Session No. 612

Effective Risk Assessment in TA, JHA, JSA, JSEA, WMS, TAKE 5, and Incident Investigation

J.F. (Jim) Whiting, MSc, Dip.Ed., CPEng, SMIE(Aust)
Managing Director, Principal Risk Engineer
risk@workplaces pty ltd
Brisbane, Australia

Introduction

Day-to-day safety management regularly requires processes such as the development and review of Task Analyses TA, Job Hazard Analyses JHAs, JSAs, JSEAs, Work Procedures and Work Method Statements (WMS), Pre-Work Risk Assessments, such as TAKE 5s, and, unfortunately, regular Incident Investigations. This paper describes how decision-making is always involved in these processes and therefore they require reliable consistent qualitative or quantitative risk assessments.

The results of many, if not most, risk estimations particularly those using the ubiquitous semi-quantitative L*C matrix methods cannot always be relied upon with much confidence because of wide variations in individual assessments. The variations are usually due to confusion in the best ways of conducting the risk assessments. When, by whom, and how to perform risk assessments effectively can be clearly defined and standardized. As a result, the assessments can be appropriately rigorous and hence produce more confident, accurate and reliable risk estimates that are needed for decision-making.

No procedure can ever be written to foresee all possible job circumstances perfectly! Often there are circumstances where a procedure may need to be varied or a work-around has to be developed. Following a procedure exactly may actually involve higher risk than using a necessary work-around *but only after* a formal risk assessment of the work-around variation has been assessed with the supervisor. ***Finding*** a necessary work-around or shortcut is "smart." ***Taking*** a work-around / shortcut ***without a risk assessment*** with the supervisor is the "dumb" part. The usefulness of the L*C matrix during different levels of risk assessment is explained. The day-to-day safety challenge is to embed the culture of work that variations, changes to work methods can only be made after joint risk assessments.

Numerous decisions need to be made before, during and after an Incident Investigation. The paper describes how effective risk assessments – formal and informal – are needed in all the decision-making processes. One of the author's investigations of a real work fatality is used to illustrate examples of this aspect of uses of risk assessment in safety.

Part 1: Decision-making Requires Risk Assessments

The safety management processes being considered all involve decision-making and choosing between options. For any job / task / activity in every aspect of life, there are always choices of options involved. *Which way will we do this job?* Which optional method exploits & maximizes exposure to the *positive opportunities* and minimizes & controls exposure to the *negative hazards*? That option choosing or *optioneering* requires some basis and risk levels from risk assessment provides it. Analysis of options to estimate which has the highest likelihood of positive outcomes and lowest likelihood of negative outcomes reveals how best the decision can be made. Emphasis on the when and the how rigorous risk assessments are performed as part of safety processes will ultimately ensure that they achieve their purposes reliably and accurately.

Making a decision based solely on severity of consequence is illogical. Decisions can only be made on the basis of the associated risk level = R = L * C which includes BOTH the severity of the Consequence C being considered AND the assessed Likelihood L of the scenario required to lead to that severity.

In Task Analyses TAs and Job Hazard Analyses JHAs [or their variants JSAs, JSEAs, JRAs], identifying task steps / phases and associated hazards / risk factors for each step is usually the first requirement. Asking WHAT could go wrong at each step in the task is not enough. The additional, more revealing and useful questions need to address clarification and agreement on the HOW a specific consequence of interest or concern could happen. Not only WHAT range of consequences / severities could happen but also the HOW – the scenario for each consequence – must be agreed. Only then can a reliable measure of the likelihood of each chosen consequence be estimated.

Defining and agreeing on the *how*, a credible scenario of events and circumstances necessary to lead to the chosen *what* consequence, is the vital part of any assessment. Most problems with assessors making a wide variation of risk estimates are related to not devoting enough time to the how stage. A full description (*verbal [risk statement]* or *graphical [risk map])* of the details of the complete risk scenario is absolutely essential before its Likelihood can be estimated. Whenever risk level estimates vary widely, go back to describing and agreeing on the details of the risk question or scenario being analysed. Otherwise each individual in the risk assessment workshop group will include / bias / exclude / ignore different risk factors in their estimates. It is no wonder that they get different estimates because they are estimating different risk scenarios.

Part 2: Risk Assessment Process

According to ANSI / ASSE Z690.2: 2011, *Principles and Guidelines for Risk Management*, ***risk assessment*** is defined and is shown in Exhibit 1 as including:

- identify (describe / define risk question / exposures in detail)
- analyze (estimate / calculate the size of the risk)
- evaluate (compare risk level against tolerance and action criteria)

In the following Part 3, OHS tools in common use are examined to see what aspects of risk assessment, as defined, are actually being used.

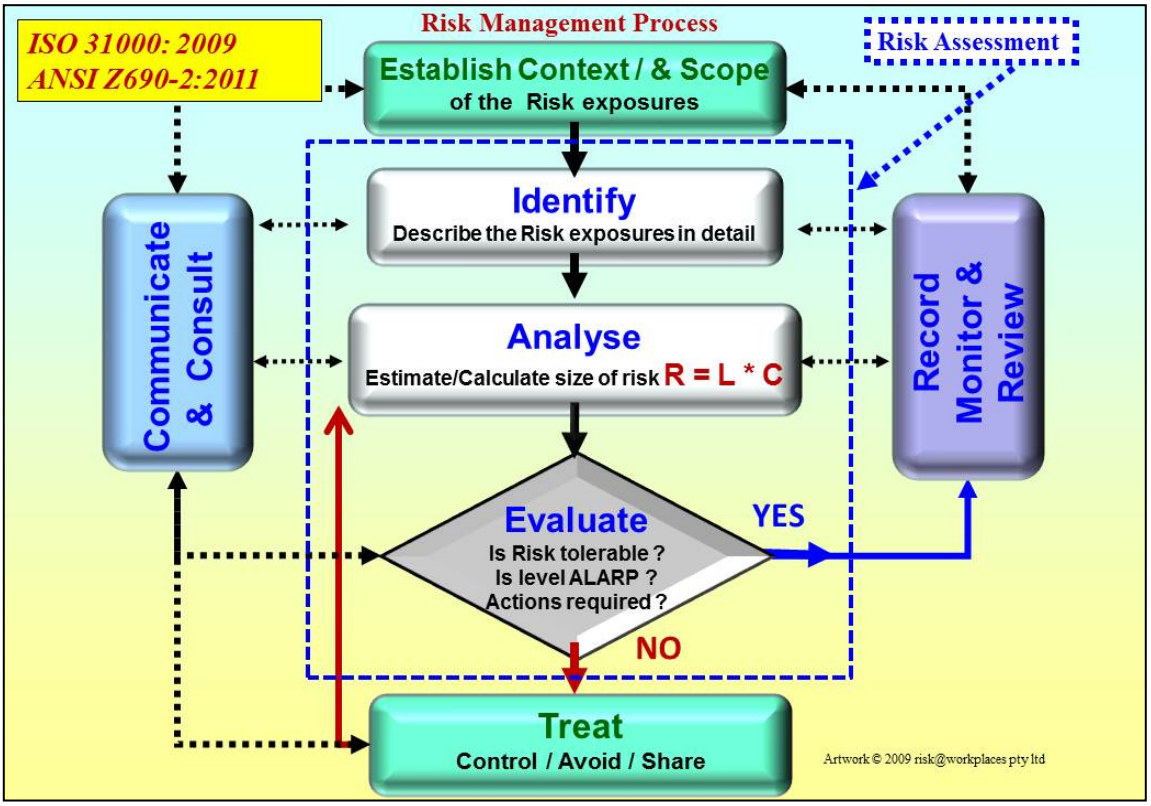


Exhibit 1. RM Process (Adapted from Clause 5, Figure 3, ISO 31000/ANSI Z690.2)

If the *analyze* and the *evaluate* stages are not included in a safety process, then it is Hazard Management, not Risk Management. If JHAs and other OHS Tools jump straight from *identify* to *treat /control* as most do, then the value of the process is seriously impaired by the lack of ways of deciding which work methods or practices are better than others. The decision can be made by evaluating whether one method has less / more risk control than another. Any decision needed in OHS activities is also compromised if there is no basis to compare options.

Risk Analysis as this crucial part of risk assessment can be performed at different levels in varying degrees of formality and quantification. Exhibits 2A and 2B show the 4 main levels of Risk Analysis. It is appropriate to do risk analysis as the second step of risk assessment by first doing a qualitative analysis and then working down with increasing rigor formality and depth. The use of more sophisticated and thorough methods involves extra cost of time, money, and effort. As such the choice of analysis method is only justified by the level of risk and the seriousness of the decisions to be made with the risk level information. It is always recommended that the hierarchy is followed downwards as a logical process filter and cost / benefit comparisons.

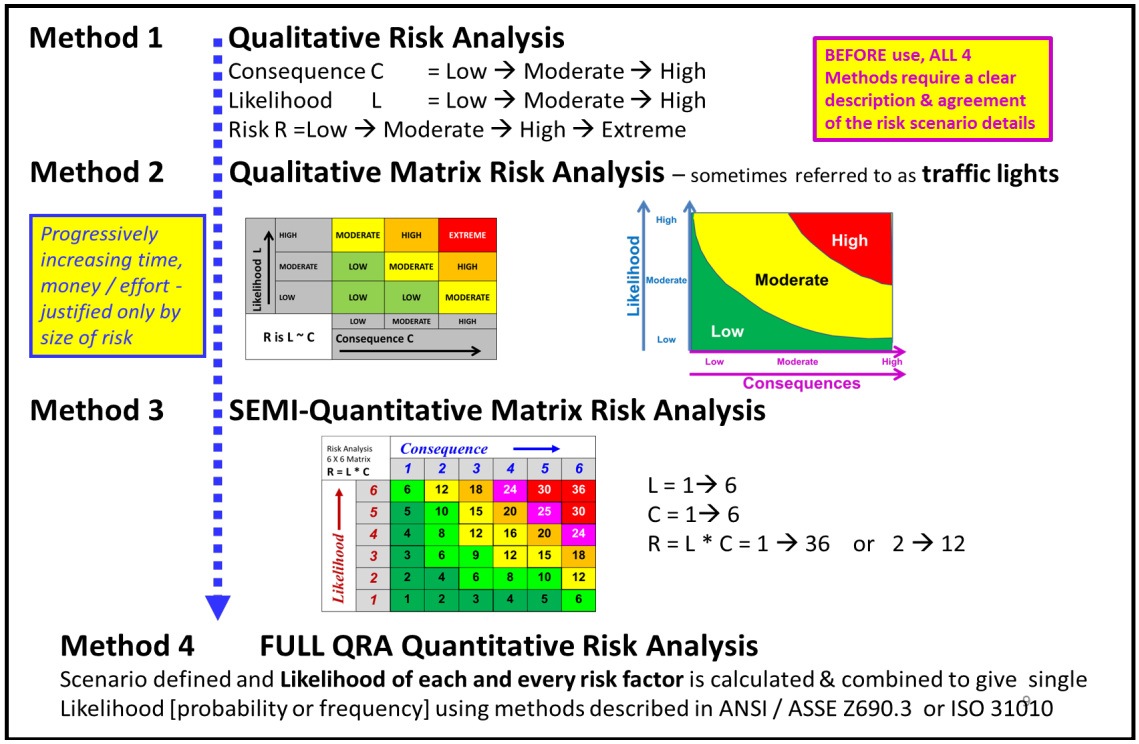


Exhibit 2A. The 4 Main Methods of Risk Analysis

Hierarchy of Alternative Risk Analysis Methods

Alternative Methods	How to calculate / estimate risk levels / sizes
Qualitative	❑ Consequence C is chosen and rated verbally = *High / Moderate / Low* ❑ Describe a scenario for HOW the chosen C could be produced ❑ Likelihood L is estimated and rated verbally = *High / Moderate / Low* ❑ Risk is expressed as a qualitative combination of Likelihood and Consequence. ❑ R = *Extreme / High / Moderate / Low* *Progressively increasing time, money and effort - justified only by size of risk*
Qualitative MATRIX	❑ Choose a Consequence of interest/concern and its Severity from a Rating Scale [say] C= A → E ❑ Describe a scenario for HOW the chosen C could be produced ❑ Estimate the Likelihood L of that Scenario from a Rating Scale [say] L = 1 → 5 ❑ Estimate the Risk of that scenario by a combination of its L and C values R = L * C ❑ Risk can be expressed as A1 → E5 and verbally such as *Extreme / High / Moderate / Low*
Semi-Quantitative MATRIX	❑ Choose a Consequence of interest / concern and its Severity from a Rating Scale [say] C= 1→ 6 ❑ Describe a scenario for HOW the chosen Consequence could be produced ❑ Estimate the Likelihood L of that Scenario from a Rating Scale [say] L = 1→ 6 ❑ Estimate the Risk of that scenario by a combination of its L and C values R = L * C ❑ Risk can be expressed numerically [say] 1 → 36 OR 2 → 12
Full QRA Quantitative Risk Analysis	❑ State a Consequence of interest or concern – Severity is NOT allocated a scale rating. ❑ Describe a scenario of hazardous events / circumstances needed to produce that Consequence ❑ Estimate the size of the Likelihood for that scenario to occur using full QRA methods such as Logic Trees / Event Trees / Fault Trees / Bow Ties Analysis described in ANSI / ASSE Z690.3 ❑ Risk is then expressed as the likelihood of the stated scenario including the chosen Consequence. *e.g. "The risk of a rigger being killed falling from that scaffold due to ….those circumstances …..... is :- 1 chance in 1000 [probability] OR 1 every 2 years [frequency]"*

Exhibit 2B. Hierarchy of Alternative Risk Analysis Methods

In a number of organizations' tools, a distinction between hazards and risks is not always clear. The terms are often used interchangeably and confusingly. The simplest useful distinction is ***risk = hazard + exposure***. You can have hazards but you cannot have risks unless "targets" are exposed to them. In many respects, risk management can be viewed as exposure Management. Risk controls are essentially exposure controls, reducing the *duration* (for how long) and *frequency* (how often) the "targets" are exposed. No or little exposure means no or little risk. Exhibit 3 shows the differences between the hazard management and risk management processes.

[NOTE: In financial risk management, the term *exposure* is usually used to describe the consequence of interest or concern, e.g., "We have an exposure of $10 million."]

Differences between Hazard Management & Risk Management

Processes	Hazard Management	Risk Management
Describing the OHS issue	❑ Usually states only the "energy"classification e.g. *"gravitational"* or *"electrical"* etc No real statement of HOW the harm can eventuate. ❑ Often mistaken belief that there is only 1 hazard per step in a job / task ❑ Inadequate consideration of "exposure" – duration [for how long] and frequency [how often]	❑ Recognises need to describe and agree on the HOW and the WHAT *e.g. Fall from scaffold due to hand slip due to loss of balance due to foot slip due to muddy surfaces …….* ❑ Recognises need to consider possible multiple OHS hazards during each step - also hazards to other business objectives – environment / finance / quality etc. ❑ Strong emphasis on "Exposure" recognising that risk management is essentially about exposure control
Considering Seriousness	❑ No explicit regard for understanding the magnitude of severity of consequences or likelihood of exposure to each of the hazards	❑ Explicit recognition that qualitative and /or quantitative risk levels need to be estimated to allow sound decision-making
Deciding Priorities	❑ Because of above, there is no means / basis for setting priorities. Only Informal judgment sometimes used to set priorities for which hazard controls first and resourced most..	❑ Risk levels provide a sound logical useful basis for setting priorities and resource allocation decision-making
Choosing Control Measures	❑ Common belief in ABSOLUTE safety - that control measures are always perfect and can completely eliminate hazards ❑ Common belief that only 1 control measure is required for 1 hazard ❑ No means / basis for selection of options of control measures - only informal judgment	❑ Recognition that "stop" " prevent" "eliminate" are false confidence words – They imply that "zero risk" is achievable and confuse it with "zero harm" ❑ Often need a combination of a range of different types of controls

Exhibit 3. Differences between Hazard Management and Risk Management

Part 3: Risk Assessment Processes and Tools

TAKE 5s and variants (Step-Back 5X5, SLAMs, STOP, WAIT, HIT, etc.) are the powerful and necessary on-the-job risk assessments *just before a job* can be started or when *changes* in job circumstances lead to different situations that were not envisaged or foreseen or assumed during development of the Procedure or Work Method Statement WMS.

JHAs usually do not address risk analysis nor risk evaluation. They are essentially hazard management tools. They intentionally concentrate on hazard identification and hazard control. By not making any qualitative nor quantitative estimate of risk level, they do not generate any means

of decision-making that requires some estimate of risk level or size. Some JHAs do include some estimation of the magnitude of the risk and some evaluation of its tolerability / acceptability. In fact that form of JHA should be better called a JRA. Many JSAs and TAs do go the extra steps and address in some ways all three parts of risk assessment: identify, analyze, and evaluate. They would also be better called JRAs.

Whatever the title for the risk analysis process or tool, the focus should be on Solutions – what new improved risk controls are necessary for better control to maximize chances of positive outcomes and minimize chances of negative outcomes. Too much effort is often misdirected at false confidence attempts at precision in likelihood calculation / estimation rather than focusing on better risk controls to reduce risk levels so far as reasonably practicable (SOFARP) or as long as reasonably practicable (ALARP) as commercially, legally and morally necessary. *"Solution Focused Risk Assessment*" should be the dominant objective.

A major theme should be that regardless of what we call the process – JHA, JSA, JOA, TRA, etc., users will benefit if as well as identifying how good / positive and bad / negative outcomes could eventuate during a task or job, we should also estimate the risk scores associated with the stated scenarios for the opportunities / hazards being considered.

If the estimation is:

- **qualitative** (verbal descriptors as in Exhibits 7B and 7D) and/or
- **semi-quantitative (**L Scales and C Scales → R scores as in Exhibit 7C)
- **fully quantitative** (numerical likelihoods of every risk factor),

then the hazards / risks can be ranked. This allows the primary purpose of risk management, which is to generate information to allow prioritized decision-making on the best order of exploiting opportunities and mitigating hazards, according to whether the outcomes are positive or negative respectively.

Some have argued that risk scoring should be done only for JSAs that are used as part of developing a procedure / WMS / SWI / SWIMS. Their claim is essentially based on the belief that in a JSA it is not wise to rank or prioritize the hazards. It is not a case of "either/or." Risk management requires *both* ranking risk levels *and* control measures. Measuring the seriousness of hazards and hence ranking them can only be achieved by extending hazard management to risk management, i.e., by formally adding the *"analyze"* and the *"evaluate"* stages. At present, many JHAs assume that the assessor is subconsciously making some form of ranking the seriousness but with no basis for doing so. Seriousness of a hazard and any associated scenario cannot be classified according to "potentiality," which is based on black and white, yes and no, with no grey scale "possibility." There is no range of "possibility." The term "potential," normally associated with a hazard, has to consider "probability" as well as "possibility." Seriousness of a hazard needs an associated scenario and must be based on a risk level or score of the scenario determined within a range of likelihood. Another concern with ranking hazards is recognized that without risk scores or levels, criteria for determining tolerability of scenarios / risks will be unclear. This concern is more than adequately faced by having a formal *risk tolerability framework,* which has clear ALARP criteria and designates risk owners according to matching risk levels or scores with levels of management responsibilities, authorities and accountabilities.

How OHS tools are involved in risk assessments generally and risk analysis in particular is described in Exhibits 4A and 4B.

OHS Tools and Risk Analysis Methods

OHS Tools	Do current users of Tool include any kind of Risk Analysis method ?	Personal Preference & Recommendation
TAKE 5 / STOP / WAIT / Step back 5X5 / SLAM / PASS / TIME OUT / HIT	MOST often do NOT include Risk Analysis – see examples	**Agree most times** - often do not need to estimate risk levels for the decisions required. But may benefit from Qualitative RA sometimes
JHA = Job Hazard Analysis **AHA** = Activity Hazard Analysis	MOST often do NOT include Risk Analysis – see examples - only hazard management - hence no basis for decision-making	**Disagree** – recommend all JHAs include a RA and be renamed / replaced by JRAs or TRAs Or even JOAs – see below
TA = Task Analysis **JSA** = Job Safety Analysis **JSEA** = Job Safety & Environment Analysis **JSEQA** = Job Safety / Environment & Quality Analysis **JRA** = Job Risk Analysis **TRA** = Task Risk Analysis	MOST often DO include some form of Risk Analysis – see examples -risk levels / risk scores provide a logical workable basis for decision-making re priority timing and resourcing of risk controls	**Agree – at least SEMI-Q Matrix method needed ALL the time** **Prefer JRA or TRA** to emphasise not just managing OHS risks and scope is ALL business domains / objectives not just OHSEQ **Use JOA or TOA** if also require emphasis on maximising chances of positive outcomes in all risk domains

Exhibit 4A. OHS Tools and Risk Analysis Methods

The recommended levels of risk assessment for the various OHS Tools are shown in Exhibit 4B.

OHS Processes and Possible Tools / Risk Analysis Methods

OHS Processes	Tools	Recommended Level of Risk Assessment
Estimating Risk level of an Individual Risk	**At least SEMI-Q Matrix JRA**	IF important decisions are going to use the risk estimates, and if Qualitative and SEMI-Q RA estimates are high then FULL QRA would be justified and necessary IF Risk Owner wants full assurance that risk is well understood, then he/she may require FULL QRA
Developing / Reviewing Policies Procedures / Formal Methods of Work / SWPs / SOPs / SWIMS / WMS / Work Practices	**At least SEMI-Q Matrix JRA**	At least SEMI-Q MATRIX method for each risk associated with the work. FULL QRA when SEMI-Q estimate is high.
Pre-Task / On-Site Assessments *Initial – before start*	**TAKE 5**	At least TAKE 5 without any explicit JRA May need JRA if qualitative estimate is high and there are unusual or infrequently experienced risk factors
On-Site Assessments *for Changes during a Task*	**TAKE 5**	ditto
Deciding with Supervisors *on required "work arounds" and "approved short cuts"*	**At least SEMI-Q Matrix JRA**	Developing "Work-Arounds" involve important joint risk decisions and if SEMI-Q RA estimates are high then FULL QRA would be justified & necessary. IF Risk Owner wants full assurance that risk is well understood, then he/she may require FULL QRA
Conducting Tool Box / Tail Gate Talks / Job Planning & Reviews	**At least TAKE 5**	Preferably Qualitative Matrix JRA to demonstrate different risk levels of different methods of work
Supervision and Counselling	**ditto**	ditto
Interactions / Observations	**ditto**	ditto
Incident Investigations Before / During / After	**ditto**	ditto

Exhibit 4B. OHS Processes and Possible Tools and Risk Analysis Methods

Part 4: Risk Control and OHS Tools

Ultimately, safety processes are required to maximize the chances of positive outcomes and minimize the chances of negative outcomes. Risks treatments or controls constitute the mechanism for achieving those objectives.

When any risk is being assessed, it is always important to clarify exactly what risk is being considered, such as *inherent* or *existing residual* or *target residual,* as described in Exhibit 5. The ultimate safety risk management objective is to manage each risk to:

ALARP – As Low As Reasonably Practicable.
OR
SOFARP – So Far As Reasonably Practicable

Risk Levels generated by Risk Analysis

Risk Level	Risk Controls	Notes
Inherent	**Without any risk controls** - Rarely are there no existing risk controls but sometimes useful to consider what the risk level would be if there were no controls at all	Emphasises need to consider if there actually are any existing controls in place and how effectively are they being implemented and working Sometimes used as a motivational legal & moral frightener
Current Residual	**With current existing risk controls** but analysing how effective / strong they are	If existing risk controls are NOT effective and working then the risk level is the Inherent level
Target Residual	**With any new / different / improved / additional risk controls** required by the **Risk Owner** to satisfy moral and legal obligations to reduce risks to ALARP	Never zero And always changing

Exhibit 5. Risk Levels generated by Risk Analysis

One interesting variation of the JHAs and JSAs being used by various organizations involves the lack of recognition that the *identify* stage, as well as the *control* stage, needs to include consideration of the nature and effectiveness of ***existing hazard / risk controls***. Many proformas / templates simply have *Job Step / Hazards / Controls / Who Responsible*. Without a clear understanding of what existing current risk controls are supposed to be in place now, and whether they are effective, then the *current residual baseline risk level* cannot be established. Also knowing which existing controls are weak or strong can provide opportunities to better manage safety by improving the weak as well as introducing new or different stronger controls. Often, assessors think they are finding the *current residual risk level* in Exhibit 5, but if the current risk controls are not in place and working effectively, then the risk being assessed is really at an *inherent level*.

Ineffective controls = no controls!

The traditional and logical basis for selecting control options - *optioneering* - is the risk control hierarchy of Exhibit 6. Note that the dollar cost always influences option choices. For tolerability considerations, the ***risk owner*** needs to determine what risk controls are needed to reduce the risk to *ALARP* (as low as reasonably practicable) or *SOFARP* (so far as reasonably practicable). Standards such as ASSE/ANSI Z690.2 do not specify the legal and moral criteria for deciding when a risk level is ALARP but they do specify that an organization must define them. Appendix 1 describes a very common set of ALARP criteria used widely around the world.

Hierarchy of Risk Controls

Needs to be used during **risk identification** as well as during **risk treatment / control**

TYPE		EXAMPLES	Reliance on Humans	Normally Effective	Apparent $ Cost
HARD	**Physical Engineering Controls**	Removal / elimination / substitution / design / interlocks / valves / cut-outs / fuses / interrupters / guards / barriers / limiters / ergonomic redesign / Fail-Safe position hold & return to home	**Low**	**More**	**More**
SOFT	**Administrative Controls**	Rules / Work Practices / Manuals / Policies & Procedures / Checklists/ Permits To Work (PTW) / Exclusion Zones / Work Rosters	↓	↑	↑
	Supervision / Enforcement	selection and preparation of personnel / behaviour reinforcement methods / Fair & Just discipline / culture			
	Checking / Assessments	Audits / Inspections / reviews / risk assessments / JSAs job safety assessments / frequency / depth / independence			
	Behavioural Controls	training in all its forms / PPE / lockouts / warnings / alarms / signs / interactions / observations / counselling / discipline	**High**	**Less**	**Less**

Exhibit 6. Hierarchy of Risk Controls

Risk controls that reduce *only* consequence severity (e.g., most types of PPE, rescue / fire fighting / first aid) are fundamentally *reactive* in nature. By definition, safety management must be primarily *proactive*. Controls that reduce likelihood must be implemented as well. Management strategies must always include a mixture of *hard* and soft controls. Even hard controls are not perfect. They need the support of soft controls and vice-versa.

Estimates of likelihood / probability must involve detailed information to assess the "strength" of risk controls. Is each control i*nappropriate / missing / wrong / not implemented / weak / ineffective / not working / not followed / not followed correctly / not conducted / inadequate?* It is always helpful to make these estimates of effectiveness of controls at least qualitative such as *weak*, *moderate* and *strong* or even numerical 1 → 3. See Exhibits 7B through 7D.

Frequent in-depth tests / audits / inspections / checks by independents are legally and morally essential to assess if risk controls continue to be *in place / effective / working correctly*. Nothing is static – **change management** and risk management go hand-in-hand. Most risk factors are related to change.

Part 5: What Is the Optimum JRA Template?

Exhibits 7B, 7C and 7D show how the very common JHA template format of Exhibit 7A can be simply and appropriately converted to a JRA by varying degrees of improvement without making it too complicated.

Sequence Of Basic Job Steps	Potential Hazards	Controls Measures	Responsibility

Exhibit 7A. Basic traditional JHA Format

Exhibit 7B shows a number of additions / changes including:

- HOW in the hazard description,
- qualitative risk analysis to estimate the risk levels before and after controls,
- rating the strengths of the risk controls

Sequence of Basic Job Steps	Potential Hazards Include HOW	Inherent Risk Level [no risk controls] Qualitative Risk Rating	Risk Control Measures Options [rate each control for effectiveness in reducing risk]		Residual Risk Level Qualitative Risk Rating	Responsibility
Operator selects casting and moves it to grinding station	Operator could lose grip and drop casting and incur a serious foot injury	Extreme High Moderate Low	1. Reposition castings on a table next to the grinder. 2. Enforce Safety Footwear 3. Use gloves with a better grip. 4. Use a clamp device to pick up castings.	weak modest modest strong	Extreme High Moderate Low	Supervisor Fred Smith By 20 March
	Can be several hazards per job step					

Exhibit 7B. Changed 7A to a Qualitative JRA Format

Sequence Of Basic Job Steps	Potential Hazards Include HOW	Existing Risk Controls [audited / in place & working effectively] [rate each control for effectiveness in reducing risk]	Current Residual Risk			Proposed Improved / New Risk Controls [rate each control for effectiveness in reducing risk]	Target Residual Risk			Responsibility
			Consequence	Likelihood	Risk Score / Rating		Consequence	Likelihood	Risk Score / Rating	
Operator selects casting and moves it to grinding station	Operator could lose grip and drop casting and incur a serious foot injury	Enforce Safety Footwear [reasonable] Use gloves with a good grip. [reasonable]	3	3	9	Reposition castings on a table next to the grinder [weak] Use a hand clamp device to pick up castings [strong]	3	2	6	Supervisor Fred Smith By 20 March
	Can be several hazards per job step									

Exhibit 7C. Changed 7B to the "Ideal" Format - a Semi-Quantitative JRA Format

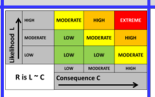
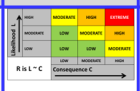
What is currently happening and could happen?			Current Risk level?	Further Action?	New Risk level?	WHO
Business Activity / Job / Task	**What could harm** people or assets or any business objective and for a given severity, the scenario for HOW it could happen?	**What are we currently doing** about controlling that Scenario? Are they effective? strong?	**How likely is the scenario** and its severity? What is the current risk level?	If **Risk Owner** wants to be convinced that the risk is ALARP, **what new improved controls** are needed? Will they be effective? strong?	**How likely** is **the new scenario** and its severity? What will be the **new risk** level?	**Responsibility**
Operator selects casting and moves it to grinding station	Operator could lose grip and drop casting and incur a serious foot injury	Enforce Safety Footwear [reasonable] Use gloves with a good grip. [reasonable]	 Extreme High Moderate Low	Reposition castings on a table next to the grinder [weak] Use a hand clamp device to pick up castings [strong]	 Extreme High Moderate Low	Supervisor Fred Smith By 20 March
	Can be several hazards per job step					

Exhibit 7D. Recommended Minimum JRA format

Part 6: Risk-Based Decision Making in Incident Investigation

Decisions need to be made before, during and after incident investigations and therefore risk assessments, qualitative and/or quantitative, are required before, during and after incident investigations.

Before an investigation**,** the appropriate risk-based decision making questions to be answered are:

Question 1: Is the Incident worth investigating at all?
If we don't investigate this incident adequately – time / resources / staffing / thoroughness, then what is the **risk of recurrence** of the same incident sequence / scenario, including the same consequence: How likely could the same things happen?

Question 2: What kind of investigation is required? 2 hours? 2 days? 2 weeks?
In most organisations, severity of actual consequence of the incident is used solely to decide the type, nature, duration, depth, allocated resources for the consequent investigation? Sometimes organisations also consider "potential" severity in their policy for making the decision of which kind of investigation process should be used. These questions / decisions must also be **based on risk,** not just "actual" or "potential" severity.

NOTE: The term *"potential"* is often wrongly interpreted solely as *"possible"* whereas it should also be considered *"probable."* When asking the question after an incident, what could have been the "potential" severity, the question is often interpreted as "what could have been a "*possible"* consequence" rather than the "*probable*" one. Possible is black or white, yes or no; it can happen or it can't. There are no ranges or degrees of "possibility" as there are with "probability". After most incidents, the question of what "potential" consequences could have been "possible" is different and useless, rather than the more appropriate question, which should always be: How "probable" could a more severe outcome such as [the incident] have been? What different events and circumstances would need to have occurred or existed to have produced the greater severity? Then how likely would it be for those different events / circumstances to occur? Some organisations attempt to consider this important distinction between "possible" and "probable" severity by using terms such as "the maximum reasonable/ credible / realistic/ consequence." A better approach is to ask / assess the risk questions below.

No decision should ever be made on the basis of severity of consequences alone. Rather, if both dimensions of risk [likelihood - as well as consequence] are assessed then there is a much more logical basis for decision making.

Question 3: "Free" proactive Risk Management / Learnings
If we don't investigate this incident adequately (using time / resources / thoroughness), then what is the **risk of occurrence** of a *similar* incident sequence / scenario *(but with some changed events and circumstances* needed to lead to the *more severe* consequence of interest or concern)? How likely could there be the necessary changes in the sequence / scenario to lead to another chosen consequence of interest or concern?

NOTE: While a single **event** *can* lead to different consequences, the same **scenario** = a set of all its events and circumstances *cannot*. There has to be some differences, however small, to lead to different consequences.

Avoid the meaningless term, *"the most likely consequence."* On the other, if a useful classifier such as *"worst case"* or *"maximum severity*" is chosen for consideration, then a credible scenario to lead to that chosen consequence needs to be determined and described in detail. Only after that scenario is completed and agreed can its likelihood / probability be estimated.

During an investigation**,** appropriate risk-based decision-making questions to be answered are:

Question 4: When to cut short or stop an investigation [related to Question 2 above]?

If we cut short or stop the information gathering stage now, after x hours / x days, then what is the **risk of missing, not detecting, some crucial causal information?** When should we stop "digging?" Is there a law of diminishing returns? When has an analysis gone deep enough? What is the **risk** of missing out / **not finding some causes?**

NOTE: The most useful criterion for deciding when we have dug as deep as we should is, "Have we dug down to underlying root causes that we cannot do anything about fixing them?? If the answer is yes, then we have dug deep enough.

NOTE: Short, quick mini-investigations could be valid and justified if a risk assessment recognizes that the increased risk of missing causes by cutting short or reducing the depth and duration of investigation is tolerable. Knowing the limitations of doing a short, quick mini-investigation and consequent qualification of its findings can sometimes be appropriate and beneficial. The usual proviso is that no steps in the investigation process are ever left out; rather, less time is spent on each process step, when it is assessed, that it is a tolerable risk that some causes will be likely missed and can be missed.

Question 5: Finding Causes

A "cause" of an incident is anything (factors / events / circumstances / weak or missing controls) that, if it was managed or controlled better, then the risk, L or C or both, of the incident would have been reduced.

Question 5a: Based on the above definition, then what were the causes of this incident?

NOTE: This question applies to all levels of causes which can be MACRO = direct / basic / immediate / active AND also can be MICRO = root / underlying / indirect / proximate / latent.

Question 6: Prioritizing causes

Which of the found **causes are worth analysing / correcting / controlling** and **in what priority order?** For an investigation that yields say 15 root causes, a risk-based decision could lead to developing controls / corrective actions for only the top 6 or 8.

Question 6(a): *If a particular* ***cause*** *is not better corrected or controlled, then what is the* ***risk*** *of recurrence of the same incident scenario****?***

For each specific cause in turn, if we don't do anything about it, then what will be the risk of the same incident happening again?

OR

Question 6(b): *If the Risk of recurrence of an incident is reduced more by correcting / managing a specific cause first, before any other cause, then that cause should be of higher priority?*

If fixing one cause has more risk reduction effect than fixing another, then they can be easily ranked or prioritized against the risk reduction benefit.

Question 7: Unresolved Causes

For various reasons, such as information-concealing, non-reporting cultures and legal privilege, often not all the information necessary to find and resolve all the causes is either achievable or made available. Some investigations are limited by legal obstacles and, with incomplete information, leads to finding a range of "possible" causes and associated "probability" of each. The example in Appendix 3 shows that often risk assessments are needed to rank a number of unproven causes according to likelihood / probability.

If causal findings still contain unresolved uncertainties, then what are the estimates of the likelihood ranking of the possible causal scenarios based on best estimates of available information? Can this ranking can included in the final investigation report?

NOTE: In these cases, most prudent organisations develop corrective actions / risk controls for ALL the identified possible causal scenarios regardless of which were actual as the others are "risks" and they need to be managed as well.

Question 8: Choosing Options for Corrective Actions / Risk Controls - Optioneering

The risk questions to decide which Options for Corrective Actions / Risk Controls are worth implementing **and** in what priority order**, should be based on effectiveness = achievable level of reduction of risk recurrence =** benefits of implementation of improved / new / different controls and costs = financial & non-financial, to implement and to maintain the chosen options. This is essentially a cost benefit analysis (CBA).

If particular options for corrective actions / risk controls *are* selected for implementation, then what are the relative **benefits of implementation** (level of reduction of risk recurrence) for each option**?**

Question 8(a): Which different / improved / new / additional risk controls will reduce the risk of recurrence most? And

Question 8(b): What are the relative costs of implementation / maintenance of each of those options?

NOTE: While difficult in practice, it is logical to first choose risk controls / corrective actions on the basis of effectiveness in reducing the risk of recurrence - before sequentially considering costs (time / money / effort, etc.). From real life, moral legal and commercial

viewpoints, cost will always filter the option choosing process. The concept of ALARP in the context of legal risk tolerability includes benefits – costs as one of the ALARP criteria. See Appendix 1.

Question 9: What combinations of risk controls are appropriate?
Similar questions to Question 8 but including recognition of the imperfect nature of all risk controls is required. While "hard" physical and engineering controls at the top of the hierarchy – Exhibit 6 – are good risk reducers they are not perfect. No risk control or combination can reduce risk to zero. Therefore risk based decision-making requires risk assessments to determine the best combinations from all levels of the hierarchy. Again, Benefits / Costs are the criteria for the risk based decisions.

After an investigation, appropriate risk-based decision making questions to be answered after an investigation are:

Question 10: Were the recommended risk controls / corrective actions validated?
If the recommended risk controls were implemented, then are they as effective as originally estimated (reduction of risk of recurrence)?

Question 11: How often should the risk controls / corrective actions be audited and reassessed?
As there are always dynamic on-going changes in risk factors, are audits evaluating the possible changes in effectiveness of the risk controls? Are the audits conducted with appropriate frequency / depth / independence?

Part 7: Conclusions

- All safety processes and discussions involve decision-making between options.
- All decision-making needs risk assessments that should include at least qualitative risk analysis.
- An Incident Investigation is one form of safety process that can be significantly improved if risk assessments are incorporated into its numerous decision-making phases.
- Embedding the language of "risk" management allows a transition from an illogical confusing "zero risk" – absolute safety paradigm to the necessary workable culture of only tolerating risks if there is proof that they are being managed to ALARP.
- All kinds of hazard and risk assessments should at least have a minimal record of what scenario is being considered.
- TAKE 5s and their equivalent do not need more than qualitative risk analysis
- Each employee should be very clear of what follow-up process is required if a TAKE 5 reveals issues. At least it should be a formal JRA with a supervisor.
- JRAs may justify short-term or permanent variations to formal methods of work – *"official work-arounds" – "authorised shortcuts"*- new revised versions of procedures
- All JHAs should be replaced by minimal JRAs which have at least some form of qualitative risk analysis and evaluation.
- JRAs are dynamic and need monitoring and review because risk factors change. *Change management and* risk management policies must be interwoven and cross-referenced.

- Decision-making involved before, during and after incident investigations benefits from risk assessments of associated issues.

Bibliography

ANSI/ASSE Z690.**1**-2011 *Vocabulary for Risk Management* [identical to ISO Guide 73:2009]. Des Plaines, IL: ASSE.

ANSI/ASSE Z690.**2-** 2011 *Risk Management – Principles and Guidelines on Implementation* [identical to ISO 31000, 2009]. http://www.asse.org/shoponline/products/EZ690-PKG.php

ANSI/ASSE Z690.**3**-2011 *Risk Assessment Techniques* [identical to ISO 31010, 2009]. Des Plaines, IL: ASSE.

Glenn, David D (2011). "Job Safety Analysis Its Role Today," *Professional Safety,* March 2011, pp 48 – 57.

OSHA 3071 (2002). (Revised) *Job Hazard Analysis.* (Retrieved March 7, 2013). http://www.osha.gov/Publications/osha3071.pdf.

OSHA 3071 (1992). (Revised) *Job Hazard Analysis.* (Retrieved March 7, 2013). http://www.setonresources.com/safety/jha/publications/osha3071.pdf.

Whiting, J.F. (2011). "How to make Matrix Methods of Risk Analysis more effective and accurate" Presented at the Professional Development Conference of the American Society of Safety Engineers, June 2011 in Chicago, IL.

Appendix 1: Criteria for Determining ALARP and SOFARP

<u>ASSE/ANSI Standard Z690.2, Clause 5.4.4 Risk evaluation</u>
The purpose of risk evaluation is to assist in making decisions, based on the outcomes of risk analysis, about which risks need treatment and the priority for treatment implementation. Risk evaluation involves ***comparing the level of risk found during the analysis process with risk criteria*** established when the context was considered. Based on this comparison, the need for treatment can be considered. Decisions should take account of the wider context of the risk and include consideration of the tolerance of the risks borne by parties other than the organization that benefits from the risk. ***Decisions should be made in accordance with legal, regulatory and other requirements.*** In some circumstances, the risk evaluation can lead to a decision to undertake further analysis. The risk evaluation can also lead to a decision not to treat the risk in any way other than maintaining existing controls. This decision will be influenced by the organization's risk attitude and the risk criteria that have been established.

Common Legal Criteria for SOFARP - So Far As is Reasonably Practicable
A legal duty imposed on a person to ensure health and safety requires the person—

(a) **to eliminate** risks to health and safety, **so far as is reasonably practicable**; and

(b) if it is not reasonably practicable to eliminate risks to health and safety, **to minimise** those risks **so far as is reasonably practicable**.

What is reasonably practicable in ensuring health and safety
In this Act, **reasonably practicable**, in relation to a duty to ensure health and safety, means that which is, or was at a particular time, *[before and after an incident]* reasonably able to be done in relation to ensuring health and safety, taking into account and weighing up **all relevant matters** including—

(a) the **likelihood** of the hazard or the risk concerned occurring; and
(b) the **degree of harm** that might result from the hazard or the risk; and
(c) **what the person concerned knows**, or ought reasonably to know, about—
  (i) the hazard or the risk; and
  (ii) ways of eliminating or minimising the risk; and
(d) **the availability and suitability of ways** to eliminate or minimise the risk; and
(e**) after** assessing the extent of the risk and the available ways of eliminating or minimising the risk, **the cost** associated with available ways of eliminating or minimising the risk, including whether the cost is **grossly disproportionate** to the risk (reduction), i.e., a cost benefit analysis (CBA) where dollar values for benefit = risk reduction and cost = cost of risk control are compared.

N.B. Any argument re: **affordability/capacity to pay** for not implementing SOFARP risk controls cannot be used as legal defense.

Appendix 2: Example—Fatality Investigation

Rigger 1 fell approx. 32 metres while working on a high voltage transmission tower.

Exhibit 8A. General View of Tower AA soon after the fatal fall of Rigger 1 from the earth wire support structure ("rabbit ear") on top left

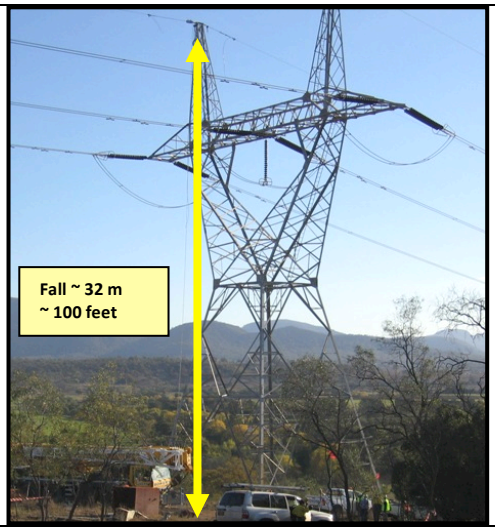


Exhibit 8B. Another View of Tower AA –
(Height of fall = approx. 32 metres / approx. 100 feet)

Table 1. Some of the over 50 questions with answers affected by legal obstacles

Outstanding Questions	Answer	Uncertain? / Likely?
Was RIGGER 1 wearing fall protection?	**YES**	**Very High Certainty** - As seen after the fall by many witnesses
Did RIGGER 1 have specific instructions re using 2 lanyards?	**YES**	**Certain** - Company XX's JHA Sheet 6 and Work Instruction - 1145-WI-001 Date ZZ
Was the harness fitted with 2 lanyards?	Not known	**Uncertain - Low likelihood** - as seen after the fall by many witnesses
Was 2-lanyard rule always used by company XX riggers?	Not known	**Uncertain - Moderate to High likelihood** – own personal gear may not have always been fitted with 2 lanyards

Most Likely Fall Sequences

* = 3 most likely scenarios

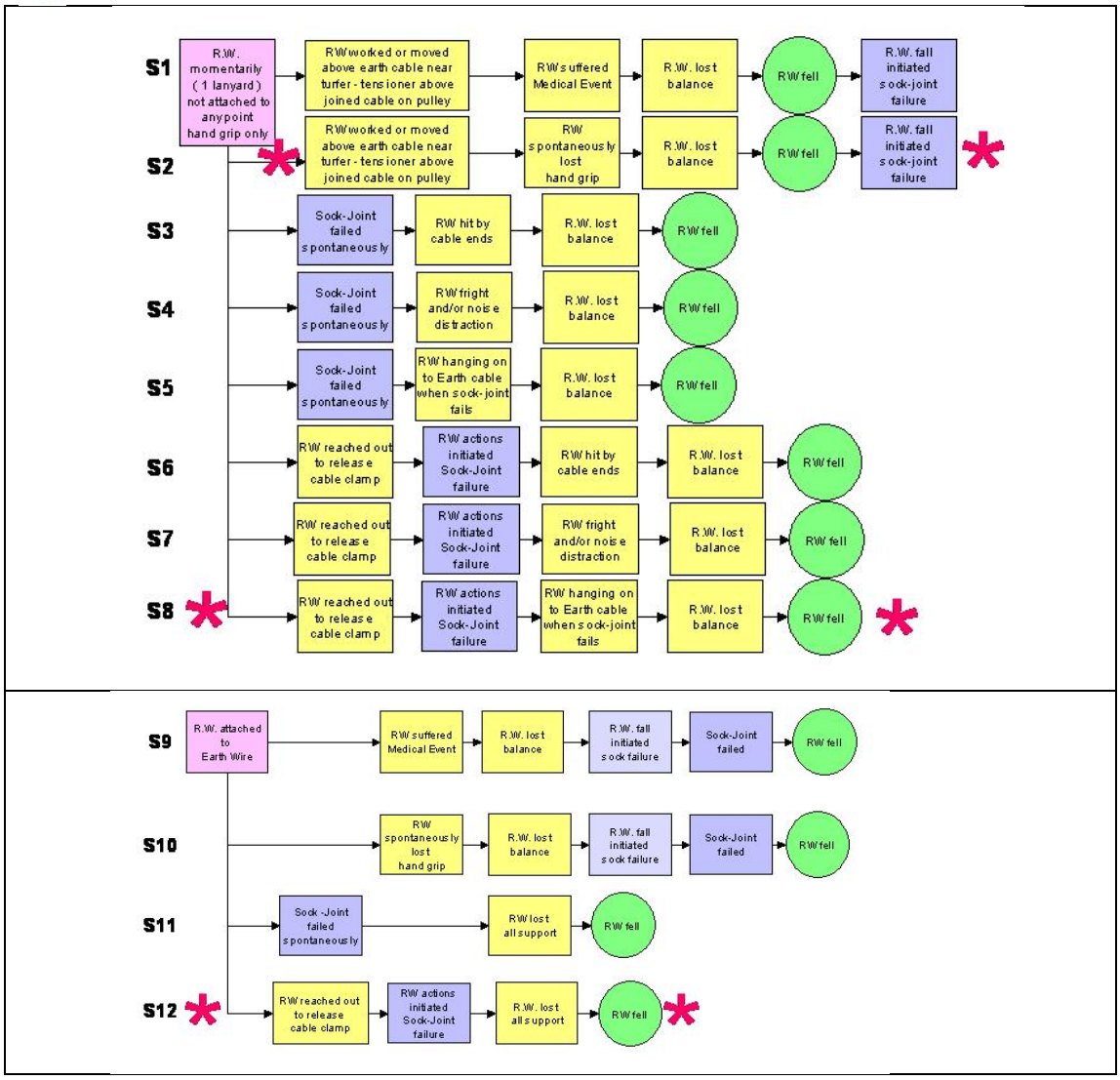
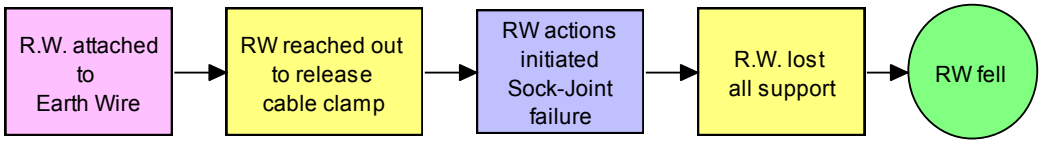


Exhibit 9. Possible 12 Scenarios that could have led to a fall and a cable joint failure

Even though uncertainty remains concerning which of the 3 most likely scenarios was the actual one, the company regarded all 3 as possible incidents with the **1 actual incident and 2 probable risks**. They decided very morally, logically, and commercially that the causes of the 2 risks needed to be managed as urgently as the causes of the actual incident so that risk controls for the causal factors and risk factors of all 3 were developed. In that way they correctly regarded the investigation as finding 3 incidents with their causes needing better management.

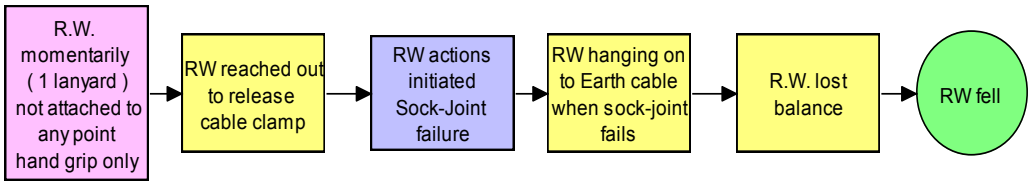
Most Likely Scenarios – 3 of the 12 above

S 12 = The Scenario estimated as the highest likelihood



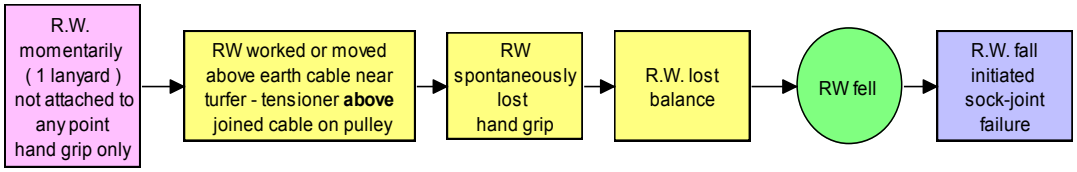
The deceased RIGGER 1 was working on removing the cable clamp part of the temporary cable tensioning equipment and was standing with his **shoulder approx. level with earth cable** under tension over pulley when he reached out to the cable clamp with lanyard attached to tower structure – but could not reach properly so connected to earth cable to grab clamp and pulled it back towards him which interfered with the sleeve of the sockette join leading to its failure and the earth cable separated and RIGGER 1 fell

S8 = The Scenario estimated as the second highest likelihood



The deceased RIGGER 1 was working on removing the cable clamp part of the temporary cable tensioning equipment and was standing with **shoulder approx. level with earth cable** under tension over pulley when he reached out to the cable clamp momentarily (1 lanyard) not attached to any point with hand grip only because he could not reach properly and pulled clamp back towards him which interfered with the sleeve of the sockette join leading to its failure and the earth cable separated & RIGGER 1 fell

S2 = The Scenario estimated as the third highest likelihood



The deceased RIGGER 1 was working on removing "turfer" / "tensioner" / "come-along" component of the temporary cable tensioning equipment and was standing high on the tower near the "turfer" / "tensioner" / "come-along" with **shoulder well above the earth cable** under tension over pulley when he reached out with lanyard attached to tower structure – but could not reach properly so momentarily disconnected lanyard to work on tensioner better leading to him spontaneously losing hand grips and fell.

A Selection of the Photos and Diagrams

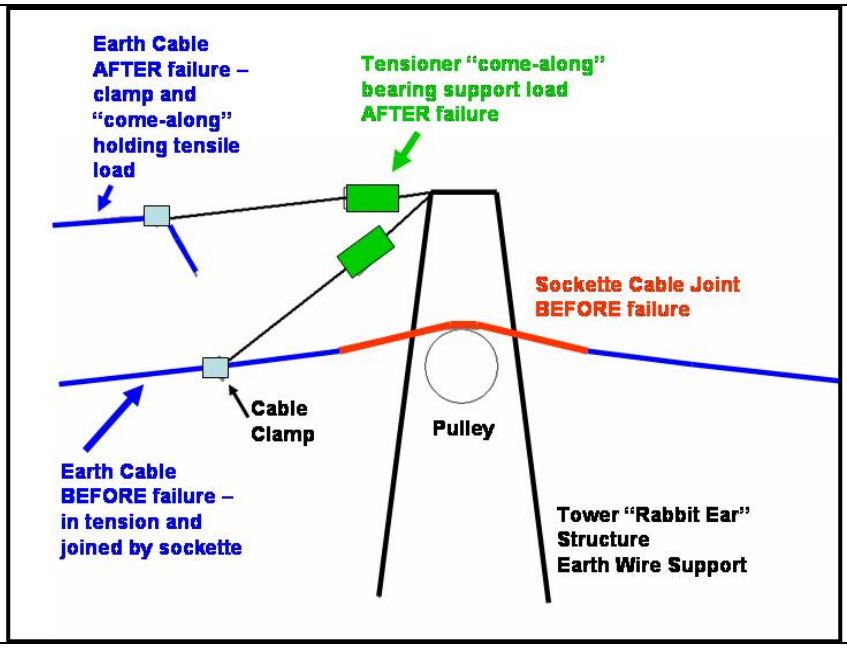


Exhibit 10A. Sketch of earth wire before and after cable joint failure

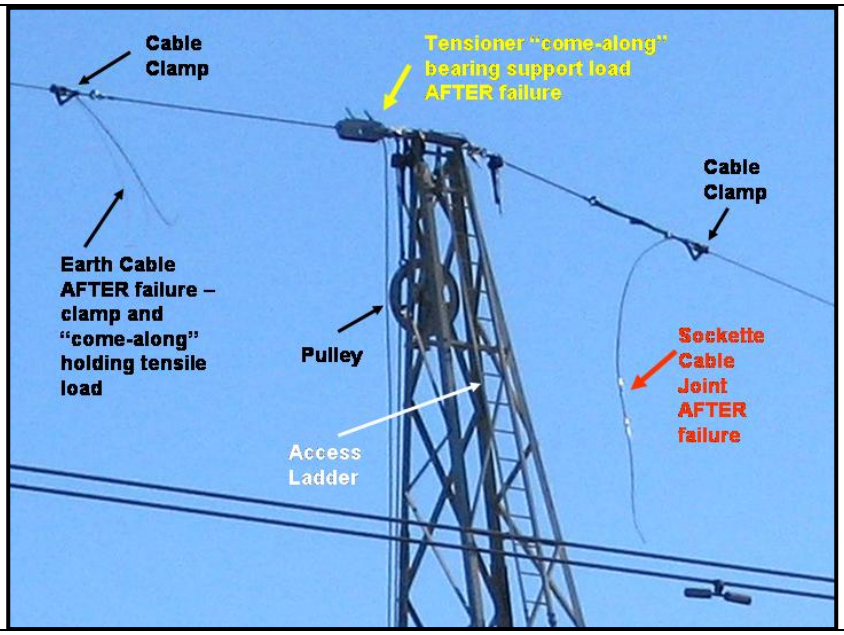


Exhibit 10b. Equivalent photo of sketch of earth wire after joint failure at top of left "rabbit ear"