Geoethical consensus building through independent risk assessments
I will first show why we as a society and industry have numerous problems,
then show a case history where problems were overcome.
Proponents and the public often strongly disagree in the analysis of significant adverse impacts.

Oftentimes we see risk assessors using a rosy outlook to make their estimates.

They call those scenarios “credible” or “average”.

They bias and censor issues.
Keystone pipeline example

Regulators read in the pre-construction project risk assessment the following:

“A spill of more than 50 barrels will occur “ not more than once every 7 to 11 years over the entire length of the pipeline in the United States”.

Let’s note that “more than 50 barrels” does not declare an upper limit, but suggests a minor accident.

The predicted frequency would be 1/7 to 1/11 per year.
However, the reality is that since 2010, the Keystone pipeline leaked three times in the United States. That puts the frequency 3 to 4 times more than initially stated.

Furthermore, two of the spills leaked about 400 barrels, and one 5,000 barrels.
Biases and censoring also occur with common practice risk assessments

For example, when looking at worst-case but “credible” accidents, we quote the word “credible” because it is never defined in this type of assessment.
The fallacy has multiple aspects beyond not defining what is “credible”

If one designs a system to withstand all the individual worst-case “credible” accidents, it is wrong to believe that inherent protections will cover “by definition” against any “credible” real-life accident hitting that system.

That is because of inter-dependencies, common cause failures, etc.
Commonly used risk assessments methods are generally misleading and fuzzy.

The Fundão Dam accident in Brazil offers an eloquent example.
Commonly used risk assessments methods are generally misleading and fuzzy (cont'd)

Talking about the results of the FMEA (Failure Mode and Effect Analysis) of the Fundão Dam before the accident, Management asked whether “the likelihood of any problems happening had changed or just the severity (In their own words: stiffness of the structure)?
Management have the greatest difficulty understanding the likelihood of a catastrophic failure

The glossary was unclear as the severity does not have any link with the “stiffness” of a structure,

Due to the arbitrary nature of FMEA (PIGs, risk matrix) the catastrophic nature of potential events was masked.

- Range compression
- Risk-Acceptance Inconsistency
- Centering Bias
- And, many others...
Defining what constitutes the success/failure of a system is paramount. Without a proper definition any attempt to produce a risk assessment will be misleading.
Solomon Islands gold mine contaminated water spill

Gold Ridge dam overflowed uncontrollably after a heavy rain.

Tens of millions of liters of water containing arsenic, cyanide and heavy metals escaped from the dam via its weir.

That event altered the life of downstream residents.
Weirs built on top (at the crest) of a dam are there to allow excess water accumulated behind the dam to run away without damaging the dam by uncontrolled overtopping.
Solomon Islands gold mine contaminated water spill (cont'd)

The environmentalist:
The dam is not protecting the environment from the chemical contained by tailings dam, therefore the tailings dam has “failed” because of the weir.

The dam engineer:
The weir and its associated spillway relieved the pressure and reduced the likelihood of a dam collapse. The system worked perfectly! (For dam engineers a dam failure is what we saw at Samarco or Mount Polley. The weir functioning is a success.)
Misleading and fuzzy risk assessment are contrary to geoethics principle and cause public rejection

The Sendai Framework recognizes these problems when it states:

"It is likely that peoples and communities will recover confidence in institutions if there is clear evidence of the willingness of States to guarantee the right to life. This means that States would have to return to work for effective regulation and protection of people. And that industry will have to adapt and respect international agreements and covenants with no tricks".
A well done risk assessment helps determining potential adverse impacts and their likelihood.

The need for a unified, emergency/accident scale is vital to facilitate clear communication and mutual understanding of the nature of the emergency, by the public, government agencies, and responding organizations.

50% of the problems with (risk) communication are due to individuals using the same words with different meanings. The remaining 50% are due to individuals using different words with the same meanings.
How do we deliver a transparent risk assessment?

- Site history
- Imagery, monitoring
- Inspections
  - Reports
  - Experts
  - Models
- Communication Strategies
- Environmental Operations
- Construction Operations

- Hazards
- Interdependencies
- Consequences
- Risks

- Corporate Tolerance
- Societal Acceptability

- ORE Dashboards
- Design Decisions:
  - Alternative Selection
  - Actions,
  - Mitigation,
  - Resilience enhancement
A risk assessment starts by laying out the goal of the system, its success or failure criteria.

This allows us to depict the risk landscape in a more nuanced and truthful way taking into account different views from different participants.

There is nothing worse than people thinking they understand each other when discussing a poorly defined problem!

The goal of the risk assessor is to deliver to the stakeholders a metric. In fact the metric should encompass all concerns to facilitate a healthy discussion.
The boundaries of the system define what is in/out

ISO 31000 requires the definition of the project “context”, including all assumptions about the project environment and chronology.

The system description includes all pertinent inter-dependencies (physical, geographical, logical, informational) necessary for its operation and a clear delimitation of selected boundaries.

That helps define threats-to and threats-from the system's elements.
The evaluation of probabilities

Probabilities have to be based on science and not “gut feeling colors”.

They should also encompass uncertainties with ranges as opposed to single values.
Definition of consequences are carried out quantitatively

The failure criteria for a risk assessment needs to cover many aspects/dimensions, at least and not in any particular order:

- direct & indirect,
- health and safety,
- environmental,
- image and reputation,
- legal, etc.
Case study: conducting a 3\textsuperscript{rd} party Risk assessment on a Mining road

In this case study after many exchanges between proponent and the Environmental Impact Review Board the latter stated:

The risk assessment presented in the DAR did not adequately address the review requirements.

Specifically, it lacked considerations for the effects of weather, human error, contamination of soil, aerial dispersal associated with spills, and spills at transfer facilities. In addition, it did not account for components or systems failures.
A third party external risk advisor was asked to develop a transparent risk assessment.

In “Mine Tailings Storage: Safety Is No Accident. A Rapid Response Assessment”, the UN states that having an independent risk assessor has to become the new norm. The report identifies this requirement in distinct ways.
An independent risk assessment is needed at every step to avoid normalization of deviance

“Reduce risk of dam failure by providing independent expert oversight” done by independent risk assessor to maintain good and unbiased oversight. This will “Ensure best practice in tailings management, monitoring and rehabilitation”. and

“Require detailed and ongoing evaluations of potential failure modes, residual risks and perpetual management costs of tailings storage facilities.”
Helping the parties to form a balanced opinion on the significant adverse impacts of the project

First you need a baseline risk assessment. It should detail and update evaluations of potential failure modes during the life cycle of the system. Defining the system is a fundamental step.

You also need to understand the multidimensional consequences and the system’s failure/success criteria.
Helping the parties to form a balanced opinion on the significant adverse impacts of the project (cont'd)

“Safety Is No Accident: A Rapid Response Assessment”, states you need to “Clarify responsibility for tailings dam performance.” which is a multi-parameter optimization problem. Indeed, oftentimes the failure of a tailings dam means different things to different stakeholders. e.g. engineer or regulators.

Finally, you need to have a risk register that quantitatively integrates the data with mitigations leading to the calculation of the residual risk.
How a quantitative risk assessment is used and discussed to reach consensus.
Failure is defined in the report as at least:

- an event forbidding a truck, its cargo, or their drivers to reach their destination,
  OR
- an event with high potential impact on drivers, vehicles and their cargo, i.e. those where a truck or parts of it go off-road (off-road excursions),
  OR
- events with various levels of impact on the environment involving a truck or its cargo.
Quantitative Risk Assessment

Process Summary:

First homogeneous segments (stratifications) are evaluated, then Stratifications are collated to yield the entire road risk assessment.
Risk Assessments enabled rational discussion going beyond gut feelings.

It includes:

1. measures of uncertainties,
2. careful selection of ranges going from minor to maximum scenarios,
3. attentive analysis of possible domino effects (propagation, inter-dependencies),
4. Common Cause Failure analysis (CCF) and finally
5. a clear definition of what is “credible” and “incredible”.
### Benchmarking

<table>
<thead>
<tr>
<th>Road/length</th>
<th>Accidents (full loss)</th>
<th>Mkm driven</th>
<th>Approx. Passages/day</th>
<th>Expected accidents using Prairie Creek road mileage, traffic, lifespan</th>
<th>Multiplier using the Saint Bernard road as basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Saint Bernard, Switzerland</td>
<td>2 in 44 years</td>
<td>26</td>
<td>20</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>2 Mine access road, Americas</td>
<td>1 in 10 years</td>
<td>7</td>
<td>12</td>
<td>5.7</td>
<td>3.8</td>
</tr>
<tr>
<td>3 Mine access road, Americas</td>
<td>4 over 16 less critical reported accidents in two years.</td>
<td>2</td>
<td>20</td>
<td>19.6</td>
<td>12</td>
</tr>
</tbody>
</table>
Expected accidents (milage/traffic/lifespan adjusted)
Delivery of the final results

Main report:
- technical terms (glossary) and
- all assumptions including the system definition,
- all limitations, etc...

Report cover letter:
- plain language,
- key findings.
Enabling a consensus-seeking discussion of mitigations of the project for a safer and more resilient society.

The proponent provided a number of accidents (ranging from minor to catastrophic consequences) they would consider acceptable.

The Proponent's acceptable numbers were significantly lower than the risk assessment forecast for some Consequences Classes.

This demonstrates an insufficient level of mitigation to reach the Proponent's own expectations.
After a fierce, healthy public hearing, the proponent updated his views on risk.

Stretches of road which may require additional mitigation were identified.

Conditions set by the Board, and the proponent were proposed to consider additional mitigation for risk of accidents to people and the environment.

Entirely available:  http://reviewboard.ca/registry/project_detail.php?project_id=680&doc_stage=0
An independent risk assessor helped the discussion of the project for a safer and more resilient society.