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What You Need to Know
About Risk Management Methods

Is it true that PIGs fly
when evaluating risks of
projects, operations, and corporations?

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Is it true that PIGs fly when evaluating risks of projects, operations, and corporations?

Recent major losses incurred by projects, operations, and corporations around the world have shown that common risk management practices based on ”risk matrices” leave organizations widely overexposed to risks that could - with thoughtful analysis and planning - be otherwise reduced, mitigated, or avoided altogether.

This white paper presents the benefits and limitations of common risk management methods, including Risk Matrices, Probability Impact Graphs, and Heat Maps (which we collectively refer to as “PIGs”), as well as Optimum Risk Estimates (ORE) a proprietary methodology by Riskope, the result of twenty years of R&D and continuous development.

While widely used, “PIGs do not fly” - these methods can be misleading, and expose organizations to potential litigation. The ORE method addresses the limitations of PIGs, providing a transparent, proven, and constructive approach that can augment risk registers based on PIGs. ORE provides organizations with enhanced capabilities to identify, quantify, and prioritize risks in order to inform action, resource allocation, and capital investment.

We will present:

- A brief review of risk exposures, and the reasons that have lead to them;
- The liabilities brought to organizations by risk management approaches that use PIGs;
- An overview of the ORE methodology, and how ORE can be applied to a wide range of risks to provide a clear, rational, defensible description of the organization's risk environment and risk horizon;
- Case studies that demonstrate how ORE has been applied.

To date, ORE have been applied by Riskope to waste systems, supplies ingress & products egress studies, environmental risk assessments and even cyber-defense programs. ORE prioritization is consistent, unambiguous, and provides context for better understanding of an organization’s risks.

What You Need to Know About Risk Management Methods

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Preface: Assessing and Presenting Risks

A report by the World Economic Forum[1], defined climate change, oil price shock, pandemic and terrorism as the "biggest risks" confronting the global economy (Sharman, in Financial Times, 2007). More recently cyber-attacks and other natural and man-made risks have been "elected risks of the year" by media and public opinion. The sources of risk are diverse, ever-changing and unpredictable.

In order to optimize efforts and investments, as well as to enhance corporate governance[2] and risk exposure benchmarking, it is desirable to implement a standardized format for risk assessments which has the capability to cover all kinds of hazards and consequences, and display them in a transparent and easy way, ready for discussions and decision making.

Industries and corporations around the world have responded to this need, over decades of practice, by defining conventions and details to speed-up the production of simplified Risk Assessments. These generally involve generating Probability-Impact Graphs, or Risk Matrices, which we collectively refer to as "PIGs".

PIGs are often based on index values of probability/likelihood and consequences to deliver simplified risk assessments of a system, a product, a process, etc. Index values are "eye pleasing" to users unaccustomed (or scared away) by real numbers representing real probabilities ranges or costs.

Today, most indexes are defined with values ranging from 1 to 5 (or whatever arbitrary number might be selected by their author) for both probability/likelihood and consequences, generating 5*5=25 values, which results in risks ranked from 1 to 25 (or whatever the numeric value assigned to the indices may be). More complicated systems of indexes actually exist, but they only bring more fuzziness, sometimes double-counting and create unwanted uncertainty in a field that already has plenty. We also know of governments that use qualitative 3x3 matrices for their risk assessments. Masking reality (the real numbers) with indexes can completely alter the outcome of a risk assessment, as we will show later in this paper.

This situation is untenable. Academia and consultants around the world are indeed starting to, or have already, published papers criticizing PIGs. We all affirm that "PIGs do not fly"; they are misleading and could, and most likely will soon, get their users straight in front of a Judge in a Court of Law.

1 In cooperation with Citigroup, MMC, SwissRE and the Wharton School Risk Center.

2 Most countries have corporate governance framework in place and risk management sits at the heart of nearly all those frameworks (Sharman, in Financial Times, 2007).

PIGs do not solve the problem at stake and it appears that the meaning of a risk matrix may be far from transparent, despite its simple appearance. In general, risk comparisons in a risk matrix require explanations—seldom or never provided in practice—about the risk attitude and subjective judgments used by those who constructed it.

In particular, as consequences are generally random variables with a large range, there may be no guarantee that risks receiving higher risk ratings in a risk matrix are actually greater than risks that receive lower ratings. That is most likely why NASA (NASA 2007) stated in their Systems Engineering Handbook that risk matrices (PIGs) are not an assessment tool, but can facilitate risk discussions and help track the status and effects of risk handling efforts, and communicate risk status information. NASA then quotes more than five limitations related to the use of PIGs.

Industry demands more than just “talking about risks”, especially hazardous ones, where very large private investments are at stake and critical consequences are lurking.

The ORE methodology has been created, after a decade of applied R&D, to solve the problems brought by PIGs and deliver to industries a powerful yet simple to use analytical tool.

With Oboni Riskope Associate's ORE, it is possible to upgrade an existing corporate Risk Register, steering operations and projects toward a rational, defensible and transparent stance.

Acceptability and Tolerability

A meaningful measurement of risk requires an understanding of relative risk tolerance – an "acceptable risk" for one organization may be an "unacceptable risk" for another organization.

Risk that is acceptable to a regulatory agency and also to the public is called "acceptable risk". There are no formally recognized regulatory criteria for risk to personnel and the public in many industries.

A risk assessment *per se* does not really help in making any decisions on risk reduction/accident prevention and other mitigative plans. It becomes rationally operational only when its results are compared with a threshold generally called "tolerable/ acceptable risk curve"[3].

Once the risks incurred by a project or operation are estimated, rational and sustainable decisions on risk mitigation are generally requested by clients wishing to adopt risk management methods and maximize the investment they have made by performing a risk assessment. These decisions can only be taken after an explicit risk tolerability function is defined.

Qualitative or hybrid risk assessments (based on indexes and matrix representations of risks) introduce more fuzziness than quantitative ones, as the tolerability/ acceptability is defined by arbitrary "steps" within the probability/ severity matrix.

Quantitative Risk Assessments (QRAs) provide instead a rational platform for decision making based on the comparison of the assessed risks with Quantitative Risk Tolerability Curves (QRTC)[4], provided due regard is given to uncertainties.

Tolerability can be defined for physical losses, acceptability for human losses, and even for public opinion induced losses. Tolerability to human losses does not mean putting a price on the loss of life if the concept of "Willingness To Pay" (WTP) is considered.

When discussing human tolerability a distinction has to be made between location-based risks and societal risks:

- Location-based risks derive from the annualized likelihood of a person being killed at a given location as a direct result of an accident associated with hazardous activities undertaken there.
- Societal risks represent the likelihood of a group of people who are not

[3] Fischhoff, B., Lichenstein, S., Slovic, P., Derby, S. C., & Keeney, R., Acceptable risk. Cambridge MA: Cambridge University Press, 1982
[4] Bruce & Oboni, Risk Management Process for Tailings Control, Mining Engineering, SME, Oct. 2002

directly engaged in an activity that involves a hazardous substance being killed in an accident arising out of that activity.

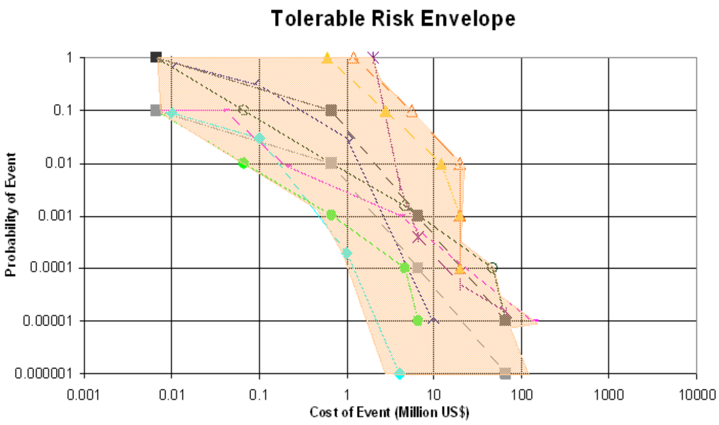
Location-based risk is an expression of the risk exposure for someone who lives or works in a place where a hazardous activity takes place. Societal risk is quite different: it looks at the consequences of mishaps from a very broad point of view of an entire society, possibly physically and emotionally removed from the mishap itself; as such, it is of interest mainly to public administrators[5]**.**

Tolerable risk curves are always project and owner-specific and indicate the level of risk which has been deemed acceptable by an owner for a specific project or operation (possibly taking into account public opinion). This means, as an example, that within large companies corporate risk tolerability may differ quite substantially from a branch operation's tolerability.

The development of empirical-estimated tolerability curves requires caution and continuous calibration; they should always be defined by a group, and not by an individual[6].

In a risk study, great attention must be exerted in ensuring that the acceptability curves are derived for the considered risks: curves derived for hazardous industrial activities cannot be used for natural hazards like for example: typhoons, quakes or flooding, or business risks.

Figure 1 shows a series of curves derived through discussion with European and North American companies that have been willing to develop their own risk tolerability. In reality, often times, these curves corresponds to the perceived tolerability rather than the real "absolute" financial capacity of the company to withstand the occurrence of a damage.



[5]The Netherlands Ministry of Housing, Spatial Planning and the Environment, Societal risk, January 2006

[6]Hofstätter, P., Gruppendynamik. Hamburg: Rowohlt,1986; Wilde GJS. Target risk 2. Toronto: PDE Publications, 2001 (First edition available at http://psyc.queensu.ca/target)

Fig. 1 Tolerability Risk Envelop

Qualitative, Quantitative and Hybrid Risk Assessments

If probabilities and consequences are expressed numerically rather than with words, i.e. a number between nil and one for p (probabilities), and a quantity for C (consequences, which could be a metric based on money, victims, number of extinct species, squares kilometers of lost Amazon Forest), then the risk assessment will be a Quantitative Risk Assessment (QRA). If neither of the two parameters, i.e. p or C, is encoded in a number, but rather it is qualified with an adjective (small, medium, large, for example), then the risk assessment is not quantitative, but qualitative. If one of p or C is defined qualitatively, then the risk assessment is a hybrid risk assessment. If p or C are defined by arbitrary indexes, then the risk assessment is indexed.

In QRAs the probabilities can be statistically derived (one should carefully note that past does not equal future), model derived (careful to what the models are based on), or subjective-negotiated probabilities based.

In any case, the first QRA will by definition merely represent a first flash view of reality, and will need to be regularly updated (when the system changes, as soon as more data comes in). If pertinent data comes in and the risk assessment is well structured, then the new data can be incorporated using mathematical techniques like Bayesian approaches to update and enhance the initial estimates and the results.

The results of a qualitative risk assessment are expressed in terms of low risk to very high risk in a table form similar to that shown below as a matrix. This type of matrix, inevitable when working qualitatively or with indexes, constitute the basis of any PIG.

CONSEQUENCES	**Very High**	Highest Risk VH/VH	VH/H	VH/L	VH/L	Low Risk VH/N
	High	H/VH	High Risk H/H	H/M	H/L	H/N
	Moderate	High Risk M/VH	M/H	Moderate Risk M/M	M/L	M/N
	Low	L/VH	L/H	L/M	Low Risk L/L	L/N
	Very Low	Low Risk VL/VH	VL/H	VL/M	VL/L	Negligible risk VL/N
		Very High	**High**	**Moderate**	**Low**	**Negligible**
		LIKELIHOOD OF OCCURRENCE				

The axes of the table are based on qualitative assessments of the level of the hazards' likelihood and the levels of the consequences. The level of risk is then defined depending on the bin in which the failure mode falls on the matrix. The definitions of high to low are agreed upon prior to the start of the exercise. This analysis is simple and useful for highlighting problem areas within any single given facility, but they do not allow Bayesian updating, comparisons and communicating results in a transparent way. The adjective used requires specification, and even with long and detailed specification there is room for interpretation.

If the purpose of the risk assessment is to allow comparison between facilities in several areas or countries, or if a total risk management methodology is proposed to assist in deciding what methods of mitigation to use, then a QRA quantitative approach, which provides actual numerical values of risk generally expressed in dollar units, is recommended. The results of the QRA provide a numerical value for the risk of each component or subsystem of the system being evaluated and also the cost of the remediation. When the QRA method is used systematically and coherently, the numeric nature of the results allows the comparison of the risk exposures.

Qualitative methodologies where likelihood and consequences are evaluated purely in terms of verbal descriptions may be successful in the preliminary identification of areas of concern at one particular project, but lack of resolution when the results have to support operational decision-making and pertinent allotment of risk mitigating funds.

The qualitative risk assessments allow broad identification of problem areas, but are not amenable for detailed prioritization of the risk exposures. Indeed, they do not allow objective quantitative comparisons between exposures, they do not offer corporations the ability to compare mitigative investments and allocate resources in an optimal way, an exercise that becomes particularly important during periods of shrinking human and financial resources. In fact the use of qualitative descriptors, which may not be entirely consistent between areas of the operation, can be misleading and can deliver confusing results, which are difficult to apply.

On the other hand, some will argue that quantitative risk assessment may lead users to unwarranted confidence in numbers and models used to derive them. This criticism can however easily be overcome by explicitly introducing uncertainty in both the probabilities and the consequences of a risk scenario.

Quantitative Risk Assessments

In a given context, a Quantitative Risk Assessment (QRA) identifies scenarios potentially leading to accidents/crises with various consequences, and establishes their probability of occurrence and consequences in monetary terms (monetary losses).

The analyses follow these summarized steps:

1. Determination, identification and characterization of various natural and man-made hazards/hazardous situations taking into account presently known, reported conditions.
2. Evaluation of the potential types of consequences generated in each scenario considering extant mitigative measures and their assumed potential efficiency, transportation mechanisms, dominoes effects (chains of failures), vulnerabilities (health, socio-economical, physical, production, etc.).
3. Evaluation of the risk associated with each accidental scenario as the product between the probability of occurrence of the mishap and the value of the evaluated damages. The probability-cost for each scenario is drafted in a p-C diagram and superimposed to a carefully selected published tolerability criteria or with the client's own tolerability curve (to be determined at a later stage, if agreed).
4. Finally, risks should be prioritized. In the past "top-ten descending priority lists" were often delivered to clients. However, using the Optimum Risk Estimates Method (ORE, © Oboni Riskope Associates Inc.) gives way better results, focusing the attention on risks that really do matter.

Summary of Risk Assessment Process

The risk assessment process encompasses the following steps:

1. Define context and system boundaries;
2. Describe the system in terms of elements and links;
3. Identify hazards and elemental failure modes;
4. Evaluate probability of hazards and elemental and compound failure modes occurring;
5. Evaluate potential targets and costs of failure;

6. Determine tolerable versus intolerable risks;
7. Present Risk and Decision Making based on risk prioritization.

Steps 1 to 3 and 5 are generally started at site using an interview process followed by reviewing documentation provided by the owner. The interview process can be conducted either as an open forum or following the Chatham House Rule[7].

A site visit is also generally undertaken by the risk managers to view the site, undertake the field assessment part of the risk assessment. This is a critical part of the overall assessment. During this period, documents pertaining to design and construction and ongoing operations would be reviewed and assessed.

The purpose of the site visit is:

- To confirm that all current reports have been reviewed;
- Interview key staff in engineering and management system to assess how the system is being operated;
- Inspect the facility to confirm the quality of the information available and assess from a third party review perspective that the system is being operated optimally;
- Provide a site debriefing meeting to provide a preliminary assessment of findings, which assesses the risks at each facility.

Steps 2, 4 and 6 are undertaken after the site has been visited and assessed and data has been quantified.

For each element that has been identified as a single homogeneous entity, the following questions have to be systematically asked:

- What are the hazards identified along each section of the links or at element?
- Given the hazards, can they damage the link or element if they occur?
- What then is the likelihood of an event occurring which will damage the link or element?

[7] The Chatham House Rule reads as follows: "When a meeting, or part thereof, is held under the Chatham House Rule, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed". The world-famous Chatham House Rule may be invoked at meetings to encourage openness and the sharing of information

(http://www.chathamhouse.org.uk/about/chathamhouserule/).

Will the incident lead to a loss of production or business interruption? What then is the likelihood of an event occurring, which will break the link or element, leading to lost production, or other consequences?

By combining the probability of the event, its degree of impact and the cost of consequences, the risk can be calculated and a comparison between sites undertaken.

If the risks are evaluated qualitatively any comparison among projects, operations, corporations will be fuzzy and could lead to wrong decisions.

Judgments are clouded by prejudices and misconceptions

Limitations and Flaws of Common Approaches

Over the last five decades or so, the risk management community has settled on representing the results of Risk Assessments with Probability Impact Graphs (PIGs). PIGs are ubiquitous, but have a number of staggering intrinsic conceptual errors, with potentially dramatic negative consequences on their users. One of the main reasons for the development of PIGs has been the reluctance of Risk Assessment developers to use quantitative estimates of the probabilities, the illusion that qualitative solutions are "easy", the ignorance about basic mathematical rules that constitute the backbone of rational analysis.

In the last decade technical literature has begun to specifically address PIGs logical and mathematical limitations (Cox *et al.* 2005, Cox 2008, Cresswell, Hubbard 2009, Chapman & Ward 2011). Reportedly, the debate has recently found its way to the UK's Association for Project Management Risk Special Interest Group; Chapman and Ward discuss this debate in their book. The quoted literature shows that little research rigorously validates PIGs performance at improving risk management decisions and exposes PIGs poor resolution and errors. Typical risk matrices can only correctly and unambiguously compare a small fraction, reportedly less than 10%, of randomly selected pairs of hazards. Furthermore, they can assign identical ratings to quantitatively very different risks, a phenomena often referred to as "range compression" and can mistakenly assign higher qualitative ratings to quantitatively smaller risks. These inaccuracies can lead to mistaken resource allocation.

A Glimpse into Behavioral Sciences

The continued "main stream" reliance of using inappropriate techniques like PIGs, and being satisfied with their results, or, using intuition to correct PIGs' evident fallacies, is simply another manifestation of what Kahneman and Tversky explored when they examined the ways Humans have found to introduce irrelevant criteria in decision-making (Kahneman & Tversky 1979, quoted in Oboni & Oboni 2007).

Kahneman and Tversky have explored in detail how human judgment can be distorted when making decisions under uncertainty: humans tend to be risk-averse when facing the prospect of a gain, and paradoxically risk-prone when facing the prospect of a loss (even if the loss is almost certain to occur). So, using improper methods like PIGs, which almost surely will lead to confusion, losses, and poor planning sits well with "main stream" human nature.

Once we realize that using PIGs is no more than a help for discussions, is not an assessment tool, and using them leads at best to wasting precious mitigative funds, the whole idea of being able to correct existing PIGs, as they stand in most industries, comes out as a clear winner: by deploying rational prioritization we give a rest to our scientifically proven fallacious intuition, and allow our rational ego to make better informed decisions.

Arbitrary Selections in Risk Management Are a Liability

Based on the discussion above, we can foresee that soon cases will be challenged in Courts of Law against companies using PIGs for their risk assessments and the resulting decisions. The questions that could be asked to those companies will be horribly embarrassing and very damaging, as they will tend to prove that the approach constituted a professional negligence, due to blatant breach of the Duty of Care. Here are a few summarized examples of questions that could be asked:

- On which basis did you decide that the probability of the event was "medium", or whatever your PIG shows, and more importantly, why did you neglect to use any of the methods, published since the '80s about (subjective, expert driven) approximations of probabilities?
- What is the basis for defining consequence (loss) classes in your PIG? ...
- Which studies did you develop to define the various class limits of likelihood, and losses? On which basis did you select those limits?
- Why did you limit the highest class to -x- casualties and -y- millions? ...
- So, did you use PIGs just because everyone uses them? ...
- Which criteria did you use to select the colors of your cells, which correspond to various levels of criticality? What criteria did you use to define those levels of criticality?
- There are tolerability criteria published since the mid '60s. How come your color threshold does not match any known tolerability criteria, ...?
- Using "credible scenario" is a censoring decision. How come you felt entitled to censor your analysis? ...
- Using "average p, C (loss)" is a biasing decision. ....

For a complete discussion on this subject, see our blog post:
http://www.riskope.com/2012/03/01/arbitrary-selections-in-risk-management-are-a-liability/

We doubt a PIGs user will be feeling in a strong position to further argue the case. The next sections will show how to avoid these pitfalls and their unpleasant consequences.

Case Studies

Case Study 1

We will use, for this first Case Study, Operation Ten (OT) belonging to our client AAA Inc. (AAA) (names, locations and risk names have been altered to respect client's confidentiality), a medium sized industrial operation. Geographic location, production type and product do not matter for this discussion.

OT's Management formulated an explicit request to the Authors to deliver a risk based decision making (RBDM) support study: “The assessment will consider the particular environment, specific location and activities of OT to envision mitigating its risks to a tolerable level and to establish a conceptual framework to support decisions regarding its future conditions. In particular, the Action Plan will be mainly targeted to OT's decision makers and should answer practical questions... ”.

The study started by analyzing the Status Quo, including the level of awareness, understanding and sophistication of OT/AAA and concluded that they were at par with the international consensus in the area of risk assessment. OT was using PIGs and it became obvious that Management was not getting the guidance they were seeking. Riskope's Optimum Risk Estimate (ORE) method was deployed as described in the following sections.

Status Quo Analysis: PIGs Approach Before ORE Deployment

OT used PIGs to prioritize risks compiled in a risk register (prepared with a commercial software) in view of their management. OT's PIG was a 5x5 classes (frequency x severity) matrix defined as follows.

Classification	Level	Characterization Frequency
	1	1 failure in over 100 years
	2	1 failure in 10 to 100 years
	3	1 failure in 5 to 10 years
	4	1 failure in 1 to 5 years
	5	more than 1 failure per year
Severity		
	1	$0 to $1,000,000 in costs
	2	$1,000,000 to $5,000,000 in costs
	3	$5,000,000 to $15,000,000 in costs
	4	$15,000,000 to $50,000,000 in costs
	5	more than $50,000,000 in costs

As it can be seen below, OT selected a four stepped thresholds of attention (criticality) for risks in the matrix: Severe, High, Medium, Low. A rule based on the value of the multiplication between the frequency and the severity indexes had been established as follows.

		Min	Max	Risk Rating	
Freq * Severity					
Severe	S	20	25	S = Severe	> 19
High	H	10	19	H = High	10 to 19
Medium	M	4	9	M = Medium	4 to 9
Low	L	0	3	L = Low	< 4

OT's 50 extant risks scenarios had been prioritized as follows: 0 Severe, 14 High, 25 Medium and 11 Low risks. Do you remember the old saying that you should “never cry wolf”? Well, with 14 High, 25 Medium, Management's reaction was to say: “too many to cope, let's wait or let's give equal attention to all”, which was intrinsically hazardous because it gave a “false completeness” sense of security.

As discussed earlier, PIGs do not have the ability to deliver clear guidance in the selection of risks priorities, or to test the adequacy of mitigation plans (See http://www.riskope.com/2010/06/08/bp-crisis-rational-analysis-what-bp-did-not-perform/ for more details.). The problem of expenditure on safety measures is one of allocation of resources and cost-effectiveness which has to be based on the whole spectrum of possible events, instead of the Maximum Credible Event, ALE (Annual Loss Expected) or some other deterministic parameter (Lees, 1980).

This inappropriate funds allotment becomes even more problematic when, as it happens in economic downturns, mitigative budgets tend to shrink.

ORE Deployment: Converting Risk Register Data into Usable Data

A series of four proprietary questions was used in a facilitated workshop with key personnel to allow the definition of tolerability. Then OT's matrix frequencies' indexes were converted into probabilities and the consequences indexes were turned back into monetary losses. Once the indexes were eliminated it became possible to evaluate “real” risks, as the product of probability and consequences, expressed in monetary terms, and plot them in a probability-Consequences (Losses) diagram, shown in Figure 2.

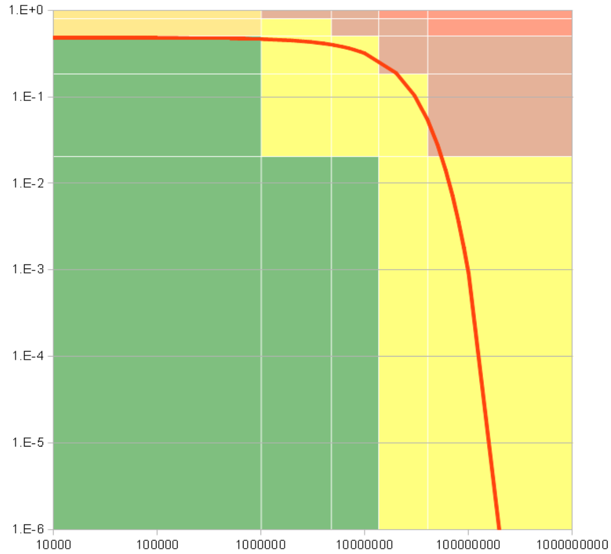


Fig. 2 The original matrix cells are shown on a log-log probability consequences plot, together with the newly developed OT's tolerability curve.

Figure 2 shows Probability (vertical axis, a number between nil and one), and Consequences (horizontal axis, dollars), and the newly defined tolerability curve. The curve follows the steps of the matrix threshold (yellow-red limit) with classes displayed here in a log-log scale.

The "total" risk for each scenario can be calculated, and when applicable, it is possible to evaluate which portion of that risk lies above the tolerability as depicted in Figure 3.

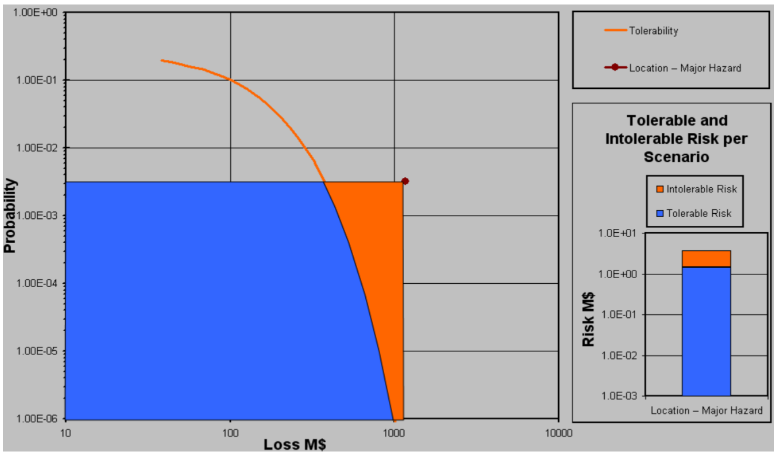


Fig. 3 When probability and consequences of a scenario are evaluated, the total risk is equal to (p*C). The blue area is the tolerable part of that scenario, the orange part is the intolerable portion. NB: the log-log scale requires some attention when interpreting the relative size of surfaces.

The bar graph in Figure 4 shows, as an example, a small portion of the risks from OT's original Risk Register, with the tolerable part in blue, the intolerable part in orange, and the total risk equal to the sum of the blue and orange bars for each scenario.

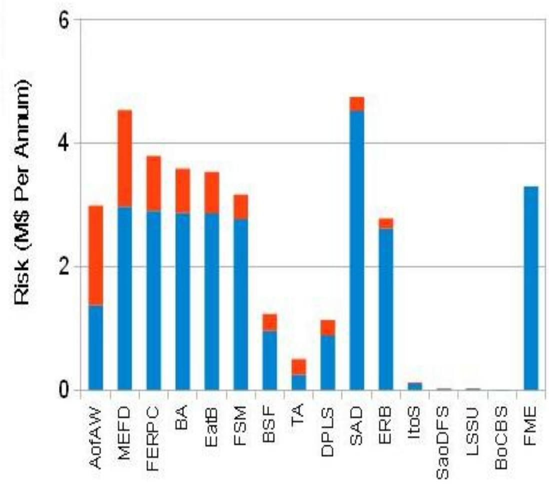


Fig. 4 A small part of OT's original Risk Register, with, for each scenario, a tolerable and intolerable risk partition.

If we plot risks from highest down to lowest, Figure 5 shows the top 20 risks. We can see that even though some risks scenarios are overall higher (blue and orange bar), the size of the intolerable part (orange bar) may lead to a completely different prioritization, resulting, of course, in a different respective allocation of mitigative resources.

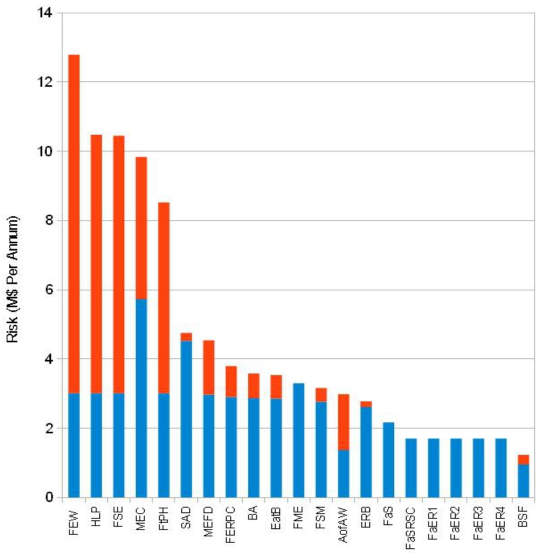


Fig. 5 OT's largest total risks, in decreasing order from left to right.

Rational Prioritization of Risks

Rational and transparent prioritization is achieved when risks (above tolerability) are ranked in decreasing order of the intolerable portion (only the orange bars), even if the overall risk is higher, leading to the graph displayed in Figure 6.

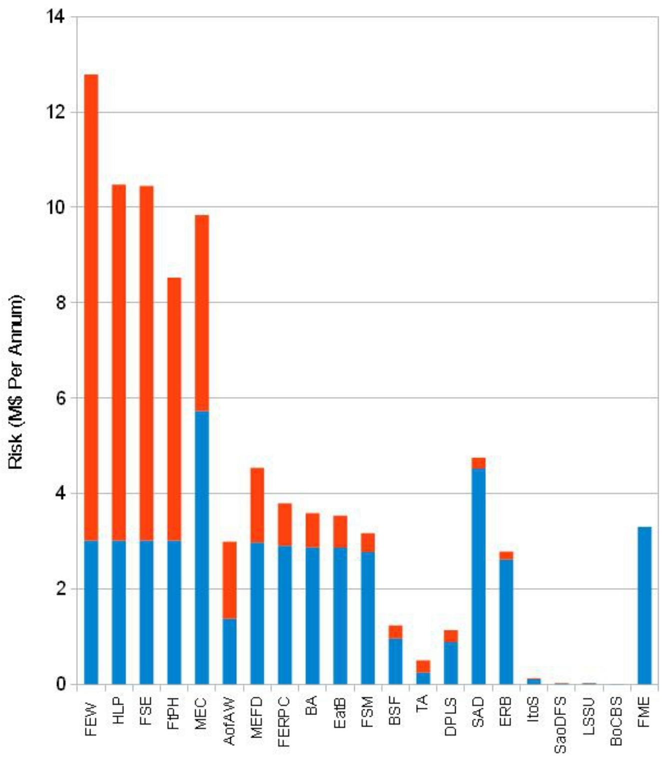


Fig. 6 OT's Risk Register risks are now ranked in decreasing order (from left to right) of their intolerable part.

At this point it becomes interesting to compare the relative value of the risks' intolerable part for the allocation of resources regarding mitigations measures.
We can see from Figure 7 that five OT's scenarios count for 83% of the total intolerable risks. We could therefore state, at first sight, that for every dollar spend for mitigations approximately 80 cents should be spent in relative proportions for the 5 "top intolerable" risks, then the remaining 20 cents should be split amongst the next 15 risks.

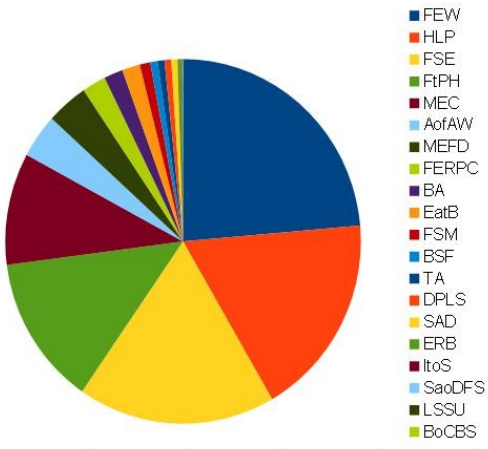


Fig. 7 Relative values of the intolerable part of OT's risks.

The remaining 30 scenarios should not even be considered at this time. In other words, among the 50 risks scenario present in OT's Risk Register, 5 should be allotted 80% of the resources and 15 others should employ 20% while the remaining 30 should not even be considered before the first 20 are not brought below the tolerability curve.

When the risk panorama will change because of implemented measures, the prioritization will change and it will be very easy to rationally and transparently update OT's ORE rankings.

Summary of Results and Benefits

From OT/AAA's original rating of 50 risks which split into 0 Severe, 14 High, 25 Medium, and 11 Low risks, by using a newly developed OT tolerability curve, and using the intolerable part of risks as a rating parameter, we determined a new rating which allows for more rational allotment of capital and effort. Following the new rating it can be seen that among those 50 risks, 5 should be allotted 80% of the resources and 15 others should employ 20% while the remaining 30 should not even be considered before the first 20 are not brought below a tolerable level.

Comparing these values to those generated using PIGs, ORE defines 5 risks that should share 80% of the available resources, whereas PIGs finds 14 (or more?) sharing an unspecified percentage of the available resources. Or 15 risks sharing 20% of the available resources, instead than 25 sharing an unspecified percentage of the same. If Management has to mitigate 5 risks instead of 14, they will be keener to do so, and it will be done faster!

ORE benefits brought to OT can be summarized as follows:

- The prevalent critical risks were brought forward in a clear, rational and defensible way.

- The number of critical issues was shown to be smaller than originally evaluated.
- The insurance portfolio (including self-insurance policies) was shown to be poorly balanced and adjustments were proposed.
- The new priority list let Management make better mitigative investments' allotments and freed moneys that could be better allocated elsewhere in the Operation.

Case Study 2

System description

This case study bears on a complex tailings pond system at a mining operation, as described in Figure 8.

Each number in the Figure represents a Tailings Dam, a Spillway or a scenario. The study lead to the definition of the risk for each element (from hazards such as Stability, Erosion, Overtopping, Vandalism & Sabotage, Internal erosion, Concrete Failure, etc.). Complex domino scenarios from multiple failure were considered. In the actual report, each element bears a number and each element was further explained in an Appendix, hence the naming of the elements as "Appendix nn".

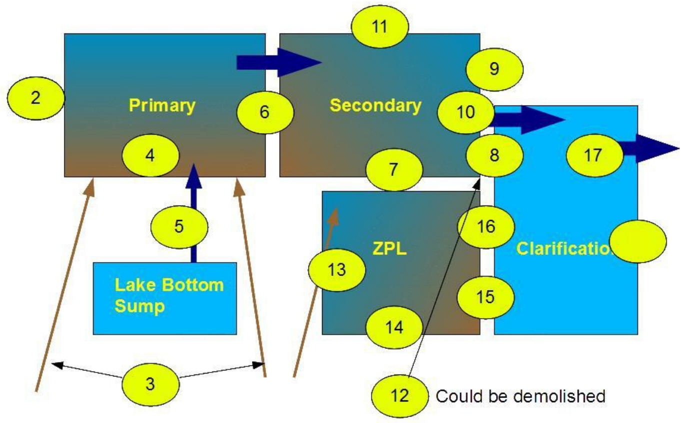


Fig. 8 Tailings pond system.

ORE Deployment

As in Case Study 1, the Tolerability Curve was first developed for the client.

If we were to proceed without ORE, *i.e.* only look at risks as displayed in Figure 9 (Total Risk per element), we would prioritize as shown in Figure 10 (Pre-ORE, Left). The same Figure 10 shows on the right the ORE prioritization.

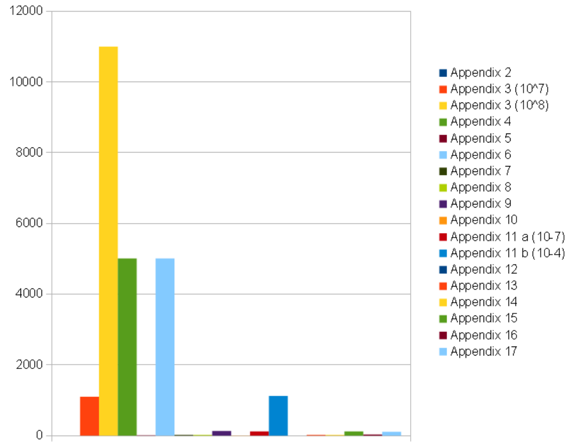


Fig. 9 Total Risk per element.

The total risk prioritization (Pre-ORE, Left) would lead us to consider the elements described in Appendix 3,4,6 as the main drivers of the Tailings System risks, covering 88% of the total exposure.

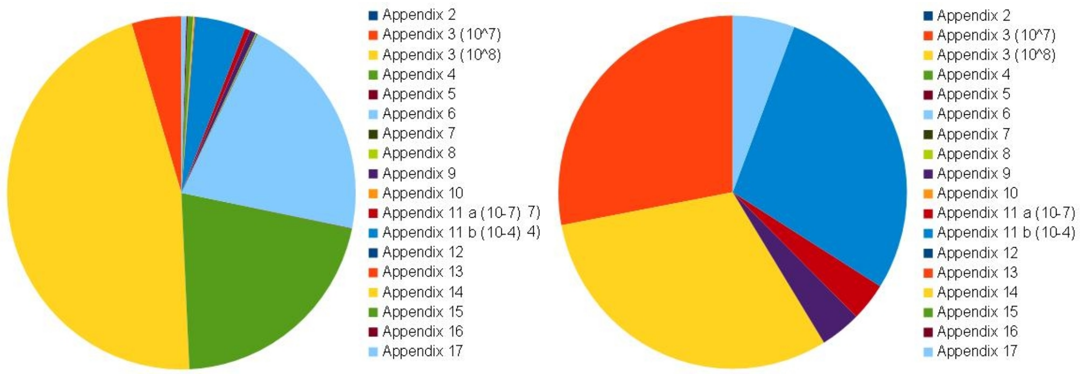


Fig.10 Pre-ORE relative Risk per element as discriminant (Left). ORE Intolerable Risk per element as discriminant (Right).

The intolerable bar of each element was then computed, leading to a better understanding of the risk environment as shown in Figure 11. Note that as only 6 Risks were intolerable, the remaining 13 were set aside for the short term.

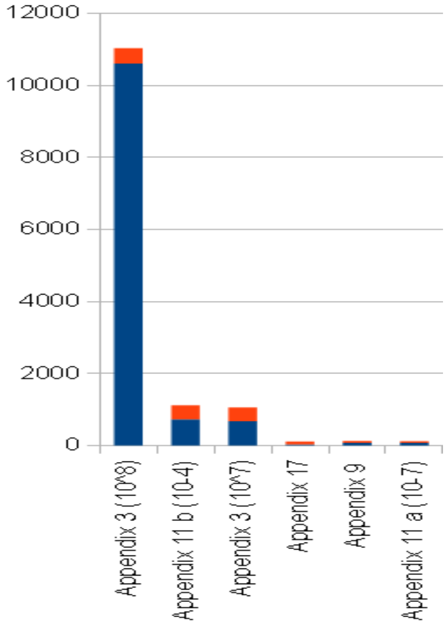


Fig. 11 Intolerable Risk per element as discriminant.

Including the next three largest risks (Appendix 3 smaller scenario, 11b, 2) would lead to covering 97% of the total exposure. Again, like in other commonly used approaches, the total risk prioritization lacks definition, leads to poor allocation of funds and causes managers to be overwhelmed by the number risks that all appear to have the same level of concern.

If we focus now the attention on the ORE prioritization (Fig. 10, Right) we see that 87% of the total intolerable exposure is shared by Appendix 3 (small and large scenario), and 11b, but 17, 9 and 11a come next (Appendix 4, 6 have vanished because their risks are tolerable). It becomes apparent now that the pre-ORE prioritization would have triggered mitigative investments toward two elements that are not critical (Appendix 4, 6).

Appendix 17 and Appendix 9 which, from a Total Risk point of view, were considered negligible, are actually intolerable and following the ORE prioritization will receive due attention.

As for the elements with two different scenarios (Appendix 3,11), they were recognized as more critical than previously imagined as even their lower risk scenarios are actually intolerable.

A Defensible Approach

In this section we show a summary of the replies that ORE users can give if asked to justify their doing:

- We did not define classes, rather we ranked risks by looking at their possible intolerable part for the specific case.
- Probabilities were defined by methods which are applicable to available data sets, by selecting the most appropriate methodology for each scenario. Inevitable uncertainties were given due consideration ...
- We did not need to define consequences classes.
- We did not need to arbitrarily select "the worse" between a physical loss or human losses, or environmental losses. ...
- We decided to use ORE because we understand the limitation and gross conceptual mistakes linked to using PIGs, and we refuse to do what everyone does as we recognize that common practice is not an excuse for negligent approaches.
- Our tolerability criteria was established using repeatable methods specifically for the client's operation under consideration.
- There are no cells in our ORE, no colors, and our tolerability criteria either matches well-known societal thresholds, or uses a specifically developed threshold (for physical losses) which suits client's organization needs and requirements.
- We did not need to censor our scenarios.
- We used a likelihood threshold of 10^{-5} to 10^{-6} for credibility, which is compliant with best practices in highly regulated industries, like, for example, chemical processing.

For a full discussion, see our blog post:
http://www.riskope.com/2012/03/22/avoid-liabilities-by-using-optimum-risk-estimates/

Conclusions

This White Paper has reviewed the benefits and limitations of common risk management methods. It has shown how "standard" risk approaches, PIGs (risk assessments, risk register, ERM), can be enhanced using ORE.

OREs offer a cutting-edge competitive advantage, freeing capital for business and production development, leading to more easily defensible, and justifiable decisions. In other words, stop wasting money and effort in mitigative measures that do not pay off, over-investing in some mitigations and probably under investing in others, with, in both cases, potentially devastating unjustified consequences. ORE prioritization is consistent, unambiguous, and provides context for better understanding organizations' risks.

ORE can be applied to projects (Project Risk Assessment), at the Pre-feasibility or Feasibility stage, or to a thriving Operation (Operational Risk Assessment), and is scalable and updatable in transparent and justifiable ways.

The benefits yielded by the approach can be summarized as follows :

- The prevalent critical risks are brought forward in a clear, rational and defensible way.
- The number of critical issues is generally shown to be smaller than originally thought.
- The insurance program is often shown to be unbalanced and adjustments can be proposed.
- The new priority list lets Management make better decisions regarding mitigative investments allotments and frees moneys that could be better allocated elsewhere in the Operation.
- The methodology allows rational updating of the probabilities when new data are gathered.

ORE can reuse most of the work already developed to establish PIGs. With ORE it is possible to upgrade existing corporate Risk Registers and to steer toward a rational, defensible and transparent stance.

For more information about applying ORE in your organization, contact us at www.riskope.com

A Note on Standards

Riskope's work and, as a result, this paper, is compliant with ISO 31000 'Risk Management - Principles and Guidelines', published in December 2009, at the end of a four-year development period, during which up to 60 experts, representing 30 countries, worked within an ISO international technical committee.

The ISO 31000 Guidelines are designed for a wide range of risk management practitioners and for those responsible for risk management implementation who are interested in benchmarking their risk management organization and practices against a recognized international reference.

The ISO 31000 code is a general and internationally recognized code of which the older and often quoted Canadian standard CSA Q850-97 (entitled Risk Management: Guidelines for Decision Makers (CSA 1997)) can be considered a subset.

ISO 31000 describes voluntary risk management guidelines, is not a prescriptive compliance requirement, is not a legal requirement and it is not intended for certification.

An important part of ISO 31000 is the recommendation to use a unified glossary (for example the ISO/IEC Guide 73 'Risk Management – Vocabulary - Guidelines for Use in Standards') for Risk Management. ORA will use a unified Glossary, which is compliant with most international standards and more complete than ISO/IEC in many areas, especially for civil/business applications.

ISO 31010 defines an arsenal of 27 methods that can be used to determine probabilities (and consequences). It also quotes, of course, PIGs, and talks about their specific limitations as well. Tolerability is quoted, but never discussed or defined.