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

MEDA Investigation Process

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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.

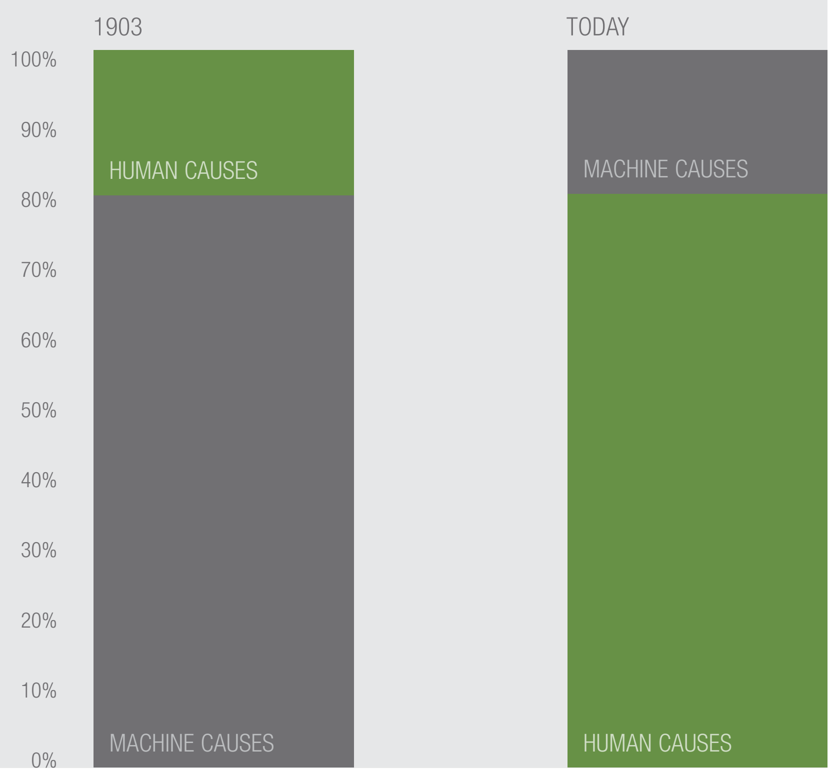
Decision. After fixing the problem and returning the airplane to service, the operator makes a decision: Was the event maintenance-related? If yes, the operator performs a MEDA investigation.

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.

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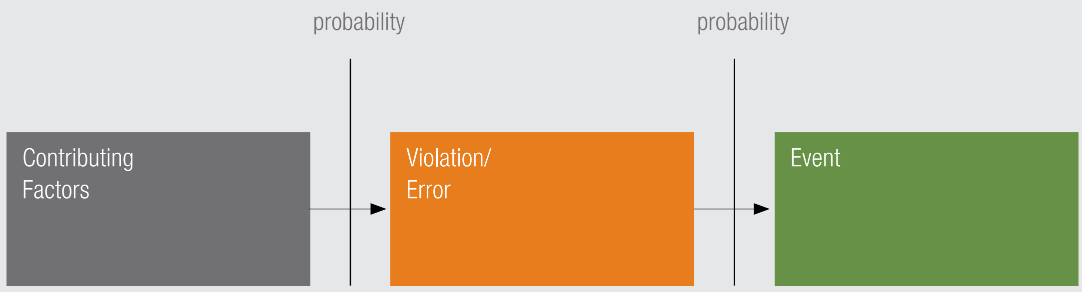
Boeing supports the "Just Culture" concept, which is based on moving beyond a culture of blame to a system of shared accountability, where both individual and system accountability are managed fairly, reliably, and consistently.

MEDA EVENT MODEL

Figure 2

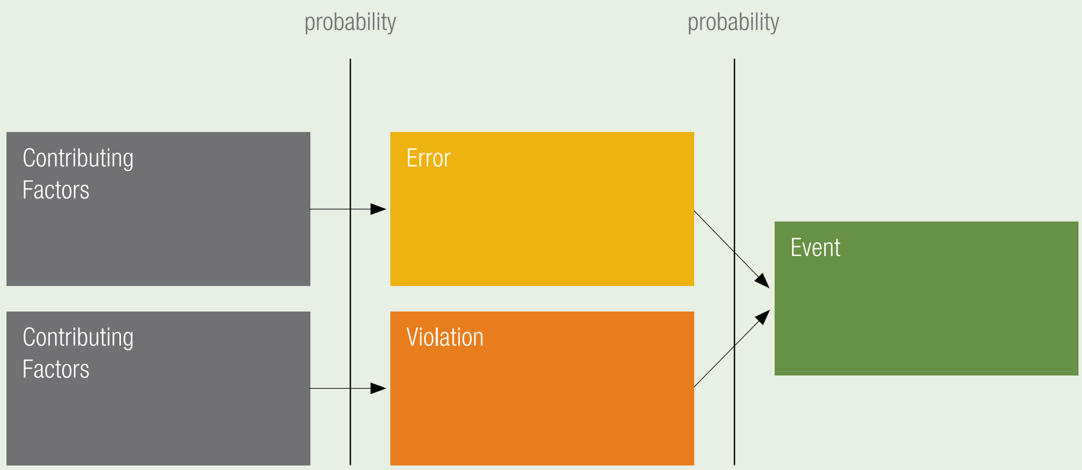
In this example, a mechanic does not use a torque wrench (violation), which leads to an engine in-flight shutdown (event). There are reasons why (contributing factors) the violation occurred (e.g., unavailable torque wrench or work group norm is not to use a torque wrench).



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.

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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. A

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.