3.0 MAINTENANCE ERROR DECISION AID: PROGRESS REPORT

William L. Rankin, Ph.D., Jerry P. Allen, Jr.,
Robert A. Sargent
Maintenance Human Factors, Boeing Customer Services Division

INTRODUCTION

Airplane maintenance errors have safety and economic costs. A study by Boeing and the U. S. Air Transport Association members[1] found that maintenance error was one factor, typically among a series of factors, that contributed to 39 of 264 (15 percent) major aircraft accidents from 1982 through 1991. More specifically, in those 39 accidents:

- 23 percent involved an incorrect removal/installation of components
- 28 percent involved a manufacturer or vendor maintenance/inspection error
- 49 percent involved an error due to an airline's maintenance/inspection policy
- 49 percent were design related

In addition, these 39 accidents resulted in 1,429 on-board fatalities.

Data from one engine manufacturer,[2] showed the percentage of specific engine events caused by error and economic costs of those events to the airlines:

- 20 percent to 30 percent of in-flight engine shutdowns are caused by maintenance error and can cost an estimated $500,000 per shutdown.
- 50 percent of flight delays due to engine problems are due to maintenance errors and can cost an estimated $10,000 per hour of delay.
- 50 percent of flight cancellations due to engine problems are caused by maintenance error and can cost an average of $50,000 per cancellation.

But can maintenance error be managed? An analysis at Boeing of in-flight (engine) shut down (IFSD) rates due to maintenance error for twenty different air carriers found that the rate differed by a factor of ten between the lowest and highest rates. Clearly, some airlines are able to manage these types of maintenance errors better than other airlines.

Also, error reduction programs are already used in some industries. For example, Lorenzo[3] discusses an error reduction program in the chemical industry based on modifying performance shaping factors (PSFs) as defined and discussed by Swain and Guttman.[4] McDonald and White[5,6,7] looked at the PSFs that lead to airport ramp accidents and incidents and developed a ramp safety program based on changes to these PSFs.

MEDA DEVELOPMENT

Based on the above ideas for error prevention and reduction, Boeing, working with three of its customer airlines--British Airways, Continental Airlines, and United Airlines--developed a process for following up maintenance-error-caused events[8,9] in order to determine what contributed to the error so that corrective actions can be taken to eliminate or reduce the probability of future, similar errors. The process is called the Maintenance Error Decision Aid (MEDA). The philosophy of the process is:

- Maintenance technicians do not make errors on purpose.
- Maintenance errors result from a series of contributing factors.
- Many of these contributing factors are part of airline processes and can be managed.

- Some individual errors will not have specific corrective actions.

The first part of the philosophy is tautological, i.e., if a maintenance technician carried out a piece of work incorrectly and on purpose, by definition this was not an error, but purposeful behavior. However, it has been a useful part of the philosophy, because it gets airline management to think about causes of error other than the technician himself/herself.

The second part of the philosophy--that maintenance errors result from a series of contributing factors--is the heart of the MEDA process. Called performance shaping factors in the human factors literature,4 these contributing factors can negatively shape human performance. Also, there are usually several factors that, working together, finally shape the error.

The last parts of the philosophy suggest that while some errors (about 20 percent) will not have corrective actions because the contributing factors are unique and specific to an individual or a unique situation, most errors (about 80 percent) will have corrective actions because the contributing factors are under the control of airline management and therefore can be changed to eliminate or reduce the probability of future, similar errors.

The MEDA process was field tested at seven airline maintenance organizations.9 Based on the field test results, the MEDA Results Form and implementation training were modified to improve the process. Beginning in November 1995, Boeing began to work with its customer airlines to help them implement MEDA.

PROGRESS REPORT

Since November 1995, the authors have trained over 40 airplane maintenance organizations on the MEDA philosophy, process, and investigation techniques. These airlines represent a range of size from several airplanes to several hundred airplanes. Most of the organizations are outside of the U. S. Several lessons have been learned during this training that are of importance to this discussion. First, the maintenance organizations that were visited differed greatly across several variables. These variables included:

- Whether a incident investigation process already existed in the maintenance organization.
- Local maintenance organization culture.
- Country aviation authority requirements.

Based on these variables, the authors are aware that not all of the implementation visits have been successful as measured by the changes the maintenance organizations made to their maintenance error investigation processes following the training/implementation visit. Below we will discuss implementation success and then discuss the variables that have influenced that success.

Implementation at Airplane Maintenance Organizations

The authors are collecting detailed information about implementation in the February 1997, time frame by using a survey sent to the Boeing Field Service Representatives at the visited airlines. Information from this survey will be presented at conference.

Existing Maintenance Error Investigation Processes

One variable that greatly affected the ease of MEDA implementation was the extent to which a formal maintenance incident investigation process already existed at the maintenance organization. Some organizations that we visited already had a formalized process in place for following up maintenance-error-caused incidents. That is,

1. An investigation would be carried out for pre-specified incidents.
2. A form was used to capture the information learned during the investigation and this form would be assigned a unique investigation number.
3. A person or team of people would be assigned to carry out the investigation.

4. Following the investigation and form completion, the form would be returned to the process owner.

5. Decisions were made about corrective actions based on the investigation results.

6. A process existed for making sure that the corrective actions were carried out.

Organizations that already had such a process in place found it easy to incorporate new ideas from the MEDA investigation. However, the continuum on this variable included organizations that had some sort of process that was used for investigations, but the process wasn't formalized. These organizations found it harder to implement a structured process, because they had to formalize what they were doing. However, some maintenance organizations had no process in place. They needed to develop a process for maintenance incident investigations from the ground up.

Organizational Culture

There were several organizational culture issues that affected MEDA implementation, but the one that had the greatest affect on ease of implementation was related to past history at the organization regarding punishment or discipline for maintenance errors. Some of the organizations that we visited had a history of disciplining the mechanics for errors. This discipline could take the form of days off without pay, reduced pay for some period of time, or termination of employment. Discipline had either been meted out uniformly (i.e., for most errors) or erratically (i.e., only for certain [costly] errors), and the mechanics often didn't see the relationship between the error and the discipline. Unfortunately, in these organizations, mechanics were reticent to talk about an error. In fact, they typically wouldn't admit to an error. Since the heart of the MEDA investigation process is an interview with the mechanic who made the error, the MEDA process couldn't be implemented at these organizations until a change occurred in their discipline policy.

Aviation Authority

The U. S. Federal Aviation Authority has an adversarial relationship with the airlines. That was an issue that had to be addressed during the Field Test with the U. S. carriers that participated. However, the additional issue that we faced during the MEDA training/implementation visits was with civil aviation authorities who had developed automatic fines for some specific errors. For example, in one country that we visited, the aviation authority fined anyone (typically a flight attendant or maintenance mechanic) who inadvertently deployed an emergency escape slide. The fine was sizable and had a very negative affect on the person who was fined (disciplined). This aviation authority discipline had the same type of affect as discussed above under organizational culture--i.e., mechanics who inadvertently deployed a slide would try to hide their error or would not admit their error for fear of the fine. The fine also had a negative affect on flight attendant safety behaviors--i.e., some of the flight attendants in this country were afraid to arm the emergency escape slides during flight for fear that they would forget to disarm the door at the airport and then deploy the slide when they opened the door for passenger off-loading.

Summary

When we first began to work with airplane maintenance organizations with MEDA, our visits were mainly aimed at training investigators. As we began to see the range of existing error investigation processes, we saw the need to work more and more with the management to help them understand their responsibilities for successful error investigation process implementation. When we first began MEDA implementation visits, we did not address the negative impacts that past discipline processes at the airlines greatly affected the ease with which MEDA could be implemented at an airline. Thus, we added a "discipline policy" portion to the management presentation and began to carefully determine the extent to which we needed to address the need for a change in the discipline practices before MEDA could be implemented. It is fair to say that we began our implementation visits as "investigator trainers" and had evolved to using our time equally between investigator training and management consulting.

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DR. WILLIAM L. RANKIN

Bill Rankin received his Ph.D. in Experimental Psychology in 1977 from Washington State University. His areas of specialization were human performance and cognitive psychology. Following his degree, he worked for the Battelle Seattle Research Centers for 10 years. The first five years there were spent in the area of opinion measurement as it related to nuclear power and other energy production technologies. His last five years at Battelle were spent carrying out human factors engineering work for the U. S. Nuclear Regulatory Commission, the U. S. Department of Energy, and the Gas Research Institute.

Since coming to Boeing in 1986, among other projects, he worked on the Cockpit Automation Technology program, which dealt with the development of a rapidly reconfigurable fighter cockpit for design testing purposes; managed the development and implementation of the Boeing Employee Opinion Survey; managed the development of the performance management process for hourly workers; developed a training evaluation process for Employee Training and Development; and helped develop a hiring assessment for tooling employees and an assessment for promotion into first-level management. He joined the Human Factors Engineering group at Boeing in 1994 and has worked on maintenance human factors projects including development, testing, and implementation of the Maintenance Error Decision Aid, and improving the Boeing fault isolation manuals used for maintenance troubleshooting.