

PETRONAS TECHNICAL STANDARDS
HEALTH, SAFETY AND ENVIRONMENT

TRIPOD-DELTA – THE INVESTIGATION TOOL
(GUIDELINE)

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PREFACE

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HSE MANUAL AMENDMENT RECORD SHEET

Chapter No.	Section No.	Description	Issue No.	Date	Rev No.	Date	App'd by: (initial)
All	All	Tripod-Delta-the Prediction tool	1	June 05	0		IGA

Chapter No.	Section No.	Description	Issue No.	Date	Rev No.	Date	App'd by: (initial)
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INTRODUCTION

Tripod-DELTA is a diagnostic tool for incident prevention based on the Tripod Theory of accident causation. Questionnaires extracted from a pre-established database of indicator questions are completed by site representatives. Answers to the questionnaires are summarised as a profile showing the relative 'health' of the HSE management of an operational unit in 11 separate areas.

This document is presented in three 'stand alone' chapters each aimed at a specific readership. For this reason, some duplication between chapters is inevitable.

Chapter 1 summarises the underlying Tripod Theory and defines the 11 Basic Risk Factors (BRFs). An overview is given of the profiling mechanism, resources involved and the benefits of the application.

Chapter 2 addresses the organisational requirements for initial implementation of Tripod-DELTA in an area of operations - planning , training, resources and communications - and the procedure for customising a generic database.

The purpose of Chapter 3 is to provide guidance to team leaders and participants running Tripod-DELTA Surveys. Human error and the Tripod Theory are discussed, a Tripod-DELTA Survey is described and guidance is given on interpretation of profiles and the process of generating an action plan to address the underlying causes.

For a full overview of the history and TRIPOD concepts, an CD Rom can be optioned from the TRIPOD Foundation

1 MANAGEMENT OVERVIEW

This chapter offers a concise overview of Tripod-DELTA (Diagnostic EvaLuation Tool for Accident Prevention) directed primarily at senior management.

The best way for an organisation to deal with incidents (in this document the term incident encompasses dangerous occurrences, near misses and all recordable incidents and accidents) is to prevent them from ever happening. Incidents cost time, money and sometimes even lives. By devoting resources to prevention an organisation can optimise the business instead of being side-tracked into dealing with the consequences of incidents.

DELTA is a proactive safety tool aimed at incident prevention. It has been specifically designed for operations where remedial information used to improve safety is scarce because of reduced incident frequency or to set a base line in new companies.

DELTA works as a self diagnostic tool which, once implemented, has been developed to run in companies by line personnel with minimum effort but maximum effectiveness. Organisations with a high incident frequency will benefit also from Tripod-BETA, the retrospective application of Tripod, dealing with incident analysis.

The programme is not a replacement for other safety initiatives, but works in conjunction with HSE Management Systems and Health Safety Environment (HSE) Cases, supported under the HSE MS Guidelines.

The main benefits of DELTA are summarised as:

- examines the organisation as a whole and not just safety in isolation
- feedback on potential incident causes before incident occurrence
- prioritisation of action to prevent incidents, targeting resources where they are most needed
- a low maintenance system coupled with a high quality deliverable
- exposes latent failures not normally addressed by traditional safety tools
- self diagnostic run by the line with assistance from the HSE department/focal point
- continual improvement through regular Tripod-DELTA Surveys
- profiling can be conducted at any time therefore avoiding peak work periods
- dissemination of improvements to multiple sites.

1.1 INCIDENTS: SETTING THE SCENE

1.1.1 Why incidents occur

In recent years most organisations have implemented comprehensive safety measures. Initiatives such as Unsafe Act Auditing (UAA), STEP change in safety, SMAT and STOP have contributed to a fall in reportable incidents. However, almost no organisation has reached a consistently flawless level of operations. This is because no matter how well an operation is run, error producing factors will always exist. Such factors include time pressure, continual operational changes in a dynamic environment and the fact that over time, known risks are underestimated and procedures are violated.

Although these factors may continue to trigger incidents, their end result can be controlled to a certain degree. If the organisation is working safely and efficiently the potential of incidents arising from such factors will be reduced. High quality operations are more adept at dealing with crises than organisations pushed beyond their limit. In poor quality operations a small crisis is often the straw that breaks the donkeys back, and something that started out as relatively insignificant becomes a full scale disaster.

1.1.2 Addressing the problem

Error-producing factors can result in either technical failure or human errors. Over the years much work has been done to improve the technical aspects of operations. As technology has progressed, machinery and equipment have become more reliable and safer to operate.

Very little, however, has been done with regard to failures of a human nature. If anything, human error has been used as a scapegoat when no other causes for an incident could be identified.

Research has confirmed that humans will always commit errors and violations. This does not mean that all humans commit the same types of errors. Inexperienced people, for instance, tend to make slips or lapses, e.g. fumbled gear change, exiting a motorway one junction too early or late. Highly experienced people, on the other hand, are more likely to commit violations. Violations are deliberate deviations from a planned action sequence. They are often caused by a person's superior understanding of an operation. It is therefore impossible to label a particular type of individual as prone to making errors. Often, the best personnel make the worst mistakes.

Tripod is a system that addresses human error. It reveals where human errors stem from and attempts to minimise its consequences.

Tripod-DELTA addresses the latent failures that are behind active failures, most of which are caused by human error. It reveals the factors that increase the likelihood of human errors so that they can be addressed.

1.2 TRIPOD: THE THEORY

1.2.1 Background

The Tripod theory recognises 11 determinants, which are critical to the level of control in an organisation. These determinants are called Basic Risk Factors (BRFs). When insufficiently controlled, these BRFs act as Latent Failures in a system and are, in the background, responsible for disruption of the intended business processes. These disruptions may become visible as incidents and accidents. The level of control of these BRFs is indicative for the quality of the management of all business/production processes in different types of organisations (Figure 1).

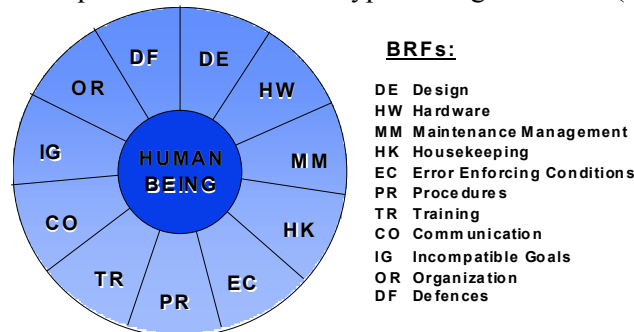


Figure 1 Basic Risk Factors

The Tripod theory has served as basic concept for a method to measure the performance (read: level of control on processes) of an organisation. This method is called Tripod-DELTA Survey and is designed to detect weak areas in the environment in which people are operating. The survey uses questionnaires to collect data relating to factual verifiable operational experiences.

In order to adapt the survey to the practical requirements of the end users, the relative abstract BRFs are each subdivided into 4 aspects (Drivers, Resources, Methods and Output). Each individual aspect is addressing a specific organisational level responsible for the quality of the aspect concerned (Figure 2).

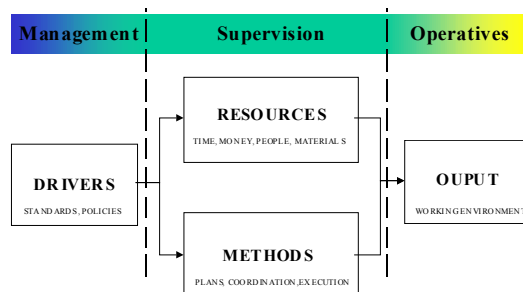


Figure 2 Aspects of Basic Risk Factors

Survey results are presented in a quantitative (a graphical profile) as well as in a qualitative way (a textual explanation about what aspect is weak/strong).

1.2.2 Tripod accident causation model

Tripod is an approach to hazard management aimed at the underlying causes of accidents. It takes its name from the three key aspects of accident causation and is represented as a three-footed diagram (Figure 3). It is best introduced by taking each foot in turn.

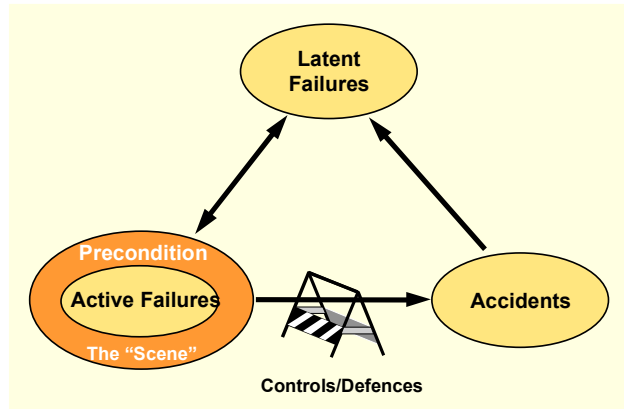


Figure 3 The Tripod framework

1.2.3 Active Failures (Unsafe acts and Technical failures)

Active failures are the events defeating the controls and defences on the hazard trajectory. In many cases these are the actions of people - categorised as unsafe acts in Tripod terminology.

Not all active failures are human actions. Physical failure of controls/defences also occurs due to conditions such as over stress / loading, corrosion or metal fatigue.

Knowing the form of human error helps in the identification of preconditions (see Figure 4).

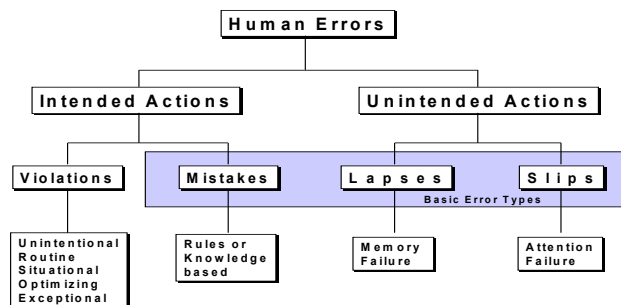


Figure 4 Sources of human error

1.2.4 Preconditions

Preconditions are the environmental, situational or psychological 'system states' or 'states of mind' that promote or directly cause active failures. Table 1 illustrates the

connection between unsafe acts and typical preconditions.

Table 1 Errors (active failures) and preconditions

Error type	Description	Possible Causes	Precondition
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	Organisational deficiency Inadequate training
Routine violation	Habitual deviation from required practice	Natural human tendency to take path of least effort	Indifferent environment (no penalties; no rewards for compliance)
Exceptional violation	Ad hoc infringement of regulated practice	Wide variety - dictated by local conditions	Particular tasks or circumstances not planned for
Act of sabotage	Deliberate violation for malicious reasons - falls outside the scope of most accident/ incident scenarios		

1.2.5 Latent failures / conditions

The core of the Tripod risk management concept is that accidents have their primary origins in latent rather than active human failures / conditions. Latent failures, the third foot of the Tripod framework, stem from decisions or actions taken by other more remote parts of the organisation. These may lie dormant for a long time, their accident-producing consequences only becoming evident when the active failures resulting from their presence combine with local triggering factors (technical faults, environmental conditions, a typical system states, etc) to breach the system's defences.

The defining characteristic of latent failures / conditions is that they were present within the organisation well before the onset of a recognisable accident sequence. In some cases, their history may stretch back several years. The effect of a latent failure may have a widespread impact on operations.

In order to reduce incident frequency one must first have an understanding of how incidents happen. Tripod research identified two types of failure: active failures and latent failures. Their roles in incident causation will be explained using the example of the Kings Cross Tube fire in 1987 (UK).

In this disaster, the triggering event was a discarded cigarette. It combined with the accumulating rubbish in the vicinity – unsafe act / condition leading to the subsequent inferno. Because of this the cause of the incident was labelled as a 'human

error'. Latent failures, however, included wooden escalators, poor fire fighting / detection equipment, (lack of) maintenance philosophy, etc, that had been present a long time before the event of the discarded cigarette.

Even though the occurrence of some active failures will be inevitable, their effects can be reduced considerably by eliminating as many latent failures as possible. For example, if the cigarette would have been dropped whilst the fire fighting / detection equipment were in good working order, the active failure would most probably not have resulted in catastrophe.

Active failures (human errors) come in many different forms, and are therefore hard to predict. Latent failures are present all the time but are often hidden, overlooked or tolerated in an organisation. Latent failures often stem from decisions made at a much earlier time. These decisions may have been correct at the time they were made, however, in a dynamic environment such as the oil and gas industry, yesterday's best decision can be tomorrow's worst source of error.

Tripod-DELTA aims at identifying and reducing latent failures so that when the inevitable active failure (human error) occurs, it does not result in an incident. In Tripod these latent failures are called Basic Risk Factors or BRFs (See also paragraph 1.2.1).

1.2.6 Controls and System Defences

Hazard controls and recovery measures are put in place based as part of the Hazards and Effects Management Process (HEMP). Risk management objectives are set out for critical processes and activities. Often these controls and defences are considered the means of protection against damage or losses. In Tripod these elements are recognised as valuable entities, however acting as last line of defence only.

1.3 TRIPOD APPLICATIONS

Tripod research demonstrated that assessments of the degree to which these BRFs are controlled in an activity or facility provide an accurate picture of its overall 'health'. A Tripod assessment is quantified in terms of 'level of control' of each of the 11 BRFs and is represented by the height of a bar in a histogram format. This histogram is called a Safety State Profile (SSP).

The two applications, proactively in the Tripod-DELTA technique and retrospectively in Incident Analysis, Tripod-BETA, are described briefly below.

1.3.1 Tripod-DELTA: Pro-active diagnosis of level of control Applications

Much of the evidence proving that there are problems in an organisation is scattered about, or has become invisible and accepted as part of the conditions under which people work. Questionnaires extracted from a pre-established central database of indicator questions (called: Delta-base) are completed by all members of an organisation. Answers to the questionnaires are summarised as a profile showing the

relative 'health' of an organisation in 11 separate areas (Basic Risk Factors).

The responses to the questions indicate a 'desirable' or 'undesirable' condition relating to the BRF. The Safety State Profile shows the relative level of control of each BRF.

Examination of a Safety State Profile can generate the following results:

1. Determine the organisation's performance in the individual BRFs and establish in which order of priority the BRFs should be tackled for improvement.
2. Compare profiles of the same unit or activity taken from previous assessments to determine if improvements have been made.
3. Compare profiles for one unit against another similar units (Benchmarking).

Note: For "unit" one can also read "area" or "company".

Tripod-DELTA is an exercise that takes place outside the environment of accident investigation and is thus a proactive rather than a retrospective risk management tool.

1.3.2 Tripod-BETA: Analysis during Incident Investigation

Tripod-BETA is a methodology for conducting the incident analysis in parallel with the investigation, supported by a PC-based tool. Interaction between these two processes - investigation and analysis - provides the investigators with confirmation of the relevance of their fact gathering and highlights avenues of investigation pointing to the identification of latent failures. The benefit to the analysis process is that logical anomalies can be highlighted and resolved while the investigation is still active.

The net result should be a deeper and more comprehensive investigation and a clearer understanding of the failures that must be addressed in order to make significant and lasting improvements in accident prevention.

The methodology is supported by software that provides the means to collect and assemble the facts from the investigation and manipulate them on screen into a graphic representation of the event and its causes - an accident tree. The program tests the tree structure to ensure that it is logical in terms of the Tripod theory of accident causation. A draft accident report can be generated for final editing using a word processing package.

1.3.3 The Benefits of Tripod

The main benefits Tripod can offer are:

- a principled way of understanding how accidents happen

Tripod explains the real reasons why intended processes are disturbed, how an organisation's resistance to these disturbances can be enhanced and what to do to improve resistance.

- early pro-active feedback on potential accident causes

The completion of SSPs provides feedback about risk management effectiveness of an organisational unit at a much earlier stage in the traditional accident causation sequence.

- Managing and controlling identified latent failures

This is the principal feature of the Tripod approach. By monitoring and influencing the BRFs, an organisation can maintain a high degree of risk management. These are the controllable factors contributing to incidents. Risk management means increasing resistance to ever-present hazards and inevitable unsafe acts and conditions. Imposed understanding of the BRFs and the fallible decisions by managers and others that lead to latent errors will enable improved decisions and fewer latent errors to be introduced into the system. The BRFs - the vital indicators - will reveal the true state of organisational risk management health, an especially important requirement as accidents become rarer events.

More information about the Tripod applications can be found on the internet sites: www.tripod.nl and <http://www.eqe.co.uk/software/eqesoftframe.html>

1.4 TRIPOD-DELTA: THE MECHANISM

1.4.1 Introduction

DELTA is a proactive tool that functions by taking a 'safety health check' of an organisation. In the same way that a doctor measures vital signs (e.g. heart rate, cholesterol, albumen, etc) as indicators for the overall health of a patient, DELTA uses 'indicator questions' to measure an organisation's health. Each indicator question is tailor-made for the operation in question, and is specific to one of the 11 BRFs. Indicator questions are objective, and can only have one desirable answer, either 'yes' or 'no'.

During a Tripod-DELTA Survey questionnaires are answered by as many as possible members of the organisation. In order to obtain a clear picture of the state of affairs, people on all levels of the organisation are involved. This includes semi-permanent contractor personnel. After answering the questionnaires the responses are analysed and a detailed report, including the Safety State Profile is generated.

Much in the same way a doctor, after a diagnosis, can warn a patient of imminent illness and thus prevent its manifestation, DELTA can forewarn an organisation of potential future problem areas. This gives the organisation time to put problems right before they potentially develop into an incident. DELTA profiling exercises are normally carried out every six to twelve months.

A Delta profile is a 'safety state profile', the BRFs are represented in the columns and a measure of 'control' is represented on the y-axis (see Figure 6). The higher a particular BRF bar, the more signs to control the latent failure have been detected in that BRF and therefore the more the BRF poses a threat to the safety of the

organisation.

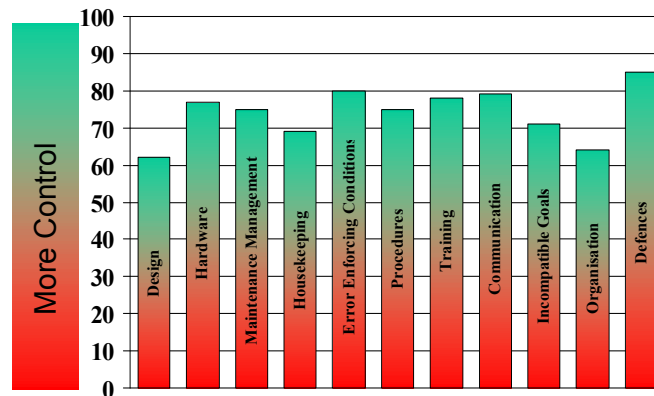


Figure 6 DELTA profile

By representing the relative difference in control between BRF areas, a profile allows a manager to prioritise improvement actions. This prioritisation process supports the manager in allocating resources where they are most needed. For reasons of manageability it is recommended to focus on the 3 lowest scoring BRFs.

In the illustration, Design, Housekeeping and Organisation are the most problematic BRFs (the lower bars). Available resources should concentrate on improving these areas first. On the other hand Defences, Error Enforcing Conditions and Communication (the highest bars) are the areas with the least number of deficiencies. They require less attention for the time being.

When the generated profile has been studied, the responsible management can determine in what way improvement of weaker BRFs should be derived. There are many ways to achieve this and every specific operation will find its own preferred way of tackling the problem areas identified.

As an example, three improvement actions can be generated for each of the three lowest scoring BRFs in the profile. In the same way a patient takes more exercise and eats more healthily in order to prevent future illness, an organisation must improve its problem areas by generating and implementing improvement actions. This process in Tripod is called action itemising. Management involvement at this stage is strongly recommended to ensure commitment to the implementation of action items.

It is important to remember that a Tripod-DELTA Survey can be run regardless whether an incident has occurred or not. In that way improvements can be made before personal injury, material loss or environmental damage have occurred.

1.4.2 Indicator Questions

At the heart of DELTA are indicator questions. Much in the same way a doctor makes a diagnosis by asking a patient questions about their health, DELTA uses indicator questions to determine the safety health of an operation. DELTA uses a database of approximately 1100 indicator questions. The intent of indicator questions is to diagnose rather than to audit or investigate. An indicator question should have

the following characteristics:

- it can only be answered with 'Yes' or 'No'
- it has only one desirable answer, which can be 'Yes' or 'No'
- it is objective, i.e. it does not ask about feelings, awareness, etc
- it is measurable, i.e. it has a specified time frame or frequency
- it is specific to the operation
- it is specific to a BRF
- it is auditable - the answer is based on facts that can be verified
- it is specific to a single item or item group, e.g. it refers to lifting equipment rather than to equipment in general
- it is directed at a specified individual or group, e.g. it refers to 'you' or to 'the drilling crew'.

An example of a good indicator question is:

Have you worked more than 16 consecutive hours in the last seven days?
The answer to this question is either 'Yes' or 'No'. However, the desirable answer is 'No'. It is objective, measurable and specific to you as an individual. The question is relevant to the BRF Organisation. Some questions are designed so that the desirable answer is a 'No' and others are designed so that the desirable answer is 'Yes'. This is to prevent an answering group assuming that all 'Yes' answers are necessarily desirable. Example 1. Desirable Answer 'No': Have you received imitation spare parts, where original parts are a requirement? Example 2. Desirable Answer 'Yes': Has there been a fire drill in the last week?

ASPECTS AND FEATURES

The BRF is a relatively broad category, identifying a topic on an abstract level. Within each BRF four aspects (Drivers, Resources, Methods, and Output) have been defined. Also for each individual BRF specific features, related to this BRF, have been defined. When a Tripod-DELTA Survey is conducted these aspects and features are considered in the analysis process, so that the final report as delivered to the unit involved will relate to its operations as practical as possible.

Aspects and Features have proven to be useful prompts for the generation of remedial actions.

1.4.3 Prior to implementation

Although Tripod-DELTA is a powerful tool, it cannot be implemented everywhere. Prior to the implementation of Tripod-DELTA, three questions should be considered:

WHERE? In order to generate meaningful profiles operational units are profiled instead of the organisation as a whole. Operational units are relative small parts of the organisation which are partly self-regulatory. A single drilling rig is a good example of an operational unit.

WHEN? Tripod-DELTA is a tool specifically designed for operational units where incident information used to improve safety is scarce because of low incident frequency or to determine a base line for improvement. Tripod-DELTA provides points for improvement without the requirement to have incidents, and thus assists an organisation in maintaining low incident statistics.

- WHAT?** For operational units that do not have a low incident frequency Tripod-DELTA may be less appropriate. There may be more benefit from the retrospective application Tripod-BETA to assist in the analysis of incidents, thereby providing information concerning points for improvement.
- WHO?** Anyone related to the operation to be surveyed. This includes top management as well as semi-permanent contractor personnel. A minimum period of 3 months of involvement with the particular operation is a requirement. In order to verify reliability and validity of the responses on the questionnaires, the group of respondents should not be less than 40 people.

1.4.4 Implementation

Effective management of Tripod will require a series of regular activities that should be integrated within your HSE program. Although in-house applications have been developed, in general OPU/JV's will not have resources for managing and running Tripod-DELTA surveys. Tripod Diagnostics International B.V. (TIBV) can be contacted to carry out the required surveys for you. They will provide you with the questionnaires, analyse the responses and produce a full survey report including your Safety State Profile.

This will reduce the preparation and analysis of the survey, but you will still be responsible for arranging your own generation of improvement actions.

Information associated with this option may be obtained from TIBV.

1.5 RUNNING TRIPOD-DELTA SURVEYS

Following is a step-by-step overview of the survey process.

STEP 1 - (All parties) Preparation

- Assignment of Focal Point (liaison between Tripod International (TIBV) and your operational organisation).
- Determine what Staff Positions are taking part in the survey.
- Determine which Departments/Units are taking part in the survey.
- Determine the amount of respondents per Department.
- Communicate the Company terminology of Staff Positions and Disciplines / Departments to TIBV?
- Discuss with TIBV what type of questions is to be issued to whom (generic /

specific)?

- Determine method of distribution of questionnaire (personal issue / mail? At work / home?)
- Assign Response Managers. These people will distribute the questionnaires over a limited group (max. about 20 people).

NOTE: Internal information/announcement about the "things to come" in relation with a Tripod DELTA Survey by line supervisors to respondents is strongly recommended.

STEP 2 - (All parties) Development of Questionnaires

(1 week after receipt of above information)

- OPTIONAL: Question Generation Session (only in case you want to include operation specific questions. This is NOT a requirement!)
- Draft questionnaire to be scrutinised by Focal Point on jargon.
- Final questionnaire to be approved by Focal Point.
- Final amount of questionnaires to be communicated.
- Distribution dates to be set.
- Delivery date and address of questionnaires to be agreed.

STEP 3 - (All Parties) Distribution of Questionnaire

(1 week after approval by Focal Point)

- OPTIONAL: Kick-off meeting with Focal Point and Response Managers.
- Issue of Questionnaires to Response Managers.
- Agreement on Closing Date (latest date to return completed questionnaires).
- Distribution of Questionnaires to Respondents.

NOTE: Questionnaires are delivered with blank envelopes to ensure confidentiality.

STEP 4 - (PETRONAS) Completion of Questionnaires by Respondents

- Keep tight control on "who has returned his/her completed questionnaire".
- Focal Point to monitor progress in collection of completed questionnaires.

STEP 5 - (TIBV) Reporting

(4 weeks after receipt of completed questionnaires by TIBV)

- Approval by client to TIBV to start analysis (no additional material (late arrivals) can be processed after that moment!).
- Agreement on Delivery Date of Survey Report by TIBV to Focal Point.
- Determine amount of Survey Reports required.

OPTIONAL: Presentation of Survey Results by TIBV to Client.

STEP 6 - (PETRONAS) Action Planning

Action planning is the crucial stage in the Tripod process. The action planning allows you to make the journey back from the relative abstract Tripod report to the practical underlying causes in your real world. Now you have three specific areas to focus on. We have observed that creative solutions with a large impact at little cost are often possible. Some users have found it helpful to plan and publish a budget for Tripod Actions.

STEP 7 - (PETRONAS) Action

Following the action planning the remedial programme is actioned.

1.6 TRIPOD BENEFITS AND BEST PRACTICE

1.6.1 The benefits of DELTA

- **resource prioritisation**

Safety and quality are simple obstacles to attain if there is an unlimited resources to spend. However, no manager has unlimited resources. DELTA identifies the BRFs that pose the greatest concern in HSE management. By concentrating efforts in these areas a manager can make efficient use of his available resources.

- **proactive measures**

When an incident occurs it cost time and resources. Management and the line has to prioritise on recovery and investigation, deviating from their set business targets. Traditional improvements in HSE management rely upon learning from mistakes. Often, it is only after an incident has occurred that lessons are learned and improvements are implemented. DELTA removes the incident out of the learning cycle replacing it with the findings of a profile. B

By running DELTA, time spent on preventing incidents can be saved many times over when compared to time spent dealing with the consequences of incidents.

- **self diagnostic**

After implementation, DELTA is run by the line. It is designed with efficiency in mind to run without the intervention of external resources. As the technique is self-diagnostic, the line and its management are the first to know about potential problems. They can use their expertise to solve their own problems and therefore the level of ownership is high.

- **profiling between audits**

Conventional audits are time consuming, costly and normally target an individual installation. Often, they produce many action points simultaneously, implementation of which requires a great deal of planning. With DELTA, however, action points are

self-generated and the quantity is limited to encourage proper implementation. They are also often low in resources. Therefore the tool is efficient and can be run regularly on several locations at a time in order to assess their 'safety health'.