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An enhanced data-analytic framework for integrating risk management and performance management

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ABSTRACT

There is increasing interest for agencies and industries to develop risk management processes for a wide variety of applications. Traditional risk management processes are motivated by controlling risk and avoiding losses. In contrast, other organizational processes focus on managing performance and value generation. In this paper we argue that risk management also adds an important contribution to these processes. However, this requires "proper" risk management extending beyond narrow safety oriented perspectives built on quantitative risk analysis and tolerability/acceptance criteria. There is need for a broad risk-performance framework with uncertainty being a main component of risk, and where knowledge and surprises are adequately reflected. In the paper we present and discuss such a framework. The framework is developed on the basis of an analysis of combinations of different risk management and performance management practices/policies. We show how the risk and performance management processes can be improved by proper risk conceptualization and a holistic thinking on how to develop and use goals in the organization, how to balance different concerns, and consider the need for agility – "sensitivity to operations", as well as how to give weight to vulnerabilities, resilience, and antifragility.

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1. Introduction

Consider a profit maximizing enterprise, like an oil company. Its principal objectives are to create value and at the same time to avoid HSE (Health, Safety and Environment) and integrity incidents (e.g Statoil [22]). Performance management is conducted to run the business activities effectively and meet the value objective. In addition, risk and HSE management are implemented to avoid such incidents and ensure that the risks related to them are acceptably low. These two sets of management processes are often separated, run by different organizational sectors and built on different scientific and professional schools and ways of thinking. They are commonly considered incompatible and in conflict: a value focus easily leads to an increase of the HSE risks, or vice versa, an improved HSE level could hamper value generation processes. On the other hand, it is also common to associate good HSE management with improving business efficiencies and productivity [6].

This paper looks closer into these issues for industry and also public sector organizations. More specifically the paper discusses the thesis that good risk management leads to good performance management. We aim to bring new insights to the topic by clarifying how "good" is to be understood for this thesis to be valid. We do this by relating good risk management to:

1) reduced risk (risk reduction shown by risk assessments or understood as perceived risk reduction)
2) improved HSE level (understood analogously to reduced risk)
3) meeting the requirements set by current practice (for example using quantitative risk analysis and risk acceptance criteria/tolerability limits)
4) meeting the ISO 31000 standard [17]
5) meeting the ideas of other "broader" risk frameworks, such as the IRGC framework [12,4] and the one studied by Aven and Krohn [3]

We relate these "good risk management" interpretations to corresponding "good performance management" interpretations:

a) increased performance (shown through metrics/indicators or interpreted as judged increased performance)
b) meeting economic objectives/targets/requirements
c) meeting economic and socio economic objectives/targets/requirements

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d) meeting economic and sustainability objectives/targets/requirements
e) being in line with a management by objectives (MBOs) regime
f) being in line with a total quality management perspective

The result is an analysis which reveals how the different risk management interpretations 1)−5) meet the various performance standards a)-f). We argue the thesis that performance management and risk management exhibit common principles that can be integrated in a combined framework. We argue that the thesis - that good risk management leads to good performance management – only holds for some combinations of this set of interpretations. This discussion is the topic of Section 4. From this analysis we present in Section 5 an enhanced framework which allows for a unified thinking of performance and risk, using the best pillars from both of these two traditions, performance management and risk management. The proposed framework is generalized to be applicable to a variety of applications, such as corporate governance, public sector, and public-private partnerships. Firstly, in Sections 2 and 3 we provide a brief review of the meanings of the two sets of interpretations 1)−5) and a)–f) of the risk management and the performance management, respectively. Section 6 introduces a case study - transportation infrastructure managed through a public-private partnership, which is used as a basis for the discussion of the unified performance-risk framework in Section 7. The final Section 8 of the paper gives some conclusions.

2. Risk management

This section will describe key concepts, strengths and limitations to the risk management strategies described above.

2.1. Interpretation 1) reduced risk (risk reduction shown by risk assessments or understood as perceived risk reduction)

The first interpretation relates to the achievement of reduced risk as shown by risk assessments or understood as perceived risk reduction. Think about the operation of a nuclear plant. Clearly, being able to reduce the risk related to a major accident could be considered good risk management. A risk assessment could show that a specific measure reduces the computed accident probability by say 1%. This would not be an objective characterization of the risk, yet it could represent a rather strong evidence for the measure having a positive effect on risk. However, it is easy to problematize the example. Say that the measure costs 100 million euros. Would it still be good risk management to implement the measure? No, proper risk management is really a balancing act, between protection on the one hand and development on the other. One cannot see the benefit side of the measure isolated from the cost.

Of course if the investment costs are small, the risk reduction effect could be a demonstration of good risk management. For many operational measures, the costs are indeed small – and the key is to find those measures that really give the desired effect. A training course may cost little, but it could be seen as an effective measure for risk reduction in many cases. Quantifying this effect with some rationale is however difficult.

Risk reduction can also indirectly be demonstrated through observable indicators, like injury frequency rates in a specific industry. This presumes however that the activities or systems we study are in operation and there is a considerable amount of relevant data. For rare type of events such data is not available and we have to use indicators, for example the number of gas leakages as an indicator for the risk related to serious hydrocarbon fire and explosion scenarios.

2.2. Interpretation 2) improved HSE level (understood analogously to reduced risk)

This interpretation can be seen as a special case of the first one - focusing on risk related to HSE.

2.3. Interpretation 3) meeting the requirements set by current practice (for example using quantitative risk analysis and risk acceptance criteria/tolerability limits)

The third interpretation concludes about good risk management to the degree that one is able to meet the requirements set by current practice (for example using quantitative risk analysis and risk acceptance criteria/tolerability limits). This means for example that the risk management of the oil and gas industry is good as long as it is in compliance with the current practice with its standards and guidelines. Hence if all audits carried out by the authorities and company internal systems, find the risk management tasks to be in line with this practice, the risk management is judged as good. However, also this perspective can obviously be discussed. How are improvements and developments in the risk field incorporated? The current practice can have strong weaknesses seen in relation to the “best principles” of the risk field, yet scores high on this interpretation as the requirements set by current practice are met. This illustrates the importance of focusing efforts on building resilience as protection against a wider variety of events.

2.4. Interpretation 4) meeting the ISO 31000 standard [13]

The fourth interpretation relates good risk management to the degree that the ISO 31000 standard on risk management is met. This standard covers many basic concepts, principles and methods of risk management, most broadly accepted, and was established through an extensive process involving many parties. Hence adherence to risk management processes described in this standard should ensure good risk management. However, this standard does not provide detail on how to perform the risk management. Take as an example the use of the risk management principles: ALARP (As Low As Reasonably Practicable). How should we implement the ALARP principle in the risk management? The ISO standard does not cover it. Many other examples could be mentioned. The standard just covers the basic structures and processes, and these are to large extent broadly accepted. For some discussions on the suitability of the ISO standard, see for example Leitch [17] and Aven [1].

2.5. Interpretation 5) meeting the ideas of other “broader” risk frameworks

The fifth interpretation relates good risk management to meeting the ideas of other “broader” risk frameworks, such as the IRGC framework. The discussion above concerning the ISO standard also applies to this interpretation, but here more details are provided on how to carry out the risk management. There is a foundation for each framework, and the degree that one sees a specific framework for providing good risk management depends on how one judges this foundation. The present authors consider the foundation for the two frameworks to be strong and useful, but there could of course be different views on what type of framework that is most adequate in practice. There is no space for detailed review of these two frameworks here, but some key points are highlighted in the following.

The Aven and Krohn [3] framework builds on a broad risk understanding capturing uncertainty, knowledge and consequences of the activity. The framework captures associated

assessment and management principles and methods, and add theories and practical insights from other fields specifically addressing the knowledge dimension and surprises (black swans). Two examples here are the collective mindfulness concept linked to High Reliability Organizations (HROs), with its five principles: preoccupation with failure, reluctance to simplify, sensitivity to operations, commitment to resilience and deference to expertise. There is a vast amount of literature (see e.g. [25,26,16,10]) providing arguments for organizations to coordinate their efforts in line with these principles to obtain high performance (high reliability) and effectively manage risks, the unforeseen and potential surprises. The second area relates to the quality discourse with its focus on variation, system thinking and continuous improvements. In addition the concept of antifragility [23] is included as a pillar in the thinking.

The IRGC risk management framework maps out a structured approach, which guides its user through the process of investigating significant risk issues and designing appropriate governance and management strategies. This approach combines scientific evidence with economic considerations as well as social concerns and societal values and, thus, ensures that any risk-related decision draws on the broadest possible view of risk. The approach also states the case for an effective engagement of all relevant stakeholders. The framework offers two major innovations to the risk field: the inclusion of the societal context and a new categorization of risk-problems. Besides the generic elements of risk assessment, risk management and risk communication, the framework gives equal importance to contextual aspects. Contextual aspects include the structure and interplay of the different actors dealing with risks, how these actors may differently perceive the risks and what concerns they have regarding their likely consequences. They also include the policy-making or regulatory style as well as the socio-political impacts prevalent within the entities and institutions having a role in the risk process, their organizational imperatives and the capacity needed for effective risk governance. The framework proposes a categorization of 'simple', 'complex', 'uncertain' and 'ambiguous' risk problems, and for each category, a strategy is then derived for risk assessment and risk management as well as the level and form of stakeholder participation, supported by proposals for appropriate methods and tools. A set of basic principles of risk management and regulation are covered, including (i) cautionary and precautionary principles, and (ii) robustness and resilience. See IRGC [12] and Aven and Renn [4] for the details.

3. Performance management

This section will describe key concepts, benefits and limitations to the performance management strategies described above.

3.1. Interpretation a) increased performance (shown through metrics/indicators or interpreted as judged increased performance)

Increase in performance can be demonstrated using objective metrics or subjective judgment. The measurement of performance varies across applications, but metrics often used include production volumes, sales volumes, efficiencies, market shares, quality metrics, and multidimensional scorecard systems. In general, the practice of using data-based metrics encourages standardization and objectivity. Performance metrics are commonly used to predict future levels of performance. Such predictions may be useful for budgeting, resource planning, capacity investments, and other decision-making activities. Historical data-based metrics could lead to poor predictions due to future changes, and they are also difficult to use for assessing the increase or decrease in performance as a result of measures implemented. For this purpose performance models are developed, and using probabilistic analysis predictions can be derived, as well as uncertainty characterizations. These predictions can for example be based on expected values, and allow for judgments of potential increase in performance.

As discussed in Section 2.1, care has to be shown in concluding about good performance management based on a measured or judged increase in such metrics. A 1% increase in a particular metric may not be an objective characterization of performance, but provides support for a claim of increased performance. It will in general be difficult to prove or justify that specific organizational decisions caused this short-term increase in performance.

3.2. Interpretation b) meeting economic objectives/targets/requirements

Performance can also be measured by the organization's ability to meet economic objectives/targets/requirements. Such objectives/targets/requirements relate to for example profit, revenue, cash flow, return on investment, operating costs, shareholder return, and working capital. Examples of such objectives/targets/requirements include a 5% increase in yearly sales volumes, a 10% increase in yearly profit, a 5% decrease in monthly transportation costs, and others. Assessments of the organization's ability to meet economic objectives/targets/requirements can be useful for making judgments about shareholder value, planning future resource needs, and supporting organizational improvement.

3.3. Interpretation c) meeting economic and socio economic objectives/targets/requirements

Increasingly, organizations are considering public perception, environmental factors, social structures, and political issues within planning decisions. Examples of measurable objectives include a 20% reduction in greenhouse gas emissions, $10,000 investment in philanthropic activities, 10% increase in usage of recycled or biodegradable materials, 20% increase renewable energy usage, and others. Examples of non-measurable objectives include creating a healthy community, improving air quality in neighboring communities, promoting fair labor policies, and others. As for b), assessments of the organization's ability to meet these objectives/targets/requirements can be useful for planning resource needs, setting organizational sub-goals, and assessing shareholder value. However, socio-economic impacts can be difficult to assess. For example, consider studying the goal of improving quality of life metrics for a nearby community. First, there is concern over which metrics are relevant, such as air quality, arts, culture, recreation, safety, and others. Then there is the challenge of measuring how these metrics have changed as a result of organizational investments. The measurement of arts or culture can be a subjective pursuit with no agreed upon method for measurement or assessment.

3.4. Interpretation d) meeting economic and sustainability objectives/targets/requirements

The focus of economic and sustainability objectives/targets/requirements provides a more holistic view of organizational performance. Sustainability objectives may include environmental impacts (carbon emissions, waste production, water consumption, wastewater quality, air emissions, etc.) as well as social metrics (community outreach, labor practices, philanthropic investments, etc.). Examples of objectives/targets/requirements include a 10% reduction in carbon dioxide emissions per year, a 5% reduction in industrial waste discharge per year, a 20% reduction in water

consumption per year, a $10,000 increase in community improvement spending per year, and others. The assessments of the organization's ability to meet these objectives/targets/requirements can be used for resource planning, assignment of sub-goals, and assessing shareholder value, as described above for b) and c). However the sustainability metrics could be difficult to measure. For example, although water quality monitoring can be accurate in the short-term, long-term effects of water quality issues are poorly understood.

3.5. Interpretation e) being in line with a management by objectives (MBOs) regime

Performance measurement with a management by objectives (MBOs) regime incentivizes organizations to focus efforts on meeting specific objectives [8]. This approach is well-established in industry and the public sector. The idea is to formulate objectives and then assess the performance of the activities in relation to these objectives. Objectives should be specific, measurable, assignable, realistic, and time-related [7]. The regime can be useful for allocation of responsibilities, capacity planning, and financial planning, etc. A MBO approach needs to be implemented with care, as a strong emphasis on formulating, assigning and satisfying objectives can easily lead to an overly strong focus on meeting these objectives rather than on identifying the overall best solutions, measures, and improvements.

3.6. Interpretation f) being in line with a total quality management perspective

The total quality management perspective is also commonly used to measure performance. It emphasizes continuous improvement, customer satisfaction and system thinking and has been implemented in many industries. Over one million certificates for ISO 9001 guidelines have been earned, including industries of food safety, information security, and manufacturing [14]. The approach can be useful for inter alia prioritizing improvement needs and measures, and resource planning. The Quality approach highlights continuous improvement, and warns us against a goal regime as discussed in the previous section.

4. Integrating risk management and performance management. Discussion

The risk management and performance management principles discussed earlier may not always be compatible. For example, risk principle *1) Reduced risk as shown by risk assessments or perceived risk reduction* and risk principle *2) Improved HSE level* may be perceived as being directly in conflict with the performance principle *A) Increased performance* by some organizational leaders. Conversely, other risk and performance management principles can be directly compatible. For example, risk principle *4) Meeting the ISO 31000 standard* can be compatible with performance principles c)-f) when properly interpreted.

The strengths of the risk management as described in Section 2 include 1) the consideration of low-likelihood events as studied in common risk assessment methods described earlier, 2) the inclusion of the societal context within decision-making processes, as described earlier through examples of socio-economic and sustainability metrics, 3) the use of risk classification with meaningful descriptions as evidenced by the IRGC framework, and 4) the inclusion of principles for vulnerability, resilience, and antifragility in operations. The weaknesses of the risk management as described in Section 2 include 1) overreliance on meeting minimum standards and regulations for risk policies, as commonly used by risk acceptance criteria and tolerability limits, 2) vague standards, such as those recommended through ISO guidelines, 3) narrow perspectives on risk paying insufficient attention to uncertainties and the knowledge that the judgments are based on, and 4) insufficient emphasis on shareholder value and operational decisions, as evidenced by the safety emphasis in all risk management examples given earlier.

The strength of the performance management as outlined in Section 3 include 1) meeting of shareholder priorities, as described in all of the performance management interpretations described earlier, and 2) the ability to align objectives/targets/requirements with existing organizational practices, as shown through the MBO regime. The weaknesses of performance management include 1) overreliance on historical data to predict future performance, as described in the discussion of meeting objectives/targets/requirements earlier, 2) overemphasis on performance to meet objectives and compliance, which can undermine true process improvement, such as in the MBO regime and the total quality management interpretation, and 3) low (but growing) emphasis on non-financial metrics, as evidenced by the socio-economic and sustainability objectives/targets/requirements described earlier.

In addition to the strengths and weaknesses described above, there is need to discuss issues in relation to the integration of performance and risk management. Common methods for managing performance assume models or decision-makers have basically “perfect” knowledge. Such knowledge can be questioned when there are concerns over data accuracy, relevance of historical data, or assumptions. In addition, traditional performance management processes are often ill equipped to address situations with multiple or conflicting objectives, such as those addressed in risk management applications. Borrowing from the study of risk, assessments can be used to inform decision makers and not necessarily prescribe actions. There is a need for managerial review and judgment processes to supplement the quantitative methods. For example, managers should evaluate trade-offs among objectives and achieve organizational balance in decision-making to align with high-level strategies. However, the end result goal for integrated performance and risk management is not necessarily to minimize risk exposure, but rather to understand risk issues in a performance-oriented setting [5].

Associated with understanding objectives is the process of defining measurable attributes of current system conditions. Current measurement of performance can be based on historical data (if available) or be based on comparable applications. However, rare and sudden occurrences such as natural disasters, work stoppages, perfect storm scenarios, and acts of terrorisms may not be represented in this available data. In addition, slowly changing conditions such as climate change, economic transitions, political movements, public perception trends and other emergent conditions may also not be represented in the available data. We need to recognize that these types of events cannot be predicted, but protective investment strategies benefit from the study of common risk principles such as agility, resilience, and recognition of uncertainty. Common perspectives use probability to describe uncertainty but there is a need for broader approaches that reflect the varying levels of knowledge strength supporting the probabilities derived.

In the next section we will present a framework for adapting mutual benefits from both risk and performance management, while also addressing the weaknesses described above. The framework should be relevant to a variety of industries such as manufacturing, energy, transportation, healthcare, technology, construction, and others. The proposed framework will expand on the ISO guidelines to emphasize concurrent performance and risk management.

5. A performance – risk framework

The performance-risk framework consists of three main steps, as shown in Fig. 1. The basic idea is to view risk and performance as a unified organizational process, in line with the ideas presented in the previous section. In the first step, concepts and principles are presented for concurrent performance and risk management. Second, a process-oriented approach is defined to address both performance and risk, using the ISO 31000 guidelines as a model. Third, methods are defined for monitoring and continuously reviewing performance-risk policies. Although this framework can be conducted informally during executive planning activities, a more formalized initiative should include the implementation of software support. A formal web-based software tool can guide discussions, facilitate interaction among stakeholders, store data from past sessions, and share information.

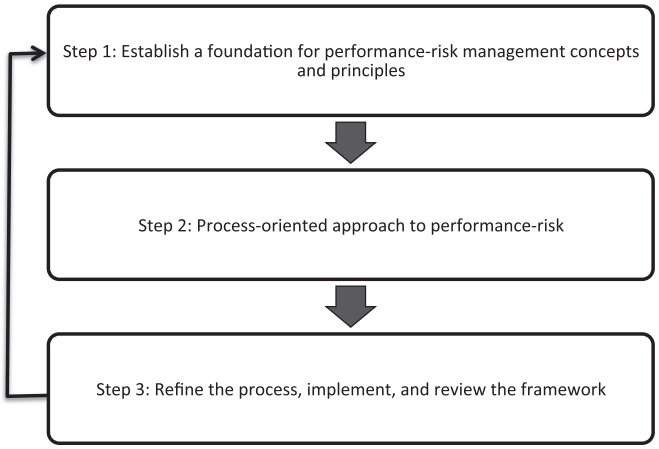

Fig. 1. Steps for the proposed performance-risk framework.

5.1. Step 1: Establish a foundation for performance-risk management concepts and principles

First, a conceptual foundation should be established which is sufficiently broad to cover all the relevant aspects of performance and risk needed. We base the framework to large extent on the recent glossary of the Society for Risk Analysis (SRA), which is founded on ideas in line with the work of the present paper. Relevant definitions are as follows:

5.1.1. Risk

General definitions include "the potential for realization of unwanted, negative consequences of an event", or "the consequences of the activity and associated uncertainties", or "uncertainty about and the severity of the consequences of an activity with respect to something that humans value" [21]. Risk has traditionally been represented using a variety of metrics, such as: 1) severity of consequences of the activity and associated probabilities, 2) expected value of consequences, 3) probability of a hazard occurring and vulnerability given the occurrence of the hazard, or 4) the triplet (C',Q,K) where C' is some specified consequence, Q is a measure of uncertainty associated with C', and K is the background knowledge that supports C' and Q [21].

5.1.2. Performance

In most general terms, performance represents the output of a system as seen in relation to the main functions of the system, the quantification of action [19], or the fulfillment of a request [11]. Performance is represented using attributes of outputs, such as 1) outputs of the system and associated probabilities, 2) the expected value of system outputs, or 3) the triplet (O, Q, K) where O is a specified system output, Q is a measure of uncertainty associated with O, and K is the background knowledge that supports O and Q. System output can be measured using monetary metrics such as profitability and revenue, or non-monetary metrics such as quality, efficiency, sustainability, and others as described above.

5.1.3. Quality

The term "quality" is often used in operations management disciplines to represent a system output relating to product durability, customer satisfaction, and manufacturing conformity to requirements. Quality has been defined as a product or service's 1) ability to satisfy stated or implied client needs (FAO 2015), or 2) freedom from deficiencies [15]. As quality is considered to be a type of system performance, it is represented using attributes of outputs, such as 1) output performance and associated probabilities, 2) the expected value of system quality, or 3) The triplet (O,Q, K) where O is now a specified quality attribute. Quality may also be measured using terms such as 1) number of defects per unit produced, 2) statistical process control metrics, 3) customer satisfaction surveys, 4) customer return rates, and others.

5.1.4. Antifragile

The antifragile concept introduced by Taleb [23] expands on the topic of resilience by reflecting how an organization can benefit from shocks caused by disturbances. See Aven [2].

5.1.5. Vulnerability

The definition of the term "vulnerability" is defined as: 1) the degree a system is affected by a risk source, or 2) the uncertainty about and severity of the consequences, given the occurrence of a risk source [21]. Vulnerability is often measured as 1) an expected value of loss metrics given the occurrence of some risk event or the probability the system capacity is unable to withstand a specific load, 2) the probability the system capacity is unable to withstand a specified load, or 3) the (C',Q,K|risk source) representing the risk given the occurrence of a risk source.

Next, key principles should be adopted for concurrent performance and risk management. The principles are described as follows:

5.1.6. Protection vs. value generation

This framework acknowledges the balance to be made between protection and value generation and examine how various instruments work in relation to this balance. For example expected net present value metrics are highly value focused. Although metrics make use of probabilities, they do not account for other types of uncertainties beyond expected values. Thus, the instrument does not serve as protection or provide cautionary or precautionary purposes. Instead, the proposed framework will highlight both probability and the uncertainty concepts within the management and decision-making processes.

5.1.7. Collective mindfulness

The framework should acknowledge the importance of collective mindfulness within management processes. As introduced by Weick et al. [25], this should include *reluctance to simplify interpretations, preoccupation with failure, sensitivity to operations, commitment to resilience, and deference to expertise*. These principles emphasize the need for organizations to consider failure and risk within all levels of organizational hierarchies. This includes developing a proactive culture that is sensitive to warning signs for systemic organizational deficiencies. In an environment with open communication, managers can benefit from obtaining a realistic view of organizational performance. Most importantly, collective mindfulness principles complement risk anticipation

with investment in resilience, which can help the organization recover from a wide variety of initiating events.

5.1.8. Stakeholders

Principles include consideration of various stakeholders in the performance-risk process. Stakeholders may include shareholders, organizational leaders, customers, workers, and others who are directly impacted by managerial decisions. Stakeholder consideration should include policy and social issues that are commonly integrated with advanced risk and uncertainty principles as described above.

5.1.9. Risk problem categorization

The performance-risk principles should also expand on traditional risk definitions by considering uncertainty within the risk categorization process. For example, managers can use a categorization of 'simple', 'complex', 'uncertain' and 'ambiguous' risk problems [20,4] thereby allowing organizations to identify 1) the appropriate stakeholders, 2) a set of alternative strategies to address the risk problem, and 3) a set of principles for selection of the most appropriate strategy.

5.2. Step 2: Process-oriented approach to risk-performance

The process-oriented approach supports broad principles for managing risk while also protecting value. This is in agreement with the ISO standard which states that "risk management contributes to the demonstrable achievement of objectives and improvement of performance in, for example, human health and safety, security, legal and regulatory compliance, public acceptance, environmental protection, product quality, project management, efficiency in operations, governance and reputation". However, the ISO standard does little to integrate the concepts. In this section, we define detailed sub-steps to perform process-oriented management for both risk and performance.

Step 2.1) Mandate a risk-performance approach with commitment from acting stakeholders
Step 2.2) Define organizational goals and risk-performance goals, objectives, and policies
a. Understand the organization and context
   i. Identify performance and risk issues relevant to the organization
   ii. Define the qualitative performance-risk goals
b. Establish performance-risk objectives and policies
   i. Develop policies for addressing risk, incorporating the need for agility, resilience, and collective mindfulness
   ii. Develop guidelines for addressing performance, incorporating quantitative performance objectives
   iii. Identify quantitative performance-risk objectives, define variables that could impact the objectives, and define a policy for protection vs. value generation
   iv. Develop strategy to integrate performance and risk.

Step 2.1 consists of first considering the many stakeholders and entities responsible for implementing the risk-performance framework. Once the stakeholders have been identified, it is imperative for stakeholders to be committed to the framework while fostering a culture of transparency in the policy-making process.

Step 2.2 consists of defining the qualitative organizational goals and the associated risk-performance quantitative objectives and policies to meet those goals. This can be performed by meeting with stakeholders to identify the top performance and risk concerns within the current environment and consequently translating those issues into general conceptualized goals. Then, specific measurable objectives and policies can be developed to include principles such as performance, agility, resilience, and collective mindfulness as described earlier in this paper. Once policies are agreed upon, it is important to consider how the meeting of goals can be influenced by events or scenarios. For example, this includes defining uncertain events, such as natural disasters, that can influence the organization's ability to meet risk and performance goals. As a result, policies can be defined to determine the organization's attitude towards protection from risk and the possibly competing objective of value generation.

Finally, the organization can develop strategies to integrate performance and risk. Using a set of alternative strategies to address performance-risk problems, principles can be defined for selection of the most appropriate strategy. Decision-support methods can then be used to incorporating multiple and possibly competing objectives defined earlier in the process.

5.3. Step 3: Refine the process, implement risk-performance management, and review framework

The following steps of the framework are common for any organizational process and not specific to any particular risk-performance guidelines.

Step 3.1. Standardize framework components with organizational structure
   a. Build Accountability
   b. Integrate into organizational processes
   c. Acquire resources
   d. Establish internal communication and reporting mechanisms
   e. Establish external communication and reporting mechanisms
Step 3.2. Continuously improve
Step 3.3. Implement risk management
Step 3.4. Monitor and review the framework

Steps 3.1-3.4 are in agreement with the ISO 31000 process, requiring firms to incorporate the performance-risk framework into the firm's operations. This includes mandating accountability of stakeholders and responsible entities, communicating both internally and externally, and implementing the agreed-upon framework. This includes continuous improvement and monitoring of the framework in order to refine the process. Often, yearly review is necessary to determine if current practices are sufficient. There may be need to adapt the framework above to broaden the scope, identify additional objectives, re-prioritize objectives, and reconsider performance-risk strategies.

Table 1 provides an itemized list of how the proposed framework meets specific performance and risk principles. A full circle implies that a particular step of the framework complies with the performance or risk principle, while a partial filled circle implies partial compliance, and an unfilled circle implies non-compliance. For example, consider one of the most important steps of the framework, Step 2.2.b.i, calling for concepts of agility, resilience, and collective mindfulness. These concepts are commonly not found within any of the performance management principles a)-f), thereby being assigned an unfilled circle. These concepts are sometimes found in broad definitions for risk management principles 1)−4), thereby being assigned a partial filled circle. These concepts maintain a large presence in risk management principle 5), representing broader risk frameworks such as the IRGC [12] and Aven and Krohn [3] framework, thereby being assigned a full

Table 1
Comparison of proposed framework and specific performance and risk principles described in this paper.

Proposed Framework			Performance Management Principles						Risk Management Principles				
			a	b	c	d	d	f	1	2	3	4	5
Step 1	Establish a foundation for performance-risk management concepts and principles		◒	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒
Step 2	Process-oriented approach to risk-performance		◒	◒	◒	◒	●	●	◒	◒	◒	●	●
	Step 2.1)	Mandate a risk-performance approach with commitment from acting stakeholders	◒	◒	◒	◒	◒	◒	◒	●	◒	●	◒
	Step 2.2)	Define organizational goals and risk-performance goals, objectives, and policies	◒	◒	◒	◒	◒	◒	◒	●	◒	◒	◒
		a. Understand the organization and context	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒
		i. Identify performance and risk issues relevant to the firm	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒
		ii. Define the qualitative risk-performance goals	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒
		b. Establish performance-risk objectives and policies	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒
		i. Develop policies for addressing risk, incorporating the need for agility, resilience, and collective mindfulness	○	○	○	○	○	○	◒	◒	◒	◒	●
		ii. Develop guidelines for addressing performance, incorporating quantitative performance objectives	●	●	●	●	●	●	◒	◒	◒	◒	◒
		iii. Identify quantitative performance-risk objectives, define variables that could impact the objectives, and define a policy for protection vs. value generation	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒
		iv. Develop strategy to integrate performance and risk	○	○	○	○	○	○	○	○	○	◒	◒
Step 3	Refine the process, implement risk-performance management, and review framework		◒	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒
	Step 3.1)	Standardize framework components with organizational structure	◒	◒	◒	◒	◒	●	◒	◒	◒	●	◒
		a. Build accountability	◒	◒	◒	◒	◒	◒	◒	◒	◒	●	◒
		b. Integrate into organizational processes	◒	◒	◒	◒	●	●	◒	◒	◒	●	◒
		c. Acquire resources	◒	◒	◒	◒	◒	◒	◒	◒	◒	●	◒
		d. Establish internal communication and reporting mechanisms	◒	◒	◒	◒	●	●	◒	◒	◒	●	◒
		e. Establish external communication and reporting mechanisms	◒	◒	◒	◒	●	●	◒	◒	◒	●	◒
	Step 3.2)	Continuously improve	◒	◒	◒	◒	●	●	◒	◒	◒	●	●
	Step 3.3)	Implement risk management	◒	◒	◒	◒	◒	◒	●	●	●	●	●
	Step 3.4)	Monitor and review the framework	●	●	●	●	●	●	●	●	●	●	●

Table 2
Performance management benefits versus the corresponding risk management benefits.

	Performance Management Benefit		Corresponding Risk Management Benefit
1.	Management to achieve high-level performance, with focus on *opportunity – maximize positive consequence*	⇔	Management to maintain high-level performance, with focus on *loss – minimize negative consequences*
2.	Driven to meet high level goals	⇔	Driven to meet high level goals, *with focus on uncertainty* in goal attainment
3.	Reliance on data-based metrics	⇔	Use of data-based metrics with also *inclusion of societal context*
4.	Setting performance goals to meet shareholder or other direct stakeholder values	⇔	Setting performance goals to meet a *direct and indirect stakeholder values*
5.	Formulation of well-defined quantitative objectives	⇔	Formulation of well-defined quantitative objectives
6.	Alignment of processes to meet well-defined quantitative objectives for *achieving high-level performance*	⇔	Alignment of processes to meet well-defined quantitative objectives for *avoiding or recovering from negative consequences*

circle.

The table also shows that, as expected, common performance management principles are insufficient in meeting the needs for risk management components of the framework. Conversely, common risk management principles fail to fully address the needs for performance management.

6. Motivating example

As a motivating example, consider the study of transportation infrastructure managed through a public-private partnership (P3). A P3 implies a service that is managed through an engagement between the private sector and the public sector. These arrangements are contractual often involving private sector being responsible for operating services, financing, or assuming certain risks. As P3 agreements are gaining support, for example within the United States MAP-21 initiative [18], there is potential for this type of agreement to show an increasing trend.

Consider the specific example of the $969 million I-95 transportation infrastructure project in the northern Virginia suburbs of Washington, DC, United States. Under this P3 agreement, the private partner assumes risk for construction and operations, but receives toll revenues [24]. This project is defined as *Design Build Finance Operate Maintain Concession*, signifying the responsibilities transferred to the private sector partner.

Under this type of agreement, it is apparent that private sector performance is tied to accelerated project delivery, design of an efficient facility, and efficient operations. However, this also exposes the private partner to risk related to design, financial, operational, and traffic risk [9]. This concurrent performance and risk consideration will be explored in the discussion below.

7. Discussion

Each of the described performance management and risk management approaches described above provide their own unique value, but also show some weaknesses. The proposed framework of this paper extracts the most important strengths from each approach while also addressing key weaknesses. Table 2 provides a comparison of the main benefits of performance management and the corresponding benefit of risk management. Here, the claim is made that there are strong parallels between performance management and risk management. Performance management is basically used to meet performance goals, while risk management is basically used for maintaining some performance level while considering uncertainties. In other words, and simplified; risk management serves to minimize negative consequences while performance serves to maximize positive

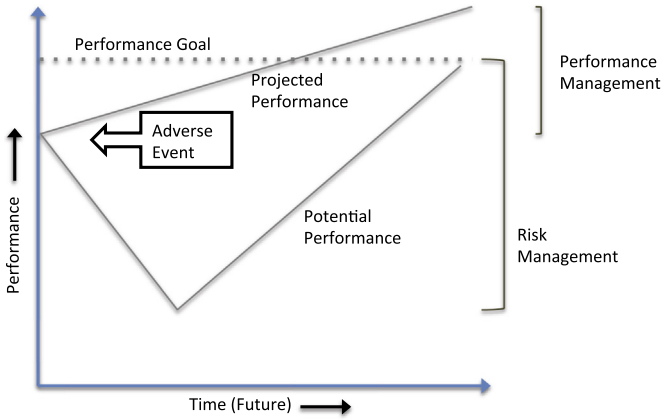

Fig. 2. Comparison of main focus areas for Performance Management and Risk Management.

consequences. As in Sections 3–5 we use the term *goals* to also cover targets, requirements or other type of reference values.

Fig. 2 provides an illustrative comparison of the main focus areas for performance management and risk management. From a performance management perspective, future performance is often forecasted to meet goals under expected conditions. For example, a forecast of performance may assume particular economic conditions, efficiencies, reputation, political conditions, and other factors. If an organization treats performance as a non-deterministic concept, the *Projected Performance* line in the figure can be non-linear or be replaced by a set of scenario-based projections. If investments are directed towards performance management initiatives, it is expected that the *Projected Performance* line would show upward movement. From a risk management perspective, future performance is assumed to be uncertain, and thereby sensitive to changes in the aforementioned conditions. Thus, the *Potential Performance* line in the figure can take on a wide variety of shapes in addition to the line shown. The figure shows that both performance and risk management serve to meet or maintain a particular performance goal in the future, while risk management considers the potential for sudden disruptions or slowly changing conditions within the studied future time horizon.

Table 3 describes how the framework of this paper incorporates key strengths from performance management and risk management. In addition, this table explains how particular framework components are demonstrated in the motivating example explained above. Table 4 describes how the framework of this paper addresses key weaknesses with both performance management and risk management, while also explaining how the framework components are demonstrated in the motivating example. As this framework is generalized to be adaptable to organizational needs, formalized implementation applied to the motivating example would require detailed analysis that is out of the scope of this paper. Future work will develop case studies and detailed software for implementation.

Several common themes are presented in the context of the motivating example illustrating both shareholder and jurisdictional motivation to manage both risk and performance, as follows:

1) What are the intricacies of the organizational goals?
   First, Step 1 of the framework calls for establishing a foundation for performance-risk management. Managers should consider the foundations from both a shareholder perspective and also a public infrastructure perspective. For example, the managers should first understand how to define performance for this system. From a shareholder perspective, performance can be measured using system revenue, operating costs, usage, and

Table 3
How benefits of Performance Management and Risk Management are incorporated into the performance-risk framework and motivating example.

Type of Management	Strengths	How the performance-risk framework demonstrates this strength	Use of this strength in the motivating example
Performance Management			
	1) Meeting of shareholder priorities	Step 2.1	Calling for commitment from those responsible for system performance, including investors, contractors, system users, residents of within close proximity to the project, economic growth agencies, public utilities mangers, etc.
	2) Ability to align objectives/targets/requirements with existing organizational practices, as shown through the MBO regime	Step 3	Standardizing framework components with the organizational structure and processes, including encouraging accountability, integrating with standards, procuring resources, and communicating with responsible parties.
Risk Management			
	1) Consideration of low-likelihood events	Step 2.2.b	Considering quantities of interest such as financial losses due to inadequate system demand, worker safety, potential surprising/unforeseen maintenance costs, system response to potential surprising/unforeseen disruptions, vulnerability to system disruptions, system resilience, and others.
	2) Inclusion of societal context within decision-making processes	Step 2.1 and 2.2, and 3.1	Employing commitment from stakeholders, including societal performance goals/objectives, and communicating with the general public and other external stakeholders
	3) Use of risk classification with meaningful descriptions as evidenced by the IRGC framework	Step 2.2.b	1) Identifying concurrent performance-risk quantitative objectives, such as decreasing crash rates by 10%, decreasing vehicle emissions by 5%, and decreasing congestion by 20%; 2) Defining variables that could impact the objectives, such as economic cycles and weather events; and 3) Defining a policy for protection vs. value generation as aided by decision-support tools
	4) Inclusion of principles for vulnerability, resilience, and antifragility in operations.	Step 2.2.b	1) Defining the most vulnerable components of the network by simulating various disruption scenarios, 2) Investing in initiatives to recover from network disruptions, such as increasing capacities, building for redundancy, and increasing security; and 3) Identifying how the network can benefit from variability, such as dynamic pricing and reversible lanes.

Table 4
How weaknesses of Performance Management and Risk Management are addressed in the performance-risk framework and motivating example.

Type of Management	Weakness	How the performance-risk framework addresses this weakness	Use of the enhanced framework in the motivating example
Performance Management			
	1) Overreliance on historical data to predict future performance	Step 2.2.b	Investing in initiatives to promote agility, resilience, and collective mindfulness to avoid overreliance on assumptions in historical data, such as investing in dynamic pricing, reversible lanes, and other congestion management practices.
	2) Overemphasis on performance to meet objectives, which can undermine true process improvement	Step 3.1	1) Focusing on accountability with management and engineering by combining risk and performance responsibilities; and 2) Integrating performance and risk management into system pricing, maintenance, and other organizational processes.
	3) Incentive for managers to overemphasize compliance instead of true process improvement, as described for the total quality management interpretation	Step 3.1	1) Focusing on accountability with stakeholders, such as operational managers, engineers, and executive managers, and 2) Integrating process improvement with tasks such as capacity planning and maintenance procedures.
	4) Low (but growing) emphasis on non-financial metrics, as evidenced by the socio-economic and sustainability objectives/targets/requirements	Step 2.2	Focusing on both risk and performance goals, such as those related to safety, sustainability, and social conditions
Risk Management			
	1) Overreliance on meeting minimum standards and regulations for risk policies, as commonly used by risk acceptance criteria and tolerability limits	Step 3.1	1) Focusing on aligning managerial decision-making with performance-risk goals and process improvement initiatives; 2) Integrating performance and risk management activities within the organizational structure, including all levels of management, engineering, and also at the field level; 3) Building accountability with all levels of management, engineering, and at the field level
	2) Vague standards, such as those recommended through ISO guidelines	Step 2.2.b	1) Developing performance-risk policies that are understood at all levels of management, 2) Implementing modeling tools to quantify system vulnerability in response to a variety of disruptive scenarios, and 3) Investing in activities to improve network resilience that are driven by quantitative models
	3) Narrow perspectives on risk, paying insufficient attention to uncertainties and knowledge	Step 2.2.b	1) Identifying key uncertainties influencing network performance, such as those existing in data resources and future conditions; 2) Defining variables that could impact objectives, such as vulnerability to disruptions (natural disaster, terrorism, etc.); 3) Considering knowledge strength within modeling assumptions
	4) Insufficient emphasis on shareholder value and operational decisions	Step 2.2	Focusing on concurrent risk and performance goals by also including non-monetary goals related to safety, sustainability, social conditions, and others.

other objective metrics. Conversely, a public infrastructure perspective requires consideration of safety, public reputation, connectivity for freight movement, impact on system commute time, environmental impact, sustainability, and other aspects that may not be easily measured.

2) Who is responsible for the attainment of the goals?
Step 2 of the framework provides a process-oriented approach to performance-risk management. Step 2.1 requires mandating a performance-risk approach that includes identifying relevant stakeholders and calling for commitment from those responsible for system performance. From a shareholder perspective, this includes considering investors, contractors, and system users. From a public infrastructure perspective, this includes considering residents of within close proximity to the project, economic growth agencies, public utilities mangers, local jurisdictions, neighboring communities, other transportation service providers, local organizations (business, schools, etc.), historic preservation entities, and others.

3) What are the quantities of interest?
Step 2.2 of the framework defines the most important performance and risk issues relevant to the organization. From a traditional shareholder perspective, risk can be investigated by considering financial losses due to inadequate system demand, worker safety, opportunity cost for other projects, and potential surprising/unforeseen maintenance costs. Conversely, performance can be investigated by considering revenues, operating costs, system demand, and other objective metrics.
From a public infrastructure perspective, risk can be investigated by considering socioeconomic implications of the project design, system response to potential surprising/unforeseen disruptions, vulnerability to system disruptions, system resilience, and others. Conversely, performance can be investigated by considering system congestion, economic development, ease of movement for people and freight, and other socioeconomic metrics.

4) How does uncertainty impact the efficacy of system investments?
Step 2.2 of the framework also calls for developing a performance-risk policy. Assuming system failure results from a negative deviation from a reference level (e.g. a forecasted prediction), the consideration of uncertainty is key to meeting system goals. A relevant question phrased from a performance perspective is: *if system performance does not meet goals, what organizational processes or principles can aid in achieving the goals?* Conversely, the question phrased from a risk perspective is: *what is the impact of unexpected/surprising/unforeseen system performance disruptions and how can they be avoided?*
A performance-risk policy requires understanding the agility

and resilience of the system. From a shareholder perspective, this includes policies to support the ability to withstand short-term financial losses, to implement operational policies to react to demand fluctuations, and to define contingency plans in response to economic changes that can influence system usage. From a public infrastructure perspective, this includes policies to support system capabilities in response to sudden-onset disruptions such as natural disasters, policies to support system performance in response to changes in regional economies, and policies to respond to capability changes in connecting or interdependent infrastructure systems.

There are several factors that could impact the system's ability to meet well-defined quantitative objectives. These factors are common among both a shareholder perspective and public infrastructure perspective. These include global economic conditions, regional economic conditions, natural disasters, acts of terrorism, values of currencies, cyber security issues, and others. The most important policy to consider is that of protection vs. value generation. Performance-risk policies should acknowledge that protection initiatives for system risks can be costly and may interfere with value generation objectives. For example, consider investment in protection, such as protecting physical buildings, multimodal terminals, and bridges. The protective actions require an investment of time and monetary resources. Consider these protective investments to be a form of insurance against potential negative consequences. Although these investments may be useful in the case of a disruptive event, they may incur an opportunity cost for performance enhancements. Any added protection to buildings and multimodal terminals may slow operations, thereby impeding system performance. Protection of bridges, including increased use of sensor data may require significant resources for ongoing study and evaluation of sensor data.

5) How should the performance-risk management be implemented?

Step 3 of the framework calls for a standardization of framework components with the organizational structure. The methods to achieve this standardization are common across both a shareholder perspective and a public infrastructure perspective. This includes the process of encouraging accountability of responsible parties, integration of the developed principles with organizational processes, the procurement of resources, and communication.

A refined implementation of this framework would include the use of a software tool that would allow for interaction among participants. This tool would most importantly include the ability for stakeholders to provide input on items such as conceptual definitions and a register of performance-risk issues. Designing this tool with a web-based interface would allow for public dissemination of continuous improvement and monitoring efforts. An enhanced tool would facilitate decision-making and tradeoff analysis for identifying the most appropriate risk-performance investments. The design of this tool is a topic for future research and development.

8. Conclusions

This paper has presented an enhanced framework for unification of performance management and risk management principles. The framework focuses on the recognition that performance management is traditionally used to meet performance goals, while risk management is used to maintain some performance level while considering uncertainties. Risk management serves to minimize negative consequences while performance management serves to maximize positive consequences.

The proposed framework focuses on utilizing the strengths of common performance and risk principles while also addressing key weaknesses. For example, the framework exhibits strengths associated with performance management, such as considering multiple stakeholders and aligning practices with standard processes. The framework also exhibits benefits associated with risk management, such as considering the impact of low-likelihood events and studying societal context in decision-making practices. The framework also addresses weaknesses common to performance management and risk management, such as overreliance on historical data, overreliance on meeting minimum standards, and others.

The proposed framework consists of several principles existing within the established ISO 31000 guidelines, but also adds key features. This framework includes the development of qualitative goals and quantitative objectives for concurrent performance-risk initiatives. The proposed framework enhances existing standards by developing policies for addressing risk, incorporating the need for agility, resilience, and collective mindfulness, policies for protection vs. value generation, and other integrative strategies.

This generalized framework is customizable and adaptable to a variety of organizational applications, such as corporate governance, infrastructure management, and P3 arrangements. Similarly to the ISO 31000 guidelines, organizations must utilize executive leadership, stakeholder interaction, and value-based judgments to effectively implement risk-performance policies. This framework is most appropriately facilitated by the use of web-based decision software tools that are a topic for future research.

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