ITA WG 2 – Guidelines for Tunnelling Risk Assessment

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Guidelines for Tunnelling Risk Assessment

Risk definitions

- Hazard:
  A situation or condition that has the potential for unwanted consequences:
  - Human injury
  - Damage to property
  - Damage to environment
  - Economic loss
  - Delay to project completion
- Risk:
  A combination of the frequency of occurrence of a defined hazard and the consequences of the occurrence

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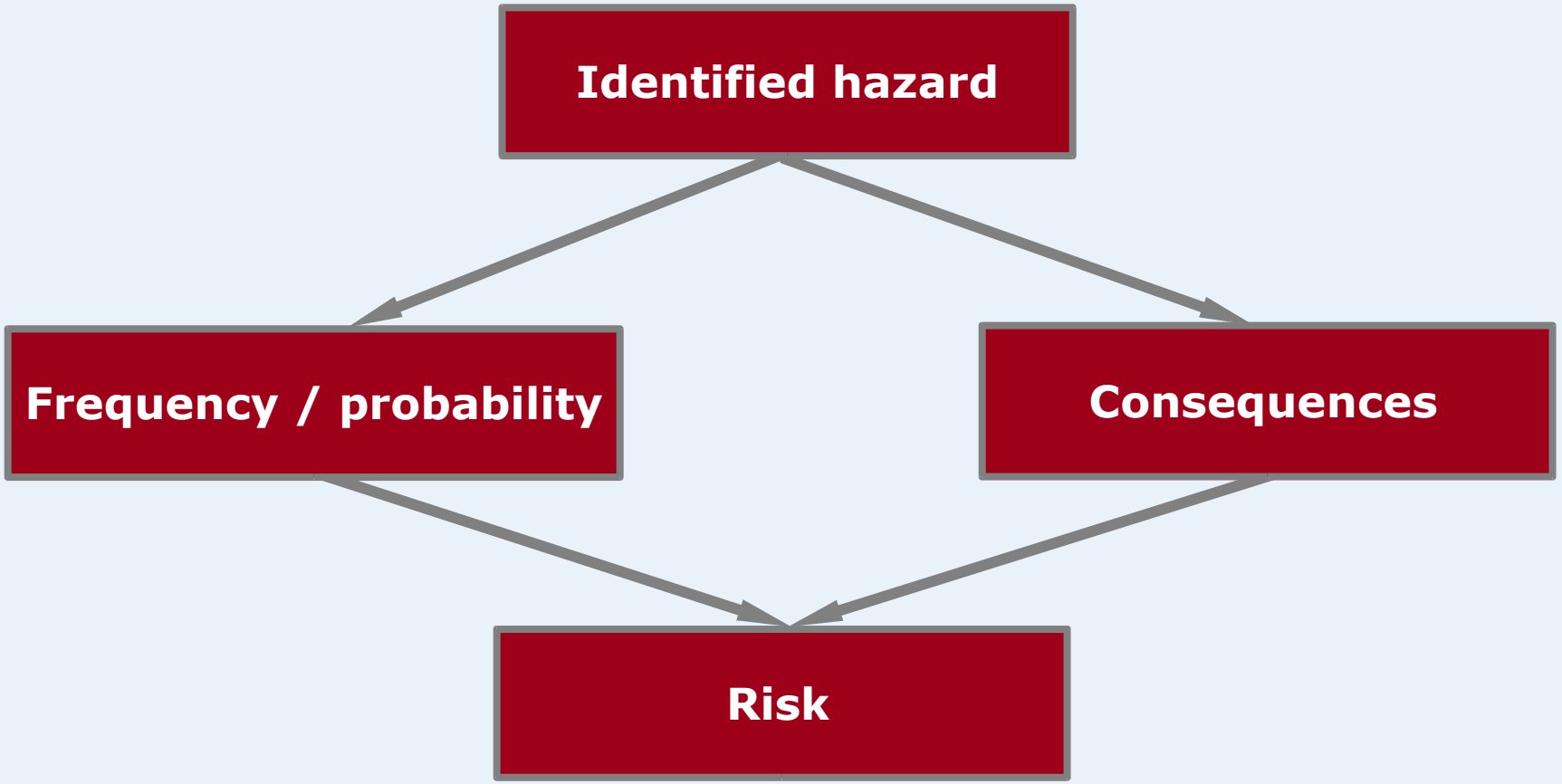
Hazard and risk



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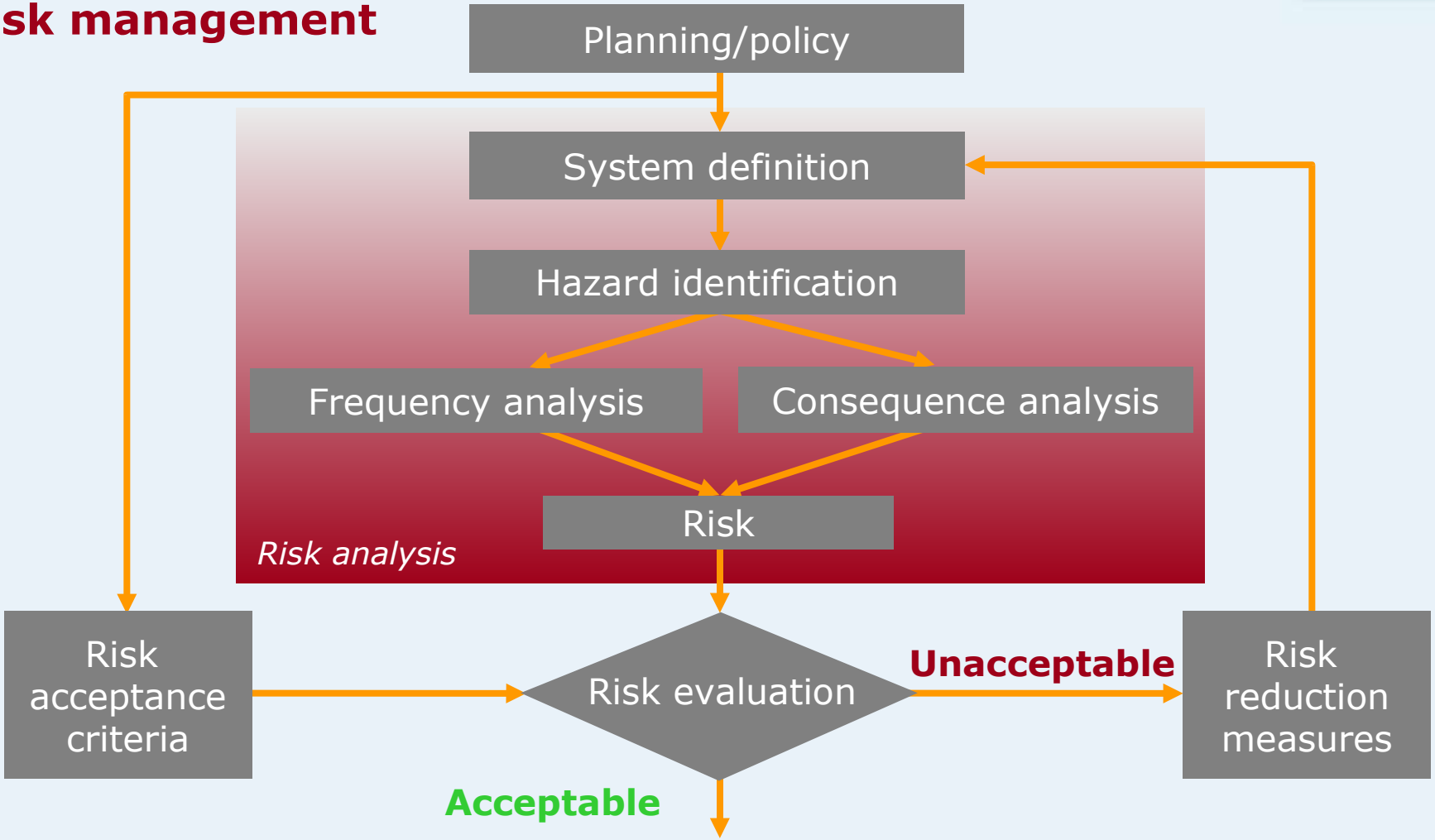
Risk management



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Risk analysis

- Risk analysis: a structured process which identifies both the probability and extent of adverse consequences arising from a given activity.
- Risk analysis includes identification of hazards and description of risks, i.e. probabilities and consequences (qualitative or quantitative)

Risk acceptance criteria

- Common sense: aim at reducing risk once identified
- More formal criteria:
  - The risk shall be below a certain value
  - Cost benefit type criteria / ALARP (As Low As Reasonable Practicable - Developed in UK and widely used)

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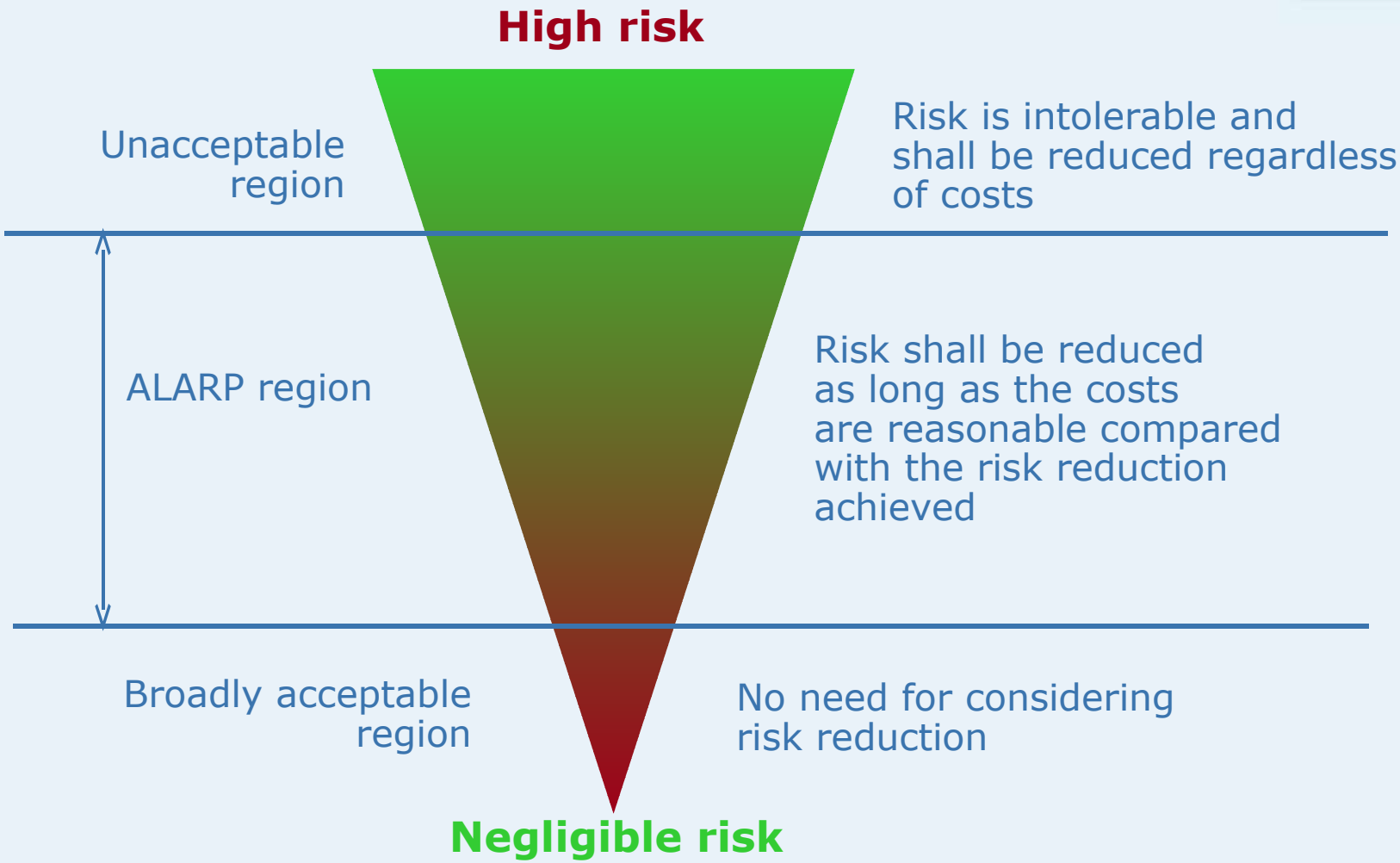

Guidelines for Tunnelling Risk Assessment

Scope and purpose

- To present a guideline

  for designers to prepare comprehensive tunnelling risk assessment

- To indicate to owners what is accepted industry practice for construction risk analysis

- Does not include guidelines for contractor's risk management

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Guidelines for tunnelling risk management: International Tunnelling Association, Working Group No. 2 ☆

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Abstract

These guidelines, prepared by Working Group 2 (Research) of the International Tunnelling Association, are prepared in order to give guidance to all those who have the job of preparing the overall scheme for the identification and management of risks in tunnelling and underground projects. The guidelines provide owners and consultants with what is modern-day industry practice for risk assessment, and describes the stages of risk management throughout the entire project implementation from concept to start of operation.

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Preface

Front page articles in the news on spectacular tunnel collapses during the 1990s focused the public and in particular potential tunnel owners' attention on the inherent risk associated with underground construction works. As a result, risk management became an integral part of most underground construction projects during the late 1990s. However, from discussions in international forums, it became clear that handling and management of risks were performed in many different ways, some more concise than others. Out of the discussions came the idea of establishing international guidelines on tunnelling risk management.

Work on these guidelines began at the meeting of ITA Working group 2 "Research" in Oslo in June 1999. After much study, discussions and investigations, the guidelines were completed in April 2003.

These guidelines consider that present risk management processes can be significantly improved by using systematic risk management techniques throughout the tunnel project development. By the use of these techniques, potential problems can be clearly identified such that appropriate risk mitigation measures can be implemented in a timely manner.

The guidelines show how risk management may be utilised throughout the phases of a project implementation:

1. Early Design Phase
2. Tendering and Contract Negotiation Phase
3. Construction Phase

The guidelines also contain some typical components of risk management and a short introduction to general risk management tools as well as a glossary of risk terms. Finally, an example of how risk management was carried out for the Copenhagen Metro following principles similar to those presented in the guidelines is included as an appendix.

The practice of performing risk management requires much experience, practical and theoretical knowledge. It is, therefore, not expected that these guidelines will cover every aspects of tunnelling risk management, but it is

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Guidelines for Tunnelling Risk Assessment

Contents

Guidelines for Tunnelling Risk Assessment

Risk Management Activities, three stages

2. **Phase I: Early design stages**
3. **Phase II: Tendering and contract negotiation**
4. **Phase III: Construction**

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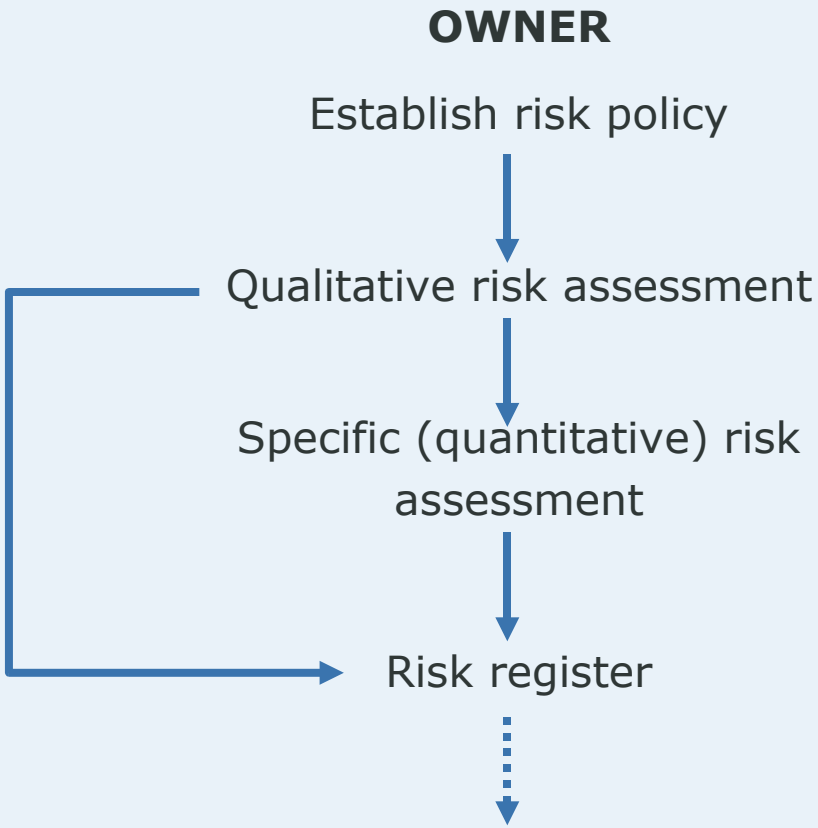
Risk management activity flow

Phase I: Early design stages



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Risk management activity flow

Phase II: Tendering and contract negotiation

OWNER

Preparation of tender documents, including:

- Description of significant technical risks
- Technical requirements to mitigate risk
- Description of required risk competence

Selection of contractor, evaluation of

- Contractor's ability to perform risk management
- Risks involved in contractor's proposed technical solutions

Prepare contract with risk clauses

CONTRACTOR

Preparation of tender, including:

- Proposed risk management system
- Description of experience and competence in risk management
- Identification and description of risks associated with the proposed technical solution
- Identification and description of proposed risk mitigation measures

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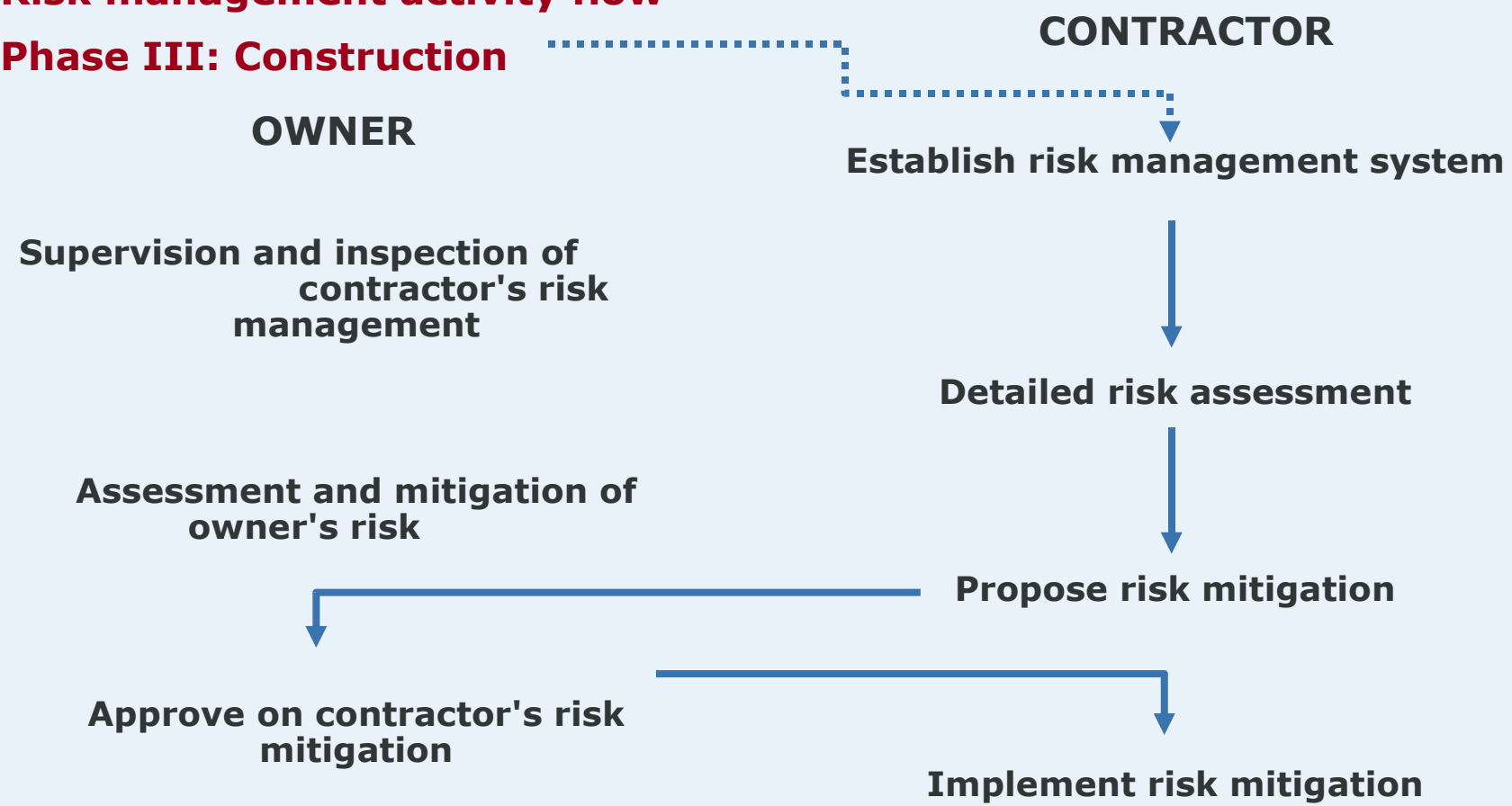
Risk management activity flow

Phase III: Construction



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List of hazards

General hazards:

1. Contractual disputes
2. insolvency and institutional problems,
3. authorities interference,
4. third party interference,
5. labour disputes

Specific hazards:

6. Accidental occurrences,
7. unforeseen adverse conditions,
8. inadequate designs, specifications and programmes,
9. failure of major equipment, and
10. substandard, slow or out of tolerance works.

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Construction risk policy

A construction risk policy may indicate:

- scope,
- risk objectives, and
- risk management strategy

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Risk Policy Scope

As an example the scope may include the following risks:

- to the health and safety of workers, including personal injury and, in the extreme, loss of life
- to the health and safety of third party people
- to third party property, specifically normal buildings, cultural heritage buildings and infrastructure
- to the environment including pollution, and damage to flora and fauna
- to the owner in delay to the completion
- to the owner in terms of financial losses

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Risk Management Strategy

The risk strategy should provide:

- a definition of the risk management responsibilities of the various parties involved (different departments within the owner's organisation, consultants, contractors)
- a short description of the activities to be carried out at different stages of the project in order to achieve the objectives
- a definition of methods to be used for follow-up on results obtained through the risk management activities. This could be accomplished by establishing a risk register of some form.

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Qualitative risk assessment

- Hazard identification through brainstorming sessions with risk screening teams.
- Classification of the frequency, consequence and risk levels of the identified hazards.
- Identification of risk reduction measures.
- Documentation of risk management work in risk register.

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Assessment of Scenario Frequencies

Frequency of occurrence in the construction period

Descriptive frequency class	Frequency class	Central value	Frequency Interval
Very likely	5	1	> 0.3
Likely	4	0.1	0.03 – 0.3
Occasional	3	0.01	0.003 – 0.03
Unlikely	2	0.001	0.0003 – 0.003
Very unlikely	1	0.0001	< 0.0003

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Consequence classes

	Disastrous	Severe	Serious	Considerable	Insignificant
Injury to workers and emergency crew (No. of fatalities / Injuries*)	> 30 F	3<F<30	1-3 F 3-30 I	1-3 SI 3-30 MI	< 3 MI
Injury to third party persons (No. of fatalities / Injuries*)	> 3 F	1-3 F 3-30 I	1-3 SI 3-30 MI	< 3 MI	-
Economic loss to third party (mio. Euro)	> 3	0.3 to 3	0.03 to 0.3	0.003 to 0.03	<0.003
Economic loss to owner (mio. Euro)	> 30	3 to 30	0.3 to 3	0.03 to 0.3	<0.03
Delay in construction (per hazard)	> 2years	½-2 years	2-6 months	½-2 months	< 2 weeks
Harm to the environment	Permanent severe damage	Permanent minor damage	Longterm effects	Impermanent severe damage	Impermanent minor damage
*F=fatality, SI=serious injury, MI=minor injury.					

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Hazard Ranking / Risk Classification

Risk Matrix		Consequence				
		Disastrous	**Severe**	**Serious**	**Considerable**	**Insignificant**
Frequency		**5**	**4**	**3**	**2**	**1**
Very likely	**5**	Unacceptable	Unacceptable	Unacceptable	Unwanted	Unwanted
Likely	**4**	Unacceptable	Unacceptable	Unwanted	Unwanted	Acceptable
Occasional	**3**	Unacceptable	Unwanted	Unwanted	Acceptable	Acceptable
Unlikely	**2**	Unwanted	Unwanted	Acceptable	Acceptable	Negligible
Very unlikely	**1**	Unwanted	Acceptable	Acceptable	Negligible	Negligible

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Risk Classification

Risk Classification	Example of actions to be applied against each class
Unacceptable	**The risk shall be reduced at least to Unwanted regardless of the costs of risk mitigation**
Unwanted	**Risk mitigation measures shall be identified. The measures shall be implemented as long as the costs of the measures are not disproportional with the risk reduction obtained (ALARP principle, *as low as reasonably practicable*)**
Acceptable	**The hazard shall be managed throughout the project. Consideration of risk mitigation is not required**
Negligible	**No further consideration of the hazard is needed**

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Quantitative risk assessment (example)

- Identify and select risks to be quantified.

- Assign most likely, minimum and maximum figure for each frequency and consequence.

- Calculate the resulting risk estimate as a probability distribution (instead of a single figure) allowing presentation of e.g. 50%, 75% and 95% fractals for the risk.

Quantification is most suitable for estimation of the risk of economic loss to the owner and delay, but may in principle be used for all types of risk.