

# Interaction Between Skill And Risk Spaces In Operational Risk

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TITLE: Interaction between skill and risk spaces

OBJECTIVES/SCOPE:

The paper discusses the interaction between the competence and experience requirements of functions and the risk spaces that the functions exist in. It goes on to examine this in the managerial and executive levels as well.

METHODS PROCEDURES, PROCESS

The Skill Paper (SPE-199446) discusses the interaction between the competence and experience and how that delivers the skill to perform tasks successfully. The Risk Space paper (SPE-199401) defines and explores a method for understanding the multidimensionality of the risks to which operations are exposed. This paper combines the multidimensionality with the skill dimensions to develop understanding about how the interactions can be understood and managed.

RESULTS, OBSERVATIONS, CONCLUSIONS

The paper shows how different variables and dimensions create different requirements for tasks and positions. These requirements are typically not understood and documented in the formal task requirements for positions. This lack of understanding enables failures in the management of risk to propagate through the safety system as the requirements are implicit rather than explicit. These implicit requirements are usually overlooked and dismissed during review and restructuring processes.

The same process is used at the managerial and executive levels to highlight the different functional requirements for the management of organisational risk. The lack of explicit understanding of these requirements is then placed in the context of a number of larger organisational failures such as MC-252.

The paper proposes a number of methods for developing better understanding of which dimensions are under skilled management.

Please explain how this paper will present novel (new) or additive information to the existing body of literature that can be of benefit to a practicing engineer.

The paper presents understanding methods and approaches to enable organisations to better resource the key risk decision-making positions. In addition, the approach helps create understanding of organisational weaknesses that can be managed or strengthened. This enables oversight and resourcing to be structured in an efficient manner.

One of the trickier issues that organisations need to understand is that as they develop their systems, they also have to develop the skills and competencies of their managerial and supervisory staff. As the organisation moves from a reactive state to a proactive state and even a generative state, the key tasks and jobs that staff perform changes greatly. This paper looks to describe the different roles and skills that are required in a general sense, depending on the cultural level that they are at, and the risk spaces that they are managing. This development in job requirements is driven by the changes in structure as set out in SPE-220464 and also the variances in risk spaces and risk space that they are managing.

## **Problem statement**

Changes by management driven by the changes in managerial causal models often fail to encompass the changes in managerial and supervisory skills required. Concepts such as workforce empowerment and changes in loci of control require more non-technical and threat and error management skills lower down in the organisation. The question is, can we come to an understanding of what type of skills are required in relation to the cultural level and the risk spaces that are being inhabited?

## **Theoretical section**

### **Skill**

As set out in the skill paper<sup>i</sup> (Hudson, 2020) the combination of competence and experience combines to provide the skill needed to successfully execute tasks and jobs. This implies that mere training and providing competence is not sufficient to provide the skill needed. Building experience through exercises and guided programs as well as pure length of time performing the task is the other side of the equation.

### **Hyper dimensional Risk spaces**

The Risk Space paper<sup>ii</sup> (Hudson, 2020) is based on the axiom “The social-technical system that runs risks does not experience or manage risks in a serial fashion. Risks within a system are parallel, and thus should be taken as a sum.

This means that risks should be summed, even when each component does not appear to be salient. *All* risks should be included even when those individual risks are below the acceptance threshold. When the summed risks are greater than a threshold (as defined by the risk system), this risk value should be seen to be equal to the single risk value of equal value.”

# Risk Space

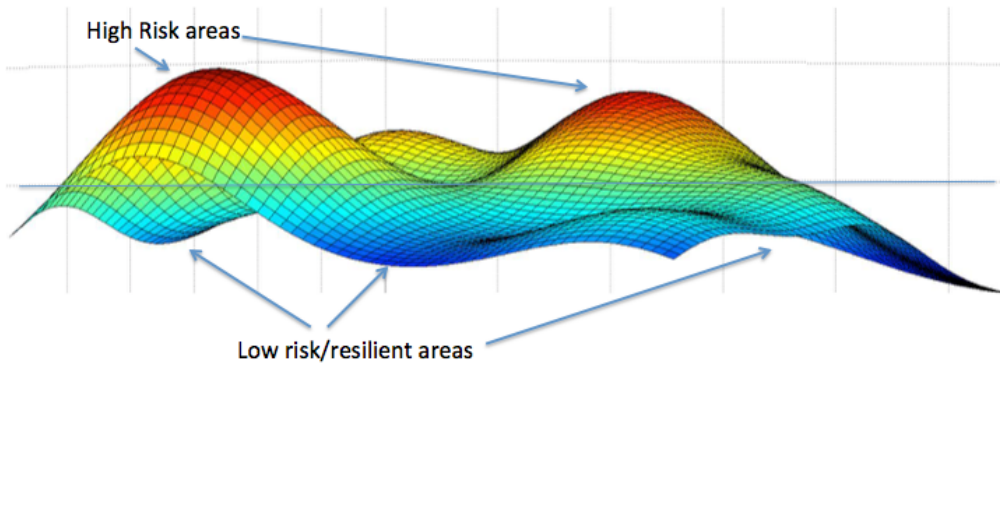


Figure 1: A risk space

Based on this axiomatic approach, the paper examines the risk space for the probability of a vehicle skidding and shows that simple, single numerical values cannot properly describe the real-world probability of skidding.

## Example – a vehicle skids

We can take an outcome we wish to avoid: a vehicle skidding. A skid can result in nothing more than some marks on the road, but can also lead to the death of the driver or passengers as well as third party fatality. The vehicle may be damaged and the environment adversely affected. If we allow a skidding vehicle to represent the loss of control then we can have a simple historical frequency – how often per year do we have skids? We can select outcomes such as injury or death and then compute the risk of such an outcome for an operation with say 1000 vehicles as  $1000 \times \text{frequency} \times \text{skid}$ . With an average skid frequency of 10 per year, the probability of such skids is simply 0.01. But the picture is more complicated than the simple ‘point probability’ value of 0.01. Under some conditions such as wet roads, poorly maintained tires, inexperienced drivers etc., the actual frequency is raised, while under ideal conditions we may only have a skid once in a year.

When driving a vehicle, the probability of skidding on wet roads is dependent not only on how wet the road is but also on factors such as driver ability.

These two factors are independent of each other, and each of these factors is clearly also a distribution. We can say that as these two factors do not interact with each other - the driver’s ability is not correlated with the wetness of the road surface - they are orthogonal.

Thus, the probability of failure (skidding on a wet road) in this example is not a simple two-dimensional distribution. It varies for each of the two orthogonal factors - road wetness and driver ability. It is thus a three-dimensional probability distribution. If we add the state of the tires, another equipment related and independent dimension, we can now distribute the overall risk over the multi-dimensional causal factors.

The consequence side of the risk equation is also a distribution, as the potential consequences depend on more orthogonal factors such as traffic density and physical obstacles. This too is a three-dimensional probability distribution.

So how can we define the risk for this driving example? It still follows the standard equation  $probability \times consequence = risk$ . If we vary the ability of the driver, the risk changes too. The same is true when we vary the traffic density, the state of the car and the weather and, by extension, several other orthogonal dimensions.

### Risk space for N-dimensions

The definition of risk provided above means that we no longer understand risk as a point or single number, but as a value that varies as all the underlying dimensions change. We can thus define a risk space as the N+1-dimensional space that describes how N-dimensions interact to define the risk at every single point in the space.

In this example the 5 orthogonal dimensions (Road wetness, Driver ability, Vehicle state, Traffic Density, and Physical obstacles) are combined to form the 6-dimensional risk space for the immediate risk of skidding on wet roads. Here, the combined risk value forms the 6<sup>th</sup> dimension, one which is also continuously distributed over the range of outcomes. The distribution for personal safety ranges from no consequence to multiple fatalities, often represented as a number (5-6) of discrete categories as used in conventional risk assessment matrices, but it is really a continuous distribution of outcome probability. If we also wish to add process risk to personal risk (and by extension add cost, environmental and reputation consequences) to make a more complex value, that is itself multi-dimensional<sup>1</sup>. The simple unidimensional risk value that is conventionally computed, such as skidding accident risk per vehicle per year, now appears as a rather impoverished number when it is exactly the variation over the distinct dimensions that we would wish to understand in order to be able to manage and reduce the likelihood of having an accident.

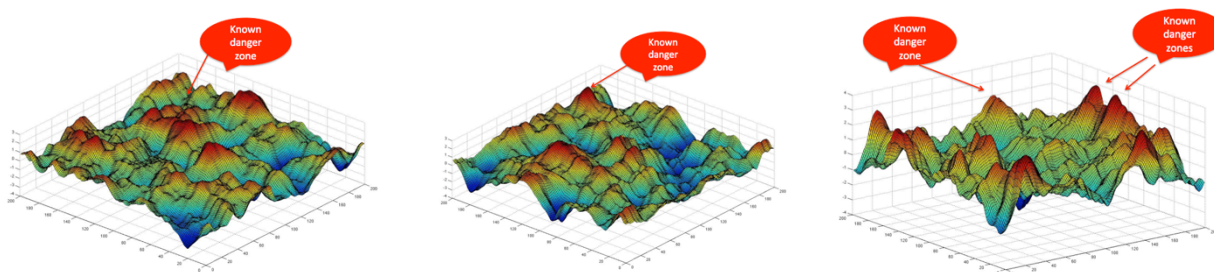


Figure 2: three risk spaces containing 6 dimensions with risk as the vertical dimension

### No higher calculus needed

A 6-dimensional risk space may be considered by many to be impossible to understand, let alone use, as they assume understanding of a higher calculus is required. This is not the case. What we are interested in is not visualizing the whole mathematical multi-dimensional space. That is impossible in conventional representations. What we are interested in is how the different dimensions interact.

The risk space described in Example 1 is actually well understood and successfully managed by billions of drivers every day. Drivers change their behavior depending on all four of the dimensions described. Numerous studies have shown that drivers manage the amount of risk they take and are prepared to accept, reacting to changes in this complex risk. When risk increases on two dimensions, in general,

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<sup>1</sup> We can imagine a particular event as having high process and environmental values but low personal and medium reputational values. This risk dimension would itself be the sum of four outcome dimensions.

risk is reduced in other ones, for example by reducing speed or increasing distance to other vehicles. In fact, Example 1 is a simplified risk space for the risk of slipping on wet roads: a risk space intrinsically understood by drivers<sup>2</sup> around the world!

The SPE paper SPE-220464 (Hudson, 2024) describes how organizational structures change as the causal models required to manage the risk spaces develop. A simple linear and deterministic model sufficient to manage a simple risk base does not require complex risk understanding lower down towards the floor of the workforce. The paper sets out the different causal models and structures required to manage the risk spaces that the organisation inhabits. The different structures that organisations use in the various cultures not only require a different paradigm of risk depending on the culture, they also require quite distinctly different skills and practices. As the organisation develops from being a simple unstructured reactive safety culture all the way to a generative culture, the structures follow the steps:

*Unstructured context free*

*Structured context free*

*Structured context sensitive*

*Dynamically structured context sensitive*

Each of these steps require novel skills but also, and quite importantly, they may not require some of the skills needed in the previous steps. Using this approach, we can examine what the broad skill requirements are for each of the steps

## **Reactive**

The most fundamental changes to organisational skill needs occur in the development of a reactive safety culture. The organisation starts taking safety seriously and thus requires its managerial staff to have the skills to do so. These skills can broadly be seen as the (non-exhaustive) collection:

Skills in incident investigation, including the ability to understanding the results of incident investigations. The staff need to understand and drive changes required by learning from incidents and accidents. This can be regarded as the defining skill for the Reactive culture. Reacting to incidents and failures and taking steps to prevent reoccurrence.

Skills in ensuring rules and procedures are actually followed. The staff need skills in driving and ensuring accountability for actions in their individual areas of responsibility. In the standard Plan-Do-Check-Act (PDCA) cycle, this can be considered the Check activity.

Skills in integrating safety and risk management into the plans and processes for which they are responsible.

These skills work to prevent the linear deterministic threats and risks that an organisation is exposed to from eventuating in incidents and accidents.

It should be noted by the reader that these skills are sufficient for most low-risk organisations to adequately and efficiently manage the risks to which they are exposed.

## **Calculative**

The calculative culture can be seen as the organisation accepting that the risk space it inhabits is not as simple as previously thought and that the management of those risks has to be done in a formal, organised, rigorous and disciplined fashion. In general, this is accomplished through the use of management systems to drive the assurance and continuous improvement of the management of risk. The change from an unstructured approach to risk to a system-driven structured approach entails that while the actual management of

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<sup>2</sup> Drivers may manage their workload by turning down the volume on the car radio or external factors by switching on more lights and hazard warnings. They may even decide to pull off the road to take a rest and avoid third parties completely.

risks is captured, contained and executed by the system processes, the managerial staff requires different skills that are much more focused on the system instead of the frontline risks. These skills can broadly be seen as the (non-exhaustive) collection:

Skills in the effective use of the management system. This includes understanding of the underlying principles that are the foundation of the management system. The skills of operating the system and the knowledge of what their function is in the system.

Managerial skills in properly investigating systemic failure and understanding the results of systemic failures. This higher-level understanding skill has to provide the ability to relate the systemic failures to different parts of the system.

Skills in meta-analysis and in depth understanding of the drivers for systemic failures. This includes the ability to properly understand the higher levels in the organisation and how they create the outcomes in the workplace.

Most fundamentally, there is a requirement to fully execute the PDCA cycle, actively driving change through learning the right lessons in the Act part of the cycle.

The defining characteristic of a Calculative culture, the structured approach, means that the managerial staff have to fully complete the PDCA cycle. The check and act parts of the cycle, often neglected in Reactive cultures, serve to ensure that decisions made are actually executed. This creates not only a tighter control of the risks being taken by an organisation, but also drives accountability. This accountability is most obvious in the operational discipline within Calculative organisations. Rules and procedures are followed because there are checking mechanisms to create the assurance that there will be negative consequences for non-compliance. Thus, the management of risk in Calculative cultures is subject to the same kind of discipline as the financial risks and expenditures are subject to.

This results in the managerial staff needing greater management system skills and the understanding that the system is also the source of the failures to which the organisation is still exposed. By leveraging the PDCA cycle, these skills can be used to effect the required changes at the right levels.

## **Proactive**

The Proactive organisation arises when organisations come to the realisation that the risk spaces the organisation inhabits are not only non-linear, but also non-deterministic. The risk spaces are literally too complex to be managed with a 'one size fits all' approach. Thus, the structured centralised approach used by the Calculative culture has to become sensitive to the operational context that the operation is exposed to. The structure of the organisation is changed to place the decision-making authority closer to the risk context. This means that the skills required for those risk decisions also have to transfer closer to the risk context. This empowerment of workforce changes the roles and requirements of both workforce and management.

The workforce now requires many of the same skills that management required in the Reactive culture:

Skills in low-level incident investigation, including the ability to understanding the results of low-level incident investigations. The staff need to understand and drive changes required by learning from incidents and accidents.

Skills in ensuring rules and procedures are actually followed. The staff need skills in driving and ensuring accountability for actions in their individual areas of responsibility. In the standard Plan-Do-Check-Act (PDCA) cycle, this can be considered the Check activity.

Skills in integrating safety and risk management into the plans and processes for which they are responsible.

At the same time, the managerial staff no longer requires those skills as the workforce is now executing those functions. Instead, the managerial staff requires understanding in how the organisational context creates disruptions and variations that drive the non-deterministic outcomes to which the operation is exposed. These skills include:

Skills in understanding the interactions between the different parts of the operation. Both within the managers' span of control, but most importantly outside of their span of control. As the workforce executes the day-to-day management of the operation, the managerial staff manages the operation's higher-level functioning.

Skills in process improvement and understanding. The staff need to be able to properly improve the risk processes using tools such as six sigma to dissect and understand the organisational functioning.

Skills in tools such as sensitivity analysis to understand and protect vulnerable organisational processes and locations.

Leadership skills in personal development and life-long learning.

These changes in function and skill requirements can demand larger organisational changes not only in function but also in personnel composition. The skills required to be a good foreman or supervisor in a Reactive organisation are very different from the skills required for supervisory staff in Proactive organisations.<sup>3</sup>

With this understanding, it becomes obvious why developing a Proactive culture can be a painful and difficult endeavour. Fundamental changes in almost all the job and task requirements means that the transition is exceptionally intensive.

## **Generative**

The Generative organisation arises when organisations come to the realisation that the risk spaces the organisation inhabits are not only non-linear, and non-deterministic, but also highly dynamic. The need for quick correct decision making due to the dynamic nature of the risk space drives the changes in the decision-making structure that defines the Generative culture. Where the Proactive culture has restructured the decision-making structure to match the decisions being made to the context of the risk decision being made in a hierarchical structure, the Generative culture accepts the highly dynamic nature of the risks being taken by the operation means that the hierarchical nature of that decision-making structure has to be removed. The Generative culture enables and empowers all members of the organisation to make organisation-wide decisions if they are the most suited to make those decisions. Thus, the organisation truly functions in Servant Leadership (reference) mode: every member of the organisation making the decisions for their operational and organisational context.

To be able to operate in this manner, the organisation has to ensure that each and every member of the organisation has the management skills associated with the Reactive and Calculative Cultures. The Supervisory staff then requires the Management Skills associated with the Proactive culture.

With the operation of not only the day-to-day running, but the management of the operation being conducted by the workforce and supervisory staff, the role of management becomes much less directive. Management works to enable and support the operation. This requires a new skill set:

Servant Leadership skills. Skills in identifying and understanding future needs and ensuring those needs will be met on time and effectively.

Systemic management skills. Skills at analysing and changing the systemic structures that support the operation

Mentoring and support skills.

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<sup>3</sup> An example of this is the changes in function requirements for module foremen in an Engine Maintenance Repair and Overhaul company I have worked with over the past three years. As they have transitioned to a more Proactive culture, they changed their operational structure to use Cross Functional Teams (CFTs) that have been assigned much more of the day-to-day decision making within the company. With these CFTs making the decisions, the foreman's role changed to a much more managerial role. This has led to the understanding that some of the current foremen do not have the right competencies for the revised role, but instead should be trained to be engineers as that is a much better fit and they have proven engineering competence. At the same time, candidates that would previously have not fitted the role were now much more viable.

## Discussion

This paper proposes an understanding of the different skills needed for the four safety cultures of the Hudson Culture ladder. The differences in requirements between the different steps on the ladder help to explain why developing a higher-level culture can be an arduous enterprise. The different skill set leads to personnel that were a good fit for a position no longer being the right person in a higher-level culture. This means that culture change is not just changing values, beliefs, and attitudes. It is a fundamental change in behaviours and abilities. It will most probably mean that culture change will mean changes in personnel.

This requires the current higher level personnel to be engaged in the teaching of their current skill sets to the levels below them, while concurrently acquiring the skills required at the higher level. This change in demands and skills will, undoubtedly, be a strain on any organisation undergoing such a change. However, the new understanding also shows that the new skills can be employed to help the training and transference of the older skill sets. Thus, the higher levels in an organisation can be guided to mentor and coach their lower level reports.

By understanding which skill sets are required and, importantly, which are no longer relevant, the organisation can undergo cultural change in a guided and efficient manner. This pragmatic approach to culture change can be contrasted to more traditional methods where the organisation hopes that speeches, posters, and videos will convince the entire workforce to change their values, attitudes, and beliefs. A structured approach should enable organisations to provide the right skill sets through training and coaching in a directed fashion. This allows the organisation to develop higher level cultural traits and behaviours in the higher risk parts of operations without expending time and resources in parts where such investments are not required due to the simplicity of the risk spaces inhabited.

Where organisations find mismatches between the available personnel and the required skill sets the possibility for proper matching between skill sets and risk space complexity should enable a more organic management of the risks through the use of proper cultural understanding.

## Conclusion

The skills required to manage the risks to which an organisation is exposed change fundamentally with the changes in the organisational Causal model. These changes create changes in organisational structures. These structures can be described as levels on the Hudson Safety Culture Ladder. These structures require different skill sets to function properly and effectively. Thus, culture change has to be effected not only through structural changes, but also changes in skills sets and most probably in personnel.

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<sup>i</sup> Hudson T.G.L. & Hudson P.T.W. SPE-199446 *Skill Equals Competence Plus Experience* Proceedings of the 15<sup>h</sup> SPE Virtual International Conference and Exhibition on Health, Safety, Environment, and Sustainability 27 - 31 Jul 2020

<sup>ii</sup> Hudson T.G.L. & Hudson P.T.W. SPE-199401 *Risk Space - Understanding the Complexity of Operational Risk* Proceedings of the 15<sup>h</sup> SPE Virtual International Conference and Exhibition on Health, Safety, Environment, and Sustainability 27 - 31 Jul 2020