16.0 ERROR MANAGEMENT IN A 3RD PARTY REPAIR STATION

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The 1996 Federal Aviation Reauthorization Act created the National Civil Aviation Review Commission. The legislation charges the Commission with considering future Federal Aviation Administration budget needs and appropriate financing mechanisms, as well as suggesting productivity and safety improvements. On December 11, 1997, the commission issued a report titled **Avoiding Aviation Gridlock and Reducing the Accident Rate, A Consensus for Change.** The following recommendation is included in the executive summary of that report:

"Aviation safety programs in industry and government need to be improved by establishing more effective safety risk management programs. This should include self-audit and self-disclosure programs within aviation companies, protecting and sharing safety information in non-punitive ways, and encouraging research to support these activities. Where possible, these programs should include the analysis of real flight and operational data. The aviation community must look deeper than accidents and incidents to identify latent and emerging problems and fix them before a mishap occurs. There needs to be a willingness in government and industry to invest in new ways of doing business. This will require changes in the traditional regulatory relationship so that tools beyond the simple enforcement of rules are available to improve safety."

INTRODUCTION

The concept is simple: pay close attention to the cause of errors; use a structured investigation process to identify contributing factors; analyze the data to look for trends; develop corrective actions that focus on the contributing factors; and make sure the results are disseminated.

Why, then, are programs such as those referenced in the above recommendation of the National Civil Aviation Review Commission still in their infancy? The problem involves many issues, including corporate inertia, hesitance to be first, sensitivities about data sharing, and the enforcement bias of the regulatory authorities--all of which a few individuals can do little about.

This problem becomes even more complex in the 3rd party maintenance industry, where it is expected that the maintenance process fall in lock step behind that of the air carrier. If the carrier is not ready for a maintenance provider to include them in an error management program, there is little chance of success.

The challenge, therefore, is to recognize the reality of the National Civil Aviation Review Commission recommendation and begin building an error management program that moves us, however slowly, toward our safety objectives. This paper describes such a first step and provides some suggestions that have thus far shown signs of success.

The growing international focus on maintenance error reduction strategies has made many new training, investigation, analysis, and corrective action tools available to the maintenance provider. An error management system, however, must go beyond the sporadic application of individual error reduction concepts to ensure that the system is properly tailored for the environment in which it is to function.

The ideas that follow form the basis of the Error Management System currently in use by the Airframe Services Division of BFGoodrich Aerospace. It was developed by taking advantage of available error reduction techniques and integrating them into the unique 3rd party maintenance environment.

This system has been in use for approximately ten months and is already showing modest improvements in error rates. It is, however, not the only way to manage and reduce errors. Other maintenance providers are using very different systems. The key is to begin some form of error management program as soon as possible so that the safety improvement process can begin.

DEVELOP A CORPORATE ERROR MANAGEMENT PHILOSOPHY

For an error management program to succeed, a maintenance provider's safety objectives must become an integral part of corporate culture. Every person in the company must recognize that safety and error reduction are as important to their collective success as administrative or financial objectives. To accomplish this it is important to understand that safety and economic success are not separate issues. Once it is generally accepted that fewer errors not only improve safety but enhance the economic performance of the maintenance provider and airline alike, a simple error management philosophy will emerge.

A corporate philosophy can take the form of a written statement, a motto, or simply be a message consistently supported by company leaders. The philosophy may be different for each company, but it should make up the underpinnings for each aspect of the error reduction program. In doing so, it should continually reinforce the importance of the economic health of the company and include the idea that diligent attention to human factors in maintenance error reduction, and improved financial performance, go hand in hand.

'Human factors' is a term, however, which is overused and under defined. For the purpose of establishing an error management philosophy, it should be clearly defined as an intervention strategy focused upon improving the opportunity for the maintenance technician to make the right decision and to perform the task properly. To implement this idea, communication with the technician and the active involvement of the technician in the error management program are of utmost importance.

ERROR MANAGEMENT PROGRAM BARRIERS TO 3RD PARTY MAINTENANCE PROVIDERS

A 3rd party maintenance company is similar to an airline maintenance department in many ways. Obviously the same basic maintenance manuals are used, the same civil aviation regulations apply, and human frailties which cause errors in any organization are always present. There are, however, a few significant differences or barriers which can impede the implementation of an error management system in a non airline environment.

These barriers are, for the most part, inaccurate perceptions often held by Repair Station upper management about how the implementation of an error management system will effect the financial aspect of the business. Though such perceptions will be overcome as the basic objectives of an error management system are better understood, it is nonetheless important to recognize the types of barriers that can develop in order to anticipate and minimize their potential effect.

Start up barriers of a 3rd party maintenance provider error management program can fall into any of the following categories:

- Concern about non compliance with air carrier maintenance programs.
- Conflict with an existing air carrier error management approach.
- Airline concern about uncontrolled data sharing.
- Questions about applicability, since all current error management research and experience is airline derived.
- Concern about government access to information and subsequent enforcement action.
- Concern over the possible negative message that an error management program start up sends to customers and authorities.

RECOGNIZE UNIQUE ERROR MANAGEMENT ISSUES FACED BY 3RD PARTY PROVIDERS

Any error management program must begin with a clear recognition that the maintenance provider plays a significant role in the continued airworthiness of the aircraft maintained, and that the maintenance process has as great an impact on safety as airplane design and operational influences. This belief must then be transformed into a maintenance safety objective designed to: 1. identify through research, proven error reduction strategies applicable to the type of maintenance performed; 2. participate in and learn from industry organized efforts to develop new error management strategies; and 3. incorporate the results of these efforts into company error management programs and measure the resultant impact on maintenance safety performance.

As these objectives are carried out, an error management system will emerge as a best fit for each unique user. As BFGoodrich Aerospace evaluated various error reduction strategies, the benefits of the application of human factors concepts to airplane maintenance surfaced as the single area having the greatest potential to aid in the improvement of maintenance safety. It also became clear that the advantages of a maintenance human factors program apply equally to both 3rd party maintenance providers and airlines. A maintenance contractor, however, must serve many airline customers requiring that the program be compatible with or at least acceptable to each customer.

A 3rd party maintenance provider should, therefore, design their error management program to take advantage of human factors concepts and to be compatible with their customers' flight safety focus, as well as ensure full compliance with each customer maintenance program. This may not be a simple task due to the political and legal sensitivities of sharing data and reporting errors.

The system-wide solution to this potential barrier must, therefore, begin by focusing on issues common to all maintenance programs, thereby initially avoiding most data sharing problems associated with specific airline customers. This process has been referred to as adjusting the maintenance error identification threshold. A low threshold error management program focusing on errors such as miss-drilled holes would be welcomed by most airlines, while a high threshold program that includes task card inadequacies and major repairs caused by errors may not be compatible with airline data control policies. The following are a few examples of high threshold error categories upon which a new 3rd party maintenance error management program could be based without raising the concern of the airline customers:

- Compliance with applicable Civil Aviation maintenance regulations. In many maintenance organizations a surprising improvement in error rates can be achieved by focusing on such basic regulatory requirements as ensuring adequate documentation of maintenance, referring to technical data, and maintaining technical competence to perform the task.

- Adhering to general maintenance manual procedures. General maintenance manual procedures vary greatly between carriers. A procedure or maintenance process required by one carrier may be considered an error if used in conjunction with another carrier's maintenance program. Training and verification to ensure appropriate application will reduce errors.

- Observing industry standard practices. Procedures common to all customers, such as fastener installation or lubrication techniques, can make up part of an error management program without infringing on carrier-specific processes.

- Maintaining housekeeping and cleanliness standards. Quite often a significant contributing factor in many system or C.A.S.E. type audit findings involves simple lack of organization.

CREATE AN ERROR MANAGEMENT PROGRAM DEFINITION

Once appropriate attention has been given to establishing an error threshold, an error management program definition or template must be defined. This template should provide a program road map or guide through the error management process.

As error management strategies are considered, it will become clear that there is no simple "off-the-shelf" comprehensive error management program available. Although a significant amount of work has been accomplished in developing new approaches to human factors training, a meaningful maintenance error reduction program must also include classical investigation, analysis, communication, and measurement components for it to be successful. The error management road map which emerged at BFGoodrich Aerospace focused on the following six primary components:

A structured human factors based error investigation system

The error investigation process selected is of significant importance to the overall success of the error management program simply because it reveals the problem area. There is a great deal of research and experimentation underway by airlines, the regulatory authorities, and a few independents to test existing systems and develop new ones. Maintaining an awareness of these new developments in human factors investigation techniques can be accomplished by participating in industry working groups and symposiums focused on maintenance safety. The Society of Automotive Engineers, the Air Transportation Association, the Federal Aviation Administration and the National Transportation Safety Board have all sponsored efforts in this area and are willing to provide information by mail or through Internet sites.

BFGoodrich Aerospace selected the Boeing Maintenance Error Decision Aid (MEDA) because it is easy to use, focuses on human error based contributing factors, and is supported very well by its creators.

Validation of investigation results

If the investigation is successful in identifying human factors oriented contributing factors, a validation process should then be conducted to confirm the findings and reveal how widespread the problem is. If an error is truly isolated to a maintenance crew or individual, appropriate corrective action would be far different than that for a problem which is determined to be systemic. This is of even greater importance in a 3rd party maintenance environment, where isolation of a recurring maintenance error to a specific airline maintenance program, or verification that it exists company-wide, is critical to the success of the design of the corrective action. Validating investigation findings, however, must be focused on the contributing factors--not the error itself--and routine information collection techniques like written statements and incident orientated investigations will quite often prove to be inadequate.

BFGoodrich Aerospace has adopted a series of special audits, inspections, and evaluations to form the basis of the validation process. We first thought that extensive research and training would be required to develop these methods; however, through trial and error we found that procedures, some complete with checklists in place, were readily available. Some ideas came from our customers, others from the FAA. The lesson learned was that checklists used by customers and regulators not only prepare a maintenance provider for eventual audits and inspections, but can form a ready-made validation procedure.

Validation techniques currently showing promise fall into the following three categories:

- Unscheduled "FAA type" audits and spot checks, using FAA guidance and checklists, conducted by small three-man teams comprised of both Quality Assurance and maintenance personnel.
- Maintenance procedure checks, called “operational audits,” designed to evaluate the performance of small or large maintenance tasks. (A major airline customer of BFGoodrich Aerospace already had procedures and checklists in place to accomplish this.)
- Focused scheduled system audits patterned after C.A.S.E. procedures and checklists are not only scheduled on a recurring basis, but are tailored around Quality Assurance issues identified during error investigations.

Data analysis

So far none of the components of the error management process requires a computer or a data base management system. In fact, if your error threshold is set high and you do relatively few investigations, computerization should not be necessary. Data basing can, however, be beneficial in large organizations where many users require access to the investigation data for corrective action purposes and where the number of investigations conducted exceeds the memory retrieval capability of the average human brain.

Computerizing the investigation process has also been shown by one company to assist greatly in the investigation documentation process by using advanced programming and search concepts to simplify the entry of standardized descriptive data. This assures more accurate categorization and, therefore, retrieval of contributing factors trend data.

The disadvantage of computerization in a 3rd party maintenance environment is that individual airlines worry that data may not be secure, and that regulators and or competitors may gain unwanted access. A second problem resulting from computerized data sharing involves a customer concern that a unique airline customer problem may become an issue for all airlines doing business with that maintenance provider.

As the investigation data base grows it becomes immensely important to track, analyze, and trend numerous error related facts and resultant contributing factors, including: time of day, maintenance line, ATA code, nomenclature, interview text, and aircraft type. Relying on memory, or support staff, will soon become inadequate. At that point you have two choices: buy a data base system or build your own. Purchasing is fast, but incurs cost and reliance for outside support; building your own system takes time and skill that you may not have.

BFGoodrich Aerospace elected to build their own system, simply because the company's needs could not be satisfied with a commercially available system at a reasonable price. The process required approximately 90 days (part time) with minimal programmer consultant assistance, and provided a very flexible system that can be changed as needed. The program is based on a well known data base management system and is formatted around the Boeing MEDA investigation technique. It resides on the company's network, and can be accessed through any personal computer. It also incorporates an occupational safety investigation and analysis tool.

A management backed corrective action system

Once an error is investigated and the contributing factors are identified, a corrective action plan must be developed. This is a commonly understood element of every continuous improvement process that both the regulatory authorities and repair station airline customers demand.

This process must now become part of the error management system so that corrective actions are focused on contributing factors identified during the investigation and validation phases. An essential element, however, is 100 percent backing of the corrective action process by senior management. This is necessary to assure the work force that management buys into the error management system and supports the necessary corrective changes. Without this management visibility, the entire error management philosophy may not be taken seriously by the work force.

Organizational responsibility and accountability for the development of corrective action plans should reside with the technical departments cited in the finding or concern. The plan should then receive management scrutiny as well as a follow up review after implementation. Each corrective action plan should include the following elements:

- Identification or description of the error.
- Analysis of objective evidence obtained during the investigation and validation phases to determine the root cause(s) of the error.
- Identification of planned corrective steps to address the factors contributing to the error.
- Implementation schedule, including a time frame for putting corrective steps in place.
- Identification of individuals or departments responsible for implementing the corrective steps.
- Follow up status reporting requirements

A metrics system to track the success or failure of correction actions

In a busy maintenance organization, there is no greater waste of time than corrective actions which do not solve problems or will not be used. To ensure that the error management program is providing positive results, the repair station should publish and distribute program performance information.

Preparing metrics information does not require complex data analysis procedures, nor should it be confused with an airline reliability program. It can be as simple as a bar chart plotting the number of like errors against time. The primary objective is to ensure that improvement, or lack thereof, is visually evident.

Collection of this data should also be kept simple to avoid non value-added effort. BFGoodrich Aerospace collects this information through the error investigation and validation process, and as a part of normal in-process and pre-delivery inspections. In addition, some information on the performance of the airplane during its first few weeks or months of service is provided by the airline customer's operational tracking system.

Examples of sources of metrics data include the following:

- Internal Quality Control identified pre-delivery discrepancies.
- Customer identified pre-delivery discrepancies.
- Post delivery operational performance evaluation (reliability).
- Records accuracy tracking through audits.
- Crew reported maintenance problems.

A feedback/ training system to ensure the results are disseminated to the work force

The final and most important step in the error reduction process is to ensure that the work force benefits from the information generated by the error management system. This is the only consistent way of effecting change. If the maintenance technicians are made aware of the impact of corrective actions, they will be able to make adjustments to ensure long term success.

The results of special inspections, the success or failure of a corrective action--or simply the fact that an error occurred--is of great value to a technician. It is important to keep in mind the core idea of a human factors based error management program, which is to provide the technician everything he or she needs to do the job right the first time. Information dissemination is the key to this process. Information flow and training addressing at least the following subjects has been found to be effective at the BFGoodrich Aerospace heavy maintenance facility:

- Error investigation and corrective action feedback, the latter of which can be accomplished through the distribution of reports or special presentations at crew meetings.
- FAA regulation and policy reviews. It is often underestimated how valuable a recurring refresher course in the basic content of the regulatory requirements can be. An improved knowledge base here allows technicians to better interface with regulators and to understand the “why” of many basic maintenance controls.
- Leadership training incorporating human factors concepts. Human factors based error reduction strategies should be integrated into company training and leadership development programs and into the development of corrective actions. Education programs should be offered that are designed to enhance awareness of the effects of human factors issues on maintenance error reduction. Sometimes referred to as Maintenance Resource Management (MRM), this education concept includes focus on human performance, situation awareness, error chain recognition, stress management, communications, assertiveness, and team synergy.
- Maintenance error investigator training (MEDA). A significant improvement in the quality of BFGoodrich Aerospace’s investigation reports resulted when investigators received formal training, including an explanation of how the process was developed and how to conduct interviews. Should you elect to use the MEDA process, Boeing provides an excellent on-site initial training course.
- Specialized "FAA oriented" auditor/inspector training. In the preceding section, “Validation of investigation results,” the benefits of using regulatory authority inspection techniques and checklists were discussed. Some training on how to use this information is warranted; available sources include former regulatory personnel, or participation in government provided training programs.

DEVELOP A PROACTIVE MAINTENANCE SAFETY CULTURE

For the error management program to be a success, its components must become a visible part of everyday corporate life. A cultural shift of this kind often requires that the error management philosophy be reinforced through talk and action on a daily basis. To accomplish this, the program must not only include training and visible management support, but company commitment must be consistently demonstrated by involving employees in all aspects of the process.

One means of providing this reinforcement is to continually look for expected behavior through scheduled follow-up reviews, special inspections, audits and evaluations. If these actions are tied to mandatory corrective actions or appropriate disciplinary steps, some behavior change is likely to take place as a result of expectation of enforcement--much like we all respond to traffic and tax laws.

An error reduction strategy must, however, be clearly communicated both to employees and customers if buy in is to be attained. Although improving safety, reducing rework, and enhancing financial performance are valid goals, the error management philosophy must be driven by actions and objectives that are tangible to the work force and visible on a daily basis. The following cultural shift strategies are currently being used by BFGoodrich Aerospace to direct the pursuit of the error management philosophy

- All company personnel, regardless of job title, are encouraged to learn about the maintenance safety performance of their company. This process must begin with senior management.
- All involved personnel are asked to participate in error reporting, audits, evaluations, and error or incident investigations.
- The repair station and the airline customer will share in the implementation of the error management system objectives.
- The FAA is encouraged to monitor the system rather than "inspect" it. This is currently a tall order in the United States since current “Partnership” programs in the 3rd party maintenance industry are at best experimental. It has been our experience that liberal use of the self disclosure process is the best avenue available to share information with the authorities without the constant threat of enforcement action.
- A structured disciplinary system is under development that recognizes the importance of obtaining information over punishment but does not tolerate deliberate or careless unsafe actions.
- Above all else, a successful maintenance safety culture should recognize that mistakes are normal, and that the error reduction process should always focus on factors that contribute to maintenance errors, not the person or the discrepancy.

DEFINITIONS

Many error management and human factors concepts are based on structured investigation, auditing, and data analysis mechanisms. Quite often the terms describing these mechanisms will be unfamiliar, or at least not clearly understood by all participants. Varying terminology becomes a larger problem when a 3rd party maintenance provider is performing maintenance for several airline customers, each with their own meanings for similar terms.

A glossary of definitions should, therefore, be developed as part of the program plan. The following key terms and phrases have been borrowed from various sources. They are offered as a starting point for any 3rd party maintenance provider error management program because these definitions are generally accepted airline industry wide.

- Airworthiness. The condition in which an aircraft, component, or part conforms to its FAA approved design and is in condition for safe operation with respect to maintenance status, wear, and deterioration.

- Error. Noncompliance with a customer maintenance program, a civil aviation authority regulation, or a company procedure that requires rework, causes an operational or schedule interruption, or results in a cost to the maintenance provider or its customer.

- Evidence. Evidence is a documented statement of fact, prepared by a maintenance error investigator, that may be quantitative or qualitative and is based on observations, measurements, or tests that can be verified. For the purpose of an audit or incident investigation, evidence should generally be in the form of technical documentation or reports that support an audit or investigation conclusion. These data are necessary to substantiate findings or concerns and to enable management or evaluators to determine root causes of, and contributing factors to, any reported findings.

- Controls. Controls are the procedures, responsibilities, and decisions used by an organization to ensure compliance with company, customer, or FAA standards.

- Finding. A finding is a conclusion that demonstrates noncompliance with a specific standard.

- Concern. A concern is a conclusion, supported by objective evidence, that does not demonstrate a finding, but rather a condition that may become a finding.

- Inspection. An inspection is the act of observing a particular event or action to ensure that correct procedures and requirements are followed during the accomplishment of that event or action. The primary purpose of an inspection is to verify that established standards are followed.

- Audit. An audit is a methodical, planned review used to determine how standards or requirements are being complied with.

- Evaluation. An evaluation is an anticipatory process, and is designed to identify and correct, or prevent potential findings before they occur. The evaluation process builds on the concepts of audit and inspection.

- Analysis. An analysis is a structured, sometimes analytical, review of all available data pertaining to an error or category of errors. The purpose of an analysis is to understand trends and to assist in the development of corrective actions.

RESPONSIBILITIES

The pragmatic approach to any new program or system requires that individual responsibilities be spelled out in the planning process. Even though such responsibilities are fluid, a formal assignment will send a clear message of expectations and often spark a healthy debate about where the responsibility really belongs.

The purpose of this section is to provide a simple example of an error management system responsibility distribution that incorporates the ideas presented above. A similar section should be included in any new error management system plan, and should identify the positions or departments within the organization that have the responsibility and authority to direct, perform, or participate in various aspects of the maintenance error management program:

- Quality Assurance will define and schedule investigations, audits, and special inspections.
- Maintenance will staff audit, investigation, and special inspection teams.
- Quality Assurance will lead scheduled audit and special inspection teams.
- Quality Assurance will identify and record any findings or concerns, and the evidence necessary to substantiate findings or concerns.
- Maintenance, Quality Control, or Engineering, as appropriate, will initiate, recommend, or develop action plans to provide solutions to findings or concerns.
- Maintenance will verify the implementation of actions and solutions within a specific time.
- Quality Assurance will communicate and coordinate all audit and special inspection activities with senior management, regulatory authorities and customer personnel on a regular basis.
- Quality Assurance will recommend, through the incorporation of investigation and audit findings, MRM education program content changes and additions to the Training Department.
- The Training Department will ensure the availability of MRM type educational opportunities for all personnel performing maintenance functions.
- The General Manager has the responsibility to ensure that the Maintenance Error Reduction Program is properly established, implemented, and maintained.
- The General Manager will conduct monthly Flight Safety Program Meetings to review program progress, and to ensure appropriate top management involvement.

RECORDS

Records documenting the actions and results of the error management program should be maintained and archived like any other maintenance record. Records are considered to be the principal form of evidence, and documented evidence is essential in analyzing and determining the root causes of maintenance errors. Evidence also substantiates the effectiveness of corrective actions so that improvements can be identified for broader application or for data sharing opportunities.

Error management program records may be maintained as part of the investigation data analysis system or in a separate location, but they should include at least the following types of data:

- Scheduled audit reports.
- Error investigation forms.
- Special inspection, audit, or evaluation reports, including the error trends or other reasons necessitating the actions.
- Follow-up evaluation reports.
- Responses to findings or concerns contained in reports.
- Corrective action plans submitted in response to findings.
- Metrics information describing the success or failure of the corrective actions.
- Individual training records pertaining to error management system training and education initiatives.

A FINAL WORD ON DATA SHARING

The National Civil Aviation Review Commission included the following statement on data sharing in their report:

“It appears that the only way to obtain in-depth safety information within a company, between companies, or involving the FAA, is for people who operate in the system (pilots, mechanics, controllers, dispatchers, airlines, manufacturers, airport operators, etc.) to agree to disclose this information and to allow it to be consolidated and analyzed for accident prevention purposes. Individuals and companies will not agree to assemble or disclose safety data if it can be used punitively, be misinterpreted by non-experts, reveal trade secrets, or expose them to undue liability.”

Data sharing, whether on a local or global level, still has two primary barriers keeping it from becoming a reality. First, the enforcement bias of the regulatory authorities have caused most error data to be considered proprietary or legally protected by airlines and repair stations. Second, data collection systems and analysis tools vary significantly, making true electronic sharing of data a technical challenge.

The National Civil Aviation Review Commission statement above recognizes data sharing as a necessity if accident rates are to be significantly reduced. Given this fact and the belief that error management techniques are ready to be implemented on a widespread basis, it is now time for the regulatory authorities to make their partnership programs a reality instead of a campaign promise. Although FAA headquarters is deeply committed to the furthering of these ideas, a workable data protection and enforcement incentive program has not been put in place; as a result, fledging industry error management programs are not progressing at an acceptable pace.

The regulatory authorities must also participate in industry efforts to develop data systems, both from a concept and cost standpoint, so that all airline and maintenance companies, regardless of financial strength, can participate.

Today, the only indication of progress toward these goals are conferences to exchange ideas, and a few emerging national programs oriented around the “self disclosure” process. Although a step in the right direction, it is not nearly enough!