

# THE MES INVESTIGATOR'S HANDBOOK

for manual application of

**M** ultilinear  
**E** vents  
**S** equencing  
technology

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(MES Investigation - 2)

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**The MES INVESTIGATOR'S HANDBOOK**

**FOREWORD**

Regulations and the policies of most organizations call for the investigation of surprise occurrences producing unexpected outcomes, including death, serious injury, significant incident, fire, emergency, or near miss. The purposes of the investigation is to determine what happened, understand why it happened, and develop new information that will permit the most effective action by the proper person(s.)

To achieve this objective, an investigation program is established to provide organization-wide cooperation with investigations, specialized investigation training, and necessary technical support. This Handbook is one technical support element. The main purpose of the Handbook is to provide investigators a convenient summary of practical incident investigation practices for use during investigations.

The Handbook contents are based on the assumptions that the user has acquired the **MES-based** investigation knowledge and skill needed to implement **MES** procedures, and the user has access to MES Guides and other documents referenced in this Handbook.

Please forward any suggestions for making this Handbook more useful to the person who supplied you with this Handbook.

NOTES:

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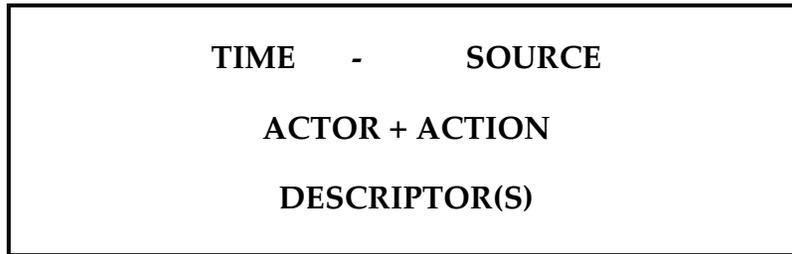


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# CONTENTS

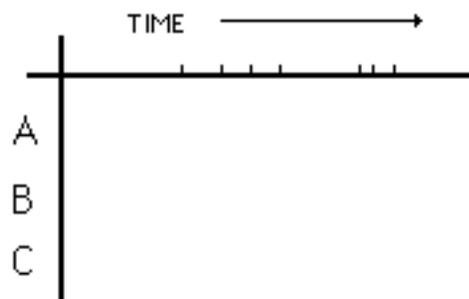
## DESCRIPTION OF TERMS USED IN THIS HANDBOOK

### Event Block (EB)

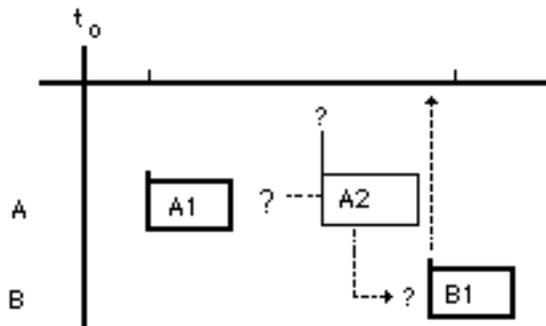


(Minimum contents)

### MES worksheet



### EB placement



**Conclusion:** a decision or judgment reached after some reasoning process.

**Deviation:** an event that differs from what was intended or expected.

**Event:** one actor + one action; the basic investigative and analytical building block.

**Inspect:** examine for a deviation.

**Investigate:** to observe and inquire into what happened; examine systematically.

**Mishap:** that process by which a normal, stable activity is transformed and produces an undesired and usually unplanned outcome.

**Objective:** the desired accomplishment for which a process is undertaken.

**Observation:** a noting and recording of an event or condition/state.

**Opinion:** a belief held confidently, but reached without positive proof.

**Process:** a system of interacting events producing changes of state in people and things for the production or achievement of some output.

**State:** a condition of existence of a person or thing.

**Systematic:** a set of orderly, structurally inter-related steps based on a network of concepts, principles and rules.

**Witness plate:** something on which is implanted partial or complete record of events to which it was exposed.

## INVESTIGATION POLICY

It is the Policy of this Organization to provide a structured process by which new knowledge to improve performance will be acquired from incidents quickly, accurately, efficiently and consistently. Investigations conducted by our personnel are expected to provide timely, thorough, unbiased, and accurate descriptions and explanations of incidents. These descriptions and explanations will be analyzed to develop actions needed to achieve improved organization performance.

Investigations are also expected to provide the information needed to assess procedures, designs, controls and related program elements, including

- ❑ effective comparison between what procedures, designs, controls and codes, standards, regulations intended and what occurred,
- ❑ effective action on any safety problems defined by this comparison, and
- ❑ determination of subsequent effectiveness of these actions.

Investigation findings should also satisfy demands imposed by management or supervisory reports, statistical reports and public inquiries.

The effectiveness of our investigations will be evaluated regularly against this Policy.

When investigators participate with other organizations' investigators, tasks performed by our personnel are expected to conform with this Handbook, including quality control checks.

Necessary support to enable investigators to accomplish their investigation objectives will be provided by all managers and supervisors.

## PART I. DETERMINING WHAT HAPPENED

### MISHAP INVESTIGATION OBJECTIVES

All incident investigations by our personnel shall have as their overall objectives

- o support of this Organization's administration of statutory mandates and
- o a prompt, accurate and complete report of the incident, suitable for all users.

Specific investigations shall have as their specific objectives

- o an accurate, objective, consistent and complete description of what happened;
- o a precise definition of opportunities for improvement demonstrated by that incident; and
- o new actions to most effectively will take advantage of those opportunities.

To accomplish these objectives, additional objectives for investigators include

- o performance of investigations using the incident investigation principles and practices summarized in this Handbook, and
- o production of reports which meet all quality criteria presented in this Handbook.

A related objective of the managers and supervisors experiencing an incident is to provide investigators with the support needed to enable its investigators to accomplish their objectives.

## INVESTIGATION QUALITY

All incident investigators are expected to perform a quality check on their work before they sign it. The quality of the investigation work will be evaluated against the following standards:

- o completeness of incident description within the assigned scope;
- o correctness of the incident description;
- o suppression of investigator biases and identification of assumptions;
- o evidence and logic supporting the problem and needs definition(s);
- o rationale supporting recommended action to solve problems;
- o level of cooperation achieved to complete the investigation;
- o application of preferred investigation methods;
- o controversies during investigation:

## INVESTIGATION PREPARATIONS

Before you begin a specific incident investigation, you should complete six key preparatory steps.

### KNOW YOUR OBJECTIVES

An incident is an undesired process that produced a harmful outcome. As an investigator, your job is to reconstruct that process from information created before and during the process and now residing in people and things. Your goal is to acquire and organize that data so you can accurately and completely describe what happened during the incident.

## KNOW YOUR LIMITATIONS

Before you begin an investigation, you should know

- o how many days or hours you have to do it,
- o who will handle your duties while you are investigating,
- o where and how you can access expert help,
- o the scope of the investigation,
- o the work products you have to deliver, and
- o how they will be judged for acceptability.

You are expected to establish and maintain good working relationships with the organization unit or individuals being investigated,

Another limitation is

- o Do no harm!

You should know how to accomplish that, and how to get help if necessary before you disturb, damage or destroy any evidence.

## KNOW ABOUT OTHERS' INTERESTS

A willing witness during an investigation is much more helpful than an antagonized, threatened or intimidated witness. Therefore, part of your preparation for investigations is to assure an open, non-hostile mind-set and introduction for yourself during an investigation.

## KNOW YOUR INVESTIGATION METHODS

Part of your preparations must include practice with **MES** tools. In investigations, you use these tools to help you produce a systematic, thorough investigation. Be prepared to

- o think about an incident as a process,
- o track the change makers,
- o transform data into event building blocks,
- o break down events to build worksheets,
- o discipline guesses (hypotheses) with MESTrees or FTA
- o use cause-effect links,
- o develop needs statements,
- o formulate recommendations, and
- o do a QC check on your work products.

As part of your preparations for investigations, you can practice using these investigator's **TOOLS** whenever you are trying to understand something that has happened. The methods require occasional use to maintain proficiency.

### **HAVE THE EQUIPMENT YOU WILL NEED**

You will need certain equipment on short notice, and should know how you can lay your hands on it when called to launch an investigation. In addition to those tools customarily carried on your job, this Handbook, 2" x 2" Post-its™, a notepad, and camera with a good battery and at least three extra rolls of film or memory cards are essential tools for your go-kit. A high quality voice recorder is desirable.

Personal safety protective equipment should be commensurate with the threats likely to be encountered at an incident location, and may be needed if normal supplies were destroyed in the incident.

### **KNOW WORK PRODUCT SPECS.**

The program relies heavily on you to quality check your own investigation work. The procedures that follow help you do this. The key yardsticks for any our incident investigation will be the **OBJECTIVES** specified at the beginning of this Handbook, unless otherwise specified in specific incidents by a supervisor.

### **KNOW SOURCES FOR HELP**

You will be the investigation expert with the best **investigation** knowledge during the investigation. Often you will need advice from someone who knows **the system** that experienced the incident in much more detail than you know it. Know who is available or who to ask about help, and ways to access them on short notice during an investigation. You may need in-house expertise, or contract services. In all cases, you should be able to get access to such help through prior arrangements that are completed before you get to the scene.

### **KNOW THIS HANDBOOK**

You should be prepared to apply the contents of this Handbook before you begin any investigation. By following its guidance, you are unlikely to have any serious problems you can't resolve during an investigation. Therefore, you

should have read it at least twice, and know where to find specific contents during your first few investigations.

If you do all that is described, you will be able to make significant contributions to better operations.

## STARTING AN INVESTIGATION

This section takes you the required tasks of the **MEST** investigation process, using **MEST** investigation methods. The procedural steps are not numbered because their order may differ from one investigation to another. The description begins with your first notice of an incident after you have completed your preparatory steps.

### START AN MES WORKSHEET

#### CONVERT NOTIFICATION INTO EBs

- ❑ When you are notified about an incident, make your notes in a building block format. Any kind of paper will suffice for a worksheet at this stage, including tablet paper. If you get a written notice, convert all the information into event building blocks (EBs). See **MES** Guide 1.
- ❑ Then start a **MES** worksheet to organize data you collect about an incident. Begin by listing the actors that you know were involved in the incident from the initial notification.

#### FORMAT YOUR MES WORKSHEET

- o Format a **MES** worksheet next. Get a large piece of paper, such as a sheet from an easel tablet or a piece of drawing paper to use as your initial **MES** worksheet. Put the title of the incident along the top edge. See **MES** Guide 2.
- o Next, list the names of all the actors you have identified so far in a column along the left edge of the large paper, about 2" apart, starting about 3" from the top. You will enter each actor's actions along the row to the right of that actor.

#### ADD EB S TO WORKSHEET

- o Now start adding the events you got from your notification onto the worksheet. Build the worksheet with the information you have for one actor at a time. Start with the actor about whom you have the most information.
- o Place each EB for an actor in its properly sequenced position along that actor's row, with the left edge directly below the time line marker to show the time the change of state was initiated.

## ADDING MORE EBS

After you start your **MES** worksheet, you quickly see that you need to add more events to describe what happened adequately. This section covers how to acquire and document these events. The next section covers how to add and analyze these new events to your worksheet.

If you do not go to the scene, focus on getting data from people only. If you go to the scene, get both the **PEOPLE** and **THINGS** data.

## LOCATE SOURCES OF DATA

Consider these techniques to help you locate incident data you need:

- list actors present
- track the change makers
- use mental movies technique;
- use witness plate data sourcing technique;
- fill in the general incident process model;
- trace actions in human response model;
- look for adaptive vs. habituated responses;
- synthesize/couple/test action sequences.
- time/loss analysis data sets
- use system definition technique

Start with the setting, and identify -- by name! -- the actors in place on that incident scene. Then use those names for the rest of the investigation.

Document all data in event format.

For efficiency, focus on data about

- **CHANGE MAKERS** (actors that shaped events, not RE-actors.)
- **OPENING NIGHT ACTORS** and actions that required adaptive response(s).

Remember: data are perishable! Mishap data will undergo changes.

- Recognize inadvertent changes!
- Guard against deliberate changes!
- **DO NO HARM** Rule

Your data gathering objective: **GET DATA TO COMPLETE WORKSHEET**

After you identify initial data sources, get the data from those sources. You will probably find more sources as you get more data.

An AI data source can be anyone or anything that has recorded "tracks" made by a change. Check for:

- PEOPLE - interests and roles in incidents include
  - o participants - influenced what happened;
  - o observers - observed what happened
  - o victims - harmed by events
  - o "programmers" - established expected events
  - o hangers-on/ volunteers - think they know but may not know anything
- THINGS - roles including
  - o initiators of changes, or stressors,
  - o acted on by events, or stressees
  - o involved recorders of events (observers)
  - o uninvolved recorders (observers)
- ENERGIES that did work needed to produce change

Focus on:

- o changes of state, and when they occurred:
  - before the incident process started?
  - during the incident process?
  - after the incident process ended?
  - when relative to other events
- o the beginning and end of the incident, i.e.,
  - FIRST change requiring adaptive response, and
  - LAST harmful change during the scenario.
- o the expectations of people and things during the incident (programming).

CAUTION: Do no harm to the sources or their data. If the scene is already disturbed, get what you can. If you are unsure about the effect your actions may have, get help.

#### ADD IF-THEN LINKAGES

With each new event added to the worksheet, add any links between coupled actions that should be added as worksheet grows.

## GETTING AI DATA FROM PEOPLE

### REMINDERS:

1st Law: Everyone and everything are always someplace doing something during an incident.

2nd Law: Time never stands still during an incident.

3rd Law: (Meeker's Law) Always expect everyone to do what they perceive to be in their best interests, and you will never be disappointed.

4th Law: Witness has it, you need it, and witness doesn't have to give it to you.

### GUIDING PRINCIPLES

Understand and apply the following two principles to successfully gather people data:

- Witness Plate Principle: people record tracks of changes made by events during a incident; and
- Mental Movie Principle: transfer mental movies from the witness' head into your head, and then convert their data into EBs.

## THE INTERVIEW PROCESS

Set yourself MBO-type objectives for the interview. **MES** worksheet gaps help you define data needs.

The objectives and procedures for the interview process itself are summarized as follows:

A General Objective: transfer "mental movie" from the witness' head to your own head, and then from your head to EBs

B Specific Objectives:

1. gain and keep control of the interview;  
gain and keep the witness' cooperation;
2. get the information you need;  
satisfy any legal requirements; and
3. leave the door open for any needed follow up.  
find out who did what from witness

C Main interview procedure is to:

1. identify events you need to learn about,
2. plan the interview sequence and how to get open data items,
3. control the interview process.

D After the interview begins, watch your body language, and make sure you ask the witness to

- describe the incident setting, witness location,
- track the witness' actions, in mental movie,
- fill in any gaps in the MM (mental movie) you get,
- explore conclusions, opinions and beliefs, and

- identify witness understanding of expectations.

E At the first opportunity, you should

- document actions, decisions, conclusions, etc. as building blocks; and
- list and then track the new actors mentioned.

F After each interview ask yourself if you

- listened objectively without leading, influencing or threatening the witness in any way;
- used incident investigation models as guidance;
- used other inquiry techniques as needed;
- mentally sequenced events as you listened;
- watched witness for body language;
- took notes unobtrusively.

G. Finally, after you have the data, restate the actions in terms of the actor that witness saw do the action and the action, citing witness as source.

## WHAT TO EXPECT FROM WITNESSES

People record data during incidents in the form of:

- ❑ direct sensory observations, or see, hear, smell, taste, touch.
- ❑ conclusions or reasoned decisions.
- ❑ impulsive reactions
- ❑ personal feelings and beliefs.

\* Separate what people DID or OBSERVED from what they CONCLUDED or BELIEVE. (Descriptive vs. interpretive data.)

Witness categories affect data a witness may supply:

- ❑ participants--involvement may limit responses.
- ❑ observer--look for good overviews of actions, easy access.
- ❑ victim--may be biased by self-interest in exploiting harm.
- ❑ programmer--informative but be alert to self-interests.
- ❑ hangers-on--may not know anything but still talk.

Stored data in people is subject to change while in storage, because people may

- ❑ forget observations or conclusions;
- ❑ rationalize observations to fit experience;
- ❑ deny or dismiss observations or conclusions; or
- ❑ cover up data to hide or obscure their role.

## GENERAL APPROACH TO INTERVIEWS

State your purpose and why the witness should help you.

1. Tell witness what you want witness to tell you.
2. Ask questions that help you track what the witness did step by step during the incident, so you can make your own timed mental movie from witness' information.
3. Document each reported action in EB format.
4. MENTALLY PLAN EACH INTERVIEW
5. Decide approach you will use for interview, including how you will state purpose.
6. Establish interview rules and stick with them. (especially if others are present.)
7. Assure that witness knows cooperation is expected and appreciated.
8. Plan an orderly questioning process.
9. Arrange for a comfortable, private interview setting.

CONDUCT THE INTERVIEW

### INTERVIEW TECHNIQUES

The preceding steps outline expectations of the overall interview process. The following material outlines ways that help you actually interview people to get information you need about an incident.

Remember, you are looking for the change making actions.

- EXPLAIN TO WITNESS WHAT YOU WANT AND WHY YOU WANT IT:
  - observe legal rights, instructions.
  - explain how you will document interview to minimize misunderstandings (record/shorthand or ??)
  - make clear you want witness to tell you what witness did, and what witness observed other people and things doing during entire time incident was going on.
  - give some examples of how to describe what happened.
- PLAN QUESTIONS TO ENCOURAGE WITNESS TO DO MOST OF THE TALKING AND BODY LANGUAGE PRESENTATION:
  - when you talk, you don't learn anything.
- GET WITNESS TO FIRST SET THE MISHAP "STAGE" OR STARTING POINT:
  - use sketches, photos, drawings, schematics, etc. to define stage
  - you and witness need to visualize beginning of your MM.
- HAVE WITNESS TELL YOU WHAT S/HE DID AND SAW OR HEARD, FROM SOME SPECIFIC START POINT TO THE END OF THE MISHAP:
  - explain you are trying to visualize witness' actions, observations.
- TRACK WITNESS' ACTIONS USING Your OWN MENTAL MOVIE:
  - try to visualize where witness went, what witness observed or did, and timing with MM.
  - "Then what did you see or do?" works wonders to restart witness talking.

- USE YOUR FIRST FOLLOW UP QUESTIONS TO FILL IN THE ACTION GAPS IN YOUR MM:
  - strategy is to ask "easy" questions first so if witness ends interview, you have as much as you can get.

Try something like:

"I can't visualize what you said when you said..."

"Forgive me, but I couldn't follow what you said when you were saying....."

- FINISH THE ACTION SCENARIO BEFORE YOU ASK FOR CONCLUSIONS.
  - here is where you start probing for understanding and reasoning behind witness' decisions, actions.
  - use the Human Mishap Decision Model to help guide your questions.
- FINISH ASKING ABOUT CONCLUSIONS BEFORE ASKING FOR WITNESS' UNDERSTANDING OF PROGRAMMED OR EXPECTED ACTIONS, DECISIONS, ETC.:
  - these and subsequent questions may be viewed by witness as threatening, and witness may turn hostile when you probe these areas; watch body language, voice for clues to distress. Avoid terms like failed, caused, mistake, etc.
- FINISH CONCLUSIONS AND EXPECTED ACTIONS BEFORE ASKING FOR OPINION ABOUT RESPONSIBILITIES, DUTIES, AUTHORITY, CONTRADICTIONS, ETC WHICH WILL BE CONSTRUED AS THREATENING BY THE WITNESS:
  - these are very sensitive areas to a witness.
  - you need this to help you understand the "whys" to help explain behaviors

- DOCUMENT YOUR DATA AND GET THE WITNESS TO CONCUR IN YOUR DOCUMENTATION IF IMPORTANT:
  - don't hesitate to make EBs with witness during personal face-to-face interviews if this is a vital point in an incident.
- LEAVE DOOR OPEN WITH WITNESS SO YOU CAN CALL BACK OR VISIT TO GET MORE INFORMATION IF YOU NEED IT:
  - doing this helps your attitude during interview.
  - remember to ask how you can make contact.
  - leave your card or note so witness can contact you with more information.

#### ESTABLISH WITNESS' EXPECTATIONS

- • Don't allege human error without comparing pre-incident expectations with what actually happened.
- • Avoid "editorial" abstract words like human error, mistake, failed to, failure, fault, etc.

Theoretical considerations:

- task performance design ok?
- adaptive learning or habituated behavior this time?
- timing, preparation for diagnostic effort?
- human decision model breakdowns in incidents?

Person's behavior during incident was programmed by

- past personal experiences (identify)?
- training (formal or OJT)?
- supervisor? (identify)

- regulations, procedures or codes? (name)
- other programmers? (describe)

Sources of data about expected behavior include

- witness' statement(s).
- training content, instructors, handouts, etc.
- co-workers, friends, supervisors.
- equipment signs, manufacturer's instructions, procedures, codes, standards or regulations, etc.

Before you allege human error or failure, state

- What was the CORRECT BEHAVIOR in **THIS** incident?
- Was the actor or victim PROGRAMMED to achieve that behavior BEFORE the incident began?
- Was ALL the INFORMATION that the programming relied on AVAILABLE in a way and time to permit the person to make a TIMELY DIAGNOSIS and response to the problem in THIS incident?

- o Check that you support your answers with good evidence that would withstand cross-examination in public.
  - Ask yourself "How would this allegation look in the newspapers?"

## GETTING AI DATA FROM THINGS

This section of the handbook helps you acquire EBs from THINGS involved in an incident.

### PROCEDURES

Things serve as *witness plates* during incidents, and capture much incident data during an incident. They are trustworthy witnesses if we know how to read what they have to tell us. Things won't talk to you, so you have to "read" every bit of information the things "recorded." Thus, the data you acquire from things depends on your "reading" skills. Data you read from things should be compatible with the incident description you get from people witnesses.

Usually, you get things data to verify or supplement people data. The exception: when no people were around or nobody survived the incident to talk to you. The basic approach is the same: track the actions of people or things on other things from when the incident began until it ended.

To get data from things think "if-then:" if you see this, then that must have acted on it to produce what you see.

- track successive changes of state;
- use energy trace and barrier analyses to track energy flows

**Stressors** = basic actors for things EBs;

- Either stressors or stresses can be things witness plates you try to "read."
- Stressors can become stressed during interactions with stressees - depends on interactions

Remember: investigation of things relies heavily on work done by energy transfers, and tracing changes of state during incidents. Changes of state are generally produced due to stressing by:

- o mechanical loads
- o electrical impulses
- o micro-organisms
- o combinations of stressors
- o thermal energy
- o chemical reactions
- o radioactivity
- o people actions

See MES ETBA Guide 5 for complete list.

- Find things data in the six "Ps"
  - o People
  - o Places
  - o Parts
  - o Properties
  - o Patterns
  - o Papers
- Access things EBs by:
  - o looking at things;
  - o operating things;
  - o dismantling thing
  - o destroying things.
- Read things to find:
  - actors that have acted upon them;
  - actions that they are exposed to;
  - changes of state over time;
  - sequences of changed state;
  - duration of events or states;
  - ranges of exposure dimensions.

These data can be extracted by working backward from observed ending or intermediate states, by:

- observing the present state of things changed during the incident,
- comparing the observed present state with known pre-incident state(s),
- tracking known or postulated changes, and energy flows or STRESSORS that induced changes, from beginning to ending states,
- transforming sequential state changes into inferred STRESSOR ACTIONS, or STRESSOR incident EBs.

NOTE: A thing may be a stressor (ACTOR) and a stessee (RE-actor) at different times during incidents.

## ORGANIZING YOUR THINGS EB s

As each piece of your things data is read,

- ❑ transform the data into the MES actor+action (stressor/action/stressee) EBs,
- ❑ add your EBs onto your MES worksheet to test their logic flow and,
- ❑ make sure that you can logically describe and explain the changes in states from the beginning states to their present observed states.

Add new actors to new rows or new actions to new columns to worksheet at any time.

### DERIVING DATA

As you first look at things involved in an incident you begin to develop ideas about what they can tell you. As you formulate these ideas, try to define the EBs you might get before you move, tear down or test things. You can do this by hypothesizing the EBs on your MES worksheet first. You often find that you don't have to do any actual tests. See Handling Unknowns, below.

### TESTING THINGS TO GET DATA

As you acquire things EBs and attempt to place them on the MES worksheet, you may find that you are having trouble and may need help to understand the system better before you can read what something has to tell you. To keep from doing harm:

- o get help!
- o make a test plan before your test anything!

**GOOD RULE: NO PLAN, NO TEST.**

(See MES Test Plan Guide 6)

NOTE: If you are working with a system that may have had a safety analysis performed before it was put into service, get a copy of that analysis and use it to save time.

## USING MES-Trees OR FTA

To fill gaps in worksheets after exhausting witness an thing data, use **MES-Tree** or logic tree techniques. (See MES-Tree Guide 3.)

### DOCUMENTING YOUR SOURCES

#### OVERVIEW

To use the information you acquire from things an people, you must document its source. That means for every EB you use, you should be able to identify the source and have evidence of that source available to you.

The approach for doing this with event-based analysis methods is to:

- o note the source of the EB data on each EB you use on an MES worksheet as you create it, and
- o have in your files a copy of all data source referenced on an EB .

#### NOTING SOURCES ON YOUR EB

Simply put the name of the source of the EB or some code identifying the source on the EBs you use on your MES worksheet.

#### DOCUMENTING "PROOFS"

The usual documentation needs for AI data come from a combination of organizational and legal requirements. Examples of "proofs" (sources) include:

- ❑ photographs with your notes
- ❑ witness statements
- ❑ audio or video tape recordings
- ❑ procedures/manuals
- ❑ medical/physicians reports
- ❑ coroners' reports
- ❑ test/analytical reports
- ❑ copies of papers
- ❑ sketches with your measurements.

NOTE: The most persuasive documentation you can provide is a fully linked **MES** worksheet that describes and explains what happened and why it happened, using documented EBs.

## ANALYZING YOUR INFORMATION

This section focuses on analyzing your worksheet to be sure you have reconstructed and described the incident validly. By analyze, we mean to separate a whole into its constituent parts so we can understand each part and how it relates to the other parts and to the whole. The parts we use are event building blocks and links. The links are cause-effect sequencing arrows between event building blocks. The whole is the incident process.

### 1 TIME/SPATIAL SEQUENCE ANALYSIS

When you 1) created each new EB and 2) fitted it into the **MES** worksheet in its proper row and column position, you performed the first analysis step - putting the events in sequence. After you have most of the information you think you can get, the next step is to check your worksheet again, to be sure all the EBs are in their proper precede/follow time order.

### 2 CAUSE-EFFECT ANALYSIS

Your next step is to determine the cause-effect relationships among the events, and place linking arrows on the worksheet between cause-effect related events. In an earlier event had to occur for the following event to occur, the events have a cause-effect relationship.

After you draw an arrow from one event to another, you begin the next analysis phase:

### 3 NECESSARY AND SUFFICIENT ANALYSIS

Use this reasoning to test the validity and completeness of your worksheet entries. To do this most effectively, start doing it as you enter each EB pair. Start at the left (earliest) event, and

begin to draw arrows to subsequent event(s) IF

1. the earlier action was **NECESSARY** before the next action could occur, and
2. it led directly to the next action without the need for any intervening action(s).

Starting at the EB to which an arrow led (later event) ask yourself IF

1. the event at the beginning of the arrow (earlier event) was **SUFFICIENT** by itself to cause the later event to occur;
2. if not sufficient by itself, try to locate additional earlier event(s) which also **MUST** have preceded the later event, and link it or them to the later event;
3. then repeat the **SUFFICIENT** test until you have linked **all and only** the EBs that had to precede the later event for the incident process to continue.

If you have events left over that you can't link to any other events, that tells you that either

1. the event didn't play a determining role in the incident process, or
2. you still have some gaps in your understanding of the incident process.

If your EBs are all linked to the last EB, forming a completed network of EBs, you probably have a complete description of the incident process. It is not unusual to have gaps because the data are not available, but those gaps are visible to all who use the finished matrix.

### GAPS IN YOUR WORKSHEET

If you do not have the additional earlier event(s) go to the next page, about handling unknowns.

#### 4. HANDLING UNKNOWNNS

As your investigation continues, gaps in your **MES** worksheet show you the parts of the incident process you don't yet understand. This may occur because you have run out of time, or the information is no longer available, or for other reasons.

If you consider it *important* to try to understand what happened during these gaps, use **MESTree** to flow chart your best guesses about what **MIGHT** have happened during the gap. See **MES** Guide 3.

#### 5. COMPLETING YOUR MISHAP DESCRIPTION

After you have acquired all the information you can get, completed the linking events on your **MES** worksheet, and done your best with the unknowns, you have reached the point to stop investigating. Next, test your incident description on your **MES** worksheet one last time to be sure it makes sense, meets your quality control standards, and is ready for further use. Your QC effort should

1. Check each **ENTRY** on your worksheet to be sure it is in the "actor/action" building block format. If you find any entries that are not in that format, fix them now. If you find any "poison words" in the blocks, change them now.
2. Check each building block entry to be sure you can identify the **SOURCE** of data for the event, and can retrieve that data if called on to do so. The source notations, if you use them, will help you do this.
3. Try to make a **MENTAL MOVIE** of the incident as you have recorded it on the worksheet, using the worksheet as your script. If you find your mental movie has any gaps that you didn't notice before, fill them in if you have the information.
4. Next, check each **CAUSE-EFFECT LINK** between events for both the "necessary" and "sufficient" tests. If you find any missing arrows, add them (or the missing event blocks), if you have the data. If you do not have the data, make sure the worksheet shows a "?" where a missing event remains

unknown. If you have arrows that link unrelated events, correct them now.

5. Now, check to be sure that your description covers the **SCOPE** of the incident you set out to investigate. As the first event the actual beginning of the incident process you are describing, and the last event the ending event of that process? If not, you should be able to explain your reasoning for cutting off your description where you did.
6. Your next check should be to make sure that all the **NAMES OF PEOPLE AND THINGS** on the chart are spelled correctly.

#### MISHAP DESCRIPTION REVIEW CHECK LIST

- EBs OK
- SOURCES NOTED OK
- MENTAL MOVIE OK
- LINKS OK
- SCOPE OK
- NAMES OK
- MES** DESCRIPTION CHECKED AND FOUND OK

If your description of the incident is OK, you are now ready to put it to work.

## PART II. DEVELOPING RECOMMENDATIONS

This section of the Handbook sets forth relevant procedures to develop and check the quality of recommendations suggested by the incident. Thus far, you focused on developing a complete, accurate understanding and credible description of the incident, and any unknowns. Your data sources have been related to the incident.

To develop recommendations, you must now "shift mental gears." You will now *use* your completed description to develop an action plan to bring about needed changes by developing valid and acceptable recommendations. *Your recommendations, when accepted and implemented, become the most valuable and lasting output of your investigation effort.* Accordingly, you should take great care to ensure that the recommendations you propose:

1. are based on new information that will support the action you propose,
2. consider all identified events, links and event sets in the incident process, and the significance of unknowns,
3. will correct the problems you have discovered and the resultant needs, if they are implemented; and
4. consider cost, capabilities, timing, organization policy and operator - and sometimes public - acceptance.

Develop your recommended corrective actions with a six-step process:

- define problems in terms of who does what, when and with what effects, and restate as a need;
- pick technical strategy to control those events
- identify candidate control options to satisfy each need,
- predict effects of candidate options
- consider trade-offs , including RAC codes if used, to find the best candidate recommendations; and

- do a QC of your best recommendations.

### DEFINE PROBLEMS

The first step is to identify all linked EB pairs that were necessary to produce the incident outcomes. Look at each EB pair and each link between EB pairs or E sets, step by step, starting with the first event on your **MES** Worksheet. At each event, ask yourself:

- "Was this expected to happen?"
- "Can this relationship be a problem because it happens too soon, too late, too fast, too slow, too much, too little, or not at all, etc?"

The answer to each question may suggest a problem relationship, and that leads to your problem definition in terms of

1. the NATURE of the event, the pair or the set, i.e. should it have occurred at all,
2. the TIMING of the event, the pair or the set, i.e. when it happens or how long it lasts,
3. the LOCATION of the event, the pair or the set, i.e., where it starts or happens,
4. the EFFECTS of the event or its interaction, i.e. who or what it affects and how or when,
5. the MAGNITUDE of the event or its interaction: i.e., how strongly or weakly, or for how long it affects something.

When you identify a problem, restate it in terms of what needs to get done to overcome it. The statement of need should establish the objective for any action that you might recommend to fix it.

## CONTROL EVENTS

As you look at the LINKS consider :

- the ADDITION of other events or relationships between events;
- the ELIMINATION OF events or the relationship between events; and
- ALTERNATIVE STRATEGIES for controlling the events or energy exchanges .

to identify candidate control options

Any changes that would favorably change subsequent interactions indicate a candidate for a possible change to recommend.

List all candidate changes as you think of them; numbering each change.

- place a "countermeasure diamond" by the changed event or link on your **MES** worksheet.

## PREDICT EFFECTS OF CANDIDATE OPTIONS

Do this step to tell you which changes will improve safety most if you

- estimate the relative effectiveness of each change and
- renumber your list in the order of the safety effectiveness of each change.

To do this, ask yourself:

- if, in this incident, the change would affect
  - only one event or link
  - more than one event or link

- if the change would affect
  - only this specific kind of accident
  - several kinds of accidents in this operation
  - several kinds of accidents in this organization
  - several kinds of accidents throughout industry.

(These effects give you a way you can state your safety objective for your recommendation later.)

- \* where is it on hazard reduction precedence list:
  - design or modify to eliminate problem;
  - install fixed or automatic safety devices;
  - devices to detect and warn of the danger;
  - change procedures; or
  - train personnel
- will this change create new safety problems?

If you use the RAC codes, what are the old and new RACs?

The changes that affect the greatest number of accident events or links, have the broadest effects, are highest on the hazard reduction precedence list, or create new problems would receive your highest ratings and reduce the risks the most show you your preferred actions.

## SELECT THE BEST CANDIDATES

At this stage of the recommendation process, you will have reviewed all the EB sets to identify candidate changes. Next, you numbered the potential changes on your list in the order of their safety effectiveness. These first two steps focused primarily on the safety aspects of the candidate changes. Next, you will assess other considerations that will help you choose the best recommendation(s) from your accident. These additional considerations include, generally,

- ❑ trade-offs with competing risks such as schedule, quality and cost;
- ❑ credibility of the problem and the proposed corrective action(s);
- ❑ perceptions of the feasibility of implementing the corrective action; and
- ❑ the effectiveness of the corrective action as perceived by those at risk.

You accomplish this step through an iterative review process involving 4 sub-steps:

### 1. Consider the trade-offs:

- Estimate the rough costs for the most effective change(s). Consider engineering, materials, labor and production down time, among others.
- Next estimate the reduction in risk or losses if the change(s) are effectively implemented.
  - o what reduction in accident frequency do you expect to see?
  - o what is the expected average loss per accident?
- ❑ how much of the accident loss will be reduced by the change?

### • Assess other trade-offs such as:

- ❑ what the recommendation will do to the operator schedules?
- ❑ financial capability to implement?
- ❑ possible pressures to bring about the changes?
- ❑ will this introduce new problems?

### 2 Assess the credibility of the problem and propose action:

- ❑ will your description of the accident convince others that your recommendation is valid?
- ❑ will others see how your recommendation will solve the problem clearly enough to consider it reasonable?

### 3 Assess the perceptions of its feasibility:

- ❑ did you discuss the recommendation with those who would have to implement it?
- ❑ do you think they will accept it or fight it?

### 4 Assess other risk acceptance considerations:

- ❑ who creates and who bears the risks?
- ❑ is the risk defined and analyzed adequately?
- ❑ are trade offs among different parties identified?
- ❑ are trade offs weighed by the proper people in a timely manner?
- ❑ are risks accepted by the proper people in the organization?

As you go through the various steps, you will recognize the trade-offs among the various candidates. The most safety effective action may not be worth recommending when weighed against the severity of the accident and other concerns. The least costly may result in unacceptable safety improvements, production delays, or undermine the public's or operators' credibility.

### DO QC OF BEST RECOMMENDATIONS

You still have to make a judgment call and decide whether or not to make any recommendations from this incident. If you have identified action(s) that would really improve safety, which seem necessary, feasible and credible, use the following checklist to review each of your proposed recommendations:

- 1 Does your work product show what safety improvement is expected to be achieved if the recommendation is implemented?
- 2 Does the recommendation simply and clearly describe the action to be taken and is presented in an option format?
- 3 Does the recommendation clearly specify who is to complete the action?
- 4 Does that person have adequate resources available to carry out the action?
- 5 Did you adequately address the event set frequency and severity in judging the safety effectiveness?
- 6 Is there enough uncertainty to indicate that you need to field test the action before making the recommendation, or before you expect it to be widely implemented? If so, your recommendation should describe the required testing.
- 7 Are appropriate implementation milestones included? If so, are they reasonable?
- 8 If you had to implement the recommendation, would you be willing to do so? Good rule: don't ask anyone to do something you wouldn't be willing to do yourself if you received the recommendation.
- 9 if more than one recommendation results from your investigation, are priorities for implementation necessary or provided?

- 10 Do you know how the people who have to implement your recommendations will respond to them?
- 11 Have you determined how both you and the recipient will be able to tell when your recommendation
  - has been carried out?
  - has proven to be effective?
- 12 Have you defined the follow up steps that are required to ensure implementation?

Bottom Line: Will your recommendation achieve your performance objectives, and will it:

- Pass Peer Scrutiny
- Support Our Mission
- Accomplish promised results
- 

Since this is a judgment call, do not be disappointed if someone else makes a different judgment call than you did as others review your work. They may put different weights on the trade-offs than you did.

### RECOMMENDATION CHECKLIST

- SAFETY OBJECTIVE
- WORD IN OPTION FORMAT
- WHO TASKED
- RESOURCES AVAILABLE
- EVENT FREQ/SEVERITY
- FIELD TEST NEEDED
- SCHEDULE MILESTONES
- GOLDEN REC RULE
- PRIORITIES PROVIDED
- RECIPIENT'S RESPONSE
- WHEN REC SATISFIED
- FOLLOW UP STEPS



## INVESTIGATION REPORTS

Complete any forms or reports according to the model you have been provided.

### CHECKING YOUR REPORT QUALITY

Remember:

**YOUR INVESTIGATION WILL BE REMEMBERED ONLY  
BY THE REPORT(S) YOU PRODUCE.  
THE BEST INVESTIGATION WILL BE WASTED BY A  
POOR REPORT.**

To do a quality check of your work:

- eliminate poison words like was or were; pronouns; words with ...ly; human error; "failed to."
- ensure that reader can make mental movie: try to visualize your accident scenario from the information in your narratives; and eliminate or append non-essential data.
- check your spelling, grammar and syntax.
- make sure opinions are in opinion sections, and not in descriptive sections of your report.
- make sure ALL opinions you offer are supported with your rationale. A good self-test is to ask yourself if you could make your opinion stand up under cross-examination by the operator or public.
- if you don't know what happened, do you say so and explain why, so reader won't discover gaps and lose confidence in the whole report?
- did you include quotations if a violation is at issue? Do you use "their" words to show "their" problems? Will your "evidence" survive attacks?
- does report include the pictures, sketches, test reports needed to help you make your points? and
- one last time: does your accident description seem believable to informed readers? Is your report complete, correct, consistent, logical and valid?

## ADDITIONAL SUBMISSIONS WITH REPORTS

A useful general rule is

:

**MAKE IT EASY FOR YOUR READER TO FOLLOW THE ACCIDENT SCENARIO, THE POINTS YOU WANT TO MAKE, AND YOUR ARGUMENTS THAT SUPPORT YOUR CONCLUSIONS.**

To satisfy this rule, you may want to add explanatory material to the reports you submit. For example, photographs help readers visualize settings for accidents. Alternatively, sketches of the setting or equipment or facilities might satisfy their needs.

When appending additional materials, please note the accident name and date on all such materials.

Examples of possible materials to append include:

- MES worksheets
- 1-page summary MES chart
- overview photograph(s) or sketch of setting
- lab test or analysis reports
- copies of quoted rules, procedures, charts, etc.
- photos to illustrate points made in text
- description of investigation if unusual

### REPORT DISTRIBUTION

Therefore, please observe the following guidelines for distribution of your accident investigation findings and reports.

- For accidents currently being investigated:
  - requests' for information from anyone not directly involved with the investigation, should be referred to an authorized spokesperson.
  - if you are the spokesperson, questions from anyone directly involved with the investigation should be answered only with factual information about what is known to have



## SUPPORTING REFERENCES

- ❑ <http://www.investigationcatalyst.com> for access to implementing software and technical notes
- ❑ <http://www.members.cox.net/lbjr99/> to view related technical papers
- ❑ 10 MES INVESTIGATION GUIDES provide detailed help with investigation tasks

## MODELS AND TABLES

Accident Process Model

General Human Decision Model

MES Worksheet Format

Investigation Process Model