Maintenance Error Decision Aid (MEDA)©

User's Guide©

Maintenance Human Factors
Boeing Commercial Airplanes – Customer Support
Email: MHF@boeing.com

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1. Introduction

The Maintenance Error Decision Aid (MEDA) is a structured process used to investigate events caused by maintenance technician and/or inspector performance. Over the past several years, we have moved away from calling MEDA an "error" investigation process to calling it an "event" investigation process. The reason for this is that it has become increasingly clear that events caused by maintenance technician and/or inspector performance can contain both an error component as well as a component involving non-compliance with regulations, policies, processes, and/or procedures. This non-compliance will be referred to as a "violation" in the remainder of this material. Thus, we have changed the MEDA "error" model to be the MEDA "event" model, and we have updated this User's Guide to reflect this new thinking.

No one wants to cause an event. The errors and violations that lead to an event are a result of contributing factors in the work place. In many cases, others confronted with the same contributing factors might well make the same error or violation that lead to the event. We estimate that 80%--90% of the contributing factors to error/violation are under management control, while the remaining 10%--20% are under the control of the maintenance technician or inspector. Therefore, management can make changes to reduce or eliminate most contributing factors to an error or violation and thereby reduce the probability of future, similar events.

The purpose of this MEDA User's Guide is to provide the information that is needed to carry out a MEDA event investigation. The investigation is, essentially, an interview with the maintenance technician and/or inspector whose performance lead to the event to find out (1) what errors and violations occurred and (2) the contributing factors to the errors and violations. The MEDA Results Form is the main tool that was developed for helping with the investigation. It is a four-page document used by the investigator during the interview. To help prepare someone to carry out a MEDA investigation, the remainder of this document is arranged, as follows:

1. Definitions of an error and a violation
2. Definition of a contributing factor
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5. The MEDA investigation process
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Maintenance Error Decision Aid (MEDA) User's Guide©

2. Definition of an Error and a Violation

What is an error? For simplicity, we will define an error in this way:

- An **error** is a human action (or human behavior) that <u>unintentionally</u> deviates from the expected action (or behavior).

Some theorists, such as Dr. James Reason, distinguish among different types of errors, such as errors of omission and commission or slips, lapses, and mistakes. In the MEDA system, we will work with more specific error descriptions, such as:

- Part not installed correctly
- Part not installed at all
- Part installed in the wrong location
- Not enough oil added during servicing
- Inspector did not see the fault
- Tool left in the engine cowling.

In using specific error descriptions, all of the error types discussed above are included. For example, not installing a part would be called an error of omission and a lapse or installing a part in the wrong location would be an error of commission and a (possible) slip. Thus, using specific error descriptions precludes the need to determine the specific error type, which simplifies the task for the MEDA investigator.

Sometimes there is confusion between an error and a violation. We define a violation in this way:

- A **violation** is a human action (or human behavior) that <u>intentionally</u> deviates from the expected action (or behavior).

This can be a violation of an aviation-related regulation or a violation of a company policy, process, or procedure. So, the obvious difference between an error and a violation is whether the behavior was intentional on the part of the maintenance technician or inspector. As we will discuss later, errors and violations sometimes act together to cause an event.

Where did we get the information that errors and violations can act together to cause an event? We have gotten data from at least three sources. The first source was our customers, who were the first to ask for MEDA implementation support in the mid 1990s. During the training, they told us that it was not only errors that caused events. They gave examples of violations that they discovered in earlier investigations. Because of this input, we added the discussion about a discipline policy to this User's Guide.

Second, in the late 1990s, the U.S. Navy developed a process much like MEDA called Human Factors Analysis and Classification System—Maintenance Extension (HFACS-ME). This system was used to investigate the causes of maintenance error on naval aircraft. In August of 2000, Captain John Schmidt reported on HFACS-ME at the Human Factors and Ergonomic Society 2000 Congress in San Diego. In the Navy system, investigators not only looked for contributing factors to error, but also determined whether any rule violations had occurred. They classified these violations at three levels:

1. Routine—A maintainer engages in practices, condoned by management, that bend the rules;
2. Situational—A maintainer strays from accepted procedures to save time, bending a rule; and
3. Exceptional—A maintainer willfully breaks standing rules disregarding the consequences.

Captain Schmidt reported on 470 existing cases that he and his colleagues had re-analyzed using the HFACS-ME classification system. He reported that ~80% of the investigations uncovered a maintainer error and that ~40% uncovered a violation. Obviously, some naval maintenance-caused incidents could be attributed to both maintainer error and a violation.

The third set of data came from a United Kingdom Flight Safety Committee report in 2004. This committee analyzed a year's worth "maintenance mishaps" reported through the Mandatory Occurrence Report (MOR) process. They determined the top 10 causes of the maintenance mishaps. The top 10 reasons (from most frequent to least frequent) were:

1. Failure to follow published technical data or local instructions
2. Using unauthorized procedure not referenced in technical data
3. Supervisors accepting non-use of technical data or failure to follow maintenance instructions
4. Failure to document maintenance properly in maintenance records, work package
5. Inattention to detail/complacency
6. Incorrectly installed hardware on an aircraft/engine
7. Performing an unauthorized modification to the aircraft
8. Failure to conduct a tool inventory after completion of the task
9. Personnel not trained or certified to perform the task
10. Ground support equipment improperly positioned for the task.

Note that reasons 1, 2, 4, 7 and 9 are violations. Note also that the third reason—supervisor accepting non-use of technical data or failure to follow maintenance instructions—is in line with the Navy violation 1—a maintainer engaging in practices, condoned by management, that bend the rules.

In summary, we have been convinced by the information that we have seen and heard over the past 12 years that we needed to move the MEDA model from an "error" investigation to an "event" investigation. This allows the consideration of violations, along with errors, as causal to an event.

In MEDA, we are specifically interested in maintenance technician/inspector performance that leads to problems on an aircraft, equipment damage, personal injury, or rework. This will become clearer as we discuss the MEDA event model.

3. Definition of a Contributing Factor

In MEDA the term "contributing factor" is used to describe conditions that contribute to an error or a violation. In the Human Factors technical literature the term "performance shaping factor" is used. However, we use the term contributing factor because it is simpler to say that "x was a contributing factor to an error" rather than "x is a performance shaping factor that increased the likelihood of an error."

What is a contributing factor? We simply define contributing factor in this way:
- A **contributing factor** is anything that affects how a maintenance technician or inspector does his/her job.

Of course, since we are using MEDA to investigate the causes of an undesired event, we will be looking at the contributing factors that have a negative affect on performance. What affects how a maintenance technician or inspector does his/her job? Some things are obvious, like lighting in the area where the task is to be carried out, having the correct tools and parts to do the job, distractions or interruptions during task accomplishment, training or lack of training to do the task, and hearing job instructions incorrectly from a supervisor. Other things are not so obvious, like decisions about staffing levels made by the management three years ago, errors made by a production planner that affects the maintenance technician's task performance, and a supervisor who assigns a task to an unqualified maintenance technician.

It is easier to understand the concept of contributing factor using a model:

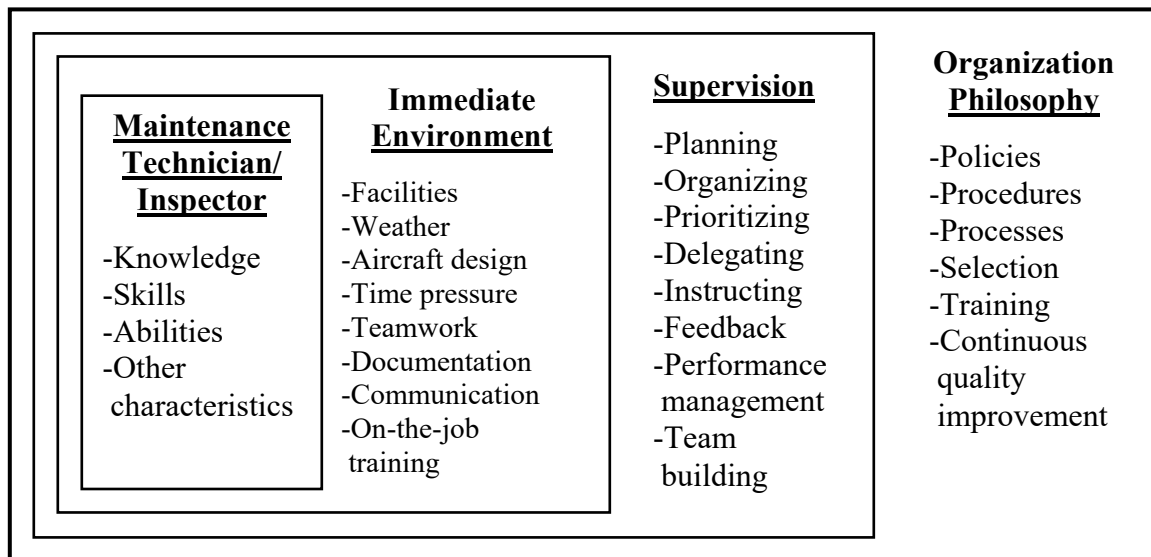| **Maintenance Technician/ Inspector**	**Immediate Environment**	**Supervision**	**Organization Philosophy**
-Knowledge -Skills -Abilities -Other characteristics	-Facilities -Weather -Aircraft design -Time pressure -Teamwork -Documentation -Communication -On-the-job training	-Planning -Organizing -Prioritizing -Delegating -Instructing -Feedback -Performance management -Team building	-Policies -Procedures -Processes -Selection -Training -Continuous quality improvement

Figure 1. Contributing Factors to Maintenance Performance

In this model, a maintenance technician or inspector works within an immediate environment under supervision within an organization. Any of these levels or any of the items listed in the model can affect how a maintenance technician/inspector does his/her

job and, therefore, could contribute to an error or violation. In Section 5.4 we will define all of the above terms and discuss how they can contribute to performance.

4. The MEDA Event Model

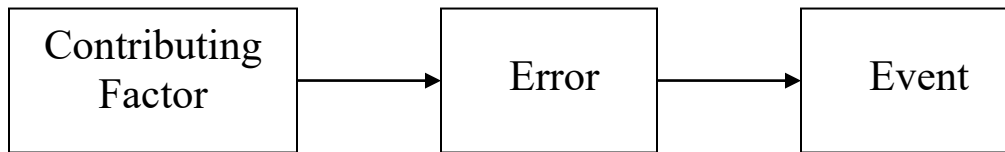The earliest and simplest form of the MEDA event (error) model is shown in Figure 2.

```
┌─────────────┐      ┌─────────┐      ┌─────────┐
│ Contributing│ ───▶ │  Error  │ ───▶ │  Event  │
│   Factor    │      │         │      │         │
└─────────────┘      └─────────┘      └─────────┘
```

Figure 2. Initial MEDA Error Model

In this simple model, one or more contributing factor(s) causes an error that causes an event. However, cause is a "strong" word. We need to think about two meanings of "cause."

- Cause-in-fact: If "A" exists (occurred), then "B" will occur.
- Probabilistic: If "A" exists (occurred), then the probability of "B" occurring increases.

We will find that in the maintenance technician/inspector's world there are relatively few "cause-in-fact" occurrences, especially with regard to contributing factors causing errors. For the "contributing factor→error" relationship, almost all causes are "probabilistic." For the "error→event," it is possible to have some "cause-in-fact" instances. For example, leaving an O-ring seal off of a master chip detector will always result in an oil leak if an engine is run at take-off power. However, as an investigator, you will find that even for the error→event relationship that most causes are probabilistic in nature. This causal thinking leads to a more complex MEDA error model.

```
            Probability               Probability
┌─────────────┐          ┌─────────┐          ┌─────────┐
│ Contributing│ Leads    │  Error  │ Leads    │  Event  │
│   Factor    │   to ──▶ │         │   to ──▶ │         │
└─────────────┘          └─────────┘          └─────────┘
```

Figure 3. Probabilistic MEDA Error Model

The model in Figure 3 shows explicitly that there is a probabilistic relationship between contributing factors and an error and between an error and an event. But based on

research and experience, we now know that there are typically three to five contributing factors to each error. In fact, there are contributing factors to the contributing factors. For example, maybe a maintenance technician did not install a spacer on a nose landing gear wheel (incomplete installation error) while re-installing the wheel, which leads to an event. During the investigation, we find that he did not use the maintenance manual to do the task because it was "not available;" he was working in a poorly lighted room and did not see the spacer on the wheel that was being replaced; and he was doing the task on overtime on the night shift and was fatigued. This leads to a more refined model, which is shown in Figure 4.
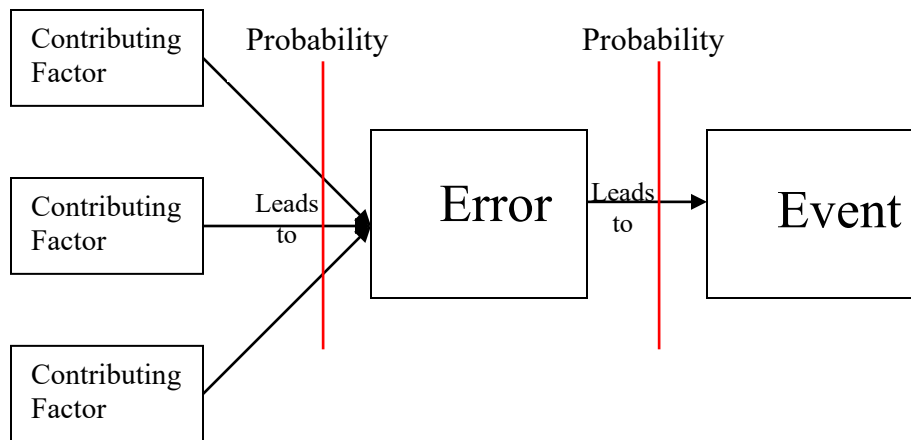

Figure 4. Enhanced MEDA Error Model

However, we also now know that there are contributing factors to contributing factors. For example, one of the contributing factors to the error in Figure 4 was that the maintenance technician was fatigued. Using the "ask why 5 times" principle, we ask the mechanic, "Why were you fatigued?" He answers, "I only got 5 hours of sleep last night." Why did you only get 5 hours of sleep?" "Well, my management asked me to work 8 hours overtime, and it's an hour drive from here to home and an hour drive back, so I only had 5 hours to sleep." Why did you have to work 8 hours of overtime?" "We are understaffed at the moment, so everyone is being asked to work some overtime." Thus, the cause of the fatigue was understaffing. This leads to Figure 5. [Note: In Figure 5 and following figures, we have dropped the terms "leads to" by the causation arrows. They should be assumed to exist by the reader.]
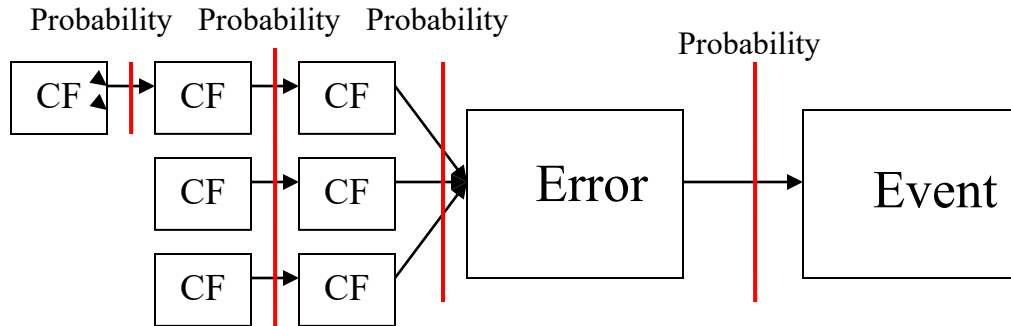
Figure 5. Further Enhanced MEDA Error Model

Now let us consider a violation in this model. There are at least two ways that a violation can contribute to an event. The first is given in Figure 6. A real-world example to fit the Figure 6 model is:

- The maintenance technician does not use a torque wrench when called out in the maintenance manual in order to torque a bolt (this is a violation)
- Because he does not use a torque wrench, he under torques the bolt (this is a system failure)
- Because the bolt is under torqued, an event occurs, like an air turn back
- But there is a reason (contributing factor) for why the maintenance technician did not use the torque wrench (maybe there was no torque wrench available to do the task or maybe the work group norm was not to use a torque wrench).

Of course, there may be contributing factors to the contributing factors, and the investigator would want to find out what these are as part of a full investigation.
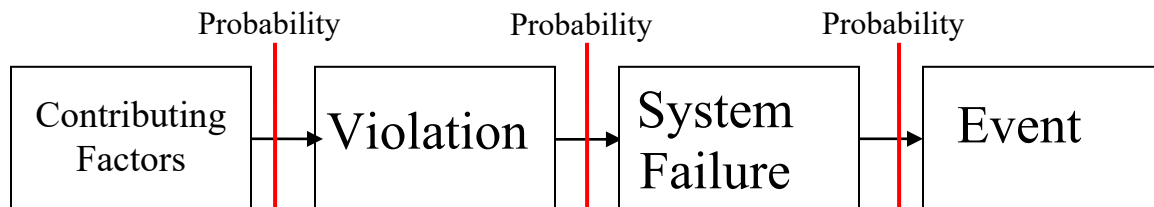
Figure 6. Event Model 1 with a Violation Leading Directly to a System Failure

In some cases the violation itself leads directly to the event rather than to an error that leads to an event. For example, a technician is supposed to use high-temperature grease, but finds that it is not available. The technician then finds that low-temperature grease is available so uses that instead even though he is aware that the greases serve two different purposes.

There is one other way in which a violation can contribute to an event. A good example of this is failure to carry out an operational check (a violation) at the end of a procedure that would catch an error. This is modeled in Figure 7.
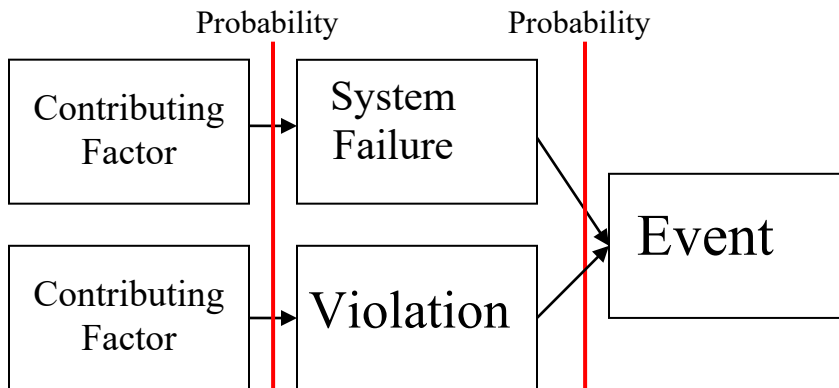
Figure 7. Event Model 2 with a Violation Causing the Technician Not to Catch an Error-Caused System Failure

Of course, both types of violations that are shown in Figures 6 and 7 can contribute to a single event. This is shown in Figure 8 below:

Figure 8. Combined Violation Model

Then we can put all of these models together to have a final event causation model that includes errors and violations. This is shown in Figure 9.
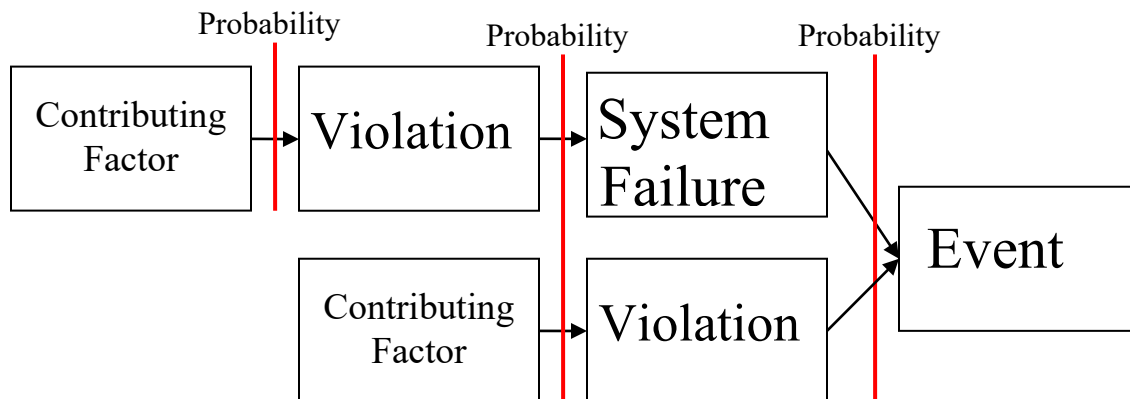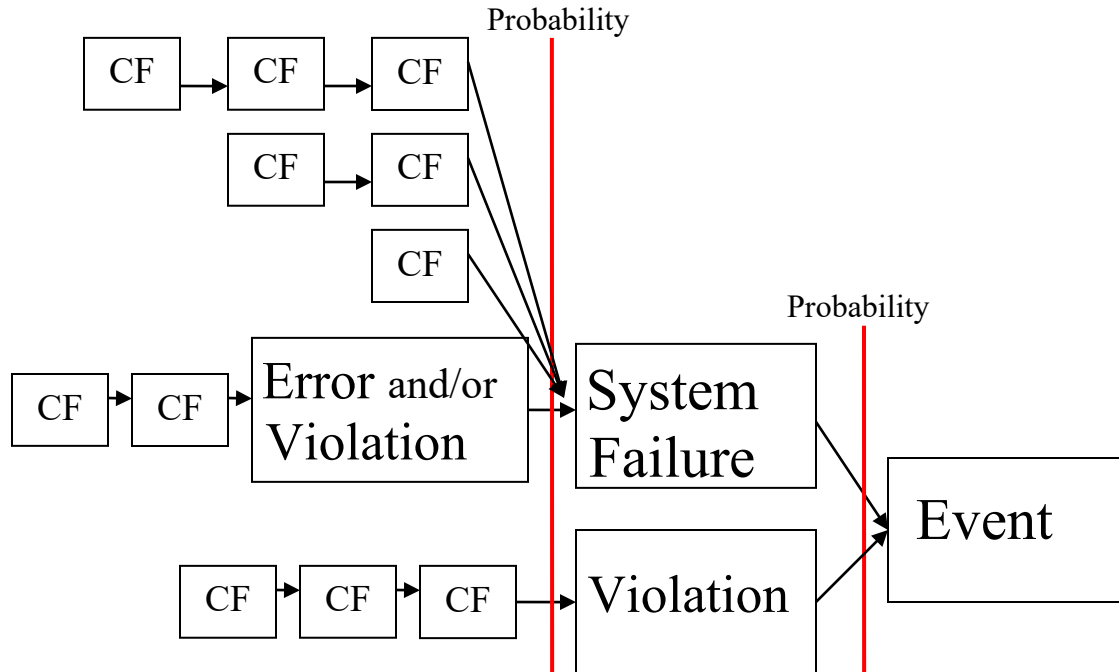
Figure 9. Final MEDA Event Model

5. The MEDA Philosophy

The MEDA philosophy is explained using the final MEDA event model (see Figure 9). The fundamental philosophy behind MEDA is:

- A maintenance-related event can be caused by an error, by a violation, or by an error/violation combination
- Maintenance errors are not made on purpose
- Maintenance errors are caused by a series of contributing factors
- Violations, while intentional, are also caused by contributing factors
- Most of these error or violation contributing factors are under the control of management, and, therefore, can be improved so that they do not contribute to future, similar events.

The central philosophy of the MEDA process is that people do not cause events on purpose. Nobody comes to work and says "I'm going to cause a flight delay today!" Some events do result from people engaging in behavior they know is risky (a violation, for example). Often, however, violations and errors are made in situations where the person is trying to do the right thing, and others in the same situation could make the same violation or error. For example, if an error is made because the maintenance manual is difficult to understand, then others using that same procedure could make the

same error. If a technician does a violation, e.g., not use a torque wrench when it is called out, and that violation is a work group norm, then others are likely to violate in that situation, also.

Typically an error (or violation) does not occur due to a single contributing factor. During the field test of the MEDA process, the field test airlines found that there were, on average, about four contributing factors to each error. So, we say that errors result from a series of contributing factors. Violations are also due to a contributing factor or a series of contribution factors, including peer pressure, time pressure, and existing normative behavior.

Most of these contributing factors are under management control. In order to change the probability that an event will occur in the future, the contributing factors must be addressed (i.e., changed or fixed). For example, if a person gets the wrong fastener from a parts bin because the bin labels are too faded to read correctly, then another maintenance technician could make the same error. If you wish to change the probability that the error will occur in the future, you need to change the bin labels. Too often, when an error occurs the maintenance technician is punished and no further action is taken. This is especially true if a violation is also causal to the error or event. Punishing the technician does not reduce the probability that others will make the same error, although it may have an impact on the violation. MEDA is a structured process for finding these contributing factors in order to address the contributing factors.

While not based on the event model per se, there are two other aspects of the MEDA philosophy:
- The maintenance organization must be viewed as a system and the maintenance technician is one part of the system, and
- Addressing the contributing factors to lower level events helps prevent more serious events.

From the systems perspective, the maintenance technician is a system component of the maintenance organization. This fact is illustrated in Figure 1 where we showed that a maintenance technician worked in an immediate work environment under supervision following the policies and procedures developed by the management in order to run the business. This is called a "socio-technical" system, which indicates that both technical issues (e.g., tooling, technical documentation, and aircraft systems) and social issues (e.g., teamwork and communication) affect the maintenance technician in doing his/her job.

Finally, we have seen good data from the U.S. Navy that showed that the contributing factors to low cost/no injury events were the same contributing factors to high cost/personal injury events. Thus, addressing the contributing factors to lower level events can prevent higher level events.

6. The MEDA Investigation Process

The purpose of this MEDA User's Guide is to provide information to the MEDA investigator. In order for the MEDA investigator to do his/her job correctly, he/she should understand their role as investigator within the whole investigation process. Figure 10 is a diagram of the MEDA investigation processes.
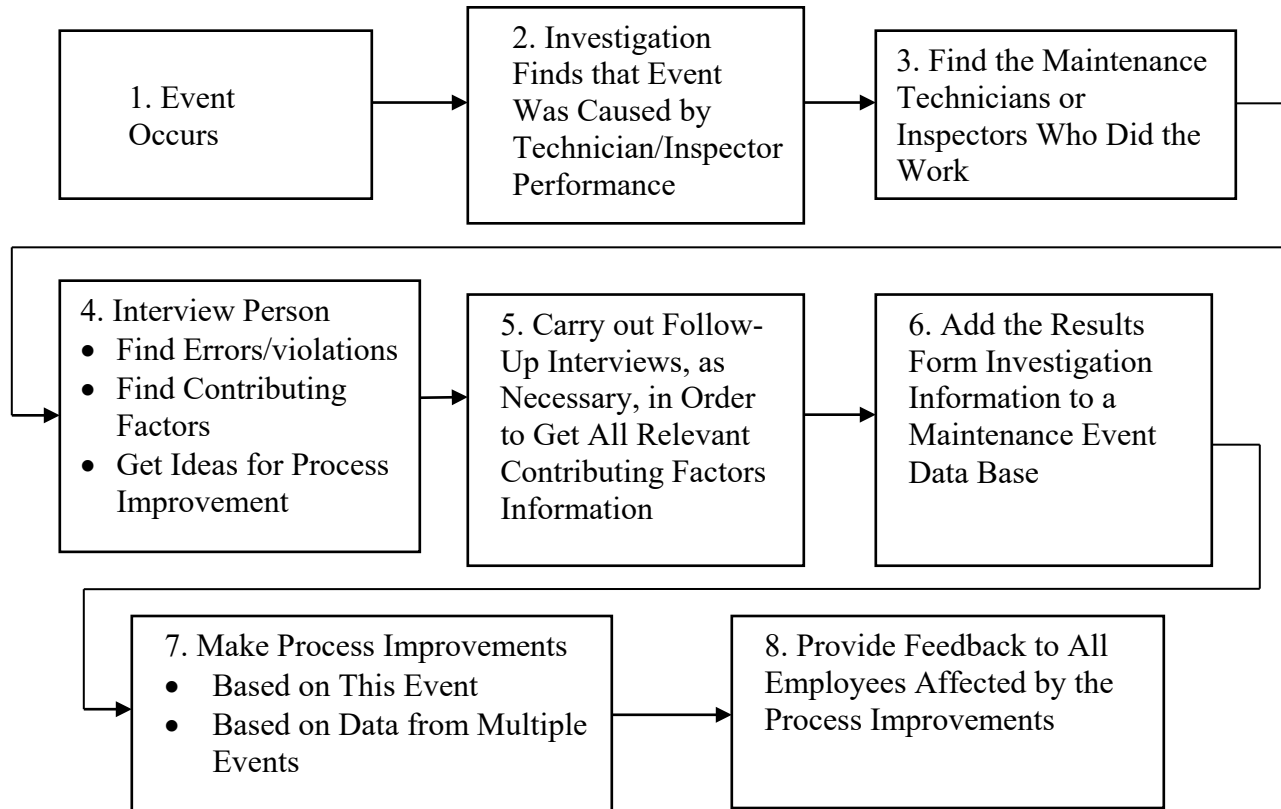
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┌──────────────┐     ┌────────────────────┐     ┌────────────────────┐
│              │     │ 2. Investigation   │     │ 3. Find the        │
│ 1. Event     │ ──▶ │ Finds that Event   │ ──▶ │ Maintenance        │
│ Occurs       │     │ Was Caused by      │     │ Technicians or     │
│              │     │ Technician/        │     │ Inspectors Who Did │
│              │     │ Inspector          │     │ the Work           │
│              │     │ Performance        │     │                    │
└──────────────┘     └────────────────────┘     └────────────────────┘

┌────────────────────┐     ┌────────────────────┐     ┌────────────────────┐
│ 4. Interview Person │     │ 5. Carry out       │     │ 6. Add the Results │
│ • Find Errors/      │     │ Follow-Up          │     │ Form Investigation │
│   violations        │ ──▶ │ Interviews, as     │ ──▶ │ Information to a   │
│ • Find Contributing │     │ Necessary, in      │     │ Maintenance Event  │
│   Factors           │     │ Order to Get All   │     │ Data Base          │
│ • Get Ideas for     │     │ Relevant           │     │                    │
│   Process           │     │ Contributing       │     │                    │
│   Improvement       │     │ Factors            │     │                    │
│                     │     │ Information        │     │                    │
└────────────────────┘     └────────────────────┘     └────────────────────┘

┌────────────────────┐     ┌────────────────────┐
│ 7. Make Process     │     │ 8. Provide         │
│ Improvements        │     │ Feedback to All    │
│ • Based on This     │ ──▶ │ Employees Affected │
│   Event             │     │ by the Process     │
│ • Based on Data     │     │ Improvements       │
│   from Multiple     │     │                    │
│   Events            │     │                    │
└────────────────────┘     └────────────────────┘
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Figure 10. The MEDA Investigation Process

1. MEDA is an event-based or reactive process. That is, a MEDA investigation is carried out after an event occurs in order to find out why the event occurred. However, before carrying out an MEDA investigation, we must know that a maintenance technician/inspector performance caused or was partially causal to the event.

2. Therefore, after an event occurs, the next thing that is done is an initial investigation to determine whether maintenance technician/inspector performance contributed to the event. If their performance was not involved, an engineering investigation may continue in order to determine why some technical system failed (e.g., from metal fatigue or failure of electronic parts). If there was an error and/or violation that caused or contributed to the event, then a MEDA investigation would follow.

3. The next thing that must be done is to find the maintenance technician or inspector who was involved in the maintenance.

4. Then you interview the maintenance technician/inspector, using the MEDA Results Form, in order to find out:
*   What the error(s) and/or violation(s) were that lead to the event
*   What the contributing factors were to the error(s) and/or violation(s), and
*   What ideas the maintenance technician/inspector has for improving/fixing the contributing factors.

Obviously, using the interview to understand the contributing factors to error and/or violation is the primary purpose of the MEDA investigation. The maintenance technician/inspector is, at that time, probably the world's expert on the contributing factors to that specific event. It is your job to find out what those contributing factors are. In addition, the maintenance technician/inspector is also probably the world's expert on what changes need to be made to the contributing factors in order to keep them from contributing to future, similar events. So, another task of the investigator is to get ideas for improvements to the contributing factors from the maintenance technician/inspector. Note that this helps make the erring maintenance technician/inspector part of the continuous improvement process, so they are no longer just "the person who caused the event."

5. During the interview with the maintenance technician/inspector you may obtain information that requires follow-up in order to gain full knowledge about the contributing factors or other circumstances. This may include follow-up interviews with other maintenance technicians in the same work group, with production planners or with spares technicians. Or, it may include inspecting something like a tool that the maintenance technician said was hard to use or the lighting in a room where the maintenance technician said it hard to see a parts label. Also, if the maintenance technician had a violation, but claimed that it was the group norm to carry out that violation, then you would want to determine if that violation was, indeed, a group norm.

6. Once all of the interviews/investigation has taken place, the Results Form data would be added to a database. Analysis can then be done to find trends in events, errors, violations, and contributing factors. This type of analysis will probably not be that useful until a number of investigations have been done—probably 20 or more—because trends might not be visible.

7. It is time to make improvements to the contributing factors. Management would typically make these types of decisions, since improvements to some contributing factors might cost money or manpower to implement. These decisions are often made at an existing meeting of managers, such as at the weekly/monthly QA audit findings meeting or the weekly/monthly management reliability findings meeting. Also, decisions about improvements might be made on the basis of one investigation, if there are obvious and relatively straightforward contributing factors that need to be fixed (like improved lighting or labeling). These decisions could also be made based on the analysis of several like events, if the improvements are less obvious or are expensive to make so that additional data are necessary to make a important, high-cost decision (like changing the shift handover procedure).

8. It is important to provide feedback to the maintenance technicians/inspectors to let them know what improvements are being made. This will show them that the process is being used to make improvements and is not being used to punish maintenance technicians/inspectors.

7. Using the MEDA Results Form

The MEDA Results Form is a four-page form consisting of six sections:
- Section I—General Information
- Section II—Event
- Section III—Maintenance System Failure
- Section IV— Chronological Summary of the Event
- Section V— Summary of Recommendations
- Section VI— Contributing Factors Checklist

Sections I, II, and III establish what happened (the event), Section IV provides a summary of the whole event in a chronological order, Section V lists recommendations for prevention strategies to prevent the errors and violations from occurring, and Section VI establishes why the event happened through listing all contributing factors.

7.1 Section I—General Information

This section is for collecting specific information about when, where, and to what the incident occurred. Your organization may have other or additional information that should be collected. We encourage organizations to change this section in order to collect the information that is most useful to you. This information often includes the variables that you would like to use when you sort the data or summarize the data. For example, you may want to summarize the MEDA results as a function of airplane type, station of error, or ATA chapter.

Reference #: Two letter airline designator plus three sequential numbers (e.g., BA001, BA002, etc.)

Airline: Two or three letter airline designator

Station of Failure: Station where the maintenance system failure occurred NOT where it is being reported (if different)

Aircraft Type: Manufacturer and model (e.g., 747-400, DC10-30, L1011-100, A320-200)

Engine Type: Manufacturer and model (e.g., PW4000, RB211-524, CF6-80A, etc.)

Reg. #: Aircraft registration number

Fleet Number: Letter or number designator

ATA #: Can be used to collect the ATA chapter (e.g., 30-10) most closely related to the error under investigation or the specific task card number for the task that resulted in the maintenance system failure.

Aircraft Zone: e.g., 001, 002, etc.

Ref. # of previous related event (If applicable): If this investigation is a repeat of a similar event, use this field to reference to the previous investigation's data

Interviewer's Name/Interviewer's Telephone #: This information is required in case the someone in the organization needs clarification or more detailed information about the causes of the event.

Date of Investigation: Date the investigation interview took place

Date of Event: Date the event occurred

Time of Event: Time of the event, if known

Shift of Failure: Shift during which the maintenance system failure occurred, if known

Type of Maintenance: Indicate whether the error occurred during line or base maintenance, and what type of check or maintenance was being performed (e.g., turnaround, A-Check, overhaul, etc.)

Date Changes Implemented: Date that recommended and approved prevention strategies were implemented and documented

7.2 Section II—Event

An event is an unexpected, unintended, or undesirable occurrence that interrupts normal operations. MEDA can be used to investigate seven major types of events:
1. Events that interrupt the normal process of flying from point A to point B, like flight delays, gate returns, cancellations, etc.
2. Aircraft damage events
3. Personal injury events
4. Finding somewhat immediately following task completion that the task had not been done correctly (e.g., through an inspection or operational/functional test), which resulted in having to do the task a second time (rework).

5. Airworthiness control events in which an aircraft was deemed airworthy, but was later determined to be unairworthy for some reason (e.g., AD overrun or incorrectly deferred defect).
6. System failures that were found during maintenance some time after the original maintenance was done and signed off.
7. Maintenance system failures that were found during flight and were corrected following the flight.

An eighth box is provided for "Other" in case the event does not fall into any of the above categories. It is entirely possible that there is more than one event checked on the form. For example, oil loss may cause an in-flight engine shutdown that is followed by a diversion.

Step 1 in the Event section is to select the event(s) that applies(apply) to this investigation.

Please select the event (check all that apply)

1. Operations Process Event
( ) a. Flight Delay ___days___hrs.___min.
( ) b. Flight Cancellation
( ) c. Gate Return
( ) d In-Flight Shut Down
(✓) e. Air Turn-back
( ) f. Diversion
( ) g. Smoke/fumes/odor event
( ) h. Other (explain below)

( ) **2. Aircraft Damage Event**
( ) **3. Personal Injury Event**
( ) **4. Rework** (didn't pass Ops check/inspection)
( ) **5. Airworthiness Control**
( ) **6. Found during Maintenance**
( ) **7. Found during Flight**
( ) **8. Other Event (explain below)**

The first category "Operations Process Event" refers to any interruption to the flight operations process, including flight delay, flight cancellation, gate return, in-flight (engine) shut down, air turn-back, diversion, smoke/fumes/odor events and other. The second type of event is "Aircraft Damage Event." The third type of event is "Personal Injury Event." The fourth event is "Rework." For instance, a mechanic performed a maintenance task, which did not pass the operational check or inspection. Therefore, a mechanic has to do the task over again.

Sometimes incorrectly performed maintenance does not cause any specific event, as was discussed in the preceding paragraph. For example, "Airworthiness Control" refers to the fact that sometimes the maintenance organization finds that something had been done incorrectly (see Section III.8 of the Results Form) that made the aircraft unairworthy (typically after a flight with that aircraft had taken place). The airline might have to self-disclose this information to the aviation authority, but we are not considering that an "event" from a MEDA investigation perspective. "Found during Maintenance" refers to a situation where a mechanic, during a maintenance task, notices that a previously-completed maintenance task had not been done correctly and needs to be rectified. "Found during flight" refers to a situation that pilots identifies a non-functioning system

or a missing piece of equipment during flight. However, they were able to keep flying to their final destination and did not need to do an air turn back or diversion. Instead they just make a log book entry about the system, so that the mechanics can fix the problem after the flight. "Airworthiness Control," "Found during Maintenance," and "Found during Flight" are a little different from other events, as we normally would think about what an "event" is. However, some of the MEDA users want to investigate these issues, so they needed to have something to check in this section.

Step 2 is to write a description of the incident/degradation/failure (e.g., could not pressurize) that caused the event using your own words. It is important that you not just check the box to indicate which event(s) occurred. You should write additional information in the blank space in the block.

Example: *After takeoff, the aircraft would not pressurize in the automatic mode. Manual control was noted as functional.*

7.3 Section III—Maintenance System Failure

In the MEDA model, the maintenance system failure (whether it is caused by an error, a violation, or an error/violation combination) leads directly to the event. The system failures that are listed are very specific and relate easily to maintenance technician and inspector performance. There are eight different major system failures listed:
   1. Installation failure
   2. Servicing failure
   3. Repair failure
   4. Fault isolation, test, or inspection failure
   5. Foreign object damage/debris
   6. Airplane or equipment damage
   7. Personal injury
   8. Maintenance control failure.
A ninth box is provided for "Other" in case the specific system failure of interest was not listed in 1-8 above.

Categories 1 through 3 refer to system failures that occurred during on-aircraft "installation" "servicing," and "repair," which could take place during line maintenance or scheduled/heavy maintenance. There is a separate MEDA Results Form for investigating events that are caused by workshop maintenance. Once you learn how to use the regular MEDA Results Form, it is intuitive to use the MEDA Results Form for the workshops. Please contact Boeing for a copy of the form.

"1. Installation failure" refers to incorrect installation that leads to the event. Here are some examples:
   a. *Equipment/part not installed*
       – The mechanic forgot to replace the battery when he replaced the Emergency Locator Transmitter (ELT).

b. *Wrong equipment/part installed*—the mechanic installed a wrong part or improperly reassembled part,
   – Misinstalled the bracket over the spray shield rather than the spray shield being over the bracket.
   – Used the wrong fastener
   – Used the wrong "dash number" part
c. *Wrong orientation*
   – Installed a hydraulic pump backwards.
d. *Improper location*
   – The mechanic was supposed to work on the No.2 engine but went to work on the No.1 engine instead.
e. *Incomplete Installation*
   – The installation was started but never completed.
f. *Extra Part Installed*
   – Installed a gate valve in a fuel line when a gate valve was already in the system.
g. *Access not closed*
   – The mechanic failed to install a top-of-wing access panel
h. *System/equipment not reactivated/deactivated*
   – The mechanic forgot to deactivate a system by pulling and collaring a circuit breaker before doing the maintenance task.
   – The mechanic forgot to reset a circuit breaker after finishing a maintenance task.
i. *Damage on remove/replace*
   – The mechanic caused damage to the part and/or subsystem during removal or replacement of the part or subsystem
j. *Cross connection*
   – The mechanic cross connected the cargo fire extinguish circuit system.
   – The mechanic cross connected the nose landing gear hydraulic system
k. *Mis-rigging (controls, doors, etc.)*
   – Misrigged flight control cables
   – Misrigged number 1L door.
l. *Consumable not used*
   – The mechanic put a master chip detector in the engine oil system, but forgot to put an O-ring seal on it.
m. *Wrong consumable used*
   – The mechanic used the wrong sealant
   – The mechanic used the wrong grease type.
n. *Unserviceable part installed*
   – The part was unserviceable, but since it was on the serviceable parts rack, it got installed.
o. Other
   – For additional installation failure if an item is not covered in the above list.

"2. Servicing failure" refers to system failures occurred during servicing that lead to the event. Here are some examples:

    a. *Not enough fluid*
- The mechanic did not add enough quantity of fluid, e.g., nitrogen for the tires, engine oil, or hydraulic fluid.

    b. *Too much fluid*
- The mechanic added too much oil to the IDG.
- The mechanic over pressurized the landing gear tires.

    c. *Wrong fluid type*
- The mechanic put engine oil in the hydraulic system.
- The mechanic used a general purpose grease when he should have used a high temperature grease.
- The mechanic used air in the tires instead of nitrogen.

    d. *Required servicing not performed*
- The mechanic did not lubricate the jack screw.
- Engine oil not added before an ETOPS flight.

    e. *Access not closed*
- The access panel was not closed after the servicing.

    f. *System/equipment not deactivate or* reactivated
- The mechanic forgot to deactivate a system before carrying out a servicing task.
- The mechanic forgot to reactive a system after carrying out a servicing task.

    g. Other – for additional servicing failure if an item is not covered in the above list.

"3. Repair failure" refers to system failures that occurred during an on-wing repair, which can be a system or structural repair. Here are some examples:

    a. *Incorrect*
- The repair was done incorrectly

    b. *Unapproved*
- The repair was not approved by Engineering or the OEM

    c. *Incomplete*
- The repair was started but not completed.

    d. *Other* – for additional repair failures, if an item is not covered in the above list.

"4. Fault isolation/test/inspection failure" refers to maintenance system failures that occurred during fault isolation, a system test, or an inspection. Here are some examples:

    a. *Did not detect fault*
- The mechanic checked the EICAS messages, but did not see that a system had failed

    b. *Not found by fault isolation*
- The mechanic used the Fault Isolation Manual to troubleshoot the fault, but the logic did not determine what the fault was.

    c. *Not found by operational/functional test*
- The mechanic did not carry out the operational test at the end of a remove and replace task.
- The mechanic carried out the operational test (e.g., motor the engine for 60 seconds) after working on the engine oil system, but the faulty oil

system coupling did not start to leak at the temperatures/pressures of the operational check.

d. *Not found by task inspection*—this refers specifically to task inspections that are carried out following a scheduled maintenance task or line maintenance task where the purpose of the inspection is to make sure the task was done correctly.
  – The QC inspector missed an incorrect installation following a scheduled maintenance task and signed off on the task.
  – The QC inspector did not see that rags and gloves were left in the wing tank when he did the inspection following the leak check and repair task.

e. *Access not closed*
  – Access panel was not closed after the remove and replace.

f. *System/equipment not deactivated/reactivated*
  – The QC inspector forgot to deactivate a system before carrying out an inspection task
  – The QC inspector forgot to reactive a system after carrying out an inspection task.

g. *Not found by part inspection*
  – The part inspection carried out by Material staff missed the fact that they received the wrong "dash number" part.
  – The part inspection missed the fact that the part they received from the workshop was unserviceable and put it into Stores.

h. *Not found by visual inspection*—this refers specifically to general visual inspections or detailed visual inspections where the task itself is the inspection task.
  – The inspector did not detect wear on a bushing during an "open up" inspection.
  – The inspector did not detect the cracking in the aluminum skin on the crown of the aircraft during a zonal inspection.
  – The inspector did not detect the corrosion in the bilge of the aircraft during a general visual inspection.

i. *Technical log oversight*
  – The line mechanic missed an item logged by the flight crew in the technical log, so the fault was not fixed or correctly deferred.

j. *Other* – for additional repair failure if an item is not covered in the above list.

"5. Foreign object damage/debris" refers to system failures that lead to foreign object damage or to foreign object debris being left on the aircraft. Here are some examples:

a. *Tooling/equipment left in aircraft/engine*
  – The mechanic left his flash light in the engine cowling.
  – The mechanic left rags and gloves in the fuel tank during tank repairs.

b. *Debris on ramp*
  – A soft drink cup was blown onto the ramp.
  – Baggage tags were torn from the bags and left on the ramp by the ground crew.

c. *Debris failing into open systems*

     – Debris fell into an uncapped engine quick disconnect line during an engine change.

  d. *Other* – for additional FOD or debris related system failures if an item is not covered in the above list.

"6. Airplane/equipment damage" refers to system failures associated with airplane/equipment damage. Here are some examples:

  a. *Tools/equipment used improperly*
     – A maintenance stairs was not locked/chocked properly and was blown into the aircraft by a gust of wind causing damage.

  b. *Defective tools/equipment used*
     – A fastener was over torqued because the torque wrench was out of calibration..

  c. *Struck by/against*
     – A mechanic accidentally dropped a wrench on the leading edge device and caused damage.

  d. *Pulled/pushed/drove into*
     – A baggage tug ran into the side of the aircraft and caused damage.

  e. *Fire/smoke*
     – The aircraft sustained smoke damage from an ECS fan.

  f. *Other* – for additional airplane/equipment damage related system failures if an item is not covered in the above list.

"7. Personal injury" refers to system failures associated with personal injury, in another work, how a personal injury has occurred.

  a. *Slip/trip/fall*
     – A mechanic slipped on an oil spill and fell breaking his wrist.

  b. *Caught in/on/between*
     – A mechanic was caught between the horizontal stabilizer jackscrew and the vertical fin when the jackscrew slipped out of the removal sling.

  c. *Struck by/against*
     – A mechanic was struck by the aircraft when it fell off the jack.

  d. *Hazard contacted (e.g., electricity, hot or cold surfaces, and sharp surfaces)*
     – A mechanic received an electrical shock when he touched a power panel.

  e. *Hazardous substance exposure (e.g., toxic or noxious substances)*
     – A mechanic passed out from fumes while cleaning the forward cargo compartment on a 747.

  f. *Hazardous thermal environment exposure (heat, cold, or humidity)*
     – *A mechanic* sustained frostbite while doing line maintenance in -30C weather.

  g. *Other* – for additional personal injury related system failures if an item is not covered in the above list.

"8. Maintenance control failure" is a relatively new category of maintenance system failures. It was added to the MEDA Results Form based on MEDA user feedback. A maintenance control failure typically results in an airworthiness control event. Here are some examples:

a. *Scheduled task omitted/late/incorrect*
   – Production Planning & Control left a task out of a stack of task cards for a heavy check.
   – Contracted maintenance could not access airline's electronic data and thereby missed a task
   – Task card moved to wrong section of the control board, scheduled at the wrong time, and left out of check
   – Task card was raised but scheduled into the wrong part of the work flow
   – Scheduled task was not able to be completed during the allotted heavy check time, so aircraft was released to service and the task was completed the following week.
   – The wrong task card or Engineering Order (EO) or task card/EO revision was issued for the aircraft check.

b. *MEL interpretation/application/removal*
   – A mechanic misinterpreted the MEL and incorrectly MELed a system
   – A system could be MELed if another system was serviceable, but the mechanic did not check the status of the system, which was not serviceable, and incorrectly MELed the system.
   – A mechanic correctly interpreted that the system could be MELed, but did not carry out the maintenance action (e.g., lock out a system or hang a placard) necessary to correctly carry out the MEL.
   – A mechanic applied MEL for the auto pilot but did not downgrade the landing status (e.g., CAT I, II, or III) capability of the aircraft for the operation restriction.
   – After the MELed system was repaired, the mechanic forgot to remove the lock out and/or the placard that was hung when the system was MELed.
   – A mechanic correctly believed that he could CDL a 777 main gear wheel hubcap that was missing, but the associated Tire Pressure Indication System was inoperative, and he dispatched the aircraft without MELing the tire pressure system indicator with MEL item 32-49-01.
   – Incorrect application of the MEL (use of incorrect MEL code)

c. *CDL interpretation/application/removal*
   – A mechanic misinterpreted the Configuration Deviation List and incorrectly CDLed a piece of structure.
   – A mechanic correctly interpreted the CDL and CDLed a piece of structure. However, structure had a related take-off/cruise/landing weight penalty, and the mechanic did not list the limitations on a placard and affix the placard in the cockpit in clear view of the pilot-in-command.

d. *Incorrectly deferred/controlled defect* – This category will not include MEL or CDL items, but may include
   – Quarantined part (serviceable part) was incorrectly sent to workshop
   – Wrong seat number put into the cabin log regarding a torn seat.

   – Cabin log item not addressed within company's approved maintenance
     program

e. *Airworthiness data interpretation* (any ICA)
   – A mechanic misinterpreted the Structural Repair Manual and thought that the
     aircraft damage was within limits and released the aircraft for flight. A
     mechanic misinterpreted the Fault Isolation Manual logic instructions, which
     lead to him not finding the fault.
   – A mechanic misinterpreted the AMM and incorrectly maintained the aircraft

f. *Technical(aircraft) log use and oversight*
   – The mechanic forgot to check the technical log and missed the fact that a
     squawk had been raised during the flight that needed to be dealt with.
   – The mechanic entered fuel oil heat exchanger needed to be exchanged when
     air oil heat exchanger needed to be changed
   – Mechanic transposed data into the log (oil added to engines)
   – The mechanic checked the log, but did not see the items that needed to be
     fixed.
   – Damage data incorrectly/not entered into the log

g. *Airworthiness Directive overrun*
   – *T*he AD was supposed to be incorporated across the airline 777 fleet by a
     certain date, but the incorporation was not completed on all of the 777 fleet by
     that date. (Missed by Engineering (CAMO) and not given to PP&C---
     Continuing Airworthiness Management Org)
   – Not done during allotted time by 145 organization

h. *Modification control*
   – CAMO purchased the wrong part based on effectivity
   – Component demodified during shop visit so it no longer meets the SB
     requirement
   – Parts ordering and control system orders wrong part based on incorrect
     effectivity

i. *Configuration control*
   – After implementing several service bulletins during a D check, the
     organization lost knowledge about the aircraft's existing configuration.
   – Engineering Order incorrectly authored
   – Incorrect information about maintenance done by MRO/145 Organization
   – Incorrect data entered into computer system (SAP, etc.)

j. *Records control*
   – The task cards that had been implemented on a specific tail number aircraft
     were lost and the status of the aircraft could not be proven to the National
     Aviation Authority.

– The airline was ready to sell an aircraft, but could not locate all of the implemented task cards and prove to the potential buyer that the aircraft was maintained up through a D check.
– Records incorrectly amended after "storage" (computerized or Technical Records storage)
– Records lost (e.g., fire or water damage)

k. *Component robbery control*
– The mechanic robbed a part from an aircraft in heavy check, but did not hang the "Removed Parts" tag. The aircraft was subsequently released to service without the part being installed.
– Incorrect effectivity of removed parts not identified
– Aircraft paperwork not raised after the part was robbed

l. *Maintenance (Mx) information system (entry or update)*
– The mechanic did not enter information about oil consumption into computerized record keeping system for an ETOPS aircraft following an ETOPS flight, so Engineering was not able to determine the oil consumption rate on the aircraft
– Incorrect parts serial numbers entered
– Decimal points entered into wrong position
– Non-routine not entered into the system
– Did not enter required data (torque settings, torque tool serial number)

m. *Time expired part on board aircraft*
– Life vests left on board the aircraft past their expiration date.
– Landing gear was not replaced after its on-aircraft time limitation.
– Automatic external defibrillator (AED) not checked
– O2 bottles out of date
– Battery on the Emergency Locator Beacon (Device) not replaced after time expired

n. *Tooling control*
– Mechanic used an out of certification torque wrench or other calibrated tooling.

o. *Maintenance (Mx) task not correctly documented*
– The mechanic saw a problem on the aircraft and performed maintenance to fix it, but did not document the work he had done
– Loosening a fuel (hydraulic) line for troubleshooting but did not raise a non-routine
– Part removed for access, not documented, and not replaced before release.
– Wrong AMM references entered into the Technical Log
– Insufficient data entered into the Technical Log ("ops check OK" or "Satis")

p. *Not authorized/qualified/certified to do task*

> – Mechanic's authorization (qualification/certification) to do a specific task had expired, but he and his manager were unaware of this, and the mechanic was assigned to and carried out that task.

q. *Other* – for additional failures that are relevant to maintenance control

Step 1 is to select the type of maintenance system failure by putting a check mark (✔) in the correct box or boxes. NOTE: Sometimes several system failures combine to cause an event. It is important to keep track of which prevention strategies and contributing factors listed in Sections V and VI relate to which system failures identified in Section III. This could be done in several ways. For example, you could fill out one Results Form for each system failure. Alternatively, you could check one system failure box with a red pencil and the second with a blue pencil. Then the factors that contributed to the first system failure could be written in red and the factors that contributed to the second system failure could be written in blue. Or, you could put a * by the first system failure and a # by the second system failure. Then you could place a * by the factors that contributed to the first system failure and a # by the factors that contributed to the second system failure.

Step 2 is to answer the question, "Did the Maintenance System Failure "fly" on the aircraft?" Check "Yes" if the system failure was not caught before the next flight of the aircraft. Check "No" if the system failure was found and corrected before the next flight of the aircraft.

Step 3 is to write a brief written description of the maintenance system failure in the open space below the listed system failures.

Example:
The auto pressure controller was installed with the sense lines backwards.

For an item checked in the "1. Operations Process Event" and/or "4. Rework" in Section II – Event, you need to select corresponding maintenance system failure(s) among the following categories in Section III – Maintenance System Failure:
1. Installation Failure
2. Servicing Failure
3. Repair Failure
4. Fault Isolation/Test/Inspection Failure
5. Foreign Object Damage

A "2. Aircraft Damage Event" in Section II – Event corresponds to maintenance system failure(s) in "6.Airplane/Equipment Damage" category in Section III – Maintenance System Failure.

A "3. A Personal Injury Event" in Section II – Event corresponds to maintenance system failure(s) in "7. Personal Injury" category in Section III – Maintenance System Failure.

A "5. Airworthiness Control" in Section II – Event corresponds to maintenance system failure(s) in "8. Maintenance Control Failure" category in Section III – Maintenance System Failure.

7.4 Section IV. Chronological Summary of the Event

The purpose of this section is to provide you with some space to describe and summarize the event in a chronological order and what you found regarding contributing factors during the interview. If any of the identified contributing factors lead to additional contribution factors, make sure you document those causal relationships here as well. If there is not enough room provided, continue the description on another piece of paper and submit it with the rest of the MEDA Results Form.

7.5 Section V. Summary of Recommendations

We recommend you summarize recommendations for each or a combination of identified contributing factors in the following manner:
First of all, write down a "Recommendation #" (e.g., 1, 2, 3, etc.), so that it is easier to refer to later on. For each recommendation, record the corresponding "Contributing Factor #" (e.g., A.1. for Information Not Understandable). [Note: One Recommendation might be related to two or more contributing factors.] Third, write down the proposed improvement to be made to the contributing factor(s) that you listed (e.g., rewrite the third step in the engineering order to make clear what the torque values are supposed to be).

In order to help you compile a summary of recommendations and think through event prevention strategies, the following material describes the four major types of strategies that you should consider for preventing system failures as the cause of the event:
1. Error reduction/error elimination
2. Error capturing
3. Error tolerance
4. Audit programs.
These strategies are discussed in more detail below.

Often, an investigation does not yield contributing factors with strong linkages to the system failures under investigation. Sometimes the effect of certain contributing factors is not fully understood until a number of events are investigated with the same contributing factor(s) related to them. The difficulty for the front-line manager performing an investigation is the pressure to take action resulting from a single event investigation. The dilemma, however, is how to decide on a prevention strategy when you do not have any strong identifiable contributing factors leading to the error. What if the error had safety implications? Somehow, the error must be addressed. The following four strategies specifically discuss error (not violation) prevention strategies.

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Error Reduction/Error Elimination: The most often used, and most readily available, error prevention strategies are those that directly reduce or eliminate the contributing factors to the error. Examples include increasing lighting to improve inspection reliability and using Simplified English procedures to reduce the potential for mis-interpretation. These error prevention strategies try to improve task reliability by eliminating any adverse conditions that have increased the risk of maintenance error.

Error Capturing: Error capturing refers to tasks that are performed specifically to catch an error made during a maintenance task. Examples include a post-task inspection, an operational or functional test, or a verification step added to the end of a long procedure. Error capturing is different than error reduction because error capturing does not directly serve to reduce the "human error." For example, adding a leak check does little to reduce the probability of a mis-installed chip detector. It does, however, reduce the probability that an aircraft will be dispatched with a mis-installed chip detector. This is why most regulatory authorities require a subsequent inspection of any maintenance task that could endanger safe operation of the aircraft if performed improperly.

While error capturing is an important part of error management, new views point to a general over-confidence in the error capturing strategy to manage maintenance error. In theory, adding a post-task inspection will require two human errors to occur in order for a maintenance-induced discrepancy to make it onto a revenue flight. In recent years, however, there has been a growing view that the additional inspection to ensure the integrity of an installation will adversely impact the reliability of the basic task. That is, humans consciously or subconsciously relax when it is known that a subsequent task has been scheduled to "capture" any errors made during the primary task. It is not unusual to hear an airline manager say that the addition of an inspection did little to reduce the in-service experience of the error. For example, several major carriers are pulling inspections out of scheduled line-maintenance tasks, in the hopes of improving quality.

Error Tolerance: Error tolerance refers to the ability of a system to remain functional even after a maintenance error. The classic illustration of this is the 1983 Eastern Airlines loss of all three engines due to O rings not installed on the chip detectors. As a strategy to prevent the loss of multiple engines, most regulatory authorities granting ETOPS (extended twin operations) approval prohibit the application of the same maintenance task on both engines prior to the same flight. The theory is that even if a human error is made, it will be limited to only one engine. This was not the case in the Eastern loss of all three engines. One type of human error, the same incorrect application of a task applied to all three engines, nearly caused an aircraft to be lost.

Another example of building error tolerance into the maintenance operation is the scheduled maintenance program for damage tolerant structures (e.g., allowing multiple opportunities for catching a fatigue crack before it reaches critical length).

Error tolerance, as a prevention strategy, is often limited to areas outside the control of the first line investigator. However, it is important for the first line supervisor or

interviewer to be aware of this type of prevention strategy, and consider error tolerance when it may be the best way to effectively deal with the error.

Audit Programs: Audit programs refer to an approach that does not to directly address a specific contributing factor. An audit is a high-level analysis of the organization to see if there are any systemic conditions that may contribute to error.

7.6 Section VI. Contributing Factors Checklist

This checklist will help the analyst identify the contributing factors that contributed to the system failure. [Remember, if two or more systems failures combined to cause the event, it is important to identify which factors relate to which system failures.] There are ten major categories of contributing factors in the checklist:

A. Information
B. Ground support equipment, tools, and safety equipment
C. Aircraft design, configuration, parts, equipment, and consumables
D. Job or task
E. Knowledge and skills
F. Individual factors
G. Environment and facilities
H. Organizational factors
I. Leadership and supervision
J. Communication

Step 1 is to put a check mark by all of the applicable contributing factors for the system failure(s) identified in Section III.

Step 2 is to provide a written description of how each factor that was identified actually contributed to the system failure in the open space in the contributing factors box.

Step 3 is to put a check mark by N/A (Not applicable), which is located to the left of each of the ten categories, if you determine that no contributing factors from that category contributed to the system failure(s).

Contributing Factors Checklist Examples

The following pages contain additional information about each contributing factor from Section VI of the MEDA Results Form. Each lettered section heading corresponds to a lettered block on the Results Form, and each numbered item beneath that heading corresponds to a numbered item on the Results Form. Use this supplemental material during your system failure analysis to assist you in filling out the Results Form.

7.6.A Information

Information refers to the written or computerized source data that a maintenance technician or inspectors needs to carry out a task or job. It includes work cards or task cards, maintenance manual procedures, service bulletins or engineering orders, maintenance tips, illustrated parts catalogs and other manufacturer supplied or internal resources. Information does not include verbal instructions from supervisors, shift handover logs, etc., which are considered to be Communication on the Results Form

To determine that information was a contributing factor to the maintenance system failure, either the information itself must be problematical (e.g., hard to understand, not complete, conflicting), or the information should have been used but was not (e.g., it was not available, it was not used). If it is expected that the maintenance technician has this information memorized, then refer to the Technical Knowledge/Skills section.

Examples to look for:

1. *Not understandable*
   - Unfamiliar words or acronyms
   - Unusual or non-standard format
   - Poor or insufficient illustrations
   - Not enough detail or missing steps
   - Poorly written procedures

2. *Unavailable/inaccessible*
   - Procedure does not exist
   - Not located in correct or usual place
   - Not located near worksite

3. *Incorrect*
   - Missing pages or revisions
   - Does not match aircraft configuration
   - Transferred from source document incorrectly
   - Steps out of sequence
   - Not the most current revision
   - Procedure does not work

4. *Too much/conflicting information*
   - Similar procedures in different resources do not agree (e.g., aircraft maintenance manual [AMM] versus task card)
   - Too many references to other documents
   - Configurations shown in different resources do not agree

5. *Update process is too long/complicated*
   - Requested revisions have not been incorporated yet
   - Configurations changed by Service Bulletins (SB) or Engineering Orders have not been updated in applicable maintenance procedures

- Document change requests are not submitted, lost, or incorrectly filled out

6. Incorrectly modified manufacturer's MM/SB
- Intent of manufacturer's procedure is not met
- Non-standard practices or steps are added
- Format does not match rest of procedure or other procedures

7. Information not used
- Not using technical documentation is potentially a violation. If the technician should have used the documentation, but did not, find out why (i.e., what the contributing factors were to not using the documentation).
- Procedure available but the technician did not have enough time to get it
- Technician thought that he/she did not need the procedure because he/she had done the task many times before

8. Inadequate
- The technical documentation did not include a detailed enough task level description for the technician to carry out the task correctly.
- The technical documentation did not include technical information needed to carry out the task, e.g., torque values or loop resistance values.
- The technical documentation did not include enough figures or graphics to help explain clearly what needed to be done by the technician.

9. Uncontrolled
- The technician used an uncontrolled copy of technical documentation, and the differences between the uncontrolled documentation and the controlled documentation contributed to the error.
- Technician used his/her "black book," and the information was no longer correct.

10. Other
- Operator cannot use digital information

7.6.B Ground Support Equipment, Tools, and Safety Equipment

<u>Ground support equipment/tools/safety equipment</u> are the tools and materials necessary for the safe performance of a maintenance task. Equipment and tools refer to things such as work stands, calibrated torque wrenches, screwdrivers, test boxes, and special tools called out in maintenance procedures. Safety equipment includes both personal protective equipment, such as hearing protection, toe protection, and safety harnesses, as well as collective safety devices, such as hazard barriers and safety railings.

Unsafe equipment and tools may cause a maintenance technician or inspector to become distracted from the task due to concern for personal safety. If equipment or tools are not available or are inaccessible, the maintenance technician or inspector may use other equipment or tools that are not fully suited for the job. Other factors that can contribute to system failure include out of calibration instruments, use of unreliable equipment, or equipment or tools with no instructions for use.

Examples to look for:
1. *Unsafe*
   - Platform moves and is unstable
   - Brakes or safety devices inoperative
   - Non-skid material worn or missing
   - A lock-out mechanism is missing or faulty
   - Placards (warnings or cautions) are missing or faded
   - Sharp edges are exposed or personal protective devices are missing
   - Power sources are not labeled or protected

2. *Unreliable*
   - Intermittent or fluctuating readings on dials or indicators
   - Damaged or worn out
   - Expired use limits
   - History of defects

3. *Layout of controls or displays*
   - Easy to read wrong display or use wrong control
   - Awkward locations, hard to reach
   - Too small to read or control
   - Directional control of knobs or dials is not clear

4. *Out of calibration*
   - Tool out of calibration from the start of use
   - Wrong specifications used during calibration procedure

5. *Unavailable*
   - Is not owned or in stock

- Not available for procurement

6. *Inappropriate for the task*
   - Standard hand tools used for leverage
   - Not capable of handling weights, forces, or pressures required for the task
   - Connections or grips not the right size

7. *Cannot use in intended environment*
   - Not enough space to operate tool
   - Requires level surface where one is not available

8. *No instructions*
   - Instructional placards missing or faded
   - Directional markings missing
   - Tool usage instructions not available

9. *Too complicated*
   - Tool usage requires too many simultaneous movements and/or readings
   - Fault isolation or testing is too complex

10 *Incorrectly labeled*
   - Hand marked labeling or operating instructions are incorrect
   - Tool has incorrect scale readings

11. *Not used*
   - Equipment/tool/part is available but not used. Not using the correct equipment/tools/safety equipment is potentially a violation. If the technician or inspector did not use the correct equipment/tools/safety equipment, find out why (i.e., what the contributing factors to not using it).

12. *Incorrectly used*
   - Safety equipment not appropriate for the hazard
   - Personal protective equipment not properly worn

13. *Inaccessible*
   - Not in usual location (possibly being used on other task or aircraft)
   - Too far away from the worksite

14. *Past expiration date*
   - The valid calibration date for torque wrench has expired.

15. *Other*
   - System protection devices on tools/equipment not available

7.6.C Aircraft Design, Configuration, Parts, Equipment, and Consumables

An aircraft should be <u>designed/configured</u> so that parts and systems are accessible for maintenance. <u>Equipment and consumables</u> need to be available and accessible. The maintenance technician should be able to see and reach a part, should be able to remove it from a reach and strength standpoint, and should be able to easily replace the part in the correct orientation. When reviewing accessibility as a contributor to maintenance system failure, it must be seen as a real contributor to the system failure and not just as an inconvenience to the maintenance technician or inspector.

Configuration variability between models and aircraft can contribute to system failure when there are small differences between the configurations that require maintenance tasks to be carried out differently or require slightly different parts.

<u>Parts</u> refer to aircraft parts that are to be replaced. <u>Equipment</u> refers to required equipment per a maintenance or inspection procedure. <u>Consumables</u> refer to materials (e.g., grease, fluorescent dye) that to be consumed for a specific maintenance or inspection task or job. Incorrectly labeled parts can contribute to improper installation or repair. Parts or equipment or consumables that are unavailable or expired can contribute to system failure by the maintenance technician/inspector who substitute or skip the required part or equipment or consumables.

Good part design also incorporates feedback that helps the maintenance technician know that something has been performed correctly. For example, an electrical connector that has a ratchet effect provides feedback to the maintenance technician when the installation is correct. If this ratchet effect is included in some connectors and not others, this could contribute to system failure. If a maintenance technician goes from a ratchet connector to a non-ratchet connector, the technician may over tighten the second connector looking for the ratchet.

Examples to look for:

1. *Complex*
   - Fault isolation on the system or component is difficult
   - Installation of components is confusing, long, or error prone
   - Multiple similar connections exist on the system or component (electrical, hydraulic, pneumatic, etc.)
   - Installation tests for the component are extensive and confusing
   - Different sized fasteners can be installed in multiple locations

2. *Inaccessible*
   - Components or area to be maintained is surrounded by structure
   - No access doors exist in the maintenance area
   - Area lacks footing space or hand-holds
   - Small or odd-shaped area

3. *Aircraft configuration variability*
   - Similar parts on different models are installed differently
   - Aircraft modifications have changed installation or other maintenance procedures between aircraft

4. *Parts/equipment unavailable*
   - Part not owned or in stock
   - Not available for procurement

5. *Parts/equipment incorrectly labeled*
   - Hand marked labeling incorrect
   - Wrong part number on part

6. *Inappropriate for the task*
   - Consumables (e.g., tapes, rags) are the same color as the inside of the fuel tanks
   - Not capable of handling weights, forces, or pressures required for the task

7. *Easy to install incorrectly*
   - Can be easily installed with wrong orientation
   - No orientation indicators (e.g., arrow, colors)
   - Connections identical in size, color or length

8. *Not used*
   - Correct part was available to use, but technician did not use it and used a different (non-interchangeable) part instead
   - Correct part was unavailable, so technician used a different (non-interchangeable) part
   - If the correct part was available, but was not used, then this could be a violation. If the technician did not use the correct part when it was available, find out why (i.e., what the contributing factors to not using it).

9. *Not user friendly*
   - Lack of feedback provided by component or system
   - Can be easily installed with wrong orientation
   - Direction of flow indicators do not exist.

10. *Consumable unavailable*
    - High-temperature grease is unavailable

11. Wrong consumable used
- Low temperature instead of high-temperature grease was used

11. Expired consumable used
- Grease was past its pull date.

12. Other
- Components are too heavy for easy removal/installation
- Lack of feedback provided by component or system
- Direction of flow indicators do not exist

7.6.D Job and Task

A maintenance technician's <u>job/task</u> can logically be separated into a series of tasks. If the interviewer feels the task was a contributing factor, he/she should analyze the combination or sequence of tasks. The interviewer, when examining the task sequencing, should also determine whether written information was being used, what technical skills and knowledge were expected of the maintenance technician, and what communication took place.

Examples to look for:
1. *Repetitive/monotonous*
    - Similar steps are performed over and over (opening and closing circuit breakers during a long test)
    - The same task performed many times in multiple locations (removing seats)
    - Checking the expiration date for all of the onboard life jackets

2. *Complex/confusing*
    - Multiple other tasks are required during this task
    - Multiple steps required at the same time by different maintenance technicians
    - Long procedure with critical step sequence
    - System interacts with other systems during testing or fault isolation
    - Multiple electrical checks are required
    - Task requires exceptional mental or physical effort

3. *New task or task change*
    - New maintenance requirement or component
    - Revision to a procedure
    - Engineering modification to existing fleet
    - New aircraft model

4. *Different from other similar tasks*
    - Same procedure on different models is slightly different
    - Recent change to aircraft configuration has slightly changed task
    - Same job at different worksites is performed slightly different

5. *Other*
    - The workgroup performs the task differently than specified in the source data (or written information)

7.6.E Knowledge and Skills

Technical skills refer to tasks or subtasks that maintenance technicians or inspectors are expected to perform without having to refer to other information. Technical skills include such things as being able to lock wire, use a torque wrench, remove common parts from an aircraft, and perform a general visual inspection for corrosion. For (lack of) technical skills to be a contributing factor to system failure, the technician must not have skill that was generally expected of him/her.

Technical knowledge refers to the understanding of a body of information that is applied directly to performing a task. Technical knowledge, in order to be a contributing factor to system failure, is knowledge that is supposed to be known (memorized) by the maintenance technician or inspector. Three broad categories of knowledge are required of a technician or an inspector: airline process knowledge, aircraft systems knowledge, and maintenance/inspection task knowledge. These are discussed in more detail below.

Airline process knowledge refers to knowledge of the processes and practices of the airline or repair station in which the maintenance technician or inspector works. Examples include shift handover procedures, parts tagging requirements, and sign-off requirements. While this knowledge is generally acquired through general maintenance operating procedures and on-the-job discussion with peers, it may also be acquired from other sources such as employee bulletins and special training.

Aircraft system knowledge refers to knowledge of the physical aircraft systems and equipment. Examples include location and function of hydraulic pumps and rework options for corroded or fatigued parts. While this knowledge is generally acquired from the aircraft design characteristics, training, maintenance manuals, and on-the-job discussion with peers, it may also be acquired from other sources such as trade journals and maintenance tips.

Maintenance/inspection task knowledge refers to the specific knowledge required to perform a unique task. Examples include the procedure for bleeding a hydraulic system and for measuring tire wear. While this knowledge is generally acquired through maintenance instructions or on-the-job discussions with peers, it may also be acquired from aircraft placards, design characteristics, or even other maintenance technicians when working as a team.

English language proficiency refers to a maintenance technician or inspector's ability to speak and read English.

Teamwork skills refer to an individual technician or inspector's skills with regard to working on a team. The technician or inspector may lack the skills needed just to participate on a team—e.g., active listening, questioning/assertiveness, persuading, respecting, helping others, sharing, and participating. The team may also lack the skills

needed to carry out team tasks—e.g., setting clear goals, being results driven, gaining consensus, and leadership.

<u>Computing skills</u> refer to a technician or an inspector's skills in using a computer. This includes—e.g., finding information on a computer, generating requests (such as for non-routine tasks), and entering information into a computer (such as employee identification information, task completion information, and ETOPS oil monitoring values).

Examples to look for:
1. *Technical skills*
   - Safety wiring
   - Rigging of controls
   - Using calibrated equipment
   - Carrying out a fault isolation task
   - Removing and replacing parts

2. *Task knowledge*
   - Slow task completion
   - Technician change of maintenance responsibilities
   - Task performed by maintenance technician for the first time
   - Task performed in wrong sequence

3 *Task planning*
   - Frequent work interruptions to get tools or parts
   - Failure to perform preparation tasks first
   - Too many tasks scheduled for limited time period
   - Task necessary for safety not performed first

4. *Airline process knowledge*
   - If the technician knows the correct airline process to follow, but does not do so, then this could be a violation. If the technician did not follow the process correctly, find out why (i.e., what the contributing factors to not following the airline process).
   - Failure to acquire parts on time
   - Technician new to airline or to type of work (from line to hangar, etc.)
   - Airline processes not documented or stressed in training

5. *Aircraft system knowledge*
   - Technician changes aircraft types or major systems
   - Fault isolation takes too much time or is incomplete

6. *English language proficiency*
   - Technician made mistake because they could not read English technical documentation well enough

- Technician made mistake because they could not understand spoken English well enough

7. *Teamwork skills*
   - Technicians arguing with each other about how to carry out/continue a task
   - One technician ignoring another technician's input on what to do next
   - One technician does not trust another technician to do what was promised.

8. *Computing skills*
   - Technician cannot access technical documentation on the local intranet
   - Technician cannot generate a non-routine in SAP (or other maintenance-related computing system)
   - Technician does not enter Extended Operations (ETOPS) oil monitoring information into the correct database because he/she cannot access the database and/or enter the data correctly.

9. *Other*
   - Technician performance/skills not accurately tracked/measured

7.6.F Individual Factors

Individual factors vary from person to person and include body size/strength, health, and personal events and the way that a technician responds to things such as peer pressure, time constraints, and fatigue caused by the job itself.

Physical health includes the acuity of human senses as well as physical conditions and physical illnesses. Human senses, especially vision, hearing, and touch, play an important role in maintenance and inspection. Technicians and inspectors are frequently required to perform tasks that are at or near the limits of their sensory capabilities. For example, some tasks require good vision and/or touch, such as visual inspection for cracks or finger inspection for burrs. Good hearing is also required in order to hear instructions or feedback before and during a maintenance task.

Physical conditions, such as headaches and chronic pain, also have been shown to relate to system failures. Alcohol/drug use, as well as side effects of various prescription and over-the-counter medicines, can negatively affect the senses. Physical illness, such as having a cold or the flu, can also negatively affect the senses and the ability to concentrate. Illnesses can also lead to less energy, which can affect fatigue.

Fatigue has been defined by the U.S. Federal Aviation Administration (FAA) as a depletion of body energy reserves, leading to below-par performance. Fatigue may be emotional or physical in origin. Acute fatigue may be caused by emotional stress, depletion of physical energy, lack of sleep, lack of food, poor physical health, or over excitement. Fatigue may also be caused by the work situation itself. The time of the day, the length one has been working, and complex mental tasks or very physical tasks can cause fatigue.

A technician's response to time pressure is an individual factor. The need to finish a maintenance task so an aircraft can be released from the gate or to finish a heavy maintenance task so an aircraft can be put back into service often cause technicians to feel pressure to get their tasks done. Studies have linked too little time with increased error and/or likelihood to engage in situational violations. There is a well-known phenomenon called the speed/accuracy trade-off. People learn to do tasks at a certain speed, like typing or keyboarding. If you ask the person to type more quickly, they can, but they will make more errors (trading off errors for more speed). If you ask the person to make no errors while typing, they will slow down (trading off speed for fewer errors). This trade-off also holds for speed and working safely. So, anytime that you tell a technician to "hurry up and finish that task," you are increasing the probability that they will make an error.

Peer pressure is the pressure that a technician/inspector's colleagues put on him/her to conform to the way the other members of the group carry out their work. A technician's response to peer pressure can influence their performance. For example, there may be peer pressure not to use maintenance manuals because it is seen as a sign of lack of

technical knowledge. Peer pressure may also influence a technician's safety-related behavior.

Complacency is over-contentment with a situation that may lead to a failure to recognize cues that indicate a potential error.

Body size and strength are two obvious factors that affect a maintenance technician's ability to perform a task. If someone is too short to reach a plug or if someone is not strong enough to let down a Line Repairable Unit (LRU) from an upper rack, this can contribute to system failure.

Personal events can affect a technician's ability to concentrate on a task. For example, if the technician had a fight with his/her spouse that morning, was in a car accident on the way to work, or has a daughter in the hospital with a life-threatening disease, the technician may start thinking about these events during task accomplishment rather than concentrating on the task itself.

Task distractions/interruptions refer to anything that causes a technician to quit working on the task at hand for any period of time. For example, a technician may be called over to help someone lift a heavy component into place or a lunch break may occur. In those cases, at least, the same technician continues to carry out the task. A very common contributing factor to an error is when task completion is interrupted by the end of the shift. In this case, the technician often has to hand over the task to someone else, so that communication issues may also play a part in an error.

Memory lapse (forgot) refers to a failure to remember something at the necessary time.

Visual perception is the ability to interpret information from visible light reaching the eye. The resulting perception is also known as eyesight, sight or vision. The various physiological components involved in vision are referred to collectively as the visual system. A technician may not visually perceive (see) something correctly for a variety of reasons, including optical illusions, parallax, inadequate lighting, obstructed view, and being too close or too far away from the object of interest.

Assertiveness is being willing to speak your mind and to state and maintain your individual position on an issue.

Stress is your body's physiological reaction to physical and psychological factors (stressors) in your environment. Stress can cause emotional, muscular, digestive system, and other physical symptoms (e.g., high blood pressure, increased heart rate, migraine headaches, and dizziness). Any of these things can interfere with a technician's ability to concentrate on task accomplishment.

Situation awareness is a technician's ability to maintain awareness of what is happening on the ramp or the hangar, as well as what is happening on the task.

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<u>Workload/task saturation</u> refers to the technician/inspector having too many different tasks to handle at the same time. A common outcome from task saturation is forgetting to do something.

Examples to look for:
1. *Physical health*
    - Sensory acuity (e.g. vision loss, hearing loss, touch)
    - Failure to wear corrective lenses
    - Failure to use hearing aids or ear plugs
    - Restricted field of vision due to protective eye equipment
    - Pre-existing disease
    - Personal injury
    - Chronic pain limiting range of movement
    - Nutritional factors (missed meals, poor diet)
    - Adverse effects of medication
    - Drug or alcohol use
    - Complaints of frequent muscle/soft tissue injury
    - Chronic joint pain in hands/arms/knees

2. *Fatigue*
    - Lack of sleep
    - Emotional stress (e.g. tension, anxiety, depression)
    - Judgment errors
    - Inadequate vigilance, attention span, alertness
    - Inability to concentrate
    - Slow reaction time
    - Significant increase in work hours or change in conditions
    - Excessive length of work day
    - Excessive time spent on one task
    - Chronic overloading
    - Task saturation (e.g., inspecting rows of rivets)

3. *Time pressure*
    - Constant fast-paced environment
    - Multiple tasks to be performed by one person in a limited time
    - Increase in workload without an increase in staff
    - Too much emphasis on schedule without proper planning
    - Perceived pressure to finish a task more quickly than needed in order to release the aircraft from the gate

4. *Peer pressure*
    - Unwillingness to use written information because it is seen as a lack of technical skills/knowledge
    - Lack of individual confidence

- Not questioning other's processes
- Not following safe operating procedures because others do not follow them

5. *Complacency*
   - Hazardous attitudes (invulnerability, arrogance, over-confidence)
   - Task repetition leads to loss of mental sharpness or efficiency

6. *Body size/strength*
   - Abnormal reach, unusual fit, or unusual strength required for the task
   - Inability to access confined spaces

7. *Personal event*
   - Death of a family member
   - Marital difficulties
   - Change in health of a family member
   - Change in work responsibilities/assignment
   - Change in living conditions

8. *Task distractions/interruptions*
   - Confusion or disorientation about where one is in a task
   - Missed steps in a multi-step task
   - Not completing a task
   - Working environment is too dynamic

9. *Memory lapse*
   - Forgot

10. *Visual perception*
    - Misread dial/display because of parallax issues
    - Misjudged distance
    - Could not easily tell whether airplane was following marking into hangar because of visual angle

11. *Lack of assertiveness*
    - Did not speak up and suggest a different solution
    - Quickly gave up trying to get their position across

12. *Stress*
    - Absenteeism
    - Medical symptoms
    - Technicians who get angry easily
    - Unable to concentrate

13. *Situation awareness*
    - Technician gets injured by passing vehicles

- Technicians tripping over cords or materials on the floor

14. Work/task saturation
- *Trying to carry out too many tasks at the same time*
- *Forgets to carry out one of the subtasks*

15. Other
- Absenteeism
- Vacations
- Medical leave
- Risk-taking behavior

7.6.G Environment and Facilities

The working environment/facilities can contribute to system failure. For example, temperature extremes (either too hot or too cold), high noise levels, inadequate lighting (reflection/glare, etc.), unusual vibrations, and dirty work surfaces could all potentially lead to maintenance system failures. Concerns about health and safety issues could also contribute to maintenance technician system failures.

Examples to look for:
1. *High noise levels*
   - High noise impacts the communication necessary to perform a task
   - Extended exposure to noise reduces ability to concentrate and makes one tired
   - Noise covers up system feedback during a test

2. *Hot*
   - Work area is too hot so the task is carried out more quickly than usual to get back to an air conditioned room as quickly as possible
   - Extremely high temperatures cause fatigue
   - Long exposure to direct sunlight
   - Exterior components or structure too hot for maintenance technicians to physically handle or work on

3. *Cold*
   - Work area is too cold so the task is carried out quickly to get back to a heated room as quickly as possible
   - Long exposure to low temperature decreases sense of touch and smell
   - Technician has to wear gloves and heavy clothing, which could interfere with carrying out the task

4. *Humidity*
   - High humidity creates moisture on aircraft, part and tool surfaces
   - Humidity contributes to fatigue

5. *Rain*
   - Causes obscured visibility
   - Causes slippery or unsafe conditions

6. *Snow*
   - Causes obscured visibility
   - Causes slippery or unsafe conditions
   - Protective gear makes grasping, movement difficult

7. *Lighting*

- Insufficient for reading instructions, placards, etc.
- Insufficient for visual inspections
- Excessive—creates glare, reflection, or eye spotting

8. *Wind*
- Interferes with ability to hear and communicate
- Moves stands and other equipment (creates instability)
- Blows debris into eyes, ears, nose or throat
- Makes using written material difficult

9. *Vibrations*
- Use of power tools fatigues hands and arms
- Makes standing on surfaces difficult
- Makes instrument reading difficult

10 *Cleanliness*
- Loss of footing/grip due to dirt, grease or fluids on parts/surfaces
- Clutter reduces available/usable work space
- Inhibits ability to perform visual inspection tasks

11. *Hazardous/toxic substances*
- Reduces sensory acuity (e.g., smell, vision)
- Exposure causes headaches, nausea, dizziness
- Exposure causes burning, itching, general pain
- Personal protective equipment limits motion or reach
- Exposure causes general or sudden fatigue
- Exposure causes general concern about long term effect on health

12. *Power sources*
- Not labeled with caution or warning
- Guarding devices missing or damaged
- Power left on inappropriately
- Circuit protection devices not utilized or damaged
- Cords chafed, split, or frayed

13. *Inadequate ventilation*
- Strong odor present
- Burning or itching eyes
- Shortness of breath
- Sudden fatigue

14. *Markings*
- White guide lines into hangar not painted
- White guide lines into hangar faded/chipped and hard to see
- Stop lines in hangar not painted or hard to see

15. Labels/placards/signage
- Bin labels for parts are faded and hard to read
- Placards needed for Minimum Equipment List (MEL) items are unavailable
- Warning signs regarding hazardous substances not posted
- Serviceable/unserviceable tags not hung on parts

16. Confined space
- Hard to enter
- Hard to move around
- Need watch person
- Need breathing equipment

17. Other
- Area(s) not organized efficiently (difficult to find parts, work cards, etc.)
- Area too crowded with maintenance technicians and/or other personnel

7.6.H Organizational Factors

The <u>organizational</u> culture can have a great impact on maintenance system failure. Factors such as internal communication with support organizations, trust level between management and maintenance technicians, management goals and technician awareness and buy-in of those goals, union activities, and attitudes, morale, teamwork, etc., all affect productivity and quality of work. The amount of ownership the technician has of his/her work environment and the ability to change/improve processes and systems is of key importance to technician morale and self esteem, which in turn, affects the quality of task performance. This section is also the section to use when violations occur as a result of not following work processes or procedures.

Examples to look for:
1. *Quality of support from technical organizations*
   - Inconsistent quality of support information
   - Late or missing support information
   - Poor or unrealistic maintenance plans
   - Lack of feedback on change requests
   - Reluctance to make technical decisions
   - Frequent changes in company procedures and maintenance programs

2. *Company policies*
   - Unfair or inconsistent application of company policies
   - Standard policies do not exist or are not emphasized
   - Standard error prevention strategies do not exist or are not applied
   - Inflexibility in considering special circumstances
   - Lack of ability to change or update policies

3. *Not enough staff*
   - Not enough trained personnel
   - Not enough trained personnel at the time

4. *Corporate change/restructuring*
   - Layoffs are occurring
   - Early retirement programs drain experience
   - Reorganizations, consolidations and transfers cause more people to be in new jobs
   - Demotions and pay cuts
   - Frequent management changes

5. *Union action*
   - Contract negotiations create distractions
   - Historical management/labor relations are not good
   - Positive or negative communication from union leadership
   - Strike, work slowdown, or other labor action creates a disruption

6   Work process/procedure
If the work process or procedure is followed but is error inducing, then check this box. Reasons that this might occur include:
- Standard operating procedures (SOPs) incorrect
- General maintenance manuals outdated
- Inadequate inspection allowed
- Process/procedure does not obtain the desired outcome

7   Work process/procedure not followed
This box would be used for a violation of work processes or procedures that should have been followed, but were not followed. If this occurs, check this box. Then determine whether not following this process or procedure is a work group normal practice (norm). If it is, then check box 9 below.
- Skipped operational check
- Required protective equipment not used=
- Did not use "parts removed" tag

8   Work process/procedure not documented (e.g., use tribal knowledge)
The work process/procedure is a part of tribal knowledge, and not officially documented. People perform the process/procedure as how they learn from others in a group, instead of following a written standard.
- No procedure for radio check before towing operation
- No inspection criteria
- No procedure for proper use of safety equipment

9   Work group normal practice (norm)
If a technician has not followed a work process or procedure that he/she should have, it is very important to determine whether most other technicians do the same thing in this situation.
- Documented procedure—most people in the same situation do not follow the written process or procedure
- Undocumented procedure—most people in the same situation do the procedure without documenting it like the technician did.

10 Team building
- Management does not provide team building training to staff
- Management does not encourage staff to work on teams to solve process issues

11 Other
- Company is acquired by another company
- Work previously accomplished in-house is contracted out
- Overall inadequate staffing levels

7.6.I Leadership/Supervision

Even though <u>supervisors</u> normally do not perform the tasks, they can still contribute to maintenance system failure by poor planning, prioritizing, and organizing of job tasks. Delegation of tasks is a very important supervisory skill and if not done properly, can result in poor work quality. Also, there is a direct link between the management/supervisory attitudes and expectations of the maintenance technician and the quality of the work that is performed.

Supervisors and higher-level management must also provide <u>leadership</u>. That is, they should have a vision of where the maintenance function should be headed and how it will get there. In addition, leadership is exhibited by management "walking the talk," that is, showing the same type of behavior expected of others.

Examples to look for:
1. *Planning/organization of tasks*
   - Excessive downtime between tasks
   - Not enough time between tasks
   - Paperwork is disorganized
   - Tasks are not in a logical sequence

2. *Prioritization of work*
   - Technicians not told which tasks to carry out first
   - Important or safety related tasks are scheduled last
   - Fault isolation is not performed without checking the most likely causes first

3. *Delegation/assignment of tasks*
   - Assigning the wrong person to carry out a task
   - Inconsistency or lack of processes for delegating tasks
   - Giving the same task to the same person consistently
   - Wide variance in workload among maintenance technicians or departments

4. *Unrealistic attitude/expectations*
   - Frequent dissatisfaction, anger, and arguments between a supervisor and a technician about how to do a task or how quickly a task should be finished
   - Pressure on maintenance technicians to finish tasks sooner than possible or reasonable
   - Berating individuals, especially in front of others
   - Zero tolerance for errors
   - No overall performance expectations of maintenance staff based on management vision

5. *Does not assure that approved process/procedure is followed*

- Supervisor sees that technician is not following a process or procedure (e.g., is not wearing personal protective equipment or is not using a calibrated wrench for a torque task)

6. *Amount of supervision*
   - "Look over the shoulder" management style
   - Frequent questioning of decisions made
   - Failure to involve employees in decision-making

7. *Other*
   - Meetings do not have purpose or agendas
   - Supervisor does not have confidence in group's abilities
   - Management does not "walk the talk" and thereby sets poor work standards for maintenance staff

7.6.J Communication

<u>Communication</u> refers to the transfer of information (written, verbal, or non-verbal) within the maintenance organization. A breakdown in communication can prevent a maintenance technician from getting the correct information in a timely manner regarding a maintenance task.

Examples to look for:
1. *Between departments*
   - Written communication incomplete or vague
   - Information not routed to the correct groups
   - Department responsibilities not clearly defined or communicated
   - Personality conflicts create barriers to communication between departments
   - Information not provided at all or not in time to use

2. *Between mechanics*
   - Failure to communicate important information
   - Misinterpretation of words, intent or tone of voice
   - Language barriers
   - Use of slang or unfamiliar terms
   - Use of unfamiliar acronyms
   - Failure to question actions when necessary
   - Failure to offer ideas or process improvement proposals
   - Personality differences

3. *Between shifts*
   - Work turnover not accomplished or done poorly or quickly
   - Inadequate record of work accomplished
   - Processes not documented for all shifts to use
   - Job boards or check-off lists not kept up to date

4. *Between maintenance crew and lead*
   - Lead fails to communicate important information to crew
   - Poor verbal turnover or job assignment at the beginning of a shift
   - Unclear roles and responsibilities
   - Lead does not provide feedback to crew on performance
   - Crew fails to report problems and opportunities for improvement to lead person
   - Communication tools (written, phones, radios, etc.) not used

5. *Between lead and management*
   - Little or no communication exists
   - Goals and plans not discussed regularly
   - No feedback from management to lead on performance
   - Lead does not report problems and opportunities for improvement to management
   - Management fails to communicate important information to lead

6. *Between flight crew and maintenance*
   - Late notification of defect
   - Aircraft Communications Addressing and Reporting System (ACARS)/data downlink not used
   - MEL/Dispatch Deviation Guide DDG interpretation problem
   - Logbook write-up vague or unclear

7. *Other*
   - Computer or network malfunctions lead to loss of information
   - E-mail not used or ignored

8. How to Carry Out the MEDA Investigation Interview

By now it should be clear that the most important part of the investigation is the interview with the maintenance technician/inspector, whose performance lead to the event, in order to find out the contributing factors to the error and/or violation. Interviewing is a skill just like using a torque wrench is a skill. You will get better at interviewing the more interviews that you carry out. There are three purposes of this section:
1. To discuss who should be on the interview team,
2. To provide guidelines for how to carry out the interview, and
3. To provide some specific rules of causation.

8.1 The MEDA Interview Team

How many people should be on the interview team? We have seen successful programs use 1 or 2 people on the interview team. How do you decide how many people to use?

The advantage of one person doing the interview is that one person is typically less threatening to the technician than several people. However, this person must be a good interviewer, since he/she has to do all of the work himself/herself. You may find that you start off with a 2-person interview team, but as the interviewers gain experience, you can move to a smaller team.

The advantage of a 2-person team is that one person can be asking questions while the second person is writing down information. In addition, the second person may think of additional questions to ask. When an organization first implements MEDA, they often start with a 2-person interview team.

We typically suggest that 3 people are too many on the interview team. The technician could start to feel outnumbered, and, therefore, uncomfortable and unwilling to tell everything that he/she knows. However, a 2-person team with a union observer has proven useful at unionized maintenance organizations. The union observer's job is to let the maintenance technician know that the union supports the MEDA process and to encourage the maintenance technician to cooperate during the interview.
Who should be on the interview team? First, whoever is on the team should have some form of MEDA training. Hopefully, that is training provided by Boeing, but it could be training provided by your training organization. Even if you receive the Boeing training, additional training on interviewing is helpful, especially if the training includes practice at interviewing that is possibly videotaped for audio and visual feedback.

The organization that is responsible for the MEDA process at the maintenance organization should be most concerned that good information is being gained from the MEDA investigations. Perhaps the best way to make sure good information is being collected is for the organization to assign one of their members as a MEDA investigation team member so they can make sure quality interviews are being carried out. Therefore,

the team should include a person from this organization. So, for example, if QA "owns" the process, one of the interviewers would be a QA auditor.

A second team member could be a respected, senior maintenance technician or inspector from the area where the error and/or violation occurred. This person should bring two things, in addition to interviewing skills, to the interview:
- He/she should have the respect of the maintenance technician or inspector being interviewed
- He/she should be technically knowledgeable about the work that was being done that lead to the event.

One person should act as the team leader. This most likely would be the person from the organization that "owns" the process. His job would be to introduce the team members, lead off on the questioning, keep the interview moving if it starts to bog down, make sure that everybody gets to ask questions, end the interview when no more useful information is forthcoming, and thank the maintenance technician for providing the information.

8.2 Guidelines for the MEDA Investigation Interview

Once the team has been chosen, it is time to carry out the MEDA investigation interview. Our suggestions for carrying out the interview are based on a method of interviewing called "Cognitive Interviewing." The Cognitive Interview technique is a systematic information retrieval strategy that has been shown to increase the amount of information that is recalled. More specifically, it typically elicits 30-70% more correct information than conventional interviewing procedures (e.g., police accepted practice), and leads to an equivalent or slightly higher accuracy level (proportion of statements that are accurate) when compared to conventional interviewing procedures.

Cognitive Interviewing is based on a method for interviewing witnesses of criminal events developed by Ronald Fisher and Edward Geiselman (Fisher, R.P., & Geiselman, R.E. (1992). Memory-enhancing techniques in investigative interviewing: The cognitive interview. Springfield, IL: Thomas). It is a systematic approach to interviewing cooperative interviewees based on scientific principles of memory and communication. The principles of cognition are converted into a number of specific techniques to help interviewees improve their memory performance, including:
- Encouraging the interviewee to concentrate
- Recreating the event context
- Explicitly requesting detailed descriptions
- Focusing on obtaining as much information as possible about a topic before moving on to another topic.

Cognitive Interviewing is consistent with the guidelines provided in other sources. Below we will first discuss general principles of cognitive interviewing followed by the specific stages/steps to follow to conduct the interview.

8.2.A General Principles of Cognitive Interviewing

There are some general principles of investigative interviewing that should be followed throughout all stages of the interview. These include:
- Develop and maintain good rapport.
- Encourage the interviewee to be actively involved.
- Help the interviewee concentrate.
- Use open, simple, and unbiased questions.
- Listen actively.
- Use a communication style to suit the interviewee.
- Work as a team with other interviewers.

<u>Develop and maintain good rapport</u>. Rapport building should be considered an investment of time and not a waste of time. The better the rapport that you build with the interviewee, the more that they trust you; the more that they trust you, the more they are likely to provide you with needed information. If the interviewee is acting especially stressed, make some small talk to begin your conversation—like last week-end's football game or whatever is of interest to the interviewee. Put yourself in their place—nobody wants to do a maintenance task incorrectly causing some event (like a flight cancellation). Act relaxed. Use a neutral tone of voice. Have your eyes at the same level as the eyes of the interviewee—never look downward at the interviewee, because this puts you in the superior position and puts them in the inferior position, which is disconcerting. Use neutral body language—i.e., do not cross your arms and your legs, because that is body language for "I do not want to hear what you have to say." Finally, make eye contact and interview the person like you would talk to a friend. Avoid arguments, judgmental comments, and criticism like:
- "You did not know what the correct procedure was?"
- "You were not using the calibrated tool for that task?"
- "I cannot believe that you did that!"
- "We do not want our technicians doing those kinds of things."

If you make comments like the above, the interviewee may quit answering your questions for fear of being criticized again.

<u>Encourage the interviewee to be actively involved</u>. At suitable times at the beginning and during the interview, make it clear to the interviewee that they are the ones with the information and that they will be doing most of the talking. At appropriate times during the interview, explain that you would like the interviewee to…
- Volunteer information whenever they think of it.
- Tell things in their own words and at their own pace.
- Give as much detail as possible.
- Not guess or make up answers.

The above should not all be done during the introduction, because you do not want to be doing that much talking.

<u>Help the interviewee concentrate.</u> Minimize distractions and disruptions during the interview. Turn off your cell phone so that it does not ring during the interview. NEVER

answer your cell phone during the interview. Close the door to the interview room to provide privacy and to minimize distractions from people walking by in the hallway. If there is an active view out the window that might distract the interviewee, close the curtains to minimize those distractions. Finally, ask all of your questions on the same topic before moving on to another topic.

Use open, simple, and unbiased questions. Use broad, open questions and then moved to framed (more narrow) open questions about a particular area. Only use closed questions to fill in any missing details that you cannot obtain through open questions. Closed questions are questions that can be answered with a simple "yes" or "no" response. Open questions require more than a "yes/no" response. For example, "Did you use the maintenance manual?" is a closed question. The open version of that question could be, "What kind of maintenance documentation were you using?" It is harder to ask open questions than closed questions, but you will get better with practice.

Keep questions simple. Use short sentences, and ask just one question at a time. Avoid jargon and the use of long words. Ask your questions calmly, slowly, and clearly. Avoid questions that lead the interviewee. Two examples of leading questions are:
- "Then you probably did ____, right?"
- "At that point, you probably asked for help, didn't you?"

Listen actively. Be other-directed; focus on the person communicating. Follow and understand the speaker as if you were walking in their shoes. Listen with your ears but also with your eyes and other senses. Do not interrupt the interviewee unless they get well off of the subject. Stop yourself and others from talking while the interviewee is talking. Use pauses after the interviewee stops talking. The pause allows the interviewee time to add additional information that they might think of. Give feedback to the interviewee to indicate that you are listening and understanding what they are saying— such as a nod, "uh huh," "OK," and "I've had that problem myself." Repeat back to them in your own words what they have just told you. Try not to act surprised by anything that the interviewee says. Maintain eye contact with the interviewee, unless it is distracting. Lean toward the interviewee to indicate interest in what they are saying. If you think of a question while the interviewee is talking, write it down and ask it later. Keep an open mind about what you expect to hear. Leave your causal biases "at the door."

Interviewer biases can be very detrimental to the interview process. A poor interviewer allows their biases to drive the questions and to get the answer that they are expecting (from their biases). MEDA has failed at several airlines because the interviewers were biased ("I don't need to go do the MEDA interview, I already know what the problem is."). In the 1970s, some social psychologists, working in the field of Attribution Theory, studied how people attribute blame when something goes wrong. Unfortunately the social psychologists found that a majority of people attribute blame in the following manner. "When I make an error, it is due to external contributing factors (like poorly written manuals, not having the right tool for the job, etc.)." "When others make an error, it is due to factors that are internal to the person (like their being lazy, complacent, or careless)." Thus, most people bring this attribution bias with them to their job.

MEDA investigators must realize that this bias exists and work actively to overcome it. There are numerous other biases that interviewers can have and must overcome. These include:

- Experience/knowledge can have a positive or negative effect. It has a negative effect when the investigator thinks things like, "I don't even need to do the interview—I know what he/she did wrong," or, "All errors are a result of poor training."
- Sometimes we believe that big events must have had a big cause. "The airplane was out of service for two full days, then Joe must have made a major error." This is not necessarily true. Remember, one of the U. S. shuttle flights crashed and killed everyone on board because of a 50-cent O-ring seal.
- Sometimes an investigator only identifies those contributing factors that are within their ability to change. However, your job is to determine all of the contributing factors, even if some of them are hard or impossible to improve.
- Factors that are close in time or space to the system failure will more likely be labeled as causal. While these factors may be causal, do not end your search for contributing factors after identifying these items. Sometimes decisions about staffing or spare parts, which were made months before the event, are contributing factors to the system failure.
- Factors that first draw the attention of the investigator will more likely be labeled as causal. While these may be true contributing factors, you must keep an open mind about other contributing factors so that you do not stop your search after the first one or two that caught your attention.
- Sometimes an investigator sees an error-caused event that is similar to an historical error event and assumes that they both had the same contributing factors since the outcomes were similar. Do not make this leap of faith—determine the specific contributing factors to the event at hand.
- Sometimes an investigator enhances or discounts a contributing factor explanation based on the presence of another contributing factor. For example, "Joe was tired; therefore the maintenance manual was confusing." Even if Joe is tired, you have to show what there was about the maintenance manual that confused Joe.
- A very common bias that must be guarded against is blaming a system failure on a person's dispositions. For example, "Joe has a history of skipping functional tests; therefore, he must have skipped the functional test when he caused this event." Do not guess at contributing factors. If you have a guess, check it out using the questions that you ask.
- Sometimes an investigator describes first what should have been and then compares the actual events to determine what is causal. "Joe should have gotten a wing walker before moving the aircraft. He did not, so not getting the wing walker was a contributing factor." Remember, the failure to act is only a contributing factor when there is a pre-existing duty to act.

Use a communication style to suit the interviewee. Use terms that the interviewee is familiar with. If the interviewee is speaking too fast, soft, or incoherently, model the desired behavior. Alternatively, specifically request the interviewee to slow down, speak louder, etc. If the interviewee appears to have a high anxiety level, deal with it

immediately. Switch to simple factual questions or ask about background issues to help build up confidence. Get the interviewee a drink or take a short break. If the interviewee appears not to be lying, proceed with the interview and try to clarify the issue of concern later on.

Tape record or not? Many of the air safety investigators use tape recorders when interviewing pilots and witnesses who were involved with/saw the incident/accident. We do not believe that a MEDA investigator should use a tape recorder during the MEDA interview/investigation. The problem with a tape recorder is that it makes the interview seem like a criminal investigation, which can cause the interviewee to limit what they tell you about the incorrectly performed maintenance or inspection task. The benefit of a tape recorder is that it records everything that is said, which is better than you will be able to do taking notes during the interview. However, if you are not using a tape recorder, do not hesitate to tell the interviewee that you "need a second to write down" what you were just told. During the interview, one of the most important things that you are doing is listening for information that needs to be followed up with more focused questions. You cannot wait until after the interview to listen to the tape recording or go through your notes to determine your follow-up questions. If you do use a tape recorder, you need to get the interviewee's permission to tape record. It is also recommended that you offer to provide the interviewee a copy of the recording within a few days of the interview.

<u>Work as a team with other interviewers</u>. Section 8.1 gave guidance on how many people should be on the interview team and what their qualifications should be. If there are two or more people on the interview team, then one person must act as the team leader. Before the interview, ensure that all interviewers know their roles and that there is a plan regarding...
- Who is leading the introduction,
- Who is asking questions, and
- Who is writing down the responses.

Introduce the other interviewer(s) into a specific conversation if they have relevant experience. If you are leading the questioning, check with the other interviewer(s) before moving to the next topic. Help other interviewer(s) if they are having difficulty.

8.2.B Stages of the Interview

There are specific stages of the interview that should be followed. These stages include:
1. Pre-Interview Preparation and Planning
2. Interview
   a. Introduction
   b. General Account of Event/Task
   c. Detailed Account of Parts of the Event/Task
   d. Background Information
   e. Conclusion
3. Post-interview Evaluation and Follow-up.

These stages are discussed below.

Pre-interview Preparation and Planning. It is important that you (and other team members) prepare yourself before conducting the interview. Before carrying out the interview, gather as much information as possible about what happened. Going into the interview, you should know the event that started the investigation, and you will probably know what the system failure was that caused the event. If any engineering investigations have taken place, read that information, also, before the interview. Before interviewing, obtain additional background information:

- About the task that was being carried out, or what was done incorrectly and led to the event. This would include getting and studying copies of the maintenance manual procedure or task card noting the tools and equipment that were to be used, etc.
- About the interviewee. Were they a licensed/certified ,maintenance technician/inspector or an unlicensed/uncertified personnel? What was their specialty area—structures, systems, avionics?

Determine aims of the interview—types of information sought. Determine the location of interview. It is important where the interview takes place. It should be an area that is quiet so that you can talk easily with the person. It is also helpful if you can find a place so that you can sit down to carry out the interview. It should be a place where the interviewer and the interviewee can talk as two people on an equal level. Do not carry out the interview with you sitting behind a supervisor's desk and the technician sitting in a chair in front of the desk. This will appear to the interviewee to put him on a lower personal level (employee vs. supervisor), and the interview could start to feel like an interrogation or cross-examination to the technician. Pick a neutral location like a private conference room or a quiet corner that is free from distractions.

Determine when the interview will take place. The interview should take place as soon as possible after the event, since the technician will begin to forget what happened over time. Allow plenty of time for the interview. MEDA interviews can last only 15-20 minutes up to 1 ½ to 2 hours, depending on the complexity of the task. Determine who will be involved. The interviewee may want a friend or union representative present. Allow these people to attend the interview.

If more than one person was involved in the maintenance task (e.g., one technician and one inspector), then interview each person separately. Many times there will only be one technician to interview, so this would not be an issue. However, if more than one technician/inspector was involved in the system failure, they should each be interviewed, and the interviews should be done separately. You are not doing this to see if you can catch someone up in a lie. You are doing this so that one technician does not influence the information provided by a second (or third, etc.) technician. No one has perfect memory, so one person's statement could influence what a second person said ("I don't really remember what happened, so Joe's view must be correct"). If you find that you get wildly differing stories from the technicians, follow-up interviews may need to be conducted.

Finally, you need to determine the interview plan (how interview will proceed). If there is more than on interviewer, then ensure interviewer roles are clearly defined. Ensure that the interview procedure is clearly understood by all of the interviewers. Develop a specific topic list to help guide some of your follow-up questions. Get plenty of notebooks, paper, pens, and a tape recorder, if you are going to use one. Finally, take along some water and perhaps some other refreshments, like coffee or soda.

Interview—Introduction. Provide a positive greeting. Use some minimal physical contact, like a handshake or a touch on the shoulder. Then determine the interviewee's preferred name and use it. Thank the interviewee for making the time available. Introduce everyone to each other. Provide a brief introduction of yourself and the other interviewer(s). [Do not talk a lot at this point—some of the below information can be stated during the interview at different appropriate times.] Explain the role of your organization, the purpose of the investigation, confidentiality provisions, and other relevant policies/processes/ procedures. In order to help put the person at ease, ask them what they know about MEDA. If they say that they are familiar with the process, then ask them to explain to you what they know about MEDA. Then correct any misperceptions that they might have and provide additional information to them, as necessary. If they say they have not heard about MEDA, then take a few minutes to explain fully the MEDA philosophy and process.

Discuss the interview process. Explain your organization's interviewing protocols. Emphasize the importance of the interviewee and encourage them to be actively involved. Outline the types of topics you will cover. Explain that you are just gathering information at this stage. Tell them that remembering the information may be difficult and will require concentration on their part. Tell the interviewee that they can ask questions at any time.

The technician may be afraid that they will be punished for making the error and/or violation and might ask you about it. If they do, tell them that you are not involved with decisions about punishment. Your job is to gather the facts, not make punishment decisions. If you want to use a tape recorder, explain why, ask permission, and tell the interviewee that it can be turned off at any time per their request.

Interview—General Account of the Task. Recreate the general context of the event or task. Speak slowly and distinctly from memory (not notes) and say something like…
- *"What I would like is for you to tell me the sequence of events as you experienced them. Start from wherever you think is relevant. Before starting, just try to put yourself back in the same situation. Don't say anything just yet—just think about the situation you were in."*

Allow the interviewee time to recreate the context before questioning them. Keep quiet during this period. Request a general description. After the interviewee has had time to recreate the context of the event or task, then say something like…
- "Would you please tell me about what was happening before and during the time you were doing the maintenance task." or

- "Tell me everything that you can remember, even the things you think are not important and even if you cannot remember something completely."

Do not interrupt unless the person gets off of the subject. Do not interrupt to ask specific questions. Take notes. When they have appeared to finish talk, pause for a moment before asking another question. This will allow the interviewee to add some information that they may not have stated earlier. Then encourage the interviewee to keep talking about what happened by saying something like, "What else can you remember?" Develop a probing strategy for follow-on questions—based on the general description, develop a list of specific issues that you want more in-depth information about.

Interview—Detailed Account of Parts of the Task. Recreate specific context. Explain that you would like more details on several issues. Let us assume that the technician said something about having trouble using the maintenance manual. Use the interviewee's own words and say something like...

- *"We'd like to get more information and clarify some issues. I'd like to start when you were reading through the maintenance manual and trying to understand what to do next. Take a few seconds and think about that part of the task. It might be easier if you close your eyes, as this often helps you to concentrate and remember things more clearly."*

Then ask for more detailed information about the relevant factors that they mentioned. Paraphrase—put key points in your own words and repeat them. Say something like…

- *"I think I heard you say that you had some difficulty understanding the maintenance manual. Please tell me what the issues were about."*

Paraphrasing assures that you understood what was said. Also, because you say "I _think_ I heard you say…" this gives the interviewee a chance to easily correct a detail. If you said, "I heard you say…" the interviewee would have to get up their courage to contradict what you just said. The paraphrase also shows *active* listening. Respond to statements in a positive manner. Say things like…

- "I have had problems with those Boeing maintenance manuals, too."
- "I agree with you—that is an error prone task."

Then continue to probe the item, using open questions, for further clarification. Encourage interviewees to use something they are familiar with (e.g., giving distances in terms of a baseball path or football field).

If relevant to the investigation, find out what contributed to a causal factor. Example— the interviewee says that they did not use the maintenance manual. Find out why. If they said that the manual was not available, find out why. Maybe they will tell you that the manuals are only on microfiche, and the microfiche printer was not working. Or maybe they will tell you that ramp maintenance was not close to manuals, so technicians did not have enough time to get the manual. If they tell you that they decided simply not to use the manual (even if it was available), find out why. Maybe they will tell you that they had done the task a lot, so did not think he needed a manual. Ask them how many times they have done the task and how recently they had done the task.

Keep asking "why" (open-ended questions) until you reach a natural stopping point. For example, if the interviewee says that they did not use the maintenance manuals because they are only on microfiche, and the microfiche printer was not working, then stop questioning this issue there, because it is not mechanic's issue why printer was broken. If they said that ramp maintenance was not close to manuals, so they did not have enough time to get the manual, then ask about time constraints and the trade-offs the interviewee made. If they said that they simply decided they did not need to use the manual because they had done the task a lot, then ask how often they do that task and when the last time was he did the task.

Review your understanding of what the interviewee has told you. First, check with the other interviewer(s) regarding whether they had any specific questions about the issue. Then restate the interviewee's recollection of an issue in detail and using their own words where possible. Ask them to correct any mistakes you make, and to also add anything new that they think of. Identify any discrepancies in the interviewee's account or between the interviewee and other data. If these are minor discrepancies, deal with them at this time. If they are major discrepancies, deal with them at the conclusion stage of the interview.

Then move on to the next issue/topic area by linking it (if possible) to the issue that you were just discussing. Continue until all specific topic areas (areas you want to probe further following the general account) have been covered.

After you have gotten the detailed information about issues raised during the general account of the task, then ask about contributing factors that have not been mentioned. Review the contributing factors categories on the MEDA Results Form that were not mentioned. Check the Not Applicable (N/A) line if you determine that the contributing factors category did not contribute to this event.

After you have gotten all of the contributing factors information, then ask the interviewee how they would improve the causal (contributing) factors in order to prevent future incidents. Record these improvement suggestions in Section V of the MEDA Results Form.

Interview—Background Information. There are at least two types of people that you could have been interviewing about the task. One type is the person or persons who were involved in carrying out the task, like technicians and inspectors. The second type is a person who witnessed the task being carried out without actually helping with the task. For witnesses, you should obtain information that will help evaluate the interviewee's ability to have seen the events they described. Much of this information will already have been obtained during the interview, but some issues will need further clarification. Explain that any such questions are routine. Ask the witness about…
- Exactly where they were at the time they observed the task, their distance away from where the task was being done, and their visibility due to obstructions and weather, if they were working outside, and visibility due to obstructions if they were working inside.

- Interviewee's state of mind at the time.
- Whether they wear eye glasses and, if yes, whether they had them on at the time.
- How often they had seen this type of task being carried out before.

Getting this type of information is best done toward the end of the interview in case it makes the interviewee feel that his/her integrity is being questioned.

The background information for interviewees who were carrying out the task is different from above. If you do not already have this information, obtain information about the interviewee's experience, how many years a mechanic, whether they have an Airframe & Powerplant (A&P) certificate or type rating or not, what their specialty area(s) is, e.g., structures, avionics, systems, or engines.

Interview—Conclusion. Review your interview plan and make sure that your questions have been covered for all topics. Check with other interviewer(s) to make sure they have asked all of their questions. Make final check of your understanding of any of the issues. Now is the time to deal with any of the larger discrepancies that you did not want to deal with earlier for fear of making the interviewee feel uncomfortable and unwilling to talk. Present the discrepancy as a problem that you have and that you want them to help your resolve, and then ask about it. Clarify the issue as much as is possible without shutting down the interviewee.

Then complete any administrative requirements. Make sure that you have all relevant administrative information—names, dates, contact details, etc. Say that this is an official requirement for all interviews. Find out if the interviewee wants a copy of the tape recording (if used) or of the filled out interview form.

Ask interviewee if they have any questions. Tell the interviewee what their further involvement might be (if any). Provide a summary of the progress of the investigation.

End on a positive note. Ask if the interviewee was happy with the interview and the way it was conducted. Give the interviewee your contact details. Tell the interviewee, "I **know** that you will think of other details after your leave, so please contact me when this happens." Make sure that it is OK with the interviewee for you to contact him/her in the near future (to ask more questions). Thank the interviewee for their assistance. Create a positive, lasting impression.

Post-interview Evaluation and Follow-up. After you are done with the interview and are back at your desk, it is time to write up the "record of interview." This would be completely filling out the MEDA Results Form or entering the information into your web-based form or database. While you are doing this, you should evaluate the completeness and accuracy of the obtained information. If there are some immediate issues that should be resolved, call the interviewee up and ask more questions. At some point in time you should also evaluate the quality of the interview. What did you and the team do well? What did you and the team not do well? For the things you did not do well, work up a plan for improving these areas. Finally, contact the interviewee again (within a week) to see if they have remembered any other relevant information.

8.3 Rules of Causation

Filling out the MEDA Results Form correctly, so that the collected information provides maximum value to the organization, is not an easy task. We have found that if the interviewer keeps four "rules of causation" in mind, then the task can be made easier. These rules are:

Rule 1—Each human error must have a preceding cause.

Rule 2—Each procedural deviation must have a preceding cause.

Rule 3—Causal statements must clearly show the "cause and effect" relationship.

Rule 4—Negative descriptors (such as poorly or inadequate) may not be used in causal statements.

Rule 5—Failure to act is only causal when there is a pre-existing duty to act.

Rule 6—Causal searches must look beyond that which is within the control of the investigator.

Let us discuss these in a little more detail.

Rule 1—Each human error must have a preceding contributing cause.
The investigation must search beyond the error to why the error has occurred. Most mishap investigations tend to stop at the mere identification of the human error. However, we need find out the contributing factors that led to the human error in order to find the best way to correct the error. Some common human errors include:
- Failure to properly document maintenance in maintenance records, work package
- Inattention to detail/complacency
- Incorrectly installed hardware on an aircraft/engine.

Rule 2—Each procedural deviation (violation) must have a preceding cause
Procedural deviations (violations) are a common contributing factor to error. However, in order to determine the best way to "fix" the procedural deviations, we need to know why the deviation occurred.   Therefore, it is important, when you determine during the interview that a procedural deviation occurred, to find out why the technician deviated. Some common procedural deviations include:
- Failure to use the maintenance manual/task card
- Failure to use torque wrench or other calibrated equipment
- Failure to carry out a functional or operational check at the end of a procedure.

In each of these cases, it is important to find out why the technician decided to deviate from the accepted procedure. There are several possible reasons, including:

1. The procedure does not really work, so all technicians have to deviate from the procedure to get the task done
2. The technician, for this one time only, decided to deviate from the procedure for some reason (e.g., was running out of shift time and wanted to get the task done, so he/she took a short cut)
3. This one technician often deviates from any procedure, even though none of the other technicians do
4. The procedure is a good one, but it has become the normal practice at this maintenance organization for technicians to deviate from this procedure
5. The procedure is a good one, but it has become the normal practice at this maintenance organization for technicians to deviate from most procedures, and this is just one example of it
6. The procedure is a local "shop practice," and it is not written down, so the technician deviated from the procedure because he/she had not been trained on it and did not know of its existence.

It is important to find out why the deviation occurred, so the MEDA Results Form can be filled out correctly and a proper "fix" can be proposed. For example:

1. If the reason for the deviation was 1. above, then you would check boxes "H.7. Work process/procedure not followed" and "H.6. Work process/procedure" on the Results Form and write in the space "the technician did not follow the procedure because it does not work, because (and give the reason)."
2. If the reason for the deviation was 2. above, then you would check box "H.7. Work process/procedure not followed" and give the reason that the technician gave you for not following the procedure.
3. If the reason for the deviation was 3. above, then you would check box "H.7. Work process/procedure not followed" and give the reason that "This technician regularly deviates from acceptable procedures, and this is another example of that behavior."
4. If the reason for the deviation was 4. above, then you would check box "H.7. Work process/procedure not followed" and box "H.9. Work group normal practice (norm)" and give the reason "The procedure was not followed, but this is the accepted practice (norm) in this work group."
5. If the reason for the deviation was 5. above, then you would check box "H.7. Work process/procedure not followed" and box "H.9. Work group normal practice (norm)" and give the reason "The procedure was not followed, but not following procedures is a normal practice for most technicians in this organization, and this is just one example of that."
6. If the reason for the deviation was 6. above, then you would check box "H.7. Work process/procedure not followed" and box "H.8. Work process/procedure not documented (e.g., use tribal knowledge)." and give the reason "The procedure was not followed, because the procedure is not documented, and the technician had never been trained on the procedure or told of its existence." [You would

probably also check box "E.4. Airline process knowledge" and give the reason "The technician was not provided training on this airline process."]

Rule 3— Causal statements must clearly show the "cause and effect" relationship.
The relationship between the contributing factor and the error and/or violation must be clearly written down. This is one of the most important rules for filling out the MEDA Results Form. You must write in the appropriate contributing factors section how the contributing factors that you checked actually contributed to the error and/or the violation.

Rule 4—Negative descriptors, such as "poorly" or "inadequate," may not be used.
If you just say that something was done "poorly" or "in an inadequate fashion," it is not clear what the corrective action is. Saying that the maintenance manual was written "poorly" does not tell someone how to rewrite the manual. We must be specific about what the real issue is. For example, "The maintenance technician was working in the vertical tail fin of the aircraft, and the task required that he/she face towards the rear of the aircraft. The maintenance manual tells him to "loosen the left bolt" (of two bolts side by side). The technician loosened the bolt on his left, but the maintenance manual was actually referring to "aircraft left.""

Rule 5—Failure to act is only causal when there is a pre-existing duty to act.
This is an important rule of causation that comes from legal findings. We should not expect someone to do something unless there is a pre-existing duty to do that thing. For example, we do not expect you to start leaving home for work 30 minutes earlier than usual just in case there is an unexpected traffic problem. We do not expect an inspector to do a full entry fuel tank inspection when the task only calls for an inspection that has the inspector putting his head through the access and using a flashlight and a stick with a mirror to do the inspection. We do not expect a technician to carry out a functional task twice just in case the first test was not enough. It is important to know in these situations exactly what pre-existing duties technicians/inspectors have. For example:
- Before closing an access panel, does the technician have a clearly stated duty to do a visual inspection of the area before closing the panel?
- If the technician is not sure how to proceed on a task, does he have a clearly stated duty to get help from the lead/supervisor/engineer before proceeding?
- If the technician deviates from a procedure, does he have a clearly stated duty to document the deviation?

Rule 6—Causal searches must look beyond that which is within the control of the investigator.
If the investigators are not in a position to change the contributing factor, they have the tendency to stop the investigation at factors only within their control. There is a belief that there is no reason to identify as causal what you cannot change. However, what might not be changeable from a single investigation might in fact be changeable if it is present in an entire class of events. Thus investigative conclusions should not be controlled by the investigator's perceived extend of control.

Key points for conducting effective cognitive interviews (Section 8.2) and six rules of causation (Section 8.3) are summarized in Appendix A.

9. Conclusion

The MEDA process has been adopted world-wide since its inception in the mid-1990s. Most of the large airlines around the world use MEDA, and many of the Maintenance, Repair, & Overhaul organizations are also using MEDA. We estimate that over 800 maintenance organizations now have a MEDA investigation process in place. When a Safety Management System (SMS) regulation is in place among all of the national aviation authorities, there will be a regulatory requirement to do "reactive" event investigation in all aircraft maintenance organizations around the world. Since MEDA is a reactive maintenance-caused event investigation process, MEDA use should continue to increase into the near future.

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Appendix A. Key Points for MEDA Interview and Six Rules of Causation

Interviewing Outline

1. **Introduction at start of interview—develop good rapport.**
   a. Introduce self/team
   b. Tell them why you are doing this interview.
   c. Ask what they know about the MEDA process. Explain to them the MEDA philosophy.
   d. Say something like, "**You are the person who knows all of the important information. So, you will be doing most of the talking. I will be asking you some questions, but I would like you to volunteer information whenever you think of it, tell me about the event in your own words, and be as specific as possible. You can ask me questions at any time. OK?**"
2. **Ask for a general account of the task/event**
   a. Say something like, "**What I would like is for you to tell me the sequence of events as you remember them. Start from wherever you think is relevant. Before starting, just try to put yourself back in the same situation. Do not say anything yet—just think about the situation that you were in.**"
   b. After 5 to 10 seconds, say something like, "**OK, would you please tell me everything that you can remember.**"
   c. While they are talking, listen for them to mention contributing factors. Write this information down on the MEDA form or on a blank piece of paper.
3. **Ask for detailed accounts of parts of the task/event.**
   a. Use the paraphrase (**I think I heard you say that**…) and open-ended questions (can't be answered "yes" or "no"), to ask for more detailed information about potential contributing factors brought up during the interviewee's general account of the task/event.
   b. Ask about other MEDA contributing factors categories that were not mentioned during the general account.
   c. Review your understanding of everything that you have heard.
   d. Deal with minor discrepancies here.
   e. Get the interviewee's input on how to improve the contributing factors that were uncovered during the interview.
4. **Background information**
   a. Collect background information, especially from witnesses to the event.
5. **Conclusion**
   a. Make sure that you and the team have asked all of your questions.
   b. Deal with large discrepancies here.
   c. Provide a positive ending.
6. **Post-interview evaluation and follow-up**
   a. Finish your paperwork
   b. Call the interviewee back if you have any questions.

General Principles of Interviewing

1. **Develop and maintain good rapport**—Avoid arguments, judgmental comments, and criticism.

2. **Encourage the interviewee to be actively involved**. Respond to their statements in a positive manner. Say such things as,
   a. "I know what you mean."
   b. "I have done that myself"
   c. "Sometimes those procedures are hard to understand and follow."
   d. "I agree with you, that is an error-prone task."
   Do NOT say things that would put the interviewee on the defensive, such as:
   a. "You did WHAT?!?"
   b. "I can't believe that you did that."
   c. "You didn't use the calibrated tool for that task?"
   d. "A good mechanic/engineer would not have done that."
   Try NOT to ask questions that can be answered with a simple "yes" or "no" response

3. **Help the interviewee concentrate**. Minimize distractions during the interview.

4. **Use open, simple, and unbiased questions**.
   Try NOT to ask questions that can be answered with a simple "yes" or "no" response.
   Do NOT asking "leading" questions like
   a. "At that point you probably asked for help, didn't you?"
   b. "Then you probably did…"

5. Go into the interview with no biases regarding culpability/blame. **Listen actively**.

6. **Use a communication style to suit the interviewee**.

7. **Work as a team with other interviewers**.

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When/Where/How Many People to Do the Interview

When: As soon as possible after the event.

Where: Pick a neutral location like a private room or a quiet corner.

How many people on the interview team: 1-3.

Rules of Causation

1. Each human error must have a preceding cause.
2. Each procedural deviation (violation) must have a preceding cause.
3. Causal statements must clearly show the "cause and effect" relationship.
4. Negative descriptors (such as poorly or inadequate) may not be used in causal statements.
5. Failure to act is only causal when there is a pre-existing duty to act.
6. Causal searches must look beyond that which is within the control of the investigator.