Guide 1

INTRODUCTION TO INVESTIGATION

This Book was originally created in 1996-97 as an overview of investigation knowledge, skills and practices for investigation programs, as a supplement to a training film on the topic. It is out of print, and no longer available from the publishers or Emergency Film Group. It is the first of four such guides created by and containing material copyrighted by Ludwig Benner Jr.

It is posted here for reference by investigators who are interested in improving their investigation knowledge and skills by exploring and applying alternative methods for investigations and investigation quality assurance processes

Guide 1

INTRODUCTION TO INVESTIGATION

To complement the Emergency Film Group's
Introduction to Investigation video

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PREFACE

Guide 1, **Introduction to Investigation,** is the first in a series of four investigation guides. It complements the Emergency Film Group's **Introduction to Investigation** video, produced in cooperation with IFSTA. Guide 1 highlights and supplements the information found in the video.

Other guides and videos in the Emergency Film Group series include:

Accident Investigation covers mechanical accidents such as those resulting from misuse of equipment, occupational illness, line-of-duty death, and motor vehicle accidents.

Hazmat Investigation covers the investigation of hazardous materials incidents, spills, leaks, and explosions.

Fire Investigation covers comprehensive investigations of fires.

These videos and guides are available from IFSTA.

INTRODUCTION TO INVESTIGATION

Everyone "knows" intuitively how to investigate something. People "investigate" an incident whenever they want to understand what happened. They look into and try to figure out why something is not working; for example, why a light does not come on when the switch is turned, why a door does not close, why a roof leaks, why a car does not start, and so forth. Their activities are attempts to try to learn from their experiences. And that is what this series of Guides is about — learning from experinces.

To do a useful investigation, you need special knowledge, skills, and tools. Investigation tasks require procedures and tools designed from the ground up for *investigations.* To learn well from experience and to produce consistent, complete, effective, and valid investigation results, it is important to prepare yourself to conduct them properly. This Guide's contents are intended to help you perform useful investigations efficiently, consistently, and in a timely manner.

If you are a novice investigator, this Guide is designed to provide you with a basic understanding of the essential *investigation* knowledge and tasks needed to do good investigations. If you are an experienced investigator, the Guide's design can enable you to review investigation basics and enhance your performance. The basics presented in this Guide apply to all kinds and levels of investigations. Additional detailed guidance for specific kinds of investigations can be found in the remaining guides and videos and in the appendices and references provided.

The ideas and methods provided in this Guide reflect over 20 years of research into investigations and successful applications of the findings. The investigation process has been proven in all kinds of investigations. The procedures are practical and have resulted in new insights into long-standing problems and assumptions, major performance improvements, and an awareness of what good investigations can do for an organization. They have been applied in accidents ranging from household falls to very large accidents of national interest.

WHO CAN USE THIS GUIDE?

- *New investigators* can learn about investigation needs and how to conduct investigations of all kinds.
- *Experienced investigators* can find ways to improve the efficiency, effectiveness, and quality of their investigations.
- *Investigation supervisors* can learn to perform specific investigations within a budget (control testing expenses) and on schedule.
- *Industry safety personnel* can learn to prepare for and do various kinds of investigations.
- Managers responsible for establishing investigation programs can learn to establish policy and specifications for investigation performance and judge the quality and value in individual cases over time.
- *Training or seminar leaders* can use this Guide to help trainees build their general investigation knowledge and skills.
- *Data analysts* can use this Guide to help them analyze episodic accident or incident reports and other information from which they wish to identify problems disclosed by others' experiences.
- *Expert investigators* can learn to improve their efficiency and effectiveness and to evaluate their own performances.
- *Designers* can learn to identify kinds of problems they need to address when designing their products.
- *Regulatory agency investigators* and codes and standards *technical representatives* can use the Guide to investigate the effectiveness of their regulations, codes, or standards scheme.

CHAPTER 1
GENERAL PREPARATIONS FOR INVESTIGATIONS

What investigators do during an investigation is determined by their preparations for the required tasks. Those preparations include how they and others think about "accidents" and what they are asked to do, as well as what they know how to do and how well they do it.

It is important to establish the expected scope of your investigation tasks before you start each investigation because this affects your objectives. The scope of your investigation involves numerous choices. For example:

- Should you develop only a description of what happened, or are you also expected to develop recommendations?
- Do you investigate only what actually happened, or should you also investigate hazards that you find but that had no direct role in the occurrence?
- Is it necessary to investigate only the direct interactions of people and objects involved, or should you also investigate the influence of regulations, standards, or procedures on what happened?
- Do you look only at what people did during the accident, or should you investigate what they were "programmed" to do?
- Should you assess the effectiveness of actions by planned or spontaneous intervenors in the occurrence?

The larger the loss, the more significant these questions become from an investigation workload perspective.

In establishing the scope of an investigation, restoration of operations may be a significant consideration. Should you cut short or skip entirely an investigation to permit a vital facility to be reopened? Alternatively, should you leave the facility restart or reopening to someone else, or do you have the task of determining how that could be done safely? If so, the scope of your investigation might be expanded to determine as quickly as possible what actions need to be taken to reopen the facility without introducing unreasonable risks and when that can be accomplished. Often these decisions depend on your gaining a sufficient understanding of what happened and quickly defining what actions are needed. As an investigator, prepare for investigations by doing the following:

- Knowing your investigation objectives
- Knowing your limitations
- Recognizing others' interests
- Knowing your investigation process and procedures
- Preparing the equipment you will need
- Knowing sources for help during investigations
- Knowing contents of this Guide
- Knowing what to do if crime is suspected

KNOWING YOUR OBJECTIVES

Investigation objectives vary widely. In the absence of a clear consensus about the nature of an accident or incident, objectives can be very subjective. A written investigation policy should set forth what is to be investigated and investigation objectives. (See Appendix A, "Incident Investigation Policy," for an example of an investigation policy that addresses these points.)

A good policy statement is built on a consensus about the process nature of an accident or incident. In its absence, you are likely to be told simply, "Go investigate that accident, incident, fire, or injury." Sometimes you are instructed to "let me know what happened" or "find out what caused it" or occasionally "who messed up this time?" Sometimes you know you are expected to fill out a form. Unfortunately, these objectives and the investigations that result do not produce effective learning tools.

The fundamental reason for investigating an accident or incident should be to determine and describe incontestably *what* happened and *why* it happened. That description gives you a learning tool that you and others can use to do better in the future. Finding out what happened is always more important than assigning blame or fault. The description should include what intervention actions influenced the process. A valid, complete description of what happened will satisfy any reasonable objectives you are given. Therefore, this Guide focuses on helping you develop your descriptions and explanations of what happened. It also guides you to use them to develop performance improvement recommendations.

You determine what happened by working from information created before, during, and immediately after the occurrence. You can receive data from people and things available after the occurrence. An important investigation task objective is to observe, document, and organize that data — efficiently and without bias. This enables investigators to describe accurately, at a reasonable cost, what happened during the occurrence and why it happened.

Reporting Objectives

Do you know who the "customers" are for your work products and how they will use your outputs? Determine the customers' reporting format, scope, content, and delivery demands you will have to satisfy. You can determine these demands by asking the following questions:

- What are the formats of your expected reports — verbal, completed form(s), written narrative, flowchart, or other format?
- What is the scope of the findings you are expected to report?
- Are any of your customers looking for your conclusions about causes, root causes, immediate causes, proximate causes, causal factors, probable cause or probable causes, all causes, causal relationships, fault, blame, or findings?
- If you are to report cause, blame, or fault, what are the criteria for selecting one or more such opinions?
- How should you handle any unrelated deficiencies you observe? Should you report problems or needs and propose recommendations?
- Should the content include a summary only or a complete description of what happened or some combination of the two?
- How can you best serve the needs of anyone who must act on the information you provide?
- To what degree should you report the rationale and trade-offs supporting any recommendations?
- Should the content be only factual, or are you expected to offer your opinions and beliefs?
- If an incident involves many people, do the reporting objectives include the following?

— A description of all injuries and why they occurred

— Categories of injuries and why they occurred

— An injury and loss map

— Discussion of regulatory prevention or loss-limiting shortcomings

— Emergency response analysis and critique

The time to settle these points is *before* rather than *after* you submit your report.

KNOWING YOUR LIMITATIONS

You cannot always do everything that you want to do during an investigation because of self-imposed limitations or limitations imposed by others. Before you begin a specific investigation, know about the imposed limitations:

- Amount of time (days or hours) you have to do investigations. The time needed to do an investigation varies with the complexity of the incident. Small does not always mean quick and easy. Large usually means a lot of data to observe and consider. Your investigation time budget may be influenced by your workload backlog, others' degree of interest, the potential loss size for that type of incident, who was harmed, or other considerations.
- Who will handle your regular work while you are investigating? If you investigate part-time, you may need to get someone to fill in for you while you are on the investigation. Determine whether this limits your investigation tasks in any way.
- Where and how you can access expert help. Your efforts to get expert help may be limited by the following:

  — Policy

  — Time budget

  — Funding source

  — Standard procedures

  — Availability on short notice for short periods of time

  — Lack of knowledge about who has the expertise

  — Conflict of interests

  — Other reasons

Identify any limitations and try to resolve them if they are likely to interfere with your task performance.

Identify Limitations

Identify any limitations on the scope of the investigation or the scope of the incident you investigate. Are you expected to take investigation shortcuts, limit interviews, avoid testing, skip quality controls, or limit your description, for example? If limits are imposed, find out what they are before you go to the scene.

After you get to the scene, you may decide that you want to limit the scope of the incident process you investigate. When that happens, be prepared to deal with this decision in a way that is acceptable to your customers.

WORK PRODUCT LIMITATIONS

You may have to observe limitations imposed on your work products, including limits on:

- Distribution
- Access
- Duplication
- Content
- Format
- Style
- Size or length
- Quality controls
- Coordination with other organizations or governmental entities
- Security considerations

Personal Safety Policies

Most investigations involve some personal risk. Exposure to traffic flows in automobile crash investigations, hazardous materials in haz mat investigations, structural weaknesses in fire-damaged structures, or restarts of damaged equipment pose risks to you during your investigation. Know the "rules of engagement" that you are expected to follow in the investigation.

Do No Damage

During an investigation, remember one very important self-imposed investigation constraint: **Do no damage.** You must manage your own actions to avoid damaging your potential data sources or changing anything you may want to observe in detail later. Resist the temptation to disturb things before you document them or to test things without a well-conceived test plan. Few problems frustrate investigators faster than learning what they are observing was changed since the incident ended.

Another limitation is your own knowledge of how systems work. Recognize your knowledge limitations and seek help so that you do not miss important data or make premature judgments or unsupported conclusions about what you think happened or what needs fixing. To guard against false confidence and failure to work within your own limitations, use a systematic investigation process.

RECOGNIZING OTHERS' INTERESTS

It is important that you recognize and be prepared to deal with others' interests in your investigations. The smallest incident is of interest to at least one other person beside yourself. Sometimes the scope of an incident involves a large number of bystanders who are interested in your investigation. For example, the number of interested parties increases dramatically when a widespread gas cloud spreads or threatens to spread into a community after a haz mat release. An incident on a major urban traffic artery can result in major disruptions of many lives in a community. This means more people (including those in public safety, political figures, and the media) may express interest in your investigation or may conduct their own inquiry with different agendas and objectives. Other concurrent investigations may affect the course of your investigation. Unless the investigation results are consistent, controversy will inevitably result.

Another group of interested persons to prepare for are witnesses. Be able to recognize what people think is in their best interests so that you can use that information to your mutual advantage during interviews. A willing witness during an investigation is much more helpful than an antagonized, threatened, or intimidated witness.

Another interested group to prepare for is the media. The most desirable way to satisfy its interest is to designate a spokesperson for your organization to work with the media during an investigation. The second way is to produce accurate outputs that minimize controversy. Any opinions in an output have the potential to stir up controversy.

KNOWING YOUR INVESTIGATION PROCESS

Generally, your preparations must include knowledge of investigation procedures and the development of skills. You will probably be called on to investigate many kinds of incidents of varying complexity and scope. This means that you will need to learn about and become skilled in applying pertinent investigation tools and techniques. Your preparations should enable you to:

- Think about what you are investigating as a process.

- Find data you need during your investigation.
- Transform observed data into documented events.
- Organize events into their sequential and logical order.
- Identify and record causal relationships among interactive events.
- Create informed hypotheses to fill gaps in your understanding.
- Discover, define, and document problems and needs disclosed by what happened.
- Formulate effective recommendations to improve performance.
- Apply quality assurance procedures to your work products during the investigation.
- Produce a satisfactory report of the investigation results.

Investigation procedures require occasional use to maintain proficiency. Part of your preparations should be to practice applying your knowledge and skills. You don't have to wait for accidents to practice. You can practice applying your investigation skills whenever you want to understand something that has happened. Once you get used to using your investigation skills, you will find more and more opportunities to apply these skills. Another way to practice is to take reports of past incidents and apply your skills to those incidents. You will find the quality control tasks especially helpful.

PREPARING THE EQUIPMENT YOU WILL NEED

You will need certain equipment on short notice and should know how to obtain it when called on to do an investigation. Many investigators maintain a personal "go-kit" containing all the equipment that they may need. In addition to tools customarily carried on your job, consider including the following in your "go-kit":

- A bound notepad (to keep together any notes you make) and pens
- Several 3- x 3-inch Post-It™ notepads to capture data in a working format
- A 35 mm camera with extra batteries and at least three extra rolls of 36-exposure, fast (400) color slide film to document the scene and other points you want to illustrate
- A small handheld tape recorder with extra tapes and extra batteries to capture interviews and also to keep your oral notes and reminders
- This Guide as a reminder checklist and "how-to" resource

Your "go-kit" contents will depend on the kinds of incidents you investigate. For example, personal protective safety equipment (PPE) should be commensurate with the threats likely to be encountered at an incident site. PPE may be needed if sources of data at the site are in risky locations.

QUALITY ASSURANCE

This Guide assumes that you want to do high quality investigations. The process relies heavily on you to check your own investigation work against quality assurance standards as your investigation proceeds. You are urged to build quality into your investigation tasks and work products *throughout* the investigation. This is a key to getting more done in less time than you may be spending now. The ideas and procedures that follow help you do this. The key yardstick for any investigation will be the achievement of your objectives.

KNOWING SOURCES FOR HELP

During investigations, you may need help. Part of your preparations are to consider the kind of help you might need and how to get access to that help. Plan ahead for help with your workload or to supplement your knowledge.

Workload Help

Workload help may involve manpower or test capabilities. Help with the investigation workload may be needed in large investigations or when the time available to complete the investigation is less time than you can devote to the case. How do you access additional investigators to help you, and how do you use them when you get them?

At other times, you may find it necessary to have someone perform laboratory examinations, tests, or simulations to support your investigation. What capabilities do you have access to in your own organization? What capabilities are available in your community to help you?

Knowledge Help

Another kind of help is needed to fill gaps in your knowledge of some topic you encounter during an investigation. This may involve systems knowledge or materials knowledge.

As a trained investigator, you are the expert with the best investigation knowledge and skills at the scene. You are best equipped to develop the description and explanation of what happened. At times during the investigation or during the recommendation development process, you will need advice from someone who knows the *system* that experienced the incident. It is not unusual to need to know in more detail about how a system was designed to operate or how it did operate. Where do you go for expert help? Where would you find references to look up the information you need in published sources?

When you deal with objects, you sometimes need help with identifying reasons for what materials did during incidents. At other times, try to identify events that produced the physical changes in the material properties observed after the incident. In another case, you may need to know about chemical behaviors or changes in properties. When these situations arise, be prepared to access help from experts or references.

Know who is available or whom to ask about help and the ways to access their advice on short notice during an investigation. You may need in-house expertise or contracted services. In all cases, make prior arrangements for accessing such help.

KNOWING CONTENTS OF THIS GUIDE

You should know and be prepared to apply the contents of this Guide before you begin an investigation. By following its guidance, you are unlikely to have any serious problems you cannot resolve during an investigation. Therefore, read it at least twice, and using the Table of Contents, know where to find specific help during your first few investigations.

KNOWING WHAT TO DO IF CRIME IS SUSPECTED

If you suspect any criminal activity is involved, you do not have to become a criminal investigator. However, be prepared to avoid any actions that would jeopardize the successful apprehension and prosecution of individual suspects when "accident" losses are willfully made to happen.

The conduct of accident and incident investigations is generally not particularly constrained by requirements of law. Conduct of crime investigations, on the other hand, must meet strict requirements established to protect individual and property rights under the Constitution. Those requirements affect evidence acquisition and witness interviewing tasks, site access, and involvement of counsel, among others. The evidence must help identify perpetrators and support their prosecution and conviction.

The instant that you begin to suspect that the incident involved an intent to do harm, call law enforcement investigators into the case. Be prepared to turn over all data and objects to that investigator. If it turns out that an incident was accidental, it is still a good idea to do the investigation methodically and follow chain of custody practices using well-documented sources and confidentiality.

Throughout this Guide, four levels of investigation are discussed.

- Level 1 investigations focus on gathering data to fill in forms created by someone else.
- Level 2 investigations develop a description of what occurred.
- Level 3 investigations develop a description and explanation of what happened.
- Level 4 investigations develop descriptions and explanations and use them to identify, define, and assess problems and propose performance improvement recommendations.

(**NOTE:** These levels of investigation were established by the author for his discussion in the Investigation Guides.)

CHAPTER 2
KNOWLEDGE FOR INVESTIGATIONS

This chapter presents the general knowledge an investigator needs for conducting acceptable investigations of all kinds. The chapter also explains how to:

- Conduct investigations.
- Find data sources.
- Make and document observations.
- Organize observed data.
- Analyze events.
- Use logic tests.
- Develop descriptions and explanations of what happened.
- Ensure work product quality.
- Discover, define, and assess problems.
- Identify, define, and assess performance improvement.
- Evaluate and select recommendations.
- Plan monitoring of implemented actions.

Two categories of knowledge are discussed in this part. The first is knowledge of the nature of an accident or incident. The second is general knowledge of the investigation process.

GENERAL KNOWLEDGE OF ACCIDENTS

What is an accident? Before you start doing investigations, answer the question: What is the nature of the occurrence commonly called an accident, incident, accidental injury, spill, fire, or near miss?

An *accident* or *incident* is a process that produces an undesired harmful outcome or loss. Much confusion exists about the beginning and end of an accident process. Accidents or incidents occur during some activity. An accident or incident begins while the activity is progressing normally when it is disturbed by something that happens, and elements engaged in the activity are then diverted from their intended outcome to a harm or loss outcome. An accident or incident ends at the time of the last loss.

Nature of Accidents and Incidents

How you view the nature of these occurrences called accidents or incidents influences what you investigate and your investigation purpose. If you look at them as processes, you will look for interactions among the process components and how they produced the outcome. This is the preferred view. If you look at accidents or incidents as undesired events, you will be inclined to seek only causes. If you look at them as a chain of events, your investigation will try to find only a series of unsafe acts or conditions or root causes that produced the loss.

Research has disclosed that the most practical way to look at these occurrences is to think of them as processes.[1] A *process* is a group of people and objects acting on each other to produce some outcome. An accident is that process by which a normal, stable activity is transformed to produce an undesired harm or loss outcome.

Processes can produce desirable products and results or, in the case of accidents, spills or fires that are undesired harm or are loss outcomes. During a process, people and objects act to produce changes in other people or objects. We describe what happened during an accident in terms of who (or what) did what to produce the outcome.

What occurs during an accident to produce the outcome is "event-dependent." This means the outcome depends on events or actions by the people and objects which proceeded it. Thus to understand an accident or incident process, you must identify the flow of the change-producing actions (events) that produced the specific outcome. These change-producing actions may occur both in sequence and at the same time (simultaneously.) Figure 2.1 depicts how you can think about process elements interacting to produce changes during an accident process leading to a "harm" outcome.

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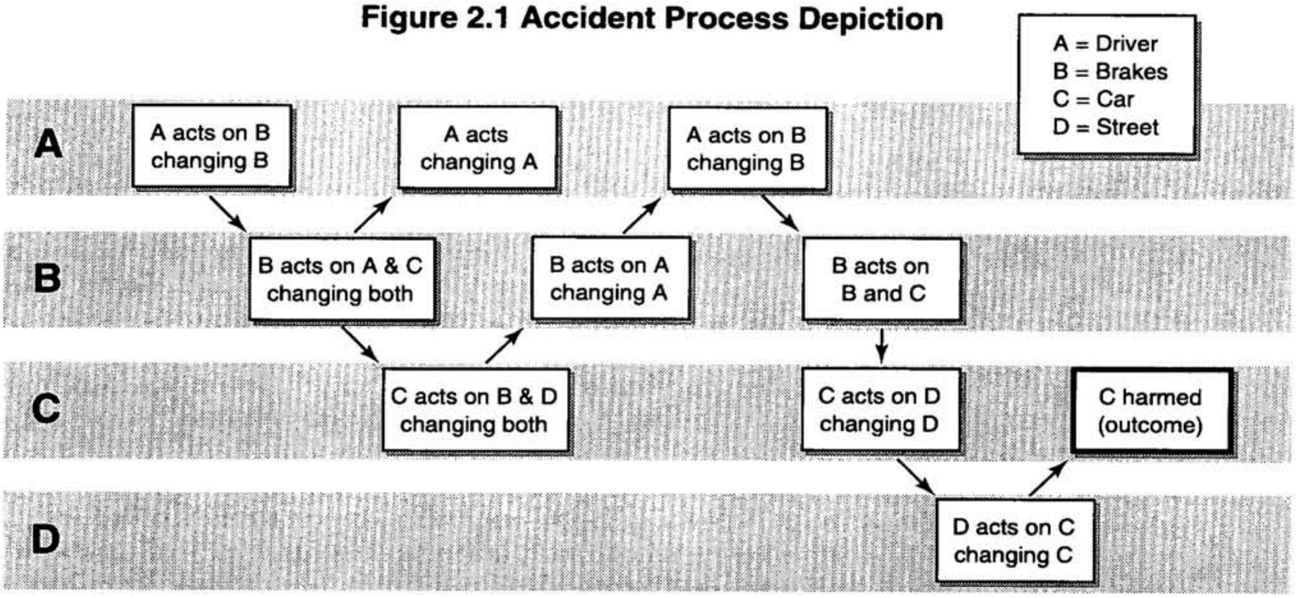
[1] Other models of the accident phenomenon consider an accident to be a single event, a linear chain of events, a random coming together of independent factors, or a converging set of chains of events. Because of major difficulties with investigations based on those perceptions, they were not selected as the preferred model for this **Guide**. Accident causation models do not address this question.

Figure 2.1 Accident Process Depiction



This illustration shows:

- A way you can describe interactions when more than one event is occurring during the same time interval
- A framework for developing a description of what happened that incorporates timing of related events

In an actual investigation, you would expand your description of the interactions between the individual, the braking system, the car, and the street behavior. You do this by expanding the description to show the behavior of components of the brake system, car, or street during this incident. You would, for example, break down the actor "brakes" B to describe actions of individual braking system anti-skid system components during the incident. You would also perform additional investigative tasks to develop the explanation of why these events occurred, using procedures described in the next section.

Incidents Differ From Accidents

Recognizing "incidents" or "near misses" or "near accidents" as candidates for investigations is also very important. Incidents differ from accidents because only a very small or partial loss outcome occurred. A larger potential loss was averted by some *successful amelioratory actions of people or objects* as the undesired process progressed. By thinking of incidents as successes, investigators also look for those interactions that produced the successful outcome. Incidents offer opportunities to discover verified performance improvements because they actually worked during an incident. Smaller losses reduce the stakes for

Assume that driver A needs to stop car C on snow-covered street D and that driver A steps on brakes B. Driver A jams on brakes B, changing the state of the braking system. The brakes B in turn act on car C wheels, trying to reduce their speed, and push driver A forward in the seat, which leads driver A to grasp the steering wheel harder to maintain control of the car (A acts on A). While this is happening, car C starts to skid, leaving skid tracks on street D and activating the brake B anti-skid devices. The brake B anti-skid devices cycling sends strange sounds so that out of old habits, driver A starts pumping brakes B. The brakes' B anti-skid operation disengages and car C starts to skid sideways toward the curb of street D. The street D curb abruptly stops skidding car C and bending (harming) the wheels on C.

anyone involved in the incident, making everyone more likely to talk about what happened and changing the entire climate of the investigation. Learning from averted losses is always preferable to learning from large losses.

Accident and Incident Losses

Think of the terms *loss* and *harm* broadly. Examples of losses to think about include injury, damage, destruction, illness, disruption, delay, reduced production, loss of confidence or credibility, tarnished reputations, environmental harm or degradation, diminished capacity, and any other kinds of undesired outcomes. Think of *loss* broadly when investigating, and try to define or at least list the losses you find.

Regulations and Accidents

Laws and regulations establish expected behaviors of people and objects. When investigating accidents, you will frequently find that what someone did is different from what you think the law or regulations require. Be careful about claiming someone or something was in violation of a law or regulation. Such requirements are often written with some ambiguity so that they can be generally applied. Knowledge of applicable requirements is needed when they involve some activity you are investigating. Motor vehicle accidents may involve laws and regulations applicable to the roadway, vehicle, operator, and cargo. Occupational safety laws and regulations at federal and state levels may be relevant in an industrial injury investigation. Know how to identify and interpret such requirements or where to get help with their application. A good way to handle this is to simply cite the requirement and then to describe what someone or something did so that readers can draw their own conclusions.

Learning From Experience

To gain maximum benefits from your work, it is important to recognize that investigations of any kind of accident or incident involve two distinct project stages. The first stage is to determine what happened and why it happened and to document this information. The second stage is to use your description and explanation to identify needs indicated by the incident and to develop recommended actions to improve future performance. Each stage requires different knowledge and skills. The following section describes the knowledge and skills required to do the second stage — discovering, defining, and assessing problems, and developing recommended actions to improve future performance.

GENERAL KNOWLEDGE OF THE INVESTIGATION PROCESS

How do you implement this knowledge of the nature of accidents and incidents in investigations? This section examines the general knowledge of the investigation process you need to produce satisfactory outputs and achieve your investigation objectives. With this knowledge, you can develop consistent, valid, and completed descriptions and explanations of accidents, incidents, fires, injuries, explosions, hazardous materials releases, breakdowns, disruptions, and most kinds of undesired losses.

Why Investigators Investigate

To determine what you have to do, you must understand *why* you do it. The primary reasons for investigating accidents and incidents are to determine *what* happened and *why* it happened. However, you should always remember that there are also other reasons for investigating.

Reasons People Want Investigations

The law, certain regulations, and insurance or labor contracts may require investigations. The law describes what you must do (investigate) rather than what you must get done and how to do it. Other reasons for investigations include:

- Settling claims or apportioning the loss
- Determining causes or root causes
- Supporting litigation
- Checking effectiveness of prevention measures

These purposes have varying effects on the investigation knowledge you need to have to satisfy your customers. A few are worth discussion. The persons asking for the investigation to determine root cause(s) have in mind a particular investigation system called *root cause analysis*, which requires you to understand those techniques. Persons asking for litigation support are motivated and constrained by certain requirements of law, and if you do investigations to support litigation, you will have to gain knowledge of what those customers need.

One need common to all reasons is a description of what happened and why it happened. As you find out, you must document what you found so that all of your "customers" can use your description as a basis for acting to satisfy their needs.

Investigators are almost invariably asked "What caused this accident?" by uninformed media or others. This is a judgment call that you can handle with a good description of what happened and why it happened. You will see why and how shortly.

Investigators may be called to perform up to four levels of investigations. In Level 1 investigations you focus on gathering data to fill in forms created by someone else. Level 2 investigations develop a description of what occurred and stop there. Level 3 investigations develop a description and explanation of what happened and report that. Level 4 investigations develop descriptions and explanations and use them to document problems and propose performance improvement recommendations. The investigation level depends on an organization's policies and objectives and occasionally its needs in specific cases. This guidance is useful for all levels of investigation.

Investigation Policy

Any organization conducting investigations should have a written investigation policy. Knowledge of this policy is needed to do investigations that implement policy requirements. Few organizations have such policy statements. A policy should address at least overall accident and incident investigation policy objectives to:

- Fulfill duties under statutory mandates.
- Learn from past experiences most efficiently.
- Produce an understanding and explanation of what happened for a basis to achieve long-term performance improvements.

See Appendix A, "Incident Investigation Policy," for suggested policy contents. Policy should identify what management expects from investigations. Without a policy, managers should not be surprised at or complain about anything they get. Policies differ depending on whether you investigate your own cases or other cases.

Investigator's Customers

Investigator's "customers" are the people that need the information that the investigator produces. All of your customers have their own particular investigation objectives. Often, more than one customer must be satisfied. You are advised to focus on tested descriptions of what happened and why it happened in order to satisfy your customers and to control controversy. It works.

Interested Parties

You must have knowledge of whom your investigation may impact and who has an interest in your investigation. Investigations impact people who are involved in accidents, as well as people who have to pay for the loss and for improvement actions. Other interested people may include system designers, resource managers, trade unions, or "outsiders" required to investigate by law. The latter might include local governmental response teams, law enforcement groups, and state or federal agencies (who may also send investigators.) The media also need special care. It can get complicated when investigators from several organizations — both private and governmental — get involved in an investigation.

Whose Investigation Is It?

You also need knowledge about investigation management authority, power, and responsibilities. Who is the "boss" of the investigation — that is, who decides conflicts, commits expenditures, or makes technical decisions? You must determine the authority that each party has and the pecking order for talking to witnesses, on-scene actions, removal and testing objects, or releasing information. The investigation will be easier for everyone concerned if it is conducted in a cooperative rather than an adversarial climate. In any case, establish *who* has *what authority* to do *what* and *when*.

Determining Site Control

The investigator needs to ask the following questions to determine site control:

- *Who owns the site*? Accidents happen on either private or public property. However, the owner of the site has basic property rights that investigators are obliged to respect. The site owner may or may not be the owner of all the objects on the site.
- *Who controls the site?* If it is a parking lot, check with the building manager. If it is inside a production facility, check with the plant manager to work out site controls. Follow the site ownership. Presence of emergency response personnel on a site operate under special rules that you should find out about.
- *Who has resources to control the site*? Before settling on site control, make sure that the person selected for this task is able to complete it. An explosion, for example, involves large areas and many people. Do local law enforcement organizations have the physical and communications resources to adequately control access to and egress from the site? If not, who does? How can those resources become involved?
- *Who will be granted access to the site?* Site control requires control of individual access onto and egress from the site. The investigator should be a party to defining who will be granted access to the site and for what specific investigation purpose. Clearly establish control of egress to prevent unauthorized removal of accident-related debris, parts, or documents.
- *Who is in charge of the site?* How long will this person be in charge? Who will be the next person in charge? If an accident like a haz mat spill, for example, extends the duration of an accident, the investigator needs to find out the name(s) and access information for the contact(s) to

get something done at the site. Make sure that changes in shifts or personnel do not leave you stranded when you need something. Remember to set up a way to end site controls.

- *Who owns debris and can authorize tests?* Site ownership and debris ownership are not necessarily the same. For example, when a private vehicle crashes on a government highway, the ownership is obviously different. Determine debris ownership for control purposes as soon after arrival as possible but certainly before any debris is disturbed (changed) or destroyed at the site. An exception to this is emergency response actions. Accident debris has to be disturbed to reduce losses, as when rescuing a person from a crashed vehicle on a highway. In some accidents, such as airplane crashes, government investigators, by law, have the authority to seize debris for investigation purposes. In those cases, determining ownership is not that high of a priority. This task is finished when the site managers have been contacted and site control procedures have been negotiated.
- *Will governmental authorities establish control of the accident site?* Governmental authorities have the power under many laws to establish control of the accident, regardless of the ownership of the site. This control is authorized to prevent harm from being inflicted on what remains or to prevent hiding something to cover up what happened. This guide assumes no criminal activity is involved. If a crime is suspected, you should consult with law enforcement personnel. On government property, the owner's representative is the local law enforcement agency or state police.

Securing the Site At the End of an Accident

The data generated by the accident process is contained in changes left in people and objects directly connected with the accident process. Most of these data are at the accident site. The purpose of securing the site is to keep these people and objects from being changed before you get to observe the data that they can offer you. During this task, keep trying to determine who and what were a part of the accident process so that the data they hold can be protected until it can be acquired and documented.

The next task is to set up site security boundaries and secure the area within those boundaries. These areas may cover a single machine in a factory, several cars on a roadway, or several city blocks when an explosion occurs. The actual physical barriers and boundaries depend on the nature of the accident, what was involved, and the resources available to establish the boundaries. Barriers can be very disruptive, so the strategy is to try to put barriers around only what will be needed for the investigation and to disrupt as little as possible.

CHAPTER 3
HOW INVESTIGATORS SHOULD INVESTIGATE

How have investigators traditionally investigated accidents and incidents? The short answer is that for individuals without training in an integrated investigation process, they have investigated accidents/incidents the best way they knew how. How is that? Traditional investigations are conducted using mostly borrowed or overly simplistic methods. The results are simplistic and not usually very complete or effective.

An integrated investigation process designed specifically for investigations can help you produce the most efficient, effective, and useful work products. Such a systematized investigation process incorporates many tasks common to all investigations and some tasks or procedures specific to the type of occurrence. The common tasks are described in this Guide, and the specific tasks are described in the remaining Guides.

SYSTEMATIC INVESTIGATION PROCESS

Outputs produced by investigations are based on investigators' observations and what they do with their observations. To perform investigation tasks, it is important to understand what needs to be done during the investigation process, why it needs to be done, and how to do it. To satisfy your needs, the investigation process you use should be based on an integrated body of concepts, principles, and procedures. The investigation process should:

- Enable you to produce valid, reliable descriptions of what happened and why it happened
- Facilitate continuous application of objective quality-assurance tests during investigations

- Help you define problems and needs indicated by the occurrence
- Help you find viable options for successful performance improvement actions
- Help you specify monitoring actions to verify that the predicted results are achieved

The starting point for an integrated systematic investigation process is knowledge of the nature of an accident or incident, as previously described. The next need is an understanding of investigation observations. Observations provide the basis for determining what happened during an incident and why.

The investigation strategy in this Guide reflects your desire to describe and explain how an unintended loss occurred. The general strategy is to start with the outcome and then reason backward to the beginning of the process that produced the outcome — this is known as "if/then reasoning."

For example, you see a damaged car sitting next to a damaged tree. If the damage to the car has the general shape of the tree and if the tree is still standing where it was planted, then you can reasonably conclude that the car must have struck the tree rather than the tree striking the car.

Think Events

During investigations, part of the overall strategy is to "think events." By this we mean that you look for people or objects that had to do something in order to produce the loss or harm outcome. The focus of your search for data is on *actions* rather than conditions, factors, or circumstances. The focus of your description and explanation of what happened is on *who* or *what* did what. To improve performance in the future, you have to change behavior of people or objects. You cannot expect to change behavior unless you know what has to be changed. Thus, throughout an investigation, focus on finding events indicated by what is still there for you to examine when you get to the site.

Break Down Events

A second part of this strategy is to "break down events" into increasingly more detailed events until you are satisfied that you can reproduce what happened with the same outcome. Implementation of this strategy becomes more apparent when you understand events and events flows. However, the strategy involves breaking down either actors or actions to clarify what happened. For example, when brakes on a car do not stop a car, you "break down" the brakes into components of the system and identify what each component did during the incident. That is an example of breaking down the "actors."

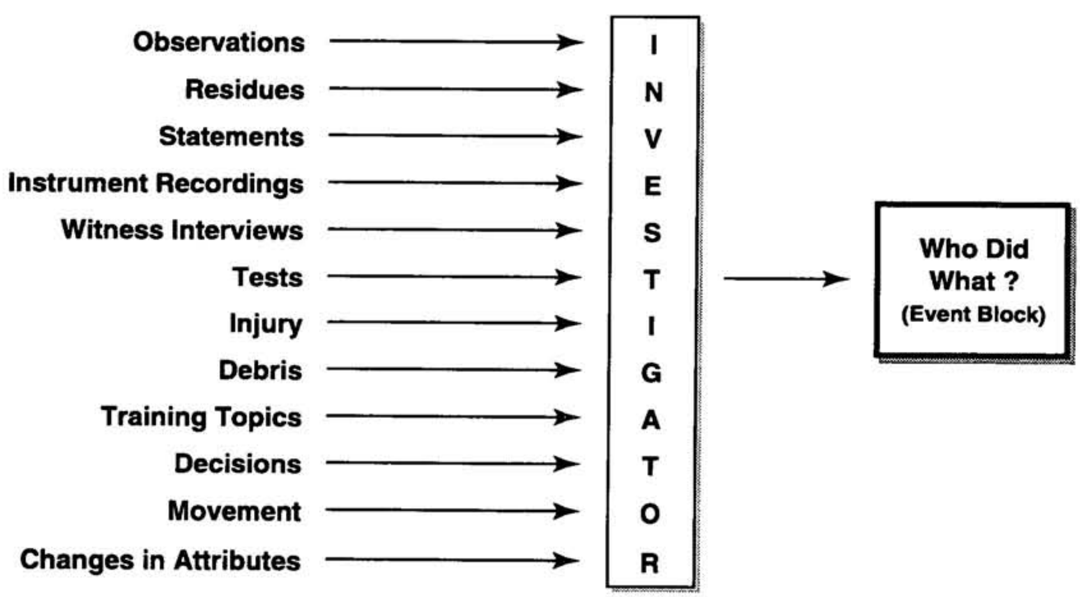
To break down actions when you interview witnesses, you "break down" what they did into increasingly more detail to understand specifically what happened. For example, if a witness says, "I locked out the machine," and the machine subsequently restarted spontaneously, you ask the witness to describe step-by-step what he or she did "to lock out the machine."

Investigation Observations

An *observation* is a noting and recording of an action, condition, or state by an observer. During an investigation, you are an observer. Your observations may include looking over the scene of the incident, hearing (and seeing) witnesses tell what they remember, and looking at objects to "read" the information they hold. You make observations to develop a description of what happened and why it happened. How do you get from what you observe to a description of what happened? An essential investigation skill is to be able to take your observations and turn them into a description of what happened.

Accident and incident processes are described mainly by describing who did what and what effect that had on the occurrence. You will make many kinds of observations of many kinds of people and things during an investigation, resulting in data that need to be further processed to produce understanding. Thus, your challenge is to take any observations of anything and transform them into descriptions of *who* did *what* or an "event block" that you can process further. This challenge is described in Figure 3.1.

Figure 3.1 Investigators Data Transformation Challenge



Stated another way, you must look for events during the entire investigation process. That means you sift your data to find out *who* or *what* did *what*, or more precisely, the actors and actions that produced the outcome. When you encounter a "condition," think about the events — *who* or *what* had to do *what* to produce the condition you see or want to describe. A *condition* is an ending state produced by the actions of someone or something.

Formatting Data

The format for recording your observations should help create building blocks that you can process for your analysis tasks. A format that has worked best for many is the "who did what, when and where" format, as shown in Figure 3.2.

Figure 3.2 Event Blocks

TIME SOURCE

ACTOR + ACTOR

DESCRIPTOR(S)

© Source: Benner, L., 4 Accident Investigation Games, Events Analysis, Inc., Oakton, VA

For convenience, we will refer to event blocks as "events" during the rest of this Guide. To transform and document data into events, use this simple procedure. It may seem tedious, but it really pays off throughout the entire investigation process. It also helps you recognize and define an event when you see one.

LOOK FOR EVENTS: *who or what did what?*
One actor + one action = An event

If you are not sure who did it, or you don't know yet what someone did, use a question mark (?) or a tentative name and a question mark to indicate what you do not know. For each observation:

- Identify what happened.
- Identify and record the name of each actor (a person or object that did something).
- Record what each actor did and any additional descriptive words needed to visualize the action.

- Describe each action so that you can visualize it from your description. (It is hard to visualize "failed" without a picture or sketch, so try to do so with words when you can.)
- Record the time if you know it.
- Record the data source from which the event block was formed.

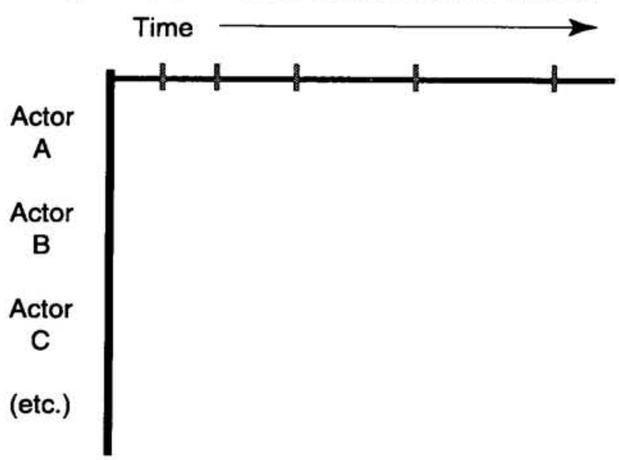
The source note allows you to go back to the source of the event when that becomes necessary. The source notes also tell you what records to retain at the end of your investigation. Finally, if the event is controversial, you can list all of the sources available to support the event.

Organizing Data

It is not a good idea to just go out with a big net and grab all the information you can, hoping that you have what you need when you start to analyze it. A better way is to analyze what you have as soon as you get it. As you identify new actions by people or objects or (events), you must have some way to keep track of and organize them so that they help you figure out what you know and what you still have to find out next.

The easiest and fastest way to organize your information is to lay out your newly-acquired events on a matrix, with time and actor as the coordinates, as shown in Figure 3.3.[1] If you use

Figure 3.3 Events Matrix Work Sheet



Source: Reference 1

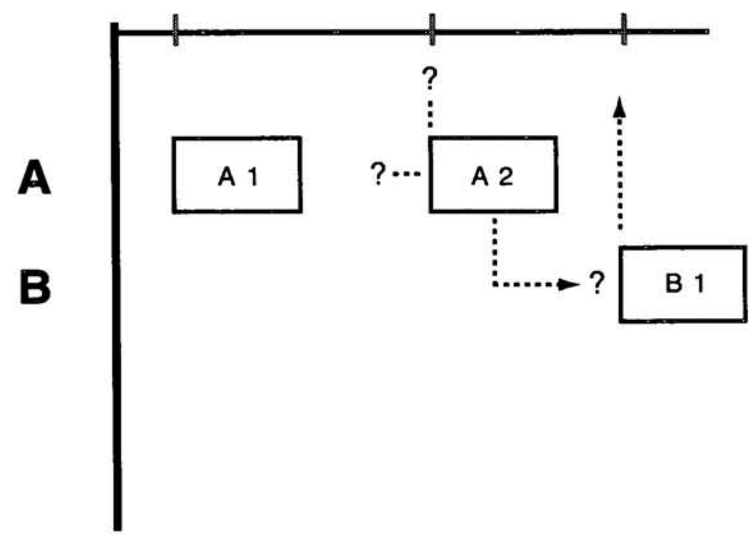
[1] The time/actor matrix work sheets produce a display somewhat similar to critical path project management (CPM) task planning flowcharts. Many other data organizing options are available, such as timelines listing times and what happened, logic trees that display converging sequences in a tree format, root cause analyses, cause-consequence diagrams, failure mode and effects analysis displays, events and causal factors charts, or MORT charts. However, these options lack the objective data search guidance, data acquisition and data entry discipline and formatting, real-time analysis, and quality-assurance testing or recommendation development capabilities of the preferred event work sheet development process described here.

this procedure, you can reduce your investigation workload and the total time required to produce your description of what happened. Events work sheets enable you to organize your information as you get it into a direct description of what happened by using the relative times or locations to put the events into their proper sequence. This procedure enables you to record the events into a form of movie script to make "mental movies" of what happened.

Placing Events on Work Sheet

As soon as you record your first observation as an event, you can start making your work sheet. Follow the example. You have learned about event A1 and placed it on your work sheet in the A row. (Refer to Figure 3.4.) You then learned about event B1, which happened after A1. You added a new row (for actor B) and placed event B1 on the work sheet along the B row. Next, you found out about another action by A described by event A2. To place A2 in A row on the work sheet, you need to determine when it happened relative to A1 and B1. The placement shown in Figure 3.4 indicates that you found it occurred after A1 and before B1.

Figure 3.4 Placing Events On Work Sheet



APPLYING LOGICAL REASONING

During investigations, logic principles and reasoning skills are applied frequently. Four kinds of logical reasoning are involved: sequential logic, cause-effect logic, necessary and sufficient logic, and deductive logic.

Sequential Logic

Sequential logic is the reasoning process applied to data in the time sequence it occurred or in the sequence in which movements of people or objects occurred. To understand *who* did *what* when, investigators have to put the information they acquire into sequential order. For example, "A" had to happen before "B."

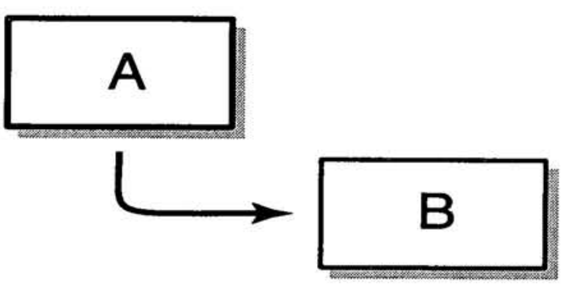
Experienced investigators know to apply sequential logic intuitively by capturing what they see in their minds as "mental movies." As new data becomes available, they picture the actors and try to visualize what they did to sustain the accident process. The mental movie helps put all the observed data into sequential order by using time and spatial sequencing logic.

Mental movies are okay for small accidents and if you are interested only in getting your facts in the right sequence. With more actors and activity or in activities with high loss potentials, the movie gets so complicated that the memory begins to mislay or forget data. Sequencing data tells you what happened, but you cannot reliably analyze a mental movie with the additional logic tools that have to be used. Additionally, other people cannot see the mental movie in your head, so they cannot help you much with its development. It is also difficult to verbally communicate what happened to other people so that they can draw conclusions solely from a movie in your head. This is why it is a good idea to record the actions as soon as you can, rather than try to memorize and test everything in your head. Serious investigators do not want to stop with sequencing what happened.

Cause-Effect Logic

Cause-effect logic is the reasoning process used to determine whether one event led to another event. You do this to establish relevance and relationships among events you identify. For example, when event "A" occurs during a process, it may cause "B" or more events. If so, you show this by drawing a "causal link" from "A" to "B" (Figure 3.5). If you think that there may be a causal relationship but need more data, add an arrow with a question mark on it.

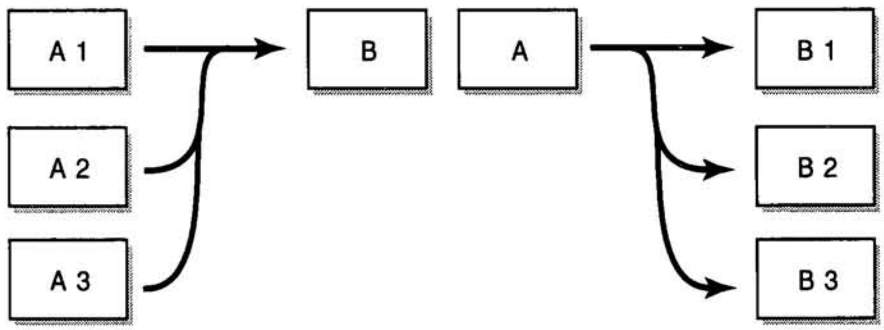
Figure 3.5



Necessary and Sufficient Logic

Necessary and sufficient logic is the reasoning process applied to pairs of events or event sets with identified cause-effect relationships to determine the validity and completeness of the description of the incident. For example, necessary and sufficient tests will disclose that "A1," "A2," and "A3" were all necessary for "B" to occur or that only "A" was necessary and sufficient for "B1," "B2," and "B3" to occur (Figure 3.6).

Figure 3.6



Deductive Logic

Deductive logic is the reasoning process applied to the observations during investigations to define events and to develop scenarios to fill gaps in your understanding of what happened. For example, you apply natural laws and scientific principles to infer the specific events that produced the observed damage to objects and to develop hypothesized events to fill gaps in your understanding of what happened.

To understand *why* an accident occurred, you must apply *cause-effect* and also *necessary* and *sufficient* logic tests. To apply those tests, you must use consistently formatted data organized in a way that allows you to perform these tests and record your results.

Analyzing Your Events

You probably noticed that when you position new events on your work sheet, you look at two events together before and after the sequential logic tests. This is called "event pairing." This "event pairing" is the basis for analyzing all your investigation information as fast as you acquire it. This is called a "progressive analytical process" because the analysis progresses as data become available, rather than waiting until you get all the data to draw and prove your conclusions.

Progressive analyses of investigation information are based on "event pairs" on time/actor matrix work sheets. By recording and organizing your observations this way, you are able to analyze your information each time you add a new event to your work sheets.

As you place new events on a work sheet, you also look for cause-effect relationships between events. For example, after placing "A2" on the work sheet in the position shown in Figure 3.4, you can ask yourself whether "A1" had to happen for "A2" to occur. If it did, then you can link "A1" to "A2" with a linking arrow to show that cause-effect relationship. Similarly, look at

"A2" and "B1," and ask the same question: If "A2" had to happen for "B1" to happen, link the events. By examining events in pairs (event pairs) on your work sheet, you can add links as your work sheet develops.

Finding Gaps in Events Flow

After a few links are added, you will begin to see events that you recognize as part of the accident process, but they are not linked to any earlier "causal" events yet. Another way you will see gaps is by visualizing the sequence of an actor's actions as shown by gaps in the events flow on that actor's work sheet row. The gaps between known events, or event pairs that you cannot link on a row, point you to what you do not know and to specific information you still must get. They steer your investigation efforts and can help you avoid wild-goose chases.

Mental movies can work similarly for investigators because a "blank" frame between two other frames points to a gap in what you know. This is a lot more efficient than approaches where you "get all the facts" and then analyze them and draw your conclusions.

Filling Gaps

When you see gaps during your investigation, you do either of the following:

- Get more observations about the actor for which data is missing to fill in the gaps.
- Identify the other actor(s) that probably did something during the gap, and get more observations about such actor(s) to show causal events or effect events.
- Apply deductive logic to develop potential scenarios describing what might reasonably have occurred during the gap. Then get more observations about such events to determine what happened or which scenario was more likely to have occurred if you discover several events pathways.

Any of these choices will focus your investigation efforts to increase your efficiency. Document and fit any events you develop into your data organization scheme.

DETERMINING COMPLETENESS OF YOUR DESCRIPTION

Each time that you decide to link a pair of events, a *cause-effect* relationship is established between the two events. To determine whether your description and explanation are complete, apply the necessary and sufficient logic test process on each linked event pair or event set (more than two linked events.) This is extremely difficult to do with mental movies and impossible if you are only looking for simple cause or unsafe acts or factors in an accident.

This logic testing procedure involves examining each linked event pair and asking yourself several questions. You know that the causing event in a linked pair was *necessary* to produce the effect event. Then ask whether the causing event was *sufficient* — will it *always* produce the effect event each time it occurs? If the answer is yes, this is all that you have to do. If the answer is no, which is much more common, then you have to analyze how the system works and determine what else people or objects have to do to make the effect event occur every time.

When you define all the sufficient events, you look for observations to confirm them. When you verify them, add them to your work sheet and complete the links. If you cannot verify that they happened, you may show what you think happened if you indicate your events are questioned or unconfirmed.

When all the linked events have been subjected to necessary and sufficient tests, a clear explanation of WHY the incident happened becomes readily visible on work sheets. Beginning with the last event, or outcome, you can trace backward the event(s) "caused" by each prior event. By the time you finish this part of the investigation process, you will recognize that the way to respond to questions such as "What caused the accident?" or "What was the root cause?" is by describing event pair relationships. ALL linked events had to occur to produce the process outcome.

If your understanding of what happened and why it happened are not complete, your work becomes vulnerable to justifiable criticism and attacks on your credibility. When you do not show the uncertainties and gaps remaining, you can bet someone with a vested interest in your results will find these gaps.

The way to show uncertainties is with a question mark (?) next to or within your entries. If you do not know what happened or are uncertain about who did something, what they did, what effect it had on other events, or what had to happen to make something else happen, say so before you deliver your work products. If you cannot establish the answers from available observations, show a question mark on your work sheet at any uncertain actors, actions, events, or links to indicate a place where the work sheet is incomplete or uncertainty remains. If you have to estimate times or any other dimension or relationship, show an "E" before the entry.

Handling Additional Workloads

Documenting observations on event work sheets enables you to manage your investigation costs and schedules by making judgments about the value of additional data-gathering efforts. If the workload required to fill in gaps or to get additional observations results in a cost or schedule budget overrun, ask for approval of the extra expenditures. Ask whoever authorized your budget for more time or money. With the work sheet displaying what you know and do not know, it is faster and easier to show the value of the additional data-gathering effort.

USING VISUALIZATION AIDS FOR DOCUMENTATION

You need to be knowledgeable about documenting graphic records of observations at the site. This documentation should capture the condition of the site to help the investigator recall details and help others visualize the scene when they try to create their mental movie of the accident from your work. It may take the form of photos, sketches, diagrams, drawings, maps, and similar graphics. See Appendix B, "Photography Support for Investigations," for specific guidance.

Your objective is to record what you see in a way that lets you effectively use it later. Humans have a tendency to focus narrowly on whatever catches their attention, and our eyes go where the mind goes.

Photos

Cameras record everything in a field of view, including the state of objects at the time of the pictures. Therefore, cover the entire scene with your camera, taking photos from the front, back, both sides, and above or below objects, if possible. Photograph the scene systematically starting at some point and going around the entire scene until you get back to the starting point.

Sketches

Generally, sketches are moderately detailed, artistic renditions of objects or relationships intended to highlight certain features considered relevant to the understanding of what happened. Label all objects with names used elsewhere in work products. Make sketch items large enough so that if the sketch is reduced to 8½ x 11 inches for your report, it will still be legible. Include in title blocks:

- A name and location of the incident site
- The topic or main subject of the sketch or diagram
- A legend showing what any symbols represent
- Relative or actual dimensions of objects or components
- A "north" indicator to orient the user, if relevant
- Distances between objects or a scale that can be used to measure them

- A case identifier, including incident date(s)
- The preparer's name
- Page numbers if more than one page is used
- The revision number and the date it was last revised

Diagrams

Diagrams are generally line drawings with symbols designed to demonstrate or explain something or to clarify relationships among the parts of a whole or to show patterns observed. For investigations, diagrams should contain the same information previously listed for sketches.

Drawings

Generally, drawings are considered to be in the nature of a blueprint or plan formally prepared by a designer or professional staff member and properly referenced and described. For example, buildings, equipment, highway, and process drawings — to name a few — are frequently referenced during investigations. Drawings can be used to help users visualize what happened, but drawings are usually too complex to serve that purpose as well as sketches do. Drawings are more exact than sketches. Sketches can be edited and highlighted to make specific points.

Maps

Maps with topographic features as well as facility locations are helpful when the scope of an accident covers a relatively large area. Maps are useful to depict where objects moved in large facilities, showing emergency response or evacuation routes and similar purposes. For example, maps can be created for incidents such as a haz mat spill with a dispersing gas cloud, environmental effects maps, or aircraft wreckage distribution after an inflight breakup. Directional orientation is needed for maps. On a smaller scale, maps with dimensions can be used to show residues and deposits, although sketches are usually as informative. (**NOTE:** Watch that you or your mapmaker, sketcher, or diagrammer do not get carried away with clever detail at the expense of basic data.)

OFF-SITE DATA GATHERING

Not all data is available at the site; therefore, you may have to seek data about what happened off-site. The purpose of off-site data collection is to get events to complete your description of what happened. Sometimes such data is available at the site, but other times they are elsewhere.

Off-Site Object Data

Examples of data that you may need to seek away from the site include:

- Design, production, and quality-control records that describe the beginning state of objects before incidents to ensure objects were as advertised.
- Aggregated performance and the service history including similar incidents that indicate problem was or should have been known. If previous incidents provided indicators, examine investigation work products to see why investigators missed them.
- Purchase offers, negotiations, or terms of sale such as price; performance or delivery schedules that affected the design; and materials, testing, or building of object involved and what they did.
- Hazards or risk analyses that were relied on to make design, material, or construction decisions that affected object.
- Compliance and enforcement history or performance monitoring records that indicate patterns or motivational influences on what happened.

People Data

You may need data about people, such as victims and participants, whose actions affected the incidents. Examples of off-site data you might require include:

- Knowledge data from prior employment, training, and claims history to identify similar actions and incidents and decision-making experiences that may have affected events in this case.
- Skill data from training course curricula and objectives, on-the-job training, or incidents to help determine diagnostic and intervention skill levels that may have affected actions in this case.
- Decision-making capabilities and influences from prior involvement in incidents, pay-plan incentives, basis of awards or citations or bonuses, or performance evaluation criteria that may have affected decisions made in this case.
- Physiological capabilities from prior medical history about any physical handicaps to assess physical capabilities that might have affected actions in this case.

Programmer Data

Programmer data gathering establishes the pre-incident design and operating assumptions, plans, documented and undocumented expectations, and communications that did or should have influenced what happened. You are looking for data to describe expected actions before an incident and to help define differences between what was expected and what happened so that you can address expectations if needed. Often these programmers are off-site and may include:

- Training course developers, training materials designers, and actual curricula, handouts, or instructors' guides
- Additional witnesses who can describe supervisors' and coworkers' manner of giving directions, silence after incidents, encouragement of risk taking, etc.
- Analysts who defined needs and prepared regulations, standards, codes, and distribution system
- Equipment designers, buyers, procedures writers, signs creators, and related operating histories or materials used to arrive at assumptions and decisions
- Managers who established working environmental policies, funding priorities, fund allocations, and performance incentives
- Customer demands or customer specifications that influenced actions
- Physicians, nurses, psychologists, or other medical advisors who influenced behavior
- Investigators of previous accidents who may have missed vital parts of an incident
- Magazines or other media that help influence attitudes toward tasks and risk taking

Library Data Acquisition

Another useful off-site data source is the "libraries" of information about codes, standards, practices, and regulations that influenced actions involved in incidents. Examples of data you might get from libraries include:

- Codes, regulations, and standards
- Operating procedures to compare what happened and to identify expectations
- System operating models, drawings, and performance analyses
- Data about materials such as physical properties, chemical behavior, toxicity, flammability, composition, etc.
- Prior accident and incident reports
- Research reports about objects, systems, or phenomena

COMPLETING THE INVESTIGATION

Your investigative actions and additional events added to your work sheet as a result of your logic testing will complete your work sheet as much as the surviving data allow. A completed work sheet should contain only relevant events — linked events or events with a tentative link and question marks.

After you have exhausted your logic testing and possible hypotheses to establish links, events with no links to the flowchart are irrelevant. Remove events without final or hypothesized causal links from your final description of what happened. If they do not lead to any other events, they played no direct role in the incident. The completed work sheet should display the elements indicated (see Appendix E, "Time/Actor Matrix Work Sheet Elements").

After you finish your description on your work sheets, check the quality of your description and explanation one last time (see Appendix G, "Quality Assurance for Incident Descriptions").

When you have made your last possible entry on your work sheet and removed irrelevant (unlinked) events, you have produced the best possible flowchart describing what happened and explaining why it happened.

DATA FROM OBJECTS

Investigators rely on data from people and objects to determine what happened and why it happened. Only people and objects can be data sources. A good rule to remember is:

Data from objects are more reliable than data from people.

In setting your data-gathering priorities, keep this rule in mind. Objects react in a predictable manner according to natural laws. Thus, you can draw inferences from your observations of objects with adequate confidence to serve your investigation needs.

People think about and may rationalize or otherwise change their recollection of what they did, so you have to ask them for their data and then verify it in a different way. Thus, you will usually want to get data from objects before you talk to any people. However, the one possible exception is to talk to emergency response personnel during your initial walk-around if they are still on site.

Objects as Data Sources

Objects capture data through energy exchanges. Things serve as witness plates during many occurrences and capture data during an incident. As energy impinges on an object, it changes in some way. If you strike a piece of wood with a hammer, the indentation left by the hammer is an example of a how the wood becomes a witness to the hammer blow. Objects are trustworthy witnesses. Things do not "talk" to investigators; therefore, investigators have to be able to "read" every bit of information the things "recorded." The investigator's reading knowledge and skills determine the data that they receive from objects. This is a task for which expert help is often needed. Learn what you can about the physics of changes to objects, but do not be embarrassed to acknowledge your need for help in actual cases until you build your own knowledge base.

Stressors and Stressees

Stressors are the actors for your things events. Changes of state result from stressing energies such as:

- Mechanical loads
- Thermal energy
- Electrical impulses
- Chemical reactions
- Microorganisms
- Radioactivity
- Ambient events
- People actions
- Combinations of stressors

To read data from things, you must know about "stressors" and "stressees." The hammer was the stressor — the energy source that introduced a change into the wood. The wood was the stressee or stressed object. When you see an object that shows indications of some change during an incident, you will want to find the stressor or "change maker" that produced the observed change.

Sometimes a stressee becomes the stressor. When the struck car bumper (stressee) reaches its distortion limits, it may begin to rebound and become the stressor acting on the striking car (then the stressee) because it is now putting rebounding energy into the striking vehicle.

What this means for you is that interactions between objects are likely to be observable by changes to both striking and struck objects in many cases. The challenge is to time the changes so that the initial stressor can be distinguished from the initial stressee. This is where you call on your sequential logical reasoning knowledge and skills.

Sometimes, you have to try get "things" data to verify or supplement data obtained from people. Track the actions of people or objects on other objects from tracks left on objects during the accident. The way to get data from objects is to:

- Track successive changes of state producing the outcome.
- Use the energy trace analysis technique to track energy flows into and out of the "object." (See Appendix C, "Energy Trace Analysis Tables." This appendix presents a comprehensive list of potential stressor energies.)

Data can be extracted by working backwards from observed ending states or in either direction from intermediate states by:

- Observing the present state of objects changed during the incident
- Comparing the observed present state with known pre-incident state(s)
- Tracking known or likely energy flows by stressors that induced changes from beginning to ending states
- Transforming observed state changes into inferred stressor actions or stressor events

The Six Ps

Sources of data about objects are the investigator's "Six Ps":

- Paper
- People
- Parts
- Positions
- Patterns
- Properties

Paper examples are tracings of recording instruments; standard procedures; operating logs; correspondence about systems design; startup or operations; maintenance records; work orders; purchase orders; training records; incident records; production records; regulatory directives such as recalls and maintenance directives; design applications or approvals; and engineering change orders, etc., used to track stressor actions or compare actual versus intended actions.

NOTE: If you are working with a system for which a safety analysis was performed before the incident, get a copy of that analysis to find out how an object or controls were expected to act.

People examples are what people saw objects do before or during the incident; how they operated objects; how they were trained or instructed to operate an object; how objects behaved in known circumstances; conditions they observed while an object was operating; any actions they took in response to what they saw an object doing; and how it turned out.

Parts examples are deformation indicating stressor(s), changes to identify sequence of stressor impingement; discoloration or changes indicating exposure to high or low temperatures; variants in chemical composition; changed physical attributes; etc. Used to define stressor actions that produced effects.

Positions examples are positions in which objects, such as switch knobs, glass inside or outside windows, structural members, access openings, vehicles relative to each other, or debris came to rest during or at the end of an incident to discover how positions changed from pre-incident positions. Used to define effects of stressor actions.

Patterns examples are patterns in metal or material fractures, wreckage distribution patterns, deposit patterns on objects, residues on objects, fragment distribution, chemical deposits, injuries to animals or damage to vegetation, charring patterns, thermal discoloration patterns, damages to interacting parts, computer memories, electrical discharge patterns, radiation effects, water stains, etc. Used to infer or define stressor behaviors, intensities, exposure durations, velocities, for example.

Properties examples are changes in materials of construction or inherent properties of objects such as metallurgical properties, chemical composition, radioactivity level, buoyancy, resistance, melting point, boiling point or other physical properties. Used to determine susceptibility to effects of stressors, for example.

Testing Objects to Get Data

The general approach to accessing events data is to get all the information you can from the object before you do anything to change it. The sequence is to:

Step 1. Look at things.

Step 2. Dismantle things.

Step 3. Operate things.

Step 4. Destroy things.

Keep in mind that the objective is to get events to add to the description or explanation of the incident.

Tests are sometimes used during steps 2-4 to read data from objects. As you acquire object events and place them on the work sheet, you may find that you are having trouble getting the data that you need. You may need help to understand the system better before you can read what something has to tell you. Know how to keep from doing damage:

- Get help! Work with someone who knows the system and how it is supposed to work before you try to do any testing.
- Prepare a written test plan describing who will do what to what, when, where, and how. Specify that deliverable as the event block for your work sheet. Settle on a test plan *before* you sample, change, dismantle, try to operate, or test anything!

> *One indispensable rule to remember is: No plan, no test!*

Then, stick to your plan. Experts from other fields and laboratory personnel use investigation tests to serve their needs, which *may* be different from yours. If you are in charge of the tests, make sure that tests help bridge gaps in your understanding rather than satisfying some other need.

PEOPLE DATA SOURCES

To understand people as data sources, it helps to recognize how people acquire and store data, what different categories of witnesses can tell you, and how their data can be changed before or while you access it.

How People Acquire Data

People record data from direct sensory observations — they see, hear, smell, taste, touch, and remember the sensory inputs. People's tendency to focus on what attracts their attention usually limits what they observe during an incident. People select data and arrive at some conclusion based on the data or decide on some action or course of action based on their conclusions and remember what they did.

People experience feelings or adopt perceptions or truths from an authoritative source, experience, or faith and remember their feelings. How they remember varies with the experience. Often, experiences are memorized in the form of mental movies. Other memories may be in the form of data learned by rote, like multiplication tables, which also may have a kind of repetitive cycle. Sometimes the trauma they experience blocks their memory.

Witness Categories

Witnesses can be categorized as participants, observers, victims, programmers, responders or physicians, and hangers-on. Each category affects the data a witness may supply.

- *Participants'* involvement may limit responses because of stress, personal feelings, and liability concerns.

- *Observers* may provide good overviews of actions, easy access.
- *Victims* may be biased by self-interest and may be thinking about exploiting damage.
- *Programmers* are informative but may be alert to self-interests.
- *Responders or physicians* can describe harm, harming actors, and actions.
- *Hangers-on* may not know anything but like to blab and get attention.

Tracking What People Do During Incidents

You must be able to track the actions of participants, victims, and responders during incidents to describe what happened. To understand why some events happened, you may also need to track the actions of "programmers" that set up the events.

A model to help you track what people did during incidents is provided in Appendix D, "General Human Decision Model for Investigators." This model and its application instructions can be used for any kind of incident where people did something to start or sustain the incident process. To apply the model, follow the guidance in Appendix D. This model will help you to discover and gain new insights into subtle "unknown unknowns" missed by many investigations.

Why People and Data Can Change

Recognize that the data people store in their minds may change because people may:

- Simply forget observations or conclusions
- Rationalize their observations to fit previous experiences
- Deny or dismiss observations or conclusions
- Listen to and accept what others tell them happened
- Distort data to hide or obscure their role

You can control some changes in witnesses by keeping witnesses from talking to others about the incident until you have talked to them or by scheduling an interview as quickly as possible after the incident occurs.

PLANNING INTERVIEWS

Planned interviews are more effective than spontaneous interviews. They are also more efficient. Appendix D, " General Human Decision Model for Investigators" helps you plan and conduct your interviews.

Your general interview objective is to hear the witness's entire "mental movie" of events during the occurrence and to place the relevant events on your work sheet or into your own mental movie. The plan does not need to be formal. An outline of points can help you remember to get needed data during interviews. Elements of an interview plan include the following:

- Gain and keep control of the interview.
- Gain and keep the witness's cooperation.
- Get all the events that the witness has.
- Satisfy any legal requirements.
- Leave the door open for follow-up questions.

Main Interview Planning Needs

- Identify events (from gaps in your mental movie or your work sheet) in general terms that you need to learn about.
- Plan the sequence of interviews and sequence of questions to get the data you need and the materials needed to support questions you ask (sensory memory, decision memory, and rationale).
- Decide how you will control the interview process if others are present (by negotiation, assertiveness, exclusion, or other means?).

Preparing for a Specific Interview

Before you start an interview make sure that you:

- Can conduct the interview in a private, neutral interview setting. Schedule interview for locations where the witness will be comfortable, and allow adequate time for the witness to talk to you.
- Clear your mind of your similar experiences, assumptions, preconceptions, expected answers, and what should have happened.
- Can state interview purpose so that you gain witness cooperation.
- Have established your interview procedures and are ready to enforce them, especially if others will be present at your interview!
- Have identified what the witness might be able to tell you and are ready to follow an orderly questioning sequence to ensure the witness's continued cooperation.
- Are ready to give the witness the opportunity to do most of the talking by the questions you ask.

- Are prepared to hear and document what the witness says and not what you are expecting to hear.
- Prepare equipment that you will need to conduct the interview and to process the interview data.

CONDUCTING INTERVIEWS

Conduct an open interview with explanation of what you are doing (trying to understand and describing what happened and why it happened) and why the witness should help you. Explain to the witness how he or she can help by describing what he or she did and what he or she saw other people and things doing during the entire incident. Give the witness some examples of how to describe what happened. Work out with the witness a way to capture accurately what the witness tells you. When using a tape recorder, get the witness's permission on tape. Written witness statements are usually very incomplete and require additional follow-up.

The witness should do 95 percent of the talking during an interview. The conduct of a witness interview is the most sensitive data gathering task for investigators. First, your attitude can make it more difficult. Successful interviewers recognize that the witness has the data they need and that the witness does not have to give it to them. This thought helps you adjust your attitude.

Interview strategy is to first ask "easy" questions to finish action scenario so that if the witness ends the interview, you have as much data as you can get. Then start to explore why events happened with questions about conclusions and opinions. Second, you need to follow your interview plan to achieve your interview objectives. Third, recognize that leading questions result in contaminated responses, which you do not need. Avoid questions that can be answered with a "yes" or "no." You must know how to ask "open-ended" questions that give the witness a chance to talk about what he or she has in mind. Some questions, such as the following, produce more data than others.

- "What happened?" and "Then what happened?"
- "I don't understand."
- "Could you clarify that?"
- "What did you see (or hear, feel, touch, etc.) next?"
- "What were you concerned about?"

Questions that suggest you do not believe the witness or that you think the witness did something dumb or wrong do not produce much data. Examples of such questions are:

- "Do you mean to tell me that..."
- "Why didn't you...?"

These are threatening questions. If it was an accident, assume that the witness is telling the truth, but verify it, logically or with other confirming data. Observe the witness's legal rights as soon as you think a crime may be involved.

When you want to get your mental movie restarted, use questions like "I can't picture what you said when you said..." or "Forgive me, but I couldn't follow what you said when you were saying....."

Don't hesitate to make event blocks with the witness during personal face-to-face interviews if a point in a incident is unclear to the witness and to you. Close the interview with a thank-you, and ask how you can make contact again if anything else is unclear. Leave your card or note so that the witness can contact you with more information. Remember, focus on finding stressor or change-maker actions.

Interview Don'ts

- Avoid using threatening terms like fault, cause, fail to, failure, wrong, poorly, inadequate, mistake, or similar words reflecting your judgment of what happened.
- Do not talk about human error without comparing pre-incident expectations with what actually happened (see Appendix D).
- Do not presume that procedures, regulations, specifications, standards, and design are correct.
- Do not let a prior incident scenario bias your questioning during this investigation — start with a blank piece of paper and use data you get from this case.
- Do not stop with something the operator did; find out who did what to program the operator to do it the way it was done.

Documenting the Interview

During or immediately after an interview, the interview data must be documented:

- Document actions, decisions, and conclusions, etc., as events.
- List names and then track actions of new actors mentioned by witness, if needed.
- After you have the witness's data, record the actions described to you in the event format, resolving differences in the names of all actors, citing the witness as source on each event.

- Ask the witness for name, address, phone number. If appropriate, because of investigation purpose, ask for the witness's employer, employment date, data of birth, license number, or social security number.
- Ask the witness to describe the incident setting, witness location, and when witness first became aware of something happening.

Interview Reality Check

To learn from your interviews and to keep improving your skills, it is a good idea after each interview to ask yourself whether you:

- Listened objectively without leading, influencing, interrupting, or threatening the witness in any way
- Captured the witness's data unobtrusively
- Watched witness for body language
- Mentally sequenced events as you listened
- Used investigation models successfully for guidance

"CREATING" EVENTS TO FILL GAPS

Often you will find that you have a gap in your understanding — but that you have acquired all the data that you can think of — and you do not know where to look next. At that point, you can hypothesize or "create" events *on paper* to see whether you can fill the gap with one or more possible scenarios.

Hypothesizing Events to Fill Gaps

"Creating" events during an objective investigation may sound like heresy, but it is not. If you use work sheets, they will discipline your guesses. Any hypothesized scenarios must be bounded by the events on each side of a gap and tested logically before they can be used. As you develop your hypotheses, you also try to define the events data you might get from objects before you touch, move, tear down, operate, or test objects. Test those events with necessary and sufficient logic against events already on your work sheet. By doing this on paper, you often find that you do not have to do actual (and costly) data searches, teardowns, or tests.

Using Logic Trees or Simulations

Another "creative" technique is to use deductive logic tree analysis techniques to develop disciplined and informed hypotheses about what happened. You should use events on both sides of gaps to limit top and bottom event selection and use the event block format for entries in the tree. See the references at the end of the appendices (Hendrick 1986), for an example of a method. When you identify potential scenario(s) to fill a gap, find data to support scenario(s) or prove it valid by demonstrating the scenario with a simulation or reenactment if it can be done safely.

Documenting Created Events

When you have data sources to support the events that fill the gap, you can add them to your incident description. If you find data to support only some of the events in your most likely hypothesized scenario, add those to your description and show the other likely events that probably occurred with a question mark to show that they are not verified.

REPORTS AND THEIR DISTRIBUTION

Complete any forms or reports according to the model and criteria you have been provided. Send them to your customers, as directed. You will need to do a final objective quality check of your description of what happened. To do this you will need objective quality criteria (see Appendix G, "Quality Assurance for Incident Descriptions.")

Preparing Deliverables

After you complete your last quality-assurance check, you are ready to produce the deliverables from your work sheet. What you deliver, of course, depends on your customers.

If you can, use a neat copy of the work sheet as a flowchart describing and explaining what happened. The work sheet can help you communicate your results more easily, show the problems and potential fixes, and save time and money. Support the work sheet with photos, sketches or diagrams, and drawings or maps to enable the users to visualize what happened.

If you are expected to fill in forms, use the work sheet to provide information and to write the narrative description of what happened in the space usually provided on forms. To write the narrative, simply state who did what when and what happened. Use the words "before," "after," or "at the same time" to describe relative timing. If recommendations are required, the problems identified on the work sheet and the options as well as the rationale for selecting the recommended actions can be described in the narrative.

If you have to prepare a narrative report, the same guidance applies. Narrative reports do not have to be works of art and should be judged on their technical merit rather than their literary merit or political correctness. They should be judged by how well you enable the reader to visualize what happened and understand why it happened. The reader should also be able to visualize the predicted effects of proposed recommendations.

Disseminating Information During Investigations

For accidents currently being investigated, refer requests for information from anyone not directly involved with the investigation to an authorized spokesperson (know who this person is). If you are designated as the spokesperson, answer questions from anyone not participating in the investigation with factual information about what is known to have happened (verified events). Do NOT give out any conclusions or opinions about the accident until your investigation has been concluded and the report approved. NEVER discuss cause, fault, or blame before your final report is released.

During the preparation of recommendations, you may need to contact someone directly involved with the accident and its investigation or someone with a direct interest in possible changes. You will have to show them what happened to get their views and exchange reasoning about possible recommendations and trade-offs. Do NOT get into a discussion of anyone's conclusions or opinions about cause, probable cause, fault, blame, or causal factors.

Completed Investigation Reports

Distribute completed reports as directed with a list of persons to whom the final approved report was distributed. Do not keep extra or personal copies. Include with the final report any data developed during the investigation. Do not keep any personal souvenirs of your investigations.

General guidance is to make it easy for your reader to follow the accident scenario you describe, the points you want to make, and your arguments to support any conclusions you report. To satisfy this rule, add illustrative material to reports you submit. For example, photographs help readers visualize settings for accidents. Sometimes, sketches of the setting, equipment, or facilities satisfy their needs, or maps can help orient your customers. When appending additional materials, remember to note the name and date of the occurrence on all materials. Examples of possible materials to append include the following:

- Time/actor event work sheet
- Overview photograph(s) or sketch of setting or details of accident with proper write-ups
- Lab test or analysis reports
- Copies of quoted rules, procedures, and charts, etc.
- Photos to illustrate points made in text
- Description of investigation if unusual

NOTE: Do not include medical records in your reports without proper authority.

Biases

Everyone has biases or preconceptions about what is or what ought to be. You can minimize the influences of your own biases by using the matrix work sheet building process to force consideration of the logic of your descriptions and explanations. If more than one investigator is working on a case, biases can be minimized the same way by using a method that forces all investigators to show the logic of their conclusions and judgment calls. Do not count on using only investigators who have no direct interest in the accident or the outcome of the investigation. Concentrate on producing an objective description of what happened with the matrix work sheet building approach.

CHAPTER 4
DEVELOPING PERFORMANCE IMPROVEMENT RECOMMENDATIONS

When investigators are charged with developing recommendations, they have to shift mental gears to "learn from the experience" and improve future performance. To do this, investigators need to know how to:

- Discover, define, and assess problems and needs.
- Identify, define, and assess options for improving future performance.
- Develop a plan to determine whether the changes implemented are producing the predicted results.

This section describes general knowledge needed to develop effective recommendations. When accepted and implemented, recommendations become the most valuable and lasting result of your investigation. Take great care to ensure that all recommendations:

- Are based on a description and explanation of the incident that support the action(s) you propose
- Identify relevant events, links, and event sets in the incident process and the significance of identified unknowns
- Consider cost, capabilities, timing, organization policy, other trade-offs, and sometimes public acceptance
- Will resolve the problems you have discovered for the life of the system
- Provide for real-time monitoring to verify predicted effectiveness

NOTE: To develop recommendations, you must understand what happened and why it happened. Then, you must develop new, different data to *predict the effects* of future actions you might propose.

To develop recommended actions, you must know how to:

- Define candidate problems in terms of *who* did *what* when and with what effects (causal links) and restate each problem as a need.
- Determine whether each problem needs to be fixed.
- Identify candidate control options to satisfy each need.
- Predict effects and "costs" of each candidate option.
- Consider trade-offs, including predicted effects, to rank order "best" candidate recommendations.
- Do quality-assurance checks of your preferred recommendations.

DEFINING CANDIDATE PROBLEMS

The first step in the recommendation development process is using the description and explanation of the incident to discover, define, and assess problems disclosed by the investigation.

Using Descriptions

The incident description based on the time/actor matrix work sheet identifies all relevant events that need to be examined in an orderly way to discover, define, and assess problems. Thus, it is the preferred description for investigators to use to develop recommendations because it facilitates innovative thinking regardless of the investigators' experiences.

Mental movies usually do not provide detailed explanations of what happened. Investigators typically experience much difficulty in finding and defining problems, and many problems demonstrated by the incident are overlooked or poorly defined. Simplistic determinations of cause, root cause, or causal factors — being subjective judgments — may or may not identify or accurately define problems or needs.

General Approach to Problem Definition Task

When you use work sheets, you can start looking for candidate problems in an ordered way by examining each linked event pair or set, one at a time, until you have studied all events that were necessary to produce the incident outcomes. Start anywhere, but cover every linked pair or set on your work sheet. For *each event pair, set or link,* ask yourself questions to determine whether the event or relationship should be considered a candidate problem. For example:

- "Was this event or relationship expected to happen at all, the way it did, where it did, when it did, why it did, and to whom it did?"
- "Can this event or relationship indicate a need for action, and if so, why?"

The answer to each question may suggest a problem event or relationship that leads to your problem definition in terms of its nature, timing, location, effects, and magnitude.

- *Nature*: should that relationship have occurred at all
- *Timing*: how fast, when it happens, or how long it lasts
- *Location*: where it starts or happens in relation to exposures at risk
- *Effects*: who or what it affects and how or when
- *Magnitude*: 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 eliminate or control it and to improve future performance. The wording of the statement of need establishes the objective for any action option to fix the problem.

Does the Problem Need Fixing?

After identifying all the candidate problems, the next step is to assess the significance of each. Is every candidate problem or deficiency worth fixing? There is not enough money in the world to fix every problem disclosed by investigations. The recommendation development process must distinguish those worth fixing from those you can accept.

A common screening technique is to apply a risk assessment matrix value for each problem and to separate risks that are unacceptable and must be changed from risks that are tolerable or acceptable. Usually this decision is heavily influenced by the extent of the likely harm if the problem is not remedied. See Appendix I, "Rank Ordering Methods," for examples of assessment techniques.

DOCUMENTING PROBLEMS

Documenting problems requires you to record your description of the problem. This description should identify *who* did *what*, etc., and why it is a problem. Next, describe the action needed in terms of what needs to get done. For example, a problem might be stated as "The gauge required the operator to spend 1.5 seconds to get a reading, during which time the system degraded beyond the operator's ability to restore equilibrium." The need is "a control that enables the operator to restore equilibrium within __ seconds."

On the work sheet, mark each event or link deemed a candidate problem with numbered diamonds or similar marking system. This notation system helps investigators to systematically identify events or links considered candidate problems.

Developing Recommended Actions

Any possible changes that would favorably alter the course of subsequent events indicate a candidate for a possible recommendation. The search for candidate actions uses event pairs or sets in much the same way as the search for problems. The difference is that the search is for changes that might be introduced to modify the process. Once options are identified, they must be evaluated to permit the selection of the "best" recommendations.

Selecting Best Control Strategy

Control strategies consist of changing people behaviors or object behaviors. Either can be complicated, but several general strategies can help investigators search for candidate actions that might lead to recommendations.

As you look at the event pairs or sets and the links between events, consider introducing changes to achieve:

- *Addition* of other events, links, or energy exchanges between events
- *Elimination* of events, links, or energy exchanges between events
- *Modification* of observed events, links, or energy exchanges

At this point in the search for options, do not rule out any possibilities based on past experiences. Experienced judgment usually recycles previous problems and imposes restrictive limits on the process. Note any changes you can conceive. You want to develop as many choices as possible.

Predicting Effects and "Costs" of Each Candidate Option

This task requires knowledge of how a system functions and how any of the changes would affect future operations if implemented. This is another example of the differences in the two stages of investigations.

To predict effects, consider not just the immediate event or link addressed but also whether it would affect:

- Only one event or link
- Only this specific kind of occurrence
- Several kinds of occurrences in this operation
- Several kinds of occurrences in this organization
- Several kinds of occurrences throughout industry

The greater the effects, the greater the trade-off weight a candidate action would deserve. To aid reviewers, sometimes it is helpful to set up a recommendation/effects matrix if you identify more than eight to ten candidates. These effects give you a way to state your improvement goal for your recommendation later.

Identifying Trade-offs to Rank Order Candidates

The previous tasks focused primarily on the possible performance improvement or control actions. The next task is to rank order the potential changes to reflect their relative desirability. After determining estimated performance improvement, you must assess other considerations that will help you choose the best recommendation(s) from your occurrence. Generally, these additional considerations include:

- Those who create, bear, and accept the risks of not acting
- Trade-offs with overlapping priorities such as schedule, quality, cost, motivation, public opinion, etc.
- Credibility of the problem and the proposed corrective actions
- Any external or internal pressures for change
- Perceptions of the need for and feasibility of implementing the preferred corrective actions
- The effectiveness of the corrective action as perceived by those at risk

You accomplish this task through an iterative review process, often with parties affected by the potential changes they will face. Be aware that performance improvement is not the sole basis for acting on your recommendations and that superiors in your hierarchy may veto your planned actions because they give different weights to the same considerations.

As you go through the various steps, you will recognize the differing trade-offs among the various options. The most 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 performance improvements or in production delays or may undermine the public's or operator's credibility.

Assuring Quality of Best Recommendations

You still have to make a judgment call and decide whether or not to make any recommendations at all from each incident. If you have identified action(s) that would really improve future performance and that seem necessary, feasible, and credible, check the quality of your recommendations and move them forward. The bottom line is this: Will your recommendation achieve your performance objectives? (See Appendix H, "Recommendation Quality-Assurance Criteria.") There are other influences, such as budget changes, that can adversely affect your investigation process and the results of your work. Prepare for them.

After doing paper analysis, which is relatively inexpensive, it may be preferable to acknowledge unknowns before spending more money on testing or simulations to verify logical hypotheses. Evaluate value of data against cost of getting it with a test or simulation.

CHAPTER 5
SUMMARY OF INVESTIGATION TASKS

The investigation process sounds complicated, but it is not. If you have a lot of events during a big incident because the accident or incident is complicated, your data organization and analysis task expands. However, the complexity of the work sheet is directly proportional to the complexity of the accident. The procedures are designed to let you process as much data as you find by expanding the number of actor rows or the time intervals.

You now know generally what you must do to determine what happened, why it happened with an investigation, and why you must do it. Generally, you know how to develop recommended actions to improve performance.

The investigation procedures are actually quite simple, fast, and efficient as you gain experience building your work sheets. Doing the logic checks as you add events to work sheets dramatically reduces the time spent on wasted motion. By documenting observed data this way on paper, you can reduce other costs too. Do not be intimidated by the process.

Armed with this knowledge, you are prepared to begin actual investigations using this process. Your skills and effectiveness will improve with experience.

This section describes common tasks investigators have to do for any investigation. They are listed and discussed in the approximate order in which they have to be performed.

VERIFY INVESTIGATION OBJECTIVES

- ☐ Assign an investigation case number for every investigation.
- ☐ Establish objectives for this investigation.

- ☐ Get deliverable specifications.
- ☐ Establish your authority and constraints.
- ☐ Set time you have to do it.
- ☐ Ask for the delivery schedule for your outputs before you start.
- ☐ Resolve any questions about your authority to spend money and the procedure to acquire goods or services within that budget before the first investigation is started.
- ☐ Determine amount of money to spend.
- ☐ Direct other people and clarify the chain of command.
- ☐ Resolve disputes.
- ☐ Clarify who resolves disagreements or disputes if they arise while you are investigating this case.

START DATA ORGANIZATION

- ☐ Use notification of occurrence.
- ☐ Form a mental movie of the occurrence.
- ☐ Set up framework for organizing data.
- ☐ Start a time/actor matrix work sheet.

ENSURE CONTROL OF THE SITE

- ☐ Identify site control capabilities and authorities.
- ☐ Secure the site.
- ☐ Set security boundaries.
- ☐ Establish access controls.
- ☐ Identify/control safety risks.
- ☐ Control site data risks.
- ☐ Control egress.

SET DATA ACQUISITION TASK PRIORITIES AT SITE

- ☐ Set up documentation materials.
- ☐ Start site data search.
- ☐ Do site walk-around.
- ☐ Document ending states at site.
- ☐ Identify people and objects involved.
- ☐ Identify people witnesses.
- ☐ Identify object witnesses.

ACQUIRE DATA TO TELL YOU WHAT THE ACTORS DID

- ☐ Ask first responders first.
- ☐ Identify people data sources.
- ☐ Identify objects as sources.
- ☐ Test events as they are documented.
- ☐ Fill gaps in work sheets.
- ☐ Get data from people.
- ☐ Identify witness categories.
- ☐ Establish realistic expectations of witnesses.
- ☐ Plan interview procedures.
- ☐ Conduct the interview.
- ☐ Get data from things.
- ☐ Pick your strategies.
- ☐ Start procedures for reading objects.
- ☐ Examine specific objects to get data for events.
- ☐ Make additional observations.
- ☐ Get off-site data
- ☐ Test events as they are documented.
- ☐ Cut out irrelevant information and words.

COMPLETE INVESTIGATION WORK PRODUCTS

- ☐ Develop performance improvement recommendations.
- ☐ Define candidate problems.
- ☐ Document problems.
- ☐ Develop recommended actions.
- ☐ Prepare description of what happened in the form of oral and written reports.
- ☐ Add illustrative material to the reports that you submit.
- ☐ Support source documentation for data used.
- ☐ Perform a quality-assurance check of your reports.

APPENDIX A
INCIDENT INVESTIGATION POLICY

The following sample investigation policy statements are offered as guidance for organizations engaged in investigations and requiring a policy statement and program. The first statement covers the investigation of incidents within an organization. The second statement applies to public investigation organizations.

Investigation Policy for Accidental Occurrences

ORGANIZATION'S NAME policy is to establish and maintain an efficient, effective investigation program to learn as much as reasonably feasible from accidental occurrences of all kinds. Managers will select accidents or incidents for investigation based on requirements of (*SPECIFY APPLICABLE LAW OR REGULATIONS*) and the degree of potential performance improvements the occurrence suggests. Trained investigators will investigate promptly selected accidents or incidents using the best available investigation technology.

The purpose of these investigations is to improve performance and to reduce future risk levels. The purpose is *not* to find fault, blame, or cause for punitive actions unless willful actions with an intent to do harm are identified (these are not considered accidents).

Every investigation is expected to provide a timely, consistent, objective, and valid *description* and *explanation* of the accidental process. Subjective opinions, unsupported conclusions, or arbitrary generalized statements are unacceptable in investigation work products. Individual investigators are expected to ensure that all work products satisfy objective quality-assurance criteria before they submit their final work products.

The descriptions will be analyzed to discover and define possible needs for action to improve future performance. The appropriate manager will define the needs and options for improvement, propose predictable and verifiable performance improvements, and recommend ways to monitor future activities to verify the predicted performance.

The descriptions and explanations of what happened will be used to assess the effectiveness of designs, decision making, operating procedures, controls, planned incident intervention and amelioratory actions, assumptions, predictive performance analyses, and any other relevant activities. They are also expected to satisfy demands imposed by internal or external reporting or regulatory requirements, statistical analyses, litigation, and public inquiries required by other policies.

If at any time during an investigation an investigator observes any indications that willful action with the intent to do harm may be involved in the occurrence, the investigator will immediately contact ***NAME OF PERSON*** for further direction.

Investigators will remain alert for indications of previously unrecognized risks *not related to the incident*. If any such risks are discovered during the investigation, the investigator will report them directly to the responsible manager in a separate work product.

New investigation knowledge gained from investigations will be distributed internally to any individual in a position to benefit from and act to improve performance or contribute to actions to improve performance. Distribution to anyone else will be on a need-to-know basis.

When investigators work with or under the direction of investigators from other organizations, under applicable statutes or contractual agreements, our personnel are expected to abide by this policy guidance, including quality-assurance procedures. Investigators will document objects removed from our premises by such other investigators and, to the extent possible, ensure that such property is not damaged or destroyed before all available data are extracted from that property.

The effectiveness of the investigations and their work products will be evaluated at least annually against this Policy and the program evaluation report made available to senior managers on request.

Implementation of this policy is the responsibility of ***NAME.*** All managers, employees, and contract personnel are responsible and accountable for providing necessary support to enable investigators to implement this investigation policy.

Approved by Date

__________ _____

Public Agency Investigation Policy

This establishes *ORGANIZATION'S NAME* policy for the investigation of accident occurrences involving other entities. It is our policy that appropriate accidental occurrences will be investigated as required by law, regulation, standard or contract, and to establish and maintain an efficient, effective investigation program to accomplish this.

Accidental occurrences or incidents will be selected for investigation based on requirements of (***SPECIFY APPLICABLE LAW, REGULATION, STANDARD, OR CODE, ETC.***) When an investigation is optional, the initial estimate of the degree of potential performance improvements that might result from such investigation also will be weighed carefully in the selection decision.

Trained investigators will promptly investigate selected accidents or incidents using the best available investigation technology. The main purpose of these investigations is to determine what happened and why it happened. Every investigation is expected to provide a timely, consistent, objective, and valid *description and explanation* of the accidental process.

All conclusions will be supported by a persuasive rationale and supporting data. Subjective opinions; unsupported conclusions; or arbitrary generalized statements, adjectives, and adverbs are unacceptable in investigation work products. Individual investigators are expected to ensure that all their work products will satisfy objective quality-assurance criteria before they submit their final work products.

If at any time during an investigation an investigator observes any indications that willful action with the intent to do harm may be involved in the occurrence, the investigator will immediately contact *NAME* for further direction.

New investigation knowledge gained from investigations will be distributed as required by law or regulation to any individual in a position to act on the information or improve future performance.

When investigators work with or under the direction of investigators from other organizations, under applicable statutes or contractual agreements, our personnel are expected to abide by this policy guidance, particularly with respect to quality-assurance procedures.

The effectiveness of the investigations and their work products will be evaluated at least annually against this Policy, and the program evaluation report will be made available to senior managers on request.

Implementation of this policy will be the responsibility of *NAME*. All managers, employees, and contract personnel are responsible and accountable for providing necessary support to enable investigators to implement this investigation policy.

Approved by Date

__________ _____

APPENDIX B
PHOTOGRAPHY SUPPORT FOR INVESTIGATIONS

Why Take Pictures During an Investigation?

People tend to focus on what attracts their attention in a scene. Photos record everything within camera sight. Photos provide visual documentation that will not change. Photos quickly show the "stage" on which the actions of the incident occurred.

Preplan

- Practice with the camera you will use so that you can use it properly. Or, arrange for local photographers who will know what is needed in advance.
- Give someone authority to hire and direct photographers.
- Make sure that everyone knows investigation policy — too many photos are always better than not enough photos.

Rules for Investigation Photography

Rule 1. Photos should provide an accurate record of the scene: You are not seeking an artistic or sensational prize-winning creation. The scene, especially in fires, should include not only the accident but also the bystanders.

Rule 2. Make sure that the photos are not reversed, cropped, or off-color. If more detail is needed, changing contrast can help. Use color referent if accuracy is important.

Rule 3. Ensure correct perspectives. Use appropriate focal length and lens angle. Grids may work on flat surfaces. Have horizontal lines to aid perspectives.

Rule 4. Use camera settings needed for the situation. To cope with lighting differences, take photos with different light sources and angles. Check shutter speed versus film speed. Use meters, extra lighting, etc.

Rule 5. Provide accurate size reference. Use people, coins, ruler, etc. Sometimes it is okay to show your hand in the picture.

Rule 6. Use color for maximum information content. Record data in colors. If exact color is important (as it is with fires), use color bar and charts to help developers and investigators.

Rule 7. Always identify each photo (OSHA has a nice form). Documentation should include: date and time, film type, lighting and exposure, location, subject/purpose of view, photographer's name, and witness (if litigation is involved).

Rule 8. Show enough of the scene to provide good orientation. Go from long shots to close-ups of detail. Cover from different angles. Aerial is invaluable for outside accidents, fires, and explosions. Aerial may be available as baseline for before and after information (check U.S. Geological service photo sources).

Rule 9. Do not skimp on film — film is relatively cheap. You may not have to print everything by the time you understand what happened. On the other hand, look at shots to see what you might be missing.

Rule 10. Do not overlook other options, such as multispectral, stereo, thermal, motion pictures, and videotapes, to capture data visually.

Summary

1. Think of visual records as documentation of incident witness plates.
2. Get as much as you can before it changes.
3. Better too much than too little.
4. Watch tricks and distortions with photography.

(Adapted from DOE MORT Training)

APPENDIX C
ENERGY TRACE ANALYSIS TABLES

Energy produces changes in objects. This appendix provides a list of energy types for investigators to use as they examine changes in objects during investigations.

Energy produces useful work and occasionally harm or loss. To do work, energy typically must be confined and directed by barriers to the point where the work is to be done. For example, such work takes various forms such as deformation, deposits, chemical reactions, motion, or heating. Work generally produces some change in the prior state of the target object on which the energy works. Investigators need to know that energy leaves tracks when it does unintended work in incidents. Those tracks may be in the barriers that were intended to control the energies or the tracks may be outside the barriers. When looking at changed objects, investigators can use these tables as a checklist to look for energy sources that might have produced the changes.

Table C.1 describes natural energy sources. Table C.2 describes energy flow change questions to ask. Table C.3 describes strategies for controlling hazards associated with energies to help with development of performance improvement recommendations. Table C.4 describes managed energy sources.

The symbols ○ = input energy and □ = output energy.

Table C.1
Natural Energy Sources

[ ]Terrestrial	[ ]Atmospheric
❍ Earthquake	❍ Wind velocity, density, direction
❍ Floods/drowning	❍ Rain (warm/cold/freezing)
❍ Landslide/avalanche	❍ Snow/hail/sleet
❍ Subsidence	❍ Lightning/electrostatic
❍ Compaction	❍ Particulates/dust/aerosols/powders
❍ Cave-ins	❍ Sunshine/solar
❍ Underground water flows	❍ Acid rain, vapor/gas clouds
❍ Glacial	❍ Air (warm/cold/freezing, inversion)
❍Volcanic	

Table C.2
ETBA Change Analysis Checklist

Energy Flow Changes	Changes in Barriers
1. Flow too much/too little/none at all	7. Barrier too strong/too weak
2. Flow too soon/too late/not at all	8. Barrier designed wrong
3. Flow too fast/too slowly	9. Barrier too soon/too late
4. Flow blocked/built up/released	10. Barrier degraded/failed completely
5. Wrong form/wrong type input or flow	11. Barrier impeded flow/enhanced flow
6. Cascading effects of release	12. Wrong barrier type selected

Table C.3
Haddon's Ten Strategies For The Control Of Energy Hazards

1. Prevent creation in first place.	6. Separate hazard from exposure by a barrier.
2. Reduce amount brought into being.	7. Modify basic attributes of hazard released.
3. Prevent release of what exists.	8. Make exposures more resistant to damage from hazard.
4. Modify rate/distribution of release.	9. Counter damage already done by hazard.
5. Separate hazard from exposure in time/space.	10. Rehabilitate object harmed.

Table C.4
Managed Energy Sources Checklist

(1) [ ] **Electrical**
- ○ ☐ AC or DC current flows
- ○ ☐ stored electrical energy/discharges
- ○ ☐ electromagnetic emissions/RF pulses
- ○ ☐ induced voltages/currents
- ○ ☐ control voltages/currents

(2) [ ] **Mass/Gravity/Height (MGH)**
- ○ ☐ trips and falls
- ○ ☐ falling/dropped objects
- ○ ☐ suspended objects

(3) [ ] **Rotational Kinetic**
- ○ ☐ rotating machinery/gears/wheels
- ○ ☐ moving fan/propeller blades

(4) [ ] **Pressure/Volume/Kinetic Displacement (P/V/KD)**
- ○ ☐ overpressure ruptures/explosions
- ○ ☐ vacuum
- ○ ☐ growth
- ○ ☐ liquid spill/flood/buoyancy
- ○ ☐ expanding fluids/fluid jets
- ○ ☐ uncoiling object
- ○ ☐ ventilating air movement
- ○ ☐ trenching/digging/earth moving

(5) [ ] **Linear Kinetic**
- ○ ☐ projectiles, missiles/aircraft in flight
- ○ ☐ rams, belts, moving parts
- ○ ☐ shears, presses
- ○ ☐ vehicle/equipment/movement
- ○ ☐ springs, stressed members

(6) [ ] **Noise/Vibration**
- ○ ☐ noise
- ○ ☐ vibration

(7) [ ] **Dust**
- ○ ☐ mineral
- ○ ☐ organic
- ○ ☐ metallic

(8) [ ] **Chemical (acute & chronic sources)**
- ○ ☐ anesthetic/asphyxiant
- ○ ☐ corrosive
- ○ ☐ dissolving/solvent/lubricating
- ○ ☐ decomposable/degradable
- ○ ☐ deposited materials/residues
- ○ ☐ detonable
- ○ ☐ oxidizing/combustible/pyrophoric
- ○ ☐ monomer/polymerizable
- ○ ☐ chemical toxin/embryotoxin
- ○ ☐ waste/mixture
- ○ ☐ water reactive

(9) [ ] **Thermal**
- ○ ☐ radiant/burning/molten
- ○ ☐ conductive
- ○ ☐ convective/turbulent
- ○ ☐ evaporative/expansive heating/cooling
- ○ ☐ thermal cycling
- ○ ☐ cryogenic

(10) [ ] **Etiologic Agents**
- ○ ☐ viral
- ○ ☐ bacterial
- ○ ☐ fungal
- ○ ☐ parasitic
- ○ ☐ biological toxins

(11) [ ] **Radiation**
- ○ ☐ ionizing
- ○ ☐ nonionizing/laser

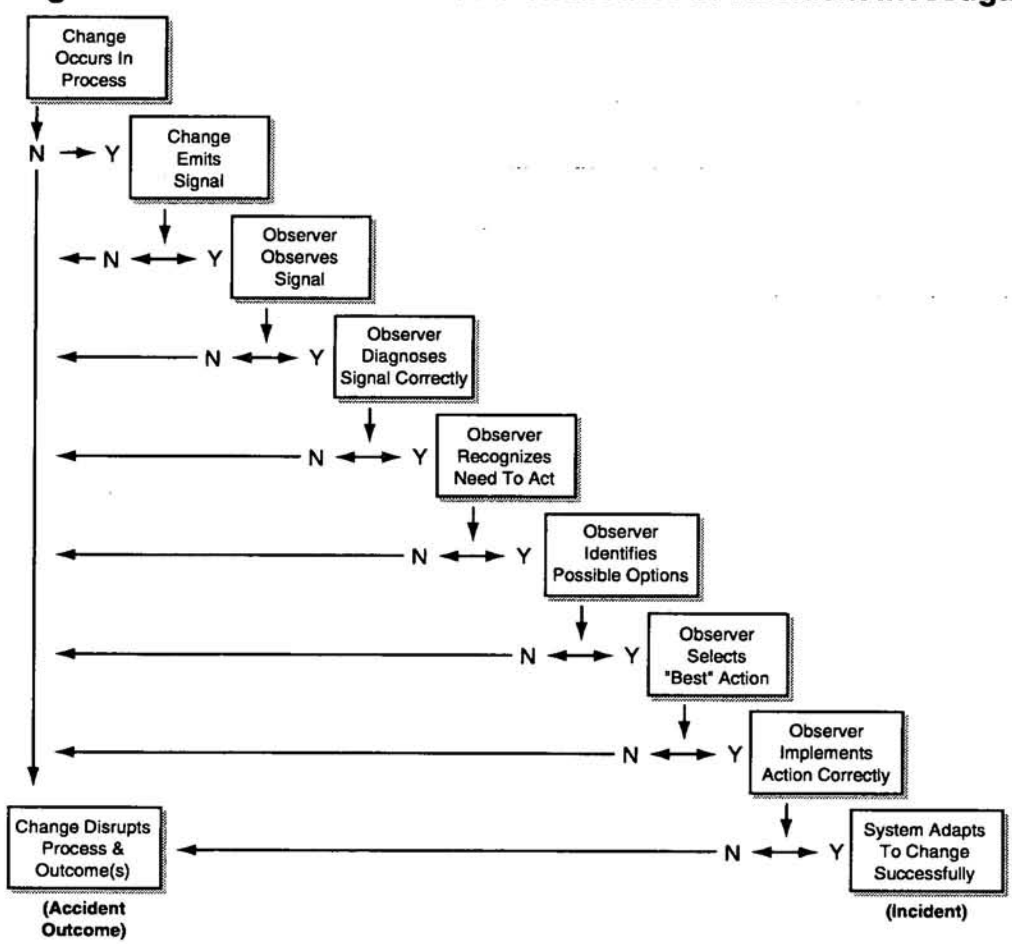
(12) ○ ☐ **Magnetic Fields**

(13) [ ] **Living Creatures or Things**
- ○ ☐ actions/interactions by people
- ○ ☐ actions by animals, other species
- ○ ☐ actions by trees, shrubs, etc.

(14) ○ ☐ **Moisture/Humidity**

APPENDIX D
GENERAL HUMAN DECISION MODEL FOR ACCIDENT INVESTIGATORS

Figure D.1 General Human Decision Model For Accident Investigators



Application of the General Human Decision Model for Investigators

This Model deals with interactions between people and objects during systems operations. It helps investigators discover many issues related to "human factors" in a way that defines specific problems, needs, and actions rather than ambiguous or abstract categories of "factors."

To apply this Model during investigations or interviews, identify people who appear to have had a role in the incident process. Then begin to look for a change in the activity that would have created a need for action by that person to keep the activity progressing toward its intended outcome.

- When you identify that change, determine whether it emitted some kind of signal that the person *could* have noticed. If it did not, you explore why it did not and what effect that had on the outcome.
- If it did emit a signal, explore whether the person saw, heard, felt, or otherwise "observed" the signal. If not, explore why and what effect that had on the outcome.
- If the person observed the signal, was the signal diagnosed correctly? Was the person able to predict the consequence of the change from the signal and his or her knowledge of the system and its operation? If not, explore why and its effects.
- If the predicted consequences of the change were correctly identified, did the person recognize a need to do something to counter those consequences? If not, explore why and its effects.
- If so, did the person identify the choices for action that were available for successful intervention? Was this a new situation where the action had to be invented? Was this something that prior training anticipated and provided the responses to implement? In other words, was the person confronted by an *adaptive* or *habituated* response? (Here, you start to get into the person's decision-making process and potential personal judgment issues; therefore, explore this area with empathy toward the witness, particularly for adaptive responses.)
- If any response actions were identified, did the person choose the "best" or effective response to implement? If a successful response was not chosen, explore why. To this point, you are asking for observations during an interview.
- If a successful response was chosen, did the person successfully implement the desired action? If not, explore why.

- If a suitable response was implemented, the system adapted to the change without an accidental loss or harm. If the response did not achieve a no-accident outcome, explore why. Often, this leads to discovery of invalid system design assumptions or other design problems.

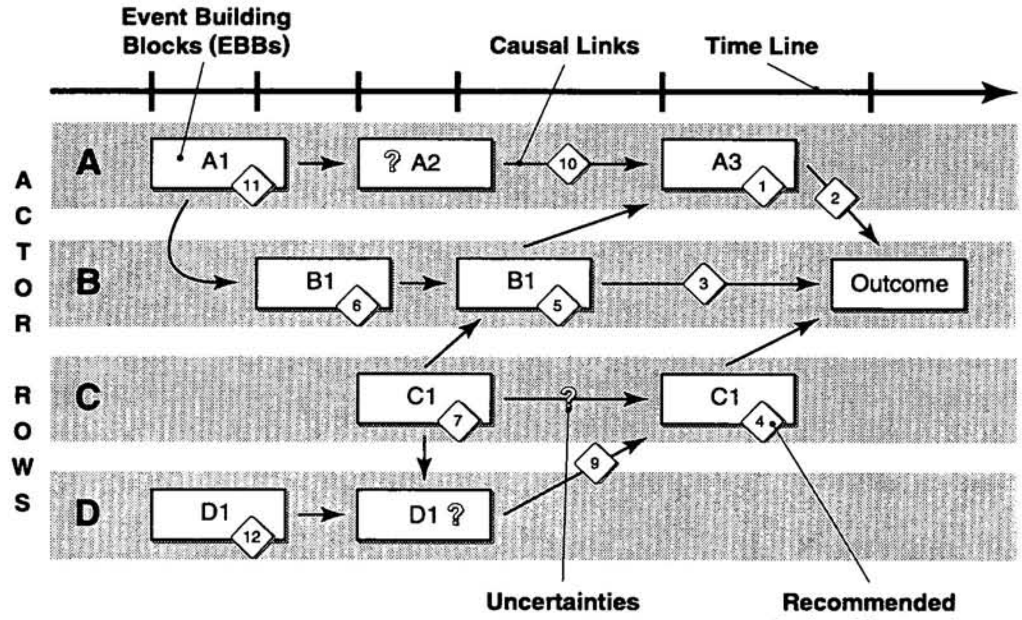
After working with this model, you will be in a much better position to describe and explain what happened when a so-called "human error" or "failure" is alleged. You will also be in a better position to identify concrete actions to improve future performance of that system.

APPENDIX E
TIME/ACTOR MATRIX WORK SHEET ELEMENTS

This appendix provides a simple example of the general elements found in a completed time/actor matrix work sheet after it has been completed by an investigator. It includes both the description and explanation elements and the problem and recommendation elements of the investigation task.

Time scales are flexible. The number of actor rows may be increased as needed. The links represent relationships that have been tested with sequential, cause-effect, and necessary and sufficient logic. Uncertainty or unknowns are shown by question marks.

Figure E.1 Time/Matrix Work Sheet Elements



Source: 10 MES Investigation Guides, Ludwig Benner & Associates, Oakton, VA

Note that all events are linked on the completed work sheet. Narrative reports can be written from the work sheet, using the sequenced events. The numbers in the diamonds represent candidate problems identified and addressed by the recommendation development process.

APPENDIX F
BASIC INVESTIGATION TEST PLAN ELEMENTS

During investigations, you may need to examine something to find out what happened. Examinations may address chemical residues from reactions on a wide range of objects, debris formed during reactions, damaged or impaired parts or components, subsystems such as a haz mat container, or process control systems or "safety" devices. To ensure that you get what you need from any testing work, you should insist on a test plan that describes what will be done and what that work is expected to produce. Elements of such a test plan are indicated in this appendix. Tailor them to develop any test plans you need.

CAUTION: Get all the data you can see from objects before you agree to their destruction by testing.

Test Plan Elements

1. Test/examination objectives
   Do you want to test something to verify that what you think happened actually did happen or to discover what did happen? Focus on gaps in the incident description that you want to address or the hypothesis for which validating data are sought. If more than one party is involved, objectives desired by each of the parties may have to be documented. *Your* deliverables should be events to add to your haz mat incident description and documentation of the source data used to define them.

2. Physical objects to be examined
   Describe the object(s) being tested or examined and document them with photos to ensure tests are performed on parts everyone expects to be examined. State any protective measures for the objects to preserve them for more tests or chain-of-custody needs.

3. General test approaches
   Use this section to record any general principles for the testers to follow, any assumptions that need to be documented before the test begins, and how the objects and tests will be documented. Identify and resolve in this section any differences in the approach. For example, should a device be operated before it is dismantled, or should a device be dismantled before it is operated? Should chemical samples be combined or tested separately? What is the progression from nondestructive examination to destructive testing?

4. Test/examination procedures to be followed
   State the name of the test protocol and equipment and the citation if it has been formalized in the literature or elsewhere. Define and document the measurements to be produced. Specify chain-of-custody requirements, precautions and responsibilities, points of contact, and any security tasks.

   This section should state the specifications for the deliverables produced and the quality control criteria used to verify the results.

5. Interpretation of results
   Hypothesize potential test outcomes, and state how each potential outcome will be stated in event block format. If this task is done properly, the specific outcome may be uncertain, but there should be no surprises at the end of the test. The place to discover differences between you and the persons performing the work is in a backSTEP or logic tree procedure on paper and not after the test has been run, the money spent, and the results unsatisfactory.

6. Schedule of testing
   State what work will be accomplished, when it will start and where, the schedule for any drafts to be circulated if applicable, and when deliverables will be delivered.

7. Distribution of deliverables
   State who "owns" rights to the deliverables and has authority to distribute them and who can use or allocate them and for what purposes in the future. Specify any confidentiality or security precautions in this section.

8. Disposition of tested objects
   State who will specify disposition of the tested object(s) and the time limit for disposition. Anticipated litigation may influence this section.

9. Funding of test work
   Specify who pays what to whom. Who will pay for the test(s)? If more than one party is asking for work to be done, who pays for what? Who will spend and who will get what monies? Be aware that this requirement can be used very effectively in negotiations to dissuade proponents of unsound hypotheses to pay for tests or forego them. It separates the "needed" from the "nice-to-know" work.

Optional Test Plan Elements

1. Media inquiries
   Haz mat releases — especially large ones or ones involving a lot of people — often generate media interest. Describe how to handle inquiries to the individuals and organizations actually performing the test(s) or others who might be contacted.

2. Safety precautions
   Where risk of injury or property damage is associated with the test procedures, state any required risk control precautions and responsibilities.

3. Concurrence
   When more than one party is involved, get every interested party — including the testers — to affix a signature to the test plan signifying concurrence in the plan.

Some Guiding Principles for Test Plan Development

1. Whoever owns the ball calls the game.
2. A golden rule of investigation testing: **NO PLAN — NO TESTS!**
3. Keep test(s) relevant (get event blocks).
4. Scale the plan to the value of the data it will produce.

Test Plan Quality Assurance

The quality control process begins with checking the quality of the event blocks created during the test. If they are flawed, further use will create problems.

Difficulty designing a test plan to produce the supporting data is usually an indicator that the event being sought may not be adequately defined or that the event may have to be broken down further into additional actors or actions to get supporting data. Sometimes you find that you are looking at the wrong object to test for the data.

Flow-chart the planned procedures on a time/actor work sheet, especially if any controversy occurs during the planning process or is expected during the test or after the results are received.

The concurrence process will disclose points of difference that may reflect quality problems, as well as differences in opinions, among investigators. Forcing funding decisions about who will pay often improves the efficiency and quality of the testing or may motivate alternative analyses plans.

Make sure that the testers are familiar with the work sheet and your event block needs for a work sheet before they begin planning, testing, or examination.

APPENDIX G
QUALITY ASSURANCE FOR INCIDENT DESCRIPTIONS

> *Your investigation will be remembered only by the report(s) you produce! The best investigation will be wasted by a poor report.*

To ensure a quality check of your description of what happened, do the following:

- Eliminate words that can "poison" your work.
- Ensure that all events used have referenced sources and that all referenced source documents are available.
- Ensure that the reader can make a mental movie to visualize your incident from the words in the narrative; append visual aids, and eliminate nonessential information.
- Check to see that your spelling, grammar, and syntax say what you intend.
- Make sure that opinions are in opinion sections and are not in descriptive sections of your report. Then make sure that ALL opinions you offer are supported with your rationale and basis for comparative conclusions. A good self-test is to ask yourself whether you could make your opinion stand up under cross-examination by the operator or public.
- Say that you do not know what happened at gaps, and explain why so that the reader will not discover gaps and lose confidence in the whole report.
- Include quotations if a deviation from some standard is noted. Do you use "their" words to show "their"

problems? Will your "evidence" survive attacks?

- Include the pictures, sketches, and test reports needed to help you make your points.
- Double-check that your accident description seems believable to informed readers. Is your report complete, correct, consistent, logical, and valid?

To do a quality check of your work sheet, use the following checklist.

- ☐ Is the event block form and its content okay?
- ☐ Are the event block names consistent?
- ☐ Are the sources noted okay?
- ☐ Are the sources in your file?
- ☐ Is the work sheet scope adequate?
- ☐ Are the causal links valid?
- ☐ Are the uncertainties indicated?
- ☐ Is the mental movie supported?
- ☐ Are the question and answer checks completed?

Sign your name to the work sheet if all checklist items are checked.

APPENDIX H
RECOMMENDATION QUALITY ASSURANCE CRITERIA

If development of recommendations is part of your investigation assignment, you still have to decide whether or not to make any recommendations for each specific incident. To review each proposed recommendation, use the following checklist:

- Does your work product show what specific improvement is expected to be achieved if the recommendation is implemented?
- Does the recommendation simply and concretely describe the action needed?
- Does the recommendation clearly identify who will have to complete the action?
- Does that person have adequate authority and resources available to implement the proposed action?
- Did you adequately address the event set frequency and severity in judging the performance effectiveness?
- 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, does your recommendation describe the required testing.
- Are appropriate implementation milestones included? If so, are they reasonable?
- If you had to implement the recommendation, would you be willing to do so? A good rule to follow: Do not ask anyone to do something you would not be willing to do yourself if you received the recommendation.

- If more than one recommendation results from your investigation, are priorities for implementation necessary or provided?
- Do you know how the people who have to implement your recommendations will respond to them?
- Have you determined how both you and the recipient will be able to tell when your recommendation has been carried out?
- Have you defined the follow-up process that is required to ensure implementation and to verify that the predicted performance was achieved?

Will your recommendation achieve predicted performance improvements?

APPENDIX I
RANK ORDERING METHODS

The rank ordering of candidate problems or performance improvement actions can be approached using a risk assessment coding (RAC) scheme in combination with a control rating coding (CRC) scheme.

Table I.1 Risk Assessment Code Table

Severity	Mishap Probability A	B	C	D
I	1	1	2	3
II	1	2	3	4
III	2	3	4	5
IV	3	4	5	5

Severity
Use the following to estimate the severity of a potential mishap attributable to a specific hazard without or with corrective action.

I = Catastrophic
II = Critical
III = Marginal
IV = Negligible

Probability
Use the following to estimate the mishap or illness probability over remaining life cycle of system, without or with corrective action.

A = Likely to occur frequently or within a short period of time
B = Probably will occur in time
C = May occur in time
D = Unlikely to occur

Problem Assessments

Estimate the relative risk of living with the candidate problem and doing nothing. Is the occurrence likely to happen again, and if it does, what is the potential severity of the incident?

These are estimates of the *relative* probabilities and severities compared to other problems that have occurred and relative to the other problems identified by this occurrence. The numbers in the matrix give you a rough problem ranking indication. Definitely fix anything that you think merits an RAC 1 or 2. Generally, the larger the RAC number is, the less the urgency and value of the fix. Problems with 5 RAC values are generally acceptable because you can live with the loss consequences if they do not occur often.

Table I.2 Control Rating Code Table

CRC Should not exceed RAC+1

Energy Control Strategy		Design Change I	Passive Control Device II	Active Control Device III	Warning Device IV	Procedure V
Eliminate energy source	A	1	1	2	3	3
Limit energy accumulated	B	1	1	2	3	3
Prevent energy release	C	1	2	2	3	3
Provide barriers to energy flows	D	2	2	3	4	4
Change release patterns	E	2	3	4	4	5
Treat/minimize harm	F	3	3	4	5	5

Recommendations

To assess candidate recommendations, use the RAC number of the problem (I-V) and the energy control strategy (A-F) to get to the Control Rating Code (CRC) number at the column and row intersection in the table. This will give you a comparative rank order for the candidate recommendations. If the CRC is greater than RAC + 1, you should consider the control unsatisfactory and eliminate it from further consideration.

APPENDIX J
GLOSSARY OF TERMS

Accident
A process by which a normal, stable activity is transformed to produce an undesired and usually unplanned outcome.

Change
A transition from one steady or dynamic state to another.

Conclusion
A decision or judgment reached after a logical reasoning process.

Deviation
An action that differs from what was planned, intended, or expected.

Event
The investigator's basic investigative and analytical building blocks. For investigation purposes, what someone or something did. Technically, one actor plus one action.

Event Pair
Two events being examined on a work sheet for their cause-effect, other relationships, or linked with cause-effect arrows.

Event Set
Three or more events being examined on a work sheet for their cause-effect, other relationships, or linked with cause-effect arrows.

Gap
The unknown events between two known events that have to be identified to complete a description of what happened during the occurrence.

Incident
An aborted accident. An incipient accident process that was prevented from producing significant loss by successful intervention actions by some person(s) or object(s).

Investigate
To observe and inquire into what happened and why it happened; to examine systematically.

Objective
The desired accomplishment for which a task is undertaken.

Observation
A noting and recording of an action, condition, or state by an observer.

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 interrelated steps based on a network of concepts, principles, and rules.

Witness Plate
Something on which is implanted a partial or complete record of events to which it was exposed.

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