Tripod Beta

User Guide

Index

1. Introduction

Each Company has its own particular way of conducting its business, i.e., its own 'organisational culture'. Within the organisational culture reside a number of processes or systems, e.g. Health Safety and Environment Management System, and Quality Management System.

One element in these systems will be a process for 'Incident Investigation, Analysis and Reporting' whose purpose is to identify why things went wrong so that they can be corrected and future losses and business interruptions prevented. The steps in this process start with an initial fact finding followed by detailed investigation, testing and analysing facts and assumptions, and formulating corrective actions to improve the management system and organisational culture that allowed the incident to occur.

In the Tripod Beta methodology the investigation process is iterative with the analysis process. From the preliminary investigation report, possible Tripod Beta models of the incident are produced which leads to further investigation and fact finding which in turn leads to a validation and refinement of the model. This continues until all relevant facts have been identified and the Tripod Beta tree accurately reflects the incident.

The result is a saving in time and effort, a deeper and more comprehensive analysis and a clearer understanding of the failures that must be addressed in order to make significant and lasting improvements in incident prevention.

The methodology is supported by software that provides the means to collect and assemble the facts from the investigation and to manipulate them on screen into a graphical representation of the incident and its causes. A draft incident report can be generated for final editing using a word processing package. (Instructions on the use of the software are contained in the 'Tripod-BETA Software.)

2. Background and application

The Tripod theory originated from research undertaken in the late 1980s and early 1990s into the contribution of human behavioural factors in accidents. The research, by the Universiteit Leiden and the Victoria University, Manchester, was commissioned by Shell International.

Tripod-Beta, which utilises this theory, is a system for conducting incident analysis during the investigation itself. This enables investigators and analysts to systematically and comprehensively:

- Direct and refine their fact finding
- Confirm the relevance of their fact gathering,
- Highlight avenues of investigation pointing to the identification of underlying causes.
- Identify and resolve any logical anomalies whilst the investigation is still active and
- Produce a definitive report

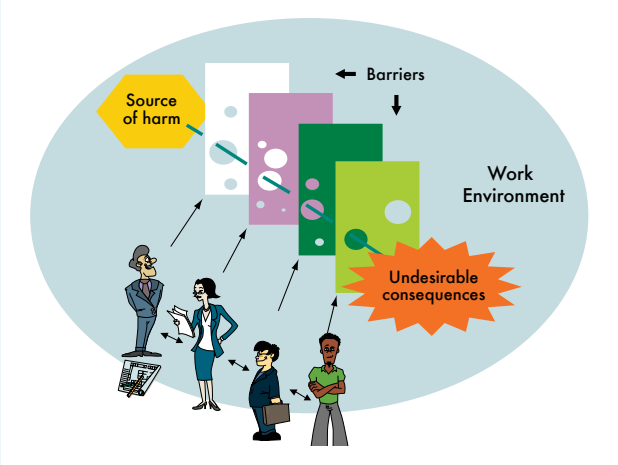
Tripod analysis can be applied to all types of business incidents, including, but not limited to, those relating to:

- Environmental impacts
- Financial losses
- Harm to peoples' safety and health
- Production losses
- Security lapses
- IT failures
- Damage to a company's reputation
- Quality short coming
- Project delays and losses

The Tripod theory and application is easy to understand. Its application in an incident analysis requires skills and experience in the application of Tripod Beta to arrive at optimal results. Training up to the level of accredited Tripod Beta facilitator is available. Management teams being presented with the results of an analysis benefit from a short presentation on the Tripod theory before being presented the results and committing to remedial actions.

3. Basic Incident Causation Theory

Incidents occur when inadequate or absent barriers fail to prevent the things that can cause harm to escalate to undesirable consequences. The barriers can be of different types e.g. related to design, systems, procedures, equipment etc. The barriers are put in place and kept in place by people with the competence to do so, in line with standards and specifications. Incidents happen when people make errors and fail to keep the barriers functional or in place e.g. people doing the wrong thing or people not doing what they should do.



The steps in an incident investigation are to identify:

- the chain of events from the cause of harm to the outcome; the undesirable consequences
- the barriers that should have stopped the chain of events
- the reason for failure of each of the barriers

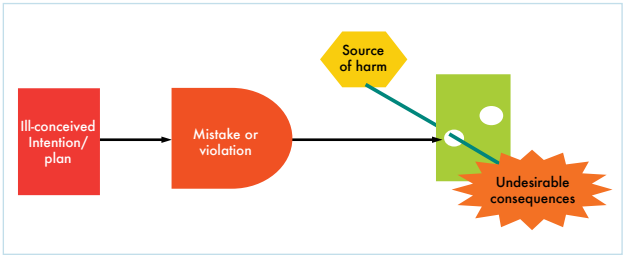
Most incident investigation techniques deal with the chain of events and the barriers that failed. Often this results in addressing symptoms and immediate causes of failure. Few techniques deal systematically with the analysis of the reasons for failure of the barrier and development of actions addressing the underlying causes.

4. Human Behaviour Theory

When trying to understand why a person has done something incorrectly, people often explain it as simply "human error", or as part of their personality. This is unhelpful and often wrong.

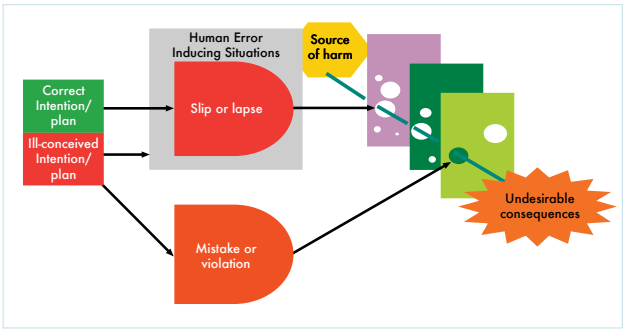
To learn from the consequences of the actions of other people, and to understand why they took such actions, it is necessary to look at the bigger picture, i.e. a "system perspective". There is a human behaviour model, which helps, to explain and why people act the way they do.

In incidents people have usually acted the way they intended, they just didn't get the consequences they expected. A person's mental plan was not clear or ill conceived, resulting in a mistake and/or a violation. A barrier was broken and an incident happened.



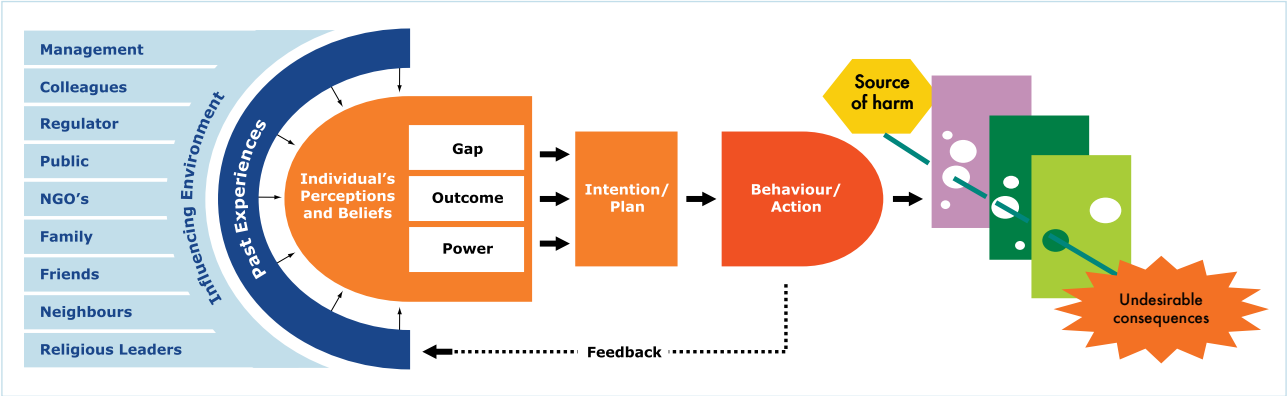
However, some actions that are based on the right plan also go wrong. These we call 'Slips' and **'Lapses'.** A slip is when people intend to do one action but perform another one instead. When people forget to do something, this is called a lapse. Slips, lapses and mistakes are usually categorised as human error

Everybody suffers from lapses and slips but often their likelihood is increased by situations that negatively affect human functioning. Examples are tiredness, lighting and noise levels, and sudden changes to routines, illogical design. We can reduce these slips and lapses by improving the circumstances e.g. by eliminating the "Human Error Inducing Situations". Usually these situations are the result of someone else's ill-conceived plan.



Despite efforts to control error-enforcing situations some errors will always occur. These can create disasters if the system is dependent on few barriers in which a slip or lapse causes the last remaining barrier to fail. Therefore it is essential to always make sure that there is an adequate number of effective barriers.

To reduce the likelihood of incidents the focus should be on ill conceived plans because they cause barriers to fail directly through mistakes and violations. Indirectly they create situations in which slips and lapses are more likely to happen, or result in systems in which a lapse or slip cause the last remaining barrier to fail. So, intentions and plans form the basis for our acts and behaviour - our human errors.



Understanding how people develop the intention or plan is therefore essential to understand and combat incidents.

Before people do anything, their brain creates a mental plan, i.e. an intention. Often it is not realised that is actually how the brain is working. Before an intention to act can be formed, the brain needs to ask three simple questions about, Gap, Outcome and Power.

The **Gap question:** Is there a gap between the current situation and how the person wants it to be?

The **Outcome Question:** Is there a reason to do something? "What's in it for me?" Will it be beneficial e.g. get reward or recognition? Will I be disciplined if I do not follow the rules? Is it more fun or pleasant etc.?

The **Power Question:** Does the person have the ability to make something happen? Is it within that person's power to start it and complete it?

Answers to these simple questions are always based on peoples' perceptions of the world and their beliefs about how the world works rather than facts. In hindsight best intentions can be wrong! In every incident people thought they were doing the right thing based on their beliefs and perceptions at the time. For them, their perceptions are their reality.

Let's look at the answers in a simple example of somebody spotting an unsafe act that could result in a person seriously injuring himself.

Let's quickly think about an incident that has already happened. A mechanic loses part of his foot when the winch he was repairing started to rotate.

Gap	The winch needed to be repaired quickly
Outcome	He expected to be commended for a quick repair of essential equipment
Power	He was a good mechanic and had worked like that before

Question	Answers
Gap?	Potential for an incident
Outcomes when intervening?	- A warm thank you for pointing out the hazard - Recognition by others for a good intervention - Satisfaction of having prevented injury - Frustration if intervention is not appreciated or effective
Outcomes when not intervening?	- Bad feelings when an incident happens that could have been prevented - Comments by others that you should have intervened
Power?	- I am sure that the potential for an incident is high - I have intervened before Or - I feel that I am not senior enough to intervene effectively - I do not have the competence to fully assess whether this is not safe

Because people are basically social animals, past experiences and contacts with other people have a major influence on the way they currently act. Family, friends and many others make up the **influencing environment**, which through our past experiences affects our beliefs and perceptions and hence how we act. It leads people to act the way they do, believing they are doing something that is acceptable.

Within a work environment, colleagues and supervisors have a strong influence. Peoples' experiences with them, and previous bosses, i.e., what they say and do, affects perceptions, which indirectly but significantly influences the way people act at work.

For an incident investigation the whole "system" in which a person is working needs to be understood. For example if someone breaks a rule, the reason why must be understood.

We know their past experiences led to their beliefs about what they should do, so the question should be asked "what was the role of others in the influencing environment?" This can take many forms, for example:

- What they thought others expected them to do?
- What others were doing or not doing at the same time?
- Previous experience of interventions, and
- The consequences of past actions and feedback from previous similar situations?

People can see themselves in this influencing environment either as management, a colleague, a supervisor, or direct report. This means everyone had a role to play in the overall "system" which led to the person acting the way they did. To prevent incidents it is necessary to look deeper to understand exactly why someone did what they did, and not just stop at blaming a person's attitude.

Tripod incident analysis is aimed at understanding these perceptions and beliefs and how the influencing environment and past experiences have created them.

Effective avoidance of all incidents, not only a repeat of the last one, starts by understanding the environment and taking action to change it.

5. Tripod Beta and Human Behaviour

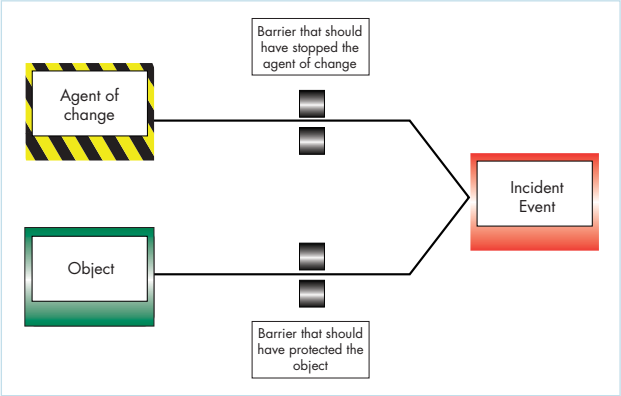
5.1 Tripod and Human Behaviour

The aim of Tripod Beta is to establish:

1. **What** was the sequence of events?
2. **How** did it happen, what barriers failed?
3. **Why** did the barriers fail?

Tripod Beta distinguishes itself from other incident investigation and analysis methods through the Human Behaviour model that is used to analyse the reasons for failure of a Barrier.

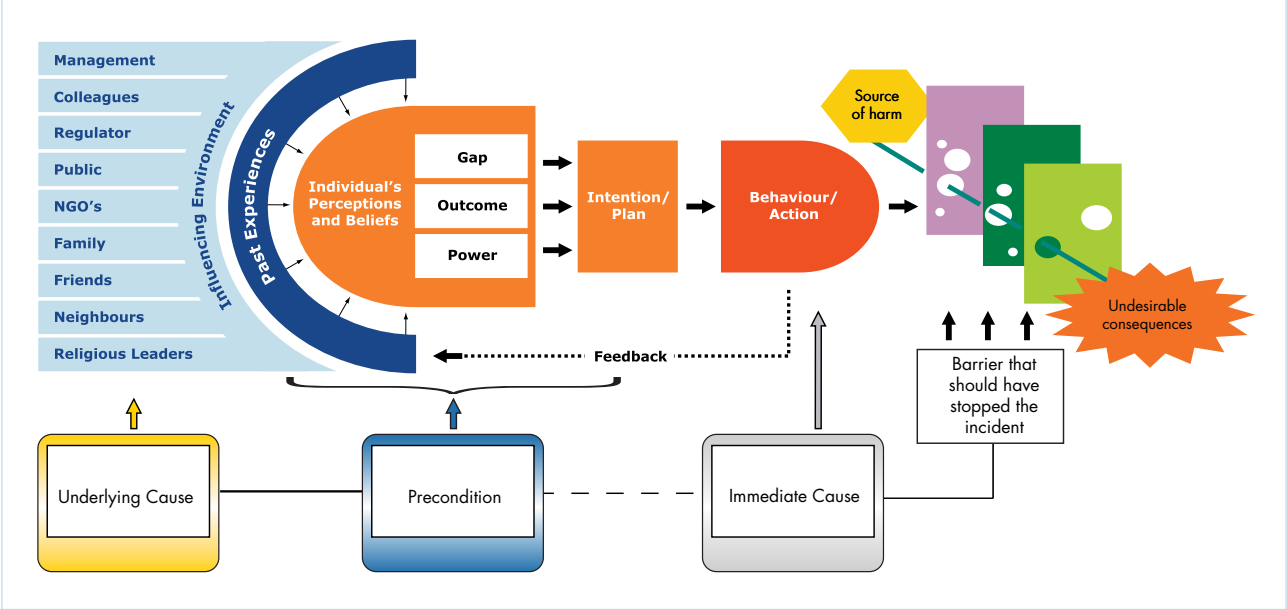
In Tripod Beta, an incident is shown as a series of trios, i.e. the *agent* of a *change*, the *object changed* and the resulting *incident event*. These discibe **what** happend. It also shows the Barriers that should have stopped the incident, i.e. **how** it happend.



The human behaviour model is used to more deeply understand *why* the barriers failed. A "Tripod causation path" is traced back in time from each failed or missing barrier to its Underlying Cause.

In the Tripod approach to analysing incidents, when a Barrier fails it is a result of a slip or lapse, or an intentional act by a person or group of people. Identifying these acts is only the first step. Next the context, or mindset, in which an action is taken, has to be identified and understood. This is referred to as a *Precondition*.

The *Preconditions* are the reasons someone believed there was a need to do something, why they thought there was a good reason for doing it the way they did, and why they believed they would be able to do it successfully.



Answering these questions leads to the start of considering the real *Underlying Causes* of the Preconditions, which are often common causes of many incidents. These Underlying Causes have often been in the "system" for a long time, lying unnoticed and hidden.

They are often the result of actions and decisions of managers and colleagues who make up the influencing environment.

For all incidents it is necessary to understand which parts of the influencing environment led to the Preconditions that influenced the person to act the way they did. If the incident was work related then it is under management control and means managers and colleagues had a role to play, therefore the underlying causes should link back to the actions and decisions taken as part of the business management system.

Using the human behaviour model with the Tripod incident analysis methodology helps to clearly identify both the Immediate and Underlying Causes. It also makes the conclusions more personal because managers and colleagues can see their role in creating the environment that led to the incident.

Everyone should try to understand the unintended consequences their actions have on the beliefs and perceptions of others. Once it is understood how people unintentionally influence others they can help create an influencing environment that promotes safe behaviour

The figure illustrates a Tripod causation path leading to a Failed Barrier. The Barriers are directly linked to Immediate Causes, (and their unsafe acts), Preconditions and Underlying Causes. Sub-standard acts describe **HOW** the Barriers failed and the Underlying Causes **WHY** the barriers failed. Each Failed Barrier will have its own causation path.

More detail on the three elements of the chain, the immediate cause, the precondition and the underlying cause are given below.

5.2 Immediate Causes (Sub-standard acts and Technical failures)

'Immediate Causes' are the failures close to the incident event that defeat the barriers. In the vast majority of cases these are the actions of a person, or group of people - categorised as sub-standard acts in Tripod terminology. By identifying the person, or group, that made the error, it is possible to analyse their beliefs and perceptions that created the error.

Sometimes, but rarely, it seems that Immediate Causes are not due to direct human error. Technical failures of barriers can also occur due to conditions such as over stress, corrosion or metal fatigue. However, human actions are often implicated as contributory causes, e.g. wrong material selected, overloading, lack of corrosion inhibitors, lack of maintenance etc. In such cases these actions should be taken as "Immediate Causes".

5.3 Preconditions

Preconditions are the environmental, situational or psychological 'system states' or 'states of mind' that promote Immediate Causes. In simple terms the precondition can be found by asking why the person or group of persons that caused the failure had the belief or perception that their act was more or less what was expected of them, commendable, unavoidable or just normal.

See also Annex 3 for further information on the relation between immediate causes and preconditions.

Examples of Preconditions

- Inattention (I didn't notice I did something wrong.)
- Unfamiliarity / over-familiarity (I have always done it this way and believed that was correct)
- Haste (I believed it had to be done quickly)
- Stress (I didn't realise that I was trying to do too much and could not cope)
- Misperception (I misread misheard or misinterpreted the information sent to me.)
- Lack of direction (Nobody told me how to do it so I did it the way I believed to be suitable)
- Competing demands (I thought that what I did had priority over what I didn't do.)
- Ignorance (I didn't know that what I did was wrong.)
- Complacency (I now everything about this and always do it correctly.)
- Poor motivation (Nobody cares whether it is done or not.)
- Personal crisis (I was preoccupied on a major problem at home.)

5.4 Underlying Causes

All identified failures should be corrected, but addressing the Immediate Causes may only have a localised effect. Underlying Causes have a more widespread influence on the integrity of an operation because they will defeat many barriers. Accordingly, measures to prevent Underlying Causes are likely to have the greatest beneficial impact in incident prevention.

Underlying Causes are deficiencies or anomalies that create the Preconditions that result in the Immediate Causes of incidents. Management decisions often involve resolution of conflicting objectives. Decisions taken using the best information available at the time may prove to be fallible with time. The potential adverse effects of decisions may not be fully appreciated or circumstances may change that alter their likelihood or magnitude.

The incident producing potential of these Underlying Causes may lay dormant, (i.e. latent or "hidden" failures), within an organisation for a long time and only become evident when identified by an analysis of an incident.

Examples of Underlying Causes

- Balanced in production/ maintenance budgets
- Downsizing without change control
- Inherently deficient procedures
- Inadequate competence standards/ training
- Uncontrolled modifications
- Inadequate preventive maintenance policy

5.5 Classification of Underlying Causes

Based upon incident investigation studies Tripod research has classified underlying causes into eleven Basic Risk Factors (BRFs), which provide a comprehensive risk management picture that is valid across a diversity of industry activities. Each BRF category represents a distinctive area of management activity where the solution of the problem probably lies. (See Annex 4 for a complete list and definitions.)

Some of these BRFs reach back over the development history of the organisation (e.g. incompatible goals and organisational failures); others assess the current quality of its specific functions (e.g. design, maintenance, procedures, etc.).

The BRF classification of underlying causes identified in any one incident has limited value in isolation, but the combination of data from a large enough number of incidents can provide an insight into the overall risk status of the operation. Therefore the classification of the underlying causes is optional in Tripod Beta.

It is also possible to classify the underlying causes in accordance with the elements of the management system involved with the incident.

6. Tripod Beta analysis

6.1 Overall Investigation and Analysis Process

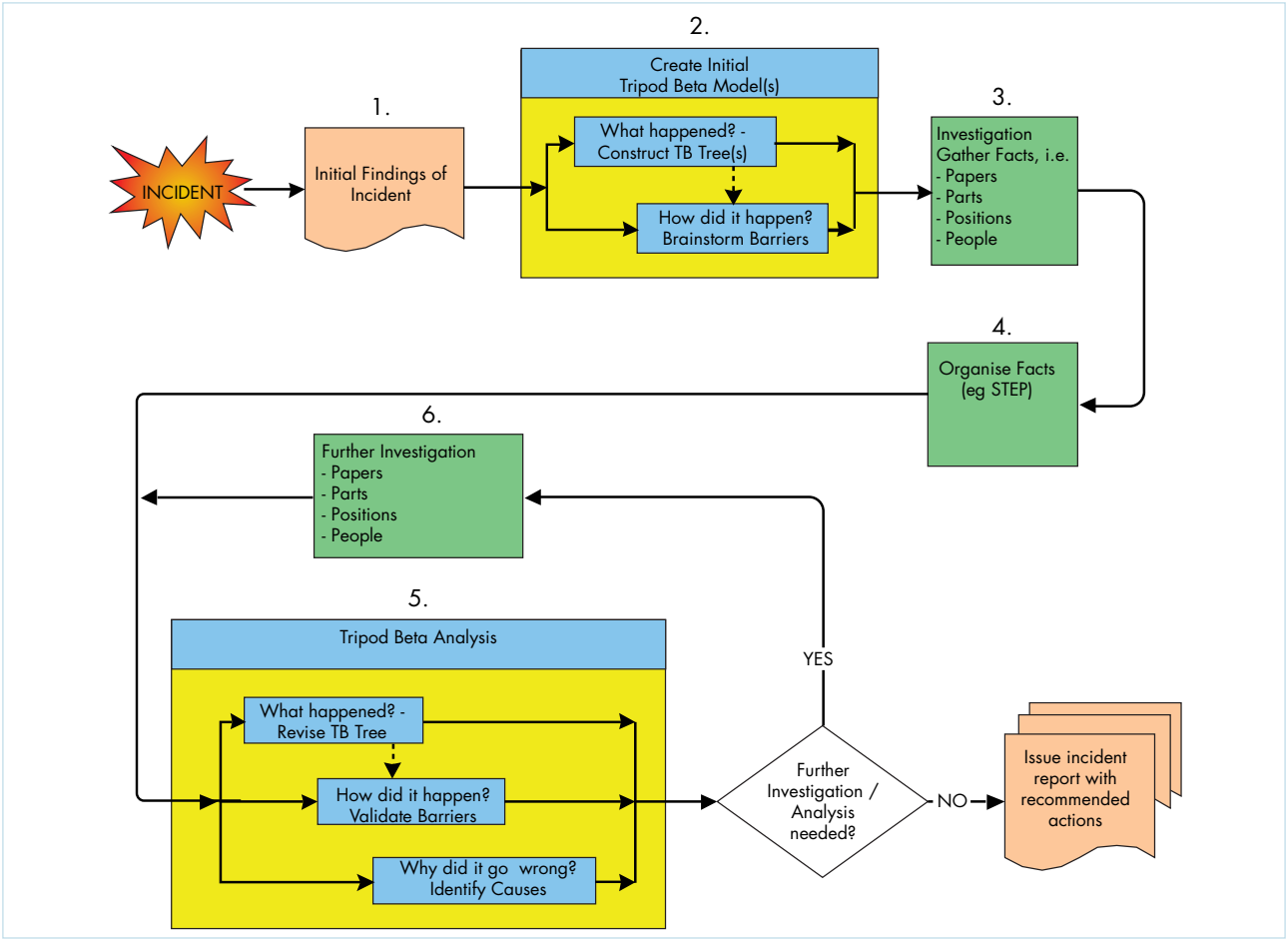
The objective of an incident investigation and analysis is to identify and correct the Immediate and underlying causes that created, or contributed to, an incident and so prevent its future recurrence.

The modern and systematic approach in achieving this is to first create conceptual possible models that describe the incident. This is based on information provided in an 'Initial Incident Report' and on how it is believed the incident occurred. Evidence is then collected and assessed to test, modify and eventually arrive at a true model of the incident.

This approach is used in a Tripod Beta analysis. The analysis is a concurrent activity with the investigation and uses information from the investigation to construct the model, i.e. the "Tripod Beta Tree". The classification and linkage of tree elements represent the cause-effect logic of the incident. Construction of the tree highlights investigation leads and information gaps that help the investigation team to cover the incident in sufficient depth and breadth to understand the full circumstance.

The overall process is illustrated in the road map in the figure and explained more fully below.

1. **Initial findings:** Concentrates on the incident site and its immediate surroundings, gathering the facts concerning the event and its consequences.
2. **Initial Tripod Beta model:** The core model of a Tripod Beta tree defines the incident mechanism in terms of Agents, Objects and Events.
3. **Fact gathering**: Further evidence is gathered through interviews, documentation reviews, research. Physical evidence relating to Papers, Parts and Positions are gathered first and the model reshaped before interviews are conducted with the People involved.
4. **Organising facts:** Facts can be organised to develop a timeline or Sequentially Timed Event Plot (STEP).



5. **Detailed analysis:** Completion of the Tripod tree. Failed or missing management measures (Barriers) are added to the core model in the second phase of Tripod Beta tree building Only then does the thorough investigative work commence to test this model. Further investigations, studies and research may be required to come to an understanding of underlying causes. The final phase of a Tripod Beta tree is to plot Tripod causal paths for each failed or missing Barrier, leading from Immediate Causes to Underlying Causes. Remedial actions are subsequently defined and reported.
6. **Review and reiteration:** A draft report is presented to management to enable a critical discussion followed by a decision on the adequacy of the analysis.

This sequence is the Tripod recommended approach. Step 2, the development of the initial Tripod Beta model, can help to focus from the beginning on the relevant issues. For organisational reasons e.g. the unavailability of a Tripod facilitator during the first days, this approach cannot always be followed in which case steps 3 and 4 can be done without the initial Tripod tree. Tripod Beta model development is then initiated and completed in step 5.

The traditional approach for performing an incident investigation, as available from many sources, is documented in Annex 9. It covers steps 1,3 and 4 of the road map and information on preparing and initiating an investigation, securing evidence, performing interviews etc.

The development of the Tripod Beta three is outlined in sections 6.2, 6.3 and 6.4. Development of remedial actions and review by management are discussed in section 6.6 and 6.7 respectively.

6.2 What happened (Building Tripod Beta "Core" diagram)

6.2.1 Initial Investigation

Most organisations that have a robust incident investigation and analysis process also have at least two levels of reporting, i.e.

- Level 1 - Initial Findings of Incident - normally produced locally
- Level 2 - Detailed Investigation and Analysis - conducted by experts

The team of experts formed to conduct the detailed, (Level 2), investigation and analysis, review this local report and from it construct a Tripod Beta "Core" diagram.

6.2.2 Core Diagram Basics

The first task in the analysis is to construct the initial core diagram (s), i.e., the series of trios representing the incident. This is based on the initial information already known about the incident and before gathering evidence or interviewing people by the Tripod Beta team. It is possible at this stage that, as all the facts are not known, more that one model, or scenario, of the incident will be produced.

The core diagram is created by a brainstorming, desk top exercise that utilises the experience of the Tripod Beta Incident Analysis team, (hence the importance of forming the right team). Active involvement of the investigation team in the preparation of this initial core diagram and agreement on the representation of the incident mechanism will provide the team with a common focus for the conduct of the investigation. Any identified missing or unclear information is noted to be pursued as part of the subsequent investigation.

6.2.3 Main Elements of the Core Diagram

The core of a Tripod analysis resulting from an investigation is a 'tree' representation of the incident mechanism, describing the main incident event and other significant events that occurred before or afterwards. The diagram comprises a number of linked 'trios', each containing three elements or 'nodes': an Agent of Change, an Event, and an Object. Other names can be given to these three elements, e.g.:

- Hazard, Event, Target
- Trigger, Event, Object
- Threat, Event, Object

Event

In incident investigation terms an event is a happening, a 'change of state', whereby an object is adversely affected (or threatened) by an Agent of Change. In the Tripod Beta model all events have 'potential' injury, damage or loss 'penalties' and some have 'actual' penalties. Examples of main events include:

- Crash of an IT System
- Missed project milestone
- Shut down of a production line

- Breach of security
- Failure of a piece of machinery
- Failure to win a contract

Specifically, typical main events in Oil and Gas industry are associated with loss of control or containment or unexpected contact e.g.:

- hydrocarbon gas release
- oil spill
- contact with hot pipe
- contact with electric current
- explosion
- fall
- collision

Agent of Change

An Agent of Change is an entity with the potential to change, harm or damage an object upon which it is acting. It can be an energy source, material condition, change of plan etc. that causes or has the potential to cause injury, damage or loss. Agents of Change that are an obvious energy source are relatively easy to identify, e.g.:

- Energy sources such as, extreme heat / cold, electricity, materials under pressure, items at height, energy of movement (kinetic), toxic, corrosive and carcinogenic chemical materials, radiation, explosives, flammable and explosive materials, liquids and gases
- Biological agents (e.g. animals and insects or micro-organisms)
- Conditions that are life threatening e.g. such as lack of oxygen, smoke, fumes, water (as a drowning medium)
- Ergonomic conditions (such as noise, light, work station layout, etc.) that could lead to stress or physical strain injury
- Natural phenomena such as wind, rain, waves, earthquakes etc.

Agents of Change that are not sources of energy but are still a driving force of change and may require a more imagination to identify include:

- Computer viruses
- Workplace stress
- Late delivery of project material
- Delayed payment of an invoice
- Batch of faulty material from which components were made

Object

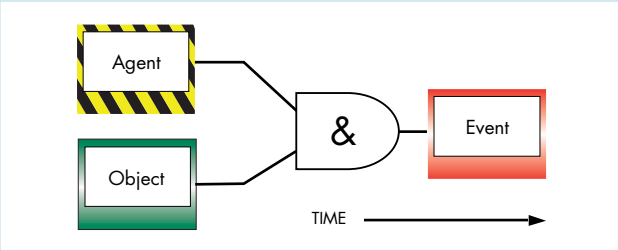
The Object is the item changed, or potentially changed by an "Agent of Change". Examples of Objects are:

IT System	Malfunction or system non operational
Project Plan	Missed milestone with cost and time overrun implications
People	Injury or damage to health (employees or third parties)
Financial Target	Cash flow, Profit, Revenue
Product Quality	Failure of product in market
Assets	Damage to plant or equipment - loss of material - disruption or shutdown of operation - damage to third party assets.
Environment	Damage or contamination - severe nuisance.
Reputation	Adverse media attention - public concern, protest - prosecution - business restriction - reactive legislation, loss of clients.
Production Schedule	Non achievement of production targets
System integrity	Breakdown of business processes.

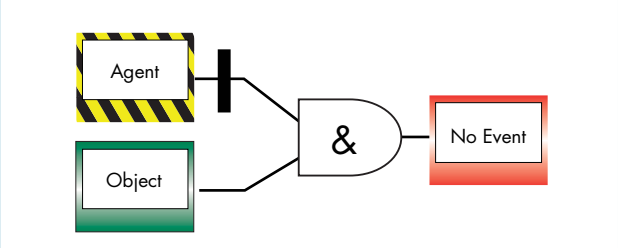
6.2.4 Building the Core Diagram

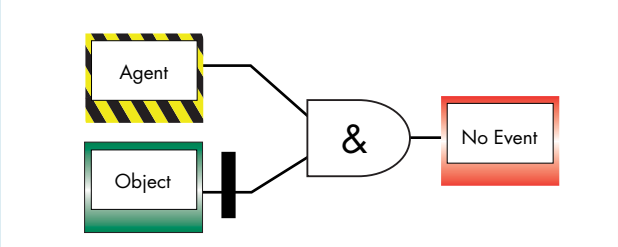
Main Event

The 'Main' Event, the 'Prior' and 'Subsequent' Events, along with their associated Agents and Objects, are then identified.



A typical core diagram is built starting with the main incident event i.e. the one that caught the initial attention by the harm that was immediately caused. The Agent and Object are placed to the left of the event, and joined by lines or trajectories.



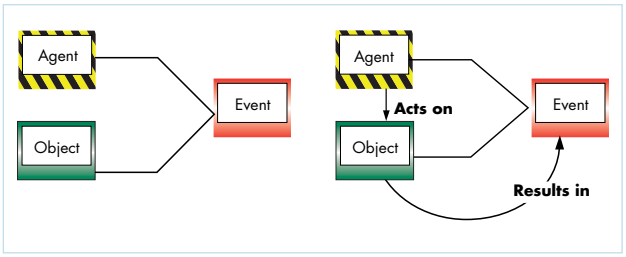


In logic terms, the trio can be explained as an AND gate where both the Agent and Object have to be present for the actual Event to occur. If a barrier exists in either one of the two pathways, then the Agent and Object do not come into contact and the Event does not happen. (This is illustrated in the **logic diagrams** shown)

The below "logic" diagram of the trio is simplified in Tripod Beta and is illustrated below. The wording used when describing the trio is that, "The Agent of Change acts on the Object to change its state or condition to that described as the Event".

Prior Events

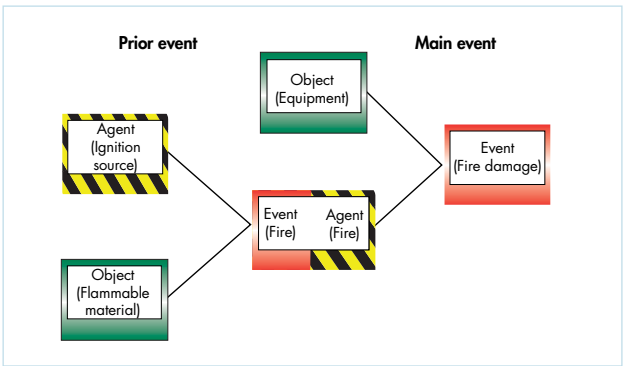
When the Agent or the Object was the outcome of a prior event, another Agent and Object combination needs to be included in the scope of the investigation. For example, if the main event was fire damage to equipment, the event causing the Agent (fire) needs to be accounted for. The core diagram



would show two Agent - Object - Event constructions If the presence of the flammable material was itself caused by another event (e.g. a pipe leak), a further Agent/ Object combination would need to be identified.

Designating the flammable material as an Object is worth a mention. The normal convention is always to regard, say, hydrocarbon gas as an Agent. However, in the context of this model it is necessary to consider the 'fire' event. The fire was the result of a chemical reaction when heat (the ignition source) was applied to the flammable material. The flammable material suffered a change of state (combustion), therefore in this specific context it was an 'Object'.

It should also be noted that 'fire' features as both an Event and an Agent. In the Tripod-Beta model this is represented by a combined 'Event-Agent' node. Similarly, an event creating an Object is represented as an 'Event-Object'.



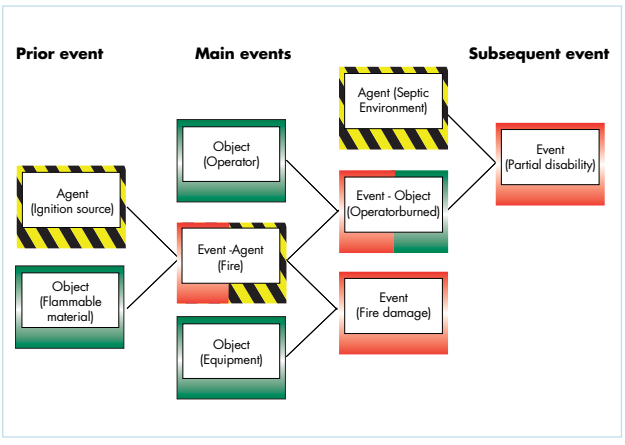
As the core diagram is being constructed all Agent and Object 'end nodes' should be examined for possible prior events. When no prior events are evident, the Agent or Object end node represents a logical limit to the investigation scope.

Subsequent Events

The main Event may not be the final event in an incident. Subsequent Events may be added in a similar manner to prior Events, to account for escalation or Events during recovery. Different Objects can be shown separately.

The figure illustrates damage and injury resulting from a fire incident. Note that the burn victim becomes an 'object' for the septic environment in which the burns exist. This may seem a novel concept, but, particularly in field operations, a septic environment can exacerbate the injury if they are not treated promptly and effectively. Recovery measures for injured persons may involve rescue, stabilisation at the incident scene and transportation to an appropriate medical centre, all of which involve additional risk. Events such as rescue and recovery operations immediately after injury or harm has occurred should always be considered as a potential investigation lead. The last Event could be a 'potential' Event, (i.e., where no harm actually occurred), if an associated Barrier had not failed.

Construction of the core diagram is critical in an incident investigation. The diagram sets out the scope of the investigation, the Agent, Object and Event 'end nodes' indicating points where no further investigation is considered necessary. The different trajectories indicate where effective risk management barriers would have prevented events or consequences. Usually 2 to 5 Agent-Object-Event trios are enough to describe most incidents. Opportunities for the next step, the identification of barriers



are usually missed if the initial core diagram is simplified too early in the investigation.

6.3 How did it happen? (Identifying the Barriers)

A business must manage its risks to protect it from potential harm. An incident means there have been failures in risk management measures, (i.e. barriers), and an investigation needs to identify these barriers so that their reasons for failure can be addressed.

To complete the model of **HOW** the incident happened, Barriers have to be identified which, had they been in place, should have prevented the subsequent Events from occurring. These can be Barriers that were in place, but failed, and those that should have been in place, but were missing. Initially barriers can be defined as Failed Barriers but after the investigation when more information is known, these could be reclassified as Missing or Inadequate Barriers

Identification of Barriers requires knowledge of the process and the facility where the incident occurred. An organisation that has properly identified its risks should have Barriers documented and in place. Many of these Barriers can usually be found in the management system for the activity under review. This requires a thorough examination of the operation, including design aspects where appropriate

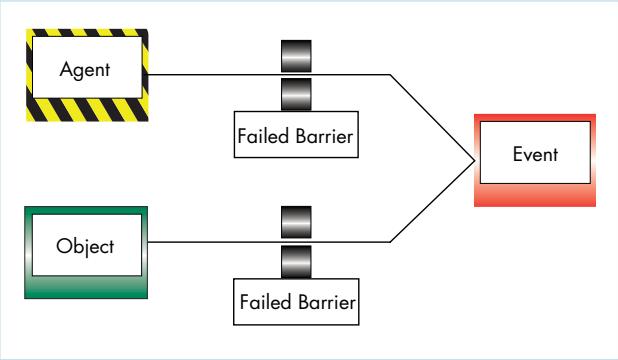
In an investigation it may help to draft 'specification questions' relevant to the incident:

- What Barriers should have prevented the exposure of the Agent of Change?
- What Barriers should have protected the Object from the Agent of Change?

Barriers should be seen in the context of the incident being investigated. For example, in an incident where crude oil has been spilled causing pollution, the Barriers for secondary containment of the spillage will be relevant whereas those Barriers for fire fighting, in context of the incident, will not.

Risk management barriers relevant to a specific incident are located on one, or both, of the trajectories in the core diagram. For convenience, Barriers guarding or containing the Agent of Change are shown on the Agent-Event trajectory and those protecting the Object show on the Object-Event trajectory.

The figure shows how these Barriers are added to the 'core diagram'.



The next figure illustrates the first part of an incident 'model' with risk management barriers located on appropriate trajectories in the core diagram. It is a representation of **WHAT** happened in an incident and **HOW** it happened.

Knowing **WHAT** happened and **HOW** is only part of the investigation. Even if the failed and missing Barriers are reinstated, the Underlying Causes of failure will remain. To make more effective recommendations to avoid similar incidents, the reasons **WHY** these Barriers failed must be established.

Validate Failed Barriers

Having identified what barriers should have been in place but assumed to have failed, the next task is for the team to test the incident model scenario(s) against the emerging facts conduct the investigation, (e.g. evidence gathering and interviews, as described in Section 4 below). In this process the incident model may change but at all times a model(s) exits which can be validated or modified further until it is fully validated as accurately modelling the incident. Barriers which were originally classified as Failed Barriers are now confirmed, removed or reclassified. In other words, the investigation and analysis processes are iterative and run concurrently.

The time spent in team discussion to agree on the core diagram, incident scope and barriers is important. Once defined, the investigation team can focus on why barriers failed. Duplication of team efforts can be avoided and facts tested for relevance against an agreed incident 'model'.

6.4 Why did the barriers fail? (Identify Causes)

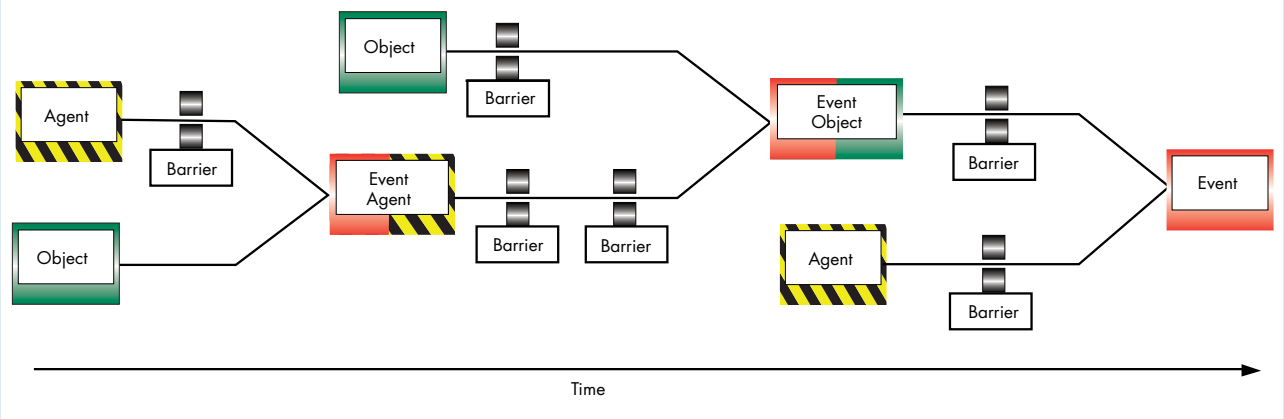
The next task is to establish the Immediate Causes and pathways to Underlying Causes for evach failed or missing Barrier. These pathways will include, as appropriate: Immediate Causes, Preconditions and Underlying Causes. See chapter 4 for the human behaviour theory and guidance to determine these pathways.

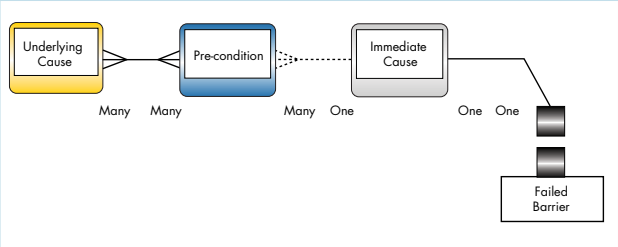
Although some failed or missing Barriers may have causes in common, they can be investigated individually using the Tripod model of causality.

Failed Barriers

The most common causal path is where an Underlying Cause creates a Precondition. This in turn creates the Immediate Cause of a Barrier to fail. The Immediate Cause can be a sub-standard act by a person or a sub-standard condition.

There is a one to one relationship between the nodes "Failed Barrier" and "Immediate Cause", and a many to one relationship between "Precondition" and "Immediate Cause". (The relationship between Precondition and Immediate Cause is not causal but probabilistic which is





indicated via a dotted line in the diagram below.) There is also a many to many relationship between Underlying Cause and Precondition. These relationships are illustrated in the figure.

In some instances the full causal chain: (i.e., Immediate Cause - Preconditions - Underlying Cause), does not apply, e.g. when the Precondition was adverse weather.

Also, sometimes the Underlying Causes, (and their remedial actions), are outside the domain of the company's management system. However, they could be in the company's "policy" domain on influencing elements outside their control, e.g. Governments, Regulation Bodies, Third Parties, etc. In such instances the full causation path is shown in the Tripod Beta Tree and with an appropriately worded action on the Underlying Cause aimed at exerting this influence.

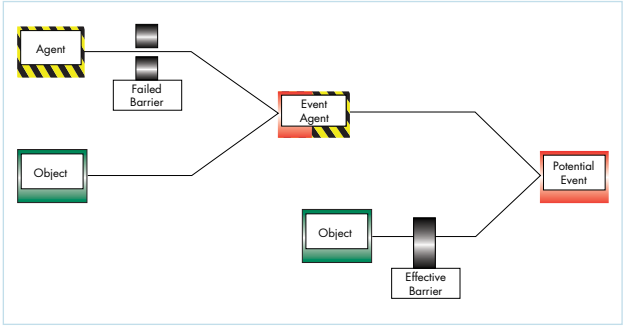
Missing / Inadequate Barriers

Sometimes, albeit rarely, a Missing / Inadequate Barrier is identified. By definition, it does not have an Immediate Cause or Precondition. These types of Barriers are usually due to inadequate planning, design. They are only classified as missing/ inadequate if no Immediate Cause can be identified.

Effective Barriers

In a Trio containing an Effective Barrier, (in either Agent-Event or Object-Event path), the Event did not take actually place and would be classified as a "Potential Event" or a "Near Miss". This is illustrated in the figure below.

Effective Barriers indicate how close the situation was to a far more serious incident and that only this 'last' single barrier was preventing this incident from happening.



Completing the Tripod Beta Tree

To complete a Tripod-Beta tree the facts relevant to the incident have to be identified from those gathered by the investigation team and then connected according to the conventions of the Tripod Beta tree model. This is done in parallel to the investigation activity and should involve discussion between investigation team members.

The facts of the investigation will need to be classified, (e.g. Agents, Failed Barriers, Preconditions etc.,) during tree construction, but the investigation team should initially be concerned more with the facts themselves, i.e. why things happened rather than with the classifications. This may generate discussion between the team to come to a common understanding of what the facts mean in terms of understanding the incident.

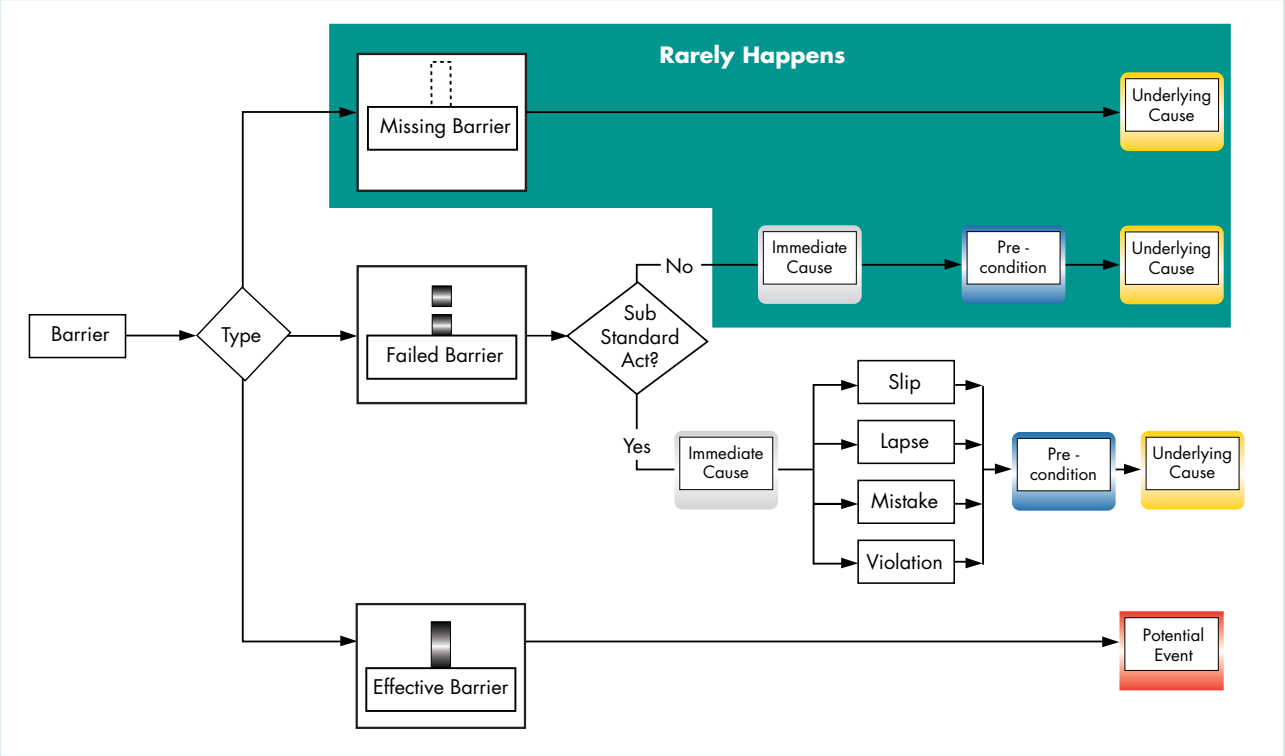
Barrier Summary

The relationships between the different Barrier nodes and the other nodes in the Tripod Beta model are shown in Figure below. Missing /Inadequate Barriers and Failed Barriers where no sub-standard act exists are rare. The most valuable part of a Tripod Beta analysis is related to identifying and analysing sub-standard acts by people involved in the incident.

Unplaced Facts

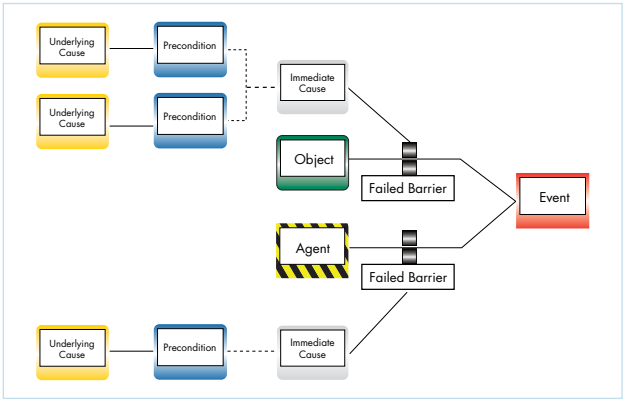
Not every fact gathered is relevant to the understanding of an incident. Especially at the start of an investigation, the gathering of information is along a broad front and not until the pattern of the incident sequence and causal chains emerges will the team concentrate on areas known to be relevant.

Some facts relating to the work environment may be necessary to improve the understanding of any readers of the incident report who are not familiar with the location or operation. However, when a fact is seen to be irrelevant to understanding the incident, it should be discarded.



6.5 The tripod tree

The Tripod-Beta 'cause and effect tree' is the combination of the **WHAT**, **HOW** and the **WHY** models. The figure demonstrates how the Tripod causation paths are connected to each failed barrier. An investigation tree with a more complex core would have more 'nodes' but the linkage of tree elements follows the same principles.



The aim of the Tripod-Beta tree is to provide a suitable set of concepts - a 'framework' - so that the investigation team can make explicit the various failures contributing to a particular incident.

An overview of the Tripod Beta symbols is in Annex 5. Annex 6 presents the rules for constructing a Tripod Beta tree e.g. allowed and forbidden combinations of events, agents, objects, barriers, immediate and underlying causes, and preconditions. A worked example of a Tripod Beta tree is provided in Annex 8.

6.6 Remedial actions

The last items required to complete the tree are action items addressing identified failures and classification of the underlying causes. The investigation team should be fully involved in completing these items. Each failed or missing Barrier and Underlying Cause should have at least one recommendation.

Failed Barriers

To ensure the area where an incident occurred is safe and to enable operations to begin as soon as possible, actions recorded against Failed Barriers are already likely to have been taken before the incident report is issued. However, these actions are recorded in the report plus any others that should be taken locally and which may have been originally overlooked.

Underlying Causes

Actions assigned to Underlying Causes are aimed at correcting 'shortcomings in the management system. These will normally require more resources to undertake and longer to complete than those assigned to Failed Barriers.

SMART Actions

Recommended actions need to be credible. Each recommendation should be clearly appropriate to the failure or deficiency and should be discussed and agreed with an action party.

Management should be convinced that if they endorse the recommendation some positive change will result. Moreover, actions should be 'SMART', i.e.

Specific: relate to a clearly identified action to be taken which is understood and agreed by the action taker.

Measurable: the results of taking action can be measured in some way and close-out verified.

Appropriate: specifically addresses a Failed Barrier or Underlying Cause identified in the report.

Realistic: able to obtain the level of change reflected in the recommended action, (knowing the resources and capacities at the disposal of the organisation).

Time based: stating the time period in which the action must be completed.

The recommended actions assigned, especially to Underlying Causes, should not be "out of reach" of an organisation to complete nor should they consolidate the "status quo". The opportunity should be taken to 'stretch' an organisation to complete them with the aim of making incremental improvements in the business culture.

Action items should be developed by those in the affected organisation albeit under the guidance of the Tripod Beta Practitioner. Also the party with the action should agree it before is formally recorded.

6.7 Senior Management Review and Action Plans

The incident report represents the team's effort, and team members should satisfy themselves that their findings and recommendations are correctly presented to the appropriate management level.

Management should have the opportunity to check the appropriateness of the recommendations and feed back their comments and endorsements to the team. This is particularly important for recommendations regarding Underlying Causes. The resolution of Underlying Causes is usually a longer term project and endorsement by management implies that resources for implementing the recommendation will be provided.In view of their experience and deeper and broader understanding of management systems, senior management could well identify issues and/or recommendations overlooked by the investigation team. If this is the case, the incident report should be amended to include this additional information and re-issued.

7. Learning and Feedback

7.1 Feed Back to Risk Assessment

Learning from incidents is essential if future incidents and losses arising from the same Underlying Causes are to be prevented. Tripod investigation and analysis is a major part of the overall "Learning from Loss" process.

Every company has its own incident reporting and investigation process but the main stages of this process are expected to be similar to the following:

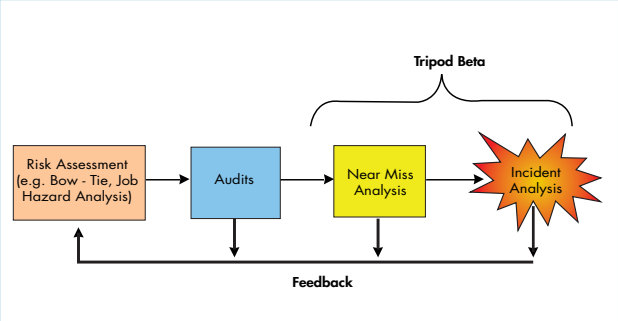
- Emergency Response, (level depends on severity of the incident), treatment of any injured persons, containment of incident.
- Making incident location safe and protecting evidence
- Initial registration of incident and informing regulatory authorities as appropriate.
- Assess potential harm of incident and deciding level of investigation and analysis.
- Appoint team leader and form incident investigation and analysis team
- Conduct investigation and analysis (using Tripod in this instance)
- Define actions and write report.
- Dissemination of lessons learned
- Monitor completion of actions
- Feedback to risk assessments

The purpose of investigation and analyses is prevention through learning. Therefore the dissemination and feedback to the pro-active risk assessments is essential if the overall Incident Management process is to be a "closed loop" system. This is illustrated in the figure which also shows information being fed back into risk assessments from Near Miss analysis and Audits.

7.2 Differing Levels of Incident Reporting, Investigation and Analysis

Not all incidents require the formality, depth and thoroughness of a Tripod Beta investigation and analysis. For minor severity and low risk incidents, the extent of the investigation and analysis is likely to be limited to simply entering the incident details into the company's Incident Reporting System, (IRS), and taking local corrective actions.

At the other extreme, all incidents rated at the higher risk areas of a risk matrix or which have caused significant actual



harm, will justify the full Tripod Beta investigation and analysis process as explained in this manual. This analysis will identify both the local remedial actions as well as those to correct the deeper systemic failings in the business.

By ensuring there is a systematic and logical approach to collecting incident information for all levels of incident investigation, reporting and analysis, it will be possible to integrate them and draw additional conclusions and learning from the knowledge thereby created. Such analysis will include, but not be limited to, trend and "comparison" analysis.

This will require:

- a powerful Incident Reporting database with an effective data structure,
- a knowledgeable operator who will be able to seek the right information from the database and interpret the findings and draw conclusions
- accurate data entry into the database

From this holistic and systematic approach, the deep learning gained from Tripod Beta investigations and analyses will be supplemented by the information obtained from the more numerous but less severe incidents.

Annex 1: Glossary

Term	Description
Agent of Change	Anything with the potential to change, harm or damage an object upon which it is acting.
Barrier	A measure which reduces the probability of releasing an Agent's potential for harm and of reducing its consequences. Barriers may be physical, (e.g. materials, protective devices, shields, segregation etc.), or non-physical, (procedures, inspection, training, drills)
Basic Risk Factors	A system for categorising Underlying Causes. An indicator of an aspect of a management system where a failure exists, and by implication where the remedy lies.
Core Diagram	A Tripod Beta tree containing only the Agent-Object-Event trios.
Effective Barrier	A barrier that was effective in restoring control or preventing further consequential injury or damage following an actual event.
Errors	Actions by people which result in the Immediate Cause of a Failed Barrier.
Event	An unplanned and unwanted happening involving the release or exposure of an Agent of Change.
Failed Barrier	A Barrier rendered ineffective by an Immediate Cause.
Immediate Cause	An action, omission or occurrence that causes a barrier to fail. Immediate Causes include sub-standard acts by people and, (by exception), sub-standard conditions where people were not the Immediate Cause of the failure. Immediate Causes occur close to the failed barrier in time, space or causal relationship and negates the Barrier.
Incident	An event or chain of events which cause, or could have caused injury, illness and/ or damage (loss), e.g., to people, assets, the environment, a business, or third parties.
Inadequate Barrier	A Barrier identified and established by the organisation as a management control measure but which failed, not due to an Immediate Cause, but due to its inadequacy. (Treated the same way as a Missing Barrier.)
Lapse	Omission/ repetition of a planned action possibly caused by Memory failure. (Type of human error.)
Missing Barrier	A barrier identified by the organisation as a management control measure but was not established. (Treated the same way as an Inadequate. Barrier)
Object	The item harmed (injured, damaged or lost), or changed, caused by an "Agent of Change".
Precondition	The environmental, situational or psychological 'system states' or 'states of mind' that cause or promote Immediate Causes.
Slip	Unintended deviation from a correct plan of action caused possibly by attention failure or mistiming. (Type of human error.)
Sub-Standard Act	An action, error or omission that causes a barrier to fail. An "Immediate Cause" attributable to an erroneous human action.
Sub-Standard Condition	A technical condition that renders a barrier to fail. An "Immediate Cause" attributable NOT to an erroneous human action.
Trios	The linked combination of an "Agent of Change", "Object" and "Event". Trios are linked to other trios by a combination node, i.e. Event/ Agent of Change or Event/ Object.
Tripod Beta Practitioner	A person who has been formally accredited as being competent to undertake a Tripod Beta Investigation and Analysis.
Tripod Beta Tree	The graphical model used to depict an incident.
Underlying Cause	The organisational deficiency or anomaly creating the Precondition that caused or influenced the commission of an Immediate Cause.

Annex 2: Tips for Tripod tree construction and quality checking

This section provides tips for quality checking of the Tripod analysis. Using an accredited Tripod practitioner will ensure that these quality checks are applied throughout the analysis.

A. Creating the Core Diagram

1. Define the Event first, then the Object which has been changed, (as described by the Event), and then the Agent, (which acted on the Object to change it). Reasoning to construct the trio is 'back in time' but diagram timeline is from left to right.
2. Does the Event describe a 'happening' to the Object?
3. Does the Object describe an item before its condition was changed to that described in the Event?
4. Does the Agent describe something that had the potential /ability to change the condition of the Object to that described in the Event?
5. Initially, create many Trios to capture as many scenarios as possible. They can be disregarded or 'collapsed' into fewer trios later on when more information emerges from the investigation.
6. Normally, a final core diagram contains 2 to 5 trios.
7. 'Time' moves from left to right, i.e. the tree starts with an Agent and an Object and ends with an Event(s).

B. Identifying Barriers

8. Is a Failed Barrier described such that, had it been effective, it should have prevented the next Event from occurring?
9. Describe the Barrier in specific, and not general, terms, (e.g. the relevant part of a procedure rather than the title of procedure or type of procedure). In the later stages of the incident analysis, the Barriers may be merged if this creates more clarity of presentation.
10. Missing /Inadequate Barriers are rare, but when they do occur, try to identify the human error in planning, design, etc., and make that the Immediate Cause of the Failed Barrier.
11. If a single Barrier for a particular AOE Trio cannot be found then merge that Trio with another one that does contain a Barrier.

C. Identifying Immediate Causes

12. Has the Immediate Cause led to the failure of a Barrier?
13. Who is the person or persons that caused failure of the barrier? Only if it is understood who the individuals are can the precondition be found!!!
14. Does the Immediate Cause describe something that happened close in the sequence of happening to Failed Barrier? (Close in logic but not necessarily close in time or location.)
15. Does the Immediate Cause describe an act of doing, or not doing, something?
16. There can be only one Immediate Cause for each Failed Barrier?
17. An Immediate Cause and Failed Barrier should be described as a "duo". The Immediate cause will be the 'opposite' of a Failed Barrier, i.e., if the Barrier is worded positively then the Immediate Cause will be worded negatively.

D. Identifying Preconditions

18. Does the Precondition explain why the individual thought that their act was normal, acceptable or even commendable?
19. Does the proposed precondition have an 'influence' on the behaviour of the person who made the error leading to the Immediate Cause that in turn led to the Barrier failing?
20. If the proposed precondition was an Immediate Cause of a Failed Barrier, rather then an indirect and influencing factor, then what is being described is not a Precondition.

E. Identifying Underlying Causes

21. Is the Underlying Cause a valid reason for the perceptions and beliefs, (Preconditions), that led the individual think that they were doing the right thing or that which was considered normal, acceptable?
22. Does it represent a failure on 'system level', i.e., its relation to the actual event is 'remote' in time and/ or location?
23. Is the organisation in question in the position to take responsibility for the existence of this system failure and is able to improve the situation. (If the organisation does not have 'direct responsibility' for this systemic failure, it can never-the-less influence others outside the organisation?)
24. Underlying Causes are related to Management Systems.

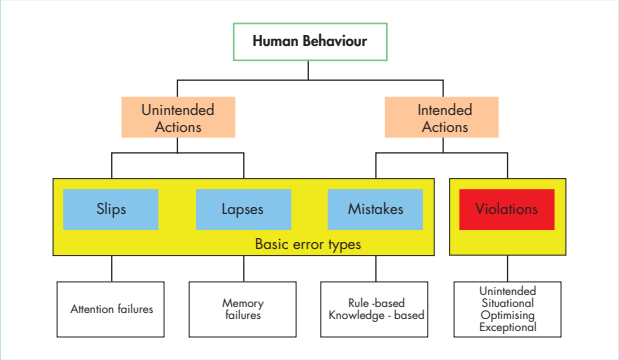
F. Creating Recommended Actions

25. Are the actions:

- SMART,
- Developed by someone within the organisation,
- Have been agreed by the action party and
- Likely to improve the business culture of the company
- Likely to effectively and efficiently solve the problem
- Enduring in that they will be effective for a long time
- Extensive in that they are applicable out with the local scene.

Annex 3: Errors, Violations and their Preconditions

The conditions that lead to mistakes are different from those that cause attention failures. Knowing the form of human error helps in the identification of Preconditions. When the Immediate Cause of a failed barrier is due to a sub-standard act, identifying the type of human error which caused it will help in identifying the related preconditions.



Preconditions are the environmental, situational or psychological 'system states' or 'states of mind' that promotes Immediate Causes. In simple terms the precondition can be found by asking why the person or group of persons that caused the failure had the belief or perception that their act was more or less what was expected of them, commendable, unavoidable or just normal. The table below illustrates the connection between sub-standard acts and typical preconditions.

Error type	Description	Possible Causes/Preconditions
Slip	Unintended deviation from a correct plan of action	- Attention failure - Mistiming - Distraction from task - Preoccupation with other tasks
Lapse	Omission/ repetition of a planned action	- Memory failure - Change in nature of task - Change in task environment
Mistake (rule-based)	Intended action inappropriate to the circumstances	- Sound rule applied in inappropriate circumstances - Application of unsound rule - Failure to recognise correct area of application - Failure to appreciate rule deficiencies
Mistake (knowledge-based)	Erroneous judgement in situation not covered by rule	- Insufficient knowledge or experience - immaturity - Time/emotional pressures - Inadequate training
Unintentional Violations - Understanding	People not knowing how to apply the procedures	Poor writing Complexity Failure to understand users
Unintentional Violations - Awareness	People acting as if there is no procedure	Poor Training Lack of availability on site
Routine Violations	Rules broken because they are felt to be irrelevant or because people no longer appreciate the dangers	Unnecessary rules Poor attitude to compliance Weak supervision
Situational Violations - (No-can-do)	Impossible to get the job done by following the procedures strictly.	Lack of resources (people, equipment, tools) Failure to understand working conditions
Optimising Violations - (I-can-do-better.) for Organisational Benefits	To get the job done faster, with less disturbances etc. by not adhering to rules.	Wanting to do a good job for the "boss" or company.
Optimising Violations - (I-can-do-better.) for Personal benefits	To get the job done more conveniently or to experience a thrill by not adhering to rules.	Personal convenience and opportunities to get more personal satisfaction from the act
Exceptional violations	Solving problems for the first time and fail to follow good practice	Unexpected situations - no obvious rules Pressure to solve problems

Annex 4: Basic Risk Factor (BRF) Definitions

1. Hardware (HW)

Failures due to inadequate quality of materials or construction, non-availability of hardware and failures due to ageing (position in the life-cycle).

The BRF does not include:

- error-generating mechanisms due to poorly designed equipment Design BRF
- hardware failures caused by inadequate maintenance Management BRF

2. Design (DE)

Deficiencies in layout or design of facilities, plant, equipment or tools that lead to the misuse or sub-standard acts, increasing the chance of particular types of errors and violations.

3. Maintenance Management (MM)

Failures in the systems for ensuring technical integrity of facilities, plant, equipment and tools, e.g. condition surveys, corrosion barriers and function testing of safety and emergency equipment.

Issues relevant to the execution aspects of maintenance are considered in the BRFs: Error-enforcing Conditions; Procedures; Design; Hardware; Communication.

4. Procedures (PR)

Unclear, unavailable, incorrect or otherwise unusable standardised task information that has been established to achieve a desired result.

5. Error-enforcing conditions (EC)

Factors such as time pressures, changes in work patterns, physical working conditions (hot, cold, noisy), etc. acting on the individual or in the workplace that promote the performance of sub-standard acts - errors or violations.

6. Housekeeping (HK)

Tolerance of deficiencies in conditions of tidiness and cleanliness of facilities and work spaces or in the provision of adequate resources for cleaning and waste removal.

7. Incompatible goals (IG)

Failure to manage conflict; between organisational goals, such as safety and production; between formal rules such as company written procedures and the rules generated informally by a work group; between the demands of individuals' tasks and their personal preoccupations or distractions.

8. Communication (CO)

Failure in transmitting information necessary for the safe and effective functioning of the organisation to the appropriate recipients in a clear, unambiguous or intelligible form.

9. Organisation (OR)

Deficiencies in either the structure of a company or the way it conducts its business that allow responsibilities to become ill-defined and warning signs to be overlooked.

10. Training (TR)

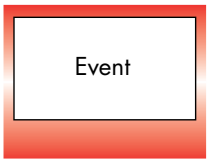
Deficiencies in the system for providing the necessary awareness, knowledge or skill to an individual or individuals in the organisation. In this context, training includes on the job coaching by mentors and supervisors as well as formal courses.

11. Defences (DF)

Failures in the systems, facilities and equipment for control or containment of source of harm or for the mitigation of the consequences of either human or component failures.

Annex 5: Tripod Beta Tree Symbols

The following notes should be used in conjunction with the definitions in the Glossary (Annex 1)

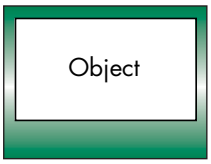


Event

An Event node represents damage, injury or loss. Events are the unplanned and unwanted happenings involving the release or exposure of Agents. An Event has exactly two inputs i.e. a line from an Agent plus a line from an Object. The Agent and Object may themselves be combined Event and Agent/Object nodes.

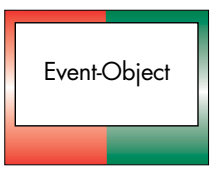
Agent of Change

An Agent of Change node represents the presence of a potential to change, harm or damage an Object upon which it is acting. It has no inputs, (i.e. lines, on the left-hand side of the node), and always connects to an Event node, typically via one or more Barriers. This will always be in partnership with the Object that it is changing, damaging or harming.



Object

An Object represents the presence of an entity, (e.g. person, equipment, reputation, project schedule), that is vulnerable to an Agent of Change. It has no inputs, (i.e. lines, on the left-hand side of the node), and always connects to an Event node, typically via one or more Barriers. It will always be in partnership with the Agent that is causing it to be changed, damaged or harmed.

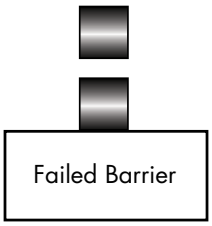


Event and Agent - Event and Object

Combination nodes are used to represent an Event (e.g., damage or injury), which goes on to play a further role in the incident as an Agent or Object. Combined nodes will often be identified in the initial investigation as Events and be changed later when Events are chained to describe the consequential effect of one Event.

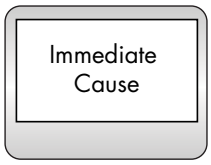
Examples:

A. An explosion weakens a structure which falls down, injuring rescue workers. The explosion Event has resulted in a new Agent being created.
B. A man falls 30 metres into the sea. The fall Event creates a new Object (the man) for an Agent (the sea).



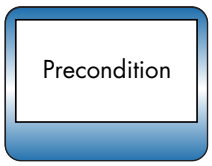
Failed Barrier

A Failed Barrier node is shown as letting the Agent or Object to pass through a 'gap' in the Barrier thereby allowing the Agent and Object to meet to create the Event. The gap in the Barrier has been caused by an Immediate Cause node.



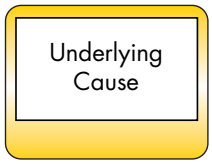
Immediate Cause

The Immediate Cause is the action, omission or technical failure that caused the Barrier to fail and is therefore directly connected to it. Immediate Causes include Sub Standard Acts - committed by people - and sub-standard conditions, e.g. equipment / technical failures. There is always only one Immediate Cause linked to a Failed Barrier and which represents the cause of the failure.



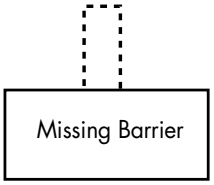
Precondition

A Precondition causes or increases the probability of the Immediate Cause of a Failed Barrier. An Underlying Cause must be identified for each organisational Precondition, but Preconditions such as natural phenomena or other conditions outside the Company's influence may be end nodes.

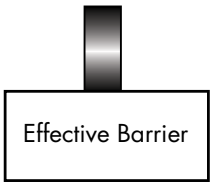


Underlying Cause

An Underlying Cause is the source of an organisational Precondition. By definition, it will be an 'end node'. There can be many Underling Causes linked to each Precondition. The Basic Risk Factors, (BRFs) or reference to Management System elements are assigned to the Underlying Cause.



Missing/Inadequate Barrier
A Missing Barrier node provides for cases where plans and procedures have specified a Barrier but investigation shows that none was established or that it was in place but was inadequate for the intended role. There are no Immediate Causes for this type of Barrier and it is linked directly to an Underlying Cause.



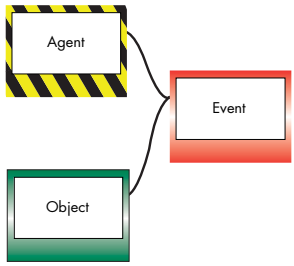
Effective Barrier
An Effective Barrier node represents a Barrier that did not fail and provided the successful containment of an Agent or protection of an Object. It is used to model a 'Near Miss' or a branch of an incident tree where further injury, damage or loss was averted. There is no Immediate Cause, Precondition or Underlying Cause nodes linked to it.

Narrative
Models, being simplifications, cannot embrace the full complexity of the real world. Occasionally there is a need to clarify the connection between two nodes. The Narrative node provides this facility and is shown on the Tripod Beta Tree as required.

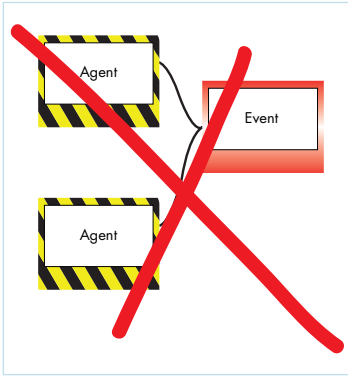
Annex 6: Tripod Beta tree rules

6.1 Trios (Agents, Objects, Events)

A. Agent and 1 object

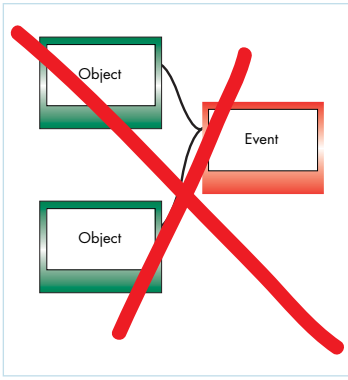


B. Multiple Agents



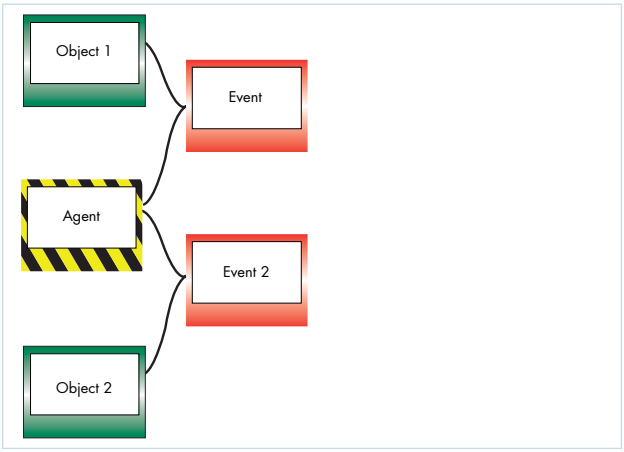
NO - One AEO trio has only one Agent

C. Multiple objects



NO - One AEO trio has only one Object

D. One Agent - Multiple Events



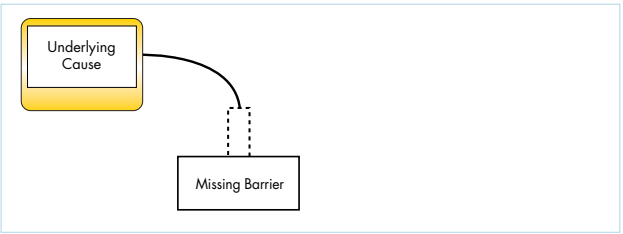
One Agent can affect multiple Objects creating multiple Events.

D. One object - Multiple Events

One Object can be affected by multiple Agents creating multiple Events

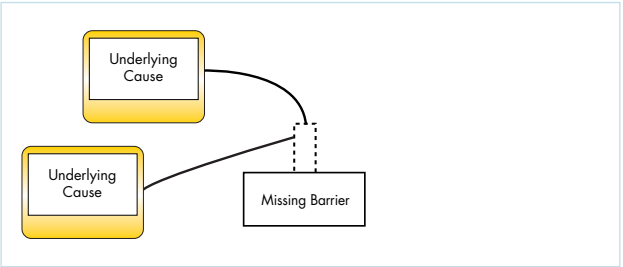
6.2 Missing Barrier

A. Underlying Cause



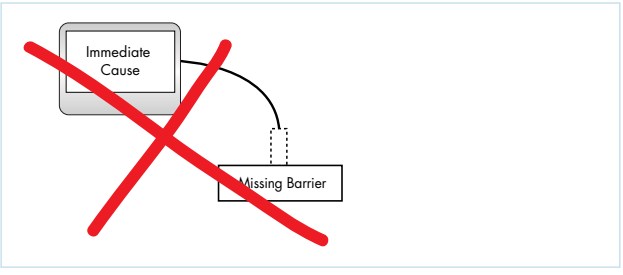
This is the case if the Missing Barrier NEVER has been there, but it was reasonable to expect it there. Also it is impossible to identify anybody who should have designed or implemented the Barrier. In cases where the Missing Barrier has been removed (after it has been there previously), or possible to identify who should have designed or implemented the barrier, it is considered a FAILED Barrier.

B. Multiple Underlying Causes



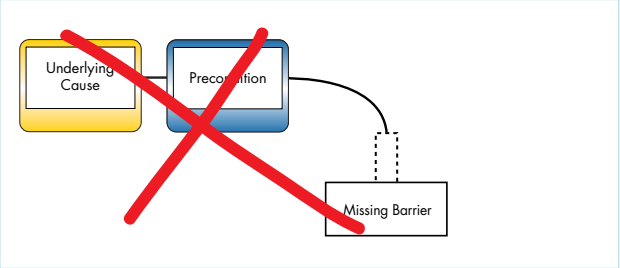
A Missing Barrier may have more than one Underlying Cause.

C. An Immediate Cause



NO - A Missing Barrier can only be connected to an Underlying Cause.

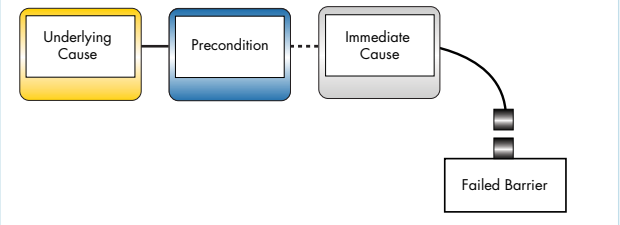
D. An Immediate Cause and Precondition



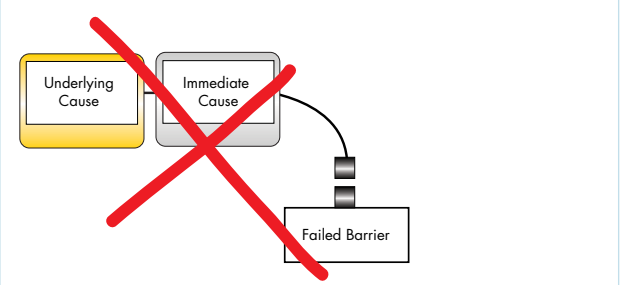
NO - A Missing Barrier can only be connected to an Underlying Cause.

6.3 Failed Barrier

A. An Immediate Cause, A Precondition and an Underlying Cause

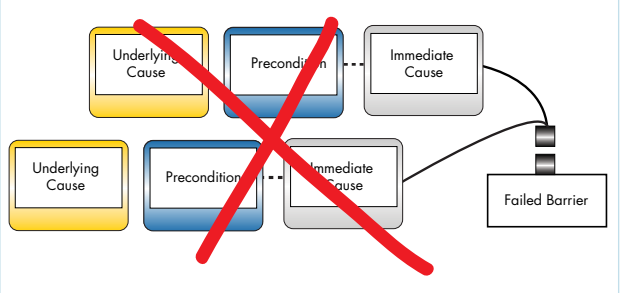


B. Precondition and underlying Causes



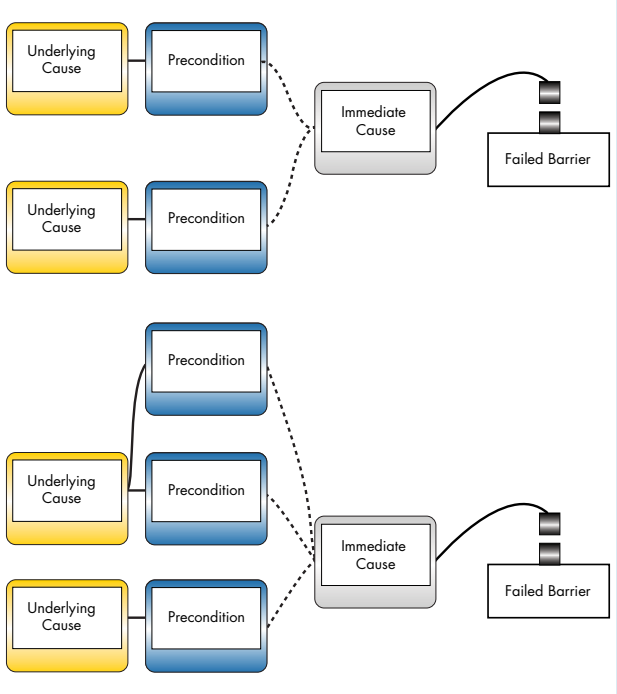
NO. A Failed Barrier must be linked to an Immediate Cause.

C. Multiple Immediate Causes Preconditions and Underlying Cause



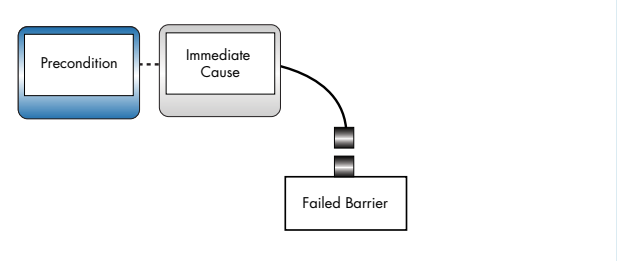
NO. There can only be ONE Immediate Cause connected to a Failed Barrier

D. An Immediate Cause, Multiple Preconditions and Underlying Causes



E. An Immediate cause, without an underlying Cause

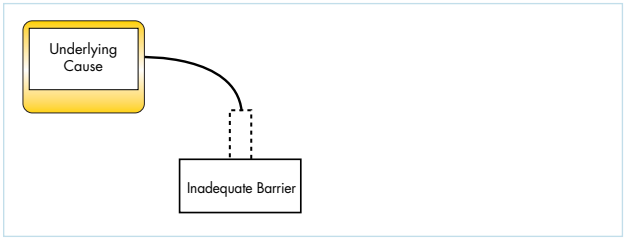
This is very exceptional; only case created by other,



(uncontrollable) parties. If this is used in a tree, explain why.

6.4 Inadequate barrier

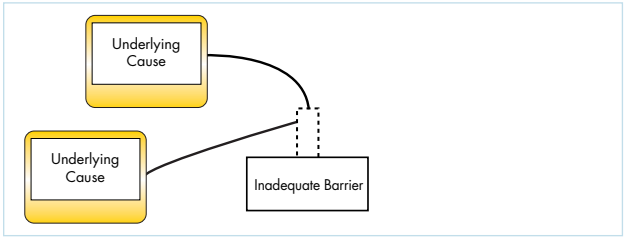
A. An Underlying Cause



This is the case where a Barrier is in proper condition, but not able to prevent the release of the Agent or protect the Object effectively. (E.g., a fence is in tact but built too low so that people can climb over it.) Also it is impossible to identify anybody who should have designed or implemented the Barrier.

This is called an INADEQUATE Barrier. It is depicted by the same symbol as a Missing Barrier.

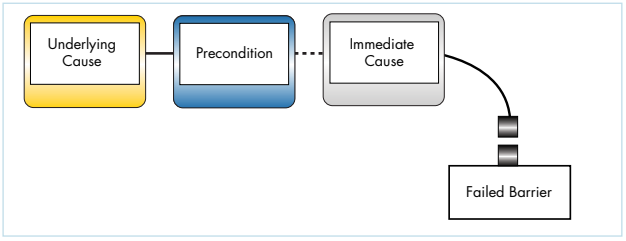
B. Multiple Underlying Causes



An Inadequate Barrier may have more than one Underlying Cause

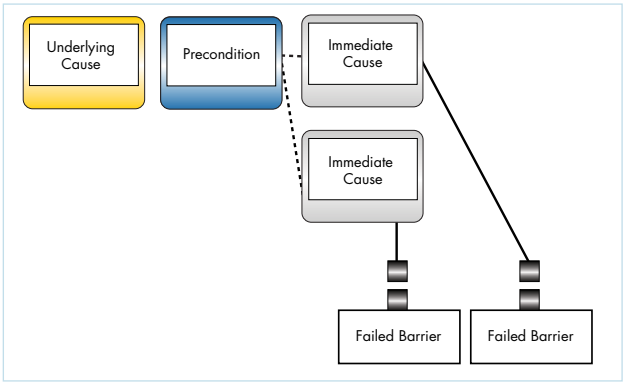
6.5 Preconditions

A. An Immediate Cause

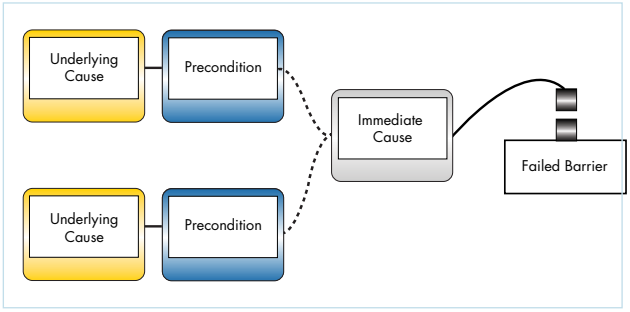


See also 6.4.3 a), c) and d).

B. Multiple Immediate Cause

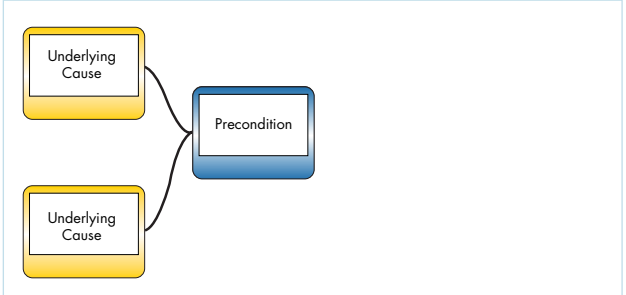


C. An Underlying Cause



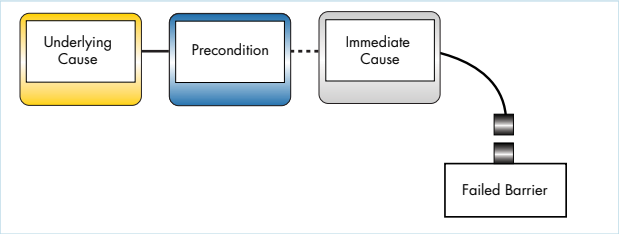
See also 6.4.3 a), c) and d).

D. Multiple Underlying Cause



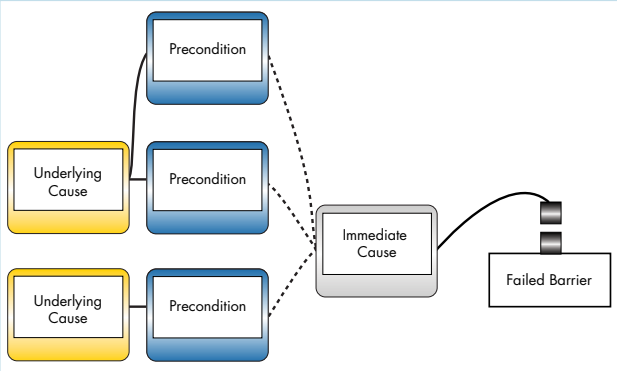
6.6 Underlying Causes

A. A Precondition

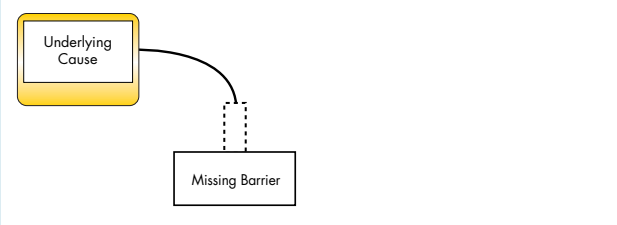


See also 6.4.3 a), c) and d).

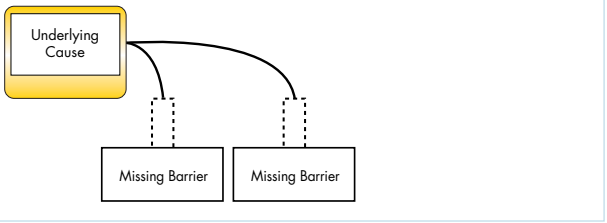
B. Multiple Preconditions



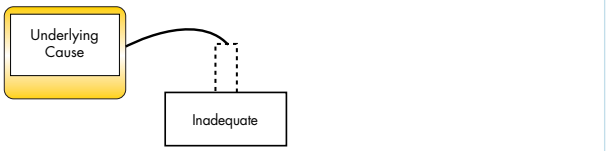
C. A Missing Barrier



C. Multiple Missing Barriers



D. Inadequate Barriers

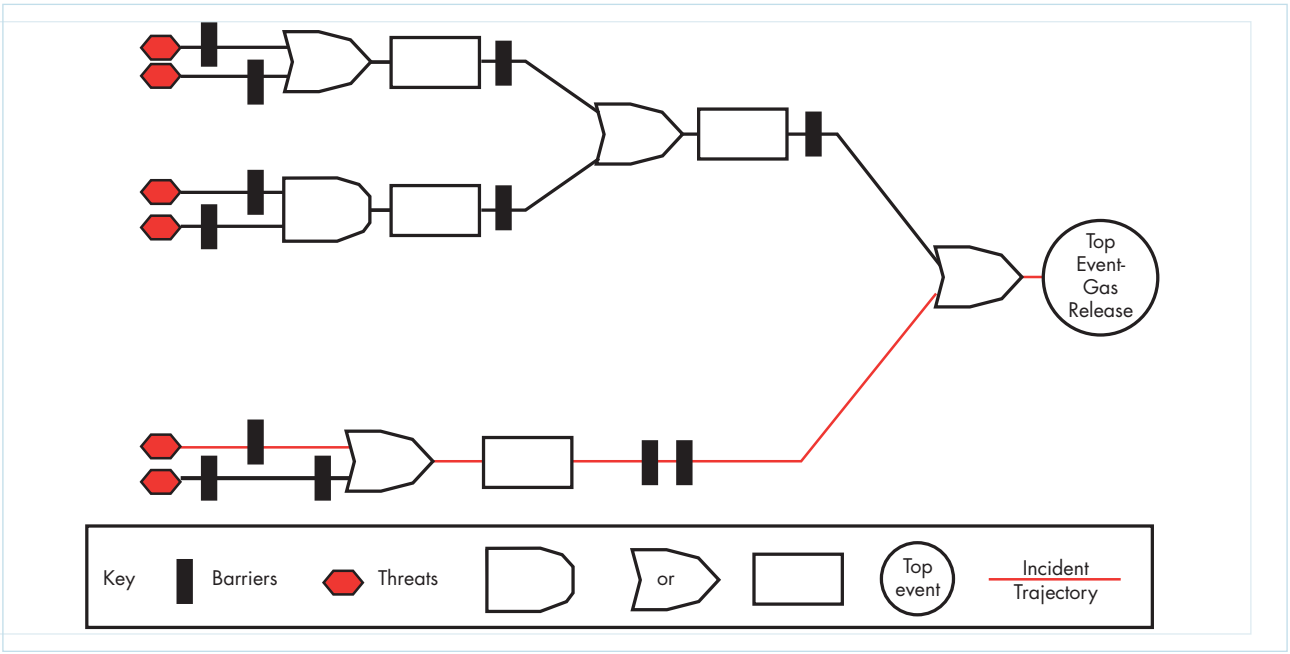


Annex 7: Tripod Beta and BowTie

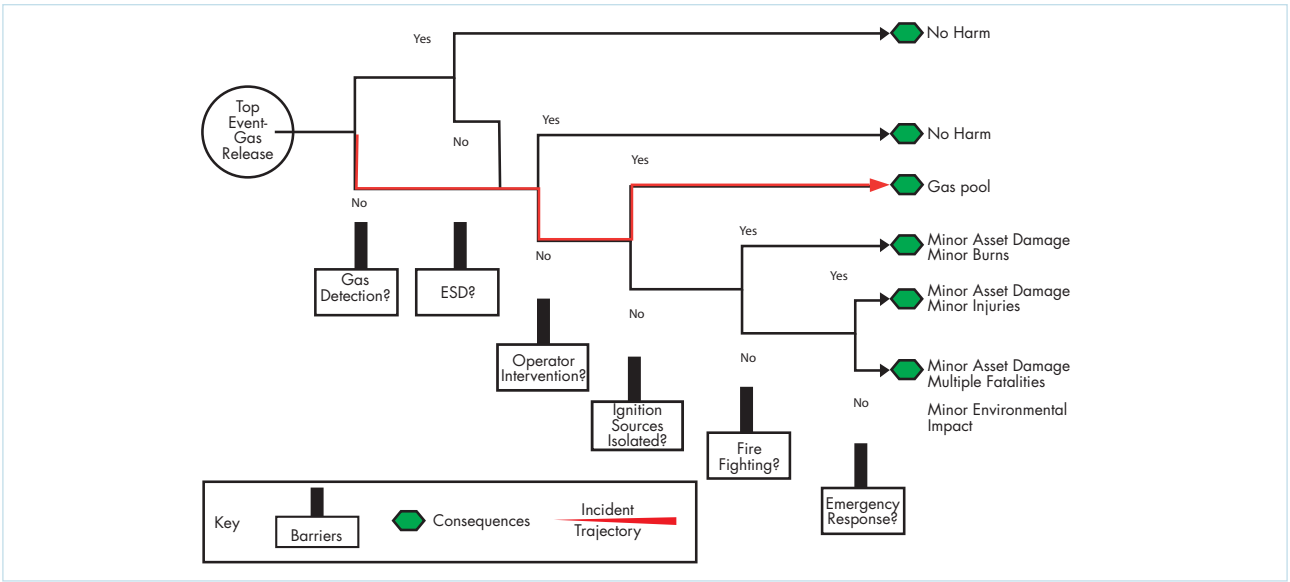
BowTie, Fault Tree and Event Tree

A BowTie diagram is a simplistic representation of a combined Fault Tree and Event Tree, as shown below. (The red lines depict the trajectory of a particular incident.)Fault Tree

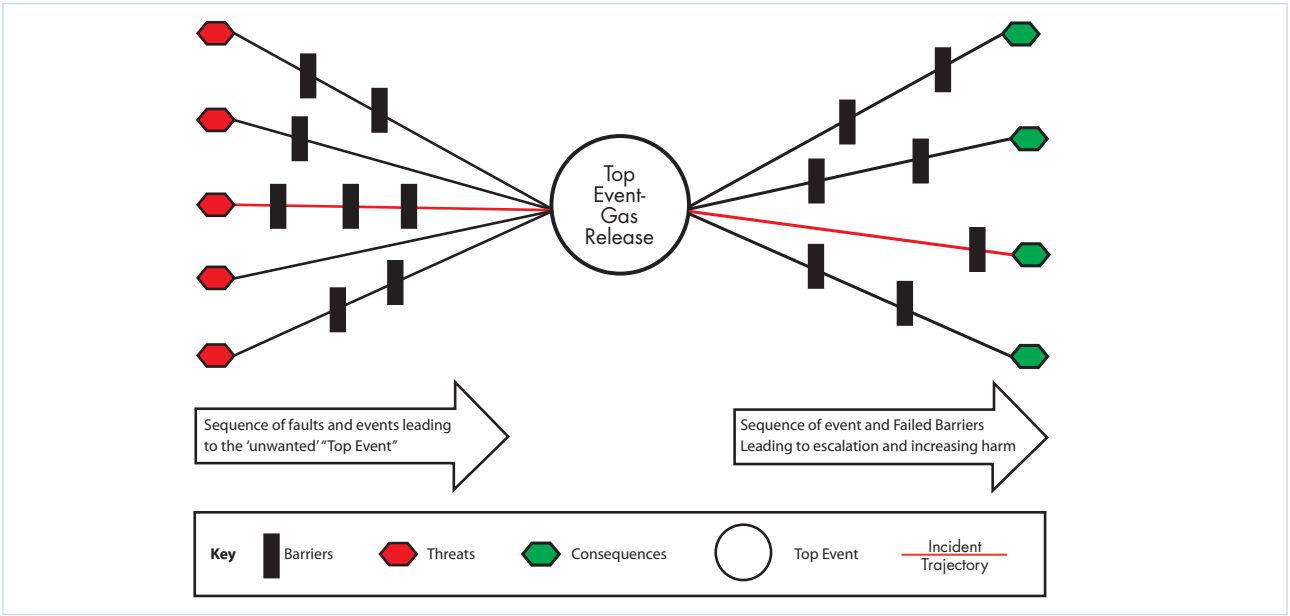
Fault Tree



Event Tree



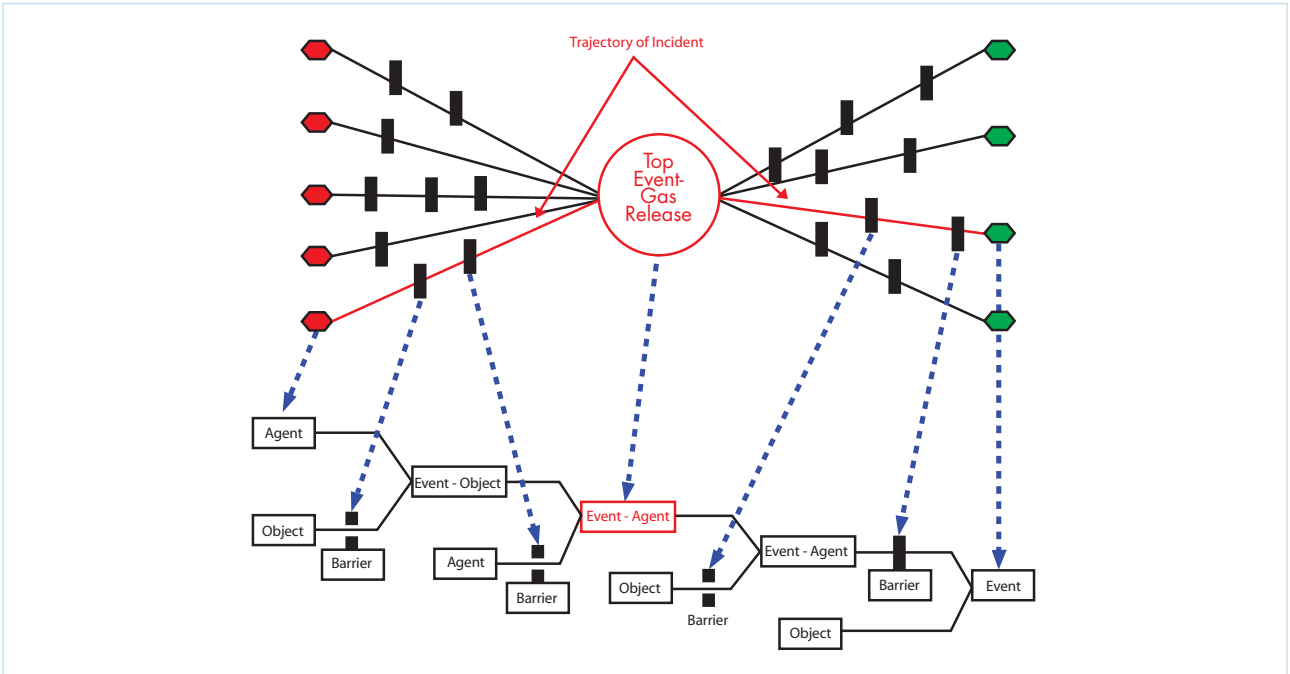
BowTie



BowTie, and Tripod Beta Tree

Whilst the BowTie risk assessment and the Tripod Beta incident analysis methodologies are based on the same scientific principles, there is not necessarily a direct one to one relationship between the entities within them. However, reviewing the appropriate BowTie risk assessment(s) associated with an incident could help identify Barriers in the Tripod Beta Tree. The simple relationship between a BowTie and a Tripod Beta Tree is shown in below.

A series of faults, Events and Failed Barriers, lead to the "Top Event", (or "Main Event" using Tripod Beta terms), via a specific incident trajectory. After the Top Event, harm was caused by a subsequent Event and a Failed Barrier along the specific incident trajectory. The consequences could have been more severe but, in the case shown below, the incident progression was stopped by an Effective Barrier and the last and End Event shown on the Tripod Beta Tree being a Potential Event.



Annex 8: Worked example of Tripod Beta Tree

Introduction

In this annex a fictitious incident is used to provide an example of the development of a Tripod tree. It should be realised that a Tripod Beta analysis, as shown in a tree, is a model of a complex incident. There is not a single correct model of any incident and this annex shows one good example of a vehicle accident. The event could be modelled in a different ways. However, different models should still identify the similar key barriers and underlying causes. Any modelling process aims to simplify a complex situation to aid understanding.

The Incident

A driver has been involved in a vehicle incident and has badly injured his back. You are tasked with leading an investigation into this incident.

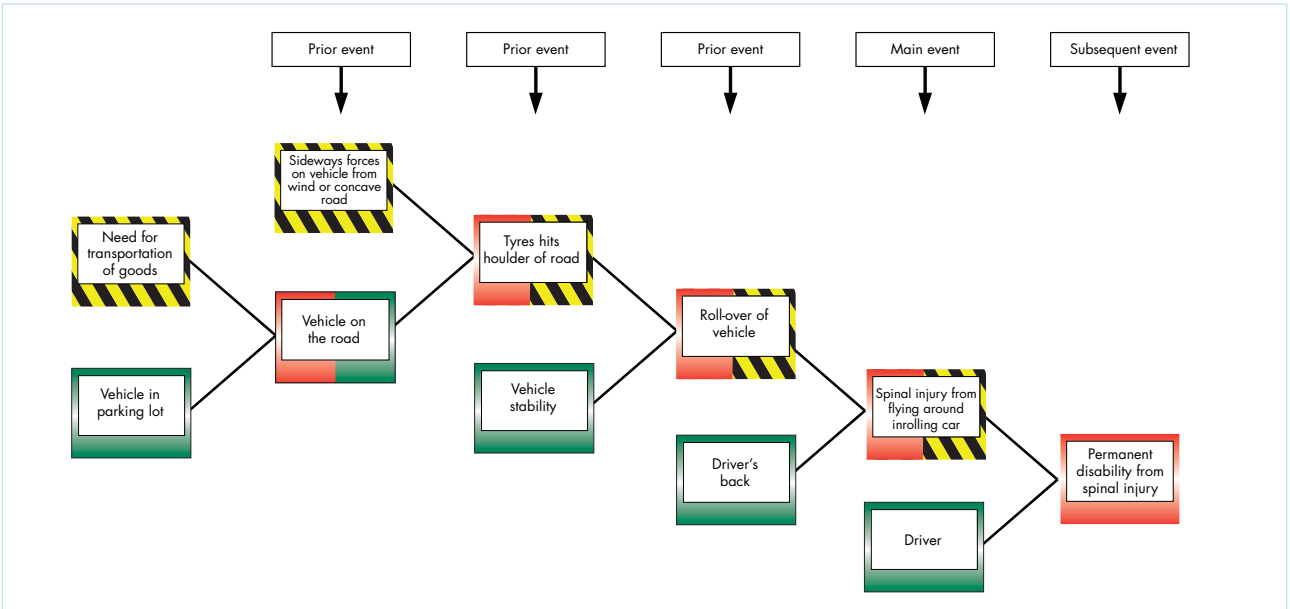
Initial Investigation

Visits by the investigation team members to the incident site, the production centre in the area and the base hospital establish the following facts:

- The driver was delivering goods to a remote location.
- He left the Area Production Centre on schedule at 0800 hours. According to his posted Journey Management plan, he was due to return to the Centre at 1230.
- His failure to return was not reported until 1500. A search was initiated at 1630 along the route he had indicated in his Journey Management Plan without success.
- The search was extended to other locations off the designated route, and the vehicle and driver were eventually located at 1830. The vehicle had left the road and rolled over and the supervisor had suspected spinal injuries.
- The injured man was evacuated by the field ambulance to the field first aid post and from there to the base hospital. The view of the doctors is that the injuries will probably result in permanent disability, and that the attempts of the victim to move around while waiting for the rescuers to find him is likely to have been a major factor contributing to the severity of the injury. The victim was conscious and had taken notice of the time and made a mental calculation of the time by which he could expect the rescue team to show up. When they did not show up at the expected time he became nervous and started to make attempts to get out of the vehicle.
- Examination of the vehicle and the site indicate that only one vehicle was involved, and that there were no indications of a tyre blow-out or other catastrophic technical failure.

The Core Diagram

The core diagram focuses on what happened. If there is evidence at this stage of why any of the events happened it should be ignored for the time being - placed in the Fact List for later use. The diagram can be built from any event in the incident sequence. Often the start is the Main Event - why the incident is being investigated.



Main Event: Spinal injury from flying around in rolling car

The injury is a rational start point in this case. You have already been told that there is a strong probability of a permanent disability, and this type of incident is potentially fatal. The initial Event-Object-Agent (EOA) trio is straightforward; the Event is *Spinal injury to the driver from flying around in rolling car.* The Object is the *Drivers back* and the Agent is the *Roll over of vehicle*.

Subsequent event: Permanent disability from spinal injury

Now examine each of the three 'nodes' in turn to determine whether there were prior or subsequent Events that need to be accounted for. Note the qualification 'that need to be accounted for'.

Start with the Event. Not every driver with spinal injury suffers permanent disability, and medical advisers have implicated failures in rescue and aftercare. The *permanent disability from spinal injury* is depicted as a Subsequent Event, the *Spinal injury* is the agent to change *the Driver* - who is the Object.

Prior event: Roll-over of vehicle

Now consider the Object in the Main Event trio. Was the driver present as a result of some prior event? In this example the driver was engaged on legitimate operational activities with his back resting against the seat; this is normal and needs no further explanation. A similar question is posed to the Agent in the Main Event trio. Was the rollover the result of some prior event? Clearly the roll over is an abnormal situation that needs to be accounted for, so there is a prior event. The Object is the vehicle stability which was changed when the tyres hitting the shoulder of the road.

Prior event: Tyres hit shoulder of road

The new Object (vehicle stability) and the new Agent (tyres hit shoulder of the road) are now examined to determine whether they were the result of prior Events. No further investigation leads are identified for the Object, the stability of the vehicle. The Agent, *tyres hitting shoulder of the road* is a result of deviating from the intended straight course which is caused by lack of control of the vehicle e.g. by the driver falling asleep at times. A convex road and side winds create forces for the vehicle to drift of the road when not properly controlled.

Prior event: Vehicle on the road

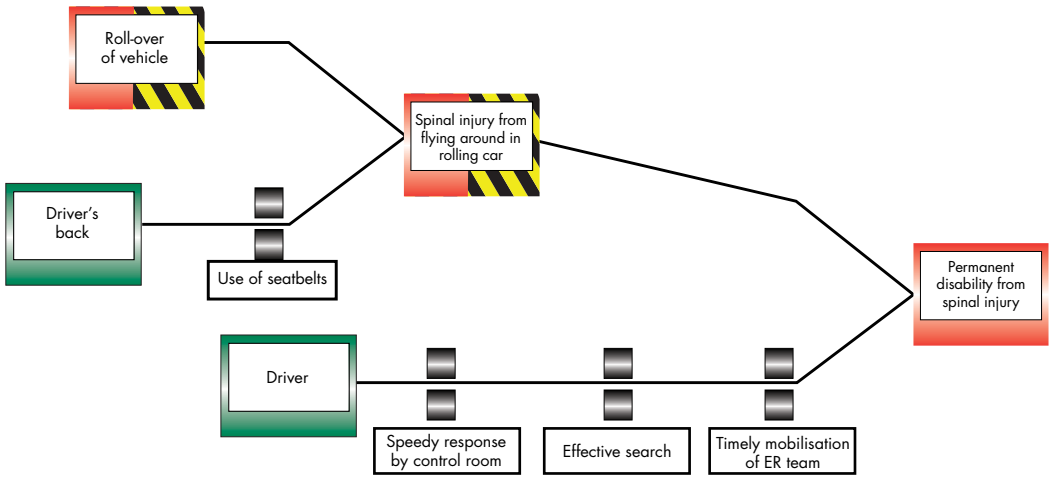
The new agent is therefore *Sideways forces on vehicle from side winds* and *convex road surface*.

No further investigation leads are identified for the new Agent as side winds and convex roads are normal. Remains to consider whether *Vehicle on road* is preceded by another trio. It is found that the need to *transport goods* is the Agent for the safely parked *vehicle in parking lot*, the object, to be result in an Event-Object *Vehicle on the road*.

The Core diagram is now complete, comprising five linked trios. It defines the limits that have been established for the investigation, prior and subsequent to, the 'Main Event'.

Barriers

Ten trajectories have been defined in the core diagram, representing the conceptual paths bringing the Agents and Objects together, resulting in the identified Events. The investigation must now identify the Barriers that should have acted on these trajectories to prevent the Events from occurring. If any of these Barriers had been effective, the sequence of events would have been interrupted causing the



outcome to be different . For the discussion the tree is broken into two parts, the first part dealing with the events after the vehicle started to roll over and the second part dealing with the events leading to the roll over.

The investigators need to examine each trio separately, applying their knowledge of the operational process, investigating further if necessary to identify what barriers had been established:

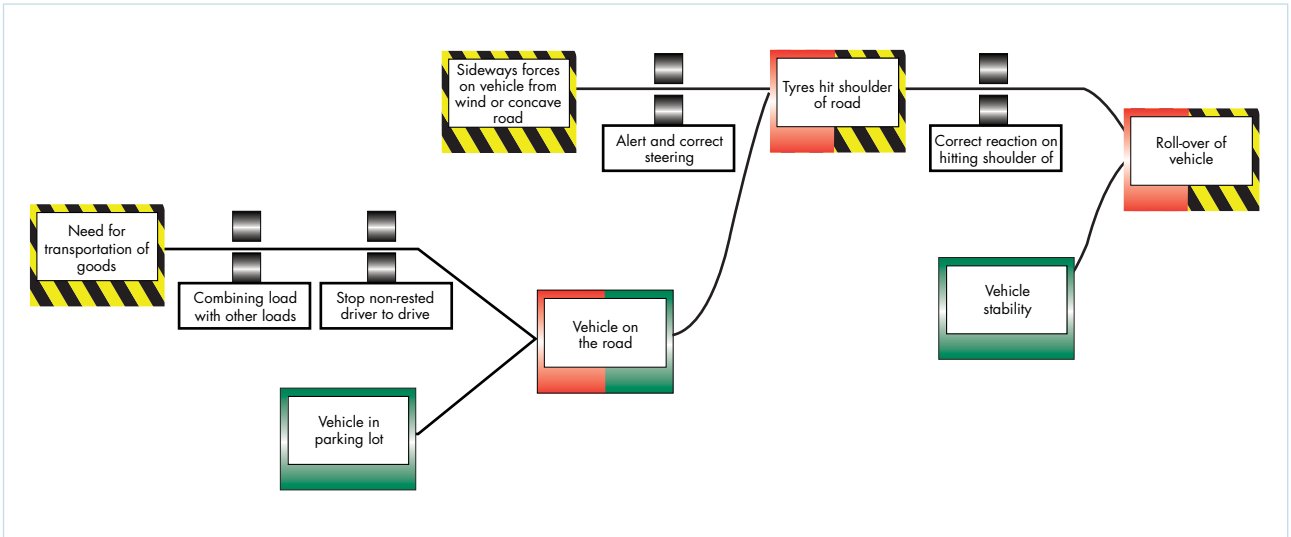
- To control the Agent
- To protect the Object.

Consider the primary injury. The driver's back was injured when the vehicle rolled over. There were no barriers in place to stop the motion of the vehicle once it started to roll. One barrier only could have protected the driver's back (preventing back injury or reducing the seriousness): *the use of a seatbelt*. In the subsequent trio three barriers could have prevented the situation of the driver to aggravate and develop into a permanent disability. All three relate to the timely location of the victim by an immediate response by the control room staff, an effective search by a team that knew where to look and by a timely mobilisation of the emergency response team once the victim had been located. Each of these barriers could have reduced the time that the victim was trying to move with a seriously injured back.

Now we consider the second part of the tree. *The vehicle on the road* could have been prevented in two ways. Firstly the urgency of the load could have been investigated by the logistics planners which would have led to the conclusion that the goods could have been combined with a large truckload which was planned to leave the following day. During the investigation it was discovered that there was no urgency for the goods to be delivered instantly. This consideration would have prevented the crashed vehicle to be on the road at all. Secondly, during the Journey Management discussion prior to departure the Journey Manager is supposed to assess whether the assigned driver is fit to drive and stop the driver if the driver himself states that he is not rested or the Journey Manager suspects that the driver is not rested and fit.

The next barrier is about the driver being on the road. Not being rested and alert does not necessarily mean that the vehicle cannot be controlled. Initially the driver was alert but after a while he occasionally dozed off. A continued Alert and Correct steering would have prevented the accident. Once the vehicle hit the shoulder of the road the driver woke up again and should have steered his vehicle onto the road in a controlled manner as taught in training courses.

At this moment one should consider the entire tree again and check whether anything else could have stopped the sequence of events. This is best done as a team effort. The HSE Case, procedures and instructions that relate to this incident should be considered to make sure that all barriers mentioned in there have been reflected in the tree.



Tripod Causation Paths

Each of the eight failed barriers has a Tripod causation path:

- The Immediate Cause that defeated the barrier.
- The Precondition(s) that caused or promoted each Immediate Cause,
- The Underlying Cause(s) that created each Precondition.

Although in some cases there may be shared causes, these paths can be investigated independently from each other.

Barrier: Combining loads with other loads

Immediate Cause

Journey Manager misses opportunity to combine loads. This is a knowledge based mistake that has become common place. There is a need to look at system to get correct information to the individual in an understandable manner

Precondition

The Journey Manager believed that an urgent delivery was required as stated on the requisition. Although he had noticed that almost all requests for transport came with an "immediate" status he did not enquire what "immediate" meant.

Underlying Cause

Communications between Journey Manager and the customers left to be desired. Usually the customers ask for immediate delivery because it is their experience that sometimes loads take weeks to be delivered if not specified as "immediate". Simple phone calls or regular meetings to discuss delivery issues do not take place.

Barrier: Stop Non-Rested driver

Immediate Cause

Journey manager does not stop the non-rested driver. A violation on the rules that would appear to be routine. Culture and organisational issues that encourage this need to be investigated.

Precondition 1

Journey Managers have a responsibility to verify that drivers are competent, physically fit for the job and rested. However, this is usually not done and the Journey Manager assumes that every driver on his doorstep is competent and rested. He has never been told about the need to check the suitability, fitness and alertness of drivers and it is not stated in any of the manuals that were issued to him.

Underlying Cause

Fitness and resting of drivers has not been addressed in the journey management procedure and has not been considered as an issue. The Journey Management Plan procedures have weaknesses in many respects.

Precondition 2

The Journey Manager has no other choice then to use the driver that is available. He beliefs that the job cannot wait and there are no other drivers available at that moment. So he decided that the job has to be done by the driver that is available

Underlying Cause

See above under "combining loads"

Barrier: Alert and correct steering

Immediate Cause

Driver fades out on and off behind the wheel. A lapse and possible violation of "pull off and stop" policy.

Precondition 1

Drivers should be informed that adequate sleep is important to ensure alertness, and that many serious road traffic accidents are caused by sleepiness. The other fact that drivers should know is that sleep is the only remedy against sleepiness. Taking a 20 minute nap combats sleepiness effectively. This driver was convinced that he was doing the right thing by rushing for his delivery and not allowing himself a nap. He believed that immediate service was expected from him and he tried to keep himself awake by singing, loud radio and chewing gum.

Underlying Cause

The company does not provide Advanced Driving Courses for its drivers in which knowledge about the relation between safe driving and driver alertness is addressed.

Precondition 2

Driver beliefs that even with a couple of hours of sleep he can drive safely. He has done this before and so far has been able to complete his trips without accidents. He considers it as a weakness to admit that he has sleeping problems and feels that he may loose his job.

Underlying Causes

There are not enough drivers for the number of trips required so sometimes drivers arrive home late and have to start very

early to get cargo loaded. Together with travel between the yard and his home he frequently has less than 8 hours at home during which he has to wash, eat, socialise and sleep. The company does not maintain any control over the length of time in-between duties (work-life balance). Company does not provide Advanced Driving Courses in which the need for regular deep sleep is explained.

Barrier: Correct reaction on hitting shoulder of the road

Immediate Cause

Driver overreacts when waking up and over steers vehicle This is mostly an instinct reaction that is difficult to resolve by training.

Precondition 1

Driver beliefs he is a good driver and while waking up he does not take a conscious action; there is hardly a thought process. The prime reaction is to get back on the road as quickly as possible (rather than slowing down and gently steering back onto the road).

Underlying Cause

The company does not provide Advanced Driving Courses for its drivers in which skills in regaining control is practised such that they become routine.

Barrier: Use of seatbelt

Immediate Cause

Driver failed to use seat belt. In a statement to the investigation team he maintained that this was a 'one off' lapse caused by his being preoccupied with his task. Further interviews with relevant staff suggest that the requirement to wear seat belts was insufficiently stressed during induction. In the country where the incident happened seat belts are not required by law, and many newcomers were under the impression that it was a strong Company recommendation but not a requirement. A violation that appears to be routine.

Precondition

The local Safety Induction Trainer incorrectly interpreted management policy relating to seat belts. This lead to the use of seatbelts not seen as part of 'driving safety culture' and whereas most drivers in the area consider the use of seatbelts as "childish" the driver concerned in this incident also preferred not to use a seatbelt.

Underlying Causes

Management failure to ensure that their policies are correctly communicated and interpreted. (Communication). Local culture stimulates risk taking, "macho driving" etc. and discourages compliant behaviours.

Barrier: Speedy response by control room:

Immediate Cause When the control room was alerted there was a 15 minute delay before there was any response.

Precondition

The control room staff occasionally had to attend to outdoor duties during which they could not always be contacted. Control room staff just did what was expected from them and did not express any concerns to there boss that they may not be able to respond quickly to emergencies when attending to their outdoor duties.

Underlying Cause

Shortage of operators due to cost cutting drive in combination with a lack of courage of operators to speak up when they cannot meet all demands put on them (afraid of being sacked with the next cost cutting round).

Barrier: Effective search

Immediate Cause

Search team was delayed in finding the car because route that driver should take was not documented or communicated. A violation of the journey management process.

Precondition

Search team were unaware of exact location of the accident.

Underlying Cause

Failure by the owner of the Journey Management Plan to ensure that those operating under the Journey Management Plan were adequately trained and competent in their use e.g. with respect to discussing the route to be taken, documenting the route and stressing the importance of not deviating from the route without clear communication with the home base.

Barrier: Delayed Search:

Immediate Cause is a failure by Duty Manager to initiate a search operation within target time (Journey Management Procedures call for search to be mounted within 45 minutes of overdue alert). In this case it took 75 minutes.

Precondition

The emergency response team attended the party to celebrate the 40 anniversary of the communications officer with coffee and cakes.***Underlying Cause***

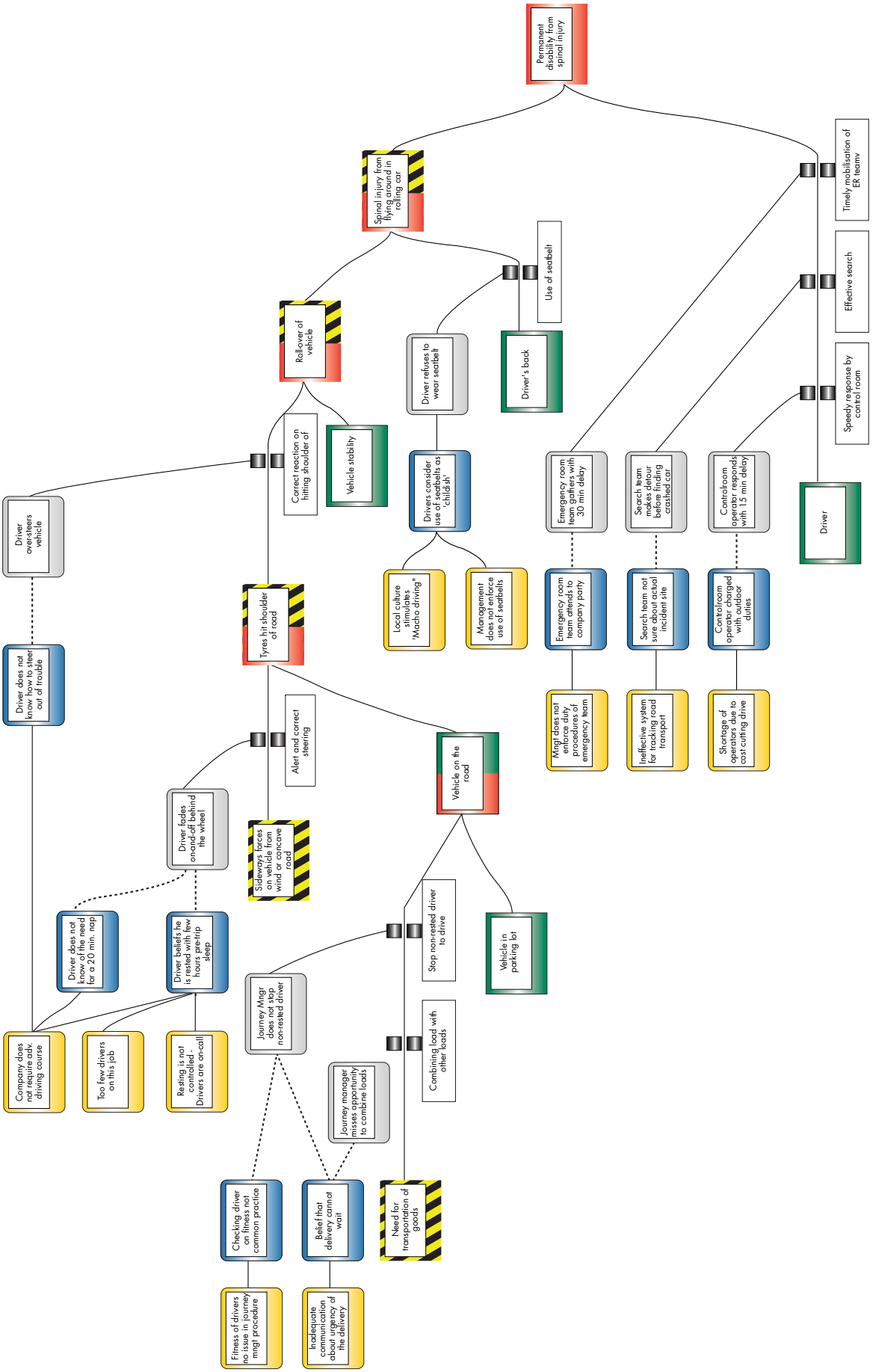
Management does not enforce regular exercises at random moments to check functioning of the Emergency Response System and to stress the need to adhere to duty procedures.

Vehicle design:

Further investigation established that the vehicle design was essentially 'fit for purpose' with respect to occupant protection. The Procurement Department have in place specifications for the vehicle the company should buy and this particular vehicle had done extremely well in crash tests. Rollover damage resulting in vehicle write-off is a comparatively rare event (fewer than one in 20 vehicles is damaged to this extent in a rollover). Previous studies indicate that attempting to avoid this damage by special vehicle design or modification would not be feasible.

Recommended Action

Recommendations are now required addressing each of the Failed Barriers (vehicle design now excluded), specifying actions that will restore the barriers at least on a temporary basis, and addressing the eleven identified Underlying Causes.


Permanent disability from spinal injury
Spinal injury from flying around in rolling car
Use of seatbelt
Timely mobilisation of ER teamv
Effective search
Speedy response by control room
Roll-over of vehicle
Driver refuses to wear seatbelt
Driver's back
Driver
Correct reaction on hitting shoulder of
Vehicle stability
Drivers consider use of seatbelts as 'childish'
Emergency room team gathers with 30 min delay
Search team makes detour before finding crashed car
Controlroom operator responds with 15 min delay
Driver over-steers vehicle
Local culture stimulates 'Macho driving"
Management does not enforce use of seatbelts
Emergency room team attends to company party
Search team not sure about actual incident site
Controlroom operator charged with outdoor duties
Tyres hit shoulder of road
Driver does not know how to steer out of trouble
Mngt does not enforce duty procedures of emergency team
Ineffective system for tracking road transport
Shortage of operators due to cost cutting drive
Alert and correct steering
Vehicle on the road
Driver fades on-and-off behind the wheel
Sideways forces on vehicle from wind or concave road
Driver does not know of the need for a 20 min. nap
Driver beliefs he is rested with few hours pre-trip sleep
Stop non-rested driver to drive
Vehicle in parking lot
Journey Mngr does not stop non-rested driver
Company does not require adv. driving course
Too few drivers on this job
Resting is not controlled : Drivers are on-call
Combining load wth other loads
Journey manager misses opportunity to combine loads
Checking driver on fitness not common practice
Belief that delivery cannot wait
Need for transportation of goods
Fitness of drivers no issue in journey mngt procedure
Inadequate communication about urgency of the delivery

Annex 9: Performing an Investigation

Introduction

It is imperative to learn from incidents, which have created loss (or potential loss), if the chances of these losses recurring are to be minimised. Therefore, a systematic investigative approach, thorough pre-investigation planning and the pooling of experience and expertise wherever possible within the organisation, is vitally important. This annex provides details of that approach.

Basics

Qualities of an Effective Investigator

Effective investigations depend heavily on a disciplined approach and also on the attributes of the investigator, i.e.,

- Integrity to be above any influences that may distort information. Fact-finding requires truthful disclosures.
- Objectivity and an open mind to avoid premature conclusions and also to be receptive to evidence contrary to hypotheses. Opinions need to be secondary to the information revealed by the objective evidence.
- Perseverance to trace "symptoms" back to underlying causes. (Tracing the roots of deficiencies into the management systems can be a painstaking task.)
- Curiosity and a persistent desire to know more and question thoroughly.
- To be observant and having an eye for detail in detecting the unusual, out of place, etc.
- Imagination to see alternative states or conditions and compare with the actual that can then stimulate the search for better evidence.
- Humility to consider and recognise the experience, ideas and observations of others.
- Intuition to recognise valid ideas that emerge from the collected data and to recognise a simple solution to a complex problem.
- Tact and patience in revealing and using critical and sensitive information.

Investigative skills in examination of parts, photography, mapping and recording, etc are important but generally secondary to the above qualities.

Timing

An investigation should be carried out as soon as possible after an incident. The quality of evidence will deteriorate rapidly with time, (often on purpose e.g. clean up or restart operations), and delayed investigations are usually not as conclusive as those performed promptly.

Categories of Evidence

Susceptibility of evidence to breakage, distortion or loss, i.e. its fragility, is important.

Evidence can be obtained from anyone or anything that provides knowledge about the mishap. A common and convenient classification of evidence is known as the four P's. This, in order of decreasing durability, (i.e. the least durable last), is as follows:

Papers are most durable and harder to change, however they may be overlooked or altered.

Parts are still durable but subject to pilferage, corrosion, marring and misplacement.

Positions are evidence of physical relationships and sequences. Post-contact positions are less durable as things are moved by emergency response crews and others involved in the incident. They may also be subject to cleanup or a desire for a rapid return to production operations.

People are sources of eye or ear witness testimony to the pre-contact, contact and post-contact phases. This is the least durable type of evidence as peoples memories fade quickly with time and can become increasingly unreliable. However where evidence of the other parts has been previously collected, the People evidence becomes more in the nature of corroboration. Interviews should still be conducted soon after the incident.

Initiating the Investigation

The first step in the investigation and analysis process is to decide on its extent, i.e., intensity, formality, timescale, reporting levels, etc. In order to maximise the organisations opportunity to learn, near misses with high potential severity and consequences should also be investigated, and as thoroughly as those where harm did actually occur.

This classification of incidents is normally based on:

A. The **actual** severity level of harm caused and/or
B. The **potential** harm that could have resulted from the incident and the likelihood of it happening.

"Near misses" are classified, using a risk matrix, as "High". "Medium" and "Low Risk" Incidents. Actual incidents are based on a categorisation of severity levels of harm.

From the classification of the incident the Investigation team leader is appointed. The higher the severity, (or risk for "near misses"), of the incident, the more senior the team leader is likely to be.

Investigation Team members are then appointed. As the investigation proceeds it may be necessary to change team members or co-opt specialists for specific inputs and advice.

Terms of reference for the incident investigation and analysis are issued which, for example, include:

- A clear understanding of the current situation;
- The roles, requirements and accountabilities of all team members;
- The scope of the investigation and its boundaries;
- A clear understanding of the deliverables and key milestones, e.g., start, interim report, final report;
- The requirements to validate findings;
- The final report format; and
- The need for actions on failed and missing barriers and also those to correct underlying causes.

Pre-Investigation Planning

Due to the fragility of site evidence planning for on-site readiness ensures a well coordinated and rapid response to incidents. A standard "ready to go" list of equipment required to conduct investigations of different types of incident would be useful.

Such items could include for example; camera, first aid, clipboard, audio recorder, graph paper, recording forms, tape measure, barrier tape, sample containers and evidence bags, identification tags, mirror, torch, etc. Protective equipment to meet universal precautions in the handling or contact with human body fluids is also essential.

Before visiting the incident location, appropriate background information should be obtained and could include:

- Procedures and standards for the type of operation involved;
- Risk assessments related to the incident;
- Records of instructions / briefings given on the particular event or job being investigated;
- Location plans;
- Organisation chart; and
- Product information.

Fact Finding

Evidence gathering Plan

The process of gathering information and evidence involves the following steps:

1. Collecting physical evidence (identifying, documenting, inspecting and preserving relevant material)
2. Collecting documentary evidence
3. Collecting human evidence (locating and interviewing witnesses)
4. Examining organisational concerns, management systems and line management oversight

Initial Actions and Observations

The conduct of the investigation follows a number steps beginning with the initial actions and observations and then followed by the detailed examination and recording of evidence.

The investigator should not overlook concern for own safety and that of others in the haste to respond. Determine priorities as early as possible on entering the scene, however, do not approach until it is safe to do so.

Decide on priorities such as, controlling site access or seeking more assistance. Emergency services may have necessarily interfered with the scene in the removal of injured or other parts and in order to bring the situation under immediate control, prior to your arrival. This is an example of the fragility of evidence.

The scene may well be confused particularly if a spectacular event has occurred. Site evidence is the most transitory and disappears first. Witnesses may be lost in a crowd or leave the site. Items and materials may be removed.

Much of the site evidence is short-lived hence it is important to act quickly to collect it. Rough sketches and photographs and careful visual observation will be vital in later reconstruction.

The initial identification should include:

- the people involved (injured and witnesses);
- equipment and tools involved (in use, on stand-by and secured or standing);
- materials (in use, ready for use and stored in the area);
- environmental factors (weather, lighting levels, heat, noise).

Recording the Incident Scene (Position)

Important facts can be gained from observations made at the scene of the incident, particularly if the location is kept is undisturbed. However, rescue operations or the presence of residual hazards may necessitate moving some of the equipment, but, if possible, the site should be kept "as is" until at least a preliminary investigation has taken place.

Photographs, both colour still and video as appropriate, should be taken to record the physical relationships, e.g. between people, tools, and equipment involved in the incident. The position of valves, switches, recorders etc, should be recorded.

Sketches should be made and include any reference measurements of distances, angles, locations.

Physical Evidence (Parts)

This phase begins after the more fragile evidence of positions is recorded. Physical evidence includes the condition of such items as; tools, equipment; materials; hardware, plant facilities; scattered debris, liquids and possibly gases, etc.

Normally physical evidence should not be removed until witnesses have been interviewed, as visual reference can stimulate their memory.

Items need to be systematically labelled, collected, protected, preserved, evaluated and recorded.

A log should be kept of location, date, time and description of evidence and controlled by signature transfer i.e. a chain of custody.

Documentary Evidence (Papers)

Documentation is the least susceptible type of evidence to loss, distortion or compromise, and may provide information relevant to the investigation. For example, written instructions and procedures may provide evidence of pre-planning and individual responsibilities. The investigation could establish the extent to which these procedures and instructions were understood and acted upon as this could indicate the effectiveness of training and supervision.

The role and functions of management systems must be considered when collecting and reviewing evidence. These can be used to develop questions that will guide evidence collection and analysis of the management system at all levels.

Documentation is a vital source of evidence in examining and comparing the 'actual' and 'expected' performance of systems and people. Documentary evidence may exist in a variety of forms and locations as indicated below.

- Automatic recording devices; voice recordings, work instructions,
- Management policies
- Procedures and standards
- Risk assessments and studies
- Purchasing documents
- Maintenance routines and records
- Personnel records
- Related incident reports
- Work assignment and instructions, electronic and paper.
- As-built drawings
- Inspection records
- Audit reports
- Log books
- Tachograph records

As with the collection of "parts" data, it is important to determine how the documentation relates to improving understanding of the incident process. The investigator need not be an expert in the aspect under study however the required knowledge can be obtained from the appropriate personnel and system specifications.

In many cases the identification of relevant documentary records becomes evident as a result of the **iterative** process of evidence collection and analysis.

A factor to consider during an investigation is recent change. It has often been found that some change occurred prior to an incident which, combining with other causal factors already present, served to initiate the incident. Changes in personnel,

organisation, procedures, processes and equipments should be investigated, particularly the hand-over of control and instructions, and the communication of information about the change to those who needed to know.

Conducting Interviews (People)

Introduction

Following the collection of the positions, parts and papers evidence, interviews with witnesses should be carried out as soon as possible after the incident. Whilst the intervening time and discussions with others can influence a person's recollection of events, the interviewer's knowledge of the evidence from the other 3 P's can beneficially influence the outcome of the interview.

The value of a witness's input can be greatly influenced by the style of the interviewer whose main task is to listen to the witness's story and not to influence it by making comments or asking leading questions. This requires patience and understanding.

An investigation team is often seen in a prosecuting role, and witnesses may be reluctant to talk freely if they think they may incriminate themselves or colleagues.

An investigator is not in a position to give immunity in return for information but must try to convince interviewees of the purpose of the investigation and the need for frankness. It should be stressed that the investigation is not seeking to apportion blame but is attempting to understand the reasons for the failures which caused the incident so that they can be corrected and future such incidents prevented.

It is important for the interviewer to have terms of reference regarding his role and responsibilities. These should be formulated by the body overseeing the investigation.

From a Tripod Beta perspective, the investigator is establishing the exact nature of the Immediate Causes that resulted in failed barriers, the human errors which caused the sub-standard acts and the 'influencing' conditions that promoted the human errors. Once these influencing factors have been identified, the emphasis of the investigation moves to interviewing those associated with the underlying causes and the weaknesses in the management system which created them.

The Interviewer

Witnesses are greatly influenced by the personality and mannerisms of the interviewer. Many have had uncomfortable experiences with higher level managers and staff officials and distrust their motives.

The interviewer should present a neat, neutral appearance. He should be relaxed, receptive, objective and adaptable, listening to what the witness says. He should make the witness feel that he wants to talk with him and time is not a factor.

Attributes of the Interviewer

Positive Interviewer attributes include:

A. **Respect** which is communicated through a caring manner and taking an interest in the interviewee. Using appropriate tone of voice, inquiring after their comfort and wellbeing communicates respect and value.

B. **Empathy** by the interviewer putting himself in the interviewee's shoes and recognising how they may be feeling etc.

C. **Genuineness**, i.e. being honest and open with the interviewee

D. **Relaxed** manner and approach which can help put the interview at ease.

E. **Receptive** listener which involves an appropriate mix of nonverbal signals (nodding, facial expressions, leaning forward etc) that visually display interest as well as the verbal skills of questioning and paraphrasing to check for understanding.

F) **Objectivity** which requires the interviewer to be aware of any prejudice, presumptions or bias that could interfere with their listening.

G) **Adaptability**, i.e. flexibility to adapt to changed arrangements, modified schedules and shifting observations of what happened.

H. **Preparedness** to be clear on the information being sought and in a systematic manner rather than in an ad-hoc' or 'take it as it comes' approach.

Negative Interviewer attributes include:

A. The **commanding type** interviewer may frighten the interviewee into silence by his officious manner and generally interrogates rather than interviews. This mannerism may also induce a witness to forget detail or feel pressed to give some information when he really has no certain facts or knowledge.

B. The **proud, overly confident** interviewer overestimates their personal ability to obtain information. Consequently, they accept the first statements on any aspect as complete and factual because they believe they would instantly recognise any erroneous or incomplete information.

C. The **overly-eager** interviewer induces errors and contradictions in evidence through tendencies toward excessive questions, and/or leading questions. Their anxious manner usually results from being eager to get to analysis and conclusions.

D. The **timid** interviewer appears to the interviewee as willing to grab the least bit of information and run. Their manner raises doubts in the interviewee as to whether producing information will serve any useful purpose, so the interviewee may respond with superficial comment.

E. The **prejudicial** interviewer reacts to aspects of the interviewees dress and mannerisms. They tend to stereotype the interviewee at first contact and hear only what they expect to hear. They may also impart resentment over the incident that has taken them from important work and involved him in investigation.

Conflicts of Interest

Conflict of interest may exist where the interviewer realises that they are not able to be independent/objective because of some past or present commitment to the organisation, the branch involved, the section or an individual involved in the incident.

The primary obligation is to collect the evidence for the team in an objective manner. Where any member of a team assesses that they cannot operate objectively, because of some past or present relationship, (positive or negative), they should discuss this with the Team Leader immediately.

The Interviewee

Interviewees can be identified as :

- Principal witnesses - persons actually involved in the incident,
- Eyewitnesses - persons who directly observed the incident or the conditions immediately preceding or following the incident,
- General witnesses - those with knowledge about the activities prior to or immediately after the incident.

Attributes of an Interviewee

People do not fall into neat, constant categories but may have some aspects of each under differing circumstances during the interview. The following distinctions of possible character types may be useful for an interviewer to observe the interviewee through; however, they must be 'held loosely' so as to not fall into the trap of 'pigeon holing people'.

Extrovert

The extrovert can be a very convincing interviewee. They can be positive in their responses, adamant about their observations, conclusions and suggestions. They can be delighted to have the attention brought to them by virtue of their witness. Their evidence may not be as correct as it appears.

Introvert

The introvert can appear to seemingly be a poor interviewee. They may be unsure of facts and indecisive in responses. Interviewing them may seem a waste of time but they might have the most important information.

Suspicion

The suspicious interviewee may be reluctant to get involved. They tend to hate publicity and may overly guard their privacy and resent being questioned. They probably will decline to give a written statement. They may question the use of information, the possibility of appearing before company executives and the value of investigations etc. They may tend to discourage the interviewer before they reveal the information they possess.

Illiterate

The illiterate interviewee presents a delicate situation. They may appear timid and hesitant, to cover the illiteracy, or decline to give a statement for this reason. If their command of language is limited, they may feign lack of knowledge of

the incident to cover there fear of shame should they make errors in grammar or expression. It will need compassion and patience to draw out the testimony.

Prejudice
The prejudiced interviewee is ill suited to give testimony. Even when honest and not personally involved, they may believe the company, the government, a supervisor or another worker who they are prejudiced against is always wrong. They may make corresponding assumptions and conclusions that blind their observations and distort the testimony.

Such behaviour may be identified by allegations like "I tried to tell 'them' but nobody ever listens to me" or that "he/she never does anything right." The interviewer can't ignore the prejudiced testimony but will have difficulty determining how much of it is valid.

Excitable
The excitable interviewee tends to exaggerate, elaborate and distort evidence. Witnessing the incident is the most exciting thing that has happened to them so they tend to provide information in volume. They tend to be basically honest but stretch facts and embellish what they recall to fill knowledge gaps to overflowing.

Reticent
The reticent or 'know-nothing' interviewee is the one identified as a prime witness who insists they do not know and did not see anything.

Hostile or Devious
The devious interviewee may distort their testimony to avoid personal implication or unfavourable reflection on an associate. They may also alter their evidence in an attempt to divert an interviewer from an area where a malpractice unrelated to the incident may have occurred. The hostile interviewee may hold back to avoid implication.

Impact on personal state
Following a stressful incident in the workplace it is common for those involved, both directly and indirectly, to experience some physical, emotional and/or mental symptoms. These may include physically shaking, disturbed sleep, vivid memories or flashbacks, strong emotions including agitation, sadness (tearful), anger, or just feeling flat. It is NORMAL to have these sorts of reactions and the interviewee can be provided with suggestions to help cope.

Assessing personal state
Given the possible impact on personal state it is important for the Interviewer to be observant both visually and in their listening for indications of physical, emotional and/or mental symptoms. Any assessment of such symptoms will be done through the 3 components of a message:

Word content
Listening to the actual language/words used that may in indicate emotional or mental issues.

Vocal content
Listening to the tone, emphasis, volume, intonation etc that may indicate emotional or mental issues.

Non-verbal content
Watching for body language that would indicate any physical, emotional or mental issues.

Interview Preparation

Requirements
Interviewing is about confirming the physical evidence so it is necessary to identify.

- What is being looked for to confirm or refine the developing incident model.
- Who needs to be interviewed to gather the information.

Allocation of Interviewers
Interviewers should be matched to interviewees on the basis of the abilities and experience of the team members. For example, if an Engineer is to be interviewed and there is an Engineer on the team it may be best to link then together.

Allot time, dates and locations
An interviewee must be comfortable and at ease and, if an interview at the incident scene is not practical or is undesirable, it is preferable to conduct the interview in a neutral or unthreatening location.

The executive offices, or even the supervisor's office, are not neutral grounds to most interviewees. A small classroom, waiting room, or library room will be more satisfactory and productive for interviews. Privacy is essential and the first interview should be a single interviewer to single interviewee discussion with a designated note-taker sitting

a short distance from the interview. (See below; Recording the Interview.) Research has shown this to be the best approach, leading to most accurate testimony.

Conducting the Interview

Introduction

A friendly, understanding, and compassionate manner in a respectful and relaxed atmosphere can put the interviewee at ease. Politeness and patience are critical as first contact is made.

Setting the scene

The interviewer should explain the nature of the investigation by telling the interviewee what the interviewer's position is and why the incident is being investigated. Also, the interviewee should be informed that the purpose of the interview is to identify problems and not apportion blame. They should also be told that they will have the opportunity to review the draft report before it is published.

Questioning

A. Open and closed questions:

Closed questions are those that can only be answered by 'yes' or 'no'.

This type of questioning is useful for obtaining or establishing definite facts, e.g. Did you see this happen? - Yes - Was it dark outside? - No

The closed question can also be used to guide or direct the conversation in a particular direction as follows: Was the operator wearing PPE? This question has allowed the interviewer to direct the conversation to the topic of PPE. If the interviewee answers 'yes' the interviewer would follow with the open question 'what PPE was being worn?'

Open questions are those aimed at exploring another person's thoughts, ideas and observations. They are asked to gather information and use the key words of:

- When did you start to see that happening?
- Where were you standing at the time?
- What was he saying when that occurred?
- How did you contact the supervisor?

B. What happened questions?

Interviewers should avoid using the question 'why' as its constant use makes the interviewee feel as if they are being grilled. An alternative is to use 'how' or 'because' as follows:

- Why are you finding it difficult at work? = How is it difficult at work for you?
- Why did you do that? = You did that because?

The interviewer will be clear about the information to be collected and should commence with the open question 'What happened?".

It is important to ask 'what happened' rather than 'why' because asking 'why things happened' tends to inadvertently push the interviewee to 'interpretation/assessment/story/assumption' rather than staying with the actual observations of the event.

C. Control questions

During the interview, the interviewer should introduce 'control' questions to ensure accuracy of statistical data as well as permit subsequent evaluation of the reliability of information supplied by the interviewee. The control questions should include those to ascertain for example.

- Time and location of the incident,
- Environment: - weather, lighting, temperature, noise, distractions, concealment. Include pre-incident, incident and post incident periods by specific question ,
- Positions of people, equipment, material and their relationships to pre-incident, incident and post incident events. Include the position of the interviewee.

D. Statements rather than questions

Too many questions can make a person feel grilled and using statements can provide some respite as follows:

- 'So, your friend was badly hurt - I can imagine that might have triggered off some strong emotions for you'
- 'I understand that the concern about the boiler was raised at a recent safety meeting'

Clarification

During an interview the interviewer may be confused or uncertain about what the interviewee is saying, and it is important to gain clarification.

A way to seek clarification is to paraphrase what it was thought the interviewee said. This involves reflecting back to the interviewee what they have just said but in the words of the interviewer. This serves three important purposes.

- It lets the interviewee know that the interviewer has been listening.
- It allows the interviewer to check the accuracy of the listening.
- It allows the interviewee to hear what they have been thinking from another person who can give perspective on the issue and help them clarify if this is really what they think or not.

Alternatively the interviewer could simply ask the interviewee to repeat their point as follows, e.g.

'I'm not sure I followed what you just said. Could you go over that again?'

Non Verbal Communication

The credibility of an interviewee may be assessed through the window of 'non-verbal language' or 'body language'. Considerable research is now available and various connections have been made to suggest what various gestures may be communicating. This subject is beyond the scope of this manual but further reading on it should be undertaken to enable more effective interviews to be undertaken.

Recording the Interview

The interviewer cannot and should not rely on his memory of information provided by the interviewee. Asking permission or stating that notes will be taken should be explained up front.

Notes will help the interviewer keep the interview organised and provide an accurate record for review for analysis.

Note taking should be unobtrusive so it is not distracting to the mental train of the interviewee. They should record essential points of evidence, but neither verbatim nor so extensive that the natural pace and flow of the interview is affected. Forcing an unnatural pace on the interviewee could cause their recollection of events to become disjointed with vital points forgotten as a consequence.

It can be useful to have a designated note-taker sitting a short distance from the interview. This allows the interviewer to focus on the interviewing task and also provides a corroborative party.

Concluding the Interview

The question, "Is there anything we missed or is there something you want to share with us?" Should be asked. This may bring out an issue that has not been covered in the interview or give the person being interviewed the opportunity to go back to a question that, on reflection, feels was not adequately answered or that the answer may have been misunderstood.

Also, questioning the interviewee for suggestions on prevention of the incident is a good method to close the interview after other questioning has been exhausted. It is an area best left until the end of the interview because it asks the interviewee to draw conclusions, including inferences and giving opinions, thus changing the tone of the interview from the fact-finding exercise.

The question has several values.

- It stimulates the individual to think incident / loss prevention.
- It provides a reservoir of ideas for the interviewer to draw from in his corrective action plan.
- It may lead the interviewer to an area of management deficiency the interviewee was deliberately avoiding for fear of repercussions.
- It reaffirms the purpose of the interview in the mind of the witness and will promote further co-operation.

Interviews should always be ended with thanks for the interviewee's time and co-operation, plus an invitation to contact the interviewer should they remember any other observations about the incident.

The interviewer can promote additional co-operation by specifically mentioning some facts or suggestions the interviewee has given that appear to be of particular value. This communicates that the interviewer was interested and really took note of what the interviewee had said.

Additional Interviews

After the interview the findings should be reviewed and checked with the investigation team to see that all items have been addressed and all questions answered. The information gained should corroborate the physical evidence.

As Tripod Beta methodology is an iterative process between investigation and analysis, further interviews are likely, e.g. to find further information or resolve points of conflict in the evidence.

Establishing the Sequence of Events

Being able to state the location of people, equipment and materials as an incident unfolds, assists with cross validation of evidence and identification of gaps. It is important to recognise that gaps are often inevitable due to the retrospective nature of the investigative process but the absence of data at certain points should not be allowed to delay the investigation.

A number of techniques are available to help the investigators to make sense of the data gathered, e.g. Timeline; Sequentially Timed Event Plot (STEP); Tripod Beta Agent-Object-Event trios;

Timeline

This is simply a list of events in chronological order and is useful in that it can be readily compiled. However, it does have a limitation of not providing visibility of the spatial relationships involved.

Sequentially Timed Event Plot (STEP)

A STEP is a means of assembling the facts obtained in a structured manner. It identifies the actions and events of key "actors" in the incident and plots them against time. The "actors" can be people, vehicles, items of equipment, equipment parameters, etc. The scale of the time axis is normally not linear but varies to suit the interval between events. Each event is described in terms of date/time, actor, and action.

A STEP diagram is often helpful in the first attempt at constructing the AEO trios in a Tripod Beta tree.

An example of a STEP Diagram is shown in on the next page.

Agent-Object-Event Trios

The Tripod Beta methodology links AOE trios to describe the sequence of events before and after the main event in an incident. The Tripod Beta software records the date/time of these events and so establishes the sequence of events of an incident.

Specialist Support Studies

Incidents of a technical or complex nature often require specialist input and further studies to determine the causes of failures.

Major outbreaks of disease, aircraft crashes, crane failures, plant explosions, IT system crashes, are examples of such incidents where specialist advice will probably be required. This should be rapidly identified and the specialists involved early in the investigation.

Specialist disciplines available depend on the factor under study, for example; occupational hygienists; ergonomists; chemists; physicists; engineers, accountants, doctors, etc.

A wide variety of sophisticated techniques are available for the detection and analysis of substances and materials. Commercial laboratories and universities are potential sources of technical support for undertaking the detection and analysis of substances and materials.

Evidence Development

The following provide a range of techniques for guiding the detailed collection and development of the evidence. This can provide further insight into the process, fill gaps in the data and reveal areas for further investigation.

The ultimate purpose of these different approaches is to gain a clear understanding of the incident mechanism, failed/missing barriers, and the event sequence, and thus provide further input to the Tripod Beta analysis.

A. Re-enactment is a last resort technique due to the real risk of recurrence. It should be used only when:

i. There is no alternative way of gaining the information,
ii. It is necessary to observe first hand the step-by-step process,
iii. It is essential to verify key facts, or resolve conflicts in testimony.

The person involved in the incident demonstrates the actions taken leading up to the event. (It may be helpful to have an expert in the process as an observer.) In the first run the motions are acted out and explained step-by-step without moving any controls, parts or materials.

After the process is understood each step is repeated in slow motion but only with approval before moving any components or barriers. The last step prior to the incident must not be repeated.

B. Reconstruction is an advanced technique which uses models to analyse the events of the incident. These can be examined for characteristics of failure modes and effects, sequences of contact and energy transfer.

The reconstruction technique may involve reassembly and repositioning of damaged parts, sometimes using scaffolding, moulds or props. Scars, marks and impact points can be matched to assess points and intensities of impacts.

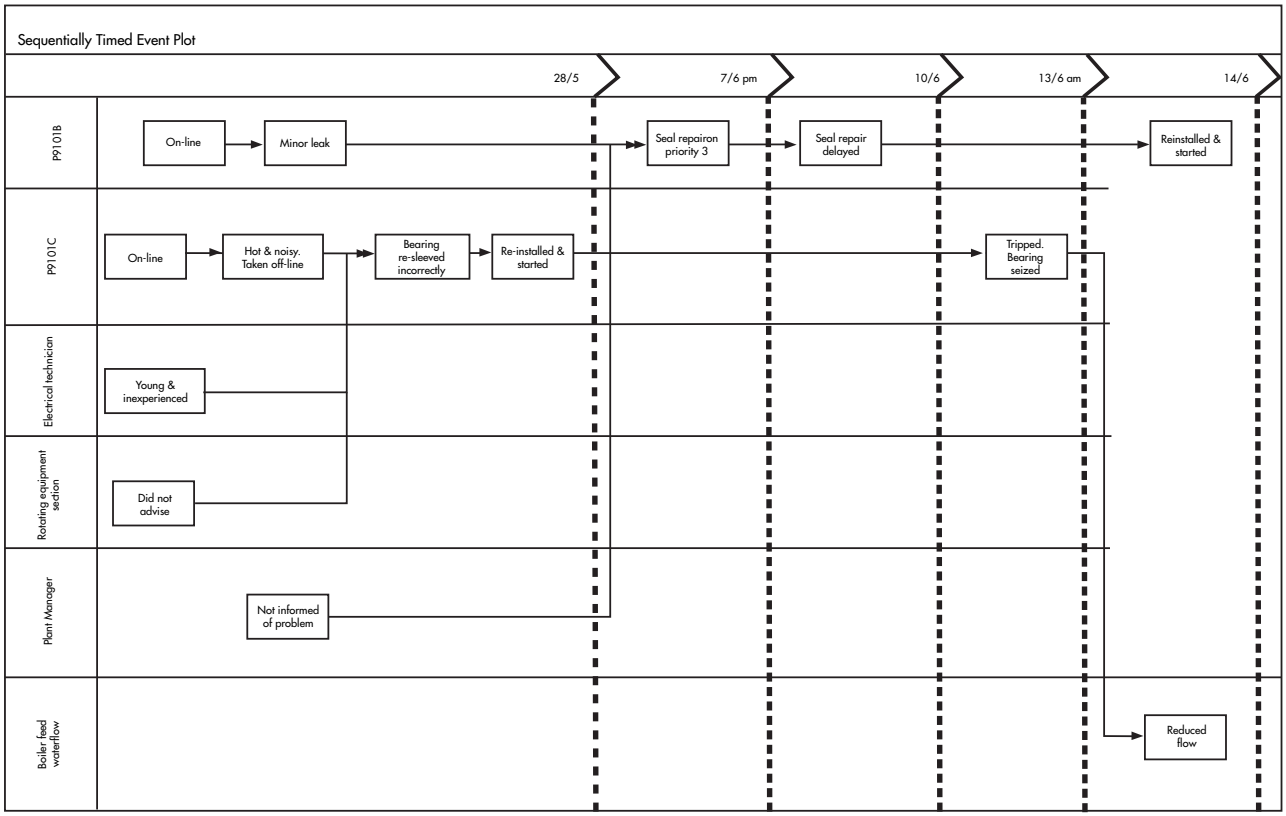
Reconstructed models also enable tests of different incident scenarios to be carried out.

Resolving Conflicts

It is not unusual for witnesses to give differing accounts of an incident. Human memory can be unreliable and, even if not motivated by self protection, or other subjective arguments, one person's recollection of an incident can differ from another person's in important details.

Faced with conflicting witness statements, investigators should look for the similarities between the statements and commonality with other evidence. The objective is to use the evidence to understand the incident and not prove the accuracy of individual statements, nor apportion blame.

This is best dealt with by having access to evidence of Positions, Parts and Papers before the interviews are conducted.



Annex 10: Previously used terminology

Tripod Beta was initially used to analyse Health, Safety and Environmental incidents in the Oil and Gas Industry. However, some of the terms used caused confusion when Tripod Beta was used to analyse incidents other than HSE, e.g. business interruptions in general, and also in industries outside the Oil and Gas industry. Accordingly some terms have been changed accordingly as shown below.

Current Term	Previously used Term
Agent of Change	Hazard
Barrier	Control and Defence
Basic Risk Factors	General Failure Types (GFTs)
Core Diagram	Core Diagram
Effective Barrier	Effective Control/ Defence
Errors	Errors
Event	Event
Failed Barrier	Failed Control/ Defence
Immediate Cause	Active Failure
Incident	Incident
Inadequate Barrier	Inadequate Control/Defence
Lapse	Lapse
Missing Barrier	Missing Control/Defence
Object	Target
Pre- Condition	Pre-Condition
Slip	Slip
Sub-Standard Act	Unsafe act
Sub-Standard Condition	Technical failure
Trios	Trios
Tripod Beta Practitioner	Tripod Beta Facilitator
Tripod Beta Tree	Tripod Beta Tree
Underlying Cause	Latent Failure

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More information on Tripod Beta training and accreditation and the other Tripod tools like the proactive Tripod Delta, the occupational health related Tripod Sigma and the investigation tool Track can be found on **www.tripodsolutions.net**

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