Conclusions and Recommendations

The exchange of information within the industry responsible for the maintenance of the U.S. air carrier fleet must be accurate, efficient, and responsive to the particular needs of this industry. Since deregulation of the airlines in 1978, the industry has grown rapidly and has become more diverse. New aircraft types have been added to the fleet, with many coming from foreign manufacturers. Older aircraft, which in former years would have been retired after 10 or 15 years of service, are being kept in use. As a consequence, there is a new problem facing the maintenance community, that of the "aging aircraft." All of these factors place new and growing demands on aircraft maintenance organizations and on communication systems to support their efforts.

Attendees at this two-day meeting represent all segments within the air carrier industry, including regulators, manufacturers, and operators. During the two days, attention was given exclusively to issues of information exchange and communications. Recommendations for improvement were offered during formal presentations, during ensuing discussions, and during a final "summing up" period. The following recommendations represent a grouping of attendee suggestions according to broad topics, with specific recommendations included within each topic.

Management of Maintenance Data

The documentation required for maintenance of the U.S. air carrier fleet is voluminous and is growing. This documentation supports a triad consisting of the Federal Aviation Administration, aircraft manufacturers, and airline operators. The flow of data within this triad is complex and multi-directional. Manufacturers require feedback from operators to determine acceptability and reliability of their product and its components. Airlines require product support information from the manufacturer. The FAA requires data from both the airlines and the manufacturers concerning product reliability and safety issues to support its industry surveillance role. The Air Transport Association (ATA) plays an important role by coordinating the flow of data among the three triad members.

The sheer volume of maintenance documentation is impressive. To illustrate one type of this documentation, Boeing maintains some 1,126 active manuals for 5,300 airplanes and 425 operators. At these levels, the management of all forms of maintenance documentation -- notices, directives, manuals, etc. -- becomes very challenging. For these data to serve their intended purposes fully, a carefully planned and operated data management system is essential. This system should include the collection, analysis, dissemination, and storage of technical information supporting aircraft maintenance.

Database Development.

A central data base for maintenance information would have many values. It would serve as a central repository, thereby making maintenance information equally available to those in both large and small aviation operations. It would offer immediate accessibility to information needed on an urgent basis. Also, and of considerable importance, a central data base, containing information from all segments of aviation, could support a variety of safety studies and analyses of safety trends.

Aircraft manufacturers and airline operators maintain a number of computerized data bases to support their individual needs. The closest to a national data base is that maintained by the Federal Aviation Administration which contains Service Difficulty Reports. These reports are required of airlines and detail events which occur in-flight or on the ground prior to flight. While the SDR data base generally supports the needs of the FAA, it is not particularly useful for the airline industry. By the time SDR reports become available, those airline operators with a particular interest in a problem have learned of the issue through an informal and more expeditious system. Also, the output at present is somewhat weakened as it is non-specific. A user needs to be able to query the SDR data base for specific information rather than having to peruse an enormous print-out. If the central SDR data base of the FAA is to achieve its full potential, it must be expanded and improved to a point where the informal data exchange system no longer is needed and where airline or aircraft-specific information can be obtained.

An improvement program for the SDR data base also should consider issues of data capture and data consistency. At this time, a problem indication below the legal reporting threshold may be lost. Thus, (1) the next inspection must rediscover the problem, if it can, and (2) other interested parties are unaware of the problem. In addition, there is a measure of inconsistency in the way in which operators interpret SDR data reporting requirements.

The need for an efficient database structure by the airline maintenance community has its parallels in the nuclear power industry. Under the auspices of the U.S. Nuclear Regulatory Commission, considerable progress has been made in the development of data bases to support nuclear power operations. One such data base, the Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR), contains data concerning both equipment and personnel and deals with both operations and maintenance. This system contains raw data describing both equipment and personnel performance and probabilistic data describing error likelihood under specified circumstances. The logic and procedures used in developing the NUCLARR data base could be of considerable value in any expansion of the FAA SDR data base.

Recommendations

1. The movement toward a central data base to support aviation maintenance should be expedited as feasible. The Air Transport Association, operating through its Improved Airworthiness Communications Systems Committee, has as one goal using information within the FAA Service Difficulty Reporting System to create an analysis loop for the airline industry geared specifically toward maintenance needs. This is a valuable initiative.

Certain requirements and cautions are in order in the development of a central data base. Access must be immediate and available to all individuals and organizations concerned with aviation maintenance. Data should be in a form so that safety and trend analyses can be done quickly and without major data transformation. The data base should include human factors data describing human reliability in various maintenance activities. Finally, developers of the data base should always be cognizant of a basic law presented by one of the meeting attendees: "The effectiveness of a maintenance program is in direct proportion to how well the mechanic accomplishes his task -- independent of the associated computer system." The data base must be oriented to the needs of maintenance personnel and not to the underlying computer system.

2. The FAA should examine in detail the logic and procedures used by the U.S. Nuclear Regulatory Commission in its development of the NUCLARR data base. Insights obtained by doing this could be of considerable value in an expansion of the FAA Service Difficulty Reporting System. This is particularly true concerning the manner in which human performance data are entered and procedures for establishing probabilistic descriptions of human reliability.

Quality of Maintenance Data

Maintenance data must be usable for all maintenance personnel, whether they be managers planning for a "heavy check," or mechanics doing a flight-line repair of a hydraulic system. Maintenance information also must maintain a consistent format as it proceeds through the system. Data generated by a manufacturer to describe a maintenance action should not be changed in format or meaning as it works its way to the mechanic on the floor.

The preparation of maintenance documentation takes place at many points in the maintenance system and involves many individuals of varying backgrounds and skills. At the manufacturer, engineers and documentation specialists prepare Service Bulletins, changes to the Manual, and other messages for airline operators. Working with the Federal Aviation Administration, Airworthiness Directives are prepared. Since ADs require a legal review, lawyers now are involved in the writing process. As a result, according to one operator undoubtedly reflecting an industry consensus, "Airworthiness Directives are not always clear-cut and easy to understand."

One approach being taken to improving the readability and understanding of technical documents is the development of "Simplified English." Interest has been expressed by manufacturers, operators, and the FAA in the development of a limited vocabulary for technical writers and engineers which is accepted through the industry. A standardized language would do much to remove elements of confusion from technical documentation. In an example provided by Boeing, a "hatch" is always a hatch. Technical writers and engineers cannot refer to it as a "door," a "panel," a "limited access area," or any of the many other designations. Under all circumstances, access is through a "hatch."

Boeing Commercial Airplanes is using a limited and standard vocabulary developed by AECMA for its documentation activities. Other organizations are pursuing a similar approach. At Boeing, the Writing Guide includes an artificial intelligence unit which, in addition to checking spelling, also reviews writing rules and saves an engineer from having to do this review. This is a real step forward in the improvement of maintenance documentation and the quality of maintenance data elements.

Recommendations

1. While "established" ways exist for the preparation of most maintenance documentation, there are no standards. In recognition of this, the Communications Committee of the Air Transport Association has, as one long- term objective, the development of a standardized technical data system. Such a system offers much in terms of improving communications and maintaining a high level of reliability in maintenance operations. The FAA should support the development of this system and consider specific projects to develop and evaluate standardization procedures.
2. A number of initiatives are underway to establish a Simplified English for use with maintenance documents. Aircraft manufacturers have done some of this; research sponsored by the Air Force has prepared other lists. The FAA, possibly working through the ATA Communications Committee, should give impetus to the development of a single Simplified English. This list then could be distributed through the U.S. industry and also through foreign manufacturers, where it would be quite helpful. In any event, every effort should be made to avoid multiple versions of Simplified English.

Transmission Efficiency

Maintenance information must move swiftly through the system if it is to serve its purpose fully. Delays in generating or transmitting maintenance documents impact maintenance performance and reduce effectiveness. Several speakers commented on the length of time required to get technical data to an operator. If a Designated Engineering Representative decides that a change in technical data is necessary, an average of about six months is required for the changes to be made and the information then sent to the operator using the aircraft. Once at the operator level, there is another delay before the manufacturer's information can be incorporated into his manuals.

Another problem relating to delays in processing of information concerns the Service Difficulty Report data base maintained by the FAA. The purpose of the SDR system is to collect information concerning aircraft difficulties on an industry- wide basis and then analyze this information as a basis for appropriate corrective action. However, these analyses proceed too slowly to serve their avowed purpose. By the time an analysis of significant SDR findings is completed, the industry is aware of the problem and has taken corrective action. The value of the SDR system could be increased significantly if it could work in a more timely manner.

Recommendations

1. New procedures to improve the flow of maintenance information must be developed. Needed information should be prepared expeditiously and transferred by electronic means. At this time, some 37 airlines obtain their maintenance manuals, or some portion of these manuals, on magnetic tape from Boeing. This is a beginning toward a complete electronic system. However, a truly satisfactory system will require that all tramsmissions of maintenance information, particularly those with safety implications, be done electronically. Movement in this direction should be encouraged.

2. The Service Difficulty Reporting System must provide needed information more rapidly. This is particularly true for analyses which show maintenance trends. Software should be developed for the SDR data base which will perform a fixed number of commonly required trend analyses upon request, with rapid distribution of trend results.

Maintenance Manuals

The printed manual has been the mainstay for aviation maintenance for years. While the format has changed little through time, the manuals have gotten bigger and more cumbersome to work with. While manuals serve a worthwhile purpose as a repository for data and as a reference source, they are not particularly useful for flight-line support. As a result, manufacturers and operators have turned to alternate systems such as Automated Work Cards and electronically generated copies of relevant portions of manuals. ATA has developed an automated Aircraft Maintenance Task Oriented Support System (AMTOSS) in which each task and subtask has a unique number identifier. Through use of this coding, an operator can collect all appropriate and related tasks described in different parts of the manual into one grouping. He can then build a basic work package.

The maintenance manual concept has been taken a significant step forward by the Air Force in the development of the Integrated Maintenance Information System (IMIS). This system integrates diagnostic and maintenance information and presents it to technicians at the flight line through a portable maintenance aid with a hypertext user interface. With this system, there is no need for a maintenance manual. All technical data, diagnostic rules, aircraft-specific information, etc. are presented as requested by the technician.

Another approach moving away from the traditional maintenance manual concept is the On-Board Maintenance Information System (OMIS) being explored by Boeing. This system will provide all required data to support ramp and flight line maintenance on a given airplane. OMIS also will carry information concerning the maintenance history of the airplane on which work is being done. All necessary information for maintenance needs will be provided.

Recommendations

1. The movement toward electronic maintenance information systems represents a significant advance and should be fostered by whatever means feasible. However, the rules for effective presentation of information remain the same, whether the presentation is in paper or electronic form. The FAA should consider the development and publication of a brief document containing an explicit list of guidelines for the preparation of maintenance manual-type information. This document should be based on the guidelines discussed at this meeting and should be distributed to aircraft manufacturers and interested documentation specialists for review and coordination with recent ATA requirements.

Coordination with Air Transport Association

The Air Transport Association formed the Airworthiness Assurance Task Force to address problems of the aging airliner fleet. Within this Task Force is the Improved Airworthiness Communications Systems Committee. This Committee, which includes representatives from the Federal Aviation Administration, has been concerned with many of the same items addressed as Conclusions and Recommendations here. For example, one goal of this Committee is to develop a standardized technical data system. Another goal is to address the role of human factors in aircraft maintenance. As one can see, the goals of the ATA Committee and those of this meeting are closely allied.

Recommendations

1. The FAA Program on Human Factors and the ATA Committee on Communications maintain close coordination. Others interested in specific topics addressed in this meeting should contact the ATA Communications Committee to learn of its agenda and its conclusions to date.

Human Factors

Topics of interest at this meeting focused on maintenance data, technical documentation and industry communications procedures. While human factors are very much a part of each of these topics, little reference was made to some of the more traditional areas of interest within human factors, such as:

Use of visual displays

Information processing

Performance measurement

Feedback requirements

Decisionmaking

The extent to which topics such as these affect maintenance performance and are related to maintenance communications is not known. One can assume that each topic represents a variable underlying maintenance proficiency.

As reported at this meeting task analyses are being performed for an array of maintenance actions as part of the FAA Human Factors Program. At the conclusion of these studies, considerable information will be available concerning the role and influence of traditional human factors variables in maintenance performance.

Recommendations

1. Results of the Human Factors Task Analyses should be reviewed as studies are completed to assess the manner in which any of the recommendations presented here should be modified or expanded to incorporate the new findings.