Maintenance Error Decision Aid (MEDA)©

Users Guide©

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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 mechanic 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 whose performance lead to the event to find out what errors and violations occurred and to find out 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
3. The MEDA event model
4. The MEDA philosophy
5. The MEDA investigation process
6. Using the MEDA Results Form
    - 6.1. Section I—General Information
    - 6.2. Section II—Event
    - 6.3. Section III—Maintenance System Failure
    - 6.4. Section IV—Contributing Factors Checklist
    - 6.5. Section V—Error Prevention Strategies
    - 6.6. Section VI—Summary of Contributing Factors, Error, and Event
7. How to carry out the MEDA investigation interview.

Maintenance Error Decision Aid (MEDA) Users Guide©

1. 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 unintentionally deviates from the expected action (or behavior).

Some theorists, such as Profession 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 intentionally 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 our material.

In the late 1990s, the US 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.

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 10 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 mechanic/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.

2. 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 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:

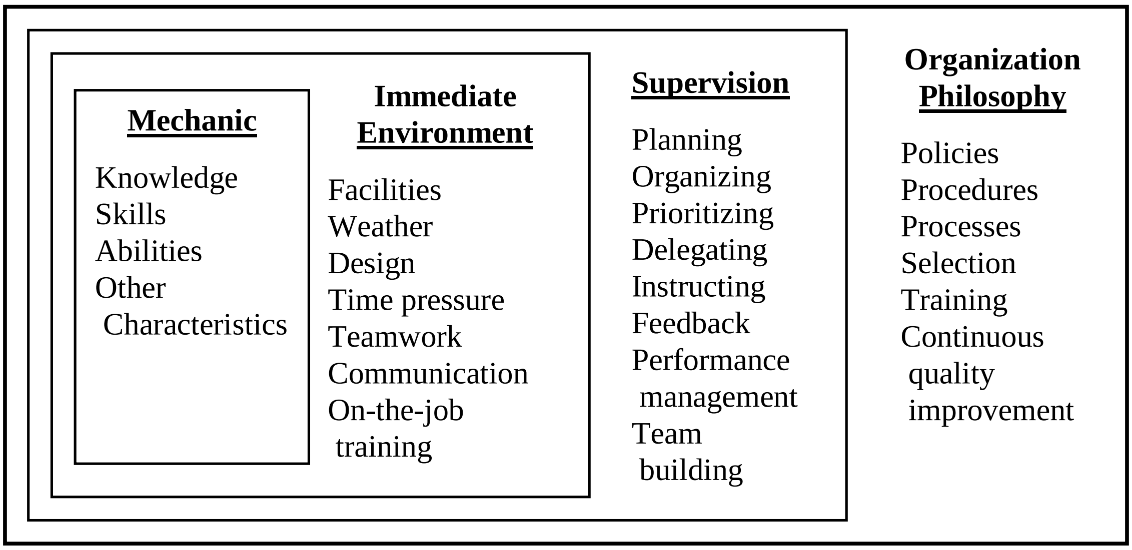

Figure 1. Contributing Factors to Maintenance Performance

In this model, a maintenance technician 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 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.

3. The MEDA Event Model

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

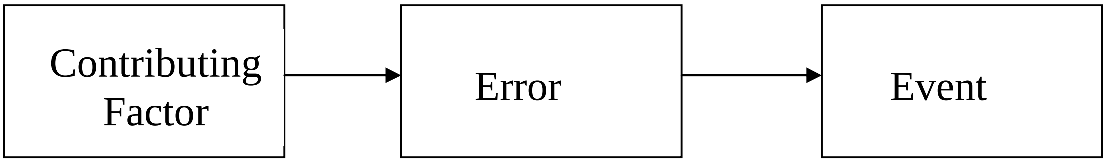

Figure 2. Initial MEDA Error Model

In this simple model, a contributing factor 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" increases.

We will find that in the maintenance technician'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.

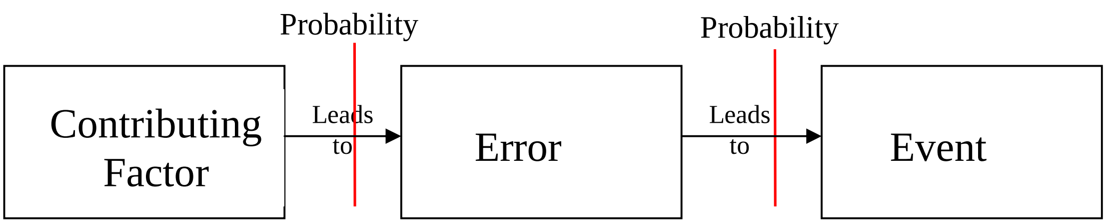

Figure 3. Probabilistic MEDA Error Model

This model 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 mechanic 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/she did not use the maintenance manual to do the task because it was "not available;" he/she was working in a poorly lighted room and did not see the spacer on the wheel that was being replaced; and he/she 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.

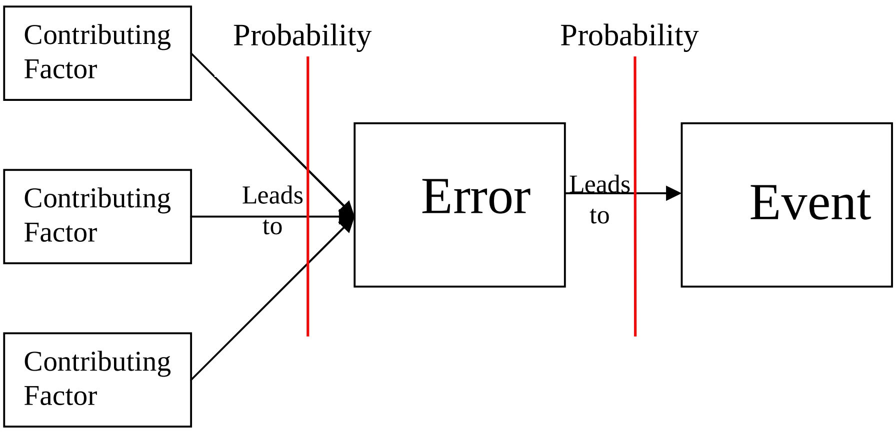

Figure 4. Enhanced MEDA Error Model

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 mechanic was fatigued. Further investigation finds that the fatigue is due to working a regular 8 hour night shift plus 4 hours of overtime. We also find out that mechanic has to work overtime because the shift is understaffed and the supervisor is making up for the understaffing through overtime. 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.]

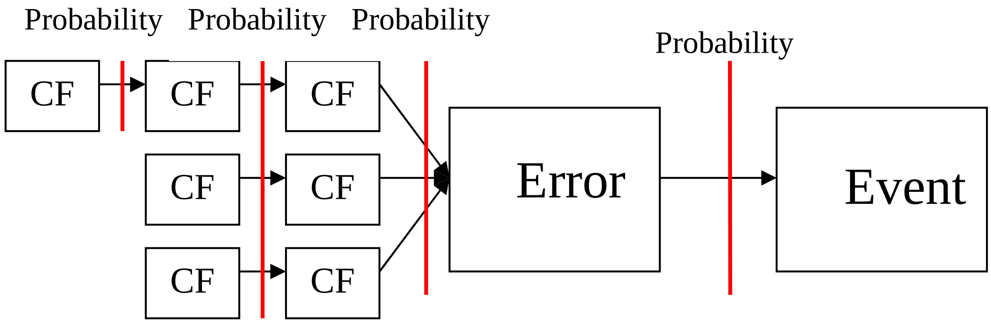

Figure 5. Further Enhanced MEDA Error Model

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 mechanic 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/she does not use a torque wrench, he/she under torques the bolt (this is a system failure)
- Because the bolt is under torqued, an event occurs, like an air turnback
- But there is a reason (contributing factor) for why the mechanic 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.

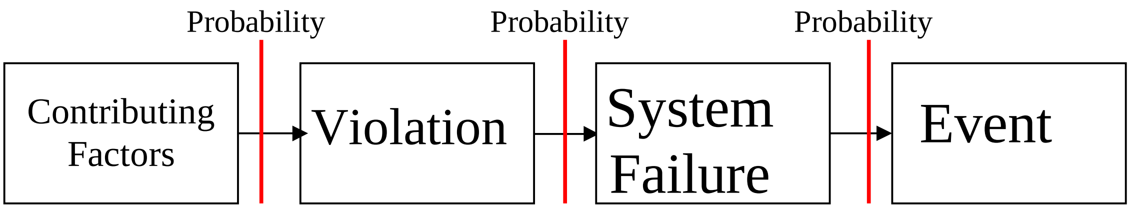

Figure 6. Error and Violation Model 1

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/she is aware that the greases serve two different purposes. We will let Model 1 in Figure 6 represent both of these cases.

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.

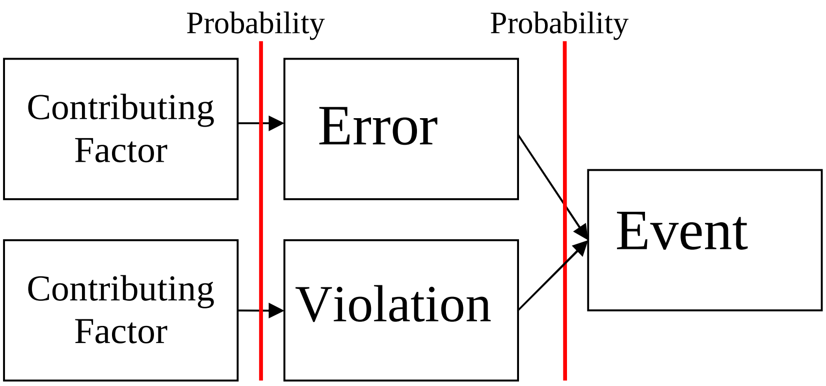

Figure 7. Error and Violation Model 2

Of course, both types of violations can contribute to a single event. This is shown in Figure 8 below:

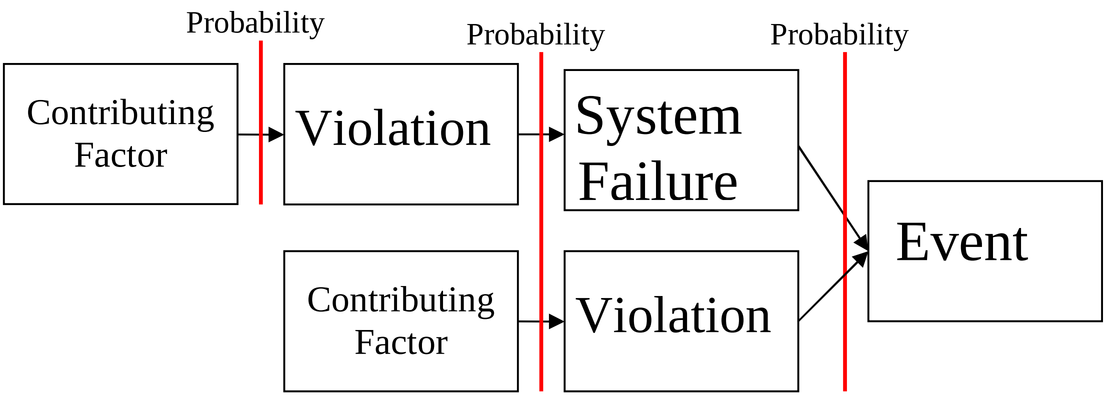

Figure 8. Combined Error and Violation Model

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.

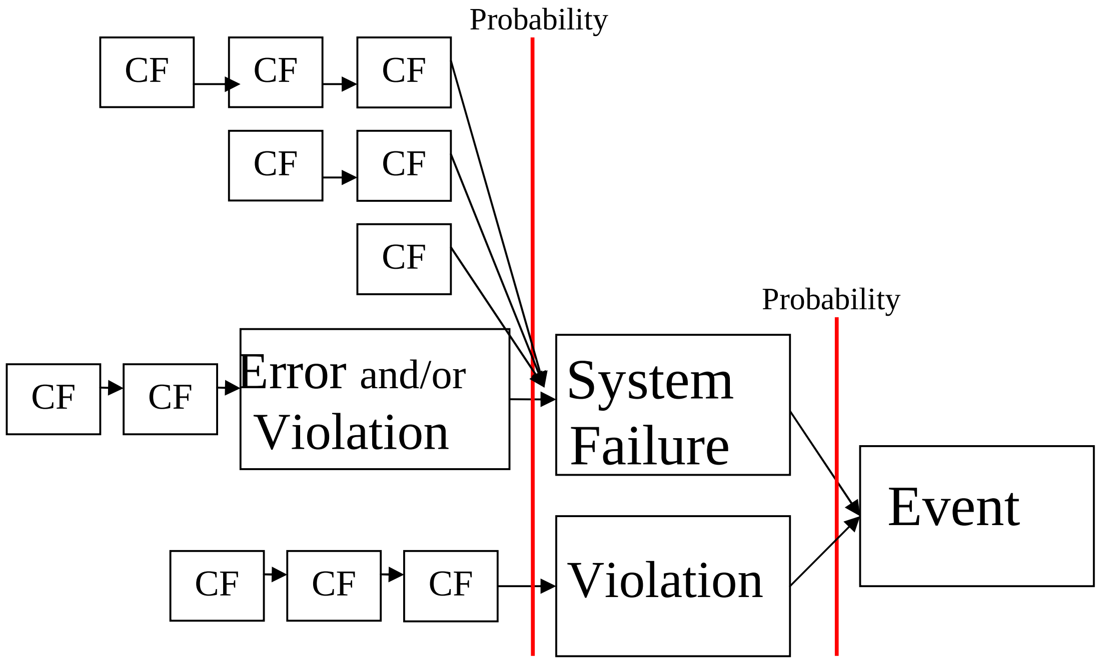

Figure 9. Final MEDA Event Model

4. The MEDA Philosophy

The MEDA philosophy is based on this event model. 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 part of an airline process, 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 mechanic 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. While we do not know as much about the causes of violations, violations also appear to be due to a contributing factor or a series of contribution factors.

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 worn 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 mechanic 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 but one part of the system, and
- Addressing the contributing factors to lower level events helps prevent more serious events.

The maintenance organization is a system, and the maintenance technician is part of that system. 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) 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.

5. The MEDA Investigation Process

The purpose of this MEDA Users 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 4 is a diagram of the MEDA investigation processes.

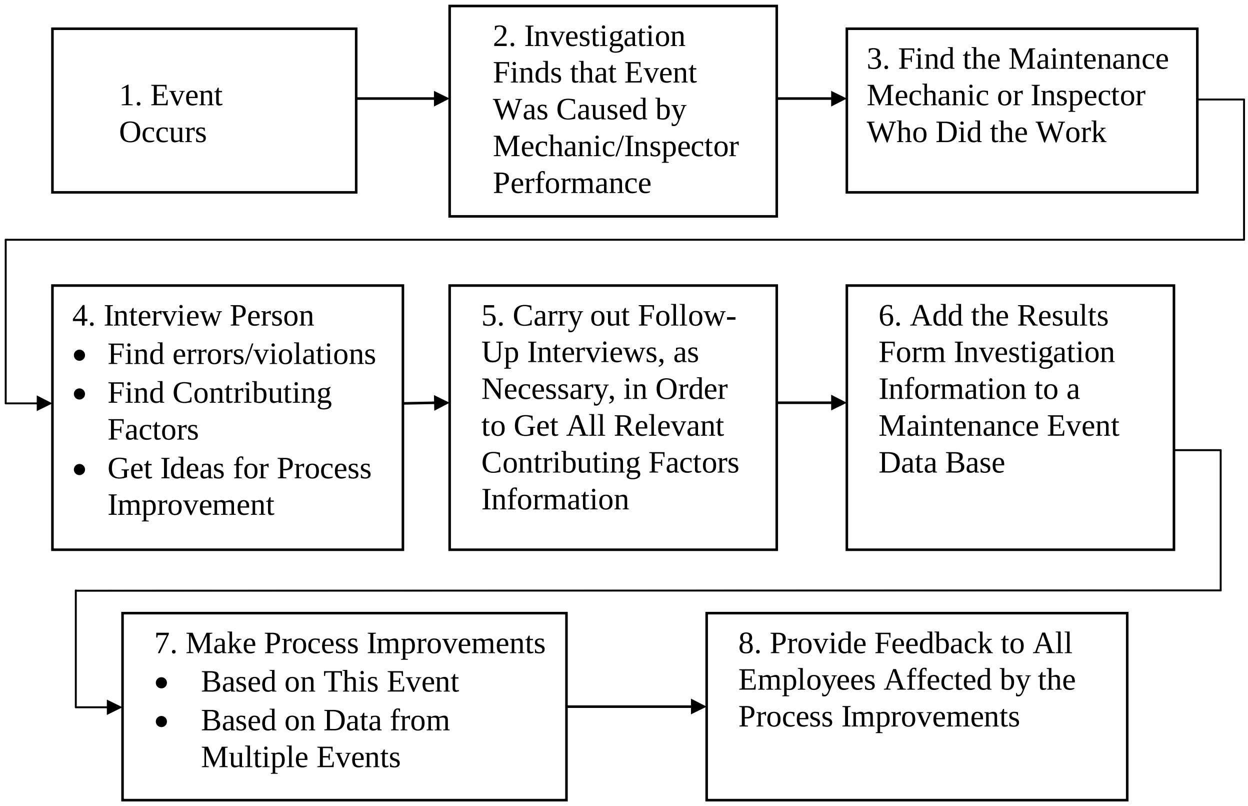

Figure 4. The MEDA Investigation Process

1. MEDA is an event-based 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 on 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.

6. 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—Contributing Factors Checklist
- Section V—Error Prevention Strategies
- Section VI—Summary of Contributing Factors, Error, and Event

Sections I, II, and III establish what happened (the incident), Section IV establishes why the incident happened (the contributing factors), Section V lists the system barriers that failed to prevent the error and recommendations for prevention strategies to prevent the error from occurring again. Section VI is for a summary of the whole incident, including the contributing factors.

6.1 Section I. General

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.)

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Airline: Two or three letter airline designator

Station of Error: Station where the error occurred NOT where it is being reported (if different)

Aircraft Type: Manufacturer and model (e.g., B747-400, 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 error.

Aircraft Zone: e.g., 210, 130, 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 MEDA focal in your organization needs clarification or more detailed data

Date of Investigation: Date the investigation starts

Date of Event: Date the event occurred

Time of Event: Time of the event, if known

Shift of Error: Shift during which the error 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

6.2 Section II. Event

An event is an unexpected, unintended, or undesirable occurrence that interrupts normal operations. MEDA can be used to investigate four 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 that a task was not done correctly (e.g., through an inspection, functional test, or system failure during flight) which results in having to do the task a second time (rework).

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 events that 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 Other (explain below)
( ) 2. Aircraft Damage Event
( ) 3. Personal Injury Event
( ) 4. Rework
( ) 5 Other Event (explain Below)

Step 2 is to write a description of the incident/degradation/failure (e.g., could not pressurize) that caused the event in 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.

6.3 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 seven 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
6. Airplane/equipment damage
7. Personal injury.

An eighth box is provided for “Other” in case the specific system failure of interest was not listed in 1-7 above.

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 incident. It is important to keep track of which contributing factors and prevention strategies listed in Sections IV and V 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 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.

6.4 Section IV. 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. Equipment, tools, and safety equipment
C. Aircraft design, configuration, and parts
D. The job or task
E. Technical knowledge and skills
F. Individual factors
G. Environment and facility
H. Organizational factors
I. Leadership and supervision
J. Communication

There is also an eleventh category (K) "Other" that is to be used in case the contributing factor cannot be found in A through J. We included this category just in case the contributing factor was not found in the checklist. However, our experience to date is that the "Other" category is never used. That is, the ten categories have been inclusive of all contributing factors.

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 IV 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.

6.4.A. Information

Information refers to the written or computerized source data that a maintenance technician needs to carry out a task or job. It includes workcards, 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 ignored). 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. MM 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 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. *Other*
   - Operator cannot use digital information

6.4.B. Equipment/Tools/Safety Equipment

Equipment, tools and safety equipment are the tools and materials necessary for the safe performance of a maintenance task. Equipment and tools refer to things such as non-destructive test equipment, 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 hard hats 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 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 may use other equipment or tools that are not fully suited for the job. Other factors that can contribute to system failure include mis-calibrated 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. *Mis-calibrated*
   - 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 be used 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 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. *Other*
   - System protection devices on tools/equipment not available

6.4.C. Aircraft Design/Configuration/Parts

An aircraft should be designed/configured so that parts and systems are accessible for maintenance. 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.

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.

Parts refer to aircraft parts that are to be replaced. Incorrectly labeled parts can contribute to improper installation or repair. Parts that are unavailable can contribute to system failure by the maintenance technician who uses a substitute part.

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 unavailable*
    - Part not owned or in stock
    - Not available for procurement

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

6. *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

7. *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

8. *Other*

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

6.4.D. Job/Task

A maintenance technician's job/task 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)

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 step sequences critical
   - 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)

6.4.E. Technical Knowledge/Skills

Technical skills (sometimes also referred to as abilities) refer to tasks or subtasks that maintenance technicians 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, and remove common parts from an aircraft. 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. Three broad categories of knowledge are required of a technician: airline process knowledge, aircraft systems knowledge, and maintenance 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 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 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's ability to speak and read English.

Examples to look for:

1. *Skills*
   - Safety wiring
   - Rigging of controls
   - Using calibrated equipment
   - Carrying out a fault isolation task

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

6.4.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. Technicians 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 constraints or 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 speed/accuracy trade-off, in that the faster one tries to finish a task the more likely an error is to happen. This trade-off also holds for speed and safety.

A technician’s response to peer pressure can also 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 small to reach a plug or if someone is unable to let down an LRU from an upper rack, this can contribute to system failure.

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 affects 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 constraints*
    - 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 don't 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. *Workplace distractions/interruptions during task performance*
   - 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. Other

- Absenteeism
- Vacations
- Medical leave
- Risk-taking behavior

6.4.G. Environment/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 quickly
   - 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
   - Long exposure to low temperature decreases sense of touch and smell

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

- Insufficient for general maintenance activity
- 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

12. 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

13. 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

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

15. 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

16. Other

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

6.4.H. Organizational Factors

The organizational 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, 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 don't 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 does not bring about the desired result, 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 a norm, 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*
   - 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 process or procedure
   - Undocumented procedure—most people do the procedure like the technician did.

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

6.4.I. Leadership/Supervision

Even though supervisors 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 leadership. 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 with the most likely causes checked 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. *Amount of supervision*
    - "Look over the shoulder" management style
    - Frequent questioning of decisions made
    - Failure to involve employees in decision-making

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

6.4.J. Communication

Communication 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
    - ACARS/data downlink not used
    - MEL/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

6.4.K. Other Contributing Factors

This section was put into the Users Guide in case a MEDA investigator found a contributing factor that did not fit into one of the ten contributing factors categories. During the field test of the Results Form, several investigators used Section K. However, upon inspection of what they wrote into the section, they had clearly failed to put the contributing factor into the correct category A-J that was already on the form. This suggested that the training needed to be improved.

Since the field test, we have never seen the “Other” category used, but we have left it on the form just in case there may be a need some day.

6.5 Section V. Event Prevention Strategies

This section is subdivided into two subsections. The purpose of Section A is to indicate organizational barriers that were in place but failed to prevent the event from occurring.

Section A asks, *"What current existing procedures, processes, and/or policies in your organization are intended to prevent the incident, but didn't?"*

The investigator needs to think about which of the listed items were involved or contributed to the system failure. For example, if a maintenance policy was not a good policy or was not followed, then you would check "Maintenance Policies or Processes" and write in which policy was not good or not followed. If an inspection was performed, but the inspector missed the fault, and the fault later caused the event, then you would check "Inspection or Functional Check" and indicate what the inspection was.

Section B asks, *"List recommendations for event prevention strategies."*

This section has three columns. The left most column (Recommendation #) is for you to put a serial number (1, 2, 3, etc.) in order to simply number the recommendation, so that it is easier to refer to it. The middle column (Contributing Factor #) is for you to put the number of the contributing factor that you are addressing (e.g., A.1. for Information Not Understandable). The right most column is for you to write in the proposed improvement to be made to the contributing factor that you listed (e.g., rewrite the third step in the engineering order to make clear what the torque values are supposed to be).

Types of Error Prevention Strategies

In order to help you think through Event Prevention Strategies, the following material describes the four major types of strategies that you should consider for preventing errors (but not necessarily violations) 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 error 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.

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 in that it 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 (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 it 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.

6.6 Section VI Summary of Contributing Factors, System Failures, and Event

The purpose of this section is to provide you with some space to write out a brief summary of what happened and what you found regarding contributing factors during the interview. If there is not enough room provided, continue the description on another piece of paper and submit it with the rest of the Results Form.

7. 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 two 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,
3. To provide some specific rules of causation, and
4. To discuss interviewer biases, so that the interviewer can try to overcome them.

7.1 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 observers 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 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 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.

7.2 Guidelines for the MEDA Investigation Interview

Once the team has been chosen, it is time to carry out the MEDA investigation interview. We suggest eight steps for carrying out the interview. They are:

1. Get as much information as possible about the system failure and the event before the interview
2. Interview people separately if more than one person is involved
3. Interview in an appropriate place
4. Put the person being interviewed (the interviewee) at ease
5. Determine the interviewee's knowledge of the MEDA process
6. Get the interviewee's view of what happened
7. Give the interviewee some feedback on what they said
8. End on a positive note.

These eight steps are described in more detail below.

1. 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.

2. Many times there will only be one technician to interview, so this would not be an issue. However, if more than one technician 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 doesn't 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.

3. 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. Try not to 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.

4. It is very important that you put the technician at ease for the interview. If the technician is worried about the incident, it may affect his memory and willingness to answer certain questions.
   a. Put yourself in their position—they probably feel that the incident reflects poorly on them and they may be concerned about punishment.
   b. So, you need to act relaxed and use a neutral tone of voice in the interview.
   c. To maintain the feeling of equality, the interviewer's and interviewee's eyes should be on the same level (for example, the interviewer should not be standing while the interviewee is sitting).
   d. The interviewer should also use neutral body language—that is, arms and legs should not be crossed.
   e. Look the technician in the eyes while asking questions. Act like you would act when you're talking to your friends.
   f. Finally, respond in a positive manner. If someone says that they had trouble understanding the maintenance manual, say something like, "Yeah, those manuals are sometimes hard to understand." Don't say something like, "Nobody else has that problem," or "Boy, I'd never do that." Those are not positive responses.

5. In order to help put the person at ease, determine their knowledge about the MEDA process. Ask them what they know about MEDA.
   a. 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.

b. If they say they have not heard about MEDA, then take a few minutes explaining fully about the MEDA process and philosophy.
c. 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.

6. Get the technicians version of what happened. Start the interview with, "Would you please tell me about what was happening before and during the time leading to the error." Then let them talk about what happened.
   a. Do not interrupt unless the person gets off the topic.
   b. Do not use a tape recorder, but use the MEDA Results Form to write down notes about possible contributing factors.
   c. When the technician has told you what he/she knows, then ask specific questions about contributing factors that you think you heard him talk about when he/she was telling you what happened.
   d. Review the other contributing factors categories to make sure that they were not contributory to the system failure(s).
   e. Do not ask questions or make statements that lead the interviewee, like, "After that, you probably went to the other side to see if the fastener had broken off. Correct?"
   f. Don't ask questions that put the interviewee on the defensive, like, "So how long after that stupid decision did you wait to talk to your supervisor?"
   g. Try to ask questions that require more than a simple yes or no answer.
   h. Again, don't make statements of judgment, like
      - That was stupid.
      - I would never do that.
      - No technician that I know of has ever done that.
      - You did WHAT!?!

      Those types of statements will quickly shut the interview down.

7. Give the person feedback on what they said. The purpose of this is to make sure you heard/interpreted what the technician said correctly. Use the <u>paraphrase</u> to do this. Put the key points in your own words and say, "I think that I heard you say that (x is the case)." The word "think" is very important here, because it gives them the opening to disagree with what you said. This process also shows active listening, which is also a very important communication tool.

8. End the interview on a positive note.
   a. One way to do this is to ask the technician to help you think through possible corrective actions for the contributing factors that were uncovered in the interview. Now the technician is part of the improvement process rather than just the person who caused the event.

b. Thank them for their time and the useful information.
c. Commit to giving them feedback about possible corrective actions. Feedback helps to show the technicians that you are using the MEDA process to solve problems rather than to punish technicians.

Often contributing factors themselves have causes that are important to an investigation. For example, you may determine that one contributing factor to a system failure was that the technician did not use the maintenance manual (a possible violation) while carrying out the task. It is important to find out why he/she did not use the manual, so find out the contributing factors to that decision. Maybe he/she didn't use the manual because:

- It was unavailable because the manuals are all on microfiche and the microfiche printer did not work.
- It was too far away to get in time to use for unscheduled (ramp) maintenance
- The technician thought that he/she had done the task often enough that he/she didn't need the manual.

Note that the various reasons why the manual was not used have widely differing corrective actions. If you do not find out why the manual was not used, you will have difficulty in coming up with an appropriate corrective action.

A commonly given "rule of thumb" is to "ask why five times." This will help assure that you would get the whole contributing factors causal chain. Then what you look for is the correct level to stop asking "why." For example:

- Person says that they did not use the maintenance manual. Find out why…
    - Not available (find out why)
        - The manuals were only on microfiche, and the microfiche printer was not working. Stop asking "why" here, because it is not the maintenance technician's issue why the printer was broken
    - Ramp maintenance area was not close to manuals, so maintenance technician did not have enough time to get the manual. Keep asking questions...
        - Ask about time constraints (when was the flight out?) and
        - The trade-off the maintenance technician made on working without manual vs. turning aircraft in time (what is their training on this and what is the company policy).
    - Decided not to use (find out why)
    - Had done the task a lot, so did not think he/she needed manual. Keep asking questions…
        - Ask how often he/she has done the task
        - Ask when the last time was he/she did the task.

7.3 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—The relationship between the contributing factor and the error must be clearly written down.

Rule 2—Negative descriptors, such as "poorly" or "inadequate," may not be used.

Rule 3—Each procedural deviation (violation) must have a preceding contributing factor.

Rule 4—Failure to act is only a contributing factor when there is a pre-existing duty to act.

Let us discuss these in a little more detail.

Rule 1—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 2—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 3—Each procedural deviation (violation) must have a preceding contributing factor.

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 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” 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 4—Failure to act is only a contributing factor when there is a pre-existing duty to act.
This is an important rule of causation that comes from the legal field. 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 leave home for work 30 minutes earlier than usual just in case there is an unexpected traffic problem.
- We do not expect a technician to come to work 30 minutes early just in case there is rush work to be performed.
- 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/she have a clearly stated duty to get help from the lead/supervisor/engineer before proceeding?
- If the technician deviates from a procedure, does he/she have a clearly stated duty to document the deviation?

7.4 Overcoming Interviewer Biases

Attribution Theory was developed in the 1960s in the Social Psychology literature. One of the major findings from those doing research in Attribution Theory is **attribution bias**:
- When I make an error, I attribute my making the error to (external) contributing factors
- When you make an error, I attribute your making the error to factors internal to the person (e.g., lazy, complacent, or careless).

Thus, unfortunately, it is "human nature" for someone to blame another's misfortune on that person's internal factors, such as being lazy, complacent, or careless. An investigator must overcome their built-in attributions and, in an open-minded fashion, search for the "true" contributing factors.

There are other types of biases of which the interviewer must be aware. Some of them are listed and defined below. The interviewer should like for these biases in themselves and try to overcome them.

- Experience/knowledge can have a positive or negative effect. It has a negative affect 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. “Joe made a major error because the airplane was out of service for 2 days.” 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 with 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 don’t 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 by 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.

Thus, as you can see, an interviewer's task is not an easy one. Not only should the interviewer follow the steps listed above in section 7.1 in order to carry out the interview, the interviewer must be able to recognize his/her interviewing biases and overcome them in order to come up with the true contributing factors to the system failure that lead to the event.