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Evolution of risk management during an underground project's life cycle

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ABSTRACT: The paper provides practical guidance in transposing the latest ISO31000 and ISO31010 to underground works. The reporting technique of risk management varies through the project phases, and consistency in implementation throughout the project's life cycle is fundamental. After recalling background notions on risk management, the paper introduces the financial risk report (according to IFPS 15 – International Financial Reporting Standard – and the European Directive in force since January 2018) addressing each project phase: the design phase, concerned with the balance between cost, time and residual risk, in interaction with the owner's evolving risk tolerance; the procurement phase, concerned with the appropriate allocation of residual risks between the parties; the construction phase focused on the contractual perspective to understand if site conditions come under previously agreed risk allocations or generate new risks; the operations phase where risks relate to design life, structure's running costs or level of service availability.

1 INTRODUCTION

1.1 *Reference Standards*

The special importance of risk management in underground projects is well understood by all and needs no further justification. However, its implementation varies widely due to many factors. The publication of ISO 31000 in 2009, updated in 2018, has set a global standard which requires adaptations to existing corporate approaches, especially as the ISO GUIDE 73:2009 has changed many ISO GUIDE 73:2002 definitions, often leading to miscomprehension between parties. The WTC's 2017 Bergen introductory talk by Professor Håkan P. Stille, confirmed the applicability of the ISO 31000 concepts to our field of endeavour.

Difficulties of interpretation can also arise between risks which can be managed by the parties to a contract, which relate to internal processes such as quality, health and safety, etc. (covered by ISO 9001, ISO 14000, etc..) and those which are outside the bounds of control by the parties, such as "Force majeure", geology or the built environment. The latter sources of risk are the main concern of the design process regarding construction risk reduction.

The industry in France has strived to produce guidelines on managing external sources of risk within tunnel construction contracts, with recommendations focusing on tender documents and Owner's requirements. The French government publishing an update to its Fascicule 69 in 2011 with guidance notes produced by the CETU (Center for Tunnelling Studies, a

French governmental institute) in December 2013. The French tunnelling association (AFTES) published its recommendations with regards to these risks through two main texts, GT32R2A1 in 2012 and GT32R3A1 in 2016, with a more general recommendations on contract in its GT25R3A1 guide in 2015.

1.2 *Scope of the paper*

The paper focuses on risk management from the owner's perspective with respect to a project, from inception to project delivery. As such, sources of risks derived from the external context – outside the control of parties to a contract, which are thus the owner's risk – are the prime focus of this paper. The internal risks of the consultants and the contractors are none-the-less discussed when these could become an owner's risk.

Operational risks, which influence design and are often managed through national or supra-national statutory requirements (in railway or road tunnels) with formats imposed by the national authorities are not addressed in the present article.

1.3 *Regulatory obligations*

The obligations imposed on the major companies of the European Union to adopt IFRS 15 (the International Financial Reporting Standard n°15: Revenue from Contracts with Customers) as the basis for their project financial reporting is a game changer and renders homogeneous reporting in our field of endeavour critical to our profession's credibility.

2 THE FUNDAMENTALS

2.1 *Overview*

The definition of risk is: *effect of uncertainty on objectives*. This definition is clarified in the ISO Guide 73:2009 with the following notes:

- a *effect* is a deviation from the expected — positive and/or negative;
- *objectives* can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process);
- *uncertainty* is the state, even partial, of deficiency of information related to understanding or knowledge of an event, its consequences, or its likelihood.

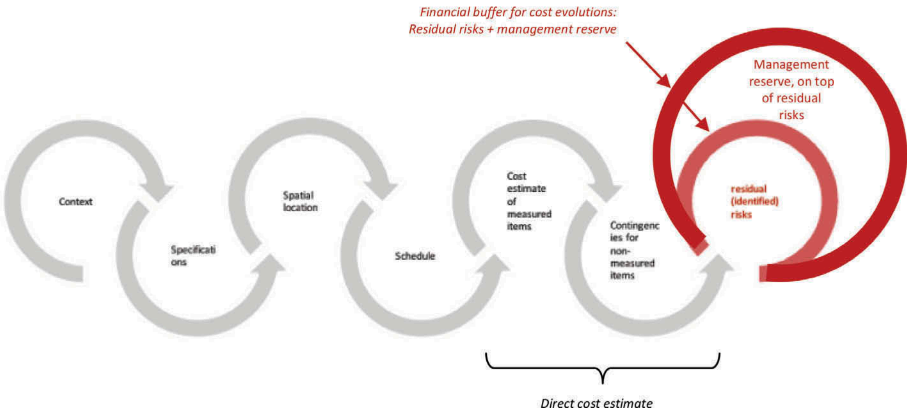

Figure 1. Risk dependencies.

Thus, any risk assessment relates to potential deviations of any or all of the following:

- context, both external (such as statutory requirements or geology) and internal (such as owner's financial capacity),
- Specifications (inclusive of the risk management plan),
- Spatial localisation (alignement, dimensions, size, etc.),
- Schedule (base).
- Cost estimate of measured items
- Contingencies for none-measured items (lack of project definition), in accordance to AACEi's definition in its RP 10S-90.

Changes in any of the above aspects requires a re-evaluation of the risks based on the revised project referential. As risk is the deviation from the expected, a change in the expected implies a re-evaluation of the risks. The expected includes, thus are NOT risks:

- *Approximations*, e.g. a cost estimate of 1′000, with precision of +-20% indicates an estimate in which that the project's cost could be 1′200, as such the risks are those which increase this cost further. The notion of imprecision must be dissociated from that of risk (which are by definition identified).
- *Contingencies*. e.g. a contingency for non-measured items is nearly certain to be incurred. And is thus part of the direct cost estimate.

The cost to cover the occurrence of residual risks, plus the management reserve (for undefined or unexpected cost evolutions) constitutes the project's financial buffer. It is usual for the management reserve to decrease as the risks are better identified during the project's development.

2.2 *Objectives*

In underground works the term of *Risk Management Plan* is of common use and should follow the structure given in chapter 6 of the ISO31000:2018, As a minimum, it must include: a risk policy specific for the project; a clear and dedicated organisation; a systematic and iterative risk analysis (risk sheets, risk registers, risk treatment plans, etc.); the quantification of the provisions for identified risk; the format and process associated with risk treatment plans and the management of residual risk. Defining the objectives of a project from the Owner's perspective, for each phase of the project's development, is the first fundamental step within any Risk Management Plan.

ITA's WG2 recommendation identified 6 objectives, which can be extended with objectives relating to fulfilling the project's objectives (traffic capacity, power production, etc..). Each phase of a project can have its specific set of objectives, i.e. design activities rarely impact health and safety of third parties. Furthermore, the risk criteria associated with the objectives may be differentiated between project development phases, e.g. a 5 months delay may be of a greater importance to the owner during statutory procedures than during construction.

2.3 *Risk policy*

As part of a project's Risk Management Plan, it is the project owner's responsibility to define the level of risk which is acceptable for his project, and hence to take a major role in the definition of the scales of likelihood and impact to be used in the project and to finally validate the quantitative acceptability criteria, as well as their requirements in terms of degree of confidence to be applied by the project's actors. The Owner can should be assisted in this by his Consultants/Designers or an experienced external advisor.

2.4 *Risk source context and ownership*

Sources of risks that are of *internal context* – that is dependent on an organisation's management and processes – are, by definition, owned by that organisation.

Risk sources of *external contexts*, that are not under the control of the organisation belong to the Owner of a project, but can by transferred to another party, in totality or partially. In underground works, typical external risks include those related to geology, to meteorological conditions, to "Force Majeures", etc. As regards risks related to geology, and in line with ITA's and international best practice, fully transferring geological risks to contractors without carrying out proper investigation phases to reduce them is not a recommended approach.

2.5 *Organisation for risk management*

Risk management required a devoted organisation starting with the owner and ending to the contractor. It is fundamental that risk management be intended as a decision-making process fully integrated in the project, and not kept as a parallel and secondary activity.

2.6 *Risk assessment*

The terms and definitions are often repeated in articles dealing with risks, the aim here is to place each term in the general context of the risk management process (in bold the terms defined in ISO 31000 standard or ISO Guide 73):

The *Risk Assessment* is split into 3 activities:

Risk Identification which aims to provide a *Risk Description* – presented in light grey in Figure 2 – has 3 components. Uncertainty is given by the *Source of Risk* and is intrinsic to the *Context* of an organisation (*Internal*) or to site specific conditions **(***External***)**. Thus, to proceed to the characterisation of an *Event* (deviation from the expected) it is required to make a baseline hypothesis. Events can combine in a cascade, resulting in distinct risks. *Consequences*, unlike Events, impact the *Objectives* directly in a quantifiable way, and each cascade of Consequences through knock-on effects or combinations become distinct risks.

i. *Risk Analysis* – presented in diagonal hash in Figure 2 – has two components. First, the estimation of the likelihood of any given cascade of Consequences, due to the relevant cascade of Events, on any specific Objective. Second, the quantification of its impact on each of the individual Objectives.

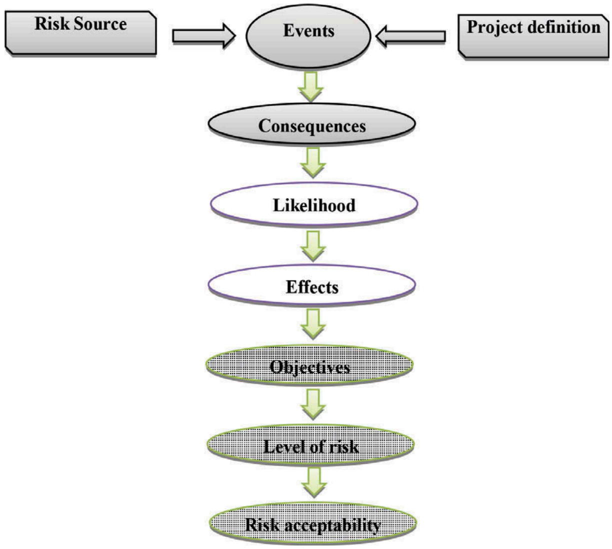

Figure 2. Risk assessment process for a given scenario prior to risk treatment.

ii. *Risk Evaluation* – presented in grey dotted hash in Figure 2 – has two components. The global appreciation of the Level of Risk with its comparison with the Risk Acceptability, as defined in the Risk Matrix.

Furthermore, the ISO Standard requires that any *Risk Assessment* be accompanied with indications on, notably:

– the limitations of knowledge, in association with an evaluation of information reliability;
– the sensitivity and confidence level, relating to the Risk Analysis itself.

The implications to existing risk management cultures within organisations can be far reaching, as no risks assessment of any kind is possible without a minimum of information, no risks can be assessed on objectives which are undefined (such as "Other Objectives") nor can risks be identified without defining an initial baseline hypothesis (such as project location, time scale, alignment, geology, geotechnical hypothesis, etc..).

2.7 *Risk treatment*

Risk treatment is initiated when the *Level of Risk* is required to be lowered. As such, the risk treatment – although its impact on the risk reduction can be uncertain – is by its very nature an action with an expected outcome.

Actions such as obtaining further knowledge or better quality of information during the design phases, or monitoring risks during construction are not risk treatment measures, as these are not actions to reduce or eliminate risks or otherwise increase opportunities by modifying one or more of the steps of Figure 2.

It is to be borne in mind that *Risk Treatment Plan* may impact many risks by removing a source of risk (e.g., changing the project's alignment to avoid a geological fault) or a possible specific consequence existing in many different risks (e.g., using TBM to improve safety of the workers, to increase the excavation speed, to reduce settlement, etc.) or any or multiple combinations of each of the risk's aspects (source, consequence, effect, likelihood).

Risk treatment plans can be classified into three levels:

– *Level 1*: Those actions which modify the project's environment or redefine the project itself in order to *influence the possible events and/or consequences* (in light grey in 2b). Sources of risk relate to the project's environment. Examples are: legal, general geological, hydrogeological, geotechnical or climatic contexts. Project definition relates to alignment adaptations, alternative excavation methodology, etc.
– *Level 2*: Those specific actions which modify a specific or a limited number of risks by *altering their likelihood or their effect* on one or more of the objectives of the owner (in dashed oblique lines in Figure 2. Examples are: reinforcing a building; locally improving the characteristics of the ground (if they are too wide spread this can be equated to change a project's environment → level 1) or risk transfer to insurers, consultants or contractor - Beware only those risks identified and analysed can be subject to transfer.
– *Level 3*: Those actions that *revise the risk process itself* by adjusting the risk criteria or acceptability, as the cost of limiting the risks may become prohibitive (in dotted hash in éb). Examples are to increase the settlement or water inflow thresholds, etc.

Level 1 and 2 are hierarchically linked, while Level 3 is the iterative result of having studied and compared scenarios and associated costs and having given the Owner the opportunity to revise his policy accordingly.

The tracing of risk improvement for Level 1 and 3 requires the use of distinct scenarios for each proposed design each of them associated with their own risk profiles. Level 2 enables risk optimisations within pre-established design scenarios.

Before implementing risk treatment an appreciation of the risk analysis's confidence level must be carried out. The cost implications of a proposed treatment may justify the further investigations (e.g., site investigations, etc..) prior to any decision to proceed with it.

2.8 *Residual risks*

Residual Risks are those risks for which no further treatment action is sought, as such they are accepted by the owner. However this term is commonly also used to qualify the remaining risks at any point in the project's development, especially to distinguish an initial risk of a scenario from those remaining after implementing a Level 2 risk treatment plan, even if the level of risk is still too high and further studies are required further down the project's development cycle.

It must be noted that implementing a treatment of Level 2 will also generate a new scenario with the associated costs, schedule, etc. Therefore, the following should apply:

– any cost review must compare the initial cost, time and risk, globally with the cost, time and residual risk after treatment;
– any modification of part of the project during construction (e.g., adaptation of construction methods, implementation of a variant solution, etc.) which modifies costs, time or potential events affecting the project must be accompanied by a reconsideration of the risk analysis.

2.9 *Rigour in differentiating Risk Sources, Events and Consequences*

With the use of risk registers within contractual documents the imperative of coherence and consistency in risk assessment has become crucial, and precise rules are required established to determine what is what. As such:

Risk sources reflect *intrinsic uncertainties* (i.e. those of the project's global environment, independent from project definition). When described, the sentence should start with "Uncertainty in…". Typically for:

– External contexts: source linked to uncertainties in the political constraints, statutory procedures (legal/standards/administrative), macro-economic, geology, meteorology, existing structures, social/cultural, interfaces with third parties.
– Internal contexts: source linked to uncertainties in management capability, organization adequacy, process robustness, staff competencies, equipment reliability, materials quality.

Events can only be described when compared to a *baseline assumption*. Typically, their description will refer to:

– Variations from the expected, in terms such as: "less rigid than expected"; "harder than expected"; "larger than expected"; "more than expected" (e.g. "more settlement than expected").
– Sudden changes, phenomena or other disruptions in such terms as "collapse of", "flooding", "failure of"; "spillage of".
– Quality issues in terms such as "ovalisation"; "departure from alignment"; "out of tolerance".
– Availability or accessibility, in such terms as: "interruption", "inaccessible for"; "unavailability of"; "war"; "social unrest"; etc.
– Location, such as: "above", "below", "in-front", "behind", etc.

Events by themselves have no effect on the objectives. For instance, "greater settlement than expected" does not impact the cost objective of the client.

Events may cascade, for instance: "Collapse of the header leading to greater settlement than expected". The use of words such as "leading to"; "entailing"; etc. can be used to describe cascading events. The deviation from the baseline assumption has to be quantitative and measurable.

Consequences are generated when the deviation of an event from the baseline assumption generates an impact on the project's objectives. Typically, these relate to:

– Quantities due to changes in dimensions or to extra-works to mitigate a more impacting risk, in terms such as "more" (e.g., more injections than budgeted), "heavier than" (e.g., heavier steel sets than planned), etc.

– Damages to the project itself, to third parties or to the environment, in terms such as "repairing damages to" (e.g., repairing structural damage to "building no.21"); "loss of revenue"; "compensation to"; "relocation of"; "deaths"; "injuries", "pollution of", etc.
– Productivity, in terms such as "slower than" (e.g., slower progress);
– Prices, in terms such as "increased cost of" (e.g., increased cost of expropriation); "inflation";
– Performance, in terms such as "reduction in" (e.g., reduction in transport capacity); "reduced speed"; etc.

As with Events, Consequences can cascade, e.g., "repairing the structurally damaged building leads to the temporary relocation of the lodgers". Cascading events are to be considered as additional events to their component parts, e.g., "Repairing the structurally damaged building" (i.e. without relocation of lodgers) is a different risk.

2.10 *Interactions between likelihood and the effect on the objective.*

Likelihood is dependent on the importance of an effect. As an example, the likelihood of inducing damages on existing buildings can change according to the importance of such damage (i.e., aesthetic, functional or structural damage).

Depending on the effect it may thus be necessary to define "tranches" and to evaluate their respective likelihoods, leading to tranches of risk (risk of aesthetic damage, risk of functional damage and risk of structural damage in the example mentioned before). However, for many risks, adopting a mean damage estimate for which the associated likelihood can be ascertained is enough for design purposes and for the definition of the associated risk provisions. Although, for contractual risk allocations risk tranches may be required.

2.11 *Active period*

A risk must always be located both in space and in time. For tunnelling works this means identifying the risks' occurrence along the tunnel profile and on the schedule.

Within the general risks review process the risk location must also be reassessed and the active period may require increased monitoring and surveillance in relation to the identified risk.

3 RISK USAGE DURING PROJECT'S DEVELOPMENT

3.1 *Risk reporting formats*

Recording and reporting is a requirement of the ISO 31000:2018 and is the practical foundation on which the usefulness and the proof of application rests. The following chapters aim to provide guidance on setting up supports for recording and reporting the risks in the various phases of a project's development.

3.1.1 *Overview*

The risk reporting to stakeholders will need to consider differing objectives, thus a unified, single representation or format in the risk reporting can be difficult to impose. However, these fall into three global categories to provide:

i. Detailed documentation, principally the *risks sheets* describing each of them and their treatment in detail (oblique lines Figure 3) or the *risk treatment plans*, with the reasons why a particular treatment is to be implemented.
ii. *Risk registers* (light grey in Figure 3), provide a list of all risks and their implemented risk treatments in order to provide for risk management decision support, both to the current project phase and to future phases (notably construction, when in a design phase). Risk registers can be the main source of registering the risks or consolidate the information from

the detailed documentation. These take various forms depending on the objectives, but provide:

a. Easy comparison between scenarios through sorting risks by importance with a view to identify priority issues.
b. Overview of the effectiveness of level 2 risk treatment measures, comparing the initial (prior to the level 2 treatment measure) and residual risks of a given scenario.
c. Check the risks allocation between parties to a contract (services and construction), with the projects' residual risks, the detail of how this risk is distributed between the parties and the Owner's residual risk after transfer.

iii. Decision support to justify *risk provisions* for risk the Owner's organisation's accounts, usually referred to as the *financial risk report* (dashed oblique lines Figure 3). During any project phase, the financial risk report shall be updated regularly as risks become out-dated or occur (no more a risk), even if the risk register itself may not evolve. It must also be stressed that financial risk reports are produced for the project's current development phase, for which the organisation has been committed or is about to be committed to.

3.1.2 *Rigour of the process*

At the inception of a project it is common to seek to establish a financial risk report without documenting the risk appreciation process. This shortcoming renders, at later stages in a project, the task of understanding risk evolution impossible. Furthermore, the proposed likelihoods often reflect the lack of confidence in the risk analysis rather than any real likelihood of the risk occurring, which can forestall projects in the early stages.

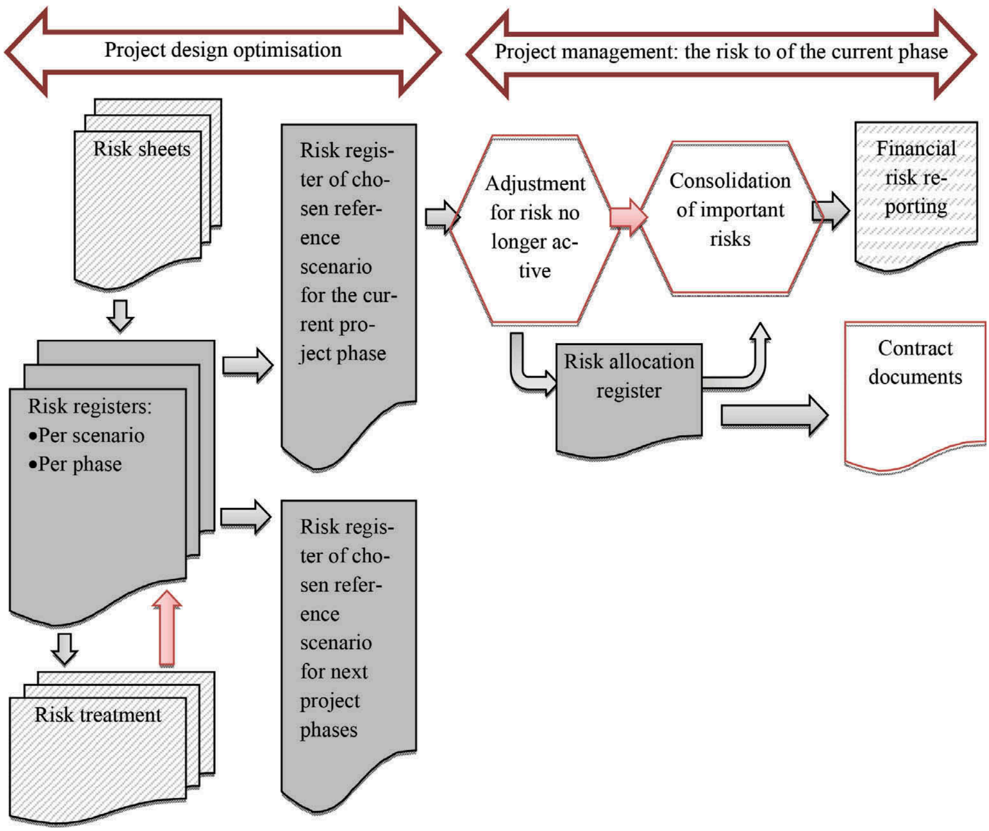

Figure 3. Risk Management through a project and associated documentation.

Thus, at all stages in the project's life cycle, a full risk register for each scenario must be kept. However, risk sheets and treatment plans may be too detailed for the purpose and thus the risk register can directly include information usually only present in the risk sheets in order to avoid the multiplication of documents.

3.1.3 *Document management*

As can be understood, a robust identification and versioning system is fundamental to proper risk management, thus all documents require a header to identify its type, the phase, the scenario, its version and the date of its last update.

As the risk process can evolve the format revision must be indicated to identify the required steps in order to update the document to the organisation's current standard.

3.2 *Detailed documentation*

All aspects of the risk assessment process must be recorded, using risk sheets and risk treatment plans to record decisions. However, these are not discussed in the present article.

3.3 *Risk registers*

The risk register summarises in a formal manner information about identified risks (from the initial risk to the residual risk, through the mitigation and corrective measures for both) and thus it constitutes the fundamental document in being able to manage the project's risks within a contractual framework.

Each risk can then be developed in a dedicated risk sheet.

- Initial design phases: it is usual at this stage to concentrate on level 1 or 3 of the risk treatment plans. These stages tend to manage risks through the management of scenarios.
- Detailed design phase: it is usual at this stage to concentrate on level 2 risk treatment plans. As such, the use of initial and residual risk analysis becomes important.
- Procurement phase: during the procurement phase it is deemed that the project's risk cannot be further reduced through design, but to a certain extent it could be reduced with respect to the owner's objectives by risk transfer.
- Construction phase: the main focus of this register is to record new risks (i.e., unforeseen at procurement) or are risks identified in the contract, but which must have their likelihood or consequences need to be reassessed or to indicate they have occurred.
- Reception: at reception there maybe remain certain risks to the structure as such.

3.4 *Financial risk reporting*

3.4.1 *Issues*

As from project inception it is required to identify the risks, the financial risk reporting has become mandatory, both in public and private corporations, and a statutory obligation under IFRS 15, with a European Directive in force since the 1st January 2018. However, the pitfalls are:

Risk source			Risk Identification			Initial Risk assessment									Risk surveyance	Risk transfert				Paiment conditions					Risk assessment after risk transfert								
							Objectives																			Objectives							
Catégory and sub category	Location, stratigraphy or structure	Description of the uncertainty	Event(s)	Conséquence(s)	Risk reference n°	likelihood	Cost	Delai	Corporal integrity	natural environment	built environment	Political - image	Performance	Level of risk	Measures implemented in the contract to monitor the risk	Description of transfered risk	Risk owner	Threshhold of transfert	Capped risk amount	Deamed included in BoQ unit rates of contract	Penalities	Extra quantities on existing bill items	Bill items on works relating only to potential risks	Not part of the contract	likelihood	Cost	Delai	Corporal integrity	natural environment	built environment	Political - image	Performance	Level of risk

Figure 4. Example of risk register for procurement purposes.

Risk register

										Impact	
Financial Reference number	Context	Active period	Risk source (incertainty)	Structure/location	Event	Consequence	likelihood	lower bound	Upper bound	lower bound	Upper bound
F04	External	Public scrutiny	Uncertainty in public acceptance	Viaduc between PK 120 and PK2230	du to lack of public involvement opposition is more extreme than expected	Project abandonnment with total loss of investments to date	P_1	L_{1i}	U_{1i}	$P_1 \times L_{1i}$	$P_1 \times U_{1i}$
F04	External	Public scrutiny	Uncertainty in public acceptance	At grade section between PK 4000 and PK4410	du to lack of public involvement opposition is more extreme than expected	Project abandonnment with total loss of investments to date	P_2	L_{2i}	U_{2i}	$P_2 \times L_{2i}$	$P_2 \times U_{2i}$

Financial risk report

		Impact	
Consequence	likelihood	lower bound	Upper bound
Project abandonnment with total loss of investments to date	$P_1 + P_2$	$\frac{P_1 \times L_{1i} + P_2 \times L_{2i}}{P_1 + P_2}$	$\frac{P_1 \times U_{1i} + P_2 \times U_{2i}}{P_1 + P_2}$

Figure 5. Example of consolidating risks in the financial risk reporting.

– The financial reporting format of risks is usually based solely on a list of consequences, often with very simplistic linear likelihood levels. In addition, usually the format is usually independent of project size or complexity.
– The common use of stochastic estimations (e.g., consolidated unit rates, such as cost per meter of tunnel, and general progress rates, derived from previous projects), especially at the early stages of a project's design, most likely integrates risks which occurred on those projects.

As the financial risk reporting can be the sole constant in the project's life cycle it is important not only to ensure the traceability of the underlying assumptions, but just as importantly to define the methodologies used in:

– summing the likelihoods of identical consequences deriving from distinct events or risk sources;
– estimating the likelihood corresponding to the mean financial effect of a given consequence and if the effect has a too wide a standard deviation then the rules in defining "tranches" of effects;
– defining the cost estimate's range and confidence level above which any consequence impacting the costs are deemed a risk, not within the assumed tolerance;
– ensuring the list of risks are distinct and "independent"

Further difficulties are induced by the format of this type of report are:

– its general nature, which precludes too much information;
– its "consequence centric" approach, too simplistic for underground projects leading to inconsistencies in the terms used in the risk titles. These often refer not to a consequence, but to a risk sources, an event or even an objective. As such, the risks are not "independent". For example, a risk may be identified as "geological" (i.e a source of risk), another risk may be described as "building damage" or "project cancellation" (i.e. a consequence) and another simply describing a risk as "a cost risk" (an objective);
– its estimation as a single value, not a range of values, induces at best an over estimation of the effect of a risk, with the likelihood reduced to adjust for this; or at worst, the likelihood of the mean effect value being used, thus over estimating the likelihood a well;
– how to cumulate identical consequences but of different risks.

3.4.2 *Format*

Risk registers are too detailed for the purpose of constituting a financial risk report, and an organisation's financial reporting of risks may be too basic for a project with underground sections. Therefore, an intermediate format could be required in between the two mentioned documents, and this could consist of a table with the columns shown in the example given in Figure 6.

Sum of the squares	20	26
Sum of the 2 most risky events	26	46
Retained maximum risk	41	

Referenc number	Context	Active period	Risk source (incertainty)	Consequence	Percentage weighting	Effet on costs lower bound	Effet on costs Upper bound	Weighted effect on costs lower bound	Weighted effect on costs Upper bound	Confidence level
F01	Internal	Dossier preparation	Uncertainty in available competencies	Delay in project submittal	15%	50.00	150.00	7.50	22.50	2
F02	Internal	Dossier preparation	Uncertainty in corporate approval	Project abandonnment with total loss of investments to date	2%	75.00	95.00	1.50	1.90	3
F03	External	Public scrutiny	Uncertainty in public acceptance	Respond to oppositions	25%	5.00	7.00	1.25	1.75	3
F03	External	Public scrutiny	Uncertainty in public acceptance	Respond to oppositions and extra studies required entailling a delay in project implementation	15%	15.00	100.00	2.25	15.00	2
F04	External	Public scrutiny	Uncertainty in public acceptance	Project abandonnment with total loss of investments to date	25%	75.00	95.00	18.75	23.75	1

Figure 6. Example of an intermediate financial risk report format.

In the example, once public scrutiny is initiated, the two first risks (F01 and F02) can be eliminated as they are not active anymore.

4 CONCLUSION

The latest ISO31000 and ISO31010 transposed to underground works require a more rigorous dictionary of definitions which does not modify the substance of risk management as described by ITA WG2's recommendation but necessary to ensure risk tracking during a project's development, enabling the reporting structure to be adapted to each of a project's development stages. The paper addresses some common mistakes and imprecisions in developing an underground project's risk analysis and it gives advice on the reporting technique and on the importance of a consistent financial risk report (as required by IFPS 15 and the European Directive in force since January 2018) throughout the project's life cycle. An effort has still to be made by the international tunnelling community for the financial risk report to be considered as part of an underground project's Risk Management Plan as far as the risk policy, the risk register, etc. In this sense ITA could contribute to clarify this need and the associated format, e.g., as suggested in the paper.

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