Aircraft Design—Original Equipment Manufacturer/Design Approval Holder Continuous Monitoring of Service History

Best Practices Task Force

Commercial Aviation Safety Team

SE−170 Task Force Output

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Executive Summary

The National Transportation Safety Board (NTSB) found that the Alaska 261 MD−83 accident about 2.7 miles north of Anacapa Island, California, on January 31, 2001, was due to the failure of the horizontal stabilizer jackscrew. The jackscrew failed due to lack of lubrication. The NTSB found some indication that a mechanic had tried to lubricate the jackscrew using the zerk fitting on the jackscrew stationary nut, but had failed to do so because of a dried plug of grease in the channel. The NTSB also expressed concern about the reliability of the end play check, which is used to measure wear on the jackscrew assembly. These two findings led to a concern about aircraft mechanics having difficulty physically performing a task and being able to verify that a task was done correctly.

The SE 170 Task Force reviewed current industry processes to determine the extent the five objectives of the SE 170 Task Force currently exist. A summary of our findings on these objectives is below. Throughout this task force report the term **safety related** means maintenance task difficulties that could affect the **safe flight and landing of the airplane**.

1. **Operator processes for identifying and documenting problems or difficulties with maintenance tasks that, in the judgment of the operator, pose a safety hazard.**

Operators have a high-level process in place to deal with difficulties that mechanics have in carrying out a maintenance procedure or in verifying that the procedure was done correctly. The issue is whether the operators have lower level procedures for reporting specific problems with various types of maintenance procedures, like task cards, maintenance manual procedures, and Engineering Orders.

Recommendations

The aviation industry should develop and reinforce a culture that all mechanics work to the operator maintenance instructions, which are based on OEM/DAH maintenance instructions.

Operators should develop or reinforce a procedure for mechanics or maintenance providers to report any problems in following maintenance instructions.

Operators should develop or reinforce a procedure for determining whether these maintenance task difficulties are safety related and need to be corrected internally or communicated to the OEM/DAHs.

Operators should develop or reinforce a procedure for providing feedback to the mechanic on the resolution to the problem that they reported.

Operators should incorporate the above recommendations in conjunction with Safety Management System implementation.

2. **Operator processes for reporting back to OEM/DAHs on maintenance task problems (including difficulties in performance or verification of task completion) that, in judgment of the operator, have a clear potential impact on safety.**

These communication processes exist, but are owned by the OEM/DAHs and not by the operators. Operators should use existing OEM/DAH communication systems (or establish one if none exists) to report safety related problems with OEM/DAH maintenance instructions. Each OEM/DAH has a proprietary electronic communication system that enables secure messaging between the OEM/DAH and the operators. These proprietary electronic communication systems have features, such as automated distribution to subject matter experts and response tracking. All OEM/DAHs on the Task Force had such a formal communication process. The airframe DAHs had more elaborate communication systems than the supplier OEM/DAHs because of the volume of communication traffic. Also, many of the questions about supplier parts/sub-systems/systems come to the airframe DAHs and are answered by the airframe DAHs. A best practice regarding the airframe DAH communication system is the ability to directly tie in the supplier in the communication system in order to get supplier input for responding to the operator issue.

Recommendation

OEM/DAHs that provide maintenance instructions directly or indirectly to an operator or maintenance provider should have a communication process for receiving and routing reports that specifically allows operators and maintenance providers to report safety related problems with OEM/DAH maintenance instructions.

3. **OEM/DAH processes for reviewing and responding to these safety-related operator maintenance issues.**

The Task Force OEM/DAHs have processes in place to identify and respond to emerging issues and concerns regarding maintenance instructions that may potentially affect the safety of the operating fleet. These processes are conducted in the context of regulatory standards and oversight. Operator reporting of technical operational problems, using the communication processes discussed in Objective 2, constitutes a major input to these processes. Maintenance difficulties and concerns experienced by operators and maintenance service providers can be acted upon through the OEM/DAH’s product safety processes. However, the information must first become known to the OEM/DAH. This occurs primarily through voluntary reporting from operators and maintenance service providers.

Recommendations

OEM/DAHs that provide maintenance instructions directly or indirectly to an operator or maintenance provider should have a process in place to identify and respond to emerging issues and concerns regarding maintenance instructions that may cause a safety related problem.

Safety Management Systems (SMS) for OEMs/DAHs should encompass the recommendation above, but until OEM/DAH SMS is implemented, existing OEM/DAH maintenance instruction processes should be evaluated to ensure they are timely and closed-loop.

4. OEM/DAH and operator recommendations for issues that could potentially impact safety and should be reported, and what information operators should include in reports.

Section V of this report provides guidance for operators and maintenance providers to use regarding when to report a safety related issue to the OEM/DAHs. This proposed reporting goes beyond 121.703. Detailed guidance for the data that should be reported was also developed in Section V, including information from investigations and root cause analyses (see Appendix B).

Recommendation

Operators should implement a practice of submitting reports on safety related issues caused by OEM/DAH maintenance instructions back to the OEM/DAHs guided by the list of issues and types of information to include provided in Section V of this report.

5. OEM/DAH and operator recommendations on issues that should be reflected in maintenance instruction changes or other feedback vehicles for operators.

The OEM/DAH should have multiple feedback vehicles in order to respond to procedurally simple, procedurally complex, and systemic issues. Procedurally simple changes (e.g., changing an incorrect torque value in a maintenance manual) would be handled through the communication system discussed in Objective 2. Procedurally complex changes (e.g., involving changes to tooling) would involve the same communication systems, but may require a validation process regarding maintenance instruction/tooling changes. Systemic issues (e.g., common usability issues) may require face-to-face meetings or other coordination with industry, like fleet conferences, technical meetings, and usability meetings, in order to resolve the issues.

Recommendations

OEM/DAH's should respond as quickly as possible to any operator report regarding a maintenance instruction problem that is safety related. Specifics for providing feedback to the operator are outlined in Section VI.

As much as possible, the OEM/DAH should partner with the operator or maintenance provider to validate updates or changes to procedurally complex maintenance instructions.

As much as possible, the OEM/DAH should incorporate human factors principles and techniques in the development of updates or changes to maintenance instructions. Many of these principles and techniques can be found in existing maintenance human factors literature.

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Table of Contents

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I. INTRODUCTION

The National Transportation Safety Board (NTSB) found that the Alaska 261 MD−83 accident about 2.7 miles north of Anacapa Island, California, on January 31, 2001, was due to the failure of the horizontal stabilizer jackscrew. The jackscrew failed due to lack of lubrication. The NTSB found some indication that a mechanic had tried to lubricate the jackscrew using the zerk fitting on the jackscrew stationary nut, but had failed to do so because of a dried plug of grease in the channel. The NTSB also expressed concern about the reliability of the end play check, which is used to measure wear on the jackscrew assembly. These two findings lead to a concern about aircraft mechanics having difficulty physically performing a task and being able to verify that a task was done correctly.

SE−170 was chartered to develop a voluntary process for improving communication between operators and OEM/DAHs on maintenance task difficulty. In particular, CAST was concerned that OEM/DAHs may develop maintenance tasks that could be physically difficult for operators to perform or verify the completion of, which could lead to degraded system safety over time.

Operators are encouraged to report safety related problems in maintenance tasks (specifically difficulties with performance or verification of correct completion) back to OEM/DAHs. OEM/DAHs are encouraged to monitor these reports to verify that their design and procedural assumptions are valid and associated instructions address safety factors. The FAA and industry representatives were encouraged to meet to discuss, document, and disseminate best practices related to current industry processes that enable this type of two-way communication. In 2008 CAST proposed that the Joint Management Team (JMT) create a task force to document current industry processes and align them in a recommended best practices report.

This effort reviewed the current industry processes of participating or represented OEM/DAHs and operators on the following:

1. Operator processes for identifying and documenting problems or difficulties with maintenance tasks that, in the judgment of the operator, pose a safety hazard.
2. Operator processes for reporting back to OEM/DAHs on maintenance task problems (including difficulties in performance or verification of task completion) that, in judgment of the operator, have a clear potential impact on safety.
3. OEM/DAH processes for reviewing and responding to these safety-related operator maintenance issues.
4. OEM/DAH and operator recommendations for issues that could potentially impact safety and should be reported, and what information operators should include in reports.
5. OEM/DAH and operator recommendations on issues that should be reflected in maintenance instruction changes or other feedback vehicles for operators.

The flow of the above five objectives is not chronological, and was interpreted by the SE−170 Task force in the following manner:

1. First, per Objective 1, operators should have a process in place that allows mechanics to report difficulties in carrying out a maintenance task. The operators would have some ability to determine whether this difficulty poses a safety hazard using information discussed in Objective 4.
2. Second, per Objective 2, operators should have a way to communicate this information back to the OEM/DAH and should include the types of information discussed in Objective 4.
3. Third, per Objective 3, OEM/DAHs should have a process for reviewing these communications from operators for safety related issues and the capability of making changes to maintenance instructions or making other improvements per the recommendations in Objective 5.

Throughout this task force report the term **safety related** <u>means</u> maintenance task difficulties that could affect the **safe flight and landing of the airplane**.

II. SE OBJECTIVE 1

Operator processes for identifying and documenting problems or difficulties with maintenance tasks that, in the judgment of the operator, pose a safety hazard.

This issue is directly addressed in the Inspector's Handbook 8900.1, Volume 3, Chapter 32, Section 11, 3−3382 Procedures.

> "F. Evaluate Manual Contents.
> The certificate holder's company manual must describe procedures and provide information appropriate to the applicable 14 CFR parts.
>
> 9) The manual is required to include programs that personnel must follow while performing maintenance, preventive maintenance, and alterations of the certificate holder's aircraft, including airframes, aircraft engines, propellers, rotors, appliances, and emergency equipment. (Ref. §§ 121.369(b) and 135.427(b).) These programs must include at least the following:
>
> *L) Instructions and procedures for maintenance personnel to follow if confronted with errors or deficiencies in documented maintenance procedures (maintenance manual, work cards, etc.), especially while performing maintenance that requires immediate corrective action to ensure safe practices and airworthy aircraft. The procedures must include instructions for documenting the error and ensuring the deviation or corrections are validated and acceptable to the FAA.*"

Maintenance tasks carried out on commercial aircraft can be specified by various kinds of media containing procedures (see Appendix A for the various types of ICA). For example, base (heavy) maintenance is typically carried out using operator-generated task cards (or, less likely, OEM/DAH developed task cards). Line maintenance is typically carried out using the OEM/DAH Aircraft Maintenance Manual (AMM) procedures, which are used directly as supplied by the OEM/DAH or reformatted and/or "localized" by the operator. Workshop maintenance is carried out using Component

Maintenance Manuals (CMMs) or other ICAs. Airworthiness Directive (AD) incorporations are typically carried out by following an Engineering Order (EO) (also called Engineering Authorization, Engineering Change Order, or Engineering Change/Repair Authorization), which are typically written by the operator engineering organization using OEM/DAH data as source data. In addition, contract maintenance providers may also request changes to operator-provided work instructions (typically task cards). Thus, operator maintenance organizations use several different types of aviation authority-accepted procedures to carry out aircraft maintenance.

Therefore, in order to address the above Inspector's Handbook item on how to deal with errors or deficiencies in documented maintenance procedures, operators will typically have a general process for dealing with these types of issues specified in their General Maintenance Manual (GMM) or its equivalent. Then lower level procedures are typically developed to deal with specific processes for revising task cards, AMM procedures, EOs, etc. One thing that FAA members of the Task Force have seen is that the larger US operators have a GMM level procedure and then lower level processes/procedures for addressing issues with the various types of maintenance procedures, while smaller US operators may not have specified lower level processes/procedures.

However, even when these processes are in place, it is not guaranteed that a mechanic, when facing a difficulty following a procedure, will report that difficulty using the operator-developed process/procedure. Some of the obstacles that need to be overcome are listed below.

First, the program must assure the mechanic that their suggestion will actually have an impact in changing the procedure. If the mechanic's experience is that past suggestions for change have not been carried out, then she/he is less likely to make future suggestions regarding procedural improvements.

Second, the mechanic must believe that the program will view them as positive contributor instead of a trouble maker or someone slowing down the work. This is becoming less of an issue than it was fifteen years ago due to implementation of programs like the Aviation Safety Action Program (ASAP), Just Culture, Critical Behavior programs, and Safety Management Systems.

Third, the program should make use of the operator's maintenance processes and train mechanics to realize that having difficulty in following a maintenance procedure is not normal and that any workaround that they may have developed may be inappropriate. The mechanic should understand that the operator has a program for reporting and resolving problems with maintenance procedures.

In addition to reports by the mechanic, incorrectly performed safety-related maintenance tasks should be investigated, using, for example, the Maintenance Error Decision Aid (MEDA) process to determine whether maintenance procedures contributed to the failure (see Appendix B).

Another issue mentioned above is that many operators, especially larger operators, do not use AMM and work card procedures exactly as they are provided by the OEM/DAH. Instead, they take the data from the OEM/DAH, make changes to it (e.g., add local process information, add operator specific materials/consumables, etc.), and then provide this data in a procedure format to their mechanics. Thus, not all improvements to maintenance procedures have to be made by the OEM/DAH data originator. However, if an operator's maintenance organization gets a report from a mechanic about not being able to carry out a maintenance task or verify that it was done correctly, and the operator determines that this is a safety related issue that stems from the OEM/DAH instruction, then the organization should contact the OEM/DAH using the communication processes discussed in Objective 2 below. One best practice found by the SE 170 Task Force was for a mechanic, who was having difficulty carrying out any kind of maintenance task, to stop work on the task and contact an operator's 24/7 engineering support group. The engineering support group will get back to the mechanic and provide resolution before work continues. This process is followed by the mechanics, in part, because paperwork and a fix is provided by engineering in a relatively short period of time. The fix is also formalized into the system and future documents reflect the changes, including inventory, parts, paperwork, etc.

In summary, operators have a high-level process in place to deal with difficulties that mechanics have in carrying out a maintenance procedure or in verifying that the procedure was done correctly. The larger operators, especially, have lower level procedures for reporting problems with various types of maintenance procedures, like task cards, AMM procedures, and EOs. Many operator maintenance organizations adapt the procedures provided by the OEM/DAHs to their operation. If the operator finds that problems with the procedures are due to their customized maintenance instructions, then the problems are resolved internally. If the problems are due to the OEM/DAH maintenance instructions, then they are referred to the OEM/DAH for changes. For all safety related issues, the operator or the OEM/DAH should determine whether the same type of problems exist on similar systems on other aircraft types.

Recommendations

The aviation industry should develop and reinforce a culture that all mechanics work to the operator maintenance instructions, which are based on OEM/DAH maintenance instructions.

Operators should develop or reinforce a procedure for mechanics or maintenance providers to report any problems in performing maintenance instructions.

Operators should develop or reinforce a procedure for determining whether the maintenance instruction problems are safety related and need to be corrected internally or communicated to the OEM/DAHs.

Operators should develop or reinforce a procedure for providing feedback to the mechanic on the resolution to the problem that they reported.

Operators should incorporate the above recommendations in conjunction with Safety Management System implementation.

III. SE 170 OBJECTIVE 2

Operator processes for reporting back to OEM/DAHs on maintenance task problems (including difficulties in performance or verification of task completion) that, in judgment of the operator, have a clear potential impact on safety.

The best practice for operators is to utilize existing OEM/DAH communication systems (or to establish communication systems if they are not available), ensure their engineering service activity identifies safety related problems with maintenance instructions, and elevate identified safety related issues to the OEM/DAHs.

A possible problem may be that operators correct an error in the OEM/DAH source data in their engineering authorization or engineering order without reporting back to the OEM/DAH. Consequently, the OEM/DAH never receives feedback on a technical error, and the error is propagated throughout the aviation industry. The operators should understand that unreported OEM/DAH errors could lead to potential safety problems in the aviation industry. The OEM/DAH is unlikely to implement future quality improvements, if the OEM/DAH has a false picture of quality because of unreported errors in OEM/DAH maintenance instructions. The OEM/DAH is genuinely interested in product defects, engineering errors, configuration problems, confusing procedures, impractical procedures, and typographical errors reported by operators. Without accurate error reporting from the operators, the products are less likely to improve.

All OEM/DAHs represented on the Task Force have a proprietary electronic communication system that enables secure messaging between the OEM/DAH and the operators. The proprietary electronic communication systems have features such as automated distribution to subject matter experts and response tracking. These communication processes exist and are owned by the OEM/DAHs and not by the operators. The airframe DAHs had more elaborate communications systems than the other OEM/DAHs represented on the Task Force because of the volume of communication traffic. Also, many of the questions about parts/sub-systems/systems come to the airframe DAHs and are answered by the airframe DAHs. However, operators will communicate directly with the non-airframe DAHs regarding complex subsystems, such as power plants, APUs, landing gear, in-flight entertainment (IFE) systems, etc. A best practice regarding the airframe OEM/DAH communication system is the ability to directly tie in the supplier in the communication system in order to get supplier input for responding to the operator issue.

Below is a general description of the communication system used by both airframe DAHs on the SE−170 Task Force. It will be referred to as the Airframe DAH Communication System (ADCS).

Communications Users and Process

ADCS is used by airframe DAH employees, operators, maintenance repair organizations, leasing companies, suppliers, and regulatory agencies to communicate service related issues. The system prioritizes the issues based on the difference between the current date and the due date the customer selects. An example of a categorization scheme is as follows:

- Due within 24 hours: High Impact
- Due in 1 to 3 days: Critical
- Due in 4 days or later: Routine.

Other attributes, in addition to the due date, are collected at the time the issue is created to allow the automatic workflow/assignment manager to assign the issue to the specialist who is best able to answer it. These attributes include, among other things, airplane model, ATA chapter, and the type of product, such as Airplane structural or systems, Maintenance and Repair Data, Training, or Flight Operations. ADCS provides visibility and tracking of communication between operators and airframe DAHs. Unlike email, ADCS tracks responses in order to ensure that all incoming messages from the operators are responded to promptly. In contrast, email messages can be deleted, lost or left unanswered.

Once a DAH specialist receives an issue, ADCS allows him/her to coordinate with other specialists and suppliers to complete the response to the customer. The specialist has the ability of providing a partial or full response and attaching any additional documentation. The specialist may also send back a request for more time to complete the response. Customers may add a follow on message to the original issue. It is not possible to correct the content of messages once it is sent. All messages sent back and forth, including attachments, are kept in a repository unchanged. Issues can be reopened at any time in the future to support additional questions.

ADCS is also used to send multi-operator messages. This is done to raise attention to issues impacting more than one operator. They include air safety issues, FAA and EASA Notice of Proposed Rulemaking, Airworthiness Directives, fleet wide structural or system issues, system outages, and conference notices. ADCS is also used to conduct surveys of the operator fleet for specific issues and is also used by operators to report Service Bulletin incorporation.

Roles and Interfaces

ADCS users are provided access through the system using an access control process. For airframe DAH employees, approval is provided by their manager. With that approval an explanation of the employee role is required. These roles can include, for example—

- Research only – read only access
- Responding to customer issues – read/write with assignment skills so that the right messages flow to the person
- Metrics development – read only with access to business analytics tools
- Administrator – ability to set up employees, new customers, new customer contacts, maintain supporting tables, etc.

Customers are set up for access by ADCS Administrators following the execution of a contract. Suppliers are set up by ADCS Administrators under direction of Supplier Management.

In summary, these communication processes exist, but are owned by the OEM/DAHs and not by the operators. Operators should use existing OEM/DAH communication systems (or establish one if none exists) to report safety related problems with OEM/DAH maintenance instructions. Each OEM/DAH has a proprietary electronic communication system that enables secure messaging between the OEM/DAH and the operators. These proprietary electronic communication systems have features, such as automated distribution to subject matter experts and response tracking. All OEM/DAHs on the Task Force had such a formal communication process. The airframe DAHs had more elaborate communications systems than the supplier OEM/DAHs because of the volume of communication traffic. Also, many of the questions about supplier parts/sub-systems/systems come to the airframe DAHs and are answered by the airframe DAHs. A best practice regarding the airframe DAH communication system is the ability to directly tie in the supplier in the communication system in order to get supplier input for responding to the operator issue.

Recommendation

OEM/DAHs that provide maintenance instructions directly or indirectly to an operator or maintenance provider should have a communication system that specifically allows operators and maintenance providers to report safety-related problems with OEM/DAH maintenance instructions.

IV. SE 170 OBJECTIVE 3

OEM/DAH processes for reviewing and responding to these safety-related operator maintenance issues.

All OEM/DAHs on the SE 170 Task Force reported having formal in-service safety or continued operational safety processes in place to identify and respond to emerging issues affecting the safety of fielded products. These processes include the capability to review and respond to safety relevant information resulting from maintenance difficulties or findings by the operators or maintenance service providers. The effective functioning of the OEM/DAH processes in response to field maintenance concerns is reliant on information supplied voluntarily by the operators and maintenance providers, using the communication processes discussed in Objective 2.

The OEM/DAH’s continued operational safety processes are conducted under a working agreement or as part of an organizational delegation from the OEM/DAH’s primary regulatory authority. The activities are typically closely coordinated with the OEM/DAH’s primary regulatory authority. Fleet corrective actions developed by the manufacturer may become mandatory through Airworthiness Directives or other means.

The following overview describes the basic elements and functionality of an OEM/DAH’s continued operational safety process. The details can be considered as generally representative of industry practice. Additional information on implementation and operation of continued operational safety processes is available in SAE industry standard document ARP 5150 “Safety Assessment of Transport Airplanes in Commercial Service.”

Manufacturer's Continued Airworthiness Process/Monitoring Product Safety Performance

Design of civil aircraft, engines, and aviation products is controlled by airworthiness regulation, industry standards, and the OEM/DAH's internal design requirements, all of which are intended to ensure the type design will be safe for its intended operation. Manufacturing is controlled by production system regulation and the manufacturer's quality system, which are intended to ensure conformance of each article to the approved type design and condition for safe operation at airworthiness certification. The objective of these systems is to ensure the safety and airworthiness of civil aviation products both at entry and in operational service. However, unforeseen issues affecting product safety can arise during operational service as the result of many variables, including product design or manufacturing deficiencies, maintenance instruction deficiencies, unexpected changes in the operating environment or maintenance practices, unanticipated product behaviors, or unforeseen interactions including human factors in operation and maintenance.

Civil aviation OEM/DAHs, therefore, monitor data and information from a variety of sources to assess the safety performance of fielded products. For mature products, the largest source of information is typically derived from the operating fleet. The nature and completeness of fleet service information can vary, as commercial aircraft are often used by a diverse range of operators. Large OEM/DAHs typically maintain field service networks to support customer operators and to facilitate the reporting of service information. OEM/DAHs also maintain communication systems to allow direct reporting by operators as discussed above in Objective 2.

Operators will use these communication systems to contact the airframe DAHs regarding safety related maintenance task with which they had difficulties with task performance or verification of correct task completion. Maintenance task issues that can be resolved through a simple fix of the task instructions will be implemented by the responsible DAH technical specialist. For more complex safety related issues, the airframe DAH may convene an internal organizational technical review board meeting, involving maintenance specialists like a chief mechanic, maintenance human factors experts, maintenance engineers, management, process experts and applicable system design engineers. The knowledge, experience and cross functional diversity of this review board is leveraged to generate a resolution to most maintenance task difficulties that eliminates or mitigates the safety related risk. At this level, the resolutions would typically be process changes, operator notifications, support product data changes (including changes to maintenance task instructions), ground support equipment changes or training. The vast majority of the maintenance task difficulties are handled by the DAH technical specialist or by the DAH organizational technical review board. Operators have mandatory reporting obligations to their regulatory authority (e.g., 14 CFR 121.703 service difficulty reporting for air carriers in the US). However, there is no regulatory requirement for operators to report information directly to the OEM/DAH. The OEM/DAH has mandatory reporting obligations when they become aware of certain events or conditions (e.g., 14 CFR 21.3 failure, malfunction and defect reporting for type certificate holders in the US) (see Appendix C for CFR 21.3 reporting criteria). [While this is specific to the US FAA, all other airframe DAHs have similar reporting requirements.] Data and information from multiple sources, including every communication sent through the Airframe DAH Communication System, is analyzed to see if it meets the criteria for a 21.3 reportable event. If the communication is believed to include a 21.3 reportable event, the message is forwarded to the regulator. Non-airframe OEM/DAHs have similar agreements with their respective regulatory authorities.

Issue or Hazard Identification

Large amounts of data and information are collected by OEM/DAHs from operator input regarding product reliability, serviceability, and performance in the field. This information can come from operators to OEM/DAHs using the communication processes described in Objective 2 above or come from additional external information sources. From the data and information collected, the OEM/DAH typically employs a variety of methods to sort, filter and identify issues that can potentially affect the safety of fielded products. When new issues or hazards are identified that may affect safety, which includes communications from operators regarding safety related issues with maintenance instructions, these issues then enter the OEM/DAH's process for safety risk management, including formal decision-making and classification.

Determination of Safety Issue or Unsafe Condition

When a potential safety related issue is identified, the OEM/DAH will typically conduct a safety risk analysis by re-evaluating the original design analysis in the light of new information or by accomplishing a unique new analysis, as appropriate. The results of the risk analysis are used to support the OEM/DAH's formal decision-making process. The responsibility for product safety decisions typically resides with a formal review board, comprised of high-level leadership within the organization. These decisions are normally made in compliance with the OEM/DAH's internally published guidance for safety risk management decisions, which are consistent with regulatory design safety requirements and industry standards. The decision making process will include a formal classification of the issue or concern as to whether it constitutes a safety related issue.

If the safety of the operating fleet is determined to be acceptable as is, even with the discovered issue, condition, or discrepancy, then no action is required for the purpose of operational safety. However, action may still be undertaken for dispatch reliability, economic performance, or other reasons. If the safety risk is unacceptable (or will become unacceptable with continued operation), the item is classified as a safety issue. In this case some corrective actions will be developed and recommended by the OEM/DAH along with its regulatory authority participation in order to maintain or restore the airworthiness of fielded products.

Corrective Action Development and Deployment

When some corrective actions must be developed and deployed, the root cause of the problem must be determined in order to develop an appropriate, effective, and practical corrective action. The nature, scope and extent of the problem must be clearly identified. The OEM/DAH will publish recommendations to operators to identify the issue or concern and to communicate the specific corrective actions. Corrective actions may take the form of product changes, repetitive maintenance, or changes to operational practices/documentation or maintenance practices/documentation. The timing for the development and deployment of corrective actions and for recommended incorporation into the operating fleet is generally based on a fleet risk management approach. Some issues have straightforward solutions that can be deployed quickly. In other cases, e.g., design changes, corrective actions can take time to develop. In these cases, interim actions, such as maintenance inspections or operational limitations, may be required.

In summary, the Task Force OEM/DAHs have processes in place to identify and respond to emerging issues and concerns regarding maintenance instructions that may potentially affect the safety of the operating fleet. These processes are conducted in the context of regulatory standards and oversight. Operator reporting of technical operational problems, using the communication processes discussed in Objective 2, constitutes a major input to these processes. Maintenance difficulties and concerns experienced by operators and maintenance service providers can be acted upon through the OEM/DAH's product safety processes. However, the information must first become known to the OEM/DAH. This occurs primarily through voluntary reporting from operators and maintenance service providers.

Recommendation

OEM/DAHs that provide maintenance instructions directly or indirectly to an operator or maintenance provider should have a process in place to identify and respond to emerging issues and concerns regarding maintenance instructions that may cause a safety related problem.

SMS for OEMs/DAHs should encompass the recommendation above, but until OEM/DAH SMS is implemented, existing OEM/DAH maintenance instruction processes should be evaluated to ensure they are timely and closed-loop.

V. SE 170 OBJECTIVE 4

OEM/DAH and operator recommendations for issues that could potentially impact safety and should be reported, and what information operators should include in reports.

When and what should operators report to the OEM/DAH?

Operator maintenance organizations will determine which maintenance tasks they consider to be safety related. These safety related maintenance tasks may vary from operator to operator but as a minimum should include the following: tasks related to Certification Maintenance Requirements, Electrical wiring Interconnection Systems (EWIS), Airworthiness Limitations, and SFAR 88; tasks that were determined to be "safety" or "hidden safety" by MSG−3 analysis and found in the Maintenance Review Board Report and Maintenance Planning Data document; certain tasks carried out on critical systems as defined by the airframe DAH; and tasks related to Airworthiness Directives and Alert Service Bulletins. When an operator encounters difficulty in performing an OEM/DAH maintenance instruction, the operator should report back to the OEM/DAH for these types of tasks if any of the following conditions apply:

- Cannot be accomplished as written due to, for example, physical difficulty, task sequencing, difficulty in using tooling, wrong access panel specified, etc.
- Could lead to a maintenance error
- Is missing, incomplete or inaccurate
- Contains the wrong configuration
- Is ambiguous, confusing, poorly written, disorganized, inefficient (Time or Labor) or impractical
- Was a contributing factor to a maintenance error as determined through root cause investigations such as:
    - Maintenance Error Decision Aid (MEDA) (see Appendix B)
    - Maintenance Line Operation Safety Assessment (M−LOSA)(see Appendix D)
    - Aviation Safety Action Program (ASAP) (see Appendix E)
- Is related to Service Difficulty Reports (SDR) as specified in 14 CFR 121.703
- Is related to a Mechanical Interruption Report as specified in 14 CFR 121.705
- Is related to an operator's Required Inspection Item (RII) task
- In a Service Bulletin (SB) that caused the operator to request an Alternate Means of Compliance (AMOC) to an AD
- Contributed to or caused an operational safety event
- Is considered to be safety critical.

Information that operators should include in the reports to the OEM/DAHs are the applicable items in the following list:

- If the request is safety-of-flight related and why the operator believes it is safety related
- If a Temporary Revision is needed
- Operator code (who is the operator of the airplane)
- Airplane model, Document, Task number, step (example: 777 AMM 27−11−00−700−801 step 2.E.(7))
- Unique airplane identifier (e.g., serial number or line number)
- Date of the event
- Engine type/manufacturer/serial number/engine hours and cycles
- Air frame flight hours and cycles

- Station
- Part number/serial number
- Statement of the problem (with as much detail as possible), including any investigation results from, for example, a MEDA investigation or other root cause analysis investigations
- If it is an Aircraft on Ground (AOG) issue
- Reference documents
- Digital media (e.g., graphics, videos, drawings, renditions, and photos)
- Recommended action or proposed revisions to text of the maintenance instructions.

When this type of information is communicated, the sender should comply with the proper safeguards for proprietary or confidential information.

In summary, for issues with the maintenance instructions of the OEM/DAH, that in the judgment of the operator are safety related, operators should submit a report to the OEM/DAH about the maintenance instruction using the criteria detailed in this section. For example, operators should report to OEMs if the instructions are incorrect, ambiguous, misleading or physically hard to perform. The operators should report such things as whether the request is safety related, a statement of the problem with as much detail as possible, and their proposed action or revision to the maintenance instructions.

Recommendation

Operators should implement a practice of submitting reports regarding safety related issues, as defined in this section, caused by maintenance instructions to the OEM/DAHs that contain the information outlined in this section.

VI. SE 170 OBJECTIVE 5

OEM/DAH and operator recommendations on issues that should be reflected in maintenance instruction changes or other feedback vehicles for (to) operators.

There are three categories of issues and feedback on these issues that are discussed below. The first is making specific safety related changes to maintenance instructions which are simple and straightforward to implement (procedurally simple change). The second is making more complex changes to maintenance instructions that might also involve, for example, changes to tooling (procedurally complex change). The third is making higher level changes to maintenance instructions regarding, for example, usability issues (systemic changes).

As an example, a procedurally simple change could result from an error, like an incorrect torque value, in the OEM/DAH maintenance instruction. First, the OEM/DAH would use its communication system to inform the operator that their suggested change will be made. Then the OEM/DAH would simply change the maintenance instruction to fix the error. For less urgent changes to the maintenance instructions, the change would be seen in the next revision cycle of the maintenance instruction, although that change may not show up for 3 to 6 months because of OEM/DAH document production cycles. The operators are aware of the OEM/DAH revision cycles. When the OEM/DAH is responding to an operator issue that is more urgent, for example, affects regulatory compliance or airworthiness (e.g., a procedure related to Special Federal Aviation Regulation 88), and the operator is expected by the aviation authorities to follow the procedure “exactly as written,” then the OEM/DAH should make the documentation changes immediately available to the operator through a Temporary Revision (TR) process and also possibly send out a multi operator message to inform all affected operators of the change.

An example of a procedurally complex change stems from the jackscrew failure that caused the Alaska flight 261 accident. The response to the accident involved a large amount of communication between the DAH and the operators, changes to maintenance instructions, and changes to the tooling used to measure jackscrew wear. The tooling changes had to be shown to be reliable (repeatable) and valid (actually measuring jackscrew wear) via industry participation before the changes could be incorporated in the maintenance instructions. In addition to this, interim mitigating actions were also required. Another example of a procedurally complex change is validating maintenance instructions, service bulletin incorporations, and special tooling/ground support equipment.

An example of a systemic change would be increasing the overall usability of maintenance instructions. The OEM/DAH would engage the operators through general feedback vehicles established by the OEM/DAH, such as fleet conferences and usability meetings. The OEM/DAH may be able to implement policy changes, new technology, or data format changes in order to assist the operators. For some subjects, the large customer base of the OEM/DAH can have multiple divergent requirements not easily accommodated by the OEM/DAH. However, the general feedback vehicles provide for ongoing dialogue between OEM/DAH and operators to engage in a search for a mutually acceptable solution.

In summary, the OEM/DAHs should have multiple feedback vehicles in order to respond to procedurally simple, procedurally complex, and systemic issues. Procedurally simple changes would be handled through the communication system discussed in Objective 2. Procedurally complex changes would involve the same communication systems, but may require a validation process regarding maintenance instruction/tooling changes. Systemic issues may require face-to-face meetings or other coordination with industry, like fleet conferences, technical meetings, and usability meetings in order to resolve the issue.

Recommendations

OEM/DAHs should respond as quickly as possible to any operator report regarding a safety related maintenance instruction problem. This response could be in the form of—

- An acknowledgement of the receipt of the report and a description of the corrective action plan

- No action on the part of the OEM/DAH is required, but the operator may need to provide awareness, training, or instruction
- A change to a maintenance instruction, to tooling, or to maintenance instruction usability.

As much as possible, the OEM/DAH should partner with the operator or maintenance providers to validate changes or updates to procedurally complex maintenance instructions.

As much as possible, the OEM/DAH should incorporate human factors principles and techniques in the development of changes or updates to maintenance instructions.

VII. SUMMARY OF RECOMMENDATIONS

Objective 1—Operator processes for identifying and documenting problems or difficulties with maintenance tasks that, in the judgment of the operator, pose a safety hazard.

All US airline maintenance and engineering organizations should have some sort of process in place to deal with this, because this issue is directly addressed in the Inspector's Handbook 8900.1, Volume 3, Chapter 32, Section 11, 3−3382 Procedures. However, because of the concern that while a high-level process is probably specified, there may not be a lower level process that specifically tells mechanics what to do when confronted with problems or difficulties with maintenance tasks. The following recommendations were made:

- The aviation industry should develop and reinforce a culture that all mechanics work to the operator maintenance instructions, which are based on OEM/DAH maintenance instructions.
- Operators should develop or reinforce a procedure for mechanics or maintenance providers to report any problems in following maintenance instructions.
- Operators should develop or reinforce a procedure for determining whether these maintenance instruction problems are safety related and need to be corrected internally or communicated to the OEM/DAHs.
- Operators should develop or reinforce a procedure for providing feedback to the mechanic on the resolution to the problem that they reported.
- Operators should develop or reinforce a procedure for determining whether these maintenance instruction problems are safety related and need to be corrected internally or communicated to the OEM/DAHs.
- Operators should incorporate the above recommendations in conjunction with SMS implementation.

Objective 2—Operator processes for reporting back to OEM/DAHs on maintenance task problems (including difficulties in performance or verification of task completion) that, in judgment of the operator, have a clear potential impact on safety.

These communication processes are owned by the OEM/DAHs and not by the operators. All OEM/DAHs on the Task Force had a communications process for interacting with their airline customers. The following recommendation was made:

- OEM/DAHs that provide maintenance instructions directly or indirectly to an operator or maintenance provider should have a communication system that specifically allows operators and maintenance providers to report safety related problems with OEM/DAH maintenance instructions.

Objective 3—OEM/DAH processes for reviewing and responding to these safety-related operator maintenance issues.

All OEM/DAHs on the Task Force had a process for reviewing and responding to customer airline safety related maintenance issues. The following recommendations were made:

- OEM/DAHs that provide maintenance instructions directly or indirectly to an operator or maintenance provider should have a process in place to identify and respond to emerging issues and concerns regarding maintenance instructions that may cause a safety related problem. SMS for OEMs/DAHs should encompass the recommendation above, but until OEM/DAH SMS is implemented, existing OEM/DAH maintenance instruction processes should be evaluated to ensure they are timely and closed-loop.

Objective 4—OEM/DAH and operator recommendations for issues that could potentially impact safety and should be reported, and what information operators should include in reports.

Safety related maintenance tasks may vary from operator to operator but as a minimum should include the following: tasks related to Certification Maintenance Requirements, Electrical wiring Interconnection Systems (EWIS), Airworthiness Limitations, and SFAR 88; tasks that were determined to be “safety” or “hidden safety” by MSG−3 analysis and found in the Maintenance Review Board Report and Maintenance Planning Data document; certain tasks carried out on critical systems as defined by the airframe DAH; and tasks related to Airworthiness Directives and Alert Service Bulletins. Maintenance task difficulties for these types of safety related tasks should be reported to the OEM/DAH when the maintenance task difficulty was brought about by OEM/DAH’s maintenance instruction and any of the following conditions apply:

- Cannot be accomplished as written due to, for example, physical difficulty, task sequencing, difficulty in using tooling, wrong access panel specified, etc.
- Could lead to a maintenance error
- Is missing, incomplete or inaccurate
- Contains the wrong configuration
- Is ambiguous, confusing, poorly written, disorganized, inefficient (Time or Labor) or impractical
- Was a contributing factor to a maintenance error as determined through root cause investigations such as:

  - Maintenance Error Decision Aid (MEDA) (see Appendix B)
  - Maintenance Line Operation Safety Assessment (M−LOSA)(see Appendix D)
  - Aviation Safety Action Program (ASAP) (see Appendix E)
- Is related to Service Difficulty Reports (SDR) as specified in 14 CFR 121.703
- Is related to a Mechanical Interruption Report as specified in 14 CFR 121.705
- Is related to an operator's Required Inspection Item (RII) task
- In a Service Bulletin (SB) and caused the operator to request an Alternate Means of Compliance (AMOC) to an AD
- Contributed to or caused an operational safety event
- Is considered to be safety critical.

Information that operators should include in the reports to the OEM/DAHs are the applicable items in the following list:

- If the request is safety-of-flight related and why the operator believes it is safety related
- If a Temporary Revision is needed
- Operator code (who is the operator of the airplane)
- Airplane model, Document, Task number, step (example: 777 AMM 27−11−00−700−801 step 2.E.(7))
- Unique airplane identifier (e.g., serial number or line number)
- Date of the event
- Engine type/manufacturer/serial number/engine hours and cycles
- Air frame flight hours and cycles
- Station
- Part number/serial number
- Statement of the problem (with as much detail as possible), including any investigation results from, for example, a MEDA investigation or other root cause analysis investigations
- If it is an Aircraft on Ground (AOG) issue
- Reference documents
- Digital media (e.g., graphics, videos, drawings, renditions, and photos)
- Recommended action or proposed revisions to text of the maintenance instructions.

Objective 5—OEM/DAH and operator recommendations on issues that should be reflected in maintenance instruction changes or other feedback vehicles for (to) operators.

OEM/DAHs should respond as quickly as possible to any operator report regarding a safety related maintenance instruction problem. This response could be in the form of:

- An OEM/DAH acknowledgement of the receipt of the report and a description of the corrective action plan
- No action on the part of the OEM/DAH is required, but the operator may need to provide awareness, training, or instruction
- An OEM/DAH change to a maintenance instruction, to tooling, or to maintenance instruction usability.

As much as possible, the OEM/DAH should partner with the operator or maintenance providers to validate changes or updates to procedurally complex maintenance instructions.

As much as possible, the OEM/DAH should incorporate human factors principles and techniques in the development changes or updates to maintenance instructions.

VIII. CONCLUSION

The process recommendations discussed in this report are generally implemented in the industry. For example, operators have processes for mechanics to use to report maintenance instruction problems. A communication process exists for operators to contact OEM/DAHs about these problems. Operators know when to report and what to report to the OEM/DAHs. OEM/DAHs have safety processes in place to evaluate these reports and to make changes to maintenance documentation, tooling, and processes, as necessary. What is needed is to give these processes a little more structure, definition, and organization by defining and following industry best practices.

The SE−170 Task Force believes that our recommendations, if followed, would improve safety. The relevance of this report to the Alaska 261 accident is that it would help make progress in preventing this type of event by identifying precursors to the event and implementing corrective actions. There are other maintenance errors that lead to safety-of-flight issues, and reporting these could improve safety by making our systems more robust and preventing some of the causal factors that can lead to a safety event.

The whole premise of a SMS is to collect and analyze hazard information to see if the hazards can lead to a safety of flight risk and to evaluate the level of that risk. SMS implementation should help overcome problems relevant to the SE−170 effort.

Acronyms/Definitions

ADCS	Airframe DAH Communication System—an electronic messaging system between the airframe DAHs and their customers. that allows communication routing, management, response, monitoring and storage.
AD	Airworthiness Directive
AOG	Aircraft on Ground
AMM	Aircraft Maintenance Manual
AMOC	Alternate Means of Compliance
ASAP	Aviation Safety Action Program—a program allowed and defined by Advisory Circular 120−66B "Aviation Safety Action Program (ASAP)" to encourage air carrier and repair station employees to voluntarily report safety information that may be critical to identifying potential precursors to accidents.
ASRS	The Aviation Safety Reporting System collects voluntarily submitted aviation safety incident/situation reports from pilots, controllers, mechanics, and flight attendants. The ASRS acts on the information these reports contain. It identifies system deficiencies, and issues alerting messages to persons in a position to correct them.
CMM	Component Maintenance Manual
Critical Behavior Programs	Aircraft maintenance organization programs that specify to the mechanic critical behaviors that must always be followed during aircraft maintenance.
DAH	Design Approval Holder
EASA	European Aviation Safety Agency
EO	Engineering Order—maintenance documentation, typically written by the Engineering Department of an airline, that provides guidance to a mechanic on how to carry out, for example, a Service Bulletin incorporation or some other modification to an aircraft.
FAA	Federal Aviation Administration
GMM	General Maintenance Manual
ICA	Instructions for Continued Airworthiness provide a method of advising those responsible for maintenance of the aircraft what actions they must take to ensure continued airworthiness after the Type Certificate or Supplemental Type Certificate is issued.
IFE	In-Flight Entertainment

Just Culture	James Reason refers to just culture as “an atmosphere of trust in which people are encouraged, even rewarded, for providing essential safety-of-flight related information, but in which they are also clear about where the line must be drawn between acceptable and unacceptable behavior.” This is also reflected by the definition provided by the European Commission, in which: ‘Just culture’ means a culture in which front line operators or others are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but where gross negligence, willful violations and destructive acts are not tolerated [EC No 691/2010].
MEDA	Maintenance Error Decision Aid—A process for investigating the contributing factors to a maintenance-error caused event (see Appendix B).
M−LOSA	Maintenance Line Operations Safety Assessment (see Appendix D)
OEM	Original Equipment Manufacturer
RII	Required Inspection Item—A maintenance task that, after task completion, must be inspected and signed off by a qualified inspector.
SB	Service Bulletin
SDR	Service Difficulty Report—a report that is required, as specified in 14 CFR 121.703, from an airline operator to the FAA.
TEM	Threat and Error Management. TEM is the philosophical basis for the M−LOSA process. The philosophy is that there are threats internal to a mechanic and external to a mechanic that, if not managed properly, can lead to errors. The errors, if not caught and corrected can lead to an event or some other outcome.

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Appendix A. A List of Instructions for Continued Airworthiness (ICA) that Was Developed by an Agreement between Boeing and the Seattle Aircraft Evaluation Group (AEG) in 2005

- Maintenance Documents (accepted by FAA-AEG)
    - Aircraft Maintenance Manual (AMM)
    - Maintenance Review Board (MRB) Report
    - Vendor Component Maintenance Manual (CMM) *
    - Airplane Configuration Definition
    - Fault Isolation Manual (FIM)
    - Wiring Diagram Manual (WDM)
    - Standard Wiring Practices Manual (SWPM)
    - Non Destructive Testing Manual (NDT)
    - Task Cards (TC) (for data not in AMM)

- Engineering Documents (accepted by FAA-ACO) **
    - Airworthiness Limitations and Certification Maintenance Requirements
    - Structural Repair Manual (SRM)
    - Configuration Maintenance Procedures (CMP)
    - Weight & Balance Manual (W&B) Airplane Weighing Procedure

Notes: * Must be provided by the Design Approval Holder

** Approved by Type Design Change Process

Appendix B. The Maintenance Error Decision Aid (MEDA) Process

THE MEDA PROCESS IS THE WORLDWIDE STANDARD FOR MAINTENANCE ERROR INVESTIGATION.

MEDA Investigation Process

by William Rankin, Ph.D.,
Boeing Technical Fellow, Maintenance Human Factors

Since 1995, Boeing has offered operators a human factors tool called the Maintenance Error Decision Aid (MEDA) for investigating contributing factors to maintenance errors. Boeing has recently expanded the scope of this tool to include not only maintenance errors but also violations in company policies, processes, and procedures that lead to an unwanted outcome.

Boeing, along with industry partners, began developing MEDA in 1992 as a way to better understand the maintenance problems experienced by airline customers. A draft tool was developed and nine airline maintenance organizations tested the usefulness and usability of the tool in 1994 and 1995. Based on the results of this test, the tool was improved. In 1995, Boeing decided to offer MEDA to all of its airline customers as part of its continued commitment to safety. Since that time, the MEDA process has become the worldwide standard for maintenance error investigation.

MEDA is a structured process for investigating the causes of errors made by maintenance technicians and inspectors. It is an organization's means to learn from its mistakes. Errors are a result of contributing factors in the workplace, most of which are under management control. Therefore, improvements can be made to the workplace to eliminate or minimize these factors so they do not lead to future events.

Boeing has recently updated the MEDA tool to reflect the latest thinking about maintenance event investigations. This article addresses the following:

- The effect of reducing maintenance errors.
- An overview of the MEDA process.
- The MEDA philosophy.
- Why MEDA has shifted to an event investigation process rather than just an error investigation process.
- Considering violations during an event investigation.
- How errors and violations often occur together to produce an unwanted outcome.
- How addressing the contributing factors to lower-level events can prevent more serious events.

EFFECT OF REDUCING MAINTENANCE ERRORS

The 2003 International Air Transport Association (IATA) Safety Report found that in 24 of 93 accidents (26 percent), a maintenance-caused event started the accident chain. Overall, humans are the largest cause of all airplane accidents (see fig. 1).

Maintenance errors can also have a significant effect on airline operating costs. It is estimated that maintenance errors cause:

- 20 to 30 percent of engine in-flight shutdowns at a cost of US$500,000 per shutdown.
- 50 percent of flight delays due to engine problems at a cost of US$9,000 per hour.
- 50 percent of flight cancellations due to engine problems at a cost of US$66,000 per cancellation.

More than 500 aircraft maintenance organizations are currently using MEDA to drive down maintenance errors. One airline reported a 16 percent reduction in maintenance delays. Another airline was able to cut operationally significant events by 48 percent. Many other operators have reported specific improvements to their internal policies, processes, and procedures.

MEDA OVERVIEW

MEDA provides operators with a basic five-step process to follow:

- Event.
- Decision.
- Investigation.
- Prevention strategies.
- Feedback.

Event. An event occurs, such as a gate return or air turnback. It is the responsibility of the maintenance organization to select the error-caused events that will be investigated.

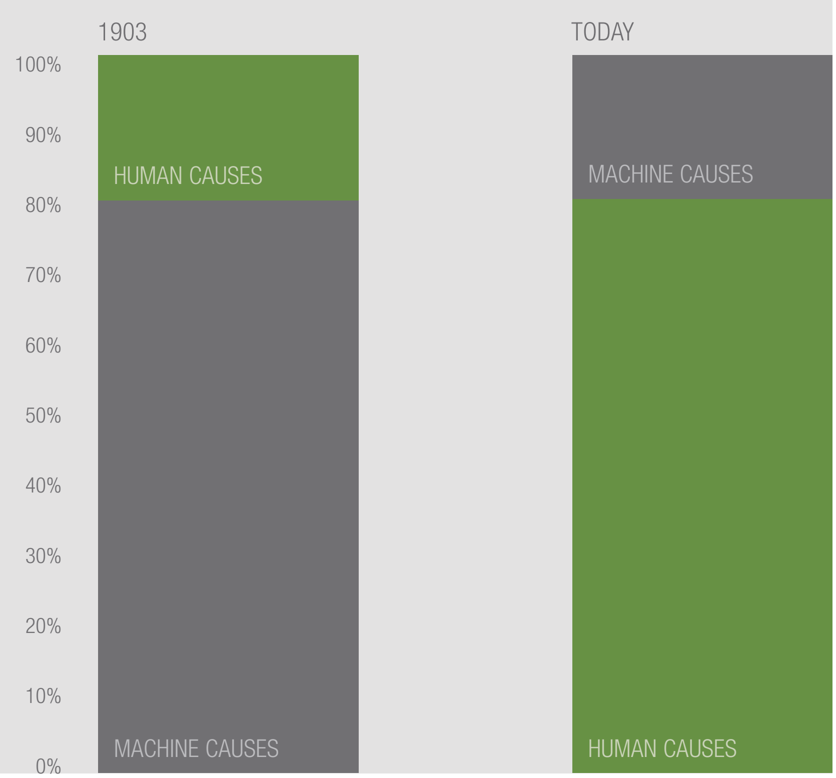
Decision. After fixing the problem and returning the airplane to service, the operator makes a decision: Was the event maintenance-related? If yes, the operator performs a MEDA investigation.

Investigation. The operator carries out an investigation using the MEDA results form. The trained investigator uses the form to record general information about the airplane, including when the maintenance and the event occurred, the event that began the investigation, the error and/or violation that caused the event, the factors contributing to the error or violation, and a list of possible prevention strategies.

Prevention strategies. The operator reviews, prioritizes, implements, and then tracks prevention

CAUSES OF ACCIDENTS
Figure 1

In the early days of flight, approximately 80 percent of accidents were caused by the machine and 20 percent were caused by human error. Today that statistic has reversed. Approximately 80 percent of airplane accidents are due to human error (pilots, air traffic controllers, mechanics, etc.) and 20 percent are due to machine (equipment) failures.



strategies (i.e., process improvements) in order to avoid or reduce the likelihood of similar errors in the future.

Feedback. The operator provides feedback to the maintenance workforce so technicians know that changes have been made to the maintenance system as a result of the MEDA process. The operator is responsible for affirming the effectiveness of employees' participation and validating their contribution to the MEDA process by sharing investigation results with them.

The resolve of management at the maintenance operation is key to successful MEDA implementation. Specifically, after completing a program of MEDA support from Boeing, managers must assume responsibility for the following activities before starting investigations:

- Appoint a manager in charge of MEDA and assign a focal organization.
- Decide which events will initiate investigations.
- Establish a plan for conducting and tracking investigations.
- Assemble a team to decide which prevention strategies to implement.
- Inform the maintenance and engineering workforce about MEDA before implementation.

MEDA PHILOSOPHY AND THE MOVE TO AN EVENT INVESTIGATION PROCESS

The central philosophy of the MEDA process is that people do not make errors on purpose. While some errors do result from people engaging in behavior they know is risky, errors are often made in situations where the person is actually attempting to do the right thing. In fact, it is possible for others in the same situation to make the same mistake. For example, if an inspection error (e.g., missed detection of structural cracking) is made because the inspector is performing the inspection at night under inadequate lighting conditions, then others performing a similar inspection under the same lighting conditions could also miss detection of a crack.

MEDA began as strictly a structured error investigation process for finding contributing factors to errors that caused events. However, in the 11 years that MEDA has been in wide use, Boeing has learned that errors and violations both play a part in causing a maintenance-related event.

An error is defined as a human action (i.e., behavior) that unintentionally departs from the expected action (i.e., behavior). A violation is a human action (i.e., behavior) that intentionally departs from the expected action (i.e., behavior).

Today, MEDA is seen as an event investigation process, not an error investigation process. This new approach means that a maintenance-related event can be caused by an error, a violation, or a combination of an error and a violation.

The central part of the MEDA process is making the improvements needed to eliminate the contributing factors. Some of these improvements will be obvious after a single event and others will be apparent only after analyzing a number of similar events. After the improvements have been made, it is important to inform the employees so they know their cooperation has been useful.

INCLUDING VIOLATIONS IN EVENT INVESTIGATIONS

Violations are made by staff not following company policies, processes, and procedures while trying to finish a job — not staff trying to increase their comfort or reduce their workload. Company policies, processes, and procedures all can be violated.

The revised version of MEDA acknowledges that violations have a causal effect, and they cannot be ignored if an airline is to conduct a complete investigation. The MEDA process distinguishes between three types of violations: routine, situational, and exceptional.

Routine. These violations are "common practice." They often occur with such regularity that they are automatic. Violating this rule has become a group norm. Routine violations are condoned by management. Examples include:

- Memorizing tasks instead of using the maintenance manuals.
- Not using calibrated equipment, such as torque wrenches.
- Skipping an operational test.

Situational. The mechanic or inspector strays from accepted practices, "bending" a rule. These violations occur as a result of factors dictated by the employee's immediate work area or environment and are due to such things as:

- Time pressure.
- Lack of supervision.
- Pressure from management.
- Unavailable equipment, tools, or parts.

Exceptional. The mechanic or inspector willfully breaks standing rules while disregarding the consequences. These types of violations occur very rarely.

CONSIDERING BOTH ERRORS AND VIOLATIONS

Because errors have been the focus of much research, there are many more theories about why errors occur than why violations occur. However, errors and violations often occur together to produce an unwanted outcome. Data from the U.S. Navy suggests that:

- Approximately 60 percent of maintenance events are caused by an error only.
- Approximately 20 percent of these events are caused by a violation only.
- Approximately 20 percent of these events are caused by an error and a violation (see figs. 2 and 3).

HOW ADDRESSING THE CONTRIBUTING FACTORS TO LOWER-LEVEL EVENTS CAN PREVENT MORE SERIOUS EVENTS

A contributing factor is anything that can affect how the maintenance technician or inspector does his or her job, including the technician's own characteristics, the immediate work environment, the type and manner of work supervision, and the nature of the organization for which he or she works.

Data from the U.S. Navy shows that the contributing factors to low-cost/no-injury events were the same contributing factors that caused high-cost/personal-injury events. Therefore, addressing the contributing factors to lower-level events can prevent higher-level events.

In a typical event investigation, as conducted at many airlines in the past, a maintenance event occurs, it is determined that the event was caused by an error, the technician who did the work is found, and the technician is punished. Many times, no further action is taken.

However, if the technician is punished but the contributing factors are not fixed, the probability that the same event will occur in the future is unchanged. The MEDA process finds the contributing factors and identifies improvements to eliminate or minimize these contributing factors in order to reduce the probability that the event will recur in the future.

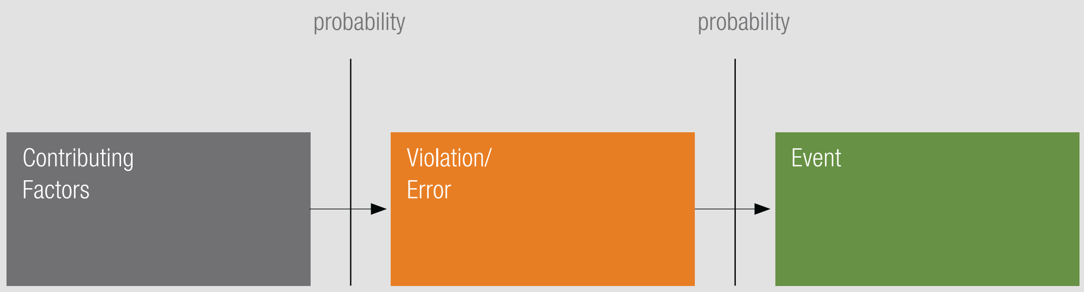
During a MEDA investigation, it is still necessary to determine whether the event is caused by human behavior and find the individual(s) involved. Instead of being punished, however, the technician is interviewed to get a better understanding of the contributing factors and get the technician's ideas for possible improvements. The information can then be added to a database.

The central part of the MEDA process is making the improvements needed to eliminate the contributing factors. Some of these improvements will be obvious after a single event and others will be apparent only after analyzing a number of similar events. After the improvements have been made, it is important to inform the employees so they know their cooperation has been useful.

Boeing supports the "Just Culture" concept, which is based on moving beyond a culture of blame to a system of shared accountability, where both individual and system accountability are managed fairly, reliably, and consistently.

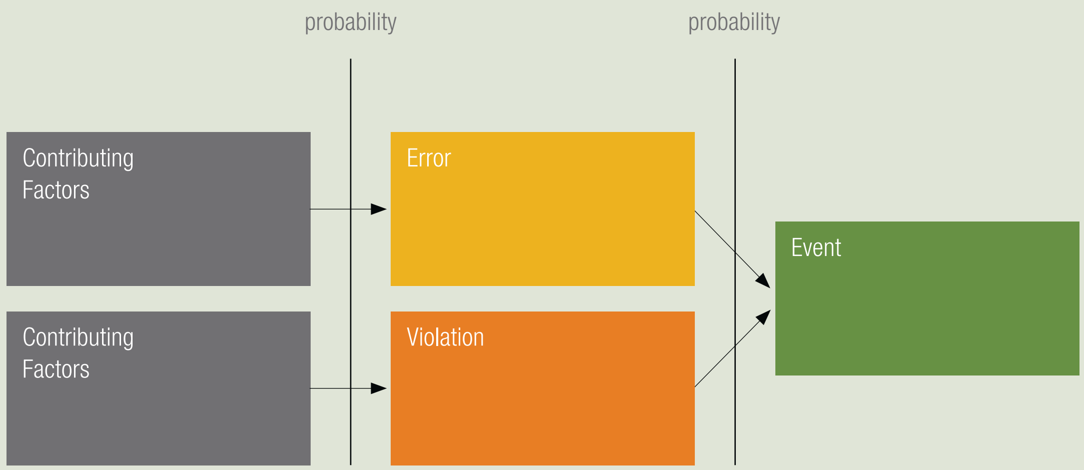
MEDA EVENT MODEL
Figure 2

In this example, a mechanic does not use a torque wrench (violation), which leads to an engine in-flight shutdown (event). There are reasons why (contributing factors) the violation occurred (e.g., unavailable torque wrench or work group norm is not to use a torque wrench).



MEDA EVENT MODEL
Figure 3

In this example, the mechanic mistakenly misses a step in the airplane maintenance manual (contributing factor), which leads to an incomplete installation (error). The mechanic decides not to carry out the operational check (violation), thereby missing the fact that the task was not done correctly. Because an error was made and this was not caught by the operational check, an engine in-flight shutdown (event) occurs.



THE IMPORTANCE OF A DISCIPLINE POLICY

It is important to have a discipline policy in place to deal with violation aspects of maintenance events. However, discipline or punishment is only effective for intentional acts. Boeing suggests a policy that:

- Does not punish honest errors.
- Does not punish routine violations.
- Considers punishment for situational violations.
- Provides punishment for exceptional violations.

Boeing supports the "Just Culture" concept, which is based on moving beyond a culture of blame to a system of shared accountability, where both individual and system accountability are managed fairly, reliably, and consistently.

NEW MEDA MATERIALS AVAILABLE

Boeing has updated the MEDA Results Form and User's Guide that reflect the process's new event investigation focus. These materials are provided to anyone at no charge. Boeing will also train operators at no charge if the training takes place in Seattle.

SUMMARY

Maintenance events have negative effects on safety and cost. A maintenance event can be caused by an error, a violation, or a combination of errors and violations. Maintenance errors are not committed on purpose and result from a series of contributing factors. Violations, while intentional, are also caused by contributing factors. Most of the contributing factors to both errors and violations are under management control. Therefore, improvements can be made to these contributing factors so that they do not lead to future maintenance events. The maintenance organization must be viewed as a system in which the technician is one part of the system. Addressing lower-level events helps prevent more serious events from occurring. For more information, please contact William L. Rankin at william.l.rankin@boeing.com.

OTHER INVESTIGATION PROCESSES

In addition to MEDA, Boeing has three other investigation processes available to the industry. Like MEDA, these tools operate on the philosophy that when airline personnel (e.g., flight crews, cabin crews, or mechanics) make errors, contributing factors in the work environment are a part of the causal chain. To prevent such errors in the future, those contributing factors are identified and, where possible, eliminated or mitigated. The additional investigation processes are:

- Ramp Error Decision Aid (REDA), which focuses on incidents that occur during ramp operations.
- Procedural Event Analysis Tool (PEAT), which was created in the mid-1990s to help the airline industry effectively manage the risks associated with flight crew procedural deviations induced operational incidents.
- Cabin Procedural Investigation Tool (CPIT), which is designed for investigating cabin crew induced incidents.

CASE STUDY

This case study illustrates how the MEDA process can help operators identify factors in the work environment that can lead to serious events.

EVENT SUMMARY

An operator's 767 was diverted when the pilot reported problems with the fuel flow indication system. After a delay, all 210 passengers were flown out on another airplane, which had been scheduled for an overnight check at that airport.

Extensive troubleshooting revealed debris in the fuel tank, including tape, gloves, and several rags that had clogged some of the fuel lines. The debris had been left during fuel tank leak checks and repairs and had not been found by the inspector at the end of the check.

MEDA INVESTIGATION

Scott and Dennis were the two maintenance technicians who performed the fuel tank leak checks and repairs. The MEDA investigation showed that Scott started the series of tasks during the third shift. He used the Airplane Maintenance Manual (AMM) as a reference to do the fuel tank purging and entry procedure. Then, he started the area-by-area leak checks and repairs as shown by the operator's work cards. Scott had trouble moving around in the tank because of his above-average height and weight. Scott made minor repairs in some areas of the tank, but his shift ended before he finished the task. Wanting to get out of the tank as soon as possible, Scott left the tape, gloves, and rags in the tank for Dennis to use to finish the task on the next shift.

Scott checked off the tasks he had completed on the signoff sheets in front of each work card. He also wrote in the crew shift handover report which tank areas had been checked and repaired and in which area he had last worked. However, he did not write in the shift handover report that he had not finished checking and repairing the complete tank, and he did not write down that he had left equipment in the tank. There was no overlap between shifts, so Scott left before the mechanics arrived for the next shift.

James was the lead technician on the next shift. He read the shift handover report. He did not notice that Scott's work card was not signed off, so he assumed that Scott's tank was finished and assigned the rest of the leak check and repair work cards for the other fuel tanks to Dennis. Dennis was the smallest member of his crew and found it easy to work in the fuel tanks.

Dennis completed the leak checks and repairs on the tanks that Scott had not worked on. Dennis saw that the AMM had recently been revised. Technicians were now supposed to count all the gloves, rags, and other equipment that were taken into and out of the fuel tanks to make sure that all equipment was accounted for. He also noticed that the work cards had not been updated to reflect these changes to the AMM. Dennis followed the instructions because they were probably added for safety reasons. Consistent with the AMM revision, he remembered hearing that his employer had moved to a process that called for each mechanic to take all equipment out with him when leaving a tank, even if the task was not completed. He noted to himself that the new process had not yet been briefed at a crew meeting. Dennis finished the remaining fuel tanks shortly before the airplane was due for final inspection. He signed off the remaining work cards and handed them over to his lead, James.

James (following a standard procedure at that operator) put all of the fuel tank work cards together in one stack. Then he attached one inspection signoff sheet to the outside of the stack. James handed this and other stacks of work cards to Bill. Bill, the maintenance inspector, did the final inspection.

The fuel tank access panels were still open when Bill did his inspection. He used a company-provided flashlight and mirror to inspect as much of each fuel tank as he could through the access panel without going inside the tanks. This was an acceptable level of inspection at this particular operator. However, Bill could not see the entire area inside of each fuel tank from the access panel openings. Bill stated during his MEDA interview that the design of the fuel tanks made it impossible for him to see every area using the flashlight and mirror. He also said that the colors of the gloves, tape, and rags were almost the same color as inside the fuel tanks. Bill signed the inspection sheet for each of the fuel tanks. The fuel tank access panels were then closed.

The MEDA investigation also found that the AMM procedures for the fuel tank purging and entry, fuel tank leak checks, and fuel tank repairs all contained instructions to make sure all objects were removed from the tanks when the procedures were complete.

RECOMMENDATIONS

This investigation enabled the operator to develop a number of recommendations to prevent a similar event from occurring in the future. These recommendations include:

- Changing work cards to include the reference, "Equipment removed from tank."
- Using brightly colored rags, gloves, and tape that contrast with the tank color.
- Changing the inspection process to a full-entry inspection or using better lighting to perform the inspection.
- Providing all of the mechanics with information and training on the new tools and equipment removal process.
- Delegating fuel tank work to smaller mechanics.

Appendix C. CFR 21.3 Event Reporting Criteria

Event Reporting Criteria
8-16-12

Volume: 1 Date: 2002–01–01

Original Date: 2002–01–01

Title: Section 21.3—Reporting of failures, malfunctions, and defects.

Context:

Title 14—Aeronautics and Space.

CHAPTER I—FEDERAL AVIATION ADMINISTRATION, DEPARTMENT OF TRANSPORTATION.

SUBCHAPTER C—AIRCRAFT.

PART 21—CERTIFICATION PROCEDURES FOR PRODUCTS AND PARTS.

Subpart A—General.

§ 21.3 Reporting of failures, malfunctions, and defects.

(a) Except as provided in paragraph (d) of this section, the holder of a Type Certificate (including a Supplemental Type Certificate), a Parts Manufacturer Approval (PMA), or a TSO authorization, or the licensee of a Type Certificate shall report any failure, malfunction, or defect in any product, part, process, or article manufactured by it that it determines has resulted in any of the occurrences listed in paragraph (c) of this section.

(b) The holder of a Type Certificate (including a Supplemental Type Certificate), a Parts Manufacturer Approval (PMA), or a TSO authorization, or the licensee of a Type of Certificate shall report any defect in any product, part, or article manufactured by it that has left its quality control system and that it determines could result in any of the occurrences listed in paragraph (c) of this section.

(c) The following occurrences must be reported as provided in paragraphs (a) and (b) of this section:

(1) Fires caused by a system or equipment failure, malfunction, or defect.

(2) An engine exhaust system failure, malfunction, or defect which causes damage to the engine, adjacent aircraft structure, equipment, or components.

(3) The accumulation or circulation of toxic or noxious gases in the crew compartment or passenger cabin.

(4) A malfunction, failure, or defect of a propeller control system.

(5) A propeller or rotorcraft hub or blade structural failure.

(6) Flammable fluid leakage in areas where an ignition source normally exists.

(7) A brake system failure caused by structural or material failure during operation.

(8) A significant aircraft primary structural defect or failure caused by any autogenous condition (fatigue, understrength, corrosion, etc.).

(9) Any abnormal vibration or buffeting caused by a structural or system malfunction, defect, or failure.

(10) An engine failure.

(11) Any structural or flight control system malfunction, defect, or failure which causes an interference with normal control of the aircraft for which derogates the flying qualities.

(12) A complete loss of more than one electrical power generating system or hydraulic power system during a given operation of the aircraft.

(13) A failure or malfunction of more than one attitude, airspeed, or altitude instrument during a given operation of the aircraft.

(d) The requirements of paragraph (a) of this section do not apply to—

(1) Failures, malfunctions, or defects that the holder of a Type Certificate (including a Supplemental Type Certificate), Parts Manufacturer Approval (PMA), or TSO authorization, or the licensee of a Type Certificate—

(i) Determines were caused by improper maintenance, or improper usage;

(ii) Knows were reported to the FAA by another person under the Federal Aviation Regulations; or

(iii) Has already reported under the accident reporting provisions of Part 430 of the regulations of the National Transportation Safety Board.

(2) Failures, malfunctions, or defects in products, parts, or articles manufactured by a foreign manufacturer under a U.S. Type Certificate issued under § 21.29 or § 21.617, or exported to the United States under § 21.502.

(e) Each report required by this section—

(1) Shall be made to the Aircraft Certification Office in the region in which the person required to make the report is located within 24 hours after it has determined that the failure, malfunction, or defect required to be reported has occurred. However, a report that is due on a Saturday or a Sunday may be delivered on the following Monday and one that is due on a holiday may be delivered on the next workday;

(2) Shall be transmitted in a manner and form acceptable to the Administrator and by the most expeditious method available; and

(3) Shall include as much of the following information as is available and applicable:

(i) Aircraft serial number.

(ii) When the failure, malfunction, or defect is associated with an article approved under a TSO authorization, the article serial number and model designation, as appropriate.

(iii) When the failure, malfunction, or defect is associated with an engine or propeller, the engine or propeller serial number, as appropriate.

(iv) Product model.

(v) Identification of the part, component, or system involved. The identification must include the part number.

(vi) Nature of the failure, malfunction, or defect.

(f) Whenever the investigation of an accident or service difficulty report shows that an article manufactured under a TSO authorization is unsafe because of a manufacturing or design defect, the manufacturer shall, upon request of the Administrator, report to the Administrator the results of its investigation and any action taken or proposed by the manufacturer to correct that defect. If action is required to correct the defect in existing articles, the manufacturer shall submit the data necessary for the issuance of an appropriate airworthiness directive to the Manager of the Aircraft Certification Office for the geographic area of the FAA regional office in the region in which it is located.

[Amdt. 21–36, 35 FR 18187, Nov. 28, 1970, as amended by Amdt. 21–37, 35 FR 18450, Dec. 4, 1970; Amdt. 21–50, 45 FR 38346, June 9, 1980; Amdt. 21–67, 54 FR 39291, Sept. 25, 1989]

Appendix D. Maintenance Line Operations Safety Assessment (M-LOSA)

Managing risks has become increasingly important in modern organizations. The aviation industry is maturing in its preference for proactive intervention over post-accident/incident remediation. Systems such as National Aeronautics and Space Administration Aviation Safety Reporting System (ASRS) and the Maintenance Aviation Safety Action Program (ASAP) encourage air carrier and repair station employees to voluntarily report unsafe conditions. However, those systems are used proactively following adverse events. Maintenance LOSA is considered a predictive hazard identification process and, therefore, addresses aviation safety proactively.

Maintenance LOSA was developed by a US Air Transport Association (ATA) human factors sub-committee. It is based on the Flight LOSA process, which is based on the Threat and Error Management (TEM) philosophy. LOSA is a peer-to-peer observation program under strict non-jeopardy conditions for the mechanics being observed.

The success of LOSA is based on ten essential characteristics:

1. "Fly on the wall" observations by peers during normal maintenance operations.
2. Joint management/maintenance staff sponsorship.
3. Voluntary crew participation.
4. De-identified, confidential and safety-minded data collection.
5. Targeted observation instrument (Maintenance LOSA Observation Form).
6. Trusted, trained, and calibrated observers who come from the maintenance staff.
7. Data verification roundtables to find data inaccuracies—e.g., due to conflicting beliefs about existing policies/processes/procedures.
8. After a series of observations, the data are analyzed and presented to crews and management.
9. Data-derived targets for improvement.
10. Feedback of results to the maintenance crews.

The goals and intent of Maintenance LOSA are:

- Observe day-to-day work behaviors during normal operations
- Discover procedural and systemic threats and errors (at risk behaviors)
- Reduce injuries and equipment/aircraft damage
- Reduce maintenance-related events
- Generate baseline data, implement corrective actions to problem areas, and generate follow-up data to assess effectiveness.

Maintenance LOSA training materials, posters, and observation checklists can be found on the FAA web site www.mrlosa.com.

Appendix E. Aviation Safety Action Program (ASAP)

Guidance for the Aviation Safety Action Program is provided in Advisory Circular 120-66B “Aviation Safety Action Program (ASAP).” The objective of ASAP is to encourage air carrier and repair station employees to voluntarily report safety information that may be critical to identifying potential precursors to accidents. The Federal Aviation Administration (FAA) has determined that identifying these precursors is essential to further reducing the already low accident rate. Under an ASAP, safety issues are resolved through corrective action rather than through punishment or discipline. The ASAP provides for the collection, analysis, and retention of the safety data that is obtained. ASAP safety data, much of which would otherwise be unobtainable, is used to develop corrective actions for identified safety concerns and to educate the appropriate parties to prevent a reoccurrence of the same type of safety event. An ASAP is based on a safety partnership that will include the FAA and the certificate holder, and may include a third party, such as the employee’s labor organization. To encourage an employee to voluntarily report safety issues, even though they may involve the employee’s possible noncompliance with Title 14 of the Code of Federal Regulations (14 CFR), enforcement-related incentives have been designed into the program.

Information obtained from these programs will permit ASAP participants to identify actual or potential risks throughout their operations. Once identified, the parties to an ASAP can implement correction actions in order to reduce the potential for reoccurrence of accidents, incidents, and other safety-related events. In order to gain the greatest possible positive benefit from ASAP, it may be necessary for certificate holders to develop programs with compatible data collection, analysis, storage, and retrieval systems. The information and data, which are collected and analyzed, can be used as a measure of aviation system safety.

An ASAP provides a vehicle whereby employees of participating air carriers and repair station certificate holders can identify and report safety issues to management and to the FAA for resolution, without fear that the FAA will use reports accepted under the program to take legal enforcement action against them, or that companies will use such information to take disciplinary action.