Session No. 609-a

How Would You Set Up an EHS Regulatory Framework in a Country without One?

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Introduction

This presentation will take the audience on this 2-year journey in the development and implementation of the Building & Construction Sector, Environment, Health and Safety Management System and the EHS Regulatory function for the newly formed Building & Construction Sector for the Emirate of Abu Dhabi., UAE.

Participants will be provided with the lessons learnt from the speakers experience as the EHS Managing Consultant for one of the world's largest EHS construction consultancy projects worth over AED 84M

Presentation Description

A professional presentation providing the implementation strategies and activities conducted for the overall management, support and co-ordination to the Task Managers in the implementation of the project core tasks including EHSMS/ Regulations/ Technical Guidelines development, OHSAS 18001 and ISO 14001 Accreditation, development and establishment of the EHS Training Department, marketing, and recruitment of the inspectorate. Finally, for participants what are the lessons they can take away from this project.

So why this presentation?
It is not often in the safety profession that one gets an opportunity such as this project and I really wanted to share a little about the experience. There are lessons to be shared but really this presentation will hopefully challenge the audience is thinking…What would you do in tackling such an enormous project?

To put it simply…what would you, where would you start if you were asked to be the Managing Consultant in a project is setting up OSHA? Imagine the issues faced

where in this case there is no OSHA in place and no laws that govern the construction industry across the US.

Background

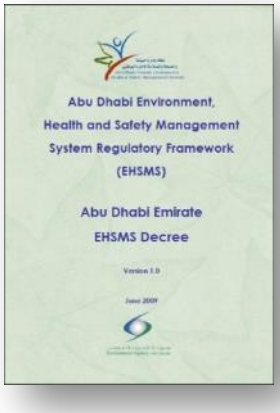
The project was tasked with the development of a Building and Construction Sector Environment, Health and Safety (EHS) Department under the Regulatory Authority of the Department of Municipal Affairs (DMA) to comply with the draft Law of 2008 concerning the EHSMS in Abu Dhabi Emirate.

The main objective of the Building and Construction EHS Department is based on the Competent Authority vision which is to develop an effective EHSMS, and assist the Sector's entities in the development of their own EHSMS.

By the end of 2009, with full implementation by 2012. The key objectives are:

- All Sectors develop EHSMS (2008- 2010).
- All Sectors implement EHSMS (2010- 2012)
- Start the journey towards:
- Minimizing pollution and waste
- Safer workplaces
- Healthy environment
- Sustainable lifestyle
- Sustainable economy
- Sustainable development

By the year 2020, it is anticipated that there will be an EHS culture that delivers these goals as a normal part of life in the Emirate of Abu Dhabi.

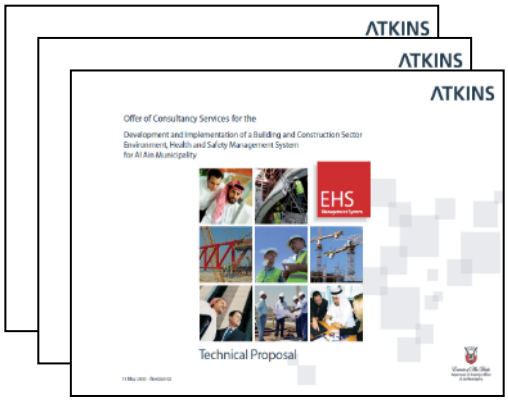


Under the draft law of Abu Dhabi Emirate concerning the EHSMS, the B&C Sector EHS Department under the authority of the DMA has been tasked with the following key responsibilities:

- Identify entities that cannot work in the Emirate without implementing the EHSMS according to the Emirate approved system.
- Revise and approve the EHSMS developed by targeted entities to ensure compliance with the requirements of the EHSMS at Abu Dhabi Emirate level and the requirements of the concerned sector.
- Monitor implementation of the system through periodical inspection of entities.
- Report to the Competent Authority on the performance of the EHSMS at the Sector level.

The Project Tasks

With the alignment of the vision with the Building and Construction Sector requirements, the focus of the EHS Department is to develop and implement a number of functions and activities that are designed to support the entities such as contractors, consultants, developers, client organization's and their workers.



11 main tasks and activities were identified to meet the goals of the project and these were developed and submitted as part of the Technical and Financial Proposal.

A: Implementation of mechanisms and sector development

- Revision and redevelop the Construction Codes
- Develop the appropriate Regulatory Regulations
- Revision and update of the Sector EHSMS
- Commence registration with pilot entities

B: Establishment of a Training Department for the B&C Sector Development;

- Develop for department employees:
  - Training Needs Analysis
  - Competency Matrix
  - Training Plan
- Establish partnerships with local training establishments
- Commence training of EHS Inspectors

C: Professional Development of B&C Sector EHS Department Employees Professional Development Plan

- Develop plan for young Emirati employment
- Implementation of the Emirati employment schedule

D: Ongoing Recruitment for the B&C Sector EHS Department

- Develop Staff Recruitment Plan
- Develop job description & remuneration packages
- Recruitment of staff
- Develop and implement scholarship programs with local universities

E: Development of Legislation and Guidance Documents

- Review of legal framework & DMA Construction Codes
- Consult with stakeholders involved in enforcement of EHS law
- Further develop the EHS B&C Sector legal framework

F: Development of Income Streams for the B&C Sector

- Review income stream options
- Identify anticipated revenue streams which include:-
- Registrations
- Training
- Certificates Of Conformity
- Penalties

G: Implementation of the Internal EHSMS for Al Aim Municipality

- Review Al Ain Municipality activities to align EHSMS to:
- ISO 14001
- OHSAS 18001
- Implementation of the documented EHSMS
- Internal auditing leading to accreditation

H: Development, Implementation and Maintenances of the IT EHS Requirements

- Prepare the technical platforms (equipment, software)
- Build and maintain the EHS Dept. Website
- Establish and maintain the regulatory authority reporting system (RARS)

I: Marketing and Awareness

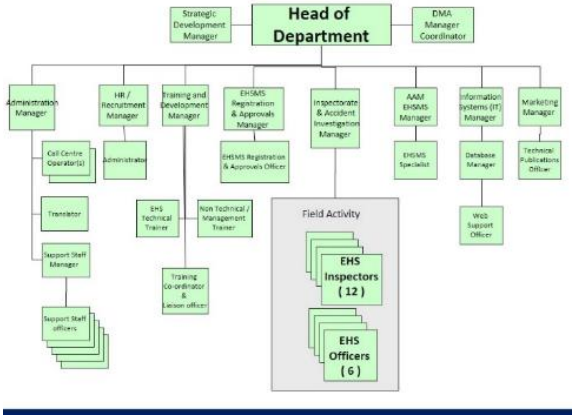
- Develop a Marketing Plan for year one
- Develop a brand identity
- Launch marketing campaign which includes;
- Advertising
- Awareness
- Roadshows
- EHS bus
- Videos

J: Establishment of Rewards Program

- Develop reward schemes for
- EHS Employees
- AAM
- Entities
- Public
- Develop an EHS Awards Competition for the Emirate

K: Accreditation of the B&C Sector EHSMS

- Accreditation implementation plan - EHSMS to;
- ISO 14001
- OHSAS 18001
- RFP, bids, award of contract
- Co-ordination of accreditation process



Lessons Learned

Whilst I have been a safety professional for over 30 years, this project brought back to home so of the key fundamental lessons that we should be mindful in tackling any such project.

All safety professionals at some time need to be reminded sometimes of the simple basics in our profession, things that we may either forget or simply make it too complicated.

The following are those key lessons that I was now recall are fundamental to the success of any project. No matter what the size of the project!!!

Project Planning

Yes there are many quotations about proper planning but, it is imperative to the success of the project that you adopt a detailed project plan that includes all the activities, responsibilities, and methods of measuring progress and reporting.

Clients' Needs and Wants

Make sure we have a clear understanding of the client's needs and wants. Be prepared that in some cases that the client may not really understand what they need, but remember they have a

The Deliverables

Establish clearly defined "Deliverables". Yes, based on the objectives but be prepared to answer the question – What are we going to deliver???

Mobilization

Do not underestimate the true important of allowing sufficient time and planning in the "Mobilization" period. We need to make sure we plan this in allowing enough time to get properly set up before we attempt to start the "Real" activities.

Culture

Understand the culture of either the country or more importantly the organization you are dealing with. Every organization has a culture – know it, understand it and work with it. Don't ignore it.

Session No. 609-b

A Vaccine for Accidents - Rethinking Incident Investigation

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Introduction

Management of safety incidents is among the most challenging of tasks required of professionals involved with health, safety and environmental management. It requires a unique set of skills not common to other areas of management. Events move at a fast pace. Infrastructure, which is usually available, has often been compromised by the incident itself. Every action is in the spotlight and the consequences of mistakes appear magnified. Internal and external stakeholders have an insatiable appetite for briefings and information. More often than not, these events play out under the watchful gaze of the media.

We all know that a health and safety disaster can cost shareholders millions and create untold legal and reputational liabilities. These disasters may often be averted by acting on the warning signs that precede most major health and safety incidents. Those warning signs are identified through one of the most potent tools in the occupational health and safety arsenal: incident investigation.

The investigation of an incident allows an organisation to get to the bottom of what happened and, more importantly, understand how to improve resilience to protect against future incidents. The logic is simple - most of the root causes of serious incidents are evidenced before serious incidents occur. As such, future safety risks may show themselves prior to their realisation in near misses or seemingly minor incidents.

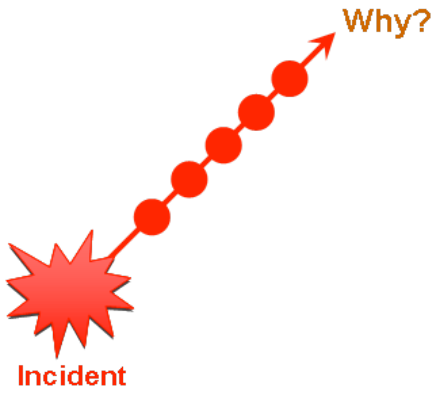
An effective incident investigation approach must allow an organisation to uncover systemic deficiencies and opportunities for improved resiliency before future incidents occur. This requires understanding both what went right as well as what went wrong leading to an incident and discerning from this what system deficiencies and vulnerabilities exist that can be addressed to stop more severe incidents from ever happening.

The purpose of this paper is to introduce an approach to incident investigation that attempts to achieve true organisational resilience. We call this approach to incident investigation the "Positive Incident Investigation" approach, which provides the investigator with the "needle" to vaccinate the organisation from future incidents by learning the most possible from the last one.

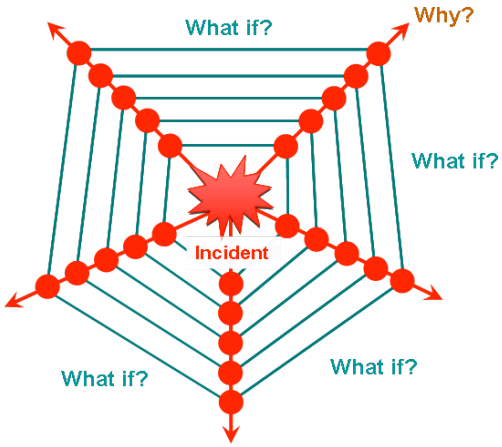
The Positive Incident Investigation – An Introduction to the "Web Analysis" Approach

Put simply, Positive Incident Investigation goes beyond linear considerations of "why" an incident occurred, towards testing the resilience of a safety management system as part of any incident investigation.

The Positive Incident Investigation Method requires the investigator to first ask "why?" an incident occurred and to identify all of the deficiencies and root causes underlying the incident.



But the analysis does not end there. This traditional root cause analysis is then taken a step further, with consideration of other possible scenarios that might have happened but did not, as well as the deficiencies and weaknesses such possible scenarios reveal. We identify these scenarios by asking "what if?" repeatedly (5 times in fact).



The end result is the identification of system vulnerabilities that go beyond the immediate root causes of the incident. By utilising the web analysis technique, an investigating organisation will not only learn from incidents that have occurred, but also explore what such incidents reveal about possible weaknesses and deficiencies that did not materialize but could have under different circumstances.

Basic Principles of Incident Investigation

Before considering this approach in more detail, we will examine some of the underlying principles of incident investigation.

What is an "incident"?

The definition of an "incident" is not consistently defined in occupational health and safety legislation. For the purpose of an incident management system, a broad definition of "incident" is necessary so that any event that involves a risk to the safety of employees, contractors, visitors or members of the public, is identified, managed effectively and investigated. With this goal in mind, an "incident" can be defined broadly as any event in which a business is directly or indirectly involved, and which involves a risk to the safety of employees, contractors, visitors or members of the public.

Basic Incident Investigation

Fundamentally, incident investigation aims to capture the root causes of incidents to learn from them and improve the resilience of the organisation to safety risks. We start from the assumption that all risks are preventable. Probing the root causes of incidents through investigation techniques is a critical part of avoiding the recurrence of safety incidents by identifying systemic weaknesses and strengths of the organisation that lead to the incident. This is done by learning from incidents and disseminating what is learnt throughout the organization for continual improvement.

The Key Objective: Organisational Resilience

The key objective behind the incident investigation process is "resilience", which can be defined as an intrinsic ability of a system or organisation to remain effective despite errors. In the safety context, resilience means that an organisation has the capability to detect, contain and bounce back from inevitable errors that may occur in their operations. Errors are inevitable and to be expected in an indeterminate world. A resilient organisation can withstand such errors while not compromising safety. We call such an organisation a "resilient" or "high reliability" organisation. A high reliability organisation is maximally resilient to health and safety risks.

Incident investigation is a key tool of a high reliability organisation. High reliability organisations must constantly be preoccupied with the possibility of failure and error and the effect these inevitable events will have on the organisation. Every incident investigation represents an opportunity to test the vulnerability of the organisation and to improve organisational resilience.

Incident investigation pitfalls

Many incident investigations suffer from pitfalls that prevent them from being useful for building organisational resilience. Investigations that focus on the actions of frontline workers to the exclusion of system factors are particularly ineffective at identifying system vulnerabilities. Some investigation findings will place implicit or explicit blame on workers involved in an incident. They often find that procedures should be revised or that adequate procedures existed that were simply not followed without asking "why" that was the case and whether systemic deficiencies existed that contributed to those outcomes.

Such conclusions may be too convenient and cheaper than engineered solutions, but do not promote organisational resilience. One goal of the Positive Incident Investigation method we will outline is to overcome these pitfalls by looking beyond the assignment of "blame" or responsibility and more towards understanding the strengths and weaknesses of the organisation in preventing future safety incidents.

Role of positive safety culture

James Reason, a leading theoretician on safety management, observes "most of the root causes of serious accidents in complex technologies are present within the system long before an obvious accident sequence can be identified". With this insight in mind, it becomes clear that incident investigation should allow for the root causes of future (and possibly more severe) incidents to be identified and corrected before future incidents can occur. To successfully intercept system deficiencies in the investigation process, there must be an openness and willingness to uncover deficiencies in the investigation process – part of an organisational learning culture conducive to good safety. A thorough investigation and analysis of incidents allows the organisation to implement systematic improvements to eliminate or minimise the re-occurrence of incidents.

The goal of any safety management system is to create a culture of safety within the business or undertaking – meaning that safety is embedded in everything that is done. In other words, making safety a part of the business' "DNA". That culture will continue to propel the safety management system towards the goal of maximum safety and health regardless of the leadership's whims or current commercial concerns. This is integral to the

creation of a resilient and high reliability organisation. The aim is to create a culture where personnel have the necessary tools and skills, and are empowered to make the right decisions in conducting safe working operations.

There are four key elements of a positive safety culture:

- ***Informed culture*** – a culture in which those who manage and operate the system have current knowledge about human, technical, organisational and environmental factors that determine the safety of the system as a whole;
- ***Reporting culture*** – a climate in which people are prepared to report their errors and near misses;
- ***Just culture*** – the environment of trust in which people are encouraged, even rewarded for providing essential safety-related information through sharing of incidents and near miss information but also expect to be held accountable for unacceptable behaviour;
- ***Learning culture*** – the willingness and competence to draw the right conclusions from the safety information system, to address system deficiencies and the will to implement major reform when needed.

Proper investigation of incidents is a core part of good safety culture. All systems, even the best systems, fail from time to time. Human error will inevitably occur. Resilience requires an organisation to have a safety management system, which is "human error tolerant", not requiring perfection from employees. This necessitates a system that supports reporting of near misses, learning from past mistakes and involvement of employees in the investigative process. This approach is consistent with a "just culture" in the workplace that is transparent and also requires accountability for actions. Good investigation practices encourage and facilitate the development of a just safety culture.

Investigation principles

The test of an effective OHS management system is not the absence of incidents but rather what is done in their aftermath. Every incident, no matter how small, represents a learning opportunity. If we properly investigate the incident and get to its root causes – the system failures or deficiencies that permitted the incident to occur – we have a chance to put in place the corrective actions necessary to avoid a repeat of the incident and improve the resilience of the system against further failure. That commitment to constant and continuous reflection, analysis and review is the essence of an effective management system. It is also critical to achieving a positive safety culture within the organisation.

The purpose of incident investigation is to identify deficiencies in a system or organisation that could cause a safety risk. Incident investigation should entail a consistent

approach to initiating, conducting and reporting on an investigation. Key principles of good investigative practice include:

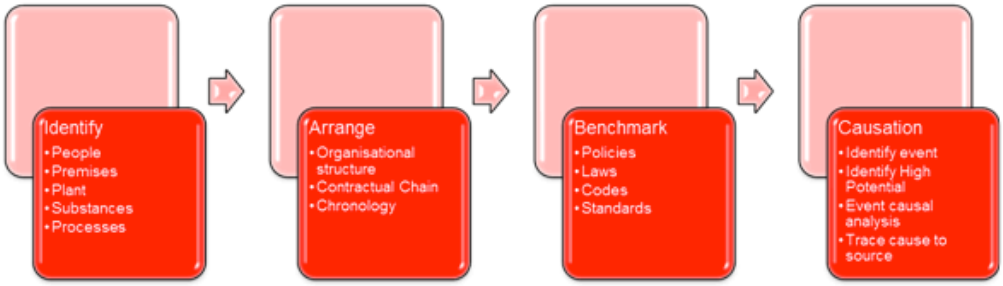
- ***Transparency*** – The investigation process must be documented and demonstrate a transparent and open investigation process;
- ***Probity*** – This involves ensuring the investigation is approached without pre-conceived notions of the causes of the incident or the investigation outcome. Approaching the investigation with an "open mind" is crucial;
- ***Clarity of role*** – This requires an understanding of the reason why investigations are occurring and what the roles and responsibilities of investigators are;
- ***Flexibility*** – This means not having fixed ideas about causes and effects as well as keeping in mind the big picture while going through the detail that is inevitable in any investigation;
- ***Rational pragmatism*** – Means taking a common sense approach to decision-making. Rational pragmatism involves an understanding that decisions should be based on real life issues, realities and complexities of the organisation and ensuring achievable realistic goals are set; and
- ***Independence*** – The investigation team must be appropriately independent from the incident and the workers involved in the incident. Supervisors of workers should therefore not be involved.

Incident investigations should be carried out consistent with the above principles to ensure effectiveness and integrity of the process. This will in turn enhance the reliability of investigative outcomes.

Getting the facts: iABC Process

The first part of the Positive Incident investigation approach is to gather the facts and evidence and to begin to analyse the root causes of incidents. We describe the preliminary fact gathering and analysis process as the iABC process – which involves a four-step investigation method, requiring the investigator to:

- ***Identify:*** including the identification of people, premises, plant, substances and processes through a process of evidence collection and witness identification and interviews;
- ***Arrange:*** involving an analysis of the relationships between each of the persons concerned as well as a chronology and validation of the events and causal factors leading to the incident;
- ***Benchmark analysis:*** involving a review of procedures, legislative provisions, codes of practice and other material to identify "what should have happened" to compare with what actually did happen, to identify gaps that may have contributed to the incident;
- ***Causation analysis:*** undertaking an analysis to determine the causes of the incident. This may be done through a barrier analysis, which draws out the latent conditions that lead to the incident. It may also involve an "Event and Causal Factor Analysis" or the "5 Whys" incident investigation method which requires the investigator to ask "why" the incident happened five times, thereby peeling back the layers of causation to get at root causes. This is done for each salient event that contributed to the incident.



The first three parts of the iABC process involved the gathering of the facts, evidence and the sequence of events leading up to the incident. The final part of the iABC process entails an examination of "causation", which requires a root cause analysis of the facts and descriptions prepared thus far. Following completion of the "causation" analysis, the next step will be to conduct a web analysis, identifying not only what happened, but also what might have happened, in order to obtain a wide scope of system deficiencies and/or strengths that can be leveraged by the learning organisation.

Understanding Causation

Root cause analysis

A "root cause analysis" requires the investigator to understand not just what happened, but "why" it happened. The practice of root cause analysis is premised on the belief that problems are best solved by addressing, correcting or eliminating the cause at the source of an incident. The causes will include the absent or failed defences that enabled the incident to occur. This consideration of root causes is to be distinguished from focusing on the failures of individuals or human factors that contributed to an incident.

Causation methodologies

There are several types of investigative and/or analytical tools that may be used to guide safety personnel through a logical and ordered investigation process. In fact, one study identified 11 different models of causation. Some techniques emphasise the cause and effect relationship between facts and the incident, while others emphasise timing and event sequences. Others focus on one accident, one factor or one individual. Others still adopt a more multidimensional approach, analysing disorders, multi-factorial relationships, multiple persons and the environment as a whole. There are several reasons for using one or a combination of investigation and analysis tools, including to:

(1) provide a framework around which data is collected and organised;
(2) assist the conduct of the investigation in following a logical path;
(3) ensure integration of differing elements of larger investigation processes;
(4) assist in logically presenting and ordering data from which a useful report may be produced; and
(5) provide a useful framework from which valid conclusions may be drawn and to assist with communication of conclusions to other parties.

The trend in incident analysis is to increase the time span of the behaviour and system under consideration.

While the Positive Incident Investigation method can interact with a variety of causation analysis methodologies, the Accident Causation Model, published in 1990 by Professor James Reason of the University of Manchester, United Kingdom, known widely as the "Reason Model" or "Barrier Analysis" method, is a leading causation analysis tool for

investigating organisational and systemic deficiencies that result in accidents that fits nicely with this approach.

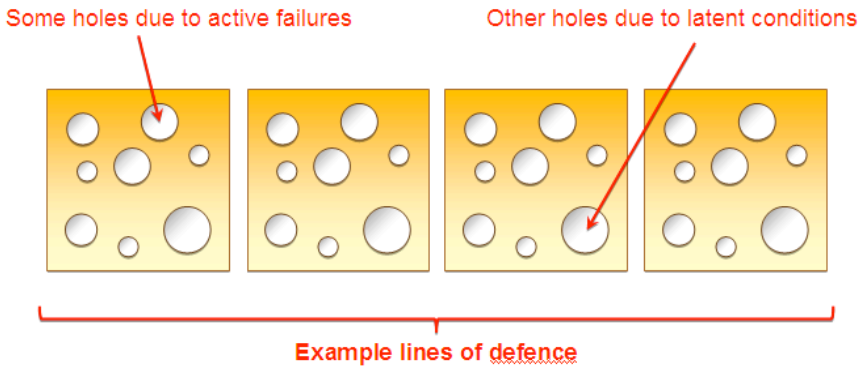
Barrier Analysis considers the contribution to incidents of latent conditions, arising mainly in the managerial and organisational spheres, which combine adversely with local triggering events (weather, location, etc) and with the active failures of individuals at the "sharp end" (errors and procedural violations) to produce an accident (or safety occurrence).

The common elements of the Barrier Analysis method are:

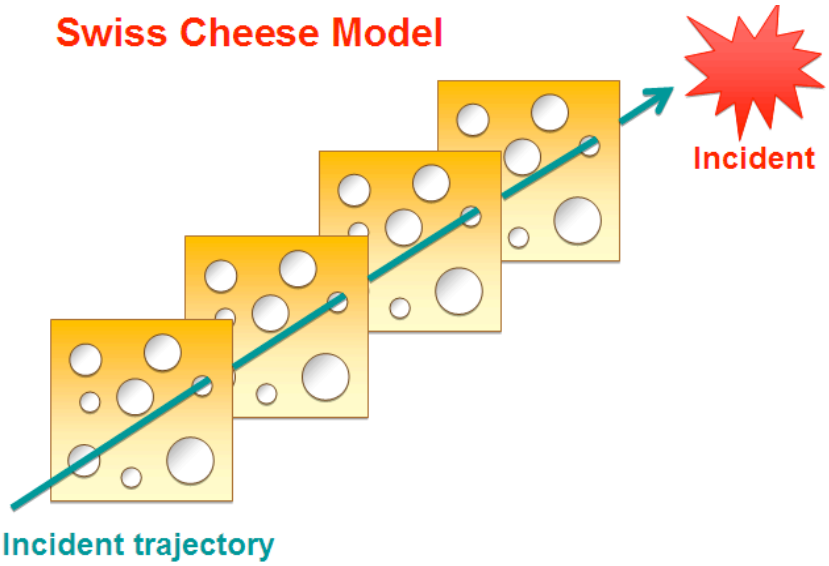
1	**ORGANISATIONAL DEFICIENCIES AND LATENT FAILURES**	These deficiencies and failures are often a result of managerial policies and actions within one or more levels of an organisation. Their effects are not immediately apparent and may lie dormant for a considerable time.
2	**LOCAL FACTORS**	These are conditions that can affect the occurrence of active failures. These include such things as task and environmental conditions.
3	**ACTIVE FAILURES**	These are errors, violations, or other unsafe acts that have an immediate adverse effect. These unsafe acts are typically associated with operational personnel.
4	**INADEQUATE OR ABSENT DEFENCES**	Defences that identify and protect against technical and human failures arising from the three previous elements.

As described by Reason, active failures are the actions or inaction of operators that are believed to have caused the accident. Traditionally referred to as "error", they are the last "unsafe acts" committed by an individual, often with immediate and tragic consequences.

The Barrier Analysis method analyses incident events by reference to the barriers or controls that should have operated to prevent the incident from happening. The deficiencies, latent failures, local factors and active failures exploit inadequate or absent defences which constitute the "holes" in the defensive barriers that are in place. These holes make each barrier analogous to a slice of Swiss cheese.



No matter how many slices of Swiss cheese (barriers) there are in place, where the holes line up they define the incident trajectory. When each barrier (slice of Swiss cheese) is lined up as part of a safety management strategy, an incident may still occur when the holes in those barriers align, creating the conditions for an incident. These conditions create an incident trajectory that may lead to an incident under the right circumstances.



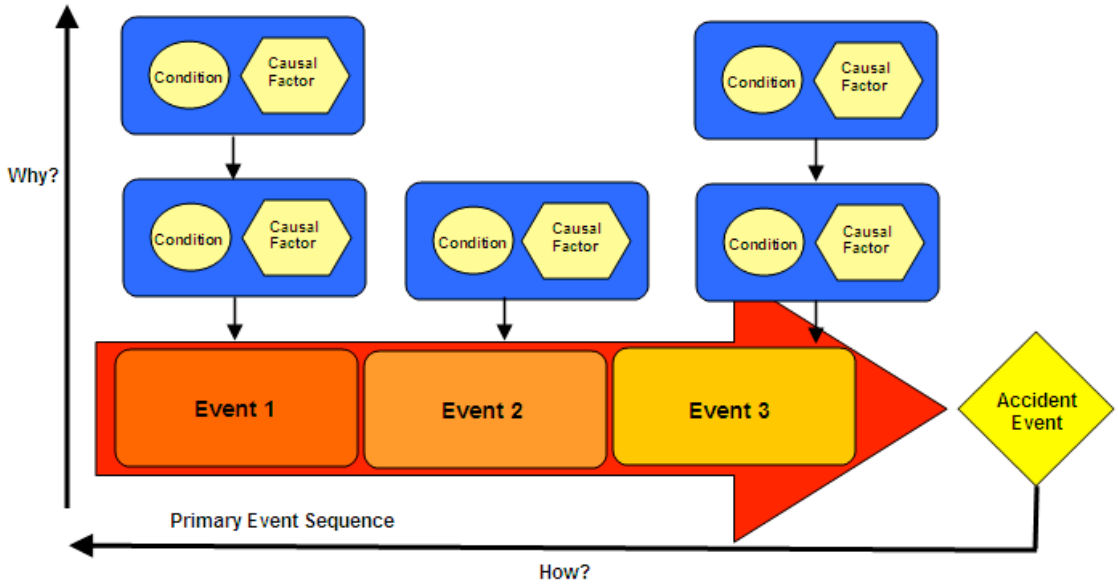
As the above diagram illustrates, multiple safety barriers may be in place. Each of these barriers may have "holes", where deficiencies or failures are possible. Where these holes line up, in a particular circumstance or context, then there is a possibility that an incident could occur. Where an incident has occurred, it is likely that holes in the existing barriers have aligned. The goal of incident investigation under the barrier method is to identify and understand these holes, so that they can be plugged to prevent future incidents.

The "5 Why's" Approach to Causation Analysis

The "5 Whys" incident investigation method is employed once the event and its associated conditions are identified following a barrier analysis review. This next step is for the causal factors enabling these conditions to be identified by repeatedly asking "why". More specifically, the "why" may entail two related questions:

- ***Why did this event occur?*** – the answer to which gives you the conditions that lead to the incident, and;
- ***Why did the system allow that condition to exist?*** – the answer to which gives you the root cause of the incident.

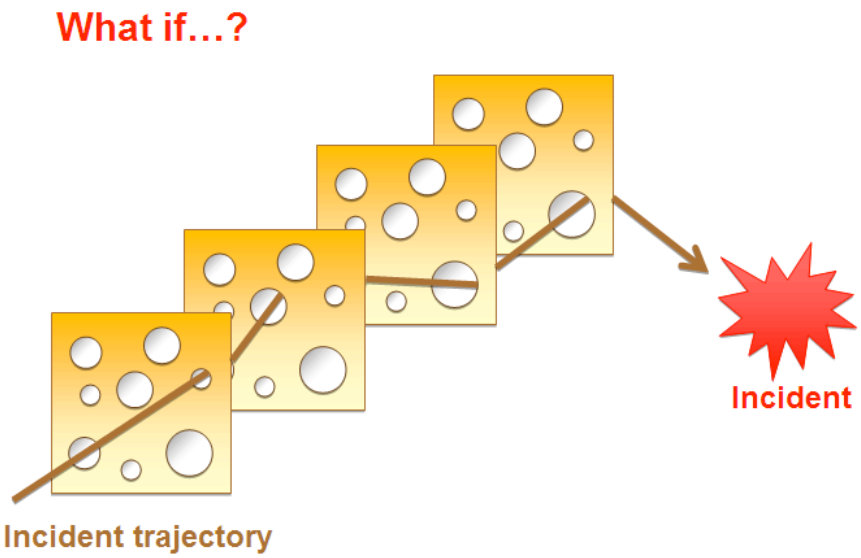
When these questions are asked five times, we are able to discern the events that lead to the incident as well as the conditions and causal factors that lead to those events. These conditions and causal factors constitute the "why" relating to the primary event sequence (which is the "how" of the incident). Below is a graphic representation of the event causal analysis method that results from the "5 why's" analysis:



The foregoing analysis will allow the investigator to identify the "why" of the incident. This includes understanding the events that lead to the incident, the conditions that permitted those events to occur and most importantly the root causal factors of the system that facilitated those conditions. The root causes of the incidents that are identified from this process reveal the system deficiencies, as well as any inadequate or absent defences that lead to the incident.

Positive Incident Investigation

While this type of root cause analysis is very useful, it is linear in the sense that it focuses on the incident that did occur, but does not tell us what other deficiencies may exist that are revealed by the incident. The Positive incident investigation approach goes beyond this linear consideration of incident trajectory to ask the further question "what if?" - with a goal of identifying additional holes or deficiencies that may not have been part of the incident trajectory under review, but which nevertheless exist and could lead to the next incident.



This enhanced review is done using the "web analysis" approached we have already introduced.

Complexity Theory

The web analysis approach is derived from complexity theory, which posits that, when faced with the same facts, people will not necessarily behave in the same way. This is a challenge to the conventional wisdom around incident investigation which is typically concerned with uncovering "the truth" and indeed "the root cause" of an incident. Complexity theory can be used to develop an incident investigation methodology which augments the human factors model by testing the resilience of a system as part of incident investigation, considering hypothetical alternative scenarios that reveal system deficiencies in the same way as root causes.

The Positive Incident Investigation approach requires the investigator to go beyond the question of causation of the incident being investigated. Beyond this linear question is the multidimensional question of what could have happened, but did not, and what those hypothetical scenarios tell us about the resilience of the organisation. When incidents occur, investigators are often amazed that things were not much worse. Events may have unfolded such that the impact of the incident was mitigated. This may be due to the fact that a possible trajectory of the incident did not in fact occur. This is the road not travelled but that could have been travelled. It presents an insight into possible incidents which could materialise in the future under different circumstances.

The question then becomes, what can these alternative incident trajectories tell the investigator? Traditional incident investigation methodologies give little or no consideration to other non-causal events. The Positive Incident Investigation process views these alternate trajectories as very valuable as they present possible root causes of future incidents that exist within the system before an incident occurs along that trajectory. These alternative scenarios can provide valuable information about the "holes" in the system that must be plugged to build resilience into the system. Importantly, they also tell us what went right in the system to avoid that alternative trajectory from materializing.

To identify these other possible deficiencies, the "5 Whys" of causation related to the incident must be followed by a more in depth analysis, which we call the web analysis, whereby the investigator must ask five "what if?" questions related to the incident. The goal of this further set of questions is to examine what would have happened if another sequence of events had occurred, in order to anticipate potential vulnerability to future events which might adopt a different trajectory from the one that did occur. This inquiry focuses the investigation process on improving the system to safeguard against unexpected future events, thereby increasing system resilience.

Conducting a Web Analysis

To perform a web analysis, the investigator must also ask five "what if's" to get to the root cause of other potential trajectories that did not eventuate in the particular incident at hand. The investigator can ask the question "what went right?" followed by a consideration of "what would have happened if it didn't go right?"

Identifying what went right in an incident can be just as instructive as identifying what went wrong. It tells us what effective defences were in place. Controls that work at a local level – and that are accepted by operators and fit into other complex systems – are rare. Their effectiveness should be celebrated. That is particularly the case in near misses where, had it not been for those controls, an incident would have occurred.

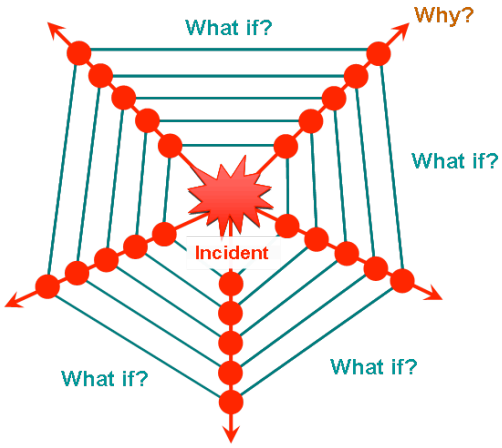
This process of questioning can also highlight potential system deficiencies that didn't materialize by sheer happenstance. By identifying effective control features, or missing control features that were not a direct cause of the incident, the investigator can make more in depth recommendations that can be replicated across the system.

If we add the "what went right?" dimension to the root cause analysis technique, we would need to adopt a multi-dimensional diagrammatical representation. If we build on the approach developed above, an incident event occurs because of a series of primary events

leading up to it, each causally related to the incident event. These are the direct causes of that event. By asking why these events happened, we uncover the root causes of that event.

For every event sequence, there is a road not travelled because of some control that worked or some other barrier whether intended or unintended. That alternate path can be uncovered by asking "what if?" Asking this question may disclose an alternate event sequence, together with its own root cause factors.

When the question "what if something else had happened?" is asked for the first time and we consider the "whys" behind that alternate scenario, we can identify more system vulnerabilities or potential deficiencies. This process is then repeated, where the question "what if something else happened?" is asked for the second, third, fourth and fifth time.



We are left with a web diagram. Each dot on the diagram represents system vulnerability or a failed or absent defence, tied to the incident trajectory or an alternative trajectory. The investigation report is then not just about linear causes but about vulnerability to future events which may adopt a different trajectory. The investigation is therefore not simply a root cause analysis, but a vulnerability analysis where the aim is to build resilience in the system to safeguard against an unpredicted and unexpected future event. This analytical process will reveal at least 25 vulnerabilities and possible deficiencies that can be used to improve the resiliency of the system. The investigation is therefore not simply a root cause analysis, but a vulnerability analysis where the aim is to build resilience in the system to safeguard against an unpredicted and unexpected future event.

Applying the Positive Incident Investigation Approach: *San Jose Mine Case Study*

Background of the San Jose Mine Collapse

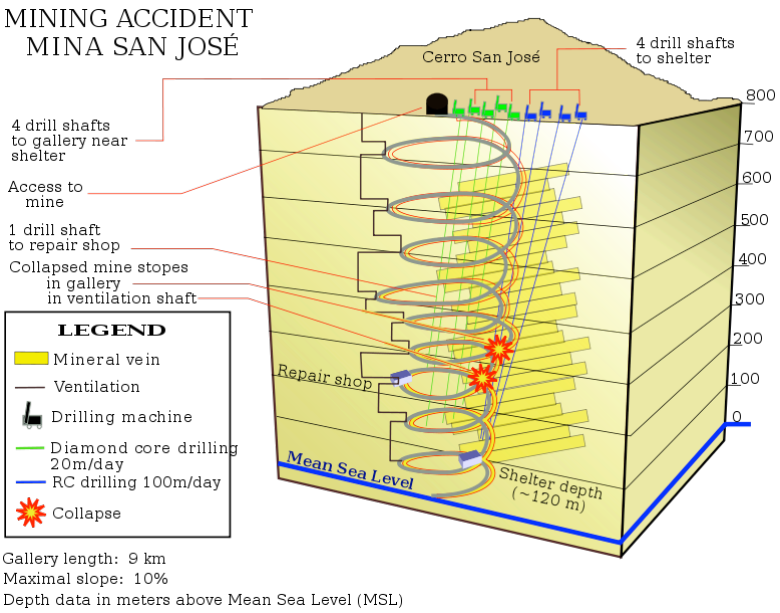
On 5 August 2010, outside the city of Copiapó, northern Chile, the San José gold and copper mine collapsed, trapping 33 miners underground. The small 121-year-old mine was owned by Compañia Minera San Esteban Primera. As the mine's ceiling caved in, it produced a heavy dust cloud, blinding the miners for several hours. The prospect of escape through a ventilation duct evaporated when the miners discovered that the emergency ladder, required by law, had not been installed. Trapped 700m into the mine in a small shelter, the men remained undiscovered for over two weeks and survived by rationing two days worth of emergency supplies found in the shelter.

The mixed crew of experienced miners and technical support personnel subsequently survived for a record 69 days deep underground before their rescue. Luis Urzúa, the duty shift supervisor, recognized the gravity of the situation and the difficulty involved in any potential rescue attempt. He gathered his men in a secure room called a "refuge" and organized them to

ensure their survival over the coming weeks. The crew survived for a record 69 days deep underground before their rescue. To ensure that high morale was maintained, experienced miners were sent out to assess the situation and men with important skills were given key roles while numerous other measures were taken to maximise the chances of surviving the disaster.

The San José mine is located deep in the Atacama Desert, one of the driest and harshest regions on earth, about 45 kilometres north of Copiapó, in northern Chile. Many parts of the San Jose mine were over 100 years old, with access to the depths of the mine's workings being reached by a long, sloping roadway with many irregular spiral turns, rather than by a vertical mineshaft and elevator system as utilised in modern mines.

The 700,000 tonne cave-in occurred at 2:00pm on 5 August 2010, causing a thick dust cloud to fill the lower ridges of the mine. At the time there were two groups of miners working underground. The first group, which were nearest to the mine's entrance, escaped immediately without incident. However, the second group of 33 workers, who were deep inside the mine, became trapped following the cave-in.



Initially the trapped miners attempted to escape through the ventilation shaft system, however, the emergency ladders that were required by mining safety codes were missing. This was despite a stipulation by the authorities, following a previous closure, that the mine could not be re-opened without the installation of escape ladders. These ventilation shafts later became inaccessible due to ground movements and could not be used by rescue teams. Mine managers did not report the accident to emergency services until six hours after the collapse had occurred. This delay in alerting emergency services is just one aspect of the company's response to the incident, which is under investigation by Chile's mining regulators and Congress.

The day following the incident, national emergency officials assembled a rescue team, intending to go into the mine and locate the missing miners. This rescue attempt stalled when the team encountered falling debris and collapsing mine walls. As a result, the trapped men remained undiscovered for more than two weeks with attempts to determine their exact location progressing slowly as a consequence of inaccurate maps supplied by the mining company and continuing collapses within the mine. Percussion drills were used to create eight exploratory boreholes about 16 centimetres in diameter in an attempt to find the miners.

Seventeen days after the accident, on 22 August 2010, a note written in bold red letters appeared taped to a drill bit when it was pulled to the surface after penetrating an area believed to be accessible to the trapped workers. It read simply "We are well in the shelter, the 33".

Upon discovering that the 33 trapped miners were still alive, the Chilean Government implemented a comprehensive recovery plan to both nurture the workers during their entrapment and to rescue the miners from the depths of the mine. It included deployment of three large, international drilling rig teams consisting of numerous government ministries and more than a dozen multi-national corporations. After 69 days trapped deep underground, all 33 men were brought safely to the surface on 13 October 2010, over a period of almost 24 hours. All 33 miners were in good medical condition with no long-term physical effects.

Previous Near misses

The age and disrepair of the San Jose mine, which was brought to light by repeated incidents, was ignored by the mine's owners. Compounding these risk factors was management's failure to maintain appropriate safety systems and emergency response measures – such as installing escape ladders and having procedures in place for notifying emergency services in the event of a serious incident.

Previous geological instability at the old mine and a long record of fines and safety violations for the mine's owners had resulted in a series of accidents, including eight deaths, during the twelve years leading up to this accident. The mine had been the subject of previous closures by Sernageomin, the government mining regulator, as a result of unsafe practices.

In particular, in 2005, workers forced the closure of the mine due to poor conditions and in 2007 a miner was killed in an explosion, prompting regulators to shut down the site for a year. Following the latter incident, the mine was closed and required to institute 'corrective measures' by the mining regulator. On 28 July 2010, a health ministry official allowed the mine to reopen, despite the fact that some of the corrective measures had not been implemented.

The ministry official resigned soon after the mine collapse occurred. When questioned by a government committee about the safety failures which led to the accident that trapped the 33 miners underground, the owners of the mine were unable to explain why the mine was reopened so quickly.

Looking to Root Causes

The Chilean Congressional Commission investigation into the accident concluded that the mine's owners, Alejandro Bohn and Marcelo Kemeny, were negligent in their management of the mine and largely responsible for the collapse.

The congressional report found there to be "clear responsibility as regards to the employers or managers of the mining operation, who are responsible for delivering a safe workplace". However, the commission also concluded the Chilean state was at fault, finding that the mining regulator should have been more proactive in the enforcement of safety legislation and regulations. In addition to failures of regulatory oversight, the condition of the mine played a large part in contributing to the collapse and its consequences.

The San Jose collapse brought the mine's safety record into focus and put mining, Chile's top industry, under close scrutiny. Soon after the disaster occurred, President Sebastian Pinera's government stated that it would ensure that lessons from the accident were learnt and that it would implement better legislation to protect Chile's miners. Since this time, mining-related deaths have fallen 36 percent in 2011 to 27 fatalities, compared to 41 in 2010. Further, according to a report compiled by the Mining Ministry accidents in Chile's 8,500 mines fell by 40 percent, their lowest level in 21 years, thanks to increased oversight by inspectors.

Examination of root causes is useful, but had a more complex investigative approach like the Positive Incident Investigation and web analysis method been applied at the San Jose mine, resilience could have been greatly improved and disasters like the August collapse possibly averted.

Learning from Alternate Trajectories with Positive Incident Investigation

There were certainly missed opportunities to improve the resiliency of the mine prior to the August 2010 collapse. In particular, the inadequacy of previous investigations of incidents at the mine that preceded the collapse meant that the weaknesses and deficiencies it revealed were not corrected. The July 2010 rock fall which preceded the August collapse was the ideal opportunity for the company and the mining regulator to appreciate and remediate the vulnerabilities and deficiencies of the mine to rock falls and collapses.

If the regulator and the company had applied a Positive Incident Investigation approach at that time, their investigation of that incident may have revealed the inadequacy of the company's preparedness for a future mine collapse. Considering alternative "what if" scenarios would have required an assessment of the mine's emergency planning and response systems, including how to recover workers in the event of a more severe rock fall than the one that occurred in July. These vulnerabilities, if adequately addressed, could have averted or lessened the severity of the August 2010 collapse.

If the "what if" web analysis methodology is applied to the July rock fall, a much broader range of possible incident trajectories can be seen. These alternate trajectories, if properly tested, could have alerted the mine's management to the alarming deficiencies in its safety systems, which in turn would have prompted the implementation of appropriate safety measures. The San Jose mine collapse illustrates well how catastrophes may be foreshadowed by less severe incidents, which if properly understood can reveal deficiencies that may contribute to future incidents.

If we put ourselves in the position of an investigator applying the Positive Incident Investigation approach to the earlier rock fall, we might find the following:

What if a more severe incident occurred?

Most basically, previous fines and the lead up incidents to the August 2010 collapse of the mine should have raised fundamental questions about the adequacy of the safety management system in place at the mine.

Former San Esteban employee Vincelot Tobar, who had been responsible for risk management with the company until 2009, claimed that the company's management focused on production at the expense of safety; the company is believed to have accumulated around 42 fines from various state safety bodies since 2004. As such, flawed or non-existent safety systems greatly increased the gravity of the incident following the mine's collapse.

The San José mine disaster and its aftermath illustrate the importance of companies maintaining stringent safety systems that comply with relevant OHS laws and industry standards. Ensuring that emergency response systems are in place and routinely tested for efficacy, and the broader significance of encouraging a workplace culture that values safety in its day-to-day operations, are further lessons to be heeded from this disaster.

What if a compliance audit were conducted tomorrow?

This line of questioning gives rise to an examination of the adequacy of San Esteban's safety systems in addressing rock falls and collapses. Ensuring that emergency safety systems are in place and are systematically audited for compliance with relevant occupational health and safety laws and regulatory standards would be necessary to ensure their adequacy.

Such an audit should have revealed the absence of evacuation ladders which were required by law but absent from the mine. In fact, installation of escape ladders was one of the basic safety measures required by Sernageomin following the mine's 2008 closure. The implications of this corrective measure would have been significant. Chile's Minister of Mining, Laurence Golborne, commented that the miners could have escaped if the ladder had been in place.

What if there was a roof collapse?
This alternate trajectory requires an assessment of the Mine's emergency planning and response systems, which in turn would have led managers to realise how inefficient their current system actually was.

The 6-hour delay in notifying emergency services immediately after the collapse highlights the importance of companies having effective emergency response systems in place.

The first 24 hours after a serious incident are crucial. Had appropriate safety mechanisms and response procedures been in place at the San José mine, the incident may not have escalated to the point where 33 men remained trapped underground for 69 days.

Additionally, once the miners had been located, rescuers planned and then discarded a number of strategies for extracting them. Entering the mine was impossible due to its instability, and equipment required to drill an alternative exit point was not readily available, causing further delay in the rescue operation.

Each of these failures in Minera San Esteban's emergency systems and planning demonstrate a number of aspects requiring consideration when formulating procedures for dealing with serious incidents. These could and should have been re-evaluated at the time of the earlier incidents and could have been of critical importance to the rescue effort following the August collapse.

What if miners were trapped underground?
Considering this alternative trajectory to the July 2010 rock fall incident should have given rise to questions regarding the adequacy of the mine's evacuation procedures and its means of locating underground miners.

Difficulties locating the miners in the aftermath of the collapse were exacerbated by reliance upon inaccurate maps of the mine supplied by its owners, according to a supervisor working with the search team.

In a video made by the miners and sent to rescuers on the ground, one worker claimed that the emergency shelter was in a state of neglect when they sought refuge there "…the energy was cut off and there was no ventilation". The shelter's food supplies were intended to last only 48 hours.

These factors could have been spotted and resolved if deficiencies that would have emerged in alternative scenarios had been investigated in relation to other incidents that occurred before the August 2010 collapse occurred.

Learning from what went right?
Looking now at the August 2010 collapse itself, we can also find learning opportunities from "what went right" when the collapse occurred. Supervisor Urzúa's actions immediately after the incident are credited with keeping the men alive on an emergency food supply during their first 17 days without contact from the outside world. This example of "what went right" reveals the importance of properly resourced protected areas that can survive a collapse and support life until external help is organised. This learning could only be captured if investigation analysis goes beyond the causal chain of the accident, towards understanding what positive actions occurred that prevented a much worse outcome.

Conclusions

Positive Incident Investigation allows incident investigators to utilize the complexity of incident trajectories to learn the most from every incident. By going beyond root cause analysis to understand not only went wrong, but also "what went right" and to identify what deficiencies would have arisen if things had been worse. Following this approach, investigators can get the most out of every incident investigation and contribute to maximal organisational resilience. That resilience may not be the "cure" to every incident, but it may well be the "vaccine" that can stop system deficiencies identified today from creating the incidents of tomorrow.