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Military Grade Risk Application For Mining Defence, Resilience And Optimization

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1. Abstract

Military and mining organizations have astonishingly strong anatomical/ physiological similarities. Diversified miners around the world have several base metals and products that require strong interdisciplinary efforts, have multiple crews and professional groups, significant social and technical inter-dependencies. The Military have different services such Army, Navy, Air Force. Those services, like mining divisions, are interdependent to some degree at strategic and tactical level. The similarities go down all the way to reconnaissance troops, translated into prospection teams in the mining world. Excellence in operations and risk management - increasing resilience of the system and optimization- are of paramount importance as military and miners have to:

1 Be ready to deliver at any given time (produce 7/24, 365 days).

2 Ensure operational sustainability (asset, maintenance, and stewardship).

3 Maintain confidentiality and security (of intelligence, prospection, outputs, etc.).

4 Satisfy public opinion while being prone to be opposed and criticized.

ORE (Riskope's Optimum Risk Estimates, ©Riskope) methodology, originally developed for specific mining applications (tailings, power generation and distribution, pipelines, logistic) and then extended to other areas of industry, including physical and logical convergence, was customized and deployed for a European Army Cyber Defence inter-forces program and is now again ready for miners from operations to enterprise-wide approaches.

This paper shows through case histories how a "military grade", convergent global risk application can benefit a miner, reducing costs, waste of time, allowing informed decision and reinforcing possible legal defences. A road-map for sustainable mitigations can be set-up from cradle to grave, including sensible economic evaluations.

In the era of IoT (internet of things) it is time for miners to embrace RiskManagement2.0 and maximize the benefits of multi-hazard, interdependent system's analysis: better understanding, better evaluations, better decisions, better defences.

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2. Introduction

Military and mining organizations (seen as systems) have astonishingly strong anatomical/ physiological (functional) similarities. Diversified miners around the world have several base metals, products and divisions, like the Military have different services such Army, Navy, Air Force. The services, like mining divisions, are interdependent to some degree at strategic and tactical level making it hard to grasp all possible ramifications, cascading sequences and complex consequences (Bobrov, 2014). The similarities go all the way down to reconnaissance troops, translated into prospection teams in the mining world. Excellence in operations and risk management - increasing resilience of the system and optimization - are of paramount importance as both, military and miners, have to:

1 Be ready to deliver at any given time (produce and operate 7/24, 365 days).

2 Ensure operational sustainability (asset, maintenance, and stewardship).

3 Maintain confidentiality and security (of business intelligence, prospection, outputs, contractual arrangements etc.).

4 Satisfy public opinion while being prone to be opposed and criticized (Warfield 2002).

In this paper we will show how ORE (Riskope's Optimum Risk Estimates) methodology, originally developed for specific mining applications (tailings, power generation and distribution, pipelines, logistic) and then extended to other areas of industry, was customized and deployed for a European Army Cyber Defence inter-forces program and is now again ready for miners from operations to enterprise-wide approaches.

3. The anatomy/physiology of a mining system

ISO and other International and National Risk Codes stress the fact that the context of the study, the environment (internal and external, functional) in which a considered system operates has to be described. However, oftentimes project teams and facilitators embarking in FMEAs or other seemingly code compliant risk related endeavours without taking the time to rigorously describe the system anatomy and physiology. Yet, the original FMEA "rules of deployment" asked for a system's functional analysis: a requirement today oftentimes forgotten.

This is generally the most neglected part of risk assessments, but the most important one. To understand the reasons and underlying assumptions we need to look back in history.

Most common practice tools date from WWII and the '50s. At the beginning only weapons and very "scary" systems (what we would call today crisis prone or media vulnerable projects/ systems) were studied using those methodologies. Industries including mining were using dedicated insurance experts, if any specialized individuals, to transfer risk without any serious evaluations to insurance companies willing to take a bet on them.

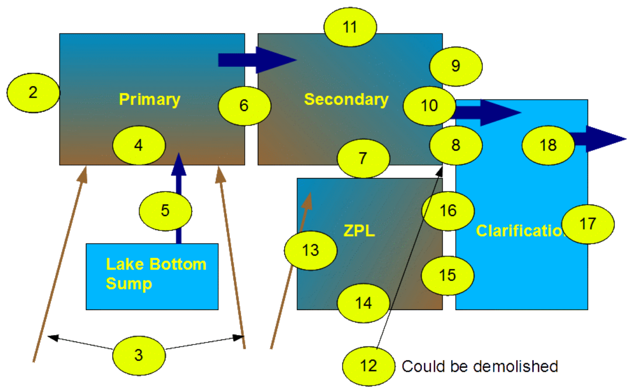

Figure 1: A mining operation's pond system with 18 macro elements including pipelines, dams, and weirs. Dams were split into subsections for the analysis. The cascading ponds suggest a high level of system's interdependency which will have to be accounted for in the risk assessment.

Then, a series of mishaps, public outcry and political pressure, lead "risk" to become a buzz-word (Appleby, Forlin, 2003). Risk assessment and risk management were nice words to use, and common practice trickled down to the minimum common denominator, using poorly applied FMEA and other inappropriate methods and models to give a "placebo" to everyone (Oboni, Oboni, 2012, Oboni & Al., 2013).

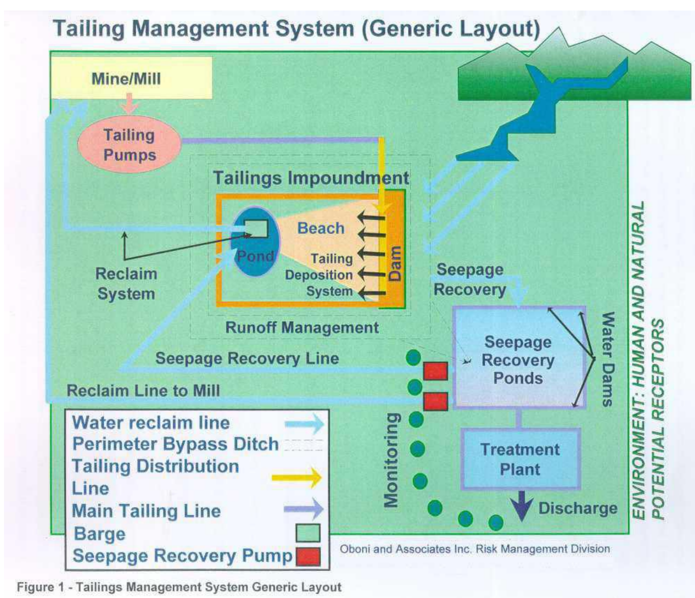

Figure 2: A higher level zoom into a tailings system, from mill to discharge.

Accidents were still occurring, failures were still qualified as "unforeseeable", potential consequences were still looked at cursorily and in a compartmentalized way. No one was carefully describing the system's anatomy and physiology (functional relationships, or interdependencies). It was

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the time of open risk workshops ("tribal" gatherings?) gaining the status of "instant risk assessment". Most of the time participants were able to voice concerns and fears, without having dissected the system under consideration, similarly to medicine before understanding human anatomy and physiology. Investing in a new silver bullet technology (Gross, 2015) became ubiquitous and large capitals were squandered in inefficient or useless mitigations. Then large scale terror acts (9-11-2001) occurred on US soil and the 2008 global economic recession occurred.

All of a sudden new words were coined to describe what we Humans knew very well already: poorly made risk assessments do not bring any value to anyone.

We Humans talked then about systemic risk, non functioning models, black-swans (legitimate ones and silly ones), fragility, complexity, etc. It was a feast of magic revival, obscurantism, denial of bad habits. All those efforts just to hide one simple fact: unless we take the time and effort to properly define our systems, we cannot perform any serious analysis on them! The parallel is striking: if we do not know the human body anatomy and physiology, any surgery or drug will have a very poor rate of success, or be detrimental. So, getting back to risk assessments:

Is it true that our systems are complex? Yes.

Do they have intrinsic fragility because of their complexity and other reasons? Yes.

Do rare, extreme events occur? Yes.

Do we have systemic risks in our systems? Yes.

Is it true we can dig our head in the sand, say there is nothing we Human can do to evaluate the above and merrily keep doing the same mistakes? YES, we can do it until our social license to operate vanishes, nobody wants to insure our projects.

Is it reasonable, socially acceptable, good for Humanity to do so? Absolutely NOT!

If you want to have fun for a moment, you can set-up the same list of question replacing "system" by "human body"; "events" by "diseases". Enjoy!

4. What is ORE?

The big picture

ORE is ISO 31000 compatible, and shines the best when paired with an asset management effort (ISO 51000). By fostering a systematic analysis of system's anatomy and physiology, ORE allows to avoid most, if not all, of common practices' pitfalls. That preliminary effort of functional system modelling brings rationality, clarity and transparency to risk assessments' endeavours. ORE makes risk studies scalable, flexible, and adaptable to new conditions. It yields a holistic and convergent understanding of the risk landscape (multi-hazards) surrounding your operations/projects (Oboni, Oboni, 2014).

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ORE requires, like a well conducted FMEA would require, the system's anatomy and physiology (functional analysis) to be described. ORE provides its users with a standardized "node" modular architecture and reproducible rules to link them up. Using these nodes any system, of any size and complexity can be described.

Strengths and Benefits

ORE studies are:

- transparent (assumptions are explicit, evaluations can be discussed, audited),
- include uncertainties (which could/will be large, at least at the beginning, but will in some cases possibly be reduced as more data are gathered in later phases),
- probabilistic (even if statistics are available (i.e. historic data), future behaviour will be estimated, in terms of annual probabilities of occurrence),
- updatable (rationally, as new information becomes available during the life cycle of the system),
- scalable (from "high level" to detailed operational, no information wasted).
- Drillable in the sense that complex queries can be performed for various stakeholders.

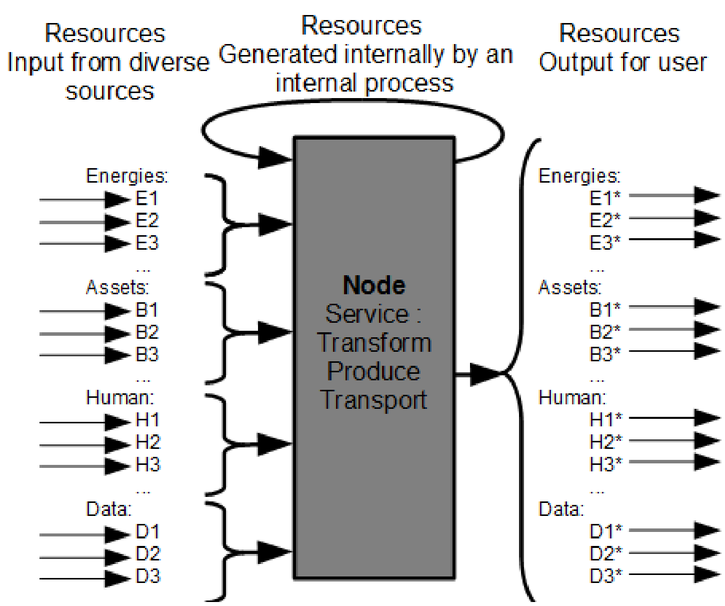

Figure 3: A ORE standard node scheme.

ORE studies cover:

- physical losses (human and assets),
- business interruption (BI),
- environmental damages,
- reputational damages and crisis potential.

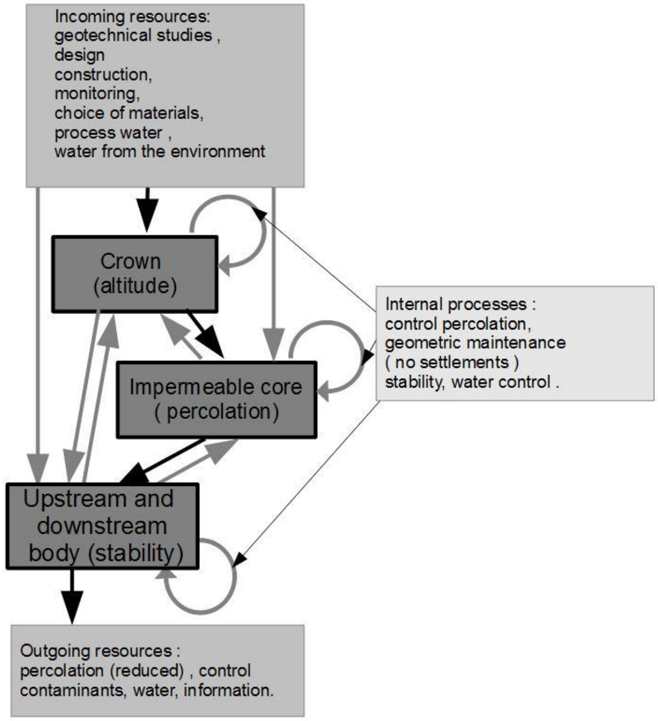

Figure 4: A ORE model for a tailings dam. Note how the model is performance oriented and answer the questions: what should each node perform for the system to deliver the intended service?

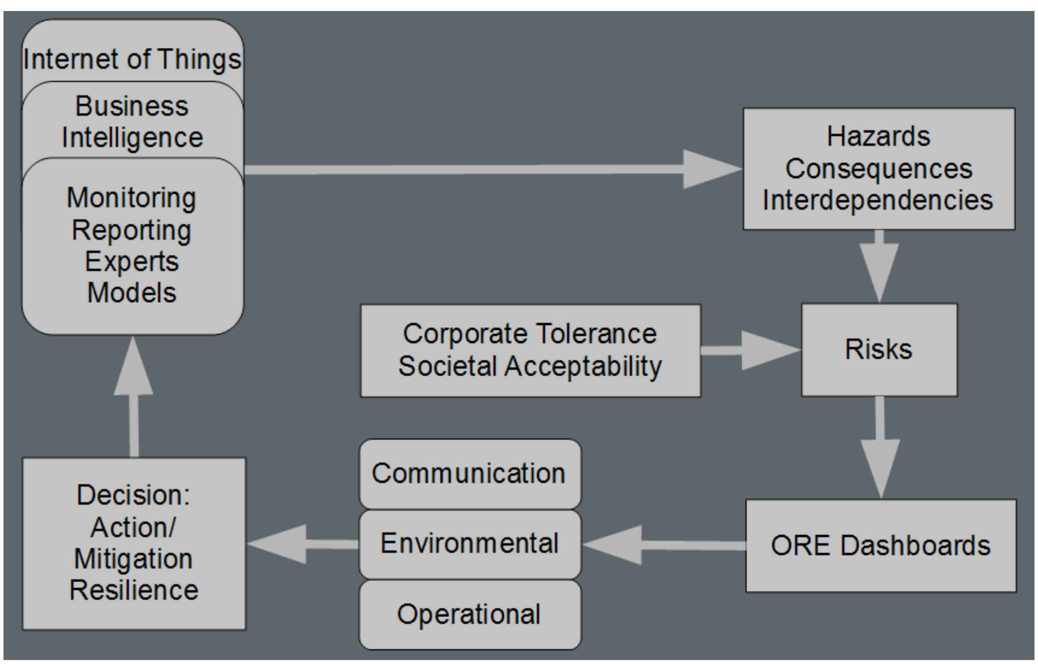

Figure 5: Scheme of the ORE (Optimum Risk Estimates) continuous process. Scalable and drillable from cradle to grave for any project, alternative, operation.

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ORE deployment procedure

Step 1a,b:

Deployments start with the definition of the boundary of the considered systems (Fig. 1, 2). The system is then split in elements (nodes) amenable to analysis (Fig. 2, 3, 4): the finer the splitting, the more detailed the analysis. The final number of nodes generally ranges from less than 50 to several hundreds, possibly thousands. In a preliminary assessment, at prefeasibility level of various alternatives, 20-30 elements (nodes) are generally considered per alternative.

1a) Hazard Identification. The deliverable of this Step is a list of Hazards and Hazardous Situation capable of generating physical losses, business interruption, environmental damages, reputational damages and related crisis potential. The list include emerging and dormant hazards based on analyst's experience, client's experience and technical support, and literature review.

1b) Threat from/Threat to analysis is used to link the identified hazards to particular targets (nodes). Each couple are qualified in terms of possible nefarious outcomes, leading to a unsorted General Hazard Scenario Register.

Step 2a,b,c,d:

For each record of the Register, the ORE foresees that one or more probability-consequences couple are generated to perform the Risk Assessment.

2a) Probabilities are evaluated using various available methodologies as a function of available data and include expert judgments related to future occurrences.

2b) Consequences are defined for each component, including uncertainties. Environmental, human, H&S and reputational-crisis consequences have to follow a different evaluation procedure, based on multipliers of the “factual costs”. Thus ORE foresees the formulation of a blended metric to be agreed in advance of any specific Risk Assessment with the Client.

2c) First order interdependencies (cascading failures, dominoes effects) are calculated using robust reliability models built in the ORE framework, allowing for rational updates when new data become available (from semi-static to real-time updates, depending on the application).

2d) Second order interdependencies (at strategic level, division to division, logistic node to logistic node, etc.) are then also evaluated. This means that at operational level people can still manage and report to higher entities about their risks meanwhile top management can understand interdependencies of one operation or division onto another one without having to share the data with the operation itself.

Using the blended metric a “total risk” will be defined for each record. Deliverable of this Step are a General Risk Scenario Register, sorted by decreasing “total risk” or other selected filters.

Step 3a,b,c: ORE foresees an optional treatment of the prior results based on proprietary methodologies as follows:

3a) Definition of the Client's Tolerability Threshold for its operations.

3b) Each risk record are compared with the Tolerability (tolerance) Threshold, leading to the intolerable risks.

3c) A ranking based on the intolerable part will be developed for the intolerable risks to highlight critical areas of the operation and to guide recommendations on possible mitigations. This ranking has proven to enhance focus, and lead to more effective risk based decisions.

The effectiveness comes from the ability to dissociate the prioritization from the "zero-risk bias" often afflicting decision making in general and especially common in the management of hazardous waste (Baron et Al. 1993; Kunreuther, 1991). Zero-risk bias is a human tendency to prefer the complete elimination of a specific risk even when alternative options produce a greater reduction in overall risks. The effects of this bias have been observed on certain real-world policies (e.g. war against terrorism as opposed to reducing the risk of traffic accidents or gun violence). The zero-risk bias comes in addition with a "false promise", i.e. that the likelihood of a threat could reach zero in a human or natural (complex) system.

Step 4:

As an option ORE also foresees the probabilistic alternatives' economic life-cycle evaluation "from cradle to grave" with CDA/ESM. In this Step risk results from the prior steps is integrated to the costs, meanwhile avoiding the pitfalls of other project evaluation methods such as NPV.

The CDA/ESM methodology allows comparisons of projects, in a simplified way, still capturing the uncertainties and stochastic aspects of reality.

The CDA/ESM methods eliminates the "problems" linked to NPV when evaluating long term projects' risks.

This approach significantly differs from a classic "provisional balance sheet" approach because risks and uncertainties are explicitly taken into account, as well as the stochastic nature of the costs.

Step 5:

ORE also comes complete with a set of communication documents which allow to properly inform all the stakeholders on the outcome of the Risk Assessment. Figure 6 displays a typical ORE dashboard where it is possible to understand what are the most critical sources of threats to the company, which products and which hazardous sectors are loaded with the largest potential losses (divided by type of loss: physical, BI, environmental, etc.), where the highest logistic risks are and even how the media vulnerabilities are distributed within several divisions (sub-projects, alternatives, operations, etc.) of a same company.

What are ORE's deliverables?

Specific custom tailored dashboards (Fig. 6), updated as data flow-in (would be up to real time if monitoring systems have the necessary broadcasting capabilities). Dashboards are prepared for specific users in order to bring up information on a need-to-know basis:

Road-map to increase durability, sustainability, sensible mitigation.
Vital elements of Stewardship.
Quantitative insurance limits, elements to fight insurance denial.
Enhancements to defensibility beyond compliance.
Force Majeure clauses.

5. Case history

A Fortune 500 company developed a qualitative and indexed approach (i.e FMEA-Probability Impact Graphs) for one of their subdivisions, but they realized it neither yielded enough specific high quality information nor allowed sensible and informed decisions. Indeed, methodologies such as FMEA, etc. generally lead omit critical "big picture" scenarios. A systematic approach to risk considerations in decision-making and management support is paramount especially when various layers of uncertainties surround alternatives, projects, operations. Therefore decision-makers need to understand the:

assumptions made, so that evaluations can be discussed, audited;
uncertainties surrounding the decision;
probabilistic future behaviour (evolution);
benefits of updating risk information during the life cycle of the system;
benefits of a scalable (from "high level" to detailed operational, no information wasted) risk analysis system.

The approach needed to cover:

physical losses (human and assets),
business interruption (BI),
environmental damages,
reputational damages and crisis potential.

ORE was selected and deployed (Fig. 5).

The boundary of the considered systems (Fig. 2) was defined collaboratively. The elements were then split to be amenable to analysis (functional analysis, Fig. 1,3,4) with a trade-off in mind, the finer the splitting, the more detailed the analysis, but also more computational intensive. Hazard Identification was then performed using Threat-from/Threat-to approaches leading to an unsorted General Hazard Scenario Register.

For each record of the Register more than one probability-consequences couple was assigned to cover for stochastic variability of a same accident magnitude. Probabilities were evaluated using various available methodologies pertinent with the available data; Consequences were defined for each component, including uncertainties. The ORE approach enabled the formulation of a blended consequence metric that encompassed H&S, environmental, reputational.

"Total risk" was defined for each record and records were then sorted by decreasing "total risk". Management then also requested different kind of sorting such as decreasing risk in function of different types of hazard and by different kind of threat-to.

Based on the client's tolerance threshold the analyst also performed a ranking based on the intolerable part of risks to highlight critical areas of the operation and to guide recommendations on possible mitigations. This ranking leads to more effective risk based decisions as stated above in step 3c.

The set of communication documents which allowed to properly inform all the stakeholders on the outcome of the Risk Assessment was displayed as a dashboard (Fig. 6).

It allowed to understand what are the most critical sources of threats to the company, which products and which hazardous sectors are loaded with the largest potential losses (split by type of loss: physical, BI, environmental, reputational), where the highest logistic risks are and even how the media vulnerabilities are distributed within several divisions (sub-projects, alternatives, operations, etc.) of a same company.

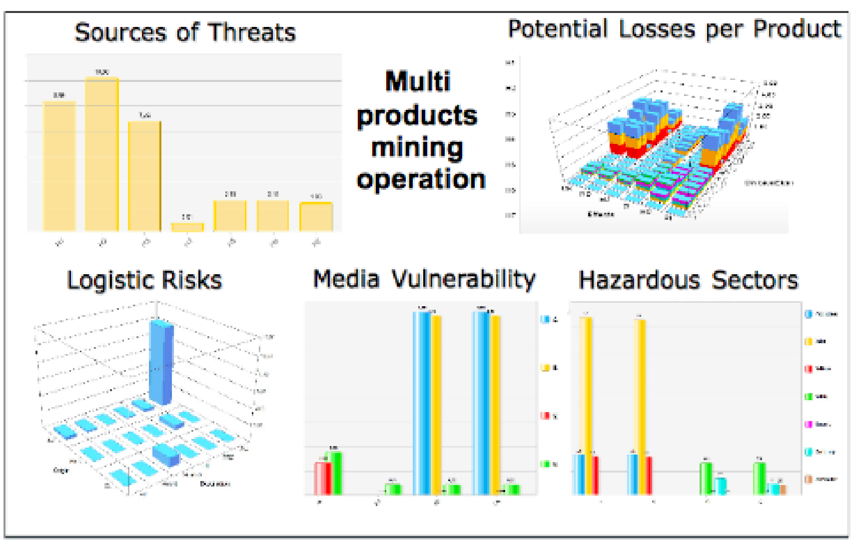

Figure 6: ORE dashboards show what are the most critical sources of threats to the company or alternatives.

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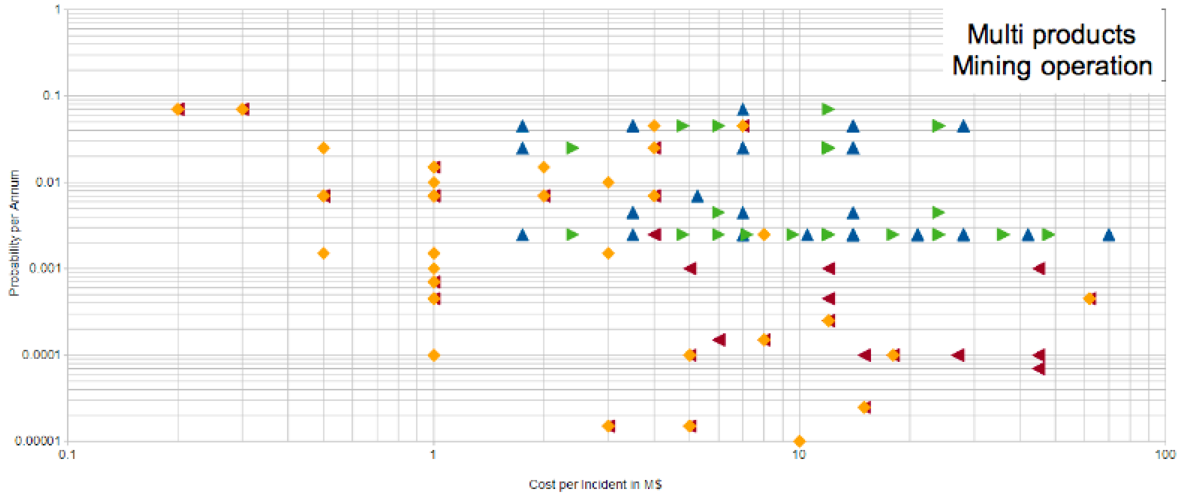

Figure 7: p,C graph displaying the centroids of the various risks for the four products of the mining operation. The tolerability/tolerance thresholds (corporate and societal) are not displayed as they will be the object of another paper.

Among possible alternative representations Fig 7, 8 show examples which may be more familiar to many accustomed to FMEAs. In Fig. 7 a probability-consequences plot displays the centroids of all the p,C couples after partial aggregation per product of the specific mining operation.

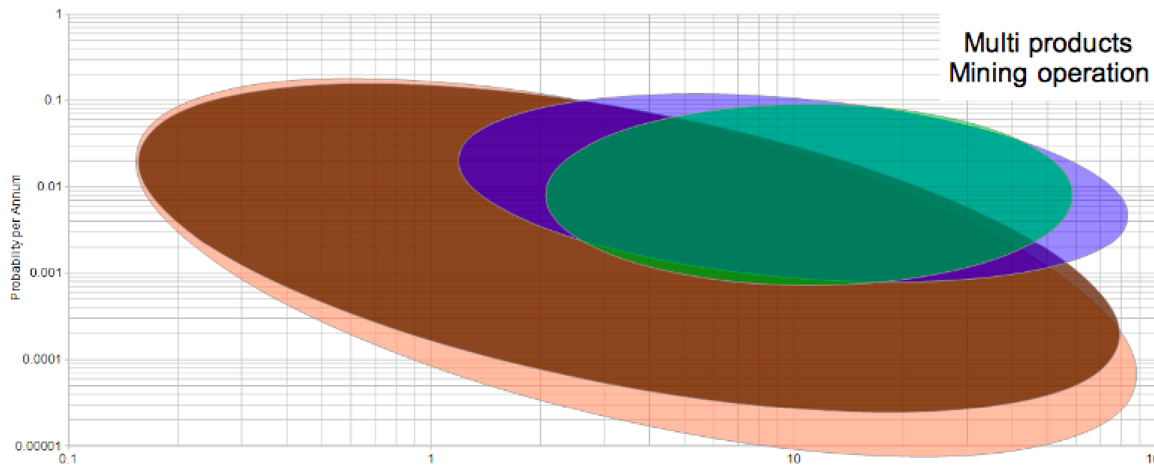

Figure 8: The same results are condensed into p,C global "bubbles" per product. This type of representation gives a first sight view of the global uncertainties surrounding each products. The wider and taller the bubble is the greater the variability of probabilities and consequences surrounding a product, thus the more uncertainties around that specific business.

As mentioned in the previous point the Fortune 500 corporation developed a qualitative and indexed approach, but realized it neither yielded enough specific high quality information nor allowed sensible and informed decisions. Quantitatively this yielded a weighted ranking of 140 for FMEA, meaning 37% of the risks had the same weight of the remaining 63%. Thus around one third of the risk were in each

FMEA colouring category including the worst one, which was indeed overwhelming and left decision makers with many unanswered questions (fig. 9).

ORE had instead a weighted ranking of 55 meaning (14% vs. 86% equilibrium) as shown in Fig. 9., thus confirming the Pareto's principle (20%-80%).

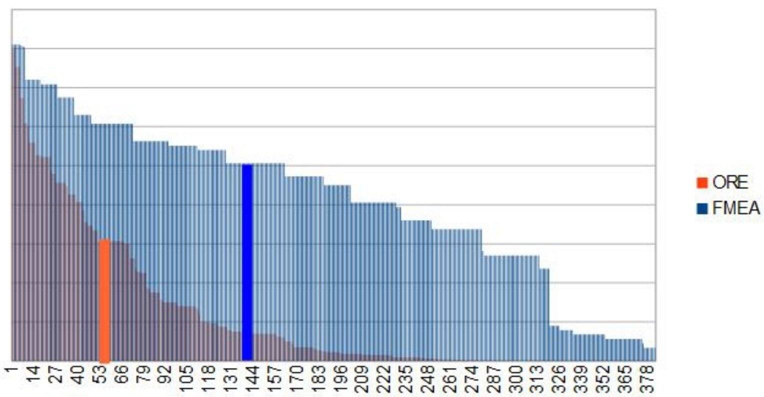

Figure 9: The horizontal axis shows the risks in the considered portfolio (numbered 1 to 400) and sorted in decreasing value of the total risk for FMEA, respectively the intolerable part of the risk for ORE. The "average" ranking sits at 140 for FMEA, respectively 55 for ORE. ORE focuses the risks in a clear and unambiguous way leading to a better, more focused, risks prioritization.

6. Conclusions

We have shown how a "military grade", global risk application can benefit miners, project managers, designers, owners, money lenders and insurers, in short all stakeholders including the public, reducing costs, waste of time, allowing informed decision and reinforcing possible legal defences.

We also have moved away from commonly found decision making biases reportedly flawing mitigative choices in hazardous waste and military spaces.

We avoided the overwhelming syndrome and confirmed the applicability of the Pareto's 80-20 rule.

In the era of IoT (internet of things) it is time for miners to embrace RiskManagement2.0 and maximize the benefits of convergent multi-hazard, interdependent system's analysis: better understanding, better evaluations, better decisions, better defence.

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