CONCLUSIONS AND RECOMMENDATIONS

The attendees at this two-day meeting had diverse allegiances, some being from the Federal Aviation Administration and the National Transportation Safety Board, some from aircraft manufacturers, others from the airlines, and others from remaining segments of the industry. As a result, many of the suggestions and recommendations which were offered were specific to that part of the industry represented by the attendees. However, some themes are apparent. The following recommendations represent a grouping of attendees suggestions according to these themes, with specific recommendations included within each major topic. Some of the recommendations are directed to the FAA; others toward the industry itself.

Communications

Communication" formed some part of more recommendations than for any other topic addressed during the meeting. Comments were made by several members that even if the meeting accomplished nothing else, it served a very useful purpose by allowing representatives from all parts of the industry to get together and exchange views. Credit was given to the FAA for providing the forum in which this exchange could take place. Apparently the changing structure of the airline industry as it proceeds through deregulation has seriously disrupted industry networking. In earlier days, there existed a more effective communication network among airline operators, a network which also included manufacturers. This network does not seem to exist today, at least not to the same extent, and attendees voiced a real need either to rejuvenate the network or replace it in some manner. At the conclusion of the meeting, several attendees expressed a desire that the FAA not let this meeting be a one-of-a-kind affair. They wished to see some comparable get-together occur at least once a year.

The purpose of a periodic meeting would be to review maintenance problems and to spread word through the industry concerning new procedures and new technologies. One attendee stated, "If we have a safety situation and have options to resolve the problem, everyone should know about it."

Another expressed need, as part of the communication entreaty, was for a data base of maintenance information to be shared throughout the industry. There does not exist at this time any central repository containing assembled knowledge concerning maintenance procedures, technologies, equipment capabilities and limitations, unique aircraft problems, personnel variables, and so on. This need is supported by the circumstances surrounding the loss of an engine by a DC-10 during take-off several years ago. In this case, apparently one operator had learned that removing the engine and pylon together for maintenance could cause cracking of part of the structure at the attach point between the pylon and the wing. While this airline obviously stopped using the procedure, work of their experience did not become immediately available to the rest of the industry.

The point was made that manufacturers need to team with aircraft operators in the collection of necessary data for an industry data base. By so doing, both parties would have better insight into the kinds of maintenance errors being made, the most frequent types, and aircraft design features relating to increased error.

The importance of continually striving to ensure good communications between airline management and the labor force was noted. Morale of the workforce can be influenced positively by letting workers know when a job has been well done. Also, the workforce should have some insight into the problems being faced by management. For example, one airline had numerous occurrences of engine oil leaks, some involving inflight shut-downs and unscheduled landings. While airline management was quite concerned over these occurrences, it apparently viewed them as a series of unrelated mechanic discrepancies instead of a systemic problem. As a appropriate information and concern was not passed to the workforce. Consequently, maintenance personnel did not give this issue the full attention it should have received.

Finally, note was taken of the fact that not all airline operators attend industry meeting, such as those sponsored by the Air Transport Association. In fact, the point was made that operators who do not attend industry meetings are the same ones who are not achieving the same level of maintenance quality as other operators. The communication value of such meetings is undeniable. Some means must be found to encourage all operators to attend these meetings.

Recommendations

1. The FAA should sponsor at least one more meeting addressing human factors and personnel problems in aircraft maintenance and inspection. All airline operators, including regional carriers, should be invited. One topic would be to assess the desirability and appropriate means for institutionalizing this industry meeting. While there might be some invited speakers to discuss new technologies or comparable matters, a good part of the meeting should be set aside for panel discussions led by an industry member and open to all other members.
2. The FAA should consider means for encouraging or developing a data base of industry information concerning maintenance technologies, procedures, and problems. An FAA-sponsored Clearinghouse for Maintenance Information would be of great value to the industry. Apparently over the last several years the Electric Power Research Institute (EPRI) has been nuclear power plants. Possibly a representative of EPRI could describe this data base, and methods for developing a similar one, as one item in the FAA/industry meeting described in Recommendation 1.

Personnel

Recruitment/Availability. The airline industry has expanded rapidly in recent years with a consequent need for larger numbers of qualified maintenance and inspection personnel. Resources to meet these new staffing requirements have not always been there. This is true both for trunk carriers and for regional airlines. In fact, regional airlines may be even harder hit as some of their personnel move to major carriers. Commuters then must fill their ranks from maintenance schools, the military, and from fixed-based operators. The result os that, both for major carriers and for regional carriers, the workload is expanding and the experience level of maintenance personnel is decreasing. To illustrate, the following statistics apply to Inspectors for one major carrier.

46% have less than three years

22% have less than two years

12% have less than one year

This is in an operation in which the Manager of the Inspection Department estimates that it takes an inspector two years to become effective; six years to become efficient.

The result of the lowered level of experience for inspectors and mechanics is that work is done more slowly and more mistakes are made that must be corrected. An additional burden is placed on the inspector force.

Training Much discussion during the meeting centered on adequacy of training for maintenance personnel. Much of the problem was attributed to requirements for training established by the FAA in Part 147 of the Federal Aviation Regulations. Some parts of the initial training covered by Part 147 deal with woodwork, welding, fabric skin repair, and radial engines, all topics of little consequence for the carrier jet fleet. The A & P curriculum was generally viewed as inadequate.

Another problem is that avionics technicians who have completed an FAA-approved avionics school are treated differently than those who have completed an airframe and power plant school. For example, an Avionics Manager cannot be Director of Maintenance without acquiring an A&P license. However, an A&P license alone qualifies one to become Director of Maintenance, while understanding little about the microprocessors, integrated circuits, and sophisticated avionics which are critical to modern aircraft.

The general dissatisfaction with Part 147 should be tempered by the knowledge that the FAA currently is reviewing this document for change. One member of the training establishment offered the suggestion that during this period of change consideration be given to expanding coverage to include topics covering professional ethics, professional communications, and personal commitment to one's job. He felt that such training could be of considerable value in expanding the professionalism of maintenance personnel in the next decade.

One suggestion for improvement was that training be expanded to include certain post-graduate specialty programs. Such programs would be added to the existing curriculum and would be elective. This would be one way of dealing with such issues as the fact that at this time no training is required for helicopter maintenance. Also, advances in nondestructive testing (NDT) technology and procedures have exceeded the number of qualified NDT personnel. One of the graduate courses might include use of such advanced test systems.

Training for maintenance personnel is ongoing, extending to some extent throughout their career. For example, one operator has five percent (5%) of the inspector force in formal training at all times. During such training, maximum use should be made of new training technologies. For instance, videotapes produced in-house are now being used by one carrier to illustrate compliance with latest Airworthiness Directives. This carrier is quite pleased with results of its video program. This and other technologies should be used industry-wide.

Licensing/Certification. The issue of "type rating" mechanics in different aircraft was raised as means of ensuring that a mechanic's qualifications are appropriate for the aircraft on which he works. Aircraft are becoming more sophisticated; helicopters are extremely complex; and avionics systems represent the very latest in technology. At this time, airline operators, in keeping with their insurance coverage, limit the duties of certain mechanics to their experience level. However, no regulation covers this. A suggestion was made that current licensing procedures, particularly with respect to avionics technicians, be reviewed and that consideration be given to the establishment of new levels of licensing and certification. The Canadian Aviation Regulations, which require licensing by aircraft type for mechanics, was cited as a possible model.

Discussions among all attendees brought forth pros and cons concerning increased licensing or certification. Concern was expressed over additional layers of regulation. However, if new licensing techniques would add to the quality of maintenance, they would meet with approval.

Recommendations

1. The current review of Part 147 should be expedited as feasible. Results should include provision for specialization training as a formal and advanced part of the curriculum of approved schools. As part of this effort, consideration should be give to current licensing procedures for avionics technicians. These procedures should be revised consistent with the growing role of avionics personnel in aircraft maintenance. The result of all of this will be a better entry product into airline operations and the resolution of some current job problems.
2. Consideration should be given to ways of promoting aviation maintenance as a career. The FAA can play a useful role by encouraging or actually developing some promotional materials. Are brochures describing aviation maintenance available for distribution at the high school level? Is there an up-to-date video which describes the profession and its rewards?
3. Should there be another meeting of this type, as recommended earlier, "training technology" should be a key topic. The FAA should invite some expert who is familiar with all of the latest training systems to conduct this session.

Job Pressures

Time pressure, also known as "gate time," is considered by many to be the most important factor affecting performance of mechanics and inspectors. Management and the mechanic force have the pressure of getting the airplane to the gate on time. Inspectors have the pressure of being certain the aircraft is airworthy. Inspectors have the pressure of being certain the aircraft is airworthy. The conflict between these two driving pressures can produce an adversarial relationship which does not benefit either side.

Ground time available for maintenance also can produce job pressures. Striving for higher aircraft utilization means that more maintenance must be accomplished in fewer hours, with these hours frequently being at night. Under these conditions, the need to meet an early a.m. departure time can again cause friction between the maintenance and inspection groups.

The consensus is that inspectors must be insulated from production and from all the rest of maintenance, yet these groups must complement one another. In some operations, this insulation is expressed in writing and supported verbally. Yet the pressure for on-time service inevitably will cause some group dissonance. The objective is to insure that such dissonance does not seriously impact the performance of either group. One way, of course, is to have inspectors and mechanics report to management through different organizational chains. Even here, however, the pressures remain.

Another factor impacting job performance is fatigue. Young mechanics just out of school who may be starting a family find it difficult to do son on entry wages. As a result, they take a second job and are quite fatigued by the end of their maintenance shift, particularly if it is the night shift. In other instances, the shortage of mechanics requires overtime work which itself contributes to fatigue. All of this tends to make maintenance personnel more error-prone.

Recommendations

1. All parties should consider ways to insulate inspectors from management and from the rest of the Maintenance Department. Inspectors should not feel the "gate time" pressure. With older aircraft, it is particularly important that inspector performance be of the highest quality. This might mean a review of inspection tasks to see how many, if any, might be shifted from ongoing maintenance activities to the longer schedule maintenance visits, where gate time is a more distant concept. Supervisor personnel should be given some training in the detection of fatigue and its insidious effect on work performance. If fatigue appears to be a constant problem, some rescheduling of maintenance activities might be considered. The first step, of course, is to determine whether fatigue is or is not a problem.

Performance Improvement/Job Design

Many individual variables can be considered in a program to improve performance for maintenance personnel. A human factors scientist in attendance indicated that, for inspector performance, such variables include conspicuity of the signal (flaw), signal-to-noise ratio, length of inspection period, social atmosphere, and others. Pursuing this list, in effect, constitutes job redesign, which has high potential for performance improvement. A proper job redesign, however, would not consider each of these variables separately.

A full job design, or redesign, would begin with a specification of overall system objectives and the contribution of the human. The human would be considered as one system component with the designer's job then being one of matching other system elements to the human. This is done on the basis of a task analysis of operator activities. The task analysis points to man/machine mismatches, workloading of the human, and many other variables related to performance. A meaningful job redesign requires a task analysis as a starting point.

An important product of a task analysis is a description of the kind of performance feedback required and the manner in which it should be presented. Human factors scientists noted that feedback must be complete, relevant, and timely to be effective. However, the requirement for feedback is highly dependent on the nature of the task. In one study for feedback is highly dependent on the nature of the task. In one study cited, performance in a visual inspection task was markedly improved simply by providing feedback concerning the inspector's performance more rapidly. The importance of feedback to job design was very apparent.

One attendee noted the need for a research center, or at least a coordinated research effort, which might be dedicated to studies of job design and aircraft design and the contribution of each to maintenance error. He noted that there is no place where regulatory agencies, operators, and manufacturers can team together to examine concepts and other variables assumed to play a part in maintenance effectiveness.

Recommendations

1. Consideration should be given by the FAA to an effort in which a task analysis could be conducted both of maintenance performance and inspection performance. To be useful, such an analysis need not describe performance on a second-by-second basis. It should be done in sufficient detail, however, that the physical, perceptual, and mental aspects of the task can be reviewed. Input/output requirements and task loading must be defined. In all, the task analysis should be conducted in sufficient detail that results can feed directly into computer-based efforts to model maintenance and inspection performance.
2. The suggestion concerning development of a research center where maintenance concepts might be studied in detail warrants careful review. In as much as either the FAA Technical Center or the Civil Aeromedical Institute could undertake such a program, no new facilities would be needed. An additional task element to either facility, with appropriate guidance and funding, could initiate this research center.

Maintenance Information

Effective maintenance is predicated on a continuing flow of information. The information supporting maintenance must be timely, accurate, appropriate to user requirement, and in a form readily understood. A number of comments indicated concern over the adequacy of maintenance information today.

The demand for new generation aircraft apparently has resulted in aircraft being placed in service before a full technical support program can be developed. One consequence, according to regional air carriers, is that maintenance manuals are inadequate. They leave much to be desired in terms of wear limits, damage limits, repair schemes, and adequate or accurate wiring diagrams. As a result, operators must frequently make requests of manufacturers for repair limits, repair schemes, and other relief. This information is only forthcoming after it has been developed by engineers and approved by FAA representatives. This causes delays in the provision of good technical information and is a source of frustration. Maintenance personnel are precluded from proceeding with subjective repair judgments which might conflict with later maintenance documentation.

Where a number of individuals are doing the same work, standardization of information is essential. Although there is an ATA system which specifies a standard format for finding material in a maintenance manual, the material itself differs among manufacturers. Maintenance manual, the material itself differs among manufacturers. Maintenance and inspection manuals themselves are not standard in terms of shape, size, of format. Standardization of language requires additional work. For example, turbine temperatures for different aircraft are expressed as: EGT, T4, T5, TIT, and TOT. Although areas of pickup on the engine may differ, all of the figures produce the same information. Standardization of format and language would be of value.

The aviation industry well recognizes the need for proper maintenance information. In an effort to improve the situation, several years ago the Douglas Aircraft Company developed an "Advanced Maintenance Information Packet." In this, maintenance tasks were presented in sequence, with accompanying graphic presentations, with cautions and warnings, fit into the sequence, and with tools and special equipment identified prior to the task. Tests showed a considerable reduction in errors when this packet was used.

The Boeing Company, in another program to improve the situation, developed an Automated Customized Task Card. In this system, material from the maintenance manual is computerized, thus eliminating the task card reader and the microfilm reader/printer. Material now is accessed directly from the computer and is more readily available. Errors encountered previously in preparing data for the mechanic have now been eliminated.

Many attendees noted issues with Service Bulletins. These bulletins, prepared by the manufacturer and reviewed by the FAA, are used to identify aircraft problems and maintenance needs after the airplane has entered service. They are prepared by engineers and con be complex, often using language more meaningful to engineers than mechanics. The Boeing Company is attempting to improve these bulletins by using "Simplified English." Apparently, however, much remains to be done by the industry at large with respect to Service Bulletins.

In an effort to extend the state-of-the-art of information presentation, the Air Force has been working for some years on an Integrated Maintenance Information System in which needed information is provided to a mechanic directly at the flight line through use of a video display. Through this display, the technician can access a number of different data bases to support his immediate requirements. In the preparation of this system, scheduled for field testing within the next few years, the Air Force has addressed many of the human factors issues involved in preparation and delivery of maintenance information.

Recommendations

1. Any program to improve maintenance performance must address the issue of adequacy of maintenance information. Technical documentation to support maintenance must be accurate and timely, must meet the needs of the user, and must be presented in a completely intelligible format. The FAA should review its surveillance of maintenance manual preparation to ensure that proper technical data are supplied to operators, particularly concerning wear limits, damage limits, and repair schemes.

2. The FAA should sponsor a program to collect and categorize information on research activities pertaining to maintenance data. We know of other industry initiatives or of relevant research outside the aviation industry. Should there be another meeting addressing human performance in aviation maintenance, one session should be devoted entirely to "Requirements and Advances in the Improvement of Maintenance Information."