Aspects of Risk Tolerability, Manageable vs. Unmanageable Risks in Relation to Critical Decisions, Perpetuity Projects, Public Opposition.

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ABSTRACT
This paper builds on case studies (major accidents) from prior papers to discuss social acceptability of risk, risk estimates and risk communication. The discussion is of critical importance in view of new projects worldwide and difficult choices humanity will have to make under demographic and climatic pressure and public opposition. Due to space limitation the first part of the paper considers consequences only in terms of casualties. Risks linked to tailings dams, nuclear reactors and a highway tunnel are compared to well known, previously published acceptability criteria. A comparison of the acceptability of these risks is then carried out from a quantitative risk evaluation point of view showing unexpected results. An additional case from the transportation world is briefly focused on, to show how risk based decision-making can be applied to alternative selection. In order to develop the discussion the concepts of social perception quantification, which could be applied to any accident, in any industry, while developing a holistic risk assessment, are illustrated. The perception gap between societal consequences and factual consequences is explored, as it is a significant source of the pervasive mistrust in technical and scientific opinions. The paper then shows that the selection of the type of consequences and their combination can severely bias the perception of the results of a classic risk assessment application. A communication strategy is suggested to convey to clients the correct message when dealing with “societal” consequences of private industry risks. The second part of the paper discusses monetary losses and shows the shape of common tolerability thresholds. The concepts developed for human losses are shown to be applicable to physical losses. The functional link between tolerability and Manageable vs Unmanageable risks is exposed and then analyzed to describe how governance and leadership can be damaged without proper risk evaluations, prioritization and a deep understanding of tolerability.

1 INTRODUCTION

This paper builds on case studies of major mishaps and accidents (Oboni and Oboni, 2013, 2014) to discuss risks' social acceptability, estimates and communication (Oboni, Oboni, Zabolotniuk, 2013). The discussion is of critical importance in view of new projects worldwide and difficult choices humanity will have to make under demographic and climatic pressure and public opposition.

Due to space limitation the first part of the paper considers consequences of mishaps only in terms of casualties; thus Risks evaluated for the case studies are defined as the product of the probability of failure (probability of an accident) by the related consequences expressed in casualties, leaving aside all other environmental and physical direct or indirect consequences. In the second part it is shown how such a censoring can skew decisions and has generated widespread public mistrust.

Risks linked to Tailings Dams (TDs), Nuclear Reactors (NRs) and a Highway Tunnel (HT) catastrophic events are compared to well known, previously published societal acceptability criteria (Whitman, 1984, Baecher, 1987) to show how risk based decision-making can be applied to alternative selection in cases were a catastrophe has not yet occurred. A mountainous highway case in South America is introduced as an example. A comparison of the acceptability of these risks is then carried out from a quantitative risk evaluation point of view, showing unexpected results.

2 COMPARING RISKS FROM VARIOUS INDUSTRIES

Rates of worldwide TDs and NRs catastrophic accidents to date were empirically estimated (Oboni and Oboni, 2013) in a prior paper. The risk analysis of the Montblanc HT accident was the object of a research reported in Riskope's blog (Riskope, 2013, Oboni and Oboni, 2014). All these cases were compared to societal and technical acceptability thresholds to understand if, present and foreseeable performances, are aligned with expectations.

2.1 Tailings Dams

Table 1 summarizes the worldwide rate of failure (p_f) of TDs in the decades aroud '79 and '99. Most of these failures were reportedly due to “slope instability”.

Table 1. Summary of historic rates of failure (p_f) of Tailings dams around the world.

When (decade)	p_f	Approx. p_f
Around '79	44/(3,500*10)	10^{-3}
Around '99	7/35,000	$2*10^{-4}$

If we consider, for comparison, the hydro dams failures in the decades around '89 and '99, based on an “average number of dams” of 30,000, we get pf $=3*10^{-6}$ to 10^{-5}, in good agreement with the common understanding and empirical knowledge that TDs are generally of “lesser quality” than hydro dams. Interestingly many different industries around the world consider values below 10^{-6} to 10^{-5} as the boundary of what is humanly credible (meaning that below that range of probability an event is generally considered “incredible”).

Based on historic records of publicly available catastrophic failure records Casualties for TDs were estimated to a minimum of nil, a maximum of ~500, and an expected value of ~80 casualties. Mediatic consequences have been often considerable, sometimes leading dam's owner bankruptcy or independence loss. However, there has been to date no known global regulatory rejection/ forced withdraw of mining operations' license to operate (however, projects worldwide have been abandoned because of public opinion pressure).

2.2 Nuclear Reactor Accidents

As of Feb. 2, 2012, 435 nuclear power-plant units were in operation in 31 countries. The cumulative nuclear reactor operating experience amounted to 14,745 years (Oboni, Oboni, 2013). The world has seen the occurrence of a number of major nuclear reactors-accidents (rated 5 and above on the International Nuclear Event Scale by the International Atomic Energy Agency), as displayed Table 2. These were due to man-made errors or catastrophic natural events. Fukushima Daiichi, the latest of the series, due to a Tsunami, was considered as one accident (Oboni and Oboni, 2013) to ensure the list is made of “independent” accidents, although more than one reactor was involved and there has been a recurrence of new accidents on site,. Assuming seven accidents, the “historic” world average rate of Scale 5+ accidents was $4.75*10^{-4}$ Scale 5+ accident/annum by Feb 2, 2012.

Table 2. Worldwide accident of Scale 5+

Level 5 Accident with wider consequences
First Chalk River (1952)
Windscale (1957),
Lucens (1969),
Three Miles Island (1979)
Level 6 Serious accident
Kyshtym (1957)
Level 7 Major accident
Chernobyl (1986)
Fukushima (2011)

This value is rather unexpected as it falls well within the realm of credibility and within the range of TDs. The surprise is even higher when considering the high-level of regulation of the nuclear industry compared to the relatively unregulated mining industry.

Casualties for Nuclear 5+ accidents are estimated to a minimum of nil and a maximum of 3,500 casualties, with a “best estimate” at 890 casualties (Oboni and Oboni, 2013). Mediatic/political consequences have been staggering, including regulatory decision to stop operations/new projects in some countries.

2.3 Risk Quantification of a Specific Accident: Mont Blanc tunnel

The Mont Blanc Tunnel was completed in 1965 and used for 34 years before a tragic accident (39 casualties) occurred due to a truck fire. Previously there had been 16 other truck fires in the tunnel, always extinguished on the spot by the drivers. The heavy truck traffic was estimated at 8.77 Mkm/yr (million kilometres per year).

In 1998 the victims' expected rate (casualties/Bkm (Billion kilometres)) due to “classic” trucks road accidents could have been estimated at 0.022 victims/yr for accidents “on trucks” , respectively 0.22 victims/yr for accidents “against the truck”. We will note that the last number seems rather unreasonably high for a tunnel where passing is forbidden and speed is controlled. Thus, we will consider this as an extreme upper bound estimate of the probability of one casualty as we prefer to use ranges rather than censoring results by arbitrarily narrowing them.

Another way of framing probabilities and related risks would have been to consider the 16 actual fires events in 34 years, which could be considered near misses of a major fire as they produced no casualties. These numbers yield an estimate of 0.35 for the probability to see one or more accidents within next year. As 16/34 is certainly an excessive estimate, by using Frank's Pyramid (Bird, Germain, 1985), recognizing its limitations, the probability of a serious accidents, can be evaluated at p=0.015 in the coming year.

The accident was vividly echoed in international media, and ultimately brought long lasting socio-political consequences throughout Europe.

2.4 Shuttle Buses on Latin American Mountainous Road

A large mining operation (XXX) required the construction of a 120km private road in the high Andes. The owner of the mine implemented a workers' bus shuttle service between the country's capital city and the mine. The shuttle trip encompassed long stretches on public roads before the final segment on the private road. The trip was exposed to significant natural (rock-falls, debris flows, landslides, flooding, avalanches, etc.) and man-made hazards (traffic, pedestrians and errant animals, etc.). A preliminary holistic risk assessment concluded that an escort vehicle should precede each and every shuttle bus, and no bus should drive during the night hours. After a couple accidents caused by natural and/or man-made hazards occurred, although their consequences were luckily far from an almost expected “full loss” of the vehicles and their passengers, the mine owner decided to explore some shuttling alternatives beside status quo. The alternatives included capital expenditures on the public road network, or investing in a high altitude airport to reduce as much as possible the length of the bus shuttling.

In order to frame a “base rate” for bus accidents mortality , we looked at France, with 8.2 Billion kilometers traveled per annum, and a system considered almost immune from under reporting. According to the French

Observatoire National Interministériel de la Sécurité Routière, France counted 14 deaths at 30 days (meaning that victims may have died immediately or up to 30 days after the accident), and 170 accident that required hospitalization for 42,568.0 passengers x Km x 10^6 in buses in 2005.

This lead to a mortality rate of 3.3 x 10^{-4} fatalities per (passenger x Mkm), respectively 4 x10^{-3} wounded per (passenger x Mkm) for bus accidents in France. By comparing this value with XXX fatality rate (1.5 x 10^{-3} as developed during the study) it was noticed that despite the extremely good record, XXX bus accident fatality rate was approximately five times higher than the French one.

These results have to be taken with caution as we are looking at a very large statistical basis for France and a very small (one could argue it's a non-statistical sample) for XXX operation, despite the apparent huge distance covered by buses over one decade. Had we performed the study a few days before the accident that triggered the owner request we would have considered the French value as a good lower bound. Should XXX operate for another ten years before a hypothetical next unfortunate event, then the mortality would become 7.5 x 10^{-4}, i.e. approximately double the French value, confirming again that the French rate could be a good lower bound. The reason that XXX's safety record so far exceeded the national one (bus accidents are reportedly among the top five causes of death in the operation's country) is probably to ascribe to the safety measures reportedly adopted by the company in terms of drivers' monitoring, speed limits, quality of the vehicles and the presence of the escort vehicle ahead of the buses.

Thus, the frequency of death (3.3 x 10^{-4} fatalities per (passenger x Mkm)) and hospitalized people (4 x 10^{-3} wounded per (passenger x Mkm)) was adopted as the low bound for probabilities of traffic accidents in a normal environment, with consequences ranging up to the death of 50% of the occupants (there is ample literature to show such a high rate of fatalities in a bus rolling down from a mountainous road).

Thus it was possible to frame out a low-bound probability as 9.8 x 10^{-3} per annum from French statistics. A high-bound probability was framed out at 4.58 x10^{-3} per annum from XXX stats.

3 ACCEPTABILITY CRITERIA AND CODES

3.1 Chemical Industry

Looking back in time, Wilson and Comar (Comar, 1987, Wilson, 1984), then in the field of chemical industry Renshaw (Renshaw, 1990) defined simple societal risk acceptability criteria as follows: the Probability of Fatality of one Individual per Year of Exposure to the Risk are deemed Unacceptable Risk if greater than 10^{-5} per annum for Renshaw; 10^{-4} for Comar, respectively 10^{-3} for Wilson.

The application of these criteria is easily understood with an example. If a limiting probability of 10^{-5} (Renshaw acceptability limit) is selected in a country with approximately 60 millions inhabitants like France, Italy or the United Kingdom, it leads to accepting a hazard potentially generating 600 fatalities per year, provided fatalities occur for one to ten individuals at a time.

That number is roughly ten times lower than traffic related casualties in Italy in 1994 (ISTAT, 1994), respectively 5,232 for France in 2004 (European Conference of Ministers of Transports, 2005), or five times lower than the 2004 observed 3,221 fatalities in the U.K. (Department for transport Scottish executive national assembly for Wales, 2006). Thus the limiting value for Renshaw is significantly exceeded by reality in those three countries. The traffic risk should be considered as unacceptable. Instead, if the Comar and Wilson criteria were used, then the risk would be considered acceptable.

Interestingly none of the criteria cited above make a distinction between voluntary risks and involuntary risks and if, on one hand, governments make huge efforts to reduce the fatality count in their respective jurisdictions, on the other, the public keeps using (and abusing) cars, with no (or very little) consideration to risks.

3.2 Federal Highway Administration (FHWA) Societal Tolerability Thresholds

Baecher (1987) showed how to select design factors of safety by comparing nominal probabilities of failure with previously derived (R.V. Whitman, 1984 & G. Morgan, L. Lave, 1990) accepted (i.e., historical) rates of failure of other civil facilities (Fig.1). Baecher noted that financial and life loss typically occur together, and the double scale shown in his original figure (Fig. 1) was not intended to imply a tradeoff of dollars vs Lives. Today human lives are generally discussed in terms of Willingness to Pay (WTP) (Marin, 1992, Lee Jones, 2004) to avoid any misunderstanding.

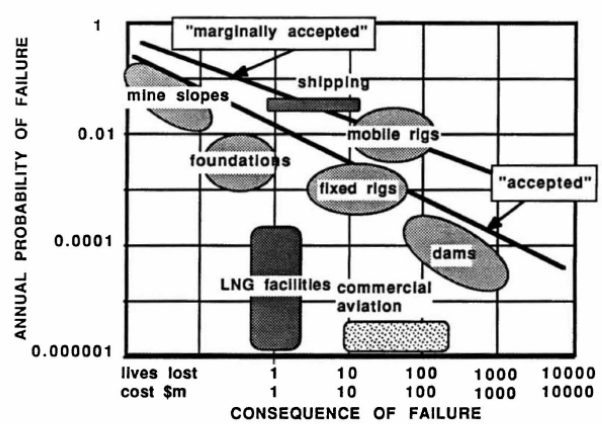

Figure 1. Empirical rates of failure for civil facilities.

3.3 F-N Curves for Nuclear Hazards and the Aerospace Industries

F-N (Frequency-Number) curves were originally developed for NRs and the aerospace industry (Kendall et al., 1977) to illustrate thresholds that reflect societal aversion to multiple fatalities during a single catastrophic event. The graph (Fig. 2) is subdivided into four areas:

●unacceptable risk;
●tolerable risk that should be reduced further if practicable according to the As Low AsReasonably Practicable (ALARP) principle (HSE.GOV.UK website);
●broadly acceptable risk; and
●a region of very low probability but with the potentialfor >1000 fatalities that require intense scrutiny.

From the perspective of potential loss of life from, for example, a landslide, new residential developments are typically approved if it can be demonstrated that the landslide risk falls in the ALARP or broadly acceptable regions of a F-N curve (Porter, Morgenstern, 2013) (Fig.2).

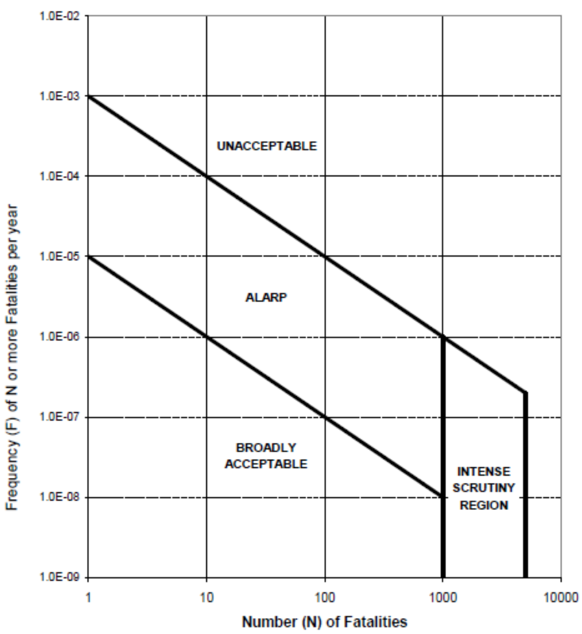

Figure 2. F-N Curve for Evaluating Societal Risk.

4 RISKS COMPARISONS (IN TERM OF LIVES LOSSES)

The values derived from TDs, Nuclear Reactors accidents, the Mont Blanc Tunnel fire and the South American highway can now be plotted on a p-C (probability-Consequences) graph also displaying societal tolerability levels (Fig. 3).

The following can be inferred from Figure 3:

●In the '79 decade TDs accidents were sliding above societal tolerability and the mining industry reacted, mostly under mediatic pressure and financial damages considerations, to reduce TDs risks to a societally tolerable level in term of losses of lives.
●The expected value of NRs risks were, as of Feb 2012, above the lower societal tolerability and governments (Germany, Italy, Japan) reacted sharply at the last accident with moratoria.
●Traffic accidents (with trucks involved) and risk estimates of HTs related accidents were high (in term of lives losses) and governments (EU), in general, sharply reacted to mitigate them with infrastructural investments and awareness/ communication campaigns (European Parliament, 2008).
●The south American road (orange continuous line) holistic risk is considered tolerable as long as there are less than 5 statistical casualties. However, if a shuttle rolled-over generating a higher number of casualties (expected on the basis of literature and recent examples) the public relations repercussions would be tremendous as the scenario would slide well above the societal tolerable level. We would expect not only general strike(s) but some regulatory changes imposed in the operation's country.

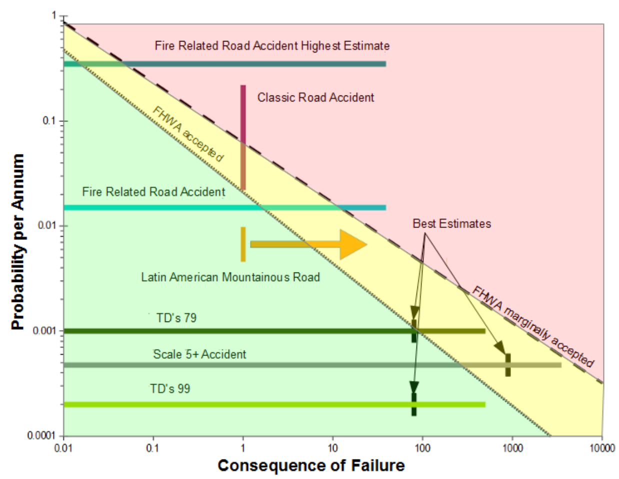

Figure 3. Various accidents (consequences are casualties only) compared to FHWA/Whitman societal tolerability curves. The black vertical traits represent the position of the consequences best estimates (Oboni, Oboni, 2013).

The first three bullet points above tend to prove that Whitman thresholds are still valid today and accidents/ industries that exceed the thresholds get instinctively societally “reprimanded”. The South American scenario discussion derived from an analysis of those points. There have actually been instances in South America where media campaigns against large employers shuttling workers were started in the aftermath of a series of significant accidents. On the other end of the spectrum, as far as the Authors know, governments and regulatory agencies very seldom perform the simple analysis we have presented above and their reactions are instinct/ guts/ re-election desire driven rather than based on formal evaluations of societal tolerability.

5 OTHER TYPES OF CONSEQUENCES AND THEIR COMBINATION

The prior sections showed risk comparisons based on one metric of consequences, i.e. casualties. If we consider the Mont Blanc HT accident as an example, consequences were tragic, complex and far-reaching beyond the casualties:

- 39 casualties,
- structural damages to the tunnel itself,
- legal costs and liabilities, and a very long and costlybusiness interruption which congested traffic inan area spanning a radius of over 300km in central Europe.

Despite the evidence of complex consequences in many accidents, old fashioned, common practice risk assessments based on Probability Impact Graphs (PIGs, matrix approaches, FMEA (Failure Mode Effect Analysis)) mostly reduce consequences to one metric (for example human life) or force users to "select the worst" among two or three families, often Health & Safety, Environmental, Direct Operation (Oboni, Oboni, 2012). In real life consequences components happen with "AND", and not with "OR" as common practice risk assessment tend to consider. Real life accidents often generate far reaching "indirect" effects.

The continued "mainstream" reliance on inappropriate techniques like PIGs, FMEA and arbitrary judgments, and being satisfied with their results is simply another manifestation of humans finding ways to introduce irrelevant criteria in decision-making (Kahneman & Tversky 1979, quoted in Oboni & Oboni 2007): humans tend to be risk-averse when facing the prospect of a gain, and paradoxically risk-prone when facing the prospect of a loss: using improper methods like PIGs, sits unfortunately well with "mainstream" human nature. Once it is accepted that PIGs are no more than a help for discussions, are not an assessment tool, (NASA, 2007) and using them for other purposes leads at best to wasting precious mitigative funds (Cresswell, 2011, Cox 2008, Hubbard 2009, Chapman & Ward 2011), the need for new tools becomes obvious. By deploying better risk prioritization, we allow our rational ego to make better informed decisions. If engineers and designers persist in using PIGs improperly to perform tasks they are not foreseen to perform, ignoring the conflict of interest that underlies designers performing risk assessments on their own designs, we can foresee that soon cases will be challenged in courts of law against these practices. The questions that could be asked will tend to prove that the approach constituted professional negligence due to blatant breach of the Duty of Care.

A recent decision bearing on a highly debated "perpetuity" environmental rehabilitation required by very large toxic material dumps in Canada (Reviewboard, 2012) defined what a modern risk assessment should include, based on public hearings results, confirming the above. Thus it becomes clear that including partial components of the consequences such as:

- Biological Impacts and Land Use,
- Regulatory Impacts and Censure,
- Public Concern and Image, Health and Safety,
- Direct and Indirect Costs,

is a better way which brings credibility and adds transparency to a risk assessment, i.e. a way to reduce public distrust toward risk assessments and mitigate opposition.

In the case of the South American highway, management was for example, and rightly so, extremely concerned by the compounding effect of public opinion on a high casualty accident which could have generated a strike leading to a significant business interruption, had another accident had occurred.

6 SOCIAL PERCEPTIONS QUANTIFICATION

As shown in the prior sections, very often hazards bear a significant portion of public perception consequences, possibly leading to increased risk levels resulting from boycotts, vandalism, eco-terrorism, and other more or less legal actions.

It is very possible that a tolerable risk (one that has p,C below tolerability) gets "shifted to intolerable grounds" based on a consequence amplification effect due to perception (Fig 4).

There is of course a part of judgment to be used by analysts, but in the Authors' experience the following procedure can be applied:

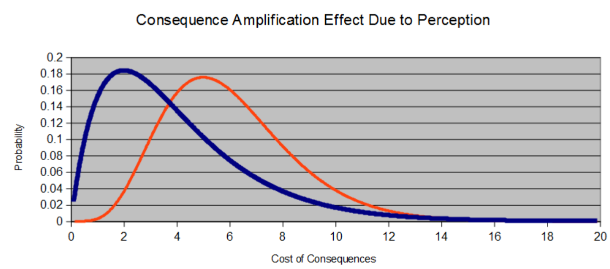

Figure. 4 A risk scenario (blue curve) may have a large crisis potential and get shifted to the right, to the Red curve (costlier consequences).

- Use a guided judgement system to decide if the potential accident will lead to high levels of local, regional, national, international scrutiny.
- If the "factual consequences" of the potential accident and the probability lead to an apparently tolerable risk, but the level of scrutiny is significant, chances are the risk will be pushed to the tolerability threshold (and possibly beyond) by social perception amplification.
- It is now possible to quantify the "social per-ception" effect by evaluating the multiplier between "factual risk" and the amplified risk.
- Define appropriate mitigation or, if un-manageable (see Section 8 for the definition of un-manageable), a shift of strategy is required.

7 MONETARY LOSS AND SHAPE OF TOLERABILITY THRESHOLDS

When moving the focus of an analysis from societal acceptability to corporate acceptability, the shape of the tolerability thresholds changes. This has been systematically observed across the world during a two decades long privately funded research by the Authors. Instead of the “straight lines (in log-log scale)” displayed in Fig. 1, or the “grossly truncated” of Fig. 2, as we can see in Fig. 5 (orange curve) there is a threshold in the consequences, different for each entity, corporate, community or governemental, that will always be considered intolerable no matter how little the probability of occurrence.

This “capping” phenomenon can be explained in 2 ways.

1)The tolerable level suddenly tends to zero once a loss volume is exceeded. Most of the time there is a limiting value of consequences that will be seen as intolerable because the outcome is so devastating that it will lead to a company's ruin or large casualties. Companies often perceive that, for those limiting losses, no matter how low the probability, the chance the loss could occur “tomorrow” renders it intolerable.

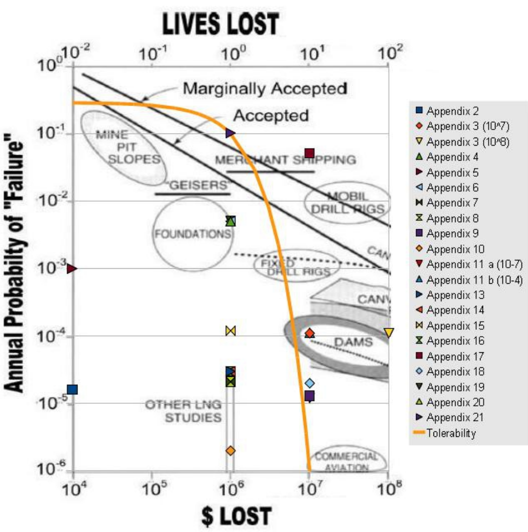

Figure 5. A pratical "general" tolerability (orange curve) compared to Whitman's societal tolerabilities. Various tolerable and untolerable risk scenarios are shown, from a real operational risk assessment. (Identically to Section 3.2, the double scale was not intended to imply a tradeoff of dollars vs. Lives. Today human lives are generally discussed in terms of Willingness to Pay (WTP) (Marin, 1992, Lee Jones, 2004) to avoid any misunderstanding.)

2)The probability of the losses is entirely disregarded. The “neglect of probability”, a well know type of cognitive bias, is the human tendency to completely disregard probabilities when making a decision under uncertainty and is one simple way in which people regularly violate the normative rules for decision making (Small risks are typically either entirely neglected or hugely overrated, the continuum between the extremes is ignored). As media and political people make decisions they tend, driven by this bias, to look only at the outcome and disregard the probability.

8 UNMANAGEABLE VS. MANAGABLE RISKS

By using any of the explicit tolerability thresholds discussed earlier it is possible to give a transparent definition of what constitutes a manageable risk: if a risk above tolerability (probability, consequence) can be brought under the selected tolerability threshold by mitigative investments, risk transfer, that still preserve the economic livelihood of a company, then that risk is manageable.

The key element here is a corporate/government choice of what level of mitigative investment preserves the economic livelihood of an entity. If the risk cannot be brought under tolerability as described, then it has to be considered unmanageable. Unmanageable risks cannot be mitigated, they require strategic shifts in the corporation/government. For example:

- TDs have been brought under tolerability by mitigating their risks, i.e. building better dams, monitoring and maintaining them to higher standards. TDs constitute, generally and as a whole, a manageable risk.
- Tunnel accidents have been mitigated by changing traffic rules, enhancing ventilation and fire extinguishing means, so they are also manageable.
- An alternative transportation mode was examined to deal with the South American highway risks as the scenario (major loss of a shuttle) was evaluated to be societally intolerable and road mitigations (tactical measures) did not significantly altered that evaluation.
- The Nuclear Reactors risks (5+ accidents) have been managed to date with moratoria and governmental statements indicating the willingness to shift to other sources of energy, thus giving the impression that they are considered unmanageable risks and they require strategic shifts.

Figure 6 shows the results from a real life large corporate risk assessment (Entreprise Risk Management, ERM) where operational (TDs, ingress/ egress, climate/natural, etc.) as well as corporate risks (i.e. economic & financial, geopolitical, social, infrastructural & environmental, business) were evaluated. Many scenarios are depicted with the “best estimate” of p,C, but others are shown as segments, in an attempt to introduce large uncertainties on the evaluation of p,C.

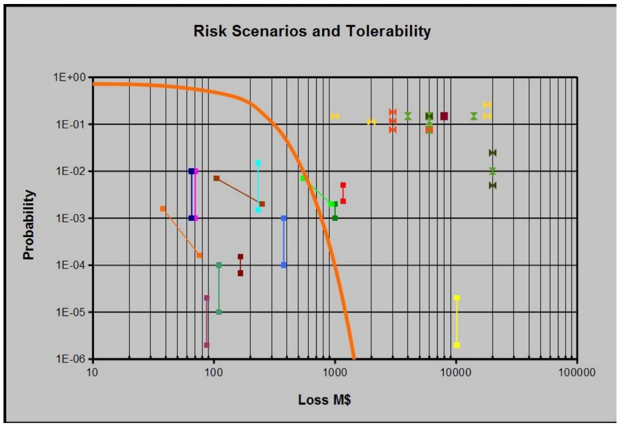

Figure 6. results from a real life large corporate risk assessment where operational as well as corporate risks (i.e. economic & financial, geopolitical, social, infrastructural & environmental, business) have been evaluated. Top-right Risks are un manageable.

It should be noted that in many studies the corporate tolerability itself is depicted as a broad band, not a line, to include uncertainties on its definition (optimistic vs pessimistic tolerability).

Thanks to these transparent and rational approaches it becomes possible to envision clear risk communication plans to preventatively mitigate public hostility against a corporation and/or investor-management conflicts. With this objective in mind it is vital to separately develop upper Management and corporate's/ investor tolerability thresholds, then compare them in an open and transparent dialogue which will help mitigation decisions “alignment” resulting in mutual protection and maximization of benefits for all parties.

Generally, once upper Management have this type of results available, they see that they cannot limit themselves to deal exclusively with arbitrarily or gut-feeling selected risks which seem “very large/ critical”, but need to have each risk defined and compared to their carefully defined acceptable threshold. As a matter of fact, there are operational risks that can jeopardize the whole corporation, and conversely, corporate risks that may be benign.

The methodologies described in this paper support with transparency Board/Government decisions to intervene with mitigations at any level after formal decision making, instead of relying on intuition and guts feeling.

To streamline the process and allow regular updates the Authors deploy commercially the methodologies described in this paper as “Optimum Risk Estimates” (ORE, (c) Oboni Riskope Associates Inc.). On top of the results shown in this paper ORE allows rational prioritization of risk portfolios and has been deployed to date on four continents, for industries going from transportation, suppliers energy, natural resources, defence.

The chances Management would adopt a “selection by consequences” are very high (see Section 7 for an explanation) if instead of using the methodologies presented herein and having a proper rational assessment, Management had in their hands a common practice (matrix based) risk assessment result (PIG/FMEA) where the tolerability has not been transparently developed and prioritization is based on arbitrarily placed colours in an oversimplified “binning” exercise (Oboni Oboni, 2012).

9 PERPETUITY CONSIDERATIONS

Regularly, when a project is publicly presented, a “narrow angle” approach is applied to risks, separating for example “engineering”, “long-term”, and “toxicological” risk assessments. Holistic approaches are uncommon, especially if designers/engineers constitute, or are too close to, the Risk Assessment team, as this almost inevitably leads to conflicts of interests and biases. Separating issues is intrinsic to good engineering practices, training and experience, meanwhile remuneration of engineers oftentimes prevents “thinking about the unthinkable”, an essential need for serious risk assessments. As a result, engineers-driven risk assessments are almost always censored and biased towards “credible events”. However history, even recent, as shown by the case studies in this paper, has shown that major failures occur when “incredible events” occur, or long chains of apparently benign events are produced. Nowadays the public has got that clearly in mind. Of course, biased/censored approaches become even more critical when long-term (perpetuity) is considered and the question is to define a maximum credible scenario on a project that will be present for perpetuity (tailings, toxic or radioactive dumps, for example).

The examples developed in Section 2 examined short- term cases, but the presented solutions work also for long- term analyses. However, on the long-term, probabilities of failures and, most likely consequences, will increase: the first because the level of care and maintenance is released, the second because of demographics and “world changes”. In contrast to, for example, hydro dams and other disposable/temporary infrastructure that would typically be breached upon the end of their production life, at mining/dumping operations closure starts the longest state of being, regardless of the duration of production phase. Production is the phase with the highest monitoring and care, Transition and Long-term treatment are phases during which monitoring and care are gradually reduced, and Closure is the phase during which the structure will be, in general, “abandoned”. For any undisposable/ permanent infrastructure a Maximum Design Hazard may, of course, occur during any of these phases, but the longer the exposure the highest the probability a hit will occur. If we add to this moving target the fact that new natural/ man-made hazards may emerge, and that climate changes and regulatory environment may be altered, we easily understand that risk assessments cannot be static. These apparently daunting problems could be tackled in a significant better way by introducing:

- Drillable Risk Registers (RR),
- Business intelligence based RR records,

- Rational RR and tolerability updating.

10 CONCLUSIONS

Perception of risks related to industrial accidents can be severely biased if consequences are censored and skewed either because the risk assessment method is too simplistic (PIGs, FMEA), or if the analyst or the client decide to apply censoring "facts driven" approaches or oversimplified metric for consequences.

Yet, numerous recent examples ranging from mining to tunnels, nuclear, railroads (Lac Megantic railroad accident in Canada was a tragic example), etc. have shown that the "fact driven" consequences evaluations approach will lead its user to unsustainable stances.

After showing that it is possible to "quantify social perception" and include it in a rational risk assessment framework, this paper suggests a communication strategy to be implemented when discussing tactical, operational and corporate risks.

The benefits for the clients of any type, corporate, community, project or a government, are very significant in terms of clarity and transparency in decision making, and clear prioritization of risk portfolios can be performed as an additional step (www.riskope.com).

By using properly defined tolerability and abiding to basic definitions it is possible to transparently define what risks are manageable and which ones are unmanageable and should therefore drive strategic changes.

It is vital to separately develop upper Management and corporate's/investor tolerability thresholds, then compare them in an open and transparent dialogue which will help mitigation decisions "alignment" resulting in mutual protection and maximization of benefits for all parties.

ERM common practices based on PIGs (Probability Impact Graphs), FMEA are not sufficient to properly represent risks and support decision making: their multiple scales and arbitrarily bound matrices, colours and indices, lead to blurred ERM registers and risk evaluations which may very well, sooner or later, be challenged in courts.

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