

Why being 95% error-free is safer than 99.9%

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Abstract

Safety Maturity Journey Models (SMJMs) are a key safety improvement tool used in Queensland mining. However, the report *Review of All Fatal Accidents in Queensland Mines and Quarries from 2000 to 2019* (Brady 2019), recommended the adoption of High Reliability Organisation (HRO) principles, given the presence of recent fatalities. *Does this mean journey models need redevelopment, reimagining, or rejection?*

Through comparing HRO theory with SMJMs, we found that SMJMs overlap with HRO principles, but HROs have seen beyond the 'end' of the SMJM vision of complete order to a better way of operating. And their safety record speaks for itself. Journey models do not need to be rejected, but reimagined, with regards to their position on:

1. What safety is and how to create it;
2. An organisation's ability to predict the occurrence and impacts of unexpected events, and;
3. An organisation's tolerance of paradox in organisation structure and function.

1.0 Background – The Brady Report and HRO Theory

High Reliability Organisation (HRO) theory has recently come into the spotlight in the mining industry in Queensland. As a result of a perceived higher than average number of fatalities in recent years in the Queensland mines and quarries, a report was commissioned and subsequently accepted by Resources Safety and Health Queensland (RSHQ) regarding the features, likely causes and possible ways forward for improving safety in these industries. A key recommendation from the report titled *Review of All Fatal Accidents in Queensland Mines and Quarries from 2000 to 2019* (Brady 2019) was that mining companies that operate in Queensland should adopt HRO principles and seek to become HRO's themselves.

The logic appears to go like this: HRO's were first identified as organisations that had impeccable safety records, despite the potential for catastrophic accidents that existed in their context. Typical examples being nuclear power plants, aircraft carriers and civil aviation. Previous research on HRO's unearthed particular characteristics that were perceived to cause this 'high reliability' state and lead to excellent organisational and safety performance (Roberts 1989, Roberts and Rousseau 1989, Roberts 1990, Weick and Roberts 1993, Roberts, Rousseau et al. 1994, Weick and Sutcliffe 2001). If mining companies in Queensland are not acting in line with HRO principles currently, it is reasonable to conclude that if they did, their safety record would be deemed excellent.

As a result, both RHSQ and many mining companies in Queensland are embarking on journeys to find out what ‘becoming a high reliability organisation’ means. Due to the external pressure on mining companies to this end, it is widely assumed they need to change how they operate, or modify their practices, to head in this direction. However, these efforts may or may not clash with practices and theory already existing in the mining industry about what safety maturity means, and how high safety performance should be achieved. It may or may not be necessary to change activities. For example, it may be that ‘being a HRO’ is either already embedded in current practice. Or, perhaps the journey to ‘become a HRO’ pulls in a different direction. If this is the case, organisational tension may result, potentially leading to a situation where there is a lot of effort with the intention of improving safety performance with no real improvement.

1.1 HRO Principles

Table 1 is a summary of the HRO principles.

Table 1 - Main Principles of High Reliability Organisations

No.	Name	Description
1	Sensitivity to Operations	<i>“Having a comprehensive understanding of organisational activities and processes so as to be able to anticipate and respond to problems” (Haslam 2021)</i>
2	Pre-occupation with failure	<i>“An essential component of being a HRO is to be continually aware of the potential for error. In these organisations, small failures were tracked, analysed, and responded to” (Johnston 2021)</i>
3	Reluctance to simplify	<i>“Digging below the surface to engage with the breadth and depth of matters that are critical for operational safety” (Haslam 2021)</i>
4	Commitment to Resilience	<i>“Being motivated to ensure that organisations are not disabled by any failures that occur and are able to recover from them quickly” (Haslam 2021)</i>
5	Deference to Expertise	<i>“Ensuring that those most qualified to provide input are able and empowered to do so (not just those with the highest rank)” (Haslam 2021)</i>
6	Collective Mind	<i>“Collective mind is conceptualized as a pattern of heedful interrelations of actions in a social system... (Weick and Roberts 1993)</i>

1.2 Safety Maturity Journey Models

The dimensions of safety maturity, from the perspective of SMJMs, are found as descriptions of categories of organisational systems or characteristics of individual people that are all required to be in some advanced state to be able to say that the whole organisation has a high level of safety maturity. The definitions of these categories in the G-MIRM model and their ‘high’ maturity is described fully in (UQ 2008). A key feature of the G-MIRM model is that its dimensions are broken into 6 people categories, and 17 (management) systems categories. This follows Hudson (2007), whereby analysis of safety culture was added into the consideration of establishing and improving (safety) management systems. Both people issues and management system issues are seen as the two major categories in SMJMs of what to ‘improve’ to achieve safety maturity.

1.3 Research Question

If mining companies are set to follow HRO principles, do they have to do away with the safety maturity journey models that have been applied throughout the industry for the last 15 years or so? This raises some other key questions:

Is HRO theory the same as Journey models? How similar? How different?

Does this mean journey models need redevelopment, reimagining, or rejection?

Do mining companies have to change?

The key question for mining companies is do companies have to change their mindset or actions in light of suggestions that they should apply HRO principles to improve safety performance? To explore the above research question, we have reviewed literature about HRO's and SMJMs to compare and contrast two main concepts: safety maturity and high reliability.

2.0 Methodology

This project is essentially a narrow literature review. The approach is to find and compare representative SMJMs that are used or known in the Queensland mining industry, and compare what they say about their central concept, being safety maturity, with the central concept of HRO literature, namely high reliability.

Table 2 - Literature Reviewed

HRO Literature	SMJM Literature
In March of 2021, a High Reliability Organisation Forum was organised by UQ for the Queensland mining industry, in collaboration with the Queensland Commissioner for Resources Safety and Health and two major mining industry partners. The papers delivered for this forum include significant literature reviews of HRO theory, principles and implementation since the concept was first introduced in the late 1980's. Therefore, the Forum material, and the list of literature they referred to, as well as subsequent work from that Forum, was considered representative of HRO literature. The full list of papers for this forum and their references are listed at: https://smi.uq.edu.au/project/high-reliability-organisations-hro-forum	Literature review-style journal papers were sought first, to capture larger reference lists for these models. Notably, a literature review by Goncalves Filho and Waterson (2018) was particularly inclusive, and covered 41 different SMJMs.
	The SMJMs studied here will be limited to those known or used by the Queensland mining industry, and Australian more broadly, such as Hudson's model (Hudson 2007).
	The Global Minerals Industry Risk Management Model (G-MIRM) SMJM (UQ 2008) was analysed particular detail. This was because: <ul style="list-style-type: none">• It was very well known to the researchers, having been generated in the Minerals Industry Safety and Health Centre (MISHC) at UQ.• The team at the MISHC have taught the G-MIRM model throughout a variety of risk management courses and other safety culture assessments performed for various mining companies in Australia since the model's inception.• Other SMJMs have been derived from it. For example, as (Goncalves Filho and Waterson 2018) point out, Anglo American has adapted the G-MIRM SMJM for their own use.

In order to do this, the grounded theory method of Strauss and Corbin (Strauss 1990) was applied. Five axial codes were applied to describe these phenomena, as follows:

- **Dimensions:** What *is* the central concept? What are the parts that make it up?
- **Structural Context:** Where do you find it? Does it exist in people's heads or the whole organisation?
- **Countervailing context:** What is the opposite of the concept?
- **Consequences:** What is the central concepts supposed to give you? What are the consequences of the concept being present?
- **Causes:** What do you do to create the concept (i.e. high reliability/safety maturity).

3.0 Results

The next sections illustrate some similarities and differences between the SMJM and HRO approach, the results of the comparison at the core of this work.

3.1 Similarities

Dimensions

There is a general overlap between the dimensions of safety maturity (UQ 2008) with the 5 main HRO principles (Weick and Sutcliffe 2001). In particular, Sensitivity to Operations and Preoccupation with Failure were well represented.

Structural Context

Both SMJMs and HRO's can be seen as expressions of a type of safety culture (Goncalves Filho and Waterson 2018). In general in SMJMs, many parts of the whole organisation are considered, whereby the culture and organisational management systems are infused with safety considerations. Similarly, in HRO's the whole organisation is the focus, and each person and group's contribution to the overall mission (Roberts 1989, Roberts 1990, Weick and Roberts 1993, Weick and Sutcliffe 2001).

Countervailing context

A world where nothing is predicted: Being pre-occupied with searching for and preventing failure is key in both HRO and SMJMs. The opposite of this is a chaotic world, where no attempt at prediction takes place and failures happen by chance, where fatalism reigns. This is the world where 'accidents will just happen, and there is nothing we can do'. If the system is not well-managed it will display unacceptably high levels of variation in its behaviour, making the task of managing safety risk and operational reliability even more challenging.

Siloism: One of the key problems that keeps an organisation becoming a HRO is organisational siloism. See this quote from Weick and Roberts (1993):

"Activities and people became isolated, the system began to pull apart, the problems became more incomprehensible, and it became harder for individuals to interrelate with a system of activities that was rapidly losing its form." (Weick and Roberts 1993)

The goal for SMJMs to have integrated SHE activities and management systems implies that having activities divided by organisational silos is undesired (UQ 2008). If people do not act as a team, working together to understand the complex nature of work, then there is no collective mind, activities are not aligned together to achieve organisational performance and safety. This is the case for both HRO and SMJMs.

Consequences

Both HROs and SMJMs are concerned with creating safety. This is clear throughout all literature studied.

Causes

People intrinsically care about safety: This is at the heart of SMJMs (Hudson 2007). What became evident in HRO literature is that people must be committed to creating safety, and maintaining it.

Trust in competent people: If you want people to care about safety inherently, you have to trust them. HRO's have trust in their people, and their people earn that trust.

A learning organisation: Both HROs and SMJMs say that you need to be always learning about all your organisations and your mining systems. Every time something wrong happens, organisations need to learn from it. Deep investigations are required.

A focus on the "group": Teamwork is mentioned in SMJM, but it is not a key area of focus. In HRO's, how groups work effectively together is effectively quite central. There is a similarity here, but not a complete overlap.

Differences

Dimensions

In the G-MIRM journey model, the HRO principles of Reluctance to Simplify, Commitment to resilience and Deference to Expertise are not focussed on so much. SMJMs focus on individual person level and the 'whole of organisation level'. However, HRO's include this but also have a focus on the group level, the formal and informal groupings of individuals that sits in between the individual person and whole of organisation levels.

Structural context

In HRO's, reliability is a property of the whole organisation. However, in SMJMs, safety maturity is a property split between individual and the whole organisation. This indicates that reliability and safety maturity are not the same, fundamental concept.

Countervailing context

Static vs dynamic safety: In HRO's there is an assumption that real systems, and the very nature of creating safety, is constantly varying, and that this will always be the case. In SMJMs, as Goncalves Filho and Waterson (2018) say above, *"Maturity models by their very nature may tend to overemphasise aspects of*

a static view of safety and may underplay the subtlety with which safety may dynamically vary according to a host of influencing factors". Journey models can imply: "if you do things this way, you will be safe".

Consequences

In HROs, the organisational mission is paramount, and safety fits within that: it is aligned with the organisation's mission. However, in SMJMs, safety is paramount, and 'production' (the organisational mission) is secondary. Here, safety and the organisational mission are 'at odds'.

Causes

A focus on documentation and compliance: Ensuring adequate documentation, and having senior management write and approve policies, is key in SMJMs (UQ 2008). However, these activities are not discussed in HRO literature. One of the reasons documentation is encouraged in SMJMs is because compliance is a key goal and activity in the SMJMs. Conversely, compliance isn't mentioned in the HRO literature as something that these organisations are concerned with. This is not to say that they aren't compliant, but we assert that they have far surpassed needing to be directly concerned with it.

Leadership and locus of decision making: One way to characterise the leadership difference is that in SMJMs leadership is done to people but in HROs leadership is done with people. If this is the case, it may also undermine new safety initiatives, like trying to become a HRO if an organisation is not already there. This is simply because it is much harder for people and teams to change practices if it comes from outside of them. If it grows up within them, it would likely need to be enabled by a different kind of leadership, such as identity leadership (Reicher, Haslam et al. 2018, Haslam, Jetten et al. 2022) which is earthed in a shared social identity (Cornelissen, Haslam et al. 2007, Haslam 2021) between leaders and their teams.

4.0 Discussion

4.1 The Short Answer

SMJMs overlaps with the HRO perspective, but HROs have seen beyond the 'end' of the SMJM vision of complete order to a truer world and way of operating. And their safety record speaks for itself.

So, do Mining companies have to change in order to become more like HROs?

The short answer is yes.

4.2 A The Longer Answer

A lot of the surface activities could be quite similar between HROs and companies following SMJMs. The HRO principles are 'covered' in some way by the SMJM. The idea of using a journey model *per se* is not the issue: having a roadmap of how to improve in terms of 'doing' safety is a wise idea. This is one way to embed learning in an organisation. And up to a certain safety level, being very well structured about

safety works (Amalberti 2001). But HROs have seen beyond the 'end' of the SMJM vision of complete order to a truer world and way of operating. And the HRO safety record speaks for itself. Because it is the *underlying beliefs* about the world and broader conception of how organisations work as complex systems that make the difference between HROs and companies following SMJMs. The next section discusses some these underlying beliefs that HRO's have that are worth reflecting on for companies who currently stick close to SMJMs to align more closely to HRO's.

4.3 Differences in Underlying Beliefs

One key difference in beliefs relates to the relationship between the expected and the unexpected nature of systems.

The expected nature of systems

To be highly reliable at anything, and to achieve a particular goal that you have planned to achieve, means an organisation needs clear processes and activities that it performs. These functions should be repeatable. That is, you need to be able to say, ahead of time, "we want to achieve X by doing actions A, B and C". This is the perspective of both HRO's and SMJMs, that at least part of work, of organisational life and operations, are predictable. In this context, the standard practices of safety risk management are appropriate, and appear in both approaches.

The evidence for this is all throughout the SMJMs. In the G-MIRM model, the fact that it has 17 dimensions of safety maturity focussed on continuous process improvement of different kinds of management systems and activities implies that predicting the impact of certain activities, and performing them is important. Hudson (2007) and Foster and Hoult (2013) display similar positions. In the HRO literature, for example, the idea of deferring to an expert (Weick and Sutcliffe 2001) implicitly captures the notion that they are an expert in something, they know the systems they work with very well and they are capable of predicting what those systems behave into the future. The bosun example from Weick and Roberts (1993) considers the likely interactions between tasks people perform. They are clearly confident in their ability to predict what will happen in that shift. Both SMJMs and HROs depend on the systems they work with being able to be predicted.

The unexpected nature of systems

HRO's are collectively mindful organisations, always looking for and keeping the activities and outputs of the organisation on track. This reflects the way they conceive of what safety is: a dynamic reality. They expect uncertainty and unexpected things to happen, and are prepared to react to them. They appear to have learnt that *surprise is normal*.

SMJMs do not tolerate surprise. They are committed to prediction of what might happen, to 'put things in place' beforehand to avoid undesired or unplanned events. There appears to be an assumption that all unexpected events and all possible surprises are in principle predictable and thus avoidable. And therefore if something unexpected occurs, then risk management efforts were lacking by definition: somebody didn't anticipate properly enough.

If you do not believe failures should happen, all of your effort will go toward preventing them. But the downside of that approach is that when surprises do happen, and cause a failure, you haven't prepared the organisation for dealing with this as you could have. It is important to stress that the resilience perspective is not about "let failures happen and then we'll deal with the problem". If that were true, it would be the same as 'accidents will always happen', the ad hoc approach to safety that SMJMs have always been trying to encourage the industry to get away from.

Thus, there is a fundamental assumption that differs between HRO's and SMJMs: in HRO, surprise can happen, unexpected events can happen, and there is a natural limit to our ability to predict events Cantu, Gharehyakheh et al. (2021) even state "*HROs do not pretend to be error free, but their errors do not disable the operation*".

4.4 Living Between Order and Disorder

Given the origin of SMJM models and early drivers to bring them into the minerals industry in Australia after the terrible disasters in the 1990s, such as Moura No. 4, consider the "Basic" level of the G-MIRM model: an ad-hoc approach to safety, where 'accidents will always happen' – a kind of fatalism. The SMJMs are trying to say 'work doesn't have to be like that! We can predict hazards and risk and put in controls to protect you! We can be organised and systematic about safety – this will improve safety performance'. This is a noble pursuit. But what SMJMs miss is that this approach has limits. To see this requires us to go to the HRO principle commitment to resilience. HROs think, 'We should understand the system deeply so as to predict what we can up to that limit, but beyond that, we need prepare for being able to adapt to the changing conditions'. In SMJMs, surprise *should* not occur, and if they do, then that must have meant we didn't work hard enough at predicting. This excludes any potential limits on our ability to predict what could occur the future. This could be a key piece of the puzzle as to why accidents, small and large, keep occurring in organisations that follow SMJMs closely. By comparison, HROs have a demonstrably excellent safety record – that is why they were selected for study by the original HRO researchers in the first place (Roberts 1989, Roberts 1990, Roberts, Rousseau et al. 1994).

The goal of a HRO is to be able to effectively manage all situations that could come up and adapt to those situations. That is, seeking to maintain and increase their *inherent adaptive capacity*. Companies that follow journey models very closely can tend drive themselves to have very well organised systems and stick to documented processes. This approach, if followed to its logical conclusion, may actually undermine the ability to be *adaptive* in the workplace, required to keep the system operating reliably, because it doesn't allow the possibility of surprise.

This is the issue of complexity: we cannot, inherently, predict beyond a certain time horizon in complex systems (Lorenz 1963, Dekker, Cilliers et al. 2011, Venkatasubramanian 2011). This means there will be events that occur that cannot be predicted before they happen. They are unforeseeable. A focus on increasing adaptive capacity is required to cope with *unforeseeable* things. This what *commitment to resilience* is all about.

The differences in perspective can be explored through engaging with where SMJMs and HROs sit on a spectrum between *complete disorder and complete order*, with regards to organisational structure and its consequent activities that are intended to deliver organisational performance and safety, as shown in Figure 1.

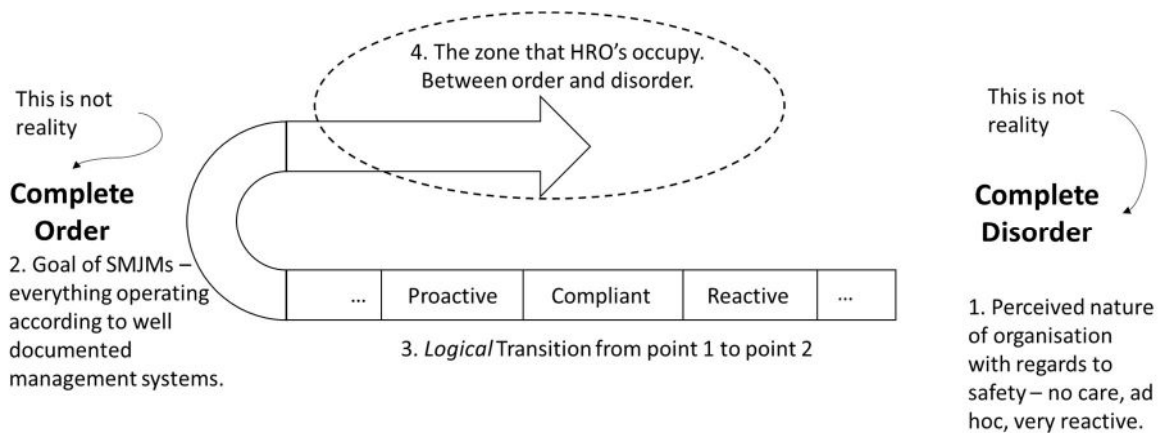


Figure 1 - The HRO Journey

The four points in Figure 1 are:

1. A no care, ad hoc, very reactive approach to safety. This manifests in a very disordered set of organisational structures and functions for creating safety.
2. Opposite perspective of point 1. This was the 'goal' offered to potentially ad hoc organisations as how best to manage safety risk as espoused in SMJMs. This makes sense as a reaction to point 1: "if disorder is the problem, let's be as ordered as possible".
3. Once having framed 'complete order' as the goal of SMJMs, the logical progression of improvement in safety is away from complete disorder in how organisations are structured, particularly with regards to safety, and towards complete order.
4. HROs have seen beyond the goal of point 2, to *look at reality as it really is*. This is where HROs sit, between order and disorder, where the organisational structure, and hence function, matches the real nature of the system – having a limit on predictability. HROs therefore have a "timely overlapping of basic organisational form with flexible organisational structure..." (Roberts 1989).

4.5 The Tolerance of Paradox

To be able to successfully deal with the complexity they face everyday, to deliver both the organisational mission and create safety, HRO's have *learnt to tolerate paradox*. For example:

How much should I reduce errors?

Try to predict system behaviour as much as you can – understand what can hurt people and put those controls in place! But realise there is a limit to this approach. If (minor) errors get too low *learning stops*, because you don't have the feedback mechanisms anymore about what is going wrong. Eliminating injury and fatalities is

important, but errors in how things work don't always lead to harm. Therefore, near miss reporting is important. That's why it's better to be 95% error free than 99.9%. As Amalberti says:

"An incident-free system becomes mute, and its safety can no longer be tuned. Investments stop being directed at safety and are earmarked towards improving performance; the control and spontaneous limitation induced by the occurrence of incidents no longer play their role. The system can then brutally find itself in a situation of disastrous accident because its over-stretched performance has given rise to new risks...." (Amalberti 2001).

Retaining rigid and flexible parts of organisation structure and function

To effectively engage with real complexity to create truly safe systems, you must allow greater flexibility in how your organisation functions, where warranted, to effectively engage with the irreducible uncertainty of real operations. This will enable success in the context of unforeseeable events and surprise. A key example of this is the strong hierarchical differentiation in the on the air craft carrier held in balance with bargaining used as a strategy for achieving goals (Roberts 1989).

5.0 Conclusions

In light of the analysis above, to better align with the HRO vision of the world journey models have to change through a revision of the core beliefs underpinning the models, and change the language and advice given to companies accordingly. To become HROs, mining companies have to change through examining their beliefs and flow-on practices regarding, for example, living between order and disorder, expectation of surprise, being a learning organisation, how much you tolerate paradox, and trust in competent people. The key message here is: Be as organised, disciplined and predictable as you can, and then expect surprise!

This analysis is not without a context, and it may be that redefining the relationship between the mining industry, the regulator and society more broadly is the most significant contributor to improving safety in Queensland mining.

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