labor force will continue to increase. By the year 2000, almost one-half of all workers will be female. Minorities in the workforce also will grow and, by the year 2000, roughly one-quarter of the labor force will be made up of persons of black, hispanic, and asian origin. These individuals certainly represent a possible source from which to meet future needs for maintenance technicians.

Another national change which impacts air carrier maintenance is the decrease in military maintenance technicians, a source that traditionally has served as a supplier for commercial needs. Many maintenance technicians, trained during their military service, have gone to work for airlines following their military tour. As the years pass, however, this labor pool is shrinking. In 1974, Department of Defense statistics show that well over 17,000 enlisted personnel were assigned to aviation maintenance within the military. By 1984, this number had dropped to just over 8,000, less than one-half the number a mere ten years earlier.

If there is to be a shortage of maintenance technicians in the immediate future, one might expect those technical training schools that award the A&P certificate to be experiencing the bow wave of the shortage at this time. Indeed, this is the case. One well known training facility, which offers a number of programs in maintenance technology, had over 1,000 students ten years ago. At the present time, the enrollment is about 600, with the majority of these students in four-year degree programs. A number of these graduates will not go directly to airline employment as an aviation maintenance technician but, rather, may be employed by competing industries. The conclusion, in any event, is that training institutions are not operating at full capacity due to a decline in applications for technical training.

One reason put forth by those involved in maintenance training for the failure to attract an abundance of applicants is the "image" problem. Too much of the world views an AMT as simply a mechanic, one who turns wrenches and works under harsh environmental conditions. To combat this perception, some airlines have begun programs under which descriptive materials and discussions are presented to local high schools. Representatives of the airlines work directly with interested students and may even introduce them to the operations of a maintenance facility. Such public relations actions represent a positive step toward improvement for the AMT image. However, the fact remains that the flow of applicants to technical training schools needs to be improved.

All of the above signs point to a deficit of qualified maintenance technicians in the 1990's and beyond. Several attempts have been made to estimate the extent of the manpower shortfall for air carrier maintenance over the next ten years. For example, the Future Aviation Professionals of America (FAPA) estimates the industry will need 46,000 technicians in the next ten years. Based on

Department of Education numbers, there will be slightly over 22,000 training completions during this period. This would indicate a shortage of 24,000 technicians. Other estimates place the shortage at over 40,000 technicians. Whatever the extent of the shortage, first effects will be felt by regional/commuter carriers since they represent the beginning of the technician career pipeline. The effect rapidly will move to the major carriers since the regional/commuters will be graduating fewer technicians for the majors.

## Recommendations

1. The likelihood of a shortage of qualified entry-level personnel for air carrier maintenance in the next decade needs better definition. Some organizations such as the Professional Aviation Maintenance Association (PAMA) or the Future Aviation Professionals of American (FAPA) should undertake, with blessings from the FAA and financial support from the airline industry, a detailed manpower modeling study of the aviation maintenance technician occupation as it is likely to change over the next decade. Factors which cause or which might serve to mitigate such changes should be documented.
2. The airline industry must begin a sustained program to draw women and minorities into maintenance. Problems, such as language, physical strength, etc., which might accompany greater use of these people should be identified early and corrective action taken before the numbers of these workers grow.
3. Efforts started by some airlines to increase the understanding of aviation maintenance by students in elementary and secondary schools are worthwhile and should be expanded. These programs should aid in improving the image of the aviation maintenance technician and should encourage young students to consider airline maintenance as a career.

## Applicant Qualifications

Many voices during the meeting were heard decrying the level of preparation of applicants for training in aviation maintenance. Basic skills in reading/writing, mathematics, and physics frequently are found wanting. These are the skills necessary for success in training and for later on-the-job performance. As the complexity of aircraft grows, as exemplified in the Airbus A-300 and the Boeing 757/67 series, the requirement for skills in communications and in science will increase in step. New aeronautical vehicles are extremely sophisticated and aviation maintenance as a profession must enlarge its capabilities. The requirement for basic skills will become more critical.

One well-known technical training school reports a 25 percent failure rate in its A&P program. This is attributed to a lack of requisite skills on the part of those entering the program. This failure rate occurs even though remedial training courses for these skills are offered by the schools. The lack of initial preparation is such that even intensive remediation is not successful.

Considerable blame for the quality of technical school applicants has been placed on the U.S. public educational system. While this blame might be justified, it does nothing to solve the immediate problem. Some means must be found to improve the average applicant's basic skills in reading, math, and physics. Certainly, the requirement for these skills in aviation maintenance will not go away.

One corrective effort that has been considered is to add another semester to the academic schedule of technical training schools to provide extensive instruction in basic skills. There are two obvious problems here. One is that the time required to obtain the A&P certificate increases. The other is that the training becomes more costly.

One suggestion was that airlines be drawn more into the issue of applicant qualifications. With financial support from a coalition of airlines, arrangements might be made with community colleges or with high schools to offer special preparation courses in the basic skills required for aviation maintenance. These courses would be offered without charge to those expressing a serious interest

in aviation maintenance as a career. The airlines could consider the funding for such programs as an investment in the quality of their maintenance operations in coming years.

## Recommendations

1. Lack of basic skills in reading, math, and physics on the part of applicants for maintenance training has been noted on a number of occasions and obviously is of real concern. A meeting should be convened to address this problem exclusively. Representatives of the Federal Aviation Administration, the Department of Education, the technical training schools, and the airlines should attend. Objectives of the meeting should be to describe the extent of the problem more clearly and to consider paths leading to improvement.

## Role of the Aviation Maintenance Technician

The work of the aviation maintenance technician obviously is vital to the safety and economic viability of airline operations. Aviation safety must never be compromised by inadequate maintenance; aircraft must be kept in service as schedules dictate. The AMT is indispensable for each of these objectives. Yet, while the contribution of the AMT is quite clear cut at these broad levels, on a day-to-day basis his/her role is less well defined. Decisions concerning maintenance are made at a higher level. Someone else may sign off on completed maintenance, thereby making the AMT not accountable for his/her own work. The working environment of the AMT may be less than it could be. Finally, all too frequently the AMT is treated as low man on the totem pole.

Anything that improves the role and stature of an AMT correspondingly should improve his productivity. A multi-year experiment conducted by the Air Force Tactical Air Command demonstrated that changes in organizational structure can affect the role of the maintenance technician and can produce measurable improvements in maintenance performance. In this experiment, the structure of TAC was changed to a more decentralized form in which decisionmaking and responsibility were moved more directly to those doing the work. Several new levels of leadership were established, with authority and responsibility at each level. Goals and performance standards were set up. The objective was to provide a unity of purpose between individual and organizational goals. Maintenance teams were established so that each team member was personally affected by the team's success or failure. Superior performance was recognized and rewarded.

Results of the changes in maintenance organizational structure and operations were measured over a 12 year period. Although some difficulties were encountered initially in changing to a new organizational structure, all indices ultimately pointed to genuine improvements in productivity. The number of Sorties flown per aircraft per month increased. Measures of aircraft readiness showed improvement. The percentage of aircraft repaired and returned to flight status within a fixed period time also increased. In all, the impact of the new organizational structure on maintenance productivity was significant.

The experiment conducted at the U.S. Air Force Tactical Air Command indicates organizational factors can be very important in maintenance. However, those who conducted this experiment are careful to note that what was appropriate for TAC may not be appropriate for other organizations. Their structure certainly could not be transferred on a one-to-one basis. However, they point out that every organization should review its structure to determine if it is organized to provide best support to those working within it.

One part of organizational structure concerns the relative importance given to persons working at each organizational level. Comments from some airline maintenance managers indicate that maintenance technicians often are not treated as being particularly important. All agree that this is unfortunate. However, management attention frequently is on other problems.

From the vantage point of the maintenance technician, requests for support from management are nominal and rational. One individual indicated during the meeting that his needs include a clean, orderly and well-lit working place; a decent seat on which to rest when tired; good manuals available at the worksite; a computer to provide an immediate maintenance history of the airplane; and a parts support system that will deliver parts in a timely manner when working under less than optimum conditions. This technician indicated he is not looking for pampering. All that he requires are the facilities and tools to do the job and the opportunity to take pride in a job well done in a timely manner.

The above comments from a senior maintenance supervisor illustrate the importance of a good working environment, proper equipment and parts, and management support as necessary. Many features of a working environment can operate either to facilitate or degrade performance. The working environment of maintenance technicians warrants study in its own right.

## Recommendations

1. Airline managers should review carefully the report of the Air Force Tactical Air Command (TAC) experiment in changing organizational factors to enhance aviation maintenance. While this military model certainly could not be adapted directly to a commercial organization, many features of it might be employed to advantage in airline maintenance operations.
2. Each airline should look to itself to determine if its working corps of maintenance technicians is given proper respect, opportunities, and management support. Enhancing the "image" of the aviation maintenance technician certainly starts within the organization.
3. Under FAA auspices, a meeting should be convened to consider the working environment of the aviation maintenance technician. This meeting should attempt to identify variables which enhance or detract from maintenance productivity. Recommendations for improvements in the working environment should be generated.

## Appendix A: Meeting Presentations

### THE CHANGING WORKFORCE TO THE YEAR 2000

*Darrel Patrick Wash  
Office of Employment Statistics  
Bureau of Labor Statistics  
U.S. Department of Labor*

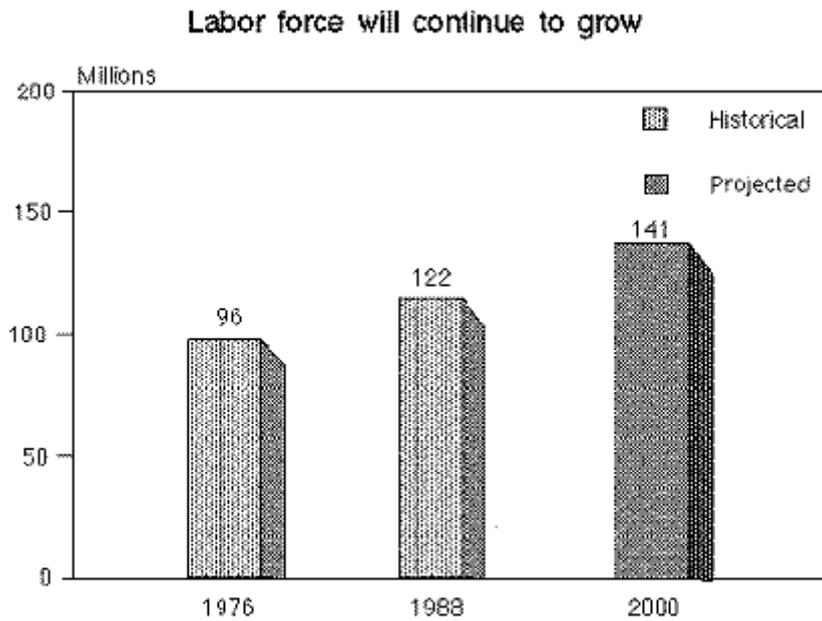
The Office of Employment Projections within the Bureau of Labor Statistics (BLS) is the office responsible for all forecasting work in BLS. Our work is in two parts. First, we develop detailed projections of the labor force and of industry and occupational employment. Second, we prepare widely used vocational guidance materials including the *Occupational Outlook Handbook* and the *Occupational Outlook Quarterly*. The audience for our work is varied and includes high school and college students, guidance counselors, education and training program planners, people interested in recruiting and retention, as well as other Government agencies.

Our work began after World War II in order to develop data to assist returning veterans reentering the workforce. Our projections generally cover 10 to 15 years. The projections reviewed today have a base year 1988 and are projected to the year 2000. We currently are revising these projections and soon will be looking at the projection period 1990-2005. Projections are revised every two years in order to monitor technological changes, changes in the way business is conducted, demographic changes, as well as correcting any mistakes. Looking into the future is not easy and our goal is not to be perfect. Rather, we strive for our projections to be generally in the proper direction and in the correct order of magnitude. We feel that we generally meet this goal.

The work of the Office of Employment Projections uses four closely integrated models covering (1) labor force, (2) aggregate economic activity, (3) industry employment, and (4) occupational employment. The last model covers occupational employment for several hundred occupations and industries. In this, we produce an industry occupational employment matrix with which we can provide detailed data on occupations in a particular industry, both current and projected. One can look at an occupation and see the industry distribution of employment both in the base year as well as in the target year. We normally produce three alternatives based on different assumptions concerning gross national product, unemployment, population growth, and labor force growth. Today's review is based on a moderate set of assumptions. This provides projections that we feel are most likely to occur.

The first step in our work is to develop estimates of the labor force, defined as those at work and looking for work. People who have become discouraged in their job search and quit looking are not considered. For the purposes of this presentation, I will present data for the most recent 12 year period, years 1976 to 1988, as well as for the projection period, years 1988 to 2000.

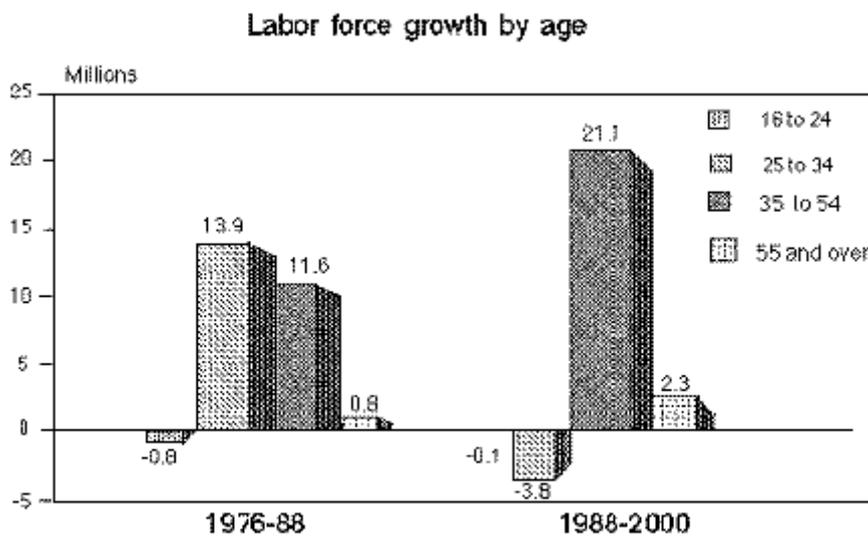
Figure 1 shows that over the 1976 to 1988 period, some 26,000,000 people entered the labor force, an increase of 27 percent. Our projection for the 1988 to 2000 year period calls for an increase of 19,000,000 persons, a 16 percent rise. This projected slowing in the growth of the labor force reflects slower population growth stemming from the decline in the birth rate in the 1960's and 1970's. It also reflects a projected slower growth rate in women's labor force participation rates, an issue to be discussed later.



Source: Bureau of Labor Statistics

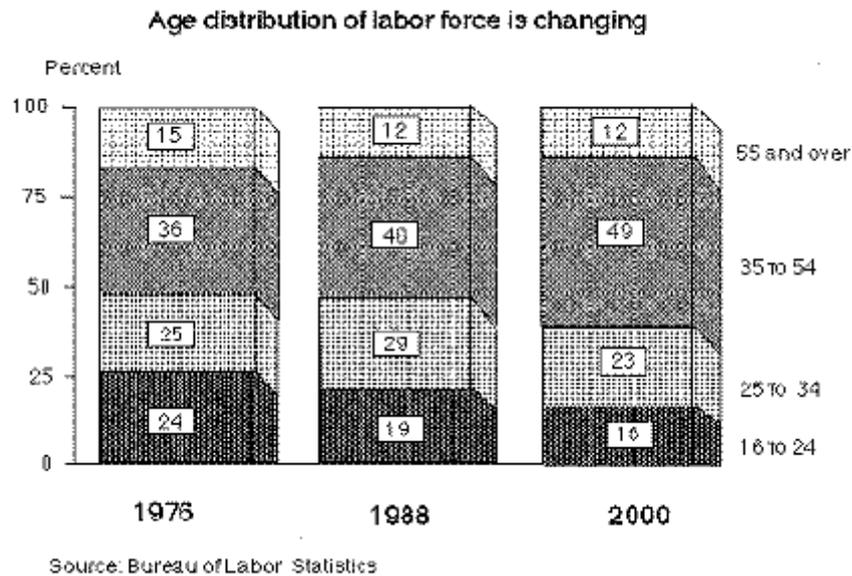
**Figure 1**

An examination of projected labor force growth by age to the year 2000 shows some changes of particular interest to those working in aviation maintenance. [Figure 2](#) shows the age projections for four major age groups. The 16-24 year old labor force, the group representing potential entrants to training programs in aircraft maintenance, shows a slight decline in size over the projected period. The 25-34 year age group, which grew by nearly 14,000,000 from 1976 to 1988 will drop nearly 4,000,000 between 1988 and 2000, again reflecting the declining birth rates of the 1960's. As shown in [Figure 3](#), almost all the growth will occur among those 35-54 years in age. This is the group that includes the "baby boom" generation.



Source: Bureau of Labor Statistics

**Figure 2**



**Figure 3**

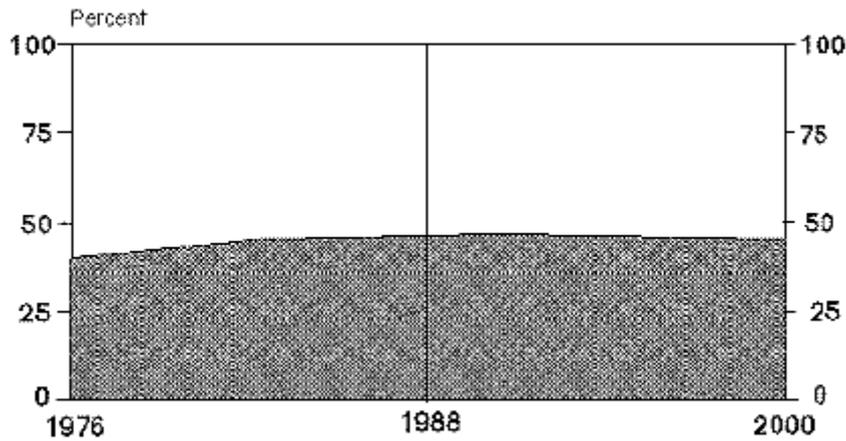
The changing patterns of growth for different age groups over the next decade necessarily will produce a different age distribution in the workforce. The 55 and over share of the labor force is projected to remain the same as in 1988, halting its earlier decline. The baby boom generation will be 35-54 years in the year 2000 and will account for almost one-half of the year 2000 labor force. Both the 25-34 year group and the 16-24 year group will decline in terms of their share in the total labor force.

Rates of labor force growth are projected to drop for both men and women. As was the case in the 1976 to 1988 period, labor force growth for women will be greater than for men, as shown in [Figure 4](#). The participation rate for women will increase by about 22 percent over the projected period. The greater labor force growth for women means that their proportionate share of the labor force will continue to increase, as indicated in [Figure 5](#). Women's share of the labor force increased from 40 percent in 1976 to 45 percent in 1988. This increase is projected to continue, reaching about 47 percent in the year 2000.



**Figure 4**

**Women's share of labor force is growing**

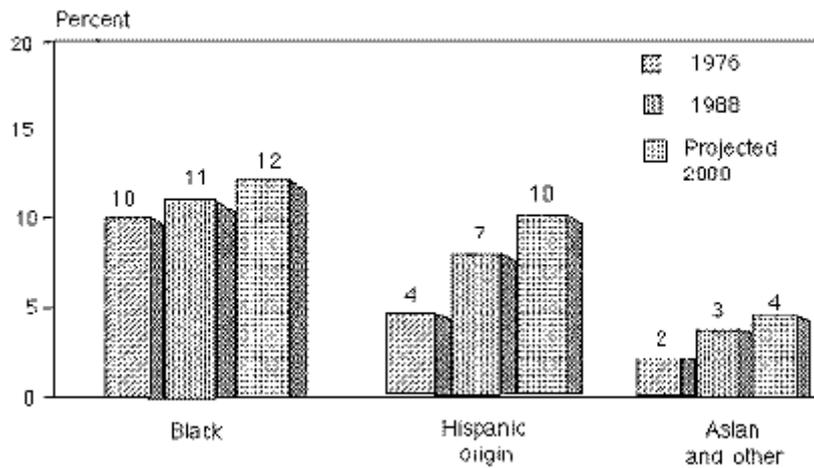


SOURCE: Bureau of Labor statistics

**Figure 5**

The labor force also is changing in terms of race and ethnic background. [Figure 6](#) shows the distribution of minority groups in the labor force in 1976 and 1988, and projected for the year 2000. Over this period, blacks have been and will continue to be the largest minority group. The hispanic share, however, will grow faster than other groups due both to their higher birth rate and to immigration. The new immigration law may moderate this somewhat, but the growth rate for hispanics will continue to be a significant factor in the changing workforce.

**Minorities' share of the labor force grows**

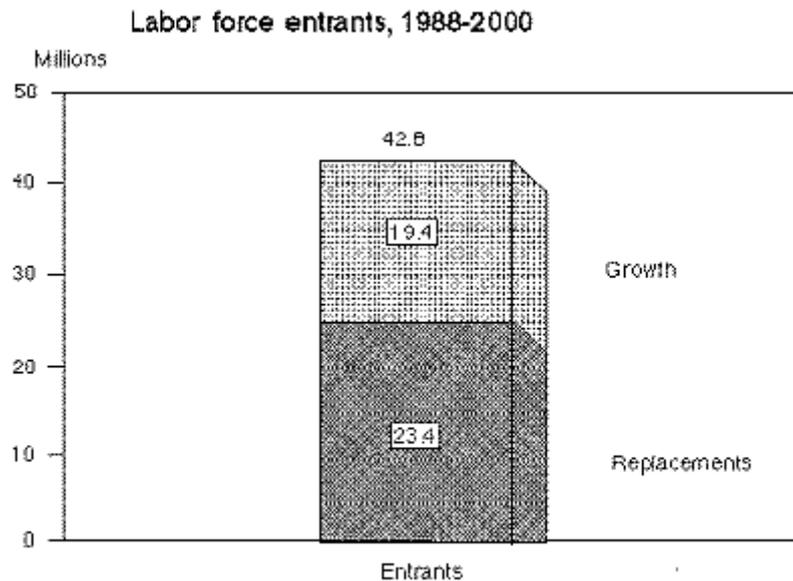


SOURCE: Bureau of Statistics

**Figure 6**

Who will be coming into the labor force? Of the 141,000,000 in the labor force in 2000, 43,000,000 will not have been there in 1988. These are entrants to the labor force over the projected period. [Figure 7](#) shows that 23,000,000 of the 43,000,000 labor force entrants, about 55 percent, will be needed to replace those leaving the labor force. For most occupations, even for many rapidly

growing occupations, replacements needed to take the place of those who leave for all reasons -- transfers, deaths, retirements, family responsibilities, school -- exceeds the number of openings generated from growth. The remaining 19,000,000 represent net growth of the labor force over the projected period. So even though 43,000,000 people are going to be at work or looking for work, only 19,000,000 will represent an expansion of the labor force.



Source: Bureau of Labor Statistics

**Figure 7**

The characteristics of the group representing growth, rather than replacement, for the 1988-2000 period are interesting. Women will account for over 12,000,000 or about 60 percent, of these entrants. Slightly over 10,000,000 of the new workers, or just over 50 percent, will be from minority groups. So we see the expansion of the labor force being fueled to a considerable extent by the addition of women and minorities.

The data presented to this point describe the present labor force and changes projected for the coming decade. Now I will turn to a subject of more direct relevance, the air transportation industry and the aviation maintenance occupation. The air transportation industry, in terms of employment, grew 72 percent over the earlier period from 1976 to 1988. We are projecting this industry to grow only 29 percent over the 1988 to 2000 period. The reason for this slowdown in employment growth rests with rising productivity. The rate of increase in industry output will be almost twice as fast as the rate of employment change over the coming period.

Table 1 summarizes some of the characteristics of the aviation maintenance occupation and reflects some of the data we have developed. As you can see, those working in this occupation are predominantly white males. The annual separation rate for employees is seven percent. This is low in comparison to the average for all occupations. A meaningful comparison can be made with the broad occupational group containing precision, production, craft, and repair occupations, which also contains aircraft mechanics. In this group, consisting of highly skilled repairers, construction craft workers, and other precision metal workers such as tool and dye makers, the separation rate in 1986 was 15 percent. This comparison indicates that aviation maintenance is a rather stable occupation, with workers exhibiting a strong attachment to their chosen career.

Table 1  
Characteristics of Aircraft Mechanics

Women	2.6%
Blacks	9.2%
Hispanics	7.5%
Separation rate	7.0%
<b>AGE DISTRIBUTION</b>	
16 - 29	31.3%
30 -49	50.7%
50 +	18.0%
<b>MEDIAN AGE</b>	36.2 yrs
<b>OCCUPATIONAL TENURE</b>	
Median	9.4 yrs
3 or fewer years	22.9%
4 - 9 years	28.5%
10 - 19 years	16.2%
20 +	32.5%

Source: Bureau of Labor Statistics

The problem that aviation maintenance will face in the years ahead is highlighted in the next section of [Table 1](#), the age distribution. Almost one out of five aircraft maintenance personnel is age 50 or older. You can imagine the kind of turnover this occupation will have over the next decade. This will come not only from retirements but also from increased mortality and disability.

The aviation maintenance workforce is quite experienced. The median time on the job is almost ten years, and one-third of these mechanics have been on the job for 20 or more years. This just confirms what you already suspect: The loss of experience and skills is likely to be relatively dramatic over the next decade.

I would now like to summarize the data we have developed for the aviation maintenance occupation. [Table 2](#) shows that wage and salary employment in 1988 is 122,000, projected to grow by about 20,000 by the year 2000. Most of this growth will be in the air carriers. The 2000 or so self employed workers are projected to show little if any change by 2000. The self employed generally are found in operations such as small repair shops where the person classifies himself as self-employed.

Table 2  
Supply / Demand

1988			2000		
Total Empl	W & S	S / E	Total Empl	W & S	S / E
124K	122K	2K	144K	142K	2K

*Total new jobs: 20,000 or 1,677/yr.*

*Separation rate: 7%*

*134,000 x .07 = 9,380 replacements annually*

*Total demand = 9,380 + 1,667 = 11,047 entrants each year over the 1988 - 2000 period.*

*Training completions: 2,221*

-----  
*Source: Bureau of Labor Statistics*

Adding the two employment categories yields a total employment change of about 20,000. This is approximately a 16 percent change, which is about average for all occupations. However, we will use the seven percent separation rate identified in 1986 for this occupation and apply it to the average number of employees (134,000) over the 12 year period. The total annual demand for employees then can be calculated as the number of new jobs per year plus the replacements needed each year. This shows an average annual requirement of 11,047 entrants each year over the 1988-2000 period. Data from surveys of training schools conducted by the Department of Education show a little over 2,000 training completions each year. Although this number seems a bit low, it represents the only data we have. If all of our input data are reasonably accurate, our analysis shows an occupational imbalance of roughly 9,000 a year. However, one must recognize that this is a national projection for an occupation in which there are many local labor markets. So there might be a real shortage in New England while, at the same time, a glut in the Southwest states, or vice versa.

The last item for discussion concerns compensation of aircraft mechanics. Compensation certainly is one variable that impacts the availability of workers. It also is one that can be manipulated in the event of a labor shortage. For this reason, a comparison of different but similar occupations can provide useful information. [Table 3](#) compares the weekly earnings for aircraft mechanics with three other occupational groups. The first comparison is with all workers. The second is with electrical and electronics technicians, a group that possibly draws some qualified technicians from the field of aviation maintenance. The third comparison is with workers in the broad category of precision production, craft, and repair occupations. Aircraft mechanics represent a subgroup within this grouping. The data in Table 3 show that compensation for aircraft mechanics compares favorably with technicians in other classifications. However, the rate of growth of compensation for aircraft mechanics over the period of 1983 to 1989 is not as rapid.

Table 3  
Median Weekly Earnings

Year	Aircraft Mechanics	All Workers	E & E Technican	Precision Prod., Craft & Repair
1983	\$ 468	\$ 313	\$ 409	\$ 377
1984	\$ 476	\$ 326	\$ 420	\$ 384
1985	\$ 491	\$ 343	\$ 426	\$ 397
1986	\$ 505	\$ 353	\$ 477	\$ 408
1987	\$ 510	\$ 373	\$ 491	\$ 419
1988	\$ 519	\$ 385	\$ 496	\$ 430
1989	\$ 532	\$ 399	\$ 512	\$ 454
% Change	13.7 %	27.5%	25.2%	20.4%

Source: Bureau of Labor Statistics

In conclusion, the data we have developed show that aviation maintenance is a stable occupation with modest turnover. However, the labor force is aging and may have problems in replacing workers during the next decade. Finally, I would like to note that the Office of Employment Projections of the U.S. Department of Labor is continually acquiring new information and upgrading its assessments of the national workforce and of specific occupations. If there are questions in the future concerning your labor force for which we might have useful information, please contact us. We will do whatever we can to help.

## ORGANIZATIONAL FACTORS IN THE ENHANCEMENT OF AVIATION MAINTENANCE

*Major General Albert G. Rogers, USAF (Ret)*  
*Integrated Engineering Services*

The impact of organizational factors on human performance is a matter which generally does not receive the attention it merits. Yet, the structure of the organization within which a person works can make a real difference in the productivity of that individual. Certainly, there is evidence that this is true in aviation maintenance. In any endeavor, however, the important feature is the personal involvement each employee has with the organization and the manner in which the organization encourages and supports this involvement.

The fundamental issue with any organization is the extent to which it has a centralized structure. Is it centralized or is it decentralized? This is an important distinction, one which definitely affects the quality of performance of employees.

Many characteristics of an organization are established as a result of the extent of centralization or decentralization. Each of these characteristics has some impact on the role and performance of employees. To illustrate, I would like to list some of the most important characteristics of each type of organization. Table 1 shows some of the key features of a centralized organization. I will comment briefly on those items in Table 1 which illustrate the way in which a centralized organization works.

A centralized organization does macromasurement and macroanalysis. As an example of

macromasurement, consider the national measure of unemployment, which currently is in the order of 5.7 percent. This unemployment index tells the young, black, 22-year old in the District of Columbia, where the unemployment rate for his group is 29 percent, very little about work in the United States. That is macromasurement.

### **Table 1** **Characteristics of a Centralized Organization**

- Macromasurement
- Macroanalysis
- Lack of *definable*, common goals and standards
- No personal stake in the action
- Leadership, authority, decisions, only at the top
- Nameless, faceless "control" functions
- "One" of something
- People work for the system

For macroanalysis, I offer as an example a measure of merit called "issue effectiveness" used by the Air Force Logistics Command. This measure shows, for all the items that people ask for, how frequently the Logistics Command responded in the time allowed. This is a nice measure of effectiveness which comes to about 99.8 percent year after year. The problem is that this measure includes writing paper, pencils, and paper towels, as well as an \$830,000 electronic black box that allows an F-16 aircraft to deliver weapons precisely. Obviously, the global groupings within this effectiveness measure greatly reduce the usefulness of the measure.

A centralized organization typically does not have a common definable goal. U.S. auto manufacturers are centralized. The production line worker, who does much the same assembly work year after year, would have great difficulty in describing the common definable goal of his organization. This same worker also perceives himself as having little if any personal stake in the action. He has very limited involvement in the successes and failures of the organization.

A key feature of a centralized organization, from a worker's point of view, is its leadership structure. A centralized organization has a few people at the top. These are to proverbial "they" or "him" or whatever. This leadership is seen as a faceless authority which makes decisions and exercises control functions. The leadership appears as a disembodied voice on the telephone, supported by nice written procedures. Most important, centralized organizations have one of something. When you have only one, it is almost impossible to judge it. Is it tall or short? Is it fast or slow? There is no way to tell. For example, there was no way to evaluate the U.S. Postal Service some years ago. Now, with the advent of Federal Express, Purolator, UPS, and others, the public can make realistic evaluations.

Finally, in a centralized organization, people work for the system. There is an inflexible, established system to which people come and go. Whoever comes and goes, there is little change in the way the organization appears to the employees within it.

Now consider the decentralized organization. Here there is competition, with at least two of something. While we may not want to have two U.S. Postal Services, or two General Motors, one can make micro-comparisons by forming subsets within the organization. Here we would have like sets of resources doing like kinds of activities with like kinds of goals. In such a situation, one can compare the different resources along any number of dimensions. Typically, when there are three of something, one does very well; one does about average; and one brings the average of the three. This will be true even though the goals and standards established for each of these subsets might be the same.

In a decentralized organization, employees will be personally tied to the product to a greater extent than with a centralized organization. They also will have many levels of leadership, with responsibility for decisions that are made at several levels. The names and faces of those leaders

making the decisions are known. Also, the system works for the people. The system is there to supplement and support their own personal efforts. They are not a slave to that system. Finally, there is a singleness of purpose. Personal goals and organizational goals match to a far greater extent than in a centralized facility.

## Improvements in Aviation Maintenance

The observations concerning centralized versus decentralized organizations suggest ways in which organizational factors might be manipulated to improve the quality of aviation maintenance. This improvement can be made through organization and through leadership. Typically, we do not think of an organization as facilitating the function of leadership. We generally take the organizational structure which is in place and then worry about the functions in that organization. What we need to do is review the organizational structure to determine if it facilitates advantageous leadership.

Any organization can be evaluated in terms of certain characteristics of that organization. To facilitate our discussion, we may characterize an organization in terms of five "P's" which describe it. These five are:

- People
- Purpose
- Pride
- Professionalism
- Product

The people within an organization consist of employees and managers, recognizing that these categories are not necessarily mutually exclusive. We will focus on managers for a moment and consider how management necessarily must provide leadership. We will accept the definition that a leader is "a person who by force of example, talents or qualities of leadership, plays a directing role, wields commanding influence or has a following in any sphere of activity or thought . . ." In more specific terms, our thesis is that a leader in an organization must recognize the five "P's" just described and must be able to deal with each. In particular, he must recognize that management of people is most important and that people are fundamentally different from things.

One of the real challenges of leadership is to achieve a common purpose for both an organization and its employees. Leaders must get employees to transcend their individual purposes to get into sufficient harmony with the fundamental purpose of the organization so that they fully support its goals. Such leadership, however, requires an organizational structure that supports the leadership and does not stifle it. In an example from the Air Force Tactical Air Command, to be provided later, this type of organization will be described.

Closely allied with common purpose is the matter of pride. Pride is the bedfellow of quality, if you will, and is something one feels inside. Good leaders understand pride and know how to appeal to it. More important, they provide a climate that produces pride.

Pride breeds professionalism. Professionalism is important. How willing are you to leave your new \$40,000 automobile for repair at a garage where the things you see lying around include food wrappers, old tin cans, a few wrenches, and an open tool box with grease all over it? Would you leave your car there? Professionalism implies norms of behavior based on self discipline and commitment. Further, professionalism is based on standards that are never compromised. Leaders recognize the need for these standards and understand that excellent standards equal an excellent organization.

The discussion to this point has centered on people but one must recognize that in any organization there is a product. Indeed, the *raison d'être* of any organization is its product or output. This is true for those in both the private and public sectors. In either case, there must be an orientation toward output and a focus on productivity. The employees within the organization must be able to relate to the product of that organization.

The organizational features represented by the five "P's" discussed above are important as determinants of organizational effectiveness and efficiency. A case study will illustrate the manner in which changes in organizational structure, based on consideration of these features, can have a positive impact on organizational productivity.

## A Case Study in Organizational Structure

The Air Force Tactical Air Command (TAC) in the year 1978 was a large organization operating from 29 different bases in the United States. TAC consisted of 34 wings, each operating 72 aircraft. Maintenance was a major activity, with some 48,000 people employed in direct maintenance support.

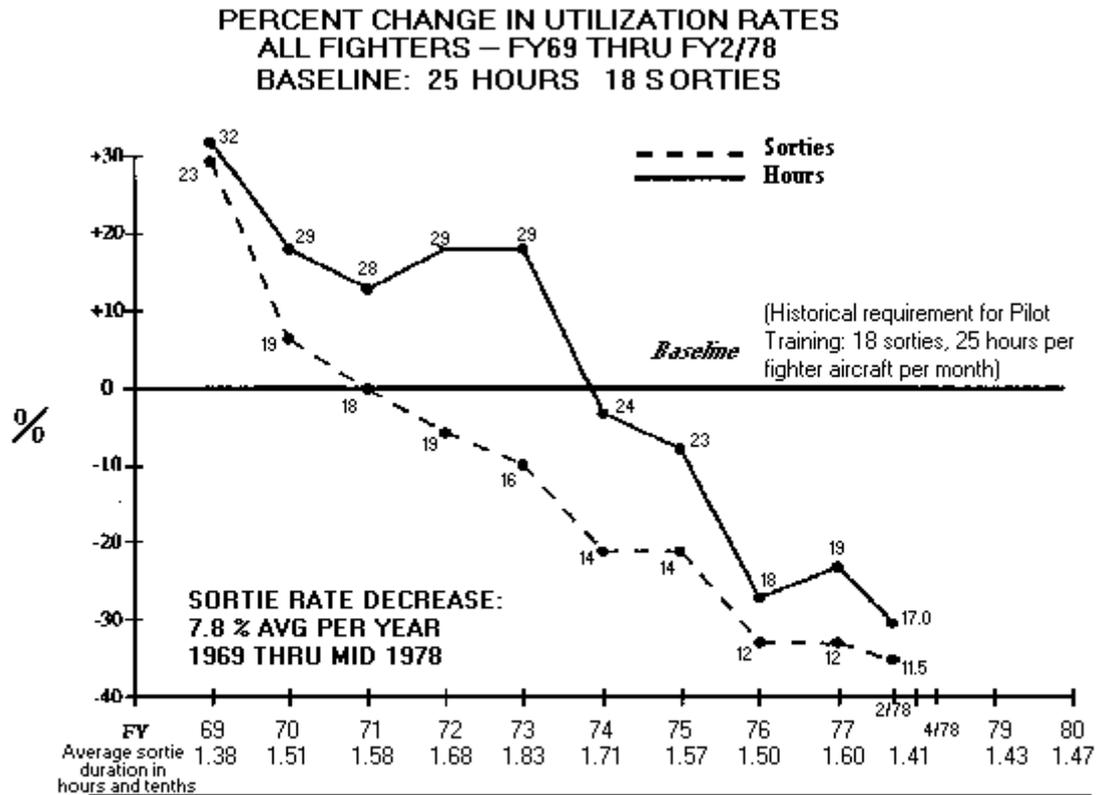
TAC at that time was a well-structured organization, centralized on a wing-wide basis. It had been so for nearly ten years. The typical flight line had somewhere between 1800 and 3500 maintenance people. All work priority and assignments for these technicians came from Job Control through a dispatch communications system. Job Control was a centralized organization and control system. They knew the big picture; they could work the priority; they could work the sequence. In this system, only a generalist crew chief was on the flight line; all other maintenance people were in "shops." A fleet of vehicles carried dispatched specialists from the shop to the job aircraft and towed dispatched support equipment. In this system, the dispatched technician frequently did not take the correct technical data. Also, he might find he was not the proper technician for the job once he arrived at the airplane.

A centralized organization called Plans and Scheduling controlled much of daily life. All preplanned maintenance and flying activity was done by a central scheduling office. While there were three separate flying squadrons, any Wing pilot flew any Wing aircraft.

There were both hidden and obvious signs of trouble in 1978. A major problem was that the existing organization was not the war-time organization. In the event of a national emergency and deployment, a maintenance force would be assembled by selecting a certain number of these people, a certain number of those people, and so on. This is analogous to a football team such as Alabama having all of its guards practice in one place, its tackles in another, and its backs in still another. Then, on Saturday you say to Coach Bryant, "Bear, take two of these, take two of those, take one of those, and likewise until you have a full team. Then go out and win the game." Obviously, the Coach would look at you like you were crazy. Yet, this is exactly how we planned to form combat maintenance teams.

There were other signs of trouble. Pilots were exiting the Air Force at an alarming rate. Experienced maintenance technicians also were leaving. Certainly caused in some measure by the fact that they were treated like second-class citizens. Stress was high and people were unhappy.

What was the effect of working under the conditions I just described? Let's examine the performance of this organization over a ten-year period. [Figure 1](#) shows the percent change in utilization rates for all TAC fighter aircraft from 1969 to 1978. The baseline represents what history and experience had told us was necessary. That is, each one of the 72 airplanes in a Wing had to fly about 18 times a month for a total of about 25 hours to provide appropriate training for the fighter pilot and necessary air-to-ground and air-to-air work. The curves of Figure 1 show that from 1969, when TAC's centralized system was introduced, to 1978 there was a continuing and dramatic decrease in organizational productivity. Aircraft that had averaged 23 Sorties per month in 1969 now were averaging 11.5.



**Figure 1 Percent decrease in TAC utilization rates FY69 through FY2/78. By fiscal year, this is the average number of sorties and hours flown by each fighter aircraft per month. This is a pure measure of production output.**

### The Combat Oriented Maintenance Organization

We in TAC recognized by 1978 that something had to be done or we would simply go out of business. A number of changes were made, some of which were immediate while others evolved over time. First, a decision was made to focus on the mission. This meant that TAC units would practice together, during peacetime garrison training, just like they were going to fight. When TAC deployed for a European exercise, a "team" would be sent, and this team would be those units that had trained together in the U.S.

Another decision was to move to a more decentralized leadership structure. There would be several levels of leadership, with authority and responsibility at each level. No longer would there be a faceless function like "Job Control." Leadership, with appropriate authority and responsibility, would be provided by individuals at levels where the leadership was needed.

A number of other changes were made in organizational structure and in personnel management. Goals and standards were established, a fixed number of Sorties per month was set as a requirement for each authorized airplane. Procedures were established to foster competition among different working groups. Ways were considered to develop a feeling of asset ownership for each of the working groups. Focus was shifted strictly toward output. The output here clearly was number of Sorties. The final decision at this point was that the new program must reward the strong and be able to identify the weak members, i.e., those who could not meet the new goals and standards.

The plans made in 1978 paid particular attention to the individual -- the maintenance technician -- in the reorganization. Unity of purpose was considered essential between individual and organizational goals. Each member of the team must be personally affected by the team's success or failure. For

self motivation, individuals must identify with and be tied to the product. Also, individuals must be allowed a measure of independence, with avenues available to emerge from the crowd while, at the same time, remaining a team member.

From the plans just described emerged a new organization called the Combat Oriented Maintenance Organization. As a first step, the 72 airplanes in a Wing were assigned to three separate 24 airplane squadrons. All maintenance people then were divided among these three squadrons. Members of each squadron then chose a particular color to identify the assets of that squadron. If green was the color chosen, green stripes were painted on the 24 airplanes; green scarves were used by the squadron's fighter pilots; and maintenance technicians wore green hats. In effect, we said "Okay, you're the green guys."

From that time on, only green-hatted mechanics worked on green-tailed airplanes. If there are no green-tailed airplanes in commission and you're a green scarf pilot, you don't fly. As a means of aiding the "ownership" issue for mechanics, each squadron was assigned its own ground support equipment. In addition a crew chief and pilot were assigned to each aircraft, with their names painted on the canopy rails. All measures were taken to foster feelings of ownership and identification.

The function of the unit known as "Job Control" was changed dramatically and renamed. This unit no longer told individual mechanics when to work on which airplane. The unit became a status keeping organization so that the Wing Commander could review overall status of the Wing. Direction and control of squadron maintenance now was moved to the squadron level. Each squadron was given the common goal -- 18 Sorties, 25 flight hours per month for every authorized airplane. Against this goal, each squadron could set its own schedule. Headquarters would not establish the schedule but instead would simply track the squadron against its schedule. The only real requirement was that the Sortie goals be achieved. Of course, various things can happen in any given month, so the real requirement was that squadrons meet these goals on an average basis through the year. Nevertheless, the goals had to be met.

Proper oversight of squadron output was maintained. Score was kept on the number of Sorties produced. These scores also deliberately were made common knowledge. At the gate to the base, there were signs identifying each squadron by color and showing "Sortie goal for the month" and "Sortie status to date." The status of squadron competition was well known.

Many steps were taken to encourage feelings of personal identification with the unit. When squadrons deployed in overseas training exercises, units maintained their identity. "Green mechanics" continued to work on "green airplanes." During these periods of deployment, competition continued among the different squadrons as well as with the enemy forces.

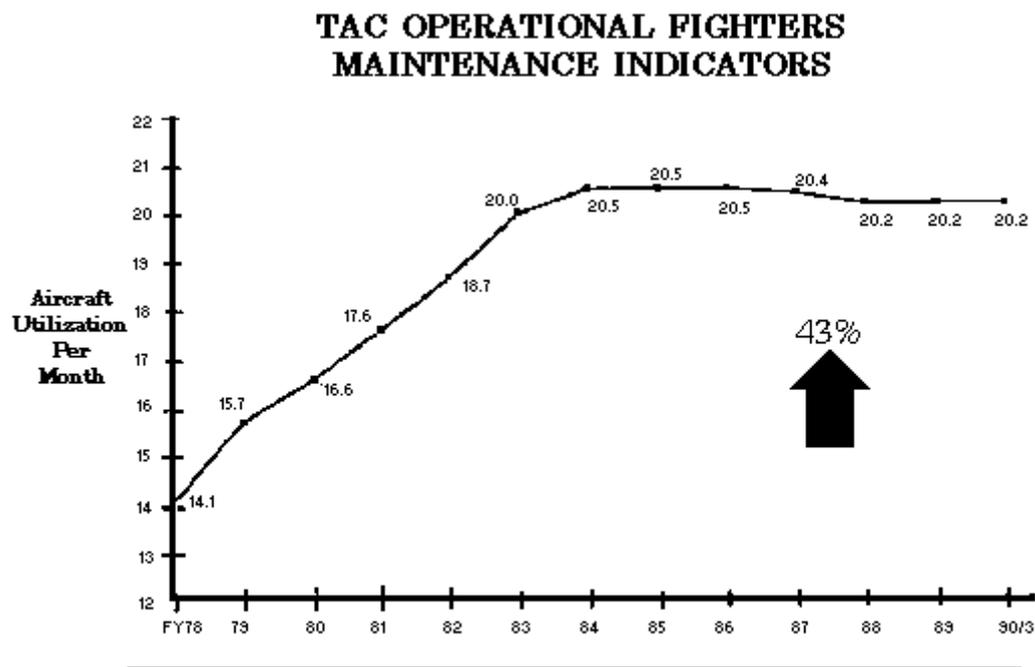
Although the sense of identification and the competition were very important variables, other changes were made. For one, maintenance technicians were treated better. We began to treat them like they were first-class citizens. Decent work and break facilities were built for each squadron. Air conditioning and proper heating units were installed in work areas. At work, maintenance crews and air crews began to live together in the same facilities. In addition to providing improved living quarters for maintenance technicians, this arrangement did much to develop a better understanding and closer rapport between flight crews and maintenance teams.

An important element in our initial planning was that superior performance should be recognized. To acknowledge outstanding maintenance technicians, we established an array of awards for different maintenance categories. At each base in Tactical Air Command, a Maintenance Awards Banquet is held once a year. In the maintenance complex, there is a "Maintenance Hall of Fame," which is a nicely appointed room with a solid walnut trophy case. In this case there is a sculpture of an Aviation Maintenance Technician with a listing of the continuing award winners year by year. This room is open to all who wish to see the names of those honored for their contributions to Air Force maintenance.

## The Results -- Maintenance Improvements

The results of the changes made in maintenance organizational structure and operations in the Tactical Air Command can now be reviewed for the 12 year period from 1978 to 1990. Inasmuch as many changes were introduced through time, results will not be immediate but must be considered as the changes took effect.

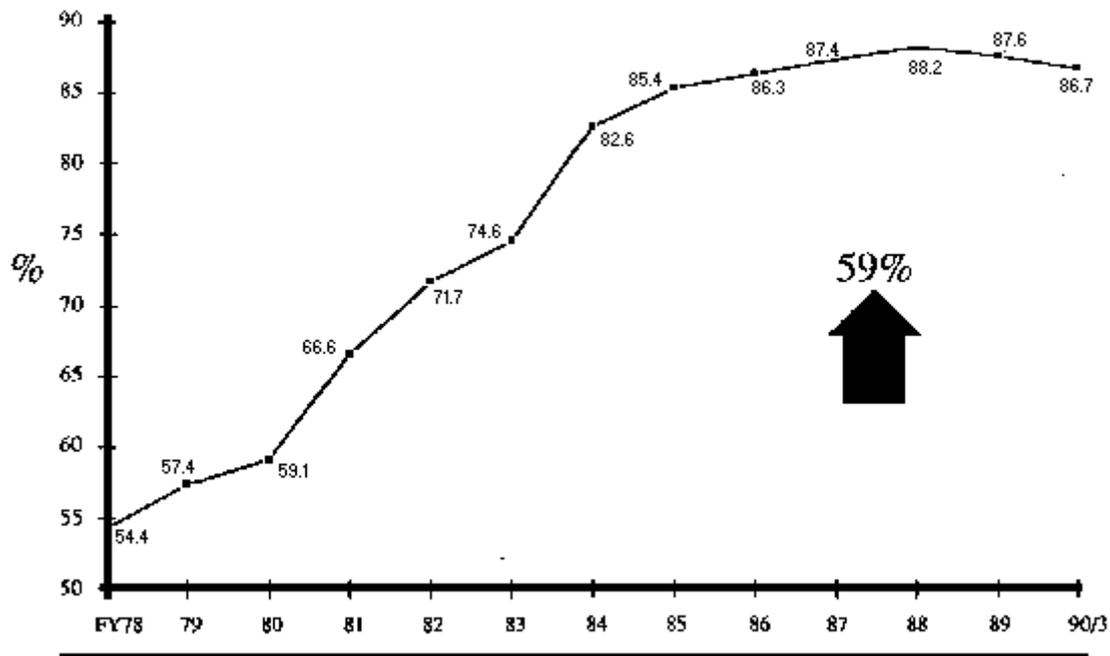
Figure 2 shows changes in Sorties, our most important product. In 1978, we were flying about 14.1 Sorties per airplane per month. We then set a goal of 18 per month. However, a new airplane was introduced around this time, the F-16, which has a dual role of air-to-air and air-to-ground. This meant more flying time was necessary to keep a pilot proficient so we changed the goal to 20 Sorties per month. By 1983, we had achieved this goal. Now why does it run somewhat above 20 in all subsequent years? This simply shows the effect of competition. When questioned, squadron members say "If you're worth your salt, you don't want to be second." Thus they always come in a bit over 20.



**Figure 2 Utilization Rate.** This is a quantity indicator showing the average number of sorties flown per month per authorized aircraft. Twenty was the described goal, thus production remains at that level.

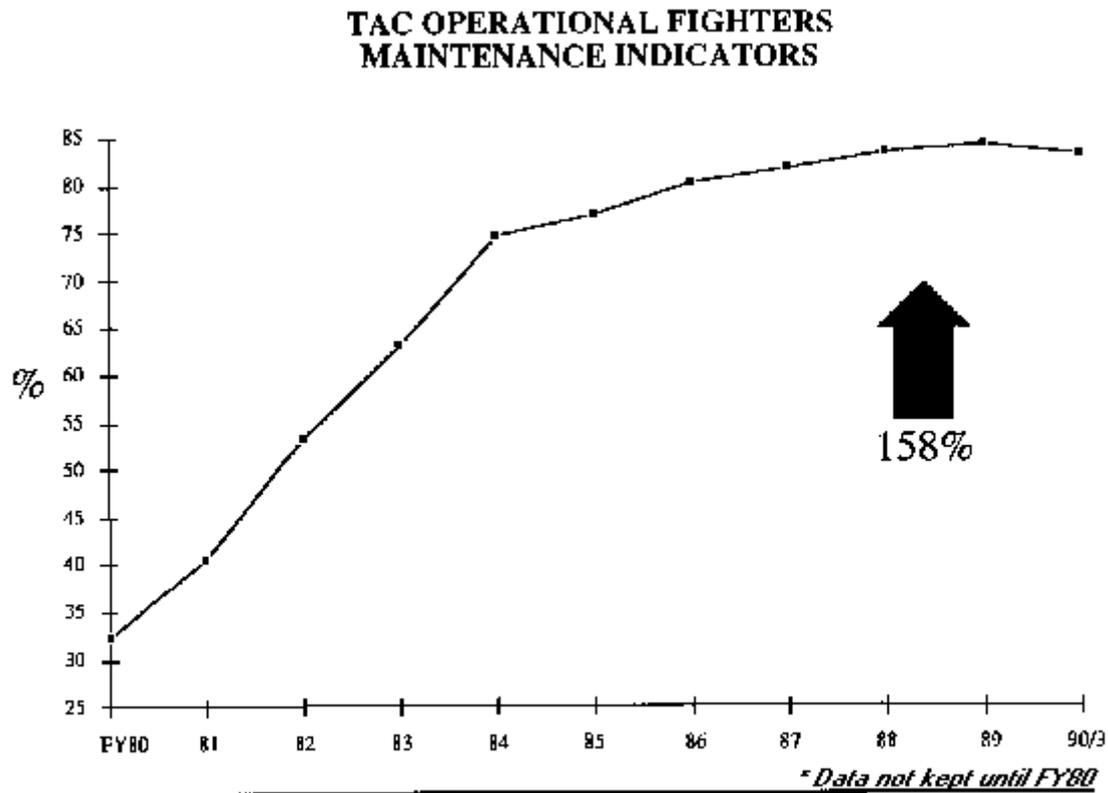
Another indicator of maintenance effectiveness is aircraft readiness. How many airplanes are ready to do their mission and fight on any given day? Figure 3 shows that in 1978 only slightly over one-half of our airplanes were ready to fight, as measured daily. By the mid-1980's, aircraft readiness had risen to the mid 80 percent. This is about as high as one is going to achieve because these data include scheduled as well as unscheduled maintenance. In any case, the data do show about a 60 percent increase in produce quality.

### TAC OPERATIONAL FIGHTERS MAINTENANCE INDICATORS



**Figure 3 Mission Capable Rate. This is a quality indicator and describes the average percentage of aircraft over a 24 hour day that can fly and do some portion of its mission.**

Figure 4 presents an additional indicator of maintenance output. This figure shows the percentage of landing aircraft that must be repaired and which are repaired within eight hours of landing. In wartime, this would show the number of airplanes requiring repair that could return to the fight on that same day. In 1978, some 30 percent of our airplanes were fixed within eight hours. By the late 1980's, this number had risen to over 80 percent, or a 158 percent improvement.



**Figure 4 Fix Rate (At 8 Hrs). This is a critical indicator of quantity. It is the percentage of landing aircraft which must be repaired, that are repaired within eight hours of landing.**

The extent to which flight schedules are met is a measure of merit for maintenance. In TAC, a flight schedule is published by noon each Friday for the forthcoming week. This schedule shows aircraft tail number and take-off time. If an airplane leaves within 15 minutes of the scheduled time, it is considered on-time performance. In 1978, about 75 percent of our airplanes flew as scheduled. This implies considerable turmoil on the flight line trying to get airplanes ready to go. By the late 1980's, on-time departures had improved to over 90 percent. This shows a real improvement in discipline in flight line maintenance activities.

## Conclusions

The changes made in 1978 by the Tactical Air Command resulted in a number of improvements in its maintenance program. Most important was in production. As shown earlier, the number of Sorties flown increased and more airplanes were available each day in a ready status. The fix rate over eight hours improved and more flights left on schedule.

The improvements noted in maintenance effectiveness were not achieved easily or without cost. For the first two years, there was great reluctance to change. After all, we were dealing with systems and a "way of life" that had been in place for many years. To overcome this reluctance, literally thousands of maintenance training courses were given, any of which involved presentations by senior personnel, including the four star General in command of Tactical Air Command.

We also found that training required separate attention. Any time training goals are placed in direct competition with production goals, training comes in second. For this reason, we took training responsibilities away from the squadrons and centralized training, drawing on each of the squadrons for training instructors.

In all, however, we judge our program to be a success. Reenlistments are up and there is evidence everywhere of pride in the organization. The quality of our output has improved and the aircraft accident/incident rate has decreased. All of these indicators point to Tactical Air Command as a more effective and efficient organization.

There are several conclusions to be drawn concerning organizational change and its possible impact on organizational performance. The conclusions we have reached are:

- The significance of organizational factors is not fully understood and frequently may be underestimated. The experiment conducted at Tactical Air Command indicates organizational factors can be very important for the performance of the organization.
- Organizational structure can facilitate or can stifle the functioning of leadership. For many activities, leadership at the hands on level is most effective and is encouraged by a decentralized structure.
- The human factors of organization are mostly generic and are not unique to a specific endeavor.
- The challenge to leadership is how to structure an organization to enhance the necessary generic human factors and consequently to improve organizational output. The efforts described at Tactical Air Command are not a prescription, just one example of how this can be done.

## ISSUES IN WORKFORCE PRODUCTIVITY

*James Diffley  
Manager, Maintenance Administration  
Delta Air Lines, Inc.*

The founder of Delta Air Lines stated, in the 1930's, that the philosophy of Delta was "to manage a company that makes a profit and treats its employees fairly." Through the years, Delta has maintained this philosophy. Doing so in recent years has not been a simple matter, particularly in light of the significant growth we have experienced. In March of 1987, just before our acquisition of Western Airlines, we had slightly more than 4,000 people working in maintenance. Now our maintenance workforce consists of about 7,600 employees. With a workforce of this size, developing procedures to ensure that each employee is treated fairly and works productively represents a real challenge. Today I would like to review some of the issues we face and the procedures we are using to deal with matters of personnel management and employee productivity.

### Selection

The first step in developing an effective workforce is through proper selection procedures. Selection procedures for maintenance technicians have been given considerable attention at Delta in recent years. From 1964 to 1988, I personally hired every mechanic at Delta. However, this can be very time consuming and eventually overwhelming. Selection at any major airline must be handled through a systematic program administered by a qualified department.

The Delta selection process is strict. We now accept three out of every 100 people who apply for a job as an aircraft mechanic. The screening process focuses on basic skills, including reading and mathematics. Since aircraft manufacturers now prepare maintenance manuals for the eighth to ninth grade reading level, we screen for a reading skill slightly higher than that. For math, we screen simply for an ability to work with basic high school mathematics and certainly do not require an understanding of calculus. For whatever reason in our educational process, we find that many applicants simply do not have the requisite language and mathematics skills.

Our selection process also attempts to evaluate the attitudes of applicants. We look for mature and self-disciplined people who want to learn and who are cooperative. In short, we look for people who will do the right thing simply because it's right. Of course, it is difficult to make such an assessment

during a short interview period. In our screening, we use mechanics on loan to the Employment Office for the preliminary screening. Final decisions are made by managers, drawing on screening information with assistance from psychological consulting services.

Our strict screening provides us with a very productive maintenance workforce with little turnover. We lose less than one-half of one percent a year. We have approximately 100 mechanics retire each year and another 100 who are promoted to other positions. Promotion, in fact, is a key factor in personnel change for the maintenance workforce. At Delta, we practice promotion from within. If a supervisory or administrative job is open, the position is filled from someone within the maintenance group. This provides opportunities for workers and helps in maintaining the stability of our workforce.

## Responsibility

Delta gives the individual mechanic virtually complete responsibility for his/her work. This approach is not taken by all major air carriers. In many operations, the lead mechanic or the foreman evaluates problems with an airplane and then gives continuing instructions to the mechanics. We do not believe in that approach. We feel that the individual mechanic should have the responsibility. If he has problems, of course, he can get help immediately.

Maintenance technicians are encouraged to think of aircraft or aircraft systems as "my unit." Technicians are given reports from Engineering that describe the liability of their unit and indicate areas where problems are being experienced. Technicians are encouraged to work with our engineers to determine best repair approaches, but in the end the technician is responsible for accomplishing the repair. The individual A&P mechanic in line maintenance must sign the aircraft logbook. His name goes on the log saying that this airplane is airworthy. This certainly makes him identify with that airplane and bear full responsibility for the quality of any repairs.

## Pay and Benefits

An important factor in attracting and keeping good mechanics is a competitive wage structure. The wage scale does not have to be highest in the industry but it does have to be competitive. Employees respond to good wages but wages alone are not sufficient to ensure employee satisfaction and productivity.

The wage scale at Delta is supported by an excellent benefits program. These benefits were put into place after long planning and are designed to promote employee security. We believe that a feeling of personal security is essential for job success. Under our insurance program, an employee and his/her family are covered from the first day the employee starts to work. Here, security and employment begin together. Likewise, our retirement program stresses security. We do not encourage early retirement. We value our senior employees and the experience they have. We also find that senior employees are important in passing on good company attitudes and work approaches to newer members of the workforce. Without these senior employees, we would have great difficulty in teaching 3,000 new people how to think and work our way.

## Training

The Delta Airlines training program is designed to ensure that every line mechanic is confident that he can handle any maintenance problem when a Delta plane rolls up to the gate. Each line mechanic is given a minimum of 60 to 80 hours of familiarization training on each aircraft type that operates in his city. In addition, mechanics receive a great deal of specialized training.

Our training staff consists principally of volunteer mechanics. When we have a new aircraft training program, we normally have about 150 mechanics volunteer to participate in the training program. Of these, we select about 25 to 30 who are given a two week program in methods of instruction. Mechanics who show an aptitude for teaching are then sent to the aircraft manufacturer for five to

six weeks of factory training on that particular airplane. When these mechanics return to Delta, they contribute to the development of Delta's training manuals for that aircraft and teach the aircraft to our other mechanics.

For our two most recent aircraft, our approach has been to give training to small groups of mechanics, with one week of classroom training followed by one week of on-the-job training. For specific systems, we use a mix of formal and on-the-job training. For example, a small class of mechanics might spend two hours going through the manuals for door rigging. Following this, instructors will take them to the airplane where they actually rig the door. Similarly, the next night they might run through the paperwork and manuals related to an engine change and then actually change an engine. In all, we have about 40 hours of classroom training and about 40 hours of on-the-job training. At the completion of this program, we will have trained some 500 to 800 mechanics on a particular airplane. The volunteer mechanics/instructors then will return to the city which is their normal base and will be well prepared to handle that airplane as it serves their city. In addition we now have some 500 to 600 mechanics scattered throughout our cities who have taught in a new aircraft training program.

Participation by aircraft mechanics in this type of training program has career benefits. Such participation allows others to see that one has the initiative and talent to succeed in management. This is a chance to be seen by higher management. Many of our current managers and general managers, including the current Vice President of Maintenance, served in this program at an earlier time.

At this time we are placing emphasis on avionics training for mechanics in line maintenance. To provide a sound basis for our avionics work, A&P mechanics are not allowed to transfer into line maintenance without a minimum of 750 hours of electrical and electronics study. Most A&P technical schools devote about 300 hours to these topics. This means that mechanics, on their own, must obtain about another 450 hours of study covering topics such as AC and DC circuits, linear devices, digital systems, microprocessors, and electronic troubleshooting. With this background, a mechanic can now be taught avionics, which is our responsibility. This program, which we feel is working well even though it is new, gives the technician sufficient electronic knowledge so that he can learn avionics skills and be confident and prepared when an advanced aircraft such as the Boeing 757 or 767 rolls up to the gate.

## Job Security

An indispensable element in workforce productivity is a feeling of job security on the part of employees. At Delta, we do a number of things to produce this sense of security. Most important is the fact that in its 61 year history the airline has never laid off a mechanic. This was true even during the time of the 1974 oil embargo when we were forced to reduce our flying by 20 percent because we faced a comparable cut back in aviation fuel. Even though we grounded part of our fleet, we did not lay off a single mechanic. In fact, we did not lay off any employees. True, many of these employees had to work at different jobs during these difficult times, but they all kept their jobs. The sense of security they now possess certainly is grounded in historical precedent.

Another dimension of job security is the belief by employees that they will not be subject to arbitrary action by management. In our system, only the Senior Vice President of Personnel has the authority to fire an employee. Foremen cannot do it; even the Vice President of Maintenance cannot do it. In the event of a problem an employee can be suspended and action initiated that might ultimately lead to termination. However, termination itself, whether for mechanic or pilot, must be approved at the Senior Vice President level.

When we have an employee with disciplinary problems, we deal with the issue first through a counseling program designed to encourage him/her to overcome their problems. If this does not appear to work, a letter is sent that discusses the problem and the need for immediate improvement in work. The last step is to put the employee on probation. If this step is not successful, then action leading to ultimate termination is started. However, as you can see, every possible opportunity is

given an employee to improve before disciplinary action is taken. Employees have no fear of abrupt and arbitrary action.

The relationship of employees to management is supported by an "open door" policy. An employee who is unhappy about something and wants to discuss it can talk to anyone in the company. Indeed, employees are encouraged to do this. If a mechanic has a problem, we try to have him work it out with the supervisor first. If this doesn't work, the employee is free to take the discussion to the next highest level or, ultimately, to the level he feels necessary. In practice, our open door policy works and is a useful system for maintaining high employee morale.

## Summary

Many variables contribute to an effective maintenance workforce. I have described those that Delta Airlines considers particularly important. All of these variables are structured to create a climate of approval. We want employees with positive attitudes who feel good about themselves and their work. Creating this climate of approval, with the positive attitudes that result, is most important in developing and maintaining an effective maintenance workforce with a high level of productivity.

## PROFESSIONALISM FOR AVIATION MAINTENANCE?

*William O'Brien  
General Aviation Staff  
Federal Aviation Administration*

Good afternoon. I would like to ask two "questions" on the very important subject of "Professionalism and the Aviation Maintenance Industry."

I raise these questions not as a representative of the Federal Aviation Administration, but as an airframe and powerplant mechanic with 23 years of experience. Hopefully exploring solutions to these questions during our time here today will give us something to think about and maybe, just maybe, offer a new course of action.

The first question is:

*Should the aviation maintenance occupation be considered as a "Professional" career field by the United States Government, the aviation industry, and the flying public?*

Before I answer, let's look at the word "Professional." The word has more "feeling" to it than substance, and I bet everyone here can give me their definition of the word.

As a mechanic I always thought I knew what it meant to be an aviation maintenance "professional."

In the 1960's I thought to be a professional mechanic you had to be so good at what you did that other people knew it. They, your peers, told you that you were professional!

In the lean years of the 1970's, to be a professional in aircraft maintenance meant that if you had a full time job, your paycheck told you that you were professional.

In the 80's I thought that if you worked for the Government, carried a briefcase to the office, did inspections on air carriers and repair stations, and drove a Government car, the kind of job you had told you that you were professional! I was wrong ..... for twenty years.

To find the right answer I tried to look at this question of professionalism objectively. I started by examining the "root" of the word professionalism which is Professional.

Webster's New World Dictionary defines the word "Professional" as "one who is engaged in, or worthy of, the high standards of a profession."

For me to understand this definition a little bit better, I next looked up the definition of the words "Standard" and "Profession."

Webster's definition of the word "Standard" means: Standard: applies to some measure or principle which things of the same class are compared in order to determine their quality or value.

Webster's defines the word "Profession" as a vocation or occupation requiring advanced education and training and involving intellectual skills such as medicine, law, theology, engineering, teaching, etc.

We now have a framework by which to judge if the aviation maintenance community should be recognized as a "professional" career field.

Being Irish, I often work backwards to solve a problem so I would like to examine the last definition first, by asking: Can the aviation mechanic's duties and responsibilities meet the Webster's definition of the word "profession?"

I think I can get you all to agree that an aviation maintenance career can meet the first part of the definition for profession ... Can it be called an occupation? ---- Occupation is something that occupies someone's time. Yes, I think most aircraft owners and operators would definitely say that aviation maintenance occupies someone's time. The maintenance bill for their aircraft can be submitted as proof.

The next part of the definition for Profession is: vocation requiring advance education, training, and involving intellectual skills such as medicine, law, engineering, teaching, etc.

I am sure all of us here would agree that professional occupations such as doctors, lawyers, and engineers require a college degree. And all of us would have to agree that a college degree is universally considered as evidence of receiving advanced training.

Since many aviation mechanics do not have a college education, this seems to forever ban all aviation mechanics from being recognized as a true professional according to our definition of the term.

Not so. The definition of the word "profession" speaks only to "advance education or training." This does not necessarily mean that it must be from a college or university. However, since a college degree is the "professional norm," then to be fair and objective we should make any comparisons of the number of hours of training in non-college training to the number of hours of training received in a college or university.

Let's begin by examining the number of hours needed to graduate from a four year college. The average number of credit hours for a college degree program is 126. This means a student must attend 42-three credit hour classes. With 40 hours of instruction per class times 42 classes, a college student must complete a total classroom instructional time of 1,680 hours in order to graduate.

A student in an FAA Part 147 Aviation Maintenance Technician school must complete a minimum of 1,900 hours of instruction covering 41 highly technical subject areas. The average Part 147 school schedule is 2,200 hours, enough time for a master's degree.

If an applicant wanted to take the FAA mechanic examination for airframe and powerplant based on "practical experience" he or she would have to show an FAA Safety Inspector a minimum total of 4,800 hours working on airframes and powerplants. In both cases, Part 147 qualified and practical experience qualified, the applicant must pass three written tests. Once the tests are successfully passed the applicant must take the oral and practical tests. These O&P tests usually take two eight-hour days to complete.

I am sure my explanation will satisfy anyone's doubts that the advance education and training requirements the FAA demands of mechanic applicants compare favorably with those requirements for a four year college degree and therefore satisfy the advance education and training requirements in the definition of the word "profession."

Some would argue that doctors, lawyers, engineers, and teachers must pass State Boards to be accredited. True. But applicants for the FAA mechanic certificates must pass Federal

examinations. And when they pass, they are issued a mechanic **certificate**.

Now let's look at the definition of the first word, "Standards," which applies to some measure or principle which things of the same class are compared in order to determine their quality or value.

The Federal Aviation Administration sets the standards for mechanics in two Federal Aviation Regulation (FAR) Parts. FAR Part 65 sets the standards for mechanic certification, and their duties and responsibilities. FAR Part 43 sets the standards of performance to which a mechanic must perform those duties.

Therefore -- Do you agree that 60,000+ active aviation mechanics should be recognized as a professional "individuals" by the United States Government, the aviation industry and the public?

Do you agree?...I don't! I do not agree because aviation mechanics do not meet all the requirements to qualify to be called a professional according to the definitions in Webster's New World Dictionary.

The definition for professional states that one who is engaged in, or worthy of the "high" standards of a profession.

Is aviation maintenance career a profession ----- yes! Is aviation maintenance "professional" .... no! Because there are not high standards to be met!

The Federal Aviation Administration by the Federal Aviation Act of 1958 is empowered by law to set only minimum standards. All 50 states set minimum standards for doctors, lawyers, engineers, and teachers. Why are these occupations considered a professional career field and not us? Because these career fields are supported by state and national organizations that set "high standards" for their members.

Sadly, in the last 64 years of United States civilian aviation, there is no recognized national aviation maintenance organization that has set the higher standards or provided a means to meet those standards.

To present this paper has not been easy for me. Remember, I am an airframe and powerplant mechanic. I apologize if I have offended any of the thousands of "professional aviation mechanics" whose own individual high standards of conduct are above reproach. But I gave you the facts as I see them.

Now it is time for my second question:

*Do you really want to raise the standards for the maintenance profession to a professional level?*

*Do you want to put in the time, the money, the sweat and tears to change the status of mechanics from semi-skilled to professional?*

If you do, may I offer you some recommendations.

1. First, create a National Organization to set professional standards and to develop procedures for aviation technicians to meet those standards. This organization must be recognized by the Government and supported, but not controlled by, all segments of the aviation industry.

Why? Individual maintenance industry representatives and organizations rarely talk to one another because each tends to focus on a narrow segment of the maintenance community. A national organization will provide the means to bring many groups together for a common goal.

2. Delete the 18 month and 30 month practical experience requirement for the airframe and powerplant mechanic's rating from FAR Part 65.77 experience requirements. This will make a graduation certificate from an approved school the only requirement to take the mechanic's examination. Classroom training in all 41 aviation subject areas will ensure the same

minimum standard for all new mechanics.

Why? Twenty years ago the military was supplying the civilian sector with mechanics who had a background in all types of aviation maintenance. In the last 10 years the trend in the military has been to limit training by having the soldier, sailor or airman specialize in one or two subject areas.

When these individuals leave the military their overall level of aviation knowledge is small. Most are married with a family and they need a job immediately so they apply for an FAA mechanic certificate based on their military occupational specialty (MOS). The FAA signs them off to take the mechanic's test based on the MOS Codes and the DD 214 forms. These forms and codes are vague and hard to verify because the applicant's supervisor usually has been transferred to some other base. We have to trust them when they say they worked the required time in the MOS. Some have lied to us.

Yes, these same individuals still have to take the FAA test. That creates no great barrier. There are many diploma mill schools in Tennessee, Texas, and California that, for a fee, will "guarantee" that you will have your mechanic certificate in a week or your money back. They can boldly make that guarantee because they teach the test question by question, courtesy of the Freedom of Information Act.

After passing the FAA written exams the diploma mill students seek out "easy" mechanic examiners who will issue a mechanic certificate and enter the system the next day. By removing the practical experience requirements this will remove any chance safety will be compromised and the standard will be raised.

3. Raise the standard level of math and reading skill requirements at all FAA Part 147 Aviation Technician Schools.

Why? Air carriers tell me that they must rewrite the aircraft maintenance manuals to a 9th and 10th grade level so the mechanics can understand how to perform a task.

A strong math background is essential for the understanding of electronics, and electronics is now the name of the game in aviation.

4. Retire the word "Mechanic" with honor.

Why? In your mind's eye give me a one word description of the word "mechanic." Instead of professional, able, smart, and capable, I bet the majority of you thought of these words first: dirty, greasy, or dumb. Since the word has such negative connotations, especially when dealing with the younger generation, I recommend that we change it to Aircraft Technician. This more professional sounding term will attract the students now in primary and secondary schools to our profession.

5. Have the industry support Part 147 schools with resources, grants, and by providing instructors to raise the teaching standards.

Why? Because the aviation industry, and the air carriers in particular, should be no less responsible than the rest of private industry.

It is common practice for large and small corporations to supply grants, low cost loans, resources, and even instructors to colleges that supply those same industries with good employees.

The aviation industry must realize that the path to a professional workforce starts in a classroom!

6. The FAA should increase the level of difficulty of the Aviation Technician examination over the next five years.

Why? Because this will force the Part 147 schools to teach the required subjects to a higher knowledge level, to a higher standard, which in turn will produce a better employee for the workforce.

7. Make recurrent training an integral part of the aviation technician career field, and then show recognition for that training.

Why? The Federal Aviation Administration is presently involved in a five year maintenance training program called Airworthiness Management. This program will produce 10 programs, two a year, over the next five years. The programs will cover subjects from regulations to non-destructive inspection. The goal of the program is designed to change attitudes about recurrent training.

The FAA is presently surveying the industry to see if a maintenance proficient award program is needed and wanted by the industry.

The awards program is not designed to be a give-away program. Each mechanic, repairman or student must meet certain "standards."

In closing, I would be most interested in hearing your comments or suggestions on how to raise the aviation mechanic's trade to qualify as a professional occupation. I would also like to leave you with my 1990's definition of the word professionalism: Professionalism is an attitude that affects one's behavior in a positive way. I hope that my attitude about creating higher standards for mechanics will affect your behavior towards this most important enterprise in a positive way.

## TRAINING ESTABLISHMENT PERSPECTIVE

*Richard Ulm Department  
Chairman Aviation Maintenance Technology  
Embry-Riddle Aeronautical University*

The training of aviation maintenance technicians has changed a great deal over the past 30 to 35 years. Aircraft today are quite different and new skills are required of those performing the necessary maintenance. Those of us who are managers of training facilities must see that maintenance technicians can meet the challenges presented by today's aircraft, both the new aircraft coming on-line and the older aircraft being retained in service.

Technician training schools represent the first step in shaping tomorrow's maintenance workforce. We generally have the first opportunity to build the skills needed by an aviation maintenance technician. To illustrate the manner in which we meet our responsibilities, I would like to briefly describe the program and facilities at Embry-Riddle Aeronautical University.

Embry-Riddle is a university in the full sense, covering many fields within aeronautics. Maintenance training is a major specialty in the university. The aviation maintenance training facility is located close to the flight ramp and includes about nine classrooms and eight laboratories, including an engine repair station. We have a separate hangar in which to conduct training and aircraft maintenance, and a separate turbine engine test cell.

Other programs within the university include aerospace engineering, management sciences, and computer science. In maintenance, we have some different goals and motivations that perhaps in some ways set us apart from the other schools. I will describe these as we go along.

The principal goal of our training program at Embry-Riddle is to "train and educate the future leaders and managers in the aerospace maintenance industry." In our Aviation Maintenance Technology program, the core curriculum qualifies an individual for his/her airframe and powerplant license. After this qualification, a student can proceed into a number of other programs, as follows:

- **Associate in Aviation Maintenance Technology.** This is the minimum degree program and requires 72 credit hours.
- **Associate in Science in Aircraft Maintenance.** Requires 93 credit hours.
- **Bachelor of Science in Aviation Maintenance Management.** Requires 150 credit hours.

- **Bachelor of Science in Aviation Technology.** Requires 145 credit hours and can be oriented either toward flight activities or avionics.

We feel that our avionics program leading to the Bachelor of Science degree in Aviation Technology is possibly tops in the industry and find that our graduates are in great demand.

Table 1 shows the curriculum for the Associate Degree program which provides the airframe and powerplant certificate. Within this program are a number of academic courses such as college level math, English, speech, computer programming, and history. Notice that there is very little left in the curriculum devoted to wood, dope, and fabric materials. Now our attention is turning to composites.

**Table 1**

Aviation Maintenance Technology  
Associate Degree Requirements

Semester	Course Number/Title	Credits
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**FIRST** (General Aeronautics)

AMT 101	Applied Science for Aerospace Technicians	2
AMT102	Aviation Regulations, Records & Documents	2
AMT 103	Basic Electricity	3
AMT 104	Aircraft Servicing Procedures	2
AMT 105	Aviation Material	3
HU 122	English Composition and Literature I	3
		15

**SECOND** (Airframe I)

AMT 201	Aircraft Structures & Sheet Metal Fabrication	4
AMT 202	Nonmetallic Structures	2
AMT 205	Aircraft Electrical Systems	4
AMT 206	Hydraulic & Pneumatic Systems	2
MA 111	College Math for Aviation I	3
		15

**THIRD** (Airframe II)

AMT 203	Aircraft Instruments & Communication/Navigation Systems	2
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AMT 204	Aircraft Welding, Assembly & Rigging	4
AMT 207	Aircraft Environmental & Fuel Systems	3
AMT 208	Aircraft Landing Gear Systems	3
HU 219	Speech II	<u>3</u>
		15

#### FOURTH (Powerplant I)

AMT 209	Aircraft Reciprocating Engines	3
AMT 210	Aircraft Powerplant Systems	3
AMT 211	Engine Electrical & Ignition Systems	3
AMT 212	Propellers & Propeller Systems	3
CS 109	Introduction to Computer Programming w/BASIC	<u>3</u>
		15

#### FIFTH (Powerplant II)

AMT 213	Engine Installation & Operation	2
AMT 214	Reciprocating Engine Overhaul	4
AMT 215	Turbine Engines & Turbine Engine Systems	6
SS 110	World History OR	
SS 120	American History	<u>3</u>
		15

TOTAL 75

Other course work is offered to supplement the basic A&P program. For example, we offer 40 hours of training in working with composite materials. We also offer programs in propeller repair and in non-destructive inspection.

To ensure that every student is given every chance to succeed, we offer a number of remedial courses. These are developmental courses to provide basic skills in math, reading, and writing. Attendance in these courses may cause a student to be in school for another semester, making the program six semesters or two years of full-time study. This program would be over 2200 hours.

The Associate in Science degree offers extended academic study, including coursework in economics, physics, management science, and statistics. This program meets requirements for the College of Continuing Education through which Embry-Riddle provides training on a world-wide

basis. Many enlisted military technicians begin their training at Embry-Riddle in this manner. They receive an Associate in Science degree which transfers directly to the Bachelor of Science programs if these students elect to continue directly at Embry-Riddle.

We also have a degree program in Aviation Maintenance Management. An individual who earns his A&P certificate can continue in this program and obtain a degree in Aviation Maintenance Management. The coursework is business oriented with an additional aviation maintenance course required on issues of reliability and maintainability. Many students who have completed this program now work for manufacturers in the fields of product support, reliability, and maintainability.

The program of which we are particularly proud is in avionics. The degree conferred is the Bachelor of Science in Aviation Technology. To complete this degree, a student must complete a core program and options in avionics, flight, or maintenance. [Table 2](#) presents the full curriculum for the Aviation Technology program with the avionics option. This table illustrates the comprehensiveness of this program. For example, mathematics training is required to the level of calculus and differential equations. A student who completes this program is very well prepared and can expect a good position in industry.

**Table 2**  
Aviation Technology\*  
Bachelor of Science Degree Requirements

<u>Semester</u>	<u>Course</u>	<u>Number/Title</u>	<u>Credits</u>
FIRST	AMT 101	Physical Mathematics	2
	AMT 102	Aviation Regulations, Records and Documents	2
	AMT 103	Basic Electricity	3
	AMT 104	Aircraft Servicing Procedures	2
	AMT 105	Aviation Material	3
	MA 241	Calculus & Analytical Geometry I	<u>4</u>
		16	
SECOND	AMT201	Aircraft Structures & Sheet Metal Fabrication	4
	AMT 202	Aircraft Wood, Fabric & Finishes	2
	AMT 205	Aircraft Electrical Systems	4
	AMT 206	Hydraulic & Pneumatic Systems	2
	MA 242	Calculus & Analytical Geometry II	<u>4</u>
		16	
THIRD	AMT 203	Aircraft Instruments & Communication/Navigation Systems	2
	AMT 204	Aircraft Welding, Assembly &	

Rigging 4

AMT 207 Aircraft Environmental and  
Fuel Systems 3

AMT 208 Aircraft Landing Gear Systems 3

HU 122 English Composition & Lit I 3  
15

FOURTH AMT 209 Aircraft Reciprocating Engines 3

AMT 210 Aircraft Powerplant Systems 3

AMT 211 Engine Electrical & Ignition  
Systems 3

AMT 212 Propellers and Propeller Systems 3

CS 210 Scientific Programming 3

\_\_\_\_\_15

FIFTH AMT 213 Engine Installation & Operation 2

AMT 214 Reciprocating Engine Overhaul 4

AMT 215 Turbine Engines & Turbine  
Engine Systems 6

PS 103 Technical Physics 3

HU 123 English Composition & Lit II 3  
18

SIXTH EL 106 Direct & Alternating Current

Fundamentals & Circuit Analysis 6

MA 245 Applied Technical Mathematics 3

ET 101 Engineering Graphics 2

PS 101 Basic Chemistry 3

PS 104 Technical Physics 3

\_\_\_\_\_17

SEVENTH EL 220 Introduction to Pulse &

Digital Circuits w/Lab 4

EL 223 Solid State Fundamentals &  
Circuit Analysis w/Lab 6

HU 221 Technical Report Writing 3

SS 220 Introduction to Psychology 3  
16

EIGHTH EL 225 Advanced Digital Circuits &  
Systems w/Lab 4  
EL 226 Electronic Systems Analysis  
w/Lab 5  
EC 200 An Economic Survey 3  
HU 219 Speech 3  
HU/SS Elective (300-400 Level) 3  
18

NINTH EL 230 Microprocessor Systems w/Lab 3  
AV 305 Aircraft Communications and  
Landing Systems 3  
AV 309 Aircraft Pulse Systems 3  
AV 339 Avionics Equipment Trouble-  
shooting & Repair Lab 2  
HU 330 Values and Ethics 3  
Open Elective (300-400 Level) 3  
17

TENTH AV 318 Low Frequency & Area  
Navigational Systems 3  
AV 320 Aircraft Surveillance Systems 3  
AV 324 Avionics System Integration &  
Flight Control 3  
AV 325 Long Range Navigation Systems 3  
AV 341 Advanced Avionics Equipment  
Troubleshooting & Repair Lab 2  
14

TOTAL 162

*\*Type 147 AMT/Avionics*

Approximately 350 students complete the Aviation Maintenance Technician program each year. About 60 percent of these continue on in the four-year academic programs. The placement rate for those graduating from all of our degree programs is quite high, almost 100 percent. As noted earlier, there is a particular demand for those who have completed the avionics program. These are highly qualified people and are sought by a number of industries.

## Problems

The training establishment faces a number of problems as it tries to provide qualified personnel to support the maintenance requirements of the aviation industry. From my vantage point, the most important of these problems include:

1. **Number of Applicants.** The enrollment in the maintenance programs at Embry-Riddle ten years ago was over 1,000 students. At the present time, we have about 600 students in the different programs. The majority of these are in four-year programs. Our Avionics program is underutilized, having no more than 25 students. You would think that the prospect of a \$40,000 job in a short period of time would entice a number of qualified people for programs such as this. Many reasons can be put forth to explain the lack of qualified applicants. One reason certainly rests with industry advertising. We do not do a proper job of telling the rest of the world what's available in aviation maintenance as a career. Also, our academic standards may preclude some people from applying. These standards, however, are an indispensable part of our training effort. We have a 25 percent failure rate in our A&P program. This is atrocious. The basic reason rests with the quality of the applicants for the program. Even though these applicants may be graduates of high school, reading and math skills may be very poor. They cannot read and write at the eighth grade level and this presents a problem for us. We need applicants who have better training in math and science. Until this occurs, attrition will remain a problem. To help students with poor qualifications, we offer a number of remedial courses. Although the intent is good, the results often are not. If a student fails a remedial course twice, he/she must leave the university. This is happening more and more often. Embry-Riddle is considering arranging a program with a community college or a high school to provide additional training in the basic skills. Other high tech industries, also seeking qualified applicants, are doing the same thing. We all are facing a common problem.

2. **Training Materials.** Much of our training materials and training equipment is not appropriate for the high technology world into which a graduate will enter. We want to train people for the equipment that is in the real world. There are many difficulties in doing this. At Embry-Riddle, we do receive some donations of equipment, which can be used for training purposes, from the air carriers. For instance, Boeing donated a 747-400 tape to us, which represents about \$1 million worth of software. We also have a Computer-Based Training laboratory which will be of greater and greater value in the future. Nonetheless, our equipment, training materials, courseware and instructor training do not remain apace with industry advances. Industry needs to help with this problem. What about training equipment grants from industry? What about stipends from industry for faculty training? There is precedence for such industry support. For example, the Daytona Beach Community College has a Nissan-supported technician training program which provide automobiles, test equipment, and trained instructors. While we cannot duplicate this approach in 170 technical training programs for aviation maintenance, the industry could do better than is being done now. \_\_\_\_\_

A short video presentation was made at this point to illustrate the equipment currently available at Embry-Riddle Aeronautical University. \_\_\_\_\_

3. **Regulations for AMT Schools.** The revision of Part 147 of the Federal Aviation Regulations will be completed shortly. This is positive and a genuine step forward. However, there is more to be done. For instance, performance objectives in Part 147 are rather vague. Perhaps the FAA should support another study similar to one done a number of

years ago by Dr. Allen in which he documented maintenance performance requirements. A task analysis is needed that will show exactly what a maintenance technician does on the ramp, in the shop, and elsewhere. Training schools then can structure their training programs with more specificity in terms of objectives and of training materials required.

Approximately 20 years passed before the current Part 147 revision was accomplished. This is too long. We need some kind of flexibility within Part 147 that would allow us to review it and make changes to it on a more frequent basis. Only by doing so will we be able to keep up with changing industry technology.

4. **Training Costs.** The training establishment needs to provide more electronics training, more material sciences training, more exposure to NDI, and more work with composite materials. All of this is costly. Perhaps I am talking a semester of additional training. The cost for this might be about \$5,000. We realize that the technician needs to know more. The question is "How much more will he be willing to pay?" Should the student pay these costs? Or should the aviation industry view this as the price they must pay for better qualifications and improved performance on the part of technicians provided by the training industry?

5. **Training Standards.** Standards for the training of maintenance technicians must be kept high. A few years ago, American colleges raised academic standards for student athletes. While there were a number of complaints at first, the standards remained and schools adjusted to these higher standards. All of this was for the betterment of sports. As standards are maintained and possibly adjusted upward in maintenance training, it will be for the betterment of our industry. Whatever the problems, we must provide a quality product.

The above problems will not be solved easily or rapidly. We must recognize their existence, however, if we are to develop programs to improve the training of aviation maintenance technicians so that such training keeps pace with the growing requirements and changing technologies in the air carrier industry.

## MAJOR AIR CARRIER PRACTICES

*Richard Yeatter  
Director of Maintenance Training  
USAir*

Topics within this address deal with issues of recruiting, training, and, in general, the sustenance of the maintenance workforce. These are topics, when discussed, that provide many questions and few answers. Other carriers, the manufacturers, and the FAA see workforce recruiting and training as difficult matters.

Before addressing specific topics in maintenance, we should pause to recognize that our industry reflects the forefront of man's technological achievements. In few other industries have we seen the rapid growth and advancement that we see in aviation. The automation found in today's aviation is required for man to cope safely with the complexities of the aircraft and support systems that we as an industry have produced. This never ending technology process that we conceived, designed, and produce and operate has provided the unique and wonderful world of high speed transportation visible only in man's imagination just a few years ago. However, as this technology advances, the maintenance workforce has inherited a task that grows constantly more complex and difficult. Nonetheless, the mechanic or aircraft technician must function to maintain and support today's new technology aircraft in an effective and efficient way.

### Workforce Recruitment

Issues of workforce recruiting and training parallel the advancing technology of our industry. The important matter for maintenance production is a qualified applicant. As we all know, such individuals are harder to find since the World War II generation of aviation maintenance

technicians. As we proceeded from the 1950's through the first part of the 1980's, there was a surplus of applicants. At that time, these people required less preparation and training to be effective as maintainers of aircraft fleet types that were less complex than those today. Now, the surplus of technicians is gone and the aircraft are more complex. This means higher training costs and more programs for the airlines to prepare technicians. Schools and colleges both find it difficult to purchase necessary costly training equipment. Faced with this more complex and expensive environment, what can we do to ensure an adequate supply of skilled technicians?

The first thing we must do is face up to this new technology so that we can increase our productivity. There are a number of things that can be done. One of the first issues we address when we acquire a technician is to ensure that we know what we have. As part of our workforce recruitment program, we now have a formal verification program for licenses, certificates, previous training experience, work history, education, reference checks and even the existence of criminal records. Drugs and drug testing now represent a real world item and must be considered.

Equal employment opportunity and minority and affirmative action programs require compliance. At USAir, we have a process where all available in-house jobs are posted on the Career Opportunity Bulletin circulated through the company. All qualified individuals then have an opportunity to bid on these positions. At the same time, we do U.S. Department of Labor listings, classified ads, inquiries of recruiting services, minority group agencies, and finally we encourage minority employees to refer other qualified applicants.

As we move to a more diverse workforce and acquire aircraft of foreign manufacture, language barriers present daily problems. We have language barriers between different cultures. We also have language issues in dealing with foreign countries. Aircraft and their supporting manuals produced by and purchased from foreign manufacturers bring semantics, intent, and translation considerations. Finally, we have new technical languages and jargon to surmount. A mechanic must learn new acronyms to understand maintenance concepts and to perform new maintenance tasks. Bite checks, TCAs, DADCs, FCCs are part of a new language that grows daily.

## **Workforce Retention**

Once a qualified and effective maintenance workforce has been developed, a company certainly wants to retain it. At this time, at least at USAir, workforce retention is not a difficult problem. We are losing very few of our maintenance workforce. However, this does not mean that workforce retention should not receive appropriate attention.

To foster retention, USAir provides opportunities for inhouse advancement. Many of our mechanics come from Embry-Riddle and other colleges with educational degrees. They would like to advance into management positions. Opportunities for advancement are announced on the Career Opportunity Bulletin. Avenues include progress into technical specialist areas and supervisory categories. Within the past year, about six employees from the Training Department have moved up the career ladder into other positions. One now has become Director of Aircraft Records.

Another factor in retention is maintaining competitive salaries and benefits. While USAir might not be at the top it is certainly right in the top level. We must be certain that we offer all employee benefits that other carriers have. In the future, more companies must realize that in order to be competitive as a company they will have to offer competitive salaries for all employees in skilled areas.

## **New Initiatives**

Under the general topic of "workforce sustenance," I would like to describe a number of new initiatives undertaken by USAir. Recently, as we all know, our industry has come upon slower times as a result of the mid-east crisis, rising fuel costs, and consequently fewer passengers flying. While cutbacks were required in some areas, USAir made no cutbacks in maintenance. One reason, of

course, is that if orders for new airplanes are reduced, older airplanes take on more of the work. With older 727's and 737's, it has been necessary to add maintenance tracks in order to keep these airplanes in service. This is encouraging in that, even in slow times, there is still brisk employment for maintenance personnel. However, even with steady employment, we feel new initiatives are required to sustain workforce effectiveness.

An important initiative we have taken is the establishment of management/employee question and answer sessions. Whenever there is a slow down period or a cutback in any part of an organization, employees need to be reassured that their jobs are safe and the company's future is secure. Senior vice presidents have been meeting with employees in these question and answer sessions and, where possible, providing answers during the session. If an answer cannot be given then, it is provided as soon as possible after the session.

The preparation of a monthly newsletter for each major department, such as Customer Services, Flight Attendant Services, and Maintenance, represents another initiative. Coverage in these newsletters is organized largely around personal achievement and recognition of employees within the department. This is part of our program of recognizing that these people are individuals and need to be treated as such. In the newsletter, we let one's fellow employees know good things about individual employees.

In an attempt to promote intra-company communications, we are promoting weekly staff and crew meetings. As has been noted, many times upper management has information which is transferred between companies but is not sent down to lower levels within the company. Everyone is busy and frequently simply does not get around to providing information to employees as they should. We are working hard to improve these management/employee communications.

We also maintain an Employee Hotline which an employee can use to ask a question or give a suggestion. One person answers these calls, fills out appropriate forms, and then sends the information to the proper department. In Maintenance, I receive two or three of these a week. I must have an answer back to the employee within 15 days. This system seems to be functioning well and is letting employees get answers for questions that can't be answered at their own supervisory level.

## Problems

There are many problems which arise each day in a maintenance department. While most of the problems are local, a few stand out as having industry-wide application. However, it is worth noting that a new program instituted by the FAA is helping us to reduce the number of our problems. I am referring to the FAA Self Disclosure Program.

In earlier days, if the FAA conducted an audit of an airline's operations to determine if the airline were in compliance with procedures specified in operating and maintenance manuals, a negative finding could be very expensive. In fact, every leg of a flight operated with an airplane that was not in compliance could cost about \$10,000. This expense was an inducement to hide problems rather than acknowledge them.

The FAA's Self Disclosure Program puts audit responsibility on the carrier. The carrier, using a specialized audit team, reviews each functional area described in the aircraft manual, develops a set of findings, and reports these findings to upper management. If, for example, it is found that an AD was missed, the carrier can report this to the FAA and the local Principal Maintenance Inspector (PMI) will deal with it. If he determines the airline has complied at this time with the necessary requirements, and systematic changes have been made to ensure the problem does not recur, the PMI can decide no further action is required. Under this system, people are considerably more willing to come forward and point out potential problem areas. The system also supports an improved working relationship with the FAA.

There are four specific problem areas worthy of mention. These are:

1. **AD's, the "fix all."** Immediately following every major aircraft incident or accident, or so it appears to those of us in industry, an Airworthiness Directive (AD) is issued to fix the problem. When an unfortunate event does happen, everyone recognizes that there is considerable pressure to do something immediately. This pressure comes from Congress, from the news media, and from many other sources.

The pressures following an aircraft incident or accident are difficult to resist. However, I feel that a better plan would be to slow down enough that proper inputs could be obtained from the regulatory agency, the manufacturers, the operators, and anyone else involved so that the ultimate solution uses a better thinking process. At this time, some solutions imposed are so unrealistic that no one can comply with them. A good example is found in the requirement for portable personal breathing equipment (PPBEs). The AD gave a date by which we had to have this equipment. The problem was that no one could buy it. Manufacturers could not manufacture enough systems by the mandated date. Therefore we could not be in compliance. Again, I feel we need more time to perform proper front end analyses and to develop better solutions that will deal with the problem effectively and, at the same time, not impose unrealistic burdens on our industry.

2. **Training inconsistencies.** Defining training requirements for different aviation activities can be a difficult task and often is not done with any consistency across operators. For example, if our marketing people decide we should begin flight operations across any of the oceans, we need to obtain ETOPS (extended twin-engine over water operations) from the FAA. Training requirements for ETOPS are significant and, we feel, frequently are measured by the pound, the height, or the month. This, I feel, is not the way to do it. I do not believe we can maintain an aircraft in a safe ETOPS condition as determined by the number of days we are going to spend in training. Also, the volume of training documentation, which can be considerable, does not necessarily ensure a safe aircraft. The bottom line is that we need to seek task-oriented, competency-based solutions that can be consistently applied in areas such as ETOPS. The weight of the training manuals, or the height of the stack of manuals, is not a sufficient indication of adequacy of training.

3. **Manufacturing design improvements.** Those of us in maintenance would be appreciative if the designers of space-age aircraft being designed and manufactured today would give more thought to the fact that these machines do some time break and do need components changed. Perhaps they could be designed so that components could be changed more easily. For example, for a DC-9, built in 1965, we can change an engine, run up the new engine, and have the airplane back on line in eight hours. With a modern, state-of-the-art 767, the same engine change takes two eight hour shifts. So, what has high technology done for us here? It has doubled the down time to get that airplane back on line for revenue service.

The above example illustrates the increasing work requirements faced by maintenance technicians as they move to more advanced aircraft. If maintainability could be given a higher priority during initial aircraft design, this might not be the case. Both maintenance personnel and the airlines would benefit.

4. **Communication and cooperation.** The matter of communication and cooperation in our industry, while probably not viewed as a major problem, certainly remains as an issue where we should work together. Meetings such as this, plus those held by PAMA and the ATA, are working toward a common cause and are drawing needed attention to problems in air carrier maintenance. I would like to see even more representatives of the airline operators; the manufacturers of airframes, engines, and components; training institutions; and anyone else interested in this field to get involved. I think the communication and cooperation brought about through these meetings will lead to better maintenance and improved industry productivity.

## INDUSTRY AND SCHOOL COOPERATION FOR MAINTENANCE TRAINING

*John Harle  
Maintenance Training Group  
Boeing Commercial Airplanes*

The Boeing Company and the North Shore Community recently entered into a partnership program designed to encourage young people to enter the aviation industry. We are trying to build an awareness in these people of the opportunities that exist in aviation. The Boeing program completed a five month pilot effort in the Spring of 1990. On the basis of this pilot program, we can begin to look at strong and weak points as well as the potential of the program for accomplishing its objectives.

The impetus for our program, which we named "Look to the Sky," comes from growing concern over a possible shortage of maintenance technicians in the immediate future. We have heard discussions on both sides of this issue. Some say there will be a shortage. Some say there will not. The problem we are having concerns the basic capabilities of entry-level personnel. They do not have the desired skill levels in math, science, and English. As a basis for our program, we then developed the following problem statement:

The predicted decline in the technical ability of the American workforce could dramatically affect the aerospace industry in the next 10 to 15 years. To assist in filling the ever growing need for technicians, engineers, and pilots, business and the education community will have to work closely to generate interest in these declining career fields.

The pilot program focused on students at the North Shore Junior High School. We considered working at the elementary school level but decided that some students at that level might not be ready for the program as it was to be presented. Also, if we went to the high school level, we felt that our program might be too late to be effective in guiding these students toward aviation careers. The final event that caused us to choose a junior high school occurred when two teachers from North Shore Junior High School approached us independently and asked if we might be interested in working with them to show their students the careers that are available in aviation.

As we began to prepare our program, we elaborated on our basic goal and developed a listing of program goals. These goals were to:

- Offer opportunities for exploration of aviation fields.
- Encourage emphasis of math, science, and motor skills.
- Stimulate student long-term goals.
- Reduce student drop-out rate.

It is one thing to encourage people; it is another to create opportunities for them. In the past, some have said that the Boeing Company, if it identifies a problem in the local community, will simply give a certain amount of money toward a solution and then walk away. We decided this would not be the case with our program. For example, in addition to encouraging students, we wanted to stimulate the development of long-term goals by showing specific opportunities in aviation, and in maintenance, toward which these goals would lead. The objective was to show students that they can be successful in an aviation career and to illustrate this with specific opportunities.

Having identified a problem, established a target population with which to work, and formulated a finite set of goals, the next step was to consider the structure of the effort. To begin, we decided this definitely would not be an in-out, quick-fix program. This would represent a long-term commitment. The problem we are addressing is difficult and any program to bring about improvement must be administered over a considerable period of time.

As a first step, the Boeing employees toured the North Shore Junior High School and examined classroom facilities that might be used. Next, school staff members were taken on a tour of Boeing Customer Training in order to provide them with a better understanding of Boeing's resources. After these tours, we held a two-day "Team Building" seminar. The purpose of this two-day workshop was to develop a number of activities designed to increase the students' level of comprehension of

present day aviation.

The program was split into two parts. These were (1) student tours and (2) student support activities. In the student tours, we attempted to provide genuine insight into aviation at the hands-on level. We wanted students to see what life was like in the noise, feel, and smell around a hangar environment. Student tours lasted for a number of hours and covered many aspects of aviation, including a visit to the factory line where the Boeing 767 and 747 aircraft are assembled. The full list of facilities in the tours included:

- Boeing Customer Training facility
- Alaska Airlines maintenance facility
- Boeing Everett factory
- Boeing Paine Field
- Sea TAC Airport

The second part of our joint program included student support activities and resources. In our pilot program, not every feature of student support could be exploited fully. However, the following listing of the major components within student support shows the scope of the program as we ultimately envision it. Student support includes:

- Career presentations to student classes
- Boeing participation in Aviation Club activities
- Material support
- Aerospace Club support
- Aviation video library
- Aviation curriculum development

The next step following development of a structure for the program was to conduct a pilot effort to see if we appeared to be on the right track. As noted, the pilot program was conducted at the North Shore Junior High School. Forty-eight administrators and teachers at the school and in the school district were involved. On our side, about 12 Boeing employees participated. The program involved 150 students in the 7th, 8th, and 9th grades and lasted for five months.

Since the pilot program concluded in May of this year, objective measures of its performance are not available. However, based on the observations and comments of those involved, we do feel that we have gained valuable insights. One was the perception held by students of aviation technicians. We wanted to determine the "image" of a maintenance technician before a student participated in this program and again afterward.

To begin a discussion, students were asked, "Can anyone offer their perception of a doctor?" I received the usual answers. Students believe that a doctor is professional; he/she drives a very nice car; he/she commands a great salary; he/she has interesting work, etc.

Next we asked about a pilot. Again, responses were very much the same. A pilot is a professional; he drives a very nice automobile; he drives a big 747 airplane; he has a tremendous amount of prestige with all of the passengers; his salary is very good.

Finally, we asked about their perception of an aircraft mechanic. Here the answers were much different. They feel that a mechanic is probably uneducated; he does not get paid well; he has poor career growth; he is the person they see dressed in yellow weather gear driving the tractor that pushes airplanes around the airport.

The above certainly shows, at least based on this one encounter with these students, that the image of the aviation maintenance technician is not good. Certainly, this image will do little to attract these students into this particular occupation. To attract people into an industry, the perception of that industry must be favorable. Perception is extremely important. If we can change the perception students have of maintenance technicians, we will have made a real contribution to the future success of our industry.

At the completion of the pilot program, those involved were asked to provide feedback concerning any aspects of the program. The first comment, and one which we appreciated, was that this program represents "an excellent start." The school staff and Boeing employees both considered the program worthwhile and felt that it should be continued. School employees added that, while the program serves as an opportunity for financial support, they were pleased that it also was providing guidance. They especially appreciated that the program was not just a nameless, faceless endeavor; that there were Boeing employees to talk to on a day-to-day basis about these problems. In all, education managers and school support staff were in agreement that this program represents a positive corporate statement by Boeing. It supports Boeing's goals in terms of citizenship and community involvement.

We also encountered concern that this program was not consistent across the divisions of the Boeing company. In the North Shore school district, some children have parents who work for the Commercial Airplane group. Parents of others work for Computer Services and others for Military Groups. We recognized there was not a large degree of consistency across divisions of our company. We received criticism saying "You came to talk to us about this program, but a year or so ago Boeing Computer Services were here and are doing something similar. You need to talk to each other to avoid this duplication." We are attempting to do so.

School staff members were unclear as to the resources available at Boeing to support this program. Our response covered a number of points. First, we noted that there is a budget supplement to each division to support full-time education managers. The problem here is that they are not funded on a full time basis. They also look at a number of different types of scholarship programs. We believe there needs to be a full time, funded position. The second point is that we recognize the need for a focused effort. The effort must have a central point of control. Under our plan, Resource Administration will act as the introductory focal point for school districts and will serve as the primary resource contact for Education Managers. This administration will spearhead the development of curriculum resource packages for teachers. It also will determine top priority items for which communities require assistance.

We have provided a Boeing Resource Guide. This lists a number of things we have to offer: We have the Aviation Video Library; tours of our various facilities; a speaker bank; a number of community education programs; scholarship information; and materials to aid in curriculum development.

As we proceed on with what we hope will be a growing program, we do not want to keep it within the Boeing Company and North Shore. We hope to share this work with other communities and with other parts of our industry that might benefit from such a program.

I have heard many references being made to an impending crisis in terms of a decline in the skills of people coming to our industry -- perhaps even a shortage of people. The word crisis denotes a problem, something bad and portentous. If you look at the Chinese word for crisis, you will find it is composed of two distinctly different character sets. The first set translates into the word "danger." The second character set translates into the word "opportunity." I would like to leave you with that thought. We are faced more with an opportunity than with a moment of real danger. If we work together in terms of this opportunity, we will be successful in developing an interest in young people in aviation as a career field.

## STATE AND AVIATION INDUSTRY TRAINING COOPERATION

*Rod Peters  
Director, Technical Training  
Northwest Airlines*

Good afternoon. I am here to describe an example of cooperation between state and industry to improve aviation maintenance training.

The Minnesota Legislature responded to the need for increased numbers of better trained aircraft maintenance technicians by funding a grant through Minnesota Job Skills Partnership. A grant of \$500,000 was voted into law for this purpose. It is to be used over two years. Any non-profit educational institution that could form a partnership with aviation business for training of aircraft maintenance technicians was eligible to apply for the money.

The four Minnesota State Technical Colleges that have aviation maintenance training programs formed a consortium to apply for the grant. Northwest Airlines joined with five Twin Cities aviation companies to become the industry half of the partnership. An application was made and granted by the Minnesota Job Skills Partnership.

The object of the program is twofold. To increase the number of quality aviation maintenance technicians (AMTs) available to the aircraft industries and to increase the technical skills of present technicians and personnel. This will be accomplished in six major objectives:

1. **To increase the number of AMTs available to the industry.** Expansion of staff made possible by the grant will increase the number of AMTs that can graduate from the four technical colleges from 220 to more than 600 per year.

With the growth and changes that have occurred in recent years at Northwest Airlines and within the airline industry, pressure has been put on the corporate and general aviation businesses to keep technicians as the larger air carriers continue to need more. Northwest has been hiring at an increased rate, sometimes 40 per week. Many of these AMTs were graduates of the technical colleges, as well as from corporate and general aviation industries. This has left openings in those areas of the aviation industry which need to be filled; however, there are not enough new A&P AMTs to fill these positions.

2. **To train present and future AMTs in advanced electronics.** An optional 18 credits of Aviation Electronics will be offered to all aviation students at the four technical colleges. This training will also be conducted for a minimum of 40 present Northwest Airlines A&Ps. Aviation Electronics was developed by the Aviation Advisory Committee, made up of representatives from aviation industry and technical colleges in Minnesota.

Maintenance of modern commercial aircraft (Boeing 757, Boeing 747-400, Airbus 320 or "digital" aircraft) has revealed a gap in training in terms of fundamental knowledge of complex large jet transports and electronics among AMTs working the line. The airline industry's previous reliance on technicians with a Federal Communications Commission license is no longer valid. The FCC license has come to have little relevance to the technology of today's aircraft. The digital aircraft the modern AMT is expected to maintain is a completely integrated set of systems where the mechanical and electrical cannot be separated. Industry's present and future AMTs need electronic training to have the "tools" to productively maintain the new fleet.

3. **To train future AMTs in large jet transport technology** Northwest Airlines will provide aircraft instructors to three technical colleges to conduct training in large jet transport technology. This will be 200 hours (15 credits) of training based on the Boeing 757. Completion of A&P training, or an A&P license, is a prerequisite. It is anticipated 400 trainees will avail themselves of this training.

FAA regulated training (FAR 147) does not address the powerplants or systems found on the new digital cockpit aircraft. Therefore, when A&P AMTs are hired, they must be trained to work on these new generation jet transports. To resolve this problem, or decrease the amount of time newly hired A&P AMTs need to spend in training, Northwest will offer the B757 initial training to A&P students at the technical colleges. This training will take place subsequent to their FAA (FAR 147) training.

4. **To train the highly skilled Northwest Airlines instructors in teaching techniques.** Northwest Airline's 34 Technical Operations aircraft instructors will receive two refresher courses on current teaching techniques. Participants will receive three degree credits for

successful completion of both courses.

Northwest and other aviation businesses have their own specialized training programs for their personnel. The major part of Northwest's is advanced training on specific aircraft that are in the Northwest fleet. The technical people teaching these classes are excellent, well-qualified technicians, but they lack training in teaching techniques to maximize the transfer of knowledge from instructor to student. The technical colleges do not have access to the highly-skilled technical people needed to provide this type of training. The resolution is to train the highly-skilled technicians in education techniques to improve the quality of classes and the retention rate of the students.

**5. To train present and future supervisors in supervisory techniques.** Sixty aircraft maintenance supervisors or supervisors-to-be will be trained in supervision techniques. They will attend Zenger-Millers' Frontline Leadership program which is comprised of 23 four-hour modules. Successful completion will give them seven degree credits.

When an industry is in a rapid growth mode and personnel are moving from company to company, or position to position, many personnel are promoted without complete training for the position they assume. This has been happening with AMT supervisors from their pool of AMTs and supervisors from other aircraft industry companies. To assist in resolving this situation, the technical colleges will offer supervisory training to present supervisors and those aspiring to become supervisors.

**6. To upgrade current technical college aviation instructors.** Participating aviation businesses have agreed to provide ten industrial internships over the two-year partnership period to A&P instructors from the technical college system.

The State of Minnesota has set standards of experience that vocational instructors must maintain in their field of expertise. The offering of internships makes it possible for instructors to go back to the workplace and renew their skills, learn the latest techniques, and satisfy their state requirements.

The long-term goal of this program is to help create an environment of cooperation and mutual support between the state's aviation industry and Minnesota's post-secondary educational or non-profit institutions. It is hoped that the partnerships formed through this program will continue to grow and set an example for similar initiatives in other states.

## MAINTENANCE PERSONNEL INITIATIVES IN REPAIR STATIONS

*Jerry L. Schumacher  
Senior Director, Contract Services  
Elsinore Aerospace Services*

In 1945, the world's population was 2.2 billion people. Ten million people, less than one-half of one percent, flew on the world's scheduled airlines. Now, 45 years later, three million passengers a day, or 1.1 billion people, fly the air routes. Passenger numbers have increased over 100 times since the end of World War II. Given this phenomenal growth rate, 11 percent per year, ICAO estimates that the current carriage of passengers and freight by air will double by the end of the decade; that in the year 2000, 2.2 billion persons, the same number as the world's population in 1945, will be flying as airline passengers. This figure will represent 33 percent of the world population.

### Statistics

- A. The current aircraft maintenance workforce is 65,000.
- B. The current workforce handles 4,100 transport category type aircraft. This amount will double within the next seven years.
- C. This means that by 1996 there will be a need for 130,000 aircraft maintenance personnel. This figure does not take into consideration any retirement of the current

workforce nor the additional modification work required on the aging fleet. This will require an additional 26,000 mechanics. This all adds up to a total of 91,000 job openings between now and 1996.

D. The Federal Aviation Administration projects that 18,000 A&P tickets will be issued in 1990.

1. Twenty-five percent of these newly licensed mechanics will go on to be engineers or pilots.
2. An additional 20 percent will be lured into other trade industries with the promise of better wages and a more stable work environment.

This leaves us with 10,800 mechanics per year, or 64,800 by 1996. If you are doing your arithmetic, you will see that by 1996 the industry will be short over 25,000 mechanics with a much larger shortage of experienced mechanics.

E. The current A&P school graduate is:

1. 26 years of age
2. Married and/or has two children
3. Is making \$13,000 per year and expects to double that when starting as an aircraft mechanic

The competition within the industry for these mechanics is only part of the problem. Other trade industries can offer these graduates better financial incentives; jobs close to home; and less likelihood of lay-offs or furloughs.

In addition to those that are leaving the aircraft industry, there is a shortage of eligible people coming into the industry due to the following:

- A. In the United States, over 29 percent of all high school students drop out of school before graduation.
- B. In 1990, it will take 53 percent of the high school graduates to fill the needs of all trade industries. However, only 48 percent will go into the trades.
- C. By 1996 it is projected that the trades will need 68 percent of the high school graduates, but only 54 percent will go into the trades.

As the demand for personnel increases in the trade industry, it will be even more difficult for the aircraft industry to get and retain the workforce they require.

## Questions

So what can or are we doing about this problem? The combination of [FAA](#)-approved schools operating under the current FAR's, and the inability of [A&P](#) schools to obtain the funds necessary to update their equipment and training aids has caused some of the repair facilities and airlines to step in and start their own schools. Many of them offer courses in sheetmetal, [NDT](#), and use of composites. Others have gone as far as opening a complete FAA-approved A&P school. There are numerous regional Government funded programs that can be utilized for funding potential local residents. One of these programs works well at our facility in Waco, Texas by paying the tuition of applicants attending our aircraft sheetmetal course. Some repair facilities and airlines are fortunate enough to be located near A&P schools. These companies have the perfect opportunity to set up a program that can offer these students paid hands-on experience. In Waco, the local students work for us four hours a day, five days a week, under the supervision of their school instructors. All of these means give the participating facility a natural source of personnel.

Two years ago we realized we needed to do something to get better control of the labor force caused by the ups and downs of the industry, so we started our own Contract Maintenance Personnel business. This business supplies us with a continuous source of qualified maintenance personnel not only for ourselves, but for our customers world-wide who require maintenance personnel on a

temporary basis.

Unfortunately, due to the shortages that we are talking about, I feel that our biggest task is yet ahead of us -- the task of safely surviving this shortage. We need to start making a concerted effort to give something back to the industry.

## What Can We Do?

Realizing that everybody looks at profits and the spending of money first, you will probably want to know what you can do to help that requires little or no outlay of cash:

- A. Attend junior high and high school Career Fairs to promote the aviation industry. Let the young people know that it is still an exciting field with good pay and exceptional benefits.
- B. Most large cities have regional occupational programs that are funded by the school districts. These programs normally consist of motivated high school students who are willing to volunteer their time to learn more about a field that they are considering for a career. The programs include some classroom instruction. The students then are placed in businesses that have volunteered their services and facilities to assist these students in getting a head start on their careers. Get involved.
- C. All public funded A&P schools desperately need equipment and tools and eagerly accept donations. Items that may be obsolete or not in use by an airline or repair station may be the most modern thing a school has in its inventory. Don't throw it away -- give it away.
- D. The recent push by our industry and the FAA to upgrade the current regulations for A&P school certification is a good sign that means we are headed in the right direction. But it still needs a lot of support to make it work for the next generation of aircraft mechanics.
- E. Think about the possibility of forming a repair facility organization to help with third party maintenance standards.
- F. The raise in starting wages for new mechanics has been a positive sign that will need to continue in order to be competitive with the other trade industries and to encourage people to get into the aircraft maintenance field.

## Conclusion

In summation, I would like to say that if we don't want this training and mechanic shortage trend to continue, and if we want to ensure a safer and more productive industry, then we must turn to the people who can help us the most -- and that would be ourselves.

## HUMAN FACTORS IN AVIATION MAINTENANCE

*Colonel Robert McMeekin, MC, USA  
Federal Air Surgeon  
Office of Aviation Medicine  
Federal Aviation Administration*

As we continue this discussion of human factors, it is clear to me that we are seeking ways for each aviation maintenance organization to fashion a better fit between itself and the people who work in it. In these discussions, we expect to see that not only safety, but also productivity, is improved by looking at human factors. Such things as job structure, expectations, and training methods do make a difference in the business of making sure that an aircraft will be where you want it to be and nowhere else.

I look at this in the way a machinist might look at the surface he prepares. If these surfaces are not engineered, built, and maintained properly, he can expect that it will not work for long. A machinist calls this "fit."

Webster's dictionary defines the word "fit" as "to be adapted to an end or . . . to an environment so as to be capable of surviving." Webster goes on to call it more than that: "competent" and "qualified."

I want to talk about this notion of "fit" as it works in the aviation maintenance industry. It seems that in our discussions about human factors we have overlooked the fact that we're talking about physical work. The men and women who perform this work have physical abilities which enable them to do their job.

In addition to making sure that a technician is drug-free, management needs to know that the person is physically capable of doing the job at hand. I am talking about being fit enough to get into a closed-in area to inspect it properly. I am also talking about vision and hearing impairments. The aviation technician workforce, with its bimodal age distribution, is prone to these impairments that often go unnoticed by both the individual and management.

We all know, from our own experience, that to look, feel, and perform our best, we need to have regular physical activity. Fifty-four percent of Americans, however, say that they do not exercise at all and forty-six percent say that they do not exercise regularly. In addition, sixty-three percent of the non-exercisers say they get sufficient exercise while fifty-three percent of the exercisers believe they are not as active as they should be. These figures can be a little confusing. They indicate that there are real gaps between the amount of exercise we need as humans --- the amount we think we need and the amount we actually get. These figures also suggest that the people in your workplace or school are not as fit as they should be to do the type of physical work that aircraft maintenance, in all its forms, requires. There's a good chance that you do not get sufficient exercise. I encourage you to be fit and I encourage you to do what needs to be done to ensure that the people who work with you are also fit.

I want to talk, also, about the need to be in a state of intellectual fitness. We can call this, as Webster does, "unimpaired condition," "soundness," and "readiness" within an organization.

The work we're about is becoming increasingly complex. Aviation maintenance technicians were usually called mechanics, and for good reason: they had a feel for machinery, a set of tools, and were willing to get dirty. Clearly these are not the only skills an AMT needs now.

In September, a "Notice of Proposed Rulemaking" was issued to revise aviation maintenance technician training regulations. These proposed rules will assist you in the industry. Schools will provide advanced training in some fundamental general subjects, such as mathematics and physics, and proportionally reduced training in some obsolescent areas such as fabric repair. There are also some new skill and knowledge areas added to the curriculum. These include areas such as solid state electronics and turbine powerplant service technologies. The proposed rules will introduce requirements in propeller blade and composite structure repair and courses in auxiliary power units or APUs. They will reduce the amount of time used to teach dope and fabric. The FAA's proposed curriculum changes are designed to respond to your needs in certification. If enacted, these rules will ensure that the people who come to your organization will have the knowledge base they need so that they are able to fit in more quickly. More importantly, they will be more fit to do the job. This is not all that is needed, however.

What is needed to satisfy technical requirements may be different from what is needed on the job. In addition to technical skills, the work we expect of technicians requires a new level of communication. People need to work cooperatively when jobs are performed by more than one person. The "lone cowboy" approach simply doesn't work any more. Technicians need to read manuals and document their work in ways prescribed by lawyers who will, hopefully, not be needed to defend them in the future. Thus, the reading and writing skills required of the people who work in your organizations need to be adequate for the task. The required cognitive skills have also increased. People working in Job Performance Aids and Training are familiar with this. Technicians need to be able not only to read an indicator but to interpret its meaning and take appropriate action.

I know many of you express the difficulty of finding enough people who come to the job with the right skills. Some of the presentations yesterday addressed this problem.

So, you may need to take some concrete steps. First, you need to respond to the expected regulatory changes. Become familiar with them and be sure that these changes will produce the type of AMTs you want.

Then, if the people you hire need additional training, you may well need to provide it. So think about your in-house training programs. Think about what AMTs need to know beyond what's provided by the schools and how best to give them that knowledge.

To deal with the expected people shortages, you may need to go outside your organization. You could alert high school students and state employment departments to the existence of the challenging and rewarding careers that are available in the aviation industry. Many of you are more than qualified to deliver this message. It might mean that you encourage your company to take an active role in your community and support football teams, school career days, technical schools and GED programs. Think of this as recruiting -- the sports folks do.

You may want to think about other ways to promote interest in aviation maintenance careers. It's too bad that there is not more space in the National Air and Space Museum in Washington devoted to careers in aviation maintenance. The flying public does not see the AMTs behind the flight attendants and pilots. Most people have only a dim idea of what AMTs do. In a sense, this is a positive, since air travel is as safe as it is, but it also has a negative side. You need to make the public -- primarily students -- more aware so that more good people enter the field. You need to help them find you.

The job of attracting and developing a fit working population may be larger than any one group represented here can handle. We need a lot of good people!

I urge you to create an industry initiative; to increase the public's awareness of the possibilities that exist for people in challenging and rewarding careers in aviation maintenance.

We're going to have to work together, Government and industry, to deal with a whole host of "people" problems ranging from manpower shortages to technician training requirements.

FAA has initiated its part of the process with the proposed rulemaking on training. I think industry can do a tremendous service by increasing the public's awareness of the need for good people and by informing them about the challenging and interesting careers in aviation maintenance. Now is the time to start working on the problem of cultivating a fit and capable AMT workforce for the future.

## **ISSUES INFLUENCING RECRUITING, TRAINING, AND RETENTION IN THE REGIONAL AIRLINE ENVIRONMENT**

*William Hinson  
Director, Technical Services  
Atlantic Southeast Airlines*

Quality of maintenance is as important for regional airlines as it is for the major air carriers. Regional airlines, however, face some significant issues and problems in maintenance. The fact that regional airlines have had a measure of success in meeting these problems means to me that they have a story to tell with regard to recruiting technicians, or mechanics as we call them; training them; and keeping them.

In reviewing the problems and programs of regional airlines, I will draw exclusively on the recent experiences of Atlantic Southeast Airlines (ASA). While ASA may be typical of the industry in many dimensions, I cannot claim to speak for all regional airlines. Each company addresses issues associated with its maintenance workforce in its own particular manner. However, while solutions may differ in some measure, the industry certainly faces a number of common problems.

A brief review of this history of Atlantic Southeast Airlines will provide some perspective on our problems and the manner in which we have dealt with them. ASA has had an excellent record of

growth in its 12 years history and, as a result, has had to deal with some serious maintenance matters without the luxury of timely planning for them.

A study by Southern Airways in the late 1970's showed that Atlanta stood to gain considerably from deregulation as a market for short-haul connecting flights. When the merger of Southern Airways and North Central Airlines was announced in mid-1978, three Southern employees used this idea as a basis for forming Atlantic Southeast Airlines. As it turns out, the idea was very much right for the time and place. The airline began service on 1 July 1979 with one Twin Otter airplane and one route from Atlanta to Columbus and return. The company was profitable in its first six months and has been profitable since then. This is important because it enabled the founders to follow their marketing plan and to obtain equipment and resources needed to further exploit the market.

Growth of Southeast Atlantic Airlines continued with the acquisition of a different type of airplane, the Bandeirante, in the Fall of 1980; then de Havilland Dash 7's were added in 1982. In 1983, the company acquired Southeastern Airlines to add six more airplanes and additional routes.

An important point in the growth of ASA was the completion of the Delta Connection marketing agreement in 1984. This caused the growth rate to accelerate further. Another type of aircraft was added to the fleet with eight Shorts 360's. By the end of 1986, the growth rate peaked with the opening of a Dallas hub. The company then had twenty-nine airplanes and 240 daily scheduled flights, all accomplished in six and one-half years.

Rapid growth, not only in a regional airline but in any industry, has special problems. In 1987, when I joined the company, virtually every problem in maintaining the aircraft and in keeping aircraft in the air was associated with this rapid growth. The size and expertise of the maintenance organization simply was not able to keep pace with the speed at which airplanes were coming on-board and the amount of time the airplanes were being flown.

The year 1987 began our current period where growth has slowed. We now have begun to solidify market positions, strengthen middle management, create support systems for the maintenance organization, and position the company for the long haul.

In 1987, maintenance problems were severe. We were in a situation where five out of every 100 flights were being cancelled for maintenance. Twenty or more flights out of 100 were being delayed for maintenance. While this could have been viewed as disastrous, we viewed it as an opportunity to bring about improvement. About six months was spent in reviewing the situation to determine exactly what was happening and to work toward meaningful plans for correction. Some of the problems were obvious. There were too few mechanics. We had over fifty airplanes in service and less than 100 mechanics. There was poor supervision, no middle management, no support organization, very poor inventory control, not enough support equipment and tools, and too little hangar space. We were trying to maintain five overnight airplanes in a hangar that was 125' by 150'. This is very bad for morale when it is twenty degrees and raining outside, the night is pitch dark, and mechanics are trying to change an engine with a tent over the wing. Little wonder that our annual mechanic turnover was in excess of forty percent.

After assessing the situation, we decided these were real problems that required real solutions immediately. In the interest of getting things moving, we had some false starts and misdirections. Fortunately, we learned from these mistakes and began moving ahead properly. There was no magic in the solution of our problems. We put a plan together and followed it with a lot of hard work.

The systematic plan of attack we put together was very straightforward. We had to build a hangar; we had to hire management; we had to hire mechanics. Since all of that could not be done at once, we began first with the design and construction of a new hangar. The longest lead time problem was one of acquiring more hangar space. This took about a year and a half longer than I thought it would initially, but it now is serving its purpose well.

Next, we began hiring management. I realize that many people in our industry believe the proper approach is to promote from within. However, when you are talking about an airline only seven years old, you must realize that everyone in maintenance at that time was either fresh from the

military or a fresh graduate of an A&P school. We had very few mechanics with extensive experience. So the decision was made to hire key management people. Some mistakes were made initially, but finally we arrived at the proper management structure.

After our hangar construction and management acquisition programs were underway, we began the process of hiring new mechanics. At this time, we noticed a rather amazing thing. Note that as we were building the hangar and "fixing" our inventory system, we were dealing with the two major frustrations of mechanics. These were having to work outside in the cold and not having available parts to fix the airplane. When they could see without a doubt that we were building the hangar and that we were working on the parts situation, a synergy began to develop both with the old and the new mechanics. An immediate manifestation was that the attrition rate started to go down. Mechanics were more committed to our program. Now I would say our attrition rate is probably less than twenty percent.

The next step was to develop a training program. At first, we had no company training program whatsoever. Training was provided by sending mechanics to the aircraft manufacturer for their schooling. In the early days, this was the quickest and best way to accomplish the training. Also, we had negotiated an agreement with the aircraft manufacturer to train, at no cost, four mechanics for every airplane that was delivered. We twisted this meaning a bit to where, since we had twenty airplanes on order, the manufacturer was obliged to train eighty mechanics. On the basis of this twist of contract language, we began shuffling mechanics to the manufacturer's school for their training without waiting for quotas to accumulate with aircraft deliveries.

As the last major step in our plan, we created a dynamic training program. This program is run by the Training Coordinator, an ex-Air Force specialist with thirty years of military experience, and a Training Instructor, a former junior mechanic of ours who had moved up to inspector. Whereas initially we had received a measure of criticism for hiring key people outside, we now had reached a point where we could begin promoting people from within.

In our plan, the key element is "the people." Under this plan, we try in very basic ways to ensure that employees are content and productive. We want to hire enough mechanics so they do not feel overworked and that one person is doing the job of two or three; train them effectively; give them proper tools and equipment; give them needed parts; and finally give them a warm, dry, well-lighted environment in which to work when it is cold, dark, and rainy outside.

Now that we have a good operating program, we come to the issues of recruiting and retention. How do you find good people and keep them? When we needed at first to get fifty or so mechanics onboard in a short period of time, we went around the country to A&P training schools and recruited mechanics. We went to a large number of schools with good reputations and gave our recruiting pitch. When we got the mechanics onboard, we began to get airplanes fixed. However, three or four months later we realized we had a problem. And now, we can say that, for the most part, none of the people hired at first are still with us because of two factors. First, the new mechanics were hired as graduates of schools all over the country. Their roots were spread all over the country. When the opportunity came for a good job closer to home, they moved. Second, these mechanics, as is probably true for all mechanics, want to work on heavy airplanes. When an opportunity came to move to a larger carrier and work on larger airplanes, they took it.

As we recognized what was happening, we revised our recruiting philosophy. We noted there are a number of good A&P schools close to Atlanta and Macon. We now concentrate our recruiting effort at these schools because most of their students are from the local area and are likely to remain there. Another important point is that the school in Americus, Georgia and the school in Ozark, Alabama regularly send classes to look at our hangar, our maintenance operations, our airplanes, and just generally observe night maintenance. We welcome and encourage them to do that. As a result, we receive a lot of applications and hire a number of junior mechanics from these schools.

In the hiring philosophy we developed as a regional airline, we gradually departed from a long-standing company mandate that a "mechanic" had to have an A&P ticket. Since we have a 100 percent buy-back policy for the hangar work area, the mechanic working on the airplane does not

have to have an A&P ticket. The inspector signing the paperwork, however, must have one. The supervisor also must have the ticket. This means that we now are able to tap the available local market in terms of special talent. This is where we acquire sheet metal workers, electricians, and avionics technicians. We hire them as mechanics and pay them the same as a junior mechanic or a senior mechanic based on their specialized experience. In this way, we are able to acquire personnel from facilities such as Warner Robbins Air Force Base, where we obtain technicians separating or retiring from active duty, plus some civilians who may wish to change from Federal employment.

We have also worked with local technical schools by identifying our needs. Here we have not specifically addressed A&P tickets but, instead, described our needs for specialized skills. One school, Macon Area Tech, listened to us and then put in an aircraft sheet metal course. Now, in addition to the small number of sheet metal workers they have sent to ASA, they have supplied a larger number to McDonnell-Douglas at Macon Airport. The school has followed up this program with radio commercials using former students. One, which is being played at this time, features a former student who works for McDonnell-Douglas and who is telling everyone "Hey, I went to Macon Area Tech; I became an aircraft sheet metal technician; and now I have a good job at McDonnell-Douglas building parts for the MD-11 airplane." It is a very effective commercial.

Another thing we learned in developing our maintenance force is the value of exit interviews. For the first two and one-half years of our plan, I personally did an exit interview with each person leaving. At first the answers were obvious. They included poor management, no tools, desire to go to larger airlines, low pay, no parts, and no future. Plus we had about fifteen percent of our losses as a result of disciplinary reasons.

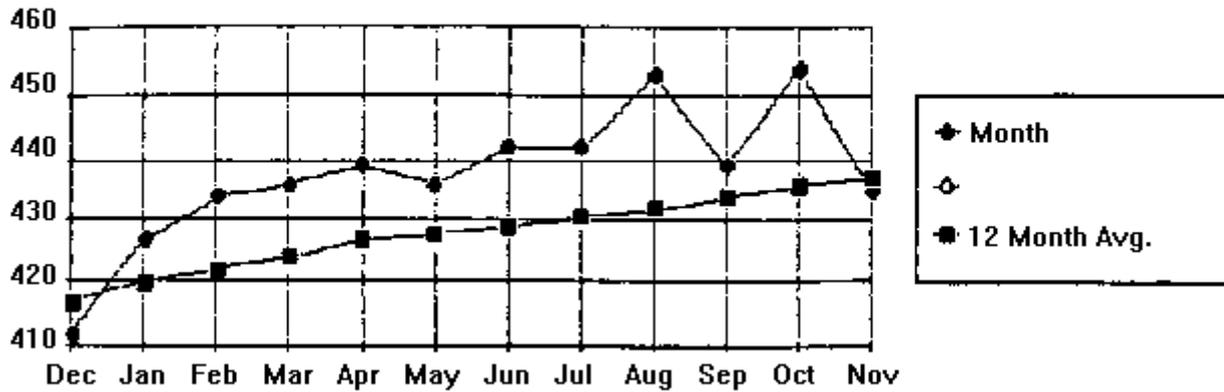
The exit interviews now tell us that the situation has changed considerably. Now there are two reasons we lose people. First, they want to go to work for the big airlines. Second, they want to move closer to home. Then, of course, we have the miscellaneous reasons, including two who wanted to quit being airline mechanics so they could indulge their auto racing hobby full time. You cannot compete with those reasons. However, we have noted that, whereas our losses for disciplinary reasons were approximately fifteen percent in earlier years, now they are quite low. This year only two of our departures were caused by disciplinary matters.

## Results

Our maintenance plan has been in effect for sufficient time that we now can begin to look at objective measures of performance. These measures provide an indication of the extent to which maintenance effectiveness has improved.

Figure 1 shows that, even though we have entered a period we consider as one of slower growth and consolidation, there remains a measure of continuing growth. The best measure of this growth is the twelve-month average which tends to take out monthly and seasonal variations. On this basis, you can see that we added about twenty scheduled flights per day during this year.

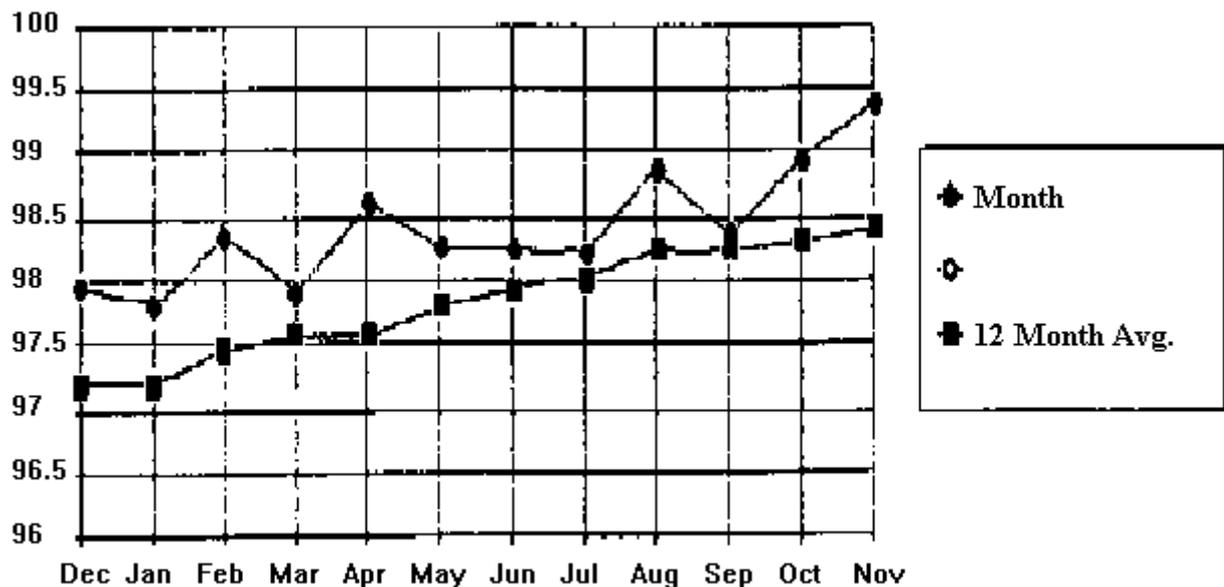
**AVERAGE NUMBER OF FLIGHTS SCHEDULED PER DAY**



**Figure 1**

The best indication of maintenance improvement is shown in [Figure 2](#). The twelve-month average for maintenance completion in mid-1988 was 94.5 percent. From a customer service standpoint, this is not good. However, as you can see in Figure 2, the twelve-month average has been steadily improving. At the present time it is almost 98.5 percent, which was our objective for this year.

**MAINTENANCE COMPLETION FACTOR**



**Figure 2**

A more direct measure of maintenance performance is provided in [Figure 3](#). This figure presents a synthetic number which shows the combination of maintenance delays and cancellation vs. the total flight schedule. As you can see, the maintenance performance factor, reflecting both delays and cancellations, for November was almost ninety-five percent and the twelve-month average slightly

above ninety-two percent. This latter figure means that, on average, less than eight flights in 100 are in any way impacted by maintenance. The nice feature, of course, is that the curve shows a continuing rate of improvement.

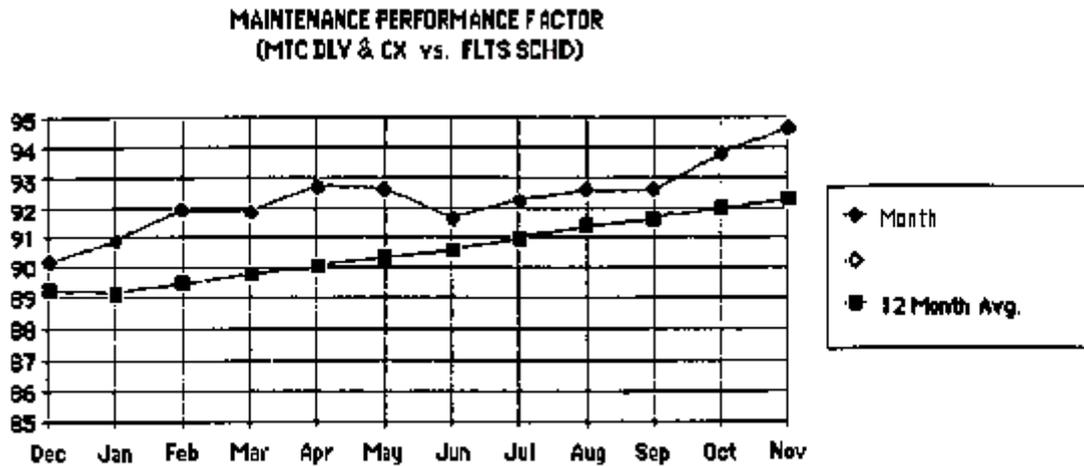


Figure 3

Figure 4 presents our maintenance on-time performance record. As of November, we were averaging almost ninety-four percent on time flights. This means we are not completing flights simply at the expense of running them late. Again, the best feature of this curve is that it shows continuing improvement.

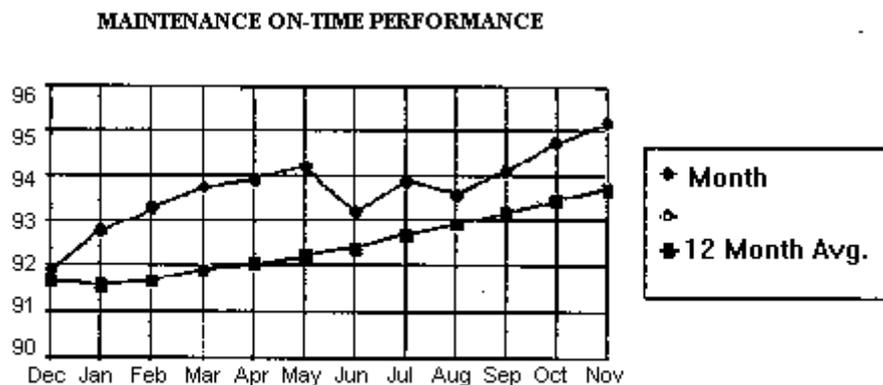


Figure 4

Two additional indices of maintenance performance are shown in the final two figures. Figure 5 presents the number of pilot reports of items requiring maintenance attention received per 1000 flight hours for a specific airplane. These are the total pilot write-ups on the airplane. In easier terms to envision, we are receiving fourteen write-ups for every 100 flight hours. This shows good system reliability and indicates maintenance is dealing with most items before they can come to the attention of a pilot.

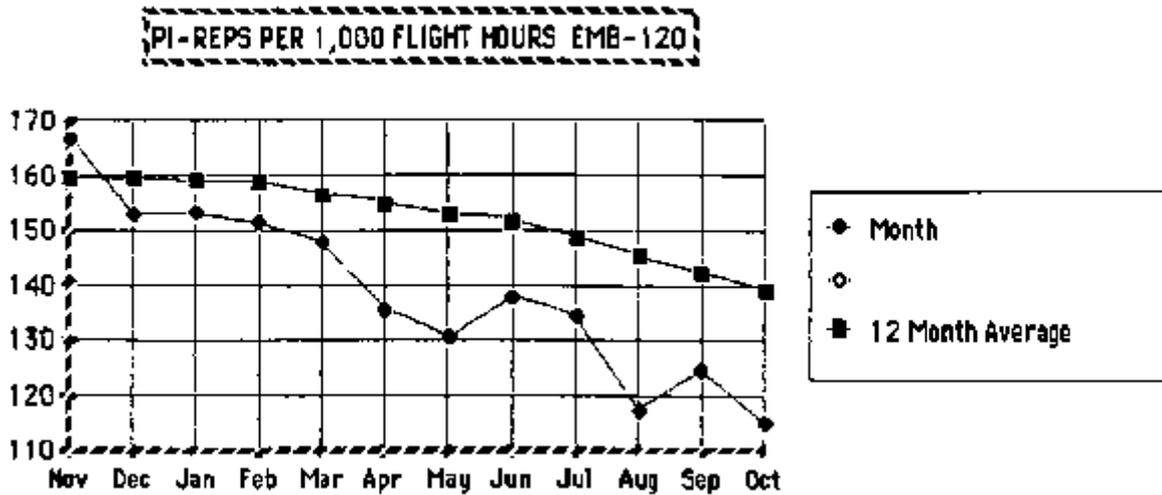


Figure 5

Figure 6 shows the number of unscheduled component removals (UCRs) per 1000 flight hours for the same airplane. Here, more simply, we see 5.5 unscheduled component removals per 100 flight hours in the most recent month. The important feature is that the number of these component removals continues to fall.

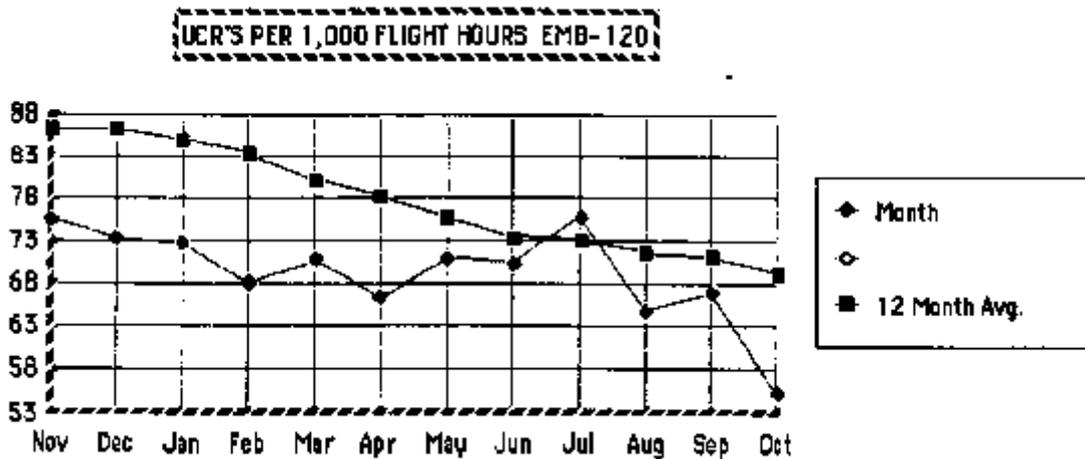


Figure 6

The final gauge of maintenance performance I want to discuss deals with maintenance carry over. These are inspection write ups or mechanic write ups found during a maintenance check or between checks that are not safety of flight items but which need to be fixed. These average about seven per airplane. While we are working to achieve a lower number, this still represents an airplane in good condition.

In conclusion, I believe that from a regional airline's standpoint, it is a cost of doing business to have a strong recruiting program, to have a strong training program, and to address the needs of mechanics for good working conditions and good tools. Then you must accept the fact that there will be a fifteen percent attrition to the large air carriers. You deal with this fact by planning for it. After all, in a very real sense we are the farm clubs for the majors.

I have described the efforts of one airline to build a maintenance workforce and to improve its

maintenance program. The procedures I described worked for us. I offer these descriptions in the hope that something here may prove useful for the maintenance programs of other regional airlines.

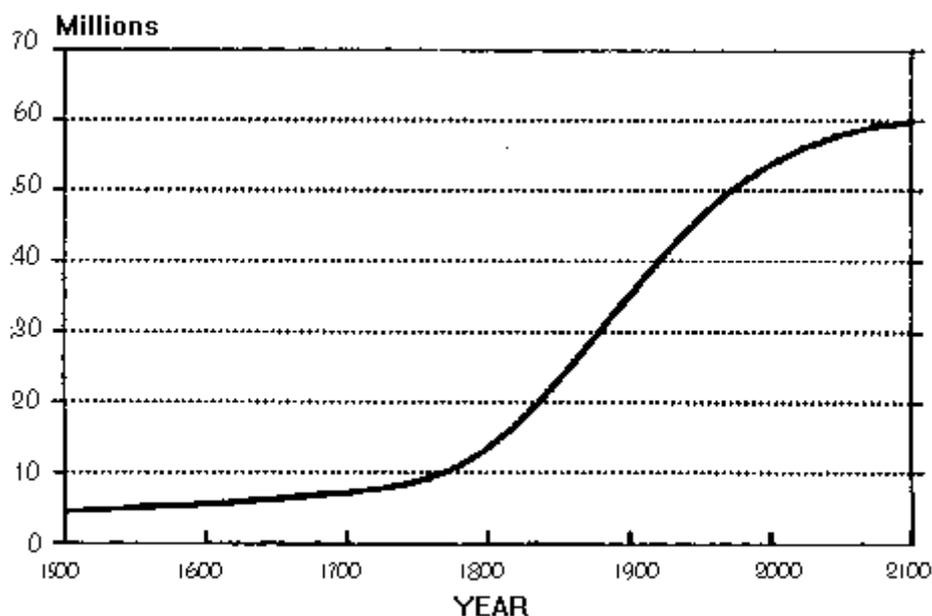
## AVIATION MAINTENANCE PRACTICES AT BRITISH AIRWAYS

*Michael Skinner  
Manager, Aircraft Training  
British Airways*

The problems we face in aviation maintenance at British Airways are, interestingly enough, the same problems you face in the United States. However, these problems are tempered somewhat by the fact that they do occur in the United Kingdom, where the culture and climate are similar but not identical to the U.S.

To establish a context for a discussion of air carrier operations in the U.K., I would first like to review a bit of history. If we wish to know where we are and where we are going, then certainly we must know where we came from. Now, if we consider the history of Europe, and particularly that of the United Kingdom, we notice a dramatic change in population growth around or just before 1800, as shown in [Figure 1](#). In the year 1800, population was around 10 million people. In the approximately 200 years since the, population has grown to almost 60 million, an increase of some 500 percent. This rapid growth does not reflect a sudden discovery of sex; rather, it shows the effect of such activities as the covering of sewers and the invention and use of carbolic soap. So the population growth curve does not show a birth rate as much as it does a survival rate. However, the important matter is that labor was available to support the demands of the Industrial Revolution.

### Actual and Projected Population Growth in the U.K.



**Figure 1**

Turning more to present day concerns, [Figure 2](#) shows the population of the European community in millions. The important feature of this figure is that it projects a leveling off of population growth in about 10 years and possibly even a modest decline in population for the decade following the year 2000. The days of an ever increasing labor force may soon be over. This may be especially true for

the European community since population growth projections show the EC trailing well behind growth for other major industrial countries such as Japan and the United States.

### Actual and Projected Population Growth in EC

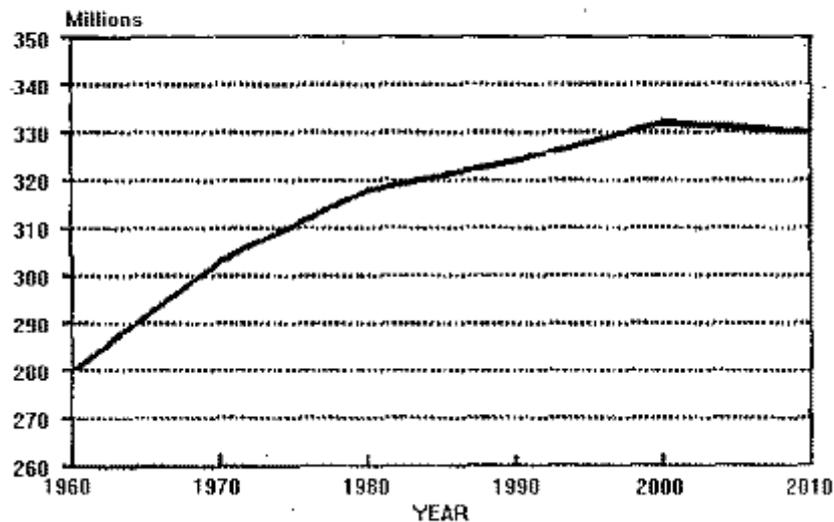


Figure 2

Looking still at the European community, the average number of children per woman to maintain our current industrial staffing levels will be 2.1 children per woman. Growth projections show the only area in Europe that will achieve that rate is Ireland. One might say "that's the religious significance of its Roman Catholic character" until one considers the case of Italy, which has one of the lowest replacement level projections.

An examination of likely occupational changes from 1988 through the year 200 shows dramatic increases in managerial and professional ranks. However, there will be a decrease in those working in semi-skilled and unskilled jobs. This is because projections show tasks for these workers being taken over by machines and robots.

Of considerable concern for those of us in aviation maintenance is the forecast for the population of 16 year olds. These, after all, are our mechanics and engineers of the future. Projections show the population of 16 year olds in a decline at this time with a possible bottoming out in the 1993-1995 timeframe. Considering the personnel demands made by our industry, we must make certain that we increase our market share of this declining resource.

In summary, we are facing what we might call a demographic time bomb. All projections point to deficiencies in the personnel resources likely to be needed to support maintenance operations for a world wide air transportation industry. There are many reasons. More extensive family planning is one. Another is the fact that children are encouraged to remain longer in school in order to obtain better qualifications and in turn better jobs at a later time. Some predictions are, by the year 2000, the number of 18 year olds in higher education in Great Britain will have risen to an all time high of 18 percent.

British Airways is aware of the coming problems and predicts a major shortage of maintenance capacity. We have recently purchased a number of Boeing 747-400 aircraft with the intention that, when these aircraft came on line, we would retire our older 747-100's. The plan was to find a buyer for these older 747-100 jumbo jets. However, if these aircraft do not have the life extension program and the corrosion prevention program done, no one will buy them. At the present time, due to current economic conditions, even if these programs are done no one will buy them anyway. We must wait for the current market to turn around. In the meantime, we are going to invest money in these old airplanes. We are going to do all the rework programs and, in due course, spend millions

of dollars. Hopefully when a resale program becomes feasible, we will have some return on our investment.

The above program presents British Airways with a genuine problem. We do not have the capacity to service the number of aircraft currently in our inventory. In fact, we have a projected shortfall in maintenance capacity over the next five years equivalent to three 747 major overhaul lines. That is a lot of hangar space, a lot of money, and a lot of people. How will we deal with this matter? To seek an answer, we have been looking not only around England, but all over the world. Our search has covered sites such as Singapore, facilities in Arab countries, and many other places. We have included in our search sites in Africa but have learned that their own industrial projections will use all available youngsters in that area.

In a continuing program to expand our capacity, British Airways have requested financial support from the Government to build a maintenance facility and recruit people with compatible skills to those we require. Under this program we are going into Cardiff in South Wales to build a maintenance facility at a small airport there, with Government backing. This makes sense to us and it also makes sense to the local residents. Many of these people were employed in the coal industry and have suffered as a result of the depression in that and other industries.

As we attempt to come to grips with the problems of the next decade, we need to know what we are going to do and also what our competitors are going to do. For example, one of our competitors is Ford U.K. This company has developed a plan in which they will release 15 engineers on a full time basis to become consultants in the English education system. These consultants will work both with educators and students to develop programs that will ensure the necessary flow of qualified labor.

British Petroleum is doing much the same thing as Ford U.K. British Petroleum has developed an apprenticeship program under which students may be prepared for later employment. In their programs, as in ours, we are concerned with the image as well as the qualifications of an aviation technician. We recognize that simply changing his name from mechanic to technician will do little unless the full image is changed along with the name. This is difficult, but we are attempting to do that in some programs that we have established at British Airways.

Apprenticeships at British Airways started to decline and we were not sure why. As we explored the problem, we found that it was due mainly to increased competition in the marketplace. Young people were going to work in computer industries. They see these jobs as having a larger image than engineering. Although most of our technicians are referred to as "engineers," it is still the same job as your mechanic. In order to improve this situation, in 1988 we began a program of "Links With Education." Under this program, we asked volunteer engineers within British Airways to adopt a school. Since our company is a world-wide organization, we have engineers within England, Scotland, Ireland, Wales, and elsewhere. Each engineer was free to adopt any school at any location.

In our Link With Education, we want to enhance the image of engineering; we want to promote it within the schools; and we want to do whatever is required to support and encourage the volunteers who form this link. We want them to be professional as they work with the schools. To ensure this, we give them training in presentation skills. We help them prepare presentations. They then go to job fairs and to school fairs where they give presentations and are supported by an abundance of information that promotes British Airways.

Another part of our link with education includes a feature called "work experience." This is available for students who are in their last year of school and are close to going into the world of employment. Many of them do not have a clear idea of just what they want to do. So we offer a two-weeks work experience program. Under this, they work at our facility and are placed as close to the job they request as we can do while still attending to all safety considerations. The program appears to be successful as a technique for getting students interested in engineering as a future. As a result, we have had an increase in the number of applications for apprentice positions.

Our Link With Education program provides one source of apprentices. Other sources of maintenance

manpower include companies with which we are affiliated such as British Airways Engine Overhaul, Ltd., who train their own apprentices. We also recruit university graduates for a one-year apprenticeship, some of whom then come to us as engineers. In many cases, however, these recruits represent future managers, with engineering assignments as only part of their career progression. Under these conditions, they do not really solve our manpower problem.

The real solution to our manpower needs rests with the British Airways Apprenticeship Program. This apprenticeship is a three-year standard based program, as outlined in Table 1. By standard based, we mean that at the end of year one, a student must have reached a certain standard. Each student is examined at the end of each year. If he does not meet the established standard, he does not proceed to the next year. A student actually can achieve this three-year program in slightly less than three years if he is an excellent student. However, for the most part, it is a straight three-year program.

### **Table 1**

#### British Airways Engineering Apprenticeship

##### -Three-Year Course-

#### **First Year**

14 weeks College studies - in house

26 weeks Engineering Skills Training Centre

06 weeks Practical work experience

#### **Second Year**

14 weeks College studies - in house

32 weeks Practical work experience

#### **Third Year**

46 weeks Practical work experience

College studies if necessary

College studies are carried out on a block release basis.

The first year of training is spent entirely in the apprentice training school. Subsequent years involve considerable hands on experience. Students rotate through all departments within our maintenance facilities. Some of the students will go on to work on airplanes. Others will proceed to working on components. In any event, when they begin their apprenticeship, they know where their program is leading. In doing this, we are relying on our learning from an earlier mistake in which we promised all apprentices that "You'll end up working on airplanes." When they finished their apprenticeship some years ago, some of the students were assigned to workshops. They did not like this at all, since they all wanted to work on airplanes. To avoid this discontent, we now tell each student exactly where he/she is going to go.

In addition to our apprenticeship procedures we have developed something called an "*ab initio* program." This program is developed to address the training needs of persons who already may have a certain measure of skill. For example, a number of our applicants have a military background. These people generally have skill in one discipline. Since we do not employ any single discipline people, we must provide training for the other skills and also ensure that these skills now address issues in civil aviation. Finally, there is the matter of standards. Generally speaking, to get to the equivalent of the U.S. A&P license -- a license without a type rating -- three years of aircraft experience is required. This represents half of the entire picture. We can take any student with appropriate skills and lead them to the aircraft maintenance certificate (AMC), which is half way toward a full license. It shows a level of attainment. With the AMC, a technician can proceed to

licensure without type rating in about two more years. At that point they become my problem, since I am the Maintenance Training Manager. We then train to authorization level those individuals who hold the license without type rating.

In summary, we have described a crisis that is coming. In one way of looking at this, the crisis may represent an opportunity. However, it is a crisis nonetheless. We have looked at our program to increase our apprentice numbers; we have looked at our links with education; we have looked at work experiences; and we have looked at the *ab initio* program. There is one other alternative. This involves placing a paper bag over one's head, with the words on the front of the bag saying "Method 1. Place bag over head and pretend it will not happen."

## INCREASED USE OF WOMEN AND MINORITIES IN MILITARY AVIATION MAINTENANCE

*Mark Eitelberg, Ph.D.*  
*Associate Professor*  
*Department of Administrative Sciences*  
*U.S. Naval Postgraduate School*

This presentation addresses the topic of women and minorities in aviation maintenance. All of the information to support this presentation is taken from aviation maintenance in a military setting. However, the information may offer something new for many of you. There are interesting trends in military aviation maintenance that perhaps are shared with civilian industry.

### Aviation Maintenance Occupations

The occupation of aviation maintenance in the military is an elaborate structure. The Department of Defense Job Classification System divides aviation maintenance positions into five general categories, all under the broad heading of Electrical/Mechanical Equipment Repairer. The five general categories include (1) aircraft, general; (2) aircraft engine; (3) aircraft accessories; (4) aircraft structures; and (5) aircraft launch equipment, which is only a Navy or Marine Corps occupation. Actually, there are about 216 separate aviation maintenance job titles within these categories, with 28 specialties in the Army, 90 in the Navy, 78 in the Marine Corps, and 20 in the Air Force.

Table 1 shows the number and percentage of enlisted personnel assigned to aviation maintenance occupations. Not surprisingly, most aviation maintenance billets are found in the Air Force, with over 69,000 enlisted personnel. By comparison, the Navy currently has close to 50,000 sailors in maintenance occupations, followed by the Army with almost 16,000 and the Marine Corps with over 11,000. Most people in each of the services work in the field called general aircraft.

Table 1  
Number and Percentage Distribution of Active-Duty Enlisted  
Personnel Assigned to Aviation Maintenance Occupations,  
by Type and Service, June 1990

Type of Occupation	Army		Navy		Marine Corps		Air Force	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
General Aircraft	12,683	80.2	27,740	56.0	5,773	50.8	35,477	51.2
Engine	656	4.1	4,201	8.5	1,391	12.2	9,142	13.2
Accessories	1,656	10.5	6,898	13.9	1,866	16.4	20,522	29.6
Structures	826	5.2	2,971	6.0	1,908	16.8	4,124	6.0
Launch Equipment	0	0.0	7,742	15.6	419	3.7	0	0.0
TOTAL Aircraft-Related	15,821	100.0	49,552	100.0	11,357	100.0	69,265	100.0

Source: Derived from data provided by the defense Manpower Data Center

Table 2 shows the number and percent of all active duty enlisted personnel assigned to each of the five areas over the period 1972-1990. This table shows that both the number and proportion of the forces involved in aviation maintenance have decreased since 1972. In the larger military force of 1972, about 10.5 percent of all enlistees were assigned to aviation maintenance. By 1980, this number had decreased to 8.7 percent and by 1990 to 8.4 percent. Table 2 also shows that, over the 18-year period from 1972-1990, there was a loss of over 60,000 jobs in military aviation maintenance.

Table 2  
Number and Percentage of Active-Duty Enlisted Personnel  
Assigned to Aviation Maintenance Occupations, By Type,  
1972, 1980, 1990

Type of Occupation	Number			Percent		
	1972	1980	1990	1972	1980	1990
General Aircraft	121,989	83,900	81,673	6.2	4.8	4.7
Engines	28,280	20,846	15,390	1.4	1.2	0.9
Accessories	48,743	32,199	30,942	2.5	1.8	1.8
Structures	9,268	9,345	9,829	0.4	0.5	0.6
Launch Equipment	*	7,186	8,161	*	0.4	0.4
TOTAL Aircraft-Related	208,280	153,476	145,995	10.5	8.7	8.4

Source: Derived from data provided by the Defense Manpower Data Center.

\* Not used as separate occupational type before 1976.

## Assignment Patterns by Racial/Ethnic Group

The proportion of minorities assigned to aviation maintenance has increased since 1972. However, one should recognize that the proportion of minorities in the military has also increased. Nineteen

hundred and seventy-two (1972) marks the end of the draft and the beginning of the All-Volunteer Force, with the last draftee entering active duty in June 1973. Over the past 10 years, the racial/ethnic composition of enlistees in aviation maintenance has remained remarkably similar, with whites representing about 80 percent, blacks about 13 percent, Hispanics about 4 or 5 percent, and people in other races about 4.5 percent.

Levels of racial/ethnic representation are shown in greater detail in the next several tables. These tables use the racial/ethnic categories of white, black, Hispanic, and other. The "other" group includes primarily persons of Asian descent. In representation studies, the proportion of a group within the total force is used as a standard or a basis for comparison. These proportions can be seen in the column labeled "Total Active Duty" at the bottom of [Table 3](#), [Table 4](#), and [Table 5](#). If the proportion of the group in a certain occupation is lower than the proportion of that group in the force as a whole, that group is considered to be underrepresented. If it is higher, of course, the group is considered overrepresented.

**Table 3**  
**Percentage of Active-Duty Enlisted Personnel Assigned to Aviation Maintenance Occupations, by Type and Racial/Ethnic Group, 1972**

Type of Occupation	White	Black	Hispanic	Other	All Groups
General Aircraft	87.9	8.0	3.3	0.8	100.0
Engines	86.7	8.6	3.4	1.3	100.0
Accessories	86.8	8.8	3.5	0.9	100.0
Structures	87.6	7.7	3.8	0.9	100.0
Launch Equipment	*	*	*	*	*
Total Aircraft-Related	87.4	8.3	3.4	0.9	100.0
Total Active Duty	81.5	12.6	4.0	1.9	100.0

Source: Derived from data provided by the Defense Manpower Data Center.

\* Not used as separate occupational type before 1976.

**Table 4**  
**Percentage of Active -Duty Enlisted Personnel Assigned to Aviation Maintenance Occupations, by Type and Racial/Ethnic Group, 1980**

Type of Occupation	White	Black	Hispanic	Other	All Groups
General Aircraft	79.7	12.1	3.8	4.4	100.0
Engines	76.9	13.3	4.5	5.3	100.0
Accessories	77.8	13.5	4.0	4.7	100.0
Structures	76.7	14.5	4.6	4.2	100.0
Launch Equipment	68.5	22.0	3.9	5.6	100.0
Total Aircraft-Related	78.2	13.2	4.0	4.6	100.0
Total Active Duty	69.7	21.9	4.0	4.4	100.0

Source: Derived from data provided by the Defense Data Center.

**Table 5**  
**Percentage of Active-Duty Enlisted Personnel Assigned to Aviation**  
**Maintenance Occupation,**  
**by Type and Racial/Ethnic**  
**Group, 1990**

Type of Occupation	White	Black	Hispanic	Other	All Groups
General Aircraft	79.0	11.9	4.6	4.5	100.0
Engines	74.8	14.1	5.7	5.4	100.0
Accessories	75.7	15.5	4.0	4.0	100.0
Structures	80.8	10.5	4.9	3.8	100.0
Launch Equipment	60.9	25.1	7.8	6.2	100.0
Total Aircraft-Related	77.1	13.5	4.9	4.5	100.0
Total Active Duty	67.7	23.0	4.9	4.4	100.0

Source: Derived from data provided by the defense Manpower Data Center.

[Table 3](#) shows that in 1972 each of the three minority groups was underrepresented in every aviation maintenance category. For example, blacks comprised about 8.3 percent of persons in all maintenance jobs though they accounted for close to 13 percent of the total enlisted force.

By 1980 ([Table 4](#)), the proportion of minorities in all maintenance positions was 21.8 percent. This is up from 12.6 percent in 1972. Yet the proportion of minorities in the enlisted force had also grown from 18.5 percent in 1972 to 30.3 percent in 1980, leaving blacks at 22 percent of the total. Again, blacks are underrepresented in all categories of aviation maintenance except Launch Equipment.

Little had changed by 1990. The proportion of minorities in the total enlisted force increased by just two percent. The proportion of minorities in aviation maintenance increased by just one percent. Again, blacks were noticeably underrepresented in all areas except Launch Equipment, a Navy occupation. This underrepresentation can be seen especially in General Aircraft and Structures. However, this pattern is not the same for Hispanics and other minorities. For example, [Table 5](#) shows that Hispanics are overrepresented in Engines as well as Launch Equipment, and approximately represented in the other areas. The same is true for other minorities, who are essentially underrepresented in only Structures and Accessories.

When racial/ethnic assignments are further considered for male and for female enlistees, the picture changes very little. For example, whites account for about 77 percent of all men assigned to aviation maintenance, while white women account for almost 80 percent of such assignments. At the same time, blacks comprise 13.6 percent of men and 12.9 percent of women serving in aviation maintenance. Gender differences will be explored in greater detail later.

[Table 6](#) compares racial/ethnic distributions by service. Blacks are underrepresented in aviation maintenance within all four branches of the military; especially in the Army, where they account for almost one-third of enlisted personnel and just 13 percent of persons assigned to these maintenance positions. Minority group participation is highest in the Navy at 28 percent and lowest in the Marine Corps at 20 percent. It is interesting to note that the Navy has the highest proportion of blacks assigned to aviation maintenance, almost 15 percent, though it has the lowest level of total black representation at just over 17 percent.

**Table 6**  
**Percentage Distribution of Active-Duty Enlisted Personnel**  
**Assigned to Aviation Maintenance Occupations, by Racial/Ethnic**  
**Group and Service, June 1990**

Racial/ Ethnic Group	Army		Navy		Marine Corps		Air Force	
	Aviation Mainte- nance	All Active Duty	Aviation Mainte- nance	All Active Duty	Aviation Mainte- nance	All Active Duty	Aviation Mainte- nance	All Active Duty
White	78.4	59.2	72.0	71.1	80.5	69.0	79.8	75.3
Black	13.1	31.9	14.7	17.4	11.0	20.7	13.2	17.6
Hispanic	3.5	4.3	6.5	5.9	6.2	7.2	3.9	3.8
Other	5.0	4.6	6.8	5.6	2.3	3.1	3.1	3.3
<b>Total</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>

Source: Derived from data provided by the Defense Manpower Data Center

### Assignment Patterns by Gender

Table 7 addresses assignment differences by gender across the services. These data show that women generally are underrepresented in aviation maintenance. Female representation is highest in the Navy, where close to 10 percent of personnel assigned to Aircraft Accessories are women. Women are overrepresented among sailors assigned to Aircraft Engines, at about 13 percent. As of June 1990, there were 6,875 women assigned to an aviation maintenance job. Over one-half of these women were in the Air Force, and 39 percent were in the Navy.

**Table 7**  
**Women as a Percent of All Active Duty Enlisted**  
**Personnel Assigned to Aviation Maintenance Occupations,**  
**by Type and Service, June 1990**

Type of Occupation	Army	Navy	Marine Corps	Air Force	All Services
General Aircraft	2.3	3.8	1.7	3.8	3.4
Engines	4.7	12.8	2.7	6.6	7.8
Accessories	2.7	9.9	4.3	6.6	6.9
Structures	3.5	8.5	1.7	5.9	5.7
Launch Equipment	*	5.7	4.5	*	2.3
<b>Total Aircraft- Related (Number)</b>	<b>(398)</b>	<b>(2,690)</b>	<b>(268)</b>	<b>(3,537)</b>	<b>(6,875)</b>
<b>Women as a Percent of All Active Duty Enlisted Personnel</b>	<b>11.3</b>	<b>9.9</b>	<b>5.0</b>	<b>13.9</b>	<b>10.9</b>

Source: Derived from data provided by the Defense Manpower Data Center.  
 \* The Army and Air Force have no personnel assigned to this occupational type.

The percentages of women in the five occupational categories (by selected years from 1972 to the present) are shown in Table 8. Basically, the number and proportion assigned to aviation maintenance increased after the end of the draft, but assignment rates have remained fairly stable for the past decade. In 1980, women represented 8.5 percent of all enlisted personnel and 4.3 percent of those assigned to aviation maintenance. By 1990, the proportion of women in the enlisted force had

risen to just under 11 percent. At this time women accounted for fewer than five percent of personnel assigned to aviation maintenance. Numerically, there were over 41,000 more female enlistees in 1990 than in 1980, yet the number serving in aviation maintenance increased only by about 300. The number of women assigned to aviation maintenance in 1990 also marked a decline from the level of 1988.

**Table 8**  
**Women as a Percent of All Active-Duty Enlisted Personnel**  
**Assigned to Aviation Maintenance Occupations, by Type,**  
**Selected Years, 1972-1990**

Type of Occupation	1972	1976	1980	1984	1988	1990
General Aircraft	a	2.0	2.7	2.1	3.0	3.4
Engines	o	2.6	6.9	6.8	7.1	7.8
Accessories	o	2.5	7.5	6.9	6.8	6.9
Structures	o	1.8	4.1	5.3	4.5	5.7
Launch Equipment	b	0.3	0.2	1.5	3.2	2.3
<b>Total Aircraft-Related</b>	<b>a</b>	<b>2.1</b>	<b>4.3</b>	<b>4.0</b>	<b>4.4</b>	<b>4.7</b>
<b>(Number)</b>	<b>(3)</b>	<b>( 3,333)</b>	<b>(6,540)</b>	<b>(5,991)</b>	<b>(6,958)</b>	<b>(6,875)</b>
<b>Women as a Percent of All Active Duty Enlisted Personnel</b>	<b>1.6</b>	<b>5.3</b>	<b>8.5</b>	<b>9.5</b>	<b>10.4</b>	<b>10.9</b>

Source: Derived from data provided by the Defense Manpower Data Center.

a. Less than 0.5 percent.

b. Not used as separate occupational type before 1976.

Possibly the most interesting column in [Table 8](#) is the one for 1972, which shows that there were just three lonely female technicians spread between General Aircraft and Launch Equipment. My guess is that the one in Launch Equipment was a coding error in the database, leaving only two women in the field, which also may be the result of coding errors. The interesting feature, however, is that in just 6-8 years, the number of women assigned to aviation maintenance grew from virtually zero to well over 6,000. This is a remarkable increase in the number of women within a specialized branch of the workforce.

### Possible Reasons for Trends in Participation by Women and Minorities

Several factors may have influenced the patterns of participation by women and minorities in aviation maintenance. First, there is the factor of individual choice. Recruiters may try to "steer" new recruits into certain occupations, but the element of personal choice reigns supreme as a possible reason for an assignment decision in our All-Volunteer Force. Nevertheless, recruiter influence is a variable to consider. Service-provided incentives are also used to fill some occupations, and service policies or legal restrictions (such as limitations on assigning women to combat) may play a role.

A critical factor, which can limit the range of choices for a new recruit, is the aptitude test used to determine eligibility for training in specific military occupations. All services use the Armed Services Vocational Aptitude Battery (ASVAB) for initial selection and for assignment to specific jobs. Each service uses its own composites of subtests from the ASVAB to determine eligibility. Composites and cut scores are validated against successful completion of training in the relevant

occupations. Yet, there remain wide differences in test performance by racial/ethnic groups. And because the selection test is a vocational aptitude battery emphasizing traditionally-male occupations, or traditionally-male skills, the scores of men generally are higher than those of women on most of the subtests and composites. The largest differences are found on ASVAB subtests dealing with electronics, automobiles, and shop practices.

For [Table 9](#), a representative aviation maintenance job was selected in each of the services and an estimate made of the proportion of the general population (ages 18-23, by racial/ethnic group) that could qualify for the job based on the service's enlistment standards and the aptitude composite cut scores for assignment to training. Physical and strength requirements were not considered here. As can be seen, enlistment and assignment criteria for these aviation maintenance jobs are more selective for minorities than for whites. For example, two out of three young white men in the general population would probably qualify for enlistment and assignment to a typical aircraft maintenance job in either the Army, Marine Corps, or Air Force. This compares with about one out of four Hispanics, and one out of ten blacks. In the Army, 64 percent of young white men could probably qualify for training as a Utility Airplane Repairer, compared with 8.8 percent of blacks, and 26.4 percent of Hispanics.

**Table 9**  
**Percentage of Young Men (18-23 years old) Who Would**  
**Qualify for Enlistment and Assignment to Aviation**  
**Maintenance Training, by Service and**  
**Racial/Ethnic Group**

Racial/ Ethnic Group	Army Utility Airplane Repairer	Navy Aviation Machinist's Mate	Marine Corps Aircraft Mechanic	Air Force Tactical Aircraft Maintenance Specialist
White	63.7	73.6	63.3	66.6
Black	8.8	21.6	10.8	13.5
Hispanic	26.4	36.4	26.0	28.6
All Group	54.2	64.4	54.1	56.7

Source: M.J. Eitelberg, *Manpower for Military Occupations* (Washington, D.C.: Office of the Assistant Secretary of Defense [Force Management and Personnel], 1988).

[Table 10](#) compares men and women in terms of the effect of the aptitude criteria on eligibility rates in the same jobs. The projected eligibility rates for all young men are over 50 percent, compared with a rates ranging from 18 percent in the Army to 27 percent in the Air Force for women. Note that eligibility rates for both men and women are higher in the Navy than in other services. Proportionately more women and minorities may be able to meet enlistment and aptitude standards in aviation maintenance in this particular service. This may help to explain why the Navy has the largest proportion of minorities serving in these occupations.

Table 10

Percentage of Population (18-23 years old)  
Who Would Qualify for Enlistment and Assignment  
to Aviation Maintenance Training, By  
Service and Gender

Gender	ARMY Utility Airplane Repairer	NAVY Aviation Machinist's Mate	MARINE CORPS Aircraft Mechanic	AIR FORCE Tactical Aircraft Maintenance Specialist
Male	54.2	64.4	54.1	56.7
Female	17.6	51.5	20.7	27.1

Source: M.J. Eitelberg, *Manpower for Military Occupations*  
[Washington, D.C.: Office of The Assistant Secretary of Defense  
[Force Management and Personnel], 1988].

Other factors may bear on assignment trends. For example, participation by women in aviation maintenance may be affected by legal and policy restrictions on women in combat. Also, certain physical or strength requirements may operate to screen out women at the start, or cause them to leave training or the job after some time. Anecdotal evidence suggests that the physical demands of the military's aviation maintenance jobs may be greater than anticipated by some women -- resulting in training attrition or personnel turnover after initial assignment.

### Continuation Rates for Enlisted Personnel Assigned to Aviation Maintenance

Once assigned to aviation maintenance, do minorities and women tend to remain in this occupation as long as their white male counterparts? [Table 11](#) presents continuation rates of enlisted personnel assigned to aviation maintenance over the 16-year period from 1974-1990. These data show that minorities originally assigned to aviation maintenance remain on active duty at rates greater than those of their white counterparts. Minorities likewise tend to continue longer than do their white counterparts in aviation maintenance. For example, over 22 percent of blacks who were originally assigned to aviation maintenance in 1974 remained on active duty as of June 1990. Almost 15 percent of these were still assigned to a job in aviation maintenance. Comparable rates for whites were 15 percent on active duty and nine percent in aviation maintenance.

Table 11

**Continuation Rates of Enlisted Personnel Assigned  
to Aviation Maintenance over a 16-year Period:  
Persons Who Joined 1974 (circa) As of 1990, By  
Racial/Ethnic Group and Gender**

<b>Racial/Ethnic Group</b>	<b>Number Assigned in 1974</b>	<b>Percent Still on Active Duty</b>	<b>Percent Still in Aviation Maintenance</b>
<b>White</b>	<b>13,695</b>	<b>14.6</b>	<b>9.3</b>
<b>Black</b>	<b>2,609</b>	<b>22.4</b>	<b>14.5</b>
<b>Hispanic</b>	<b>888</b>	<b>18.6</b>	<b>12.8</b>
<b>Other</b>	<b>292</b>	<b>26.7</b>	<b>1.5</b>
<b>Gender</b>			
<b>Male</b>	<b>16,107</b>	<b>15.9</b>	<b>10.8</b>
<b>Female</b>	<b>1,377</b>	<b>18.4</b>	<b>5.9</b>
<b>Total</b>	<b>17,484</b>	<b>16.1</b>	<b>10.4</b>

**Source: Derived from data provided by the Defense Manpower Data Center.**

Continuation rates for women assigned to aviation maintenance are consistently lower than the rates for men. At the same time, differences between the active duty continuation rates of men and women are smaller, with the percentage of women actually higher than that of men after 16 years. [Table 11](#) shows that just six percent of women originally assigned to aviation maintenance in 1974 were still serving in a related area after 16 years, compared with about 11 percent of men.

One reason military technicians may be leaving is because they are offered jobs in civilian industry. This may be a real problem for the military in years ahead. As demographers have pointed out, the available population will be shrinking. At the same time, there has been a remarkable decline in scores on widely-used tests of aptitude and scholastic achievement -- including a drop in scores on the Scholastic Aptitude Test that began in 1963 and apparently leveled off in the 1980's. The proportion of people who can qualify for high-tech occupations or aviation maintenance occupations or avionics occupations is relatively small in the general population, particularly in the case of minorities and women. There may well be serious competition between the military and the civilian sector for these qualified people in coming years.

Several factors may help to explain continuation rates for different groups. Minorities tend to reenlist in the military at relatively higher rates. This often is attributed to the "push/pull" relationship between military opportunities and civilian employment. Pushing the minority member into the military are civilian unemployment or underemployment, and other social or economic inequities. Pulling the minority into the military are the many benefits of military service, which now include substantial money for college (through the G.I. Bill) and training in "civilian-transferable" occupations.

Women who enlist in the military seem to look for traditional employment. Surveys conducted over the past several years have found that women joining the military were most interested in traditionally-female jobs such as administration and nursing. This may say something about our school systems, about our culture and upbringing. It may also say something about how the military is "sold" to these women. Nevertheless, placing women into non-traditional areas has not been particularly easy.

### **Commissioned Officers Assigned to Aviation Maintenance by Racial/Ethnic Group and Gender**

This section looks at the racial/ethnic and gender differences among commissioned officers, those who lead and direct the aviation maintenance crews. [Table 12](#) shows that black officers are somewhat underrepresented in aviation maintenance, a trend that has continued for at least 18 years. For example, as of June 1990, blacks accounted for about seven percent of all officers and between five and six percent of officers working in aviation maintenance. Hispanics and other minorities make up a small proportion of the officer corps, but are approximately represented in aviation maintenance.

**Table 12**  
**Percentage Distribution of Commissioned Officers Assigned to Aviation Maintenance and all Occupations, by Racial/Ethnic Group, Selected Years 1972-1990**

Racial/ Ethnic Group	1972		1980		1990	
	Aviation Mainte- nance	All Occu- pations	Aviation Mainte- nance	All Occu- pations	Aviation Mainte- nance	All Occu- pations
White	96.9	96.1	93.5	90.7	89.7	87.9
Black	1.6	2.3	3.5	5.0	5.5	7.0
Hispanic	1.1	1.2	1.2	1.1	2.1	2.1
Other	0.4	0.4	1.8	3.2	2.7	3.0
<b>Total</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>

Source: Derived from data by the Defense Manpower Data Center.

To become an officer in the military, a candidate must have a college degree. Blacks account for about six percent of all persons (ages 20 through 29) with a four-year college degree. If that figure is used for comparison, the military is doing quite well. If the general population is used for comparison, then blacks should be considered underrepresented in the officer corps.

[Table 13](#) shows the percentage distribution of commissioned officers by gender over the 18-year period since the start of the All-Volunteer Force. Female officers have been underrepresented in aviation maintenance for the entire 18 years. Women currently comprise over 11 percent of the officer corps and just over eight percent of officers in aviation maintenance. In 1972, about four percent of officers were women, compared with one-tenth of one percent of female officers assigned to aviation maintenance. Since then, the picture has improved, but they remain underrepresented.

Table 13

**Percentage Distribution of Commissioned Officers Assigned  
to Aviation Maintenance and All Occupations, by Gender,  
Selected Years, 1972-1990**

Gender	1972		1980		1990	
	Aviation Maintenance	All Occupations	Aviation Maintenance	All Occupations	Aviation Maintenance	All Occupations
Male	99.9	96.2	95.6	92.3	91.7	88.7
Female	0.1	3.8	4.4	7.7	8.3	11.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Derived from data provided by the Defense Manpower Data Center.

## Conclusions

This discussion has been more descriptive than prescriptive, but several important issues are noted. Following the advent of the All-Volunteer Force in 1972, the percentage of women and minorities working in aviation maintenance has increased. However, these groups remain underrepresented in this area. Certainly, an important element -- perhaps even more important than personal choice -- is the test used to determine eligibility for specific jobs. Performance on this test will ultimately determine the alternative job choices available to the new recruit.

Both the military forces and civilian industry in coming years will be drawing on an increasingly tight labor market to meet their demands for aviation maintenance. Women and minorities must be used more extensively. We must continue to explore better ways to recruit, train, and use these valuable resources.

## AVIATION MAINTENANCE WITH A SMALL WORKFORCE

*Brian Whitehead  
Air Worthiness Branch  
Canadian Air Transport*

When I was first asked to speak about the problems of managing aviation maintenance in a country that can only draw on a small workforce, my immediate answer was that I could speak about the problems, but would not be able to shed much light on the solutions. That assessment has not changed. I can, of course, outline the systems we have adopted in the Canadian industry, but I cannot claim that they are the answer to all our prayers. In fact, in some ways I think we are moving in the wrong direction. In these particular areas, my personal views may differ from those of the industry at large and the present policies of my department. I should say, therefore, that these opinions are mine alone.

Although we speak of Canada as drawing on a small work-force, this is true only by comparison with the United States. In global terms, the Canadian Air Transport industry is quite large. In fact, the Canadian civilian aircraft fleet is the second largest in the western world.

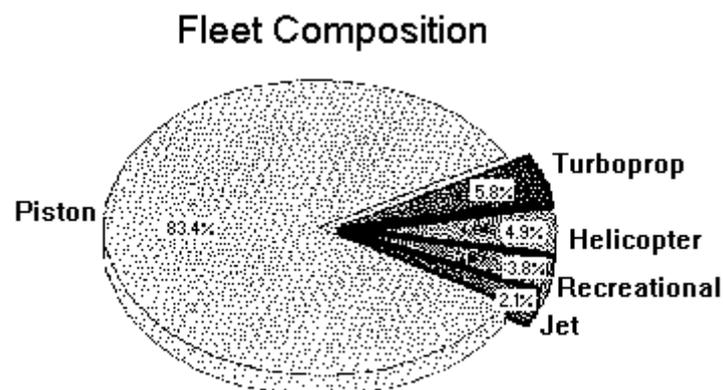
Canada's geography makes air transport an essential part of the country's infrastructure. The country covers an area slightly larger than that of the United States, although the population is only one tenth the size. Most of this population is spread along a narrow ribbon bordering the U.S. and this is where most of the large jet activity takes place, as shown in [Figure 1](#). There are a few large northern communities that are served by the big airlines, but there are many more small settlements distributed across the entire northern area. Here the demand is more for bush aircraft, including float planes and helicopter services. For some more remote communities, air travel is the only practical means of access. Even between major centers, the distances involved effectively rule out other means of transportation.



**Figure 1**

The Canadian Air Transport industry is like the U.S. industry in microcosm. It is one tenth the size, by almost any yardstick you care to apply. Not only do we have one tenth of the total number of aircraft, but the same ratio applies to the numbers of aircraft in various categories and even, to a large degree, to the numbers of each type of aircraft.

We have a total of about 28,000 aircraft on the register, most of them private; two place and four place machines. [Figure 2](#) shows the proportions of the various classes of aircraft that make up the fleet. I believe the general distribution is similar to the U.S. register.



**Figure 2**

The important thing to keep in mind here is that the type of technology is far more important than the

total numbers. An operator acquiring, say, five aircraft of a new type faces the same challenges as an operator acquiring fifty. What he does not get are the economies of scale.

Although the Canadian fleet is one tenth the size of the U.S. fleet in terms of the number of aircraft, it is practically the same in terms of the types operated. Almost every type of aircraft certified in the western world is represented on the Canadian registry eventually.

Apart from the differences in size, there are of course cultural and political differences between the two countries. The most obvious cultural difference is the use of two official languages, but another is a different perception of the role of government. Compared with the U.S. there is maybe more of a tendency to look to government, rather than private industry, for solutions, although that gap seems to be closing on both sides of the border. The political differences show in the rulemaking process. Although the system is more rigidly controlled than the European models, it is probably still considerably more flexible than the U.S. system.

Like many of our maintenance rules, the Canadian aircraft maintenance licensing system was initially based on the British model. Although it has since undergone major changes, it still has more in common with that system than with FAR 65.

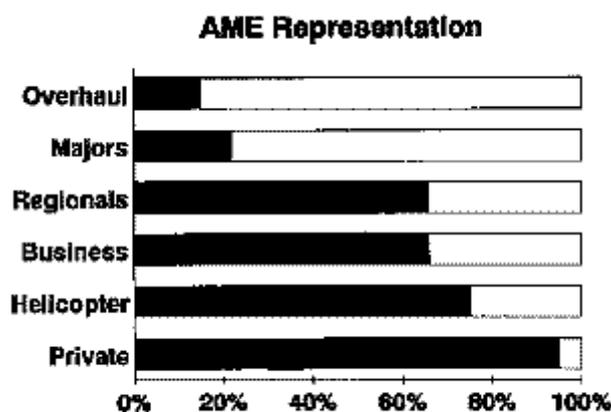
The differences between the Canadian Licence system and the FAA system are so great as to make comparisons almost meaningless. For a start, the privileges of the AME licence are concerned with the certification of the work, not with its performance.

Anyone may perform maintenance except that, if the aircraft is engaged in commercial operation, the work must be done under the control of an approved organization. Only an AME may make the necessary certification. It is difficult to draw direct comparisons, but the privileges of the AME Licence are broadly equivalent to the FAA Inspection Authorization.

The requirements for issue are roughly in line with this. For the basic category "M" licence, they specify four years experience, plus the examination and training requirements. There are additional experience requirements for each of the various rating groups.

One element of the U.S. system for which there is no counterpart is the practical test. We would like to introduce practical testing but it is just too costly. Even a delegated system such as you have in the U.S. would be expensive and, I think most people would agree, open to abuse.

Since the AME licence is a supervisory qualification rather than a tradesman standard, it follows that not everyone employed in the industry need hold one. [Figure 3](#) will give some idea of the proportions of licensed AMEs in the work force for various segments of the industry.



**Figure 3**

As you can see, the segments that tend to work in large organized teams need relatively few AMEs,

usually in supervisory positions. In general aviation, where it is much more common for the individual to work alone, almost everyone holds a licence. Another factor influencing the proportion of AMEs in the workforce is the degree of specialization required. Although the licence system makes some provisions for specialists, for the most part the AME is a general practitioner. Some more highly specialized off-aircraft maintenance tasks are performed by organizations having no AMEs at all.

I should add here that my previous statement that only AMEs are allowed to certify maintenance applies only to work done on the aircraft. In specialist component shops, unlicensed technicians may be authorized to sign. This procedure corresponds roughly to the FAA certified repairman system.

Although the aircraft technician forms the single largest segment of the work force, this still only amounts to 38 percent of the total. The various other specialties combined total almost twice as much.

When certifying maintenance, the AME is not acting for his employer. He is exercising professional judgement on his own behalf and will be held personally accountable for his decisions. The same applies to authorized signatories in component shops. The employer is held separately accountable under parallel legislation.

The Canadian Aircraft Maintenance Engineer (AME) Licence comes in one of four categories, as shown in [Figure 4](#). It is a complex system, that takes a lot of administering. It has had advantages but I personally think that it has now outgrown its usefulness. I will say more about this later.

### AME Licence Categories

- ✈ "M" Aircraft Maintenance
- ✈ "E" Avionics
- ✈ "S" Structures
- ✈ "P" Propulsion

**Figure 4**

Over the past few years, as the effects of deregulation have started to be felt, it has become obvious that one of the main factors limiting the growth of the industry is the supply of skilled maintenance personnel. The Canadian Employment and Immigration Commission (CEIC) recently completed a study of this problem and reported that, although the recent period of growth was expected to level off in the short term, the long term prospects for the industry were strong. They estimated that the Canadian aircraft maintenance industry will require 10,000 to 30,000 new workers by the year 2000.

The industry has traditionally neglected any kind of forward planning for future personnel needs. This contrasts strongly with the European approach with its apprenticeship system. Instead, Canada has relied on three major sources of supply; the armed forces, immigration, and on-the-job training. The first two are now almost non-existent. Our present armed forces are so small as to make only a negligible contribution and, in any case, they offer a sufficiently attractive career in their own right so that the really qualified people tend to stay in. Even for those who do leave, the armed forces trade specializations are so narrow that the transition to civil aviation is difficult and many ex-servicemen become discouraged.

The pattern of immigration has changed and Canada is no longer as attractive to the skilled European tradesman as it once was. In fact, for the first time, we are now seeing the flow reversed and European companies are recruiting in North America. We still get some qualified people from Asia but, by and large, the shortage of aircraft maintenance technicians is worldwide, so we have to compete on that basis. Given that the profession carries a higher status in most countries than it does

here, we are not doing too well.

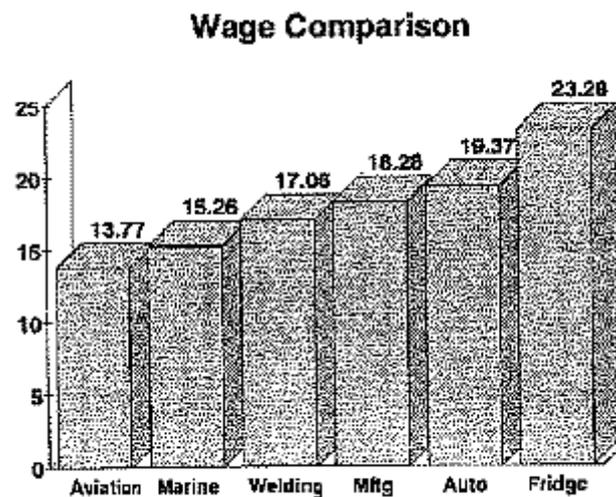
So far as on-the-job training is concerned, the complexity of modern aircraft pretty well rules it out altogether. In fact, as of this year, formal structured training has been made a mandatory requirement.

The demand for skilled personnel will not be limited to [AMEs](#). The areas of greatest need will be in the specialized trades. Sheet metal and composite structure technicians, avionics technicians, interior refurbishers, and [NDT](#) specialists will be in particular demand. The problems are compounded by the lack of a structured career system for these specialties.

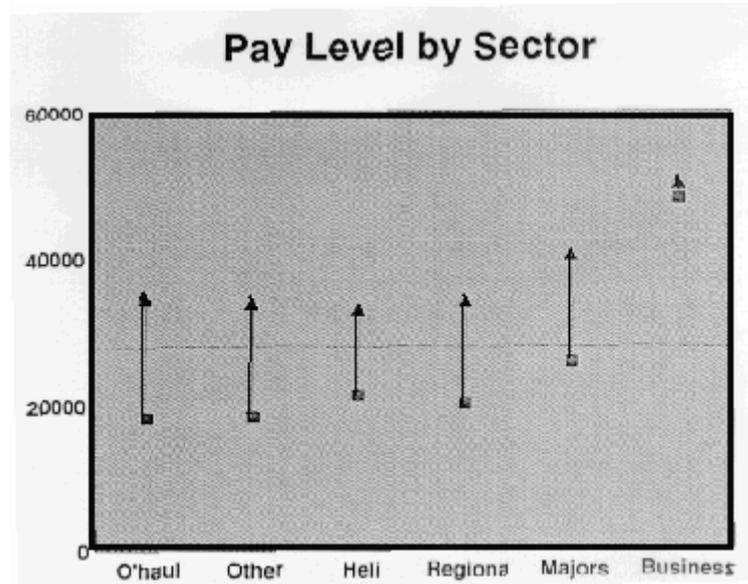
In the short term, the difficulty in recruiting is likely to be felt most by the smaller carriers. In the long term though, the large carriers and the repair and overhaul sectors will be the most affected.

The present rate of turnover for the industry as a whole is in the order of 10 to 15 percent. If evenly distributed, this would not be too bad but, unfortunately, the turnover in the smaller carriers and general aviation is considerably higher than the average. Also, much of the activity is a result of workers leaving the industry altogether.

There is a definite drift of trained workers away from the industry. There are many reasons for this drift but one obvious one is uncompetitive pay rates. [Figure 5](#) shows entry level pay rates for comparably skilled workers in several industries. These figures relate to unionized companies. Many smaller carriers are not unionized and the pay rates are accordingly lower. [Figure 6](#) shows the breakdown of pay levels by industry sector and contrasts starting levels with the levels paid to experienced personnel. Business aviation is the clear winner here perhaps because they tend to hire mostly senior technicians. After that, the major carriers pay reasonably well but the rest of the industry is uncompetitive. The horizontal line at \$25,000 represents the mean rate for all hourly paid workers in Canada.



**Figure 5**



**Figure 6**

Aviation maintenance has never been known for high pay levels but it has traditionally made up for this by offering other incentives. In particular, the glamour of aviation used to be a big drawing card and probably most of us were first attracted to the industry by the mystique of flight. I know I was and I still feel the same way. I have a lot in common with the honey cart driver who went home after a particularly hard day covered in the contents of a toilet that had spilled out due to a stuck valve. When his wife suggested he think about changing jobs, he replied, "What, and get out of aviation?".

It would be a mistake to expect today's youth to see the industry through our rose tinted spectacles. To many, the airplane is just another means of transportation. Compared with the current glamour jobs in computing and communications, there is no contest.

The industry as a whole has done a lousy job of selling itself as a field in which to have a satisfying career. The public at large still does not have the slightest idea of what aircraft maintenance is. Much of this ignorance is the result of previous airline policies. Years ago, when I worked for BOAC, we were told to keep out of sight when we were in coveralls. The management thought it was bad for business for the passengers to see a mechanic and be reminded that aircraft were technical devices that could go wrong.

Personally, I would be concerned to fly on an airplane that appeared to have no maintenance but the public was thought to believe otherwise. Things are changing now, to the extent that some airlines are even stressing the competence of their maintenance staff in commercials but we still have a long way to go. During the CEIC study, high school students in technology related courses, who might have been expected to be strong candidates for a career in aviation, speculated that aircraft maintenance must be dirty, boring work; consisting mostly of refueling.

So, we not only have to do something about our pay levels, we have to work on our image. We also need some nationally, or better yet internationally, recognized standards for some specialist trades. Some of these specialties are unique to aviation but many can be based on the requirements of other industries. Among the major specialties are avionics technicians, [NDT](#) technicians, sheet metal technicians, welders, composite material specialists, engine overhaulers, hydraulic and pneumatic specialists, machinists, painters, and upholsterers.

Another area in need of standards is maintenance management. In this respect, the U.S. is definitely ahead of Canada as several colleges already offer courses on the subject. I hope we can develop something similar in Canada soon because it is a real area of weakness. If we are to make the most of our limited resources, we will need knowledgeable leadership. We will also need a regulatory framework that will allow the leaders to use their knowledge. We hope to get that through an

emphasis on regulation by objective.

The only basic aircraft maintenance training available in Canada is for the aircraft maintenance technician and the avionics technician. In both cases, the training is more appropriate for the general aviation field than for large carrier aircraft although the need is for the latter.

Figure 7 shows the distribution of the workload across various sectors of the industry. If we contrast this with the earlier pie chart on fleet composition (Figure 2), we can see that the massive preponderance of small piston powered aircraft does not have much effect on the requirement for maintenance personnel. Only 4.1% of the work force is employed in this area. But this is the sector the schools are teaching for! Figure 8 gives some idea of the distribution of the work force within the commercial sector. You can see that the biggest employers are in third line support, mainly equipment overhaul, with the major carriers a close second.

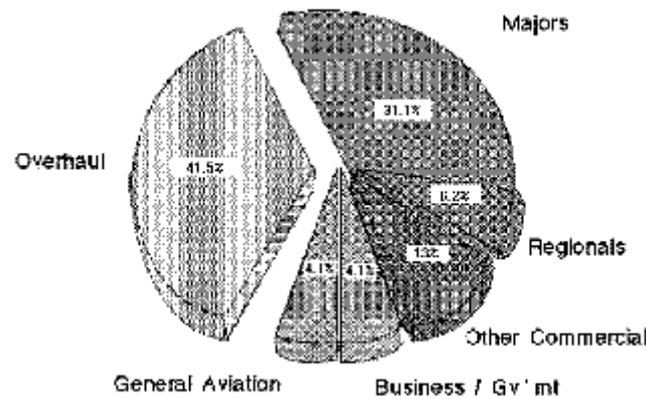


Figure 7 Workload Distribution

**Aircraft Maintenance Industry**

	Companies	Aircraft	Employees
Major Carriers	2	231	6000
Regional / Charter	17	235	1200
Other Commercial	718	3619	2500
Overhaul	200	-	8000
Business / Gv'mt	88	535	800

Figure 8

The schools have a tendency to teach what they are equipped for, rather than equipping for the training that the industry needs. It is hard to blame them for that, though, as the required equipment is pretty expensive. Nevertheless, the emphasis will have to change. Computer based interactive training techniques might be one answer to the equipment problem.

Currently, we have 12 colleges in Canada, offering [aircraft maintenance training] with course lengths from one to three years. They collectively graduate about 675 students per year. Not all graduates enter the industry; some go on to higher education and eventually work in other related fields. Others simply move to a more attractive career in a different industry.

To meet the needs that will arise over the next decade, we need to attract more suitably qualified

young people to a career in aircraft maintenance. To do this, we must not only ensure that pay levels are competitive with other industries but we must also improve the image of the business. We also have to keep an open mind regarding new developments that will allow us to get the most efficient use of our people in a rapidly changing field.

As you can see, the problems in Canada are the same as in the U.S. The solutions may be a little more difficult due to the absence of the economies of scale that apply in the much larger industry.

We are trying to combat the image problem by taking the message to the high schools. As part of this campaign, we will be making an effort to attract women and visible minorities. At present, the Canadian aircraft maintenance industry is almost exclusively white and male.

I already mentioned the change in attitude of the airline marketing departments who are no longer afraid to mention maintenance and are beginning to treat it as a selling point. This should help by providing some much needed visibility. Whether the pay levels will rise sufficiently to make a difference remains to be seen. The economic climate right now is not conducive to big increases but the problem has at least been recognized and compensation levels will probably grow slowly.

The Department of Transportation is working closely with the industry associations and educators to try to ensure that the training requirements for aircraft technicians are valid and up-to-date. Apart from the obvious need to address modern technology, we have to put more emphasis on analytical skills, problem solving, and communication.

Transport Canada policy will be to concern itself directly only with the core skills of aircraft maintenance. I should qualify that by saying with the "supervision" of aircraft maintenance. In the area of the specialist trades, we will take an advisory role only. These trades have so much in common with other, provincially regulated, occupations that it would be wasteful for the Federal government to duplicate the existing requirements. We will be available for consultation, as required, and we will offer advice where necessary.

We have already assisted in identifying some trade areas that are deserving of registration on the "Red Seal" program. This is a program designed to give inter-provincial recognition of certain trade qualifications in order to facilitate movement of labour between provinces. This will also be of real value to the large carriers who have bases in a number of provinces.

In the strictly aviation courses, we will attempt to achieve a level of standardization that will enable the granting of cross-credits between courses but, at the same time, we recognize that the field of maintenance is so broad that no one school will be able to cover all aspects of it equally. There is much to be said for a degree of specialization that will allow each school to develop its own niche. The success of this approach will depend to a large extent on a liberal attitude on the part of the provincial education authorities in regard to opening of enrollment to out-of-province students.

The new Canadian Maintenance Regulations emphasize freedom-of-choice for the maintenance organization and will, therefore, support different modes of employment from traditional patterns. We will probably see more specialized maintenance organizations offering services, under contract, to a number of air carriers. This kind of arrangement enables more efficient use of limited resources. The new Canadian maintenance rules are specifically designed to accommodate these organizations. Something similar is now being introduced in the European JARs and has been proposed here as FAR 146.

One of the remaining problem areas is the AME licence system. I mentioned earlier that my personal views were not necessarily shared by the Department, or by the majority of the industry, and it is in the field of licensing that the differences show.

Along with the management of Transport Canada, I am a strong supporter of the AME licence. We have made big improvements in the licensing system lately and it is only by having an effective licensing system that we have been able to weather the storms of deregulation with so few maintenance problems. In my opinion, however, the basic structure of the system is showing its age.

Our licence system would be complex under any circumstances but it is particularly inappropriate in a country with such a widely dispersed work force. It certainly compounds the difficulties of obtaining properly qualified staff.

There are three major aspects to the problem; one is the specialized "off-aircraft" licence, for structural repair, engine overhaul, and propeller overhaul. These were originally called "ICAO Type I" licences, as opposed to the "Type II", line maintenance, licences.

This entire Type I - Type II concept is now generally accepted as being outdated. Indeed, in Canada, we already extend Type I privileges to the Category "M" line maintenance AME. This is logical as there is no need for a special licence to perform work that is "Major" in the sense that it constitutes a major design change. A good example of this is a change in engine model. The change may well be "Major" to the engineer who has to assess its effect on the airworthiness of the aircraft but, to the AME who complies with the change, it is just a matter of taking the old engine out and putting the replacement engine in.

Once this fact is acknowledged, it becomes apparent that the off-aircraft licences are really tradesman qualifications and are best associated with the approved organizations. The closest equivalent in U.S. terms is the certified repairman working in an approved repair station.

The existing specialist licence holders, however, are loath to give up their status and, indeed, the pressure to maintain this type of licence is so great that we have recently introduced a new one, for turbine engine overhaul.

Another problem is the avionics licence. This was only introduced about five years ago and was long overdue but, such is the speed with which our business is changing, it is already obsolete. The reason is the introduction of integrated systems. With the latest generation of aircraft exemplified by the A320, mechanical and electronic systems are so closely integrated that it is impossible to say where one discipline ends and the other begins.

It seems to me that the only long term answer is to go back to the idea of having a single person qualified on the entire aircraft. Of course, we will always have individuals who are specialists in one field or the other, but the average line technician is going to have to be an all-rounder.

This is actually the least controversial proposal. It has gained a fair degree of acceptance to the point that we have already introduced a requirement for an exam in basic electronics for the AME applying for a rating on these advanced aircraft. This will probably be the first step in a process that will integrate the mechanical and avionic licences into a new "super licence" by the next century.

Finally, the most controversial proposal relates to the type rating system. The "M" licence is made up of a highly complex system of type ratings. It is highly regarded by most Canadian AMEs who take pride in amassing an impressive list of licence endorsements. The system has been very successful in the past. It provided assurance that the licence holder was truly qualified, not only in his basic profession but also, on the particular aircraft on which he worked.

Once again, though, things have changed. Transport Canada has neither the resources nor the expertise to examine applicants on all of the various types on the register. As I mentioned before, although our register is only a tenth of the size of the U.S. in sheer numbers, we have just as many different types of aircraft. The emphasis has therefore shifted from examination to training. Type endorsements are mostly based on the applicant's having completed an approved course.

In addition, the new rules ensure that each maintenance organization that maintains commercial aircraft has an acceptable training program. And there lies the problem. The maintenance organizations are, naturally, expected to teach the aircraft configuration that they operate. The licence rating, however, is generic. Modern aircraft undergo many changes over their service life of twenty years or more, all under the same general type designation. There is a world of difference between the first Boeing 737 and the product being manufactured today but they are both covered by the same licence rating.

It is possible to allow for this to some extent, of course, and we do this in the case of the 747, for example. The 400 series is treated as a separate type for licensing purposes but this approach is a band-aid at best. It certainly cannot allow for the major differences between individual aircraft of the same series and model due to extensive in-service alterations.

The only acceptable long term solution I can see is to treat the AME licence like any other professional qualification; set the standard high enough so that we can have a good degree of confidence that the licence holders can handle anything that they might reasonably be expected to encounter. We will leave it to the professionalism of the individual and the other regulatory provisions to ensure that they get the required additional specialized training on type.

If this sounds familiar, it should. What I am advocating in Canada has a lot in common with the existing FAA A and P licence system. I hasten to add that does not mean I favour the existing A and P standards. We need some serious changes in the scope and depth of the curriculum. A licence with the authority I envision would require up to three years of training and a further three years of practical experience but it would do more to meet the needs of the industry than anything we have now.

As I mentioned before, however, most AMEs are proud of their type ratings so, at the present time, only a small minority in the industry agree with me. I hope that this will change as they come to see the advantages that go with a qualification that would be regarded as truly professional.

## Appendix B: Meeting Program

### Fourth Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection "The Aviation Maintenance Technician" 12 - 13 December 1990

*Wednesday Morning - Carlyle I & II*

7:30 a.m. Registration

Coffee

#### INTRODUCTORY ADDRESSES

8:30 a.m. Meeting Welcome *J. Kern* **Deputy Associate Administrator for Regulation and Certification Federal Aviation Administration**

9:00 a.m. Meeting Objectives *W. T. Shepherd, Ph.D.* **Office of Aviation Medicine Federal Aviation Administration**

#### THE MAINTENANCE WORKFORCE IN AVIATION OPERATIONS

9:30 a.m. The Changing Labor Workforce: 1990-2000 *D. Patrick Wash* **USDOL/Bureau of Labor Statistics Washington, DC**

10:15 a.m. Break

10:30 a.m. Organizational Factors in the Enhancement of Military Aviation Maintenance *Major General A. Rogers, USAF (Ret)* **Formerly Deputy Chief of Staff for Logistics, Tactical Air Command, United States Air Force (USAF)**

*Wednesday Morning - Carlyle I & II - Continued*

#### THE MAINTENANCE WORKFORCE IN AVIATION OPERATIONS - Continued

11:15 a.m. Issues in Workforce Productivity *James Diffley* **Manager, Maintenance Administration Delta Airlines**

12:00 noon Lunch

*Wednesday Afternoon - Carlyle I & II*

#### WORKFORCE RECRUITING, TRAINING, AND SUSTENANCE

1:00 p.m. Professionalism in Aviation Maintenance *William O'Brien* **General Aviation Staff Federal Aviation Administration**

1:45 p.m. Training Establishment Perspective *Richard Ulm* **Department Chairman Aviation Maintenance Technology Embry-Riddle Aeronautical University**

2:30 p.m. Break

2:45 p.m. Major Air Carrier Practices *Richard Yeatter* **Director of Maintenance Training USAir**

3:30 p.m. Industry and Schools Cooperation for Maintenance Training *John Harle* **Maintenance Training Group Boeing Commercial Airplanes and Rod Peters** **Director of Technical Training Northwest Airlines**

*Wednesday Afternoon - Carlyle I & II - Continued*

**WORKFORCE RECRUITING, TRAINING, AND SUSTENANCE - Continued**

4:30 p.m. Maintenance Personnel Initiatives in Repair Stations *Jerry Schumacher Senior Director, Contract Services Elsinore Aircraft Services, Inc.*

5:15 Adjourn

*Thursday Morning - Carlyle I & II*

7:15 a.m. Coffee

8:15 a.m. Human Factors in Aviation Maintenance *Colonel Robert McMeekin, MC, USA Federal Air Surgeon Office of Aviation Medicine Federal Aviation Administration*

**WORKFORCE RECRUITING, TRAINING, AND SUSTENANCE - Continued**

8:30 a.m. Issues Influencing Recruiting, Training, and Retention in the Regional Airline Environment *William Hinson Director, Technical Services Atlantic Southeast Airlines*

**AVIATION MAINTENANCE PRACTICES IN NON-U.S. CARRIERS**

9:15 a.m. Aviation Maintenance Practices at British Airways *Michael Skinner Manager, Aircraft Training British Airways*

10:00 a.m. Break

**NEW PERSPECTIVES ON THE AVIATION MAINTENANCE WORKFORCE**

10:15 a.m. Increased Use of Women and Minorities in Military Aviation Maintenance *Mark Eitelberg, Ph.D. DoD Accessions Policy The Pentagon, Washington, DC*

11:00 a.m. Aviation Maintenance Practices Drawing on a Small Labor Force *Brian Whitehead Transport Canada*

11:45 a.m. Lunch

*Thursday Afternoon - Carlyle I & II*

**RECOMMENDATIONS AND CONCLUSIONS**

1:00 p.m. PANEL SESSION

Recommendations and Conclusions

2:30 p.m. Adjourn

## Appendix C: Meeting Attendees

### Fourth Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection 12 - 13 December 1990

#### THE AVIATION MAINTENANCE TECHNICIAN

#### MEETING ATTENDEES

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