

RIAAT - A Software Tool for Probabilistic Cost and Risk Analysis



Linz, 15.07.2011

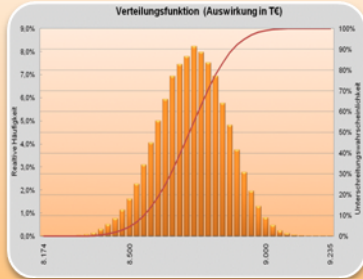
Philip Sander

Overview

1. Introduction
2. Modeling uncertainty
3. Structuring the Risk-Management-Process
→ software supported
4. Example (risk scenario)
5. Summary

1. Introduction

Risk Management



- Risk analysis → probabilistic
- Process moderation
- Workshops

Cost Management

Beschreibung	Menge	Einheit	Planned	Actual	Variance
Summe			1.000,00	1.000,00	0,00
Subtotal			1.000,00	1.000,00	0,00
Cost Breakdown			1.000,00	1.000,00	0,00
Material			1.000,00	1.000,00	0,00
Labor			0,00	0,00	0,00
Overhead			0,00	0,00	0,00
Contingency			0,00	0,00	0,00
Risk			0,00	0,00	0,00
Total			1.000,00	1.000,00	0,00

- Verification of planning costs
- Cost controlling
- Cost estimation (also probabilistic)
- Investigations of variants

Software Development



- Individual solutions for major projects
- Controlling tools
- Implementing guidelines

1. Introduction

PEP Project Cost Estimation Program



Projektstrukturplan

- OBB XX9999 TestProjekt 1 59,378 Mio. €
- OBB BAU.NA9999 TestProjekt 2 74,466 Mio. €
 - 01 Entwurfsplanung
 - 08 PM und Öffentlichkeitsarbeit 2,645 Mio. €
 - 09 Nicht aktivierbare Aufwendungen
 - 10 Liegenschaften 6,409 Mio. €
 - 11 Bauvorhaben 65,412 Mio. €
 - 11.01 Gesamte Freistrecke 65,412 Mio. €
 - 11.01.EFI Oberleitung 4,372 Mio. €
 - 11.01.ELU Energietechnikanlage 0,760 Mio. €
 - 11.01.KYI Telekom 1,744 Mio. €
 - 11.01.PBI Brückenbau 2,948 Mio. €
 - 11.01.PHI Hochbau 0,421 Mio. €
 - 11.01.POI Oberbau 15,571 Mio. €
 - 11.01.PPI Planung allgemein 0,193 Mio. €
 - 11.01.PSI Straßen- u. Wegenetz 6,318 Mio. €
 - 11.01.PUI Unterbau 26,718 Mio. €
 - Unterbauarbeiten allg. 10,182 Mio. €
 - Erdarbeiten Unterbau (8,354 Mio. €)
 - Alternative Erdarbeiten Unterbau 5,681 Mio. €
 - Durchlässe 2,013 Mio. €
 - Drainagen und Kanäle 0,956 Mio. €
 - Steinsätze 3,481 Mio. €
 - Steinschlüchtungen 0,194 Mio. €
 - Felsicherung 0,331 Mio. €
 - Dienstleistung 3,881 Mio. €
 - 11.01.SII Schaltanlagen 6,366 Mio. €

Kostenelement: Dienstleistung ID: 223

Basisdaten

letzte Änderung: 20.07.2010
Angelegt: 20.07.2010
Preisbasis: 01.01.2011

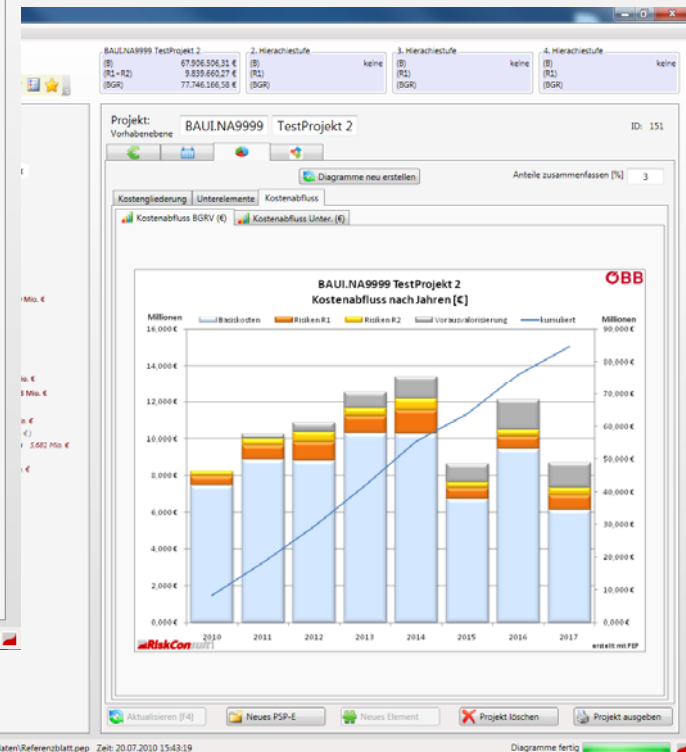
Elementkosten (€)

Basiskosten (B)	Unbekanntes (R1)	Plankosten (BGR)
B Element: 3.528.306,60	U Element: 352.830,66	BGR Element: 3.881.137,26
UR ^{Ek} =8: 2,91% (102.766,21)	U Errichter: 100,00% (352.830,66)	
UR ^B : 3,00% (102.766,21)	U Besteller: 0,00% (0,00)	
Sum. Positionskosten: 3.425.540,39	Alig [%]: 0,00 (0,00)	
UR ^{Ek} : 0,00% (0,00)	BG [%]: 0,00 (0,00)	
Pos.-Kosten o. UR ^{Ek} : 3.425.540,39	BG Anteil [%]: 0,00 (0,00)	

Positionen

Pos. Nr.	Positionenname	Menge	EH	EP [€]	u _R ^{Ek} [%]	Positionskosten [€]
001	Unterbau	15,00	%	10.182.028,19	0,00	1.527.304,23
002	Erdarbeiten	15,00	%	5.680.635,59	0,00	852.095,34
003	Durchlässe	15,00	%	2.012.981,00	0,00	301.947,15
004	Dänagen	15,00	%	956.397,34	0,00	143.459,60
005	Steinsätze	15,00	%	3.480.773,22	0,00	522.115,98
006	Steinschlüchtungen	15,00	%	193.585,53	0,00	29.037,83
007	Felsicherungen	15,00	%	330.535,08	0,00	49.580,26

- Program for cost estimation
- Used by Austrian Federal Railways (ÖBB)
- Applied:
 - Semmering base tunnel (27km long tunnel)
 - Summerauerbahn (Linz – Czech border)



1. Introduction



- Program for probabilistic cost and RA
- Applied:
 - Koralm base tunnel – RA cost estimation stage (32km long tunnel)
 - Hydro-electric power plants
 - Spullersee
 - Tauernmoos
 - New rail corridor lower Inn valley (TEN 1)
 - RA – construction stage
 - other projects

Risiko-Erfassung

Basissdaten
 Projekt: **BSP** Projektphase: **Ausführung** Risikozyklus: **001** Erfasser: **SSP** Datum aktuelle Erfassung: **22.10.2008** Risiko ID (fest): **OR_001_SSP_0036** Sortierer: **R013** Version speichern

Einzelrisiko | Aggregation

Identifikation | Maßnahmen | Bewertung | Auswertung

Eintrittswahrscheinlichkeit

Einzel auftretendes Risiko | Mehrfach auftretendes Risiko

Verbale Auswahl: **Durchaus möglich (15-30%)** EW min.: **15** EW erw.: **22.5** EW max.: **30**

Szenariounterscheidung und Wahrscheinlichkeit

Position: **Kompakt** Einheitspreis: **Kompakt**

Position	Anker	m	Menge			Funktion	Einheitspreis			Funktion	det. Summe	Szenario
			min.	erw.	max.		min. EP	erw. EP	max. EP			
Sonstige Aufwendu	PA	1	1	1	1	Rechteck	3000	3500	4500	Dreieck	3500	
Lohnkosten	Mh	40	85	190		Dreieck	5500	7000	10000	Rechteck	595000	
Zeitgebunden Kost	KT	0	1	4		Dreieck	11500	12000	15000	Dreieck	12000	

Kompaktbewertung | Detailbewertung

deterministische Summe: **137902,5**

Korrelation der Kostenpositionen

Mengen unabh. / Preise unabh. Mengen korreliert / Preise unabh. Mengen unabh. / Preise korreliert mit Mengen

Mengen unabh. / Preise korreliert Mengen korreliert / Preise korreliert Mengen korreliert / Preise korreliert mit Mengen

Speichern Daten für neues Risiko übernehmen Neues Risiko Risiko löschen Zurück

Risiko-Erfassung

Basissdaten
 Projekt: **BSP** Projektphase: **Ausführung** Risikozyklus: **001** Erfasser: **SSP** Datum aktuelle Erfassung: **22.10.2008** Risiko ID (fest): **OR_001_SSP_0036** Sortierer: **R013** Version speichern

Einzelrisiko | Aggregation

Identifikation | Maßnahmen | Bewertung | Auswertung

Auswertung aktuell: **64000** Simulationsdurchgänge: **64000** Simulation starten LHS Simulation

Verteilungsfunktion | Lorenzkurve

Verteilungsfunktion (Auswirkung in T€)

VaR5: 0
 VaR10: 0
 VaR20: 0
 VaR30: 0
 VaR40: 0
 VaR50: 0
 VaR60: 0
 VaR70: 0
 VaR80: 505,4
 VaR90: 846,1
 VaR95: 1057,9

Menge deterministisch
 Preis deterministisch

Speichern Daten für neues Risiko übernehmen Neues Risiko Risiko löschen Zurück

2. Modeling uncertainty

Risk assessment:

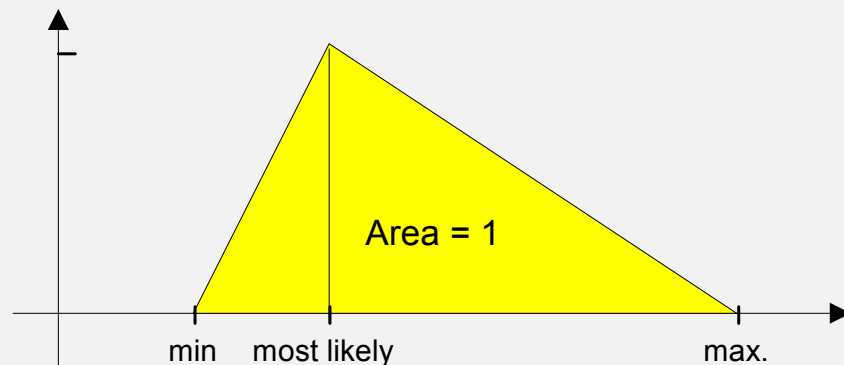
- Probability of occurrence (in %)
- Financial consequences (e.g. in €)

→ reality can be modelled better by using distribution densities than by using single deterministic figures

Deterministic method	Probabilistic method
➤ Single figure	➤ Values within a bandwidth
	➤ Additional weighting

Most cases: no statistical background → better using “simple” function → subjective probability

Example: The triangle function is easy to determine and offers flexibility in its shape



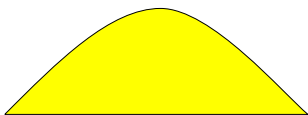
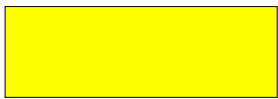
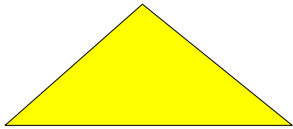
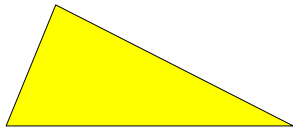
Advantages of triangle function:

- ✓ Three point estimate (minimum, most likely, maximum)
- ✓ Exact definition of min. and max.
- ✓ Easy handling of asymmetric shapes
- ✓ Requires no additional and complex input parameters (e.g. stand. deviation)

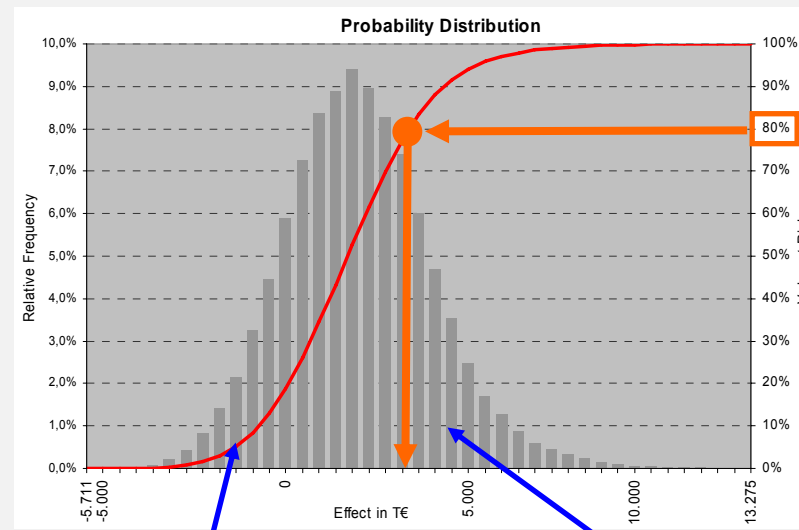
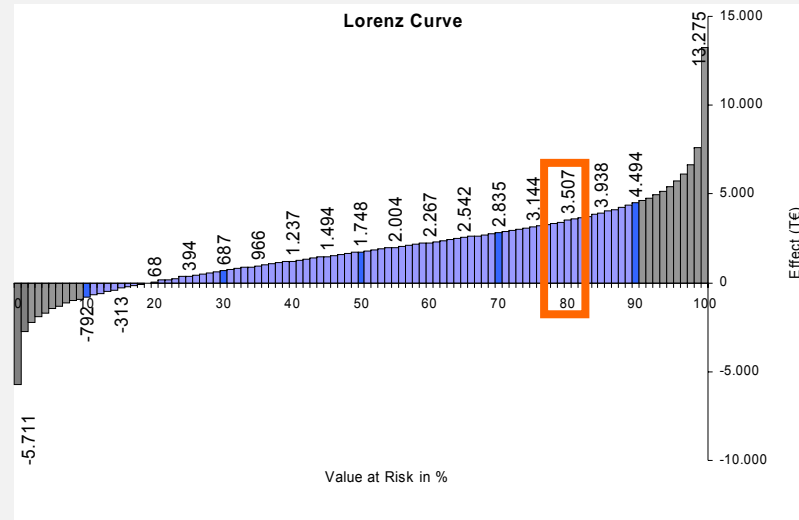
2. Modeling uncertainty

Aggregation of distributions density through simulation (Monte-Carlo-Simulation, Latin Hypercube Sampling)

Input:
probability
distributions



... other
distributions



Distribution function

Distribution density

Result:

Probability distribution
which displays the
overall risk potential.

Example:

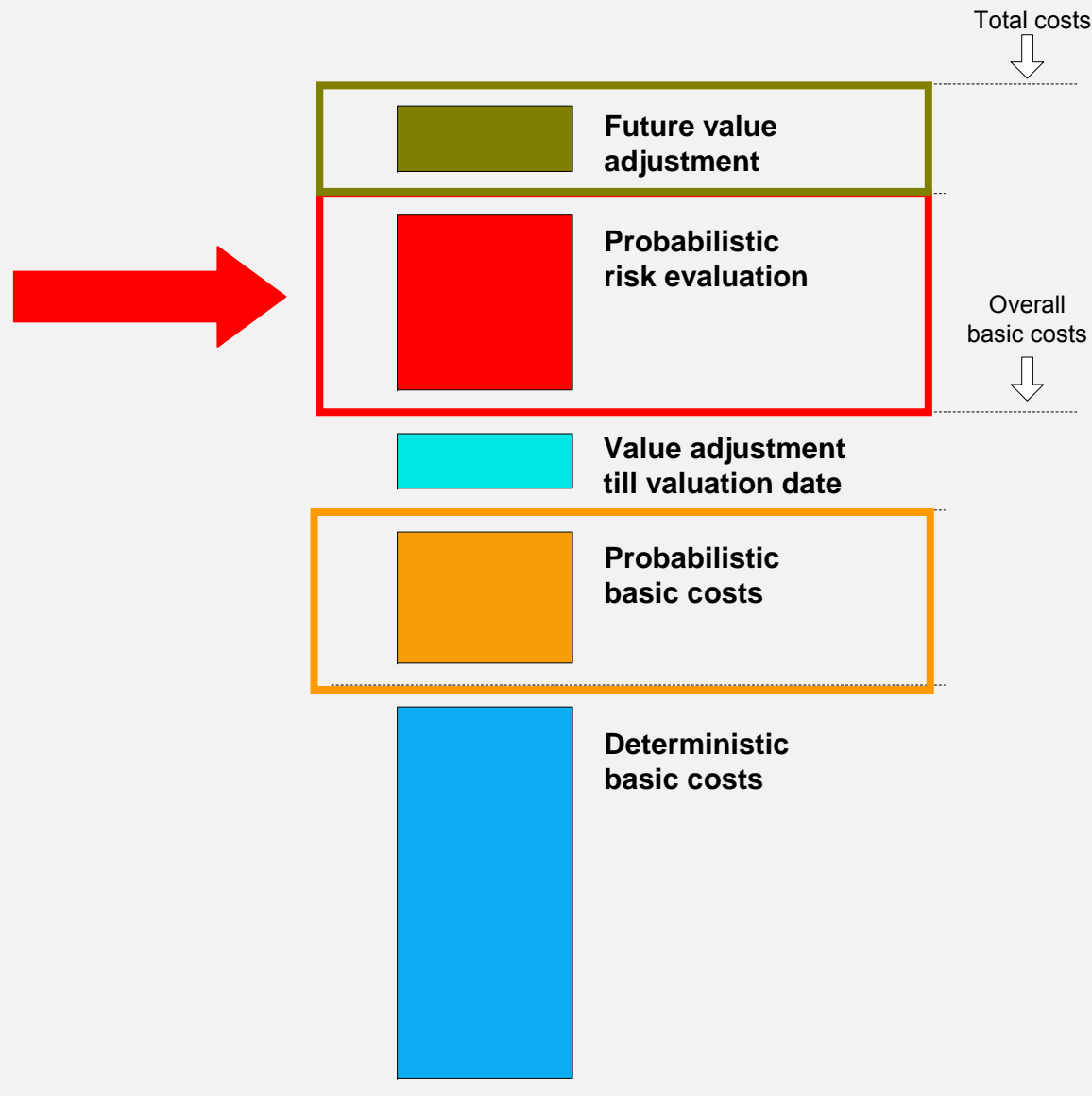
Cover 80% of the risk
potential
Choose Value at risk
(VaR) 80

Software support is
necessary!

RIAT
Risk Administration and Analysis Tool

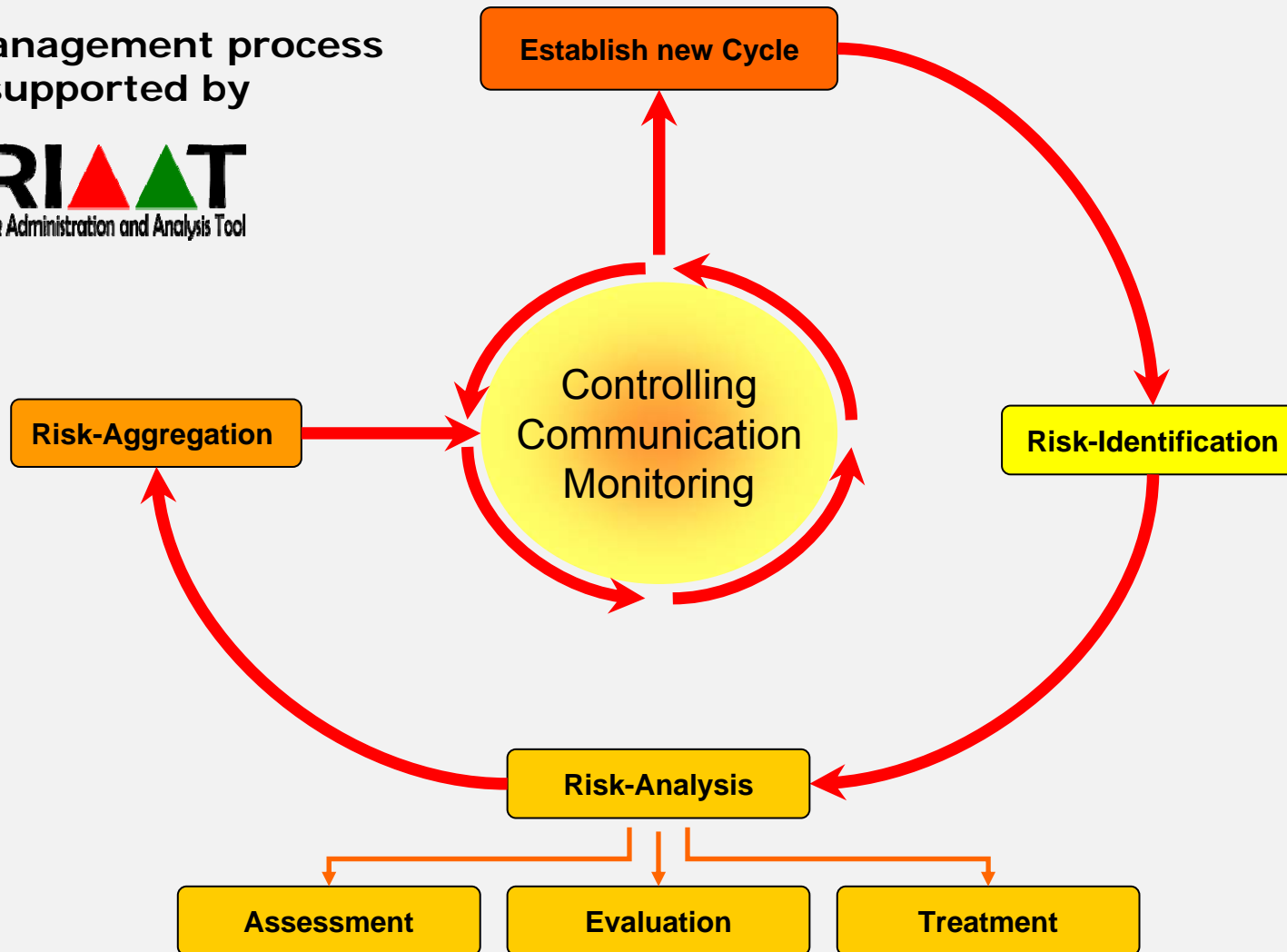
4. Structuring the Risk-Management-Process

Cost structure of an infrastructure project

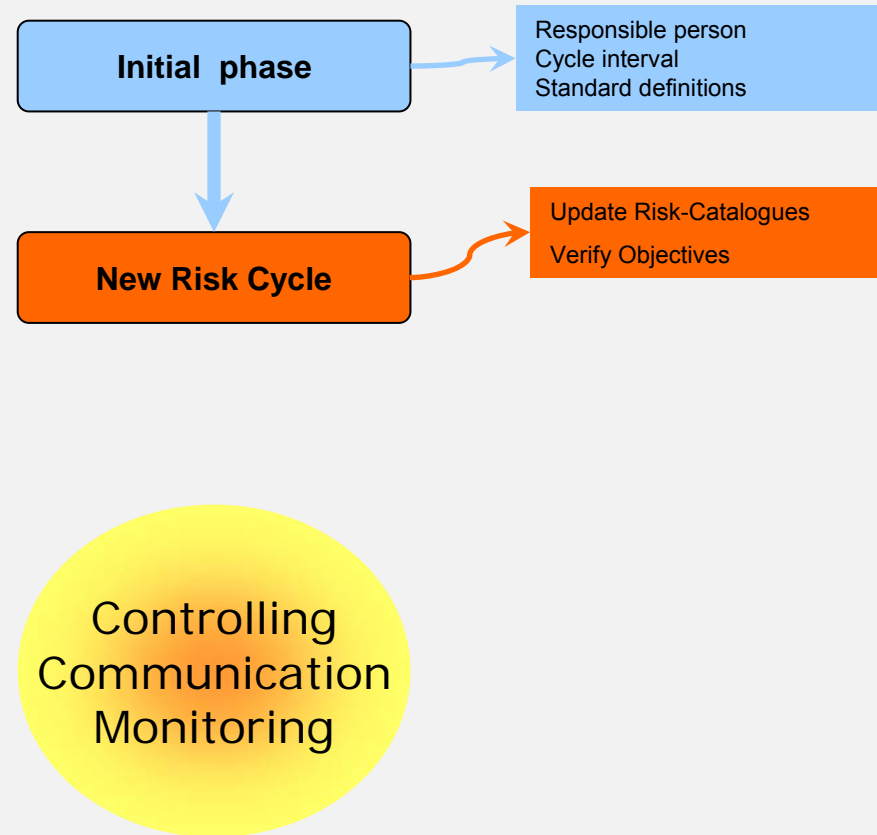


3. Structuring the Risk-Management-Process

Risk management process supported by



3. Structuring the Risk-Management-Process



Risk-Catalogues

- ▶ Differentiate risks
- ▶ Support Risk-Identification
- ▶ Aggregate similar risks to get a specific risk-potential

Different types of catalogues to identify and classify risks:

Themes

- ▼ Ground risks
 - ▼ Excavation pits
 - ▼ Deformations of drilled piles
 - ▼ Batter stability
 - ▼ TBM tunnelling
 - ▼ Driving problems TBM
 - ▼ Tubblings
 - ▼ TBM burying
 - ▼ TBM deadlock
 - ▼ NATM

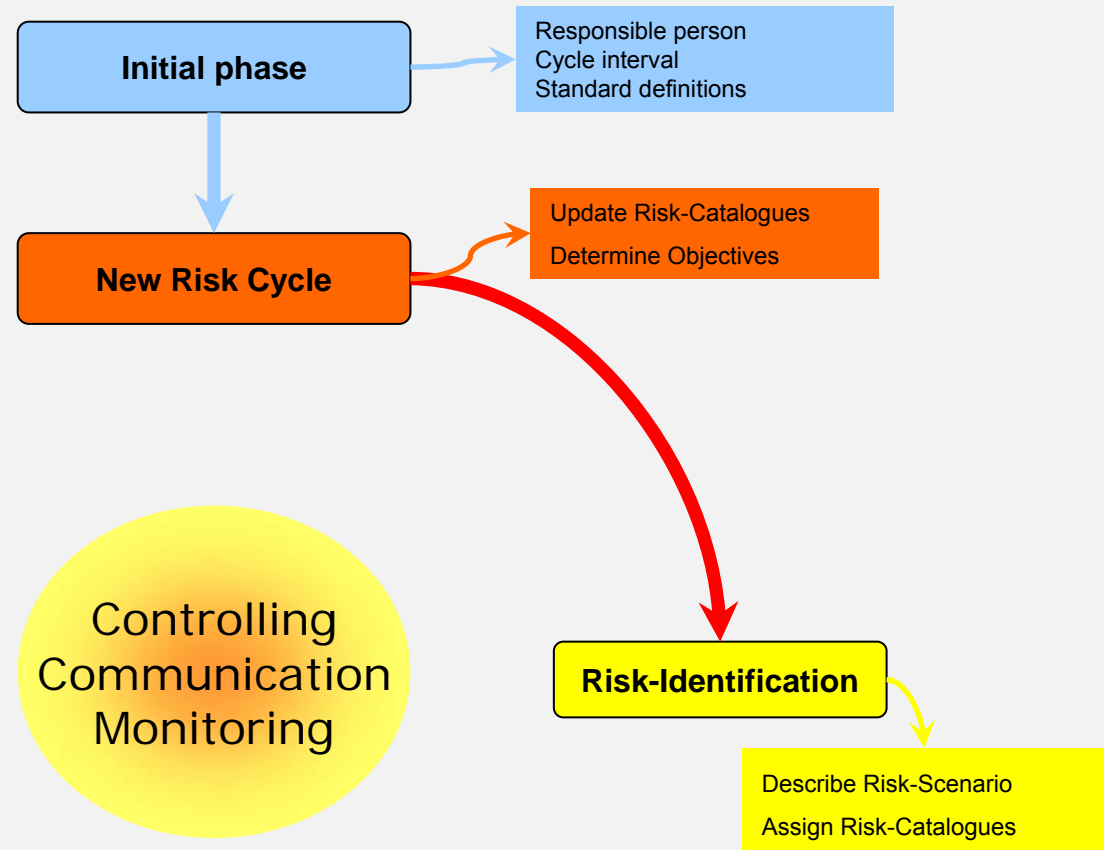
Geological

- ▼ Geological sections
 - ▼ North tube
 - ▼ N01
 - ▼ N02
 - ▼ N03
 - ▼ South tube
 - ▼ S01
 - ▼ S02
 - ▼ S03

Spheres

- ▼ Owner
- ▼ Client
- ▼ Contractor

3. Structuring the Risk-Management-Process



3. Structuring the Risk-Management-Process

Project data

Risk-Identification

Risk-Aquisition

Base Data		Phase	Risk Cycle	Editor	Date	Risk ID	Sort No.	Save version
Project	Example	Planning	001	SSP	18.02.2009	OR_001_SSP_0002	R001	Versions

Single risk | Aggregation

Identification | Measures | Quantitation | Evaluation

Risk-Identification

Description (short)
Personal qualification and productivity

Scenario description

Risk-Identification
Scenario-Description

Pre risk indications

Description Source of values: Det. Sum | Scenarios | Bandwidth in % | empty

SAVE | Copy data to new Risk | New Risk

Catalogue selection

Risk-Catalogues

Themes | Tunnel sections | Sphere | Editor | - | - | - | -

Catalogues

Catalogue: Themes

01-01-00-00	2	Personal
01-02-00-00	2	Finance
01-03-00-00	2	Technics
01-04-00-00	2	Geology
01-05-00-00	2	Politics

Assign catalogue elements

Description

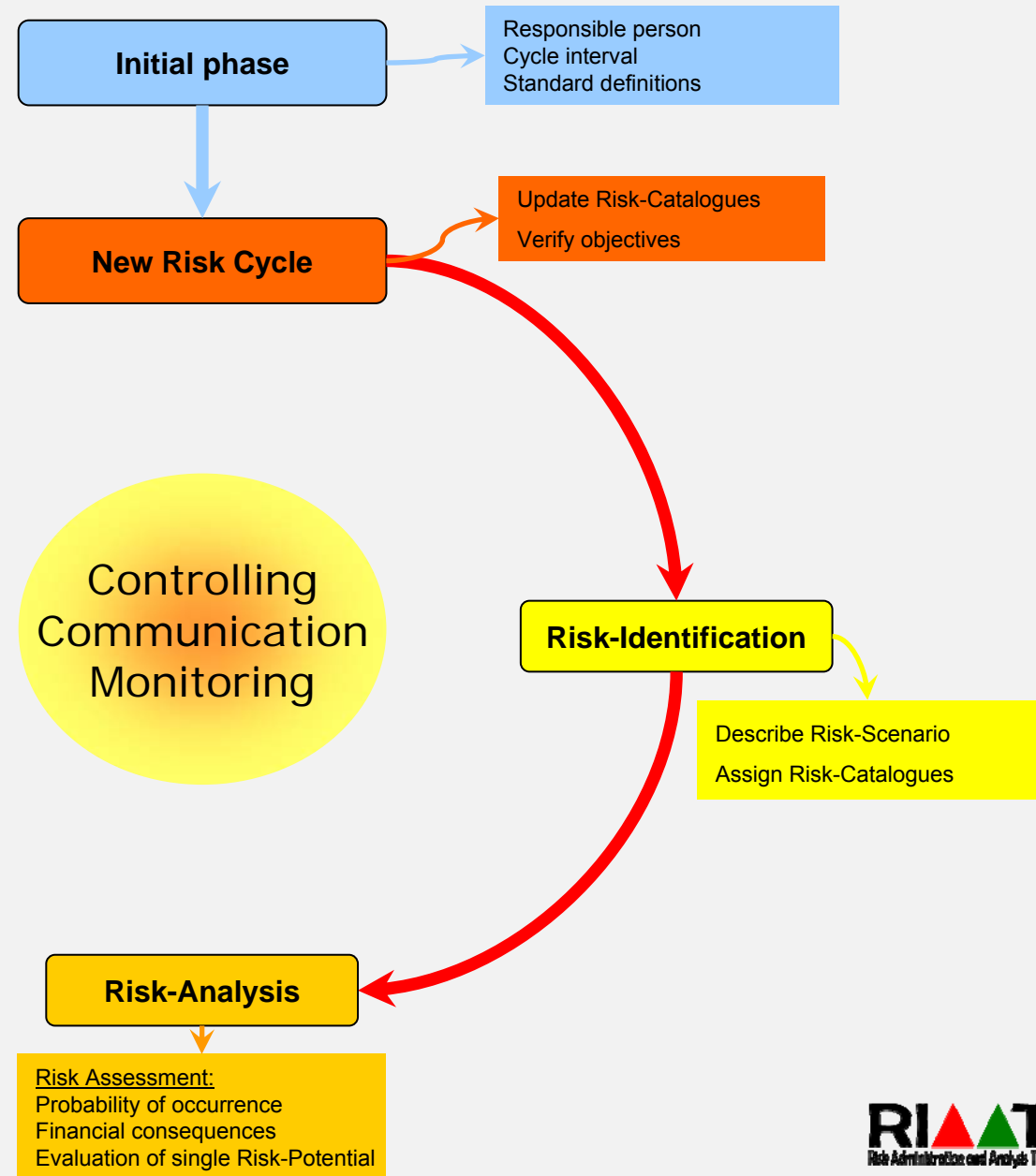
Apply element | Delete element | Empty list

Applied elements

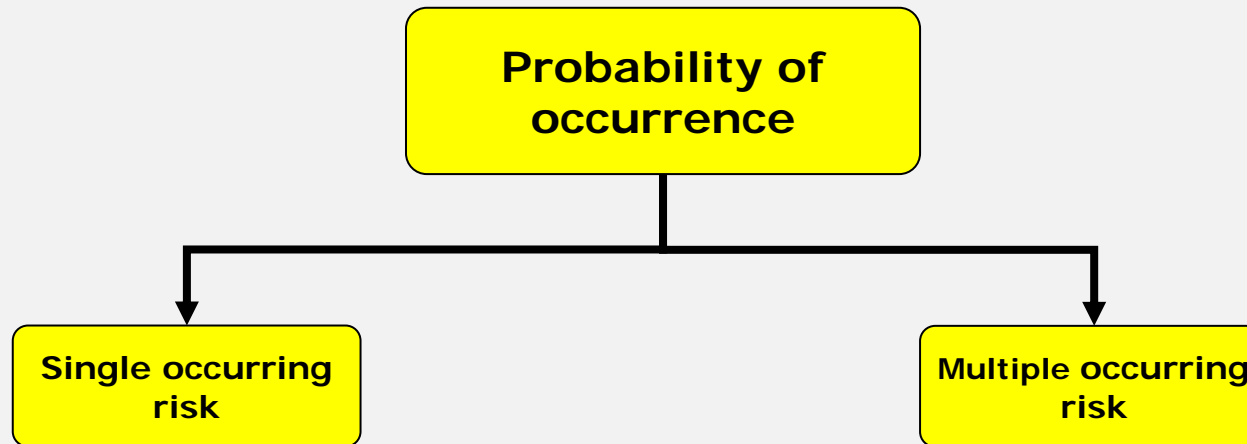
01-01-00-00	Personal
-------------	----------

BACK | Apply

3. Structuring the Risk-Management-Process



3.a Details of Risk-Analysis



Input:

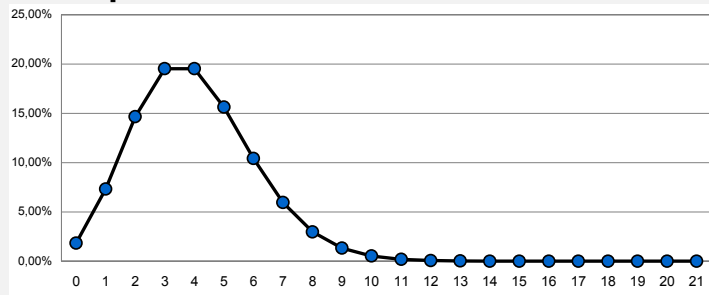
Standard value for probability between 0 and 100%

Events of similar nature can occur within a section several times at different locations.

Examples:

- cave-ins in tunnelling (e.g. 4 times in 1000m)
- replacement of defective segments of lining
- correction of surface imperfection in road construction

Example: Poisson distribution $\lambda=4$

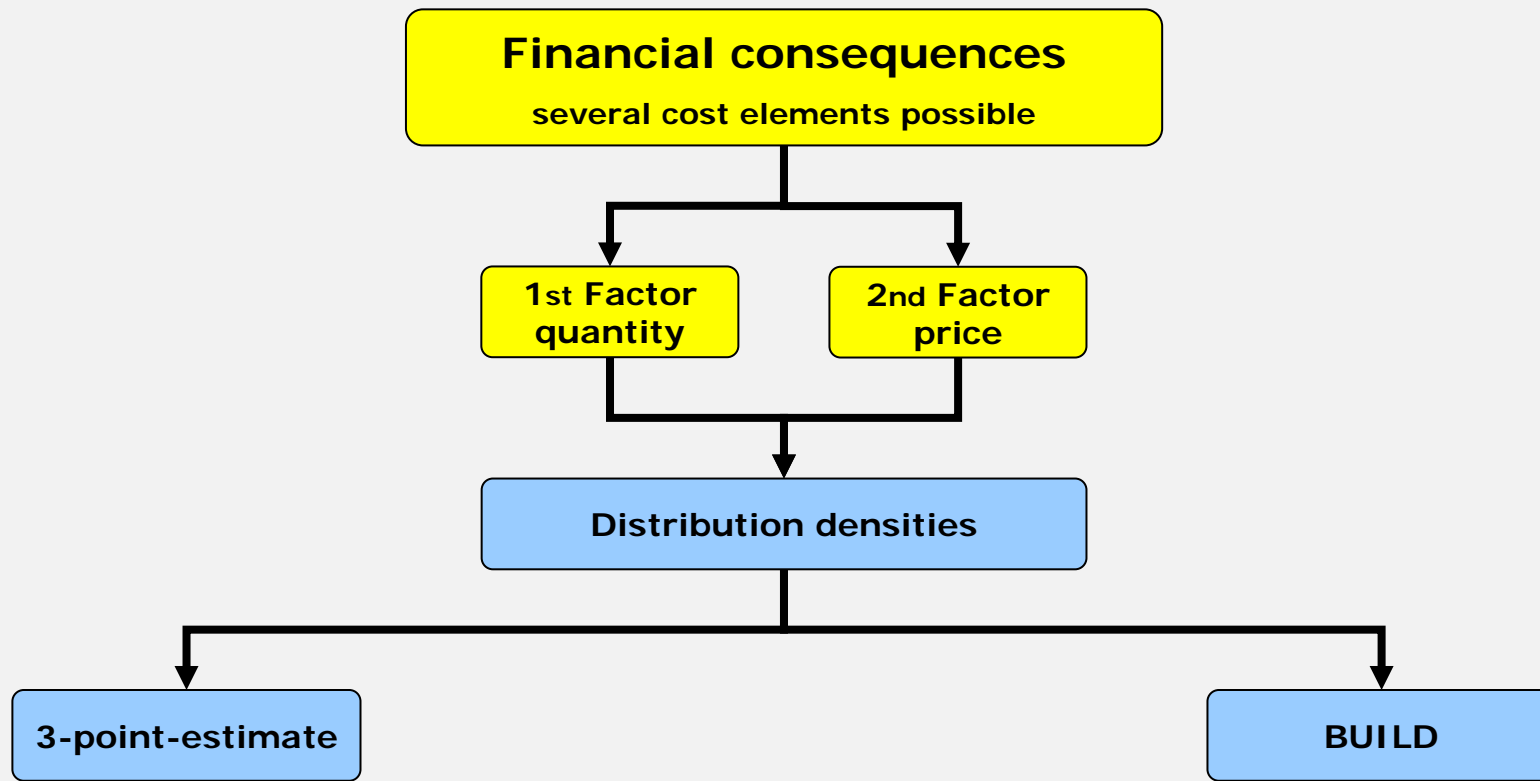


Input: average rate of event occurrence

Poisson distribution to calculate the possible scenarios

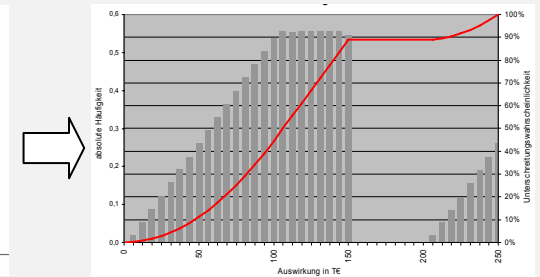
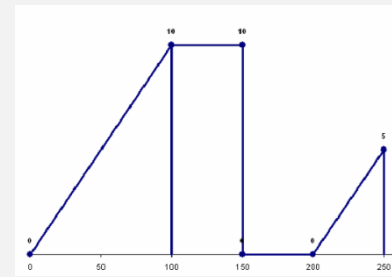
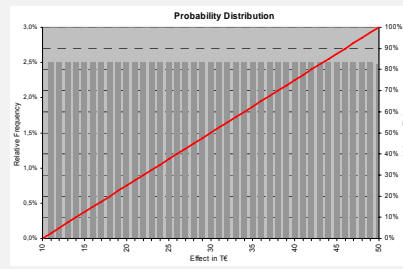
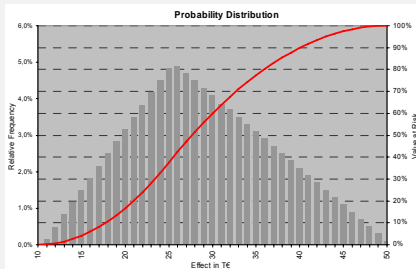
Output: probability for possible number of events

3.a Details of Risk-Analysis



(minimum, most likely, maximum)
 → Triangle, Beta-PERT, Uniform

Offers more flexibility
 Free in modeling distribution densities



3.a Details of Risk-Analysis

Example:
Deformations of drilled piles

Risk Aquisition

Base Data
 Project: Example Project Stage: Planning Risk Cycle: 001 Typist: PHS Date: 17.02.2009 Risk ID: Example_001_PHS_0042 Sort Nr.: 53

Einzelrisiko Aggregation

Identification Measures Quantitation Evaluation

Probability of occurrence
 Single occuring Risk Multiple occuring risk

Verbal expression: Likely P min.: 15 P ml.: 22,5 P max.: 30

Financial consequences
 Compact assessment Detailed assessment

clear

Position: Anchors Unit: m

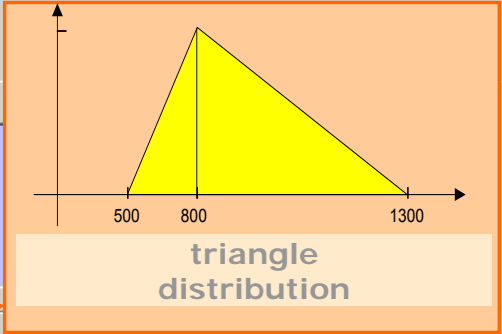
New Entry Overwrite Delete

Quantity
 Compact BUILD

min. Quantity: 500 ml. Quantity: 800 max.: 1300
 Triangle

Price
 Compact BUILD

min. Price: 15 ml. Price: 21 max. Price: 30
 Triangle



Position	Unit	Factor 1 (Quantity)			Function.	x	Factor 2 (Price in €)			Function.
		min.	ml.	max.			min.	ml.	max.	
Anchors	m	500	800	1300	Triangle		15	21	30	Triangle
Labour	h	50	80	130	Triangle		25	30	35	Triangle
Running costs of site	d	0	2	5	Triangle		7500	7700	8000	Triangle
Planing costs	h	10	15	25	Triangle		50	60	70	Triangle

Correlations

Quantities indep. / Prices indep.
 Quantities corr. / Prices indep.
 Quantities indep. / Prices corr. to Quantities
 Quantities indep. / Prices corr.
 Quantities corr. / Prices corr.
 Quantities corr. / Prices corr. to Quantities

SAVE A Copy data to new Risk New Risk ◀ ▶ Delete Risk BACK

3.a Details of Risk-Analysis

Risk Report

Project Example	Token Example	Project stage Planning	Cycle 001	Due date cycle 22.07.2008	Typist SSP	Date 22.07.2008	Risk-ID OR_001_SSP_0013	No. R012
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Description (short) TBM deadlock		Type SINGLE RISK	Status OK
Risikobeschreibung inkl. möglicher Auswirkungen und Folgen TBM deadlock causes a standstill in tunnelling. The consequences will include time extension and additional costs.		Kataloge und Zuordnungen	
<div style="background-color: #e0ffe0; padding: 5px; text-align: center;">Risk-Identification description (verbal)</div>		Catalogue Group	01-05-01-00 Project Risks / Technical Risks / Ground Risks
		Sphere	Client
		Event sector	M11
		Contract section	1-K
		<div style="background-color: #e0ffe0; padding: 5px; text-align: center;">Catalogue assignment</div>	
		<div style="background-color: #e0ffe0; padding: 5px; text-align: center;">Classification</div>	

Measures		Classification	Iteration steps	Simulation method	Cost of measures included
Employing experienced personal	Earlier perception and identification of problems	Ranking (25 risks)	192.000	LHS	
Cost	80,0 T€	VaR			
Proper operation planning	Can help to deplete the risk	VaR5	108,0		3
Cost	28,0 T€	VaR10	108,0		7
		VaR20	328,0		3
		VaR30	471,0		2
		VaR40	606,0		2
		VaR50	740,0		2
		VaR60	886,0		2
		VaR70	1.057,0		1
		VaR80	1.271,0		1
		VaR90	1.587,0		1
		VaR95	4.646,0		1

Probability of occurrence		
<input type="checkbox"/> Single occurring risk	Probability of occurrence t (verbal)	minP erwP maxP
<input checked="" type="checkbox"/> Multiple occurring risk	Section	expected occurrence P [%]
	5,8km	2 86,5

Financial consequences		Quantity	Price in €
Function	min.	ml.	max.
Running costs of site [d]	Triangle	2	12
Labour costs [d]	Triangle	2	12

Function	min.	ml.	max.	Function	min.	ml.	max.	
Running costs of site [d]	Triangle	2	12	45	Triangle	11.500	12.000	13.000
Labour costs [d]	Triangle	2	12	45	Uniform	5.700	6.000	6.500

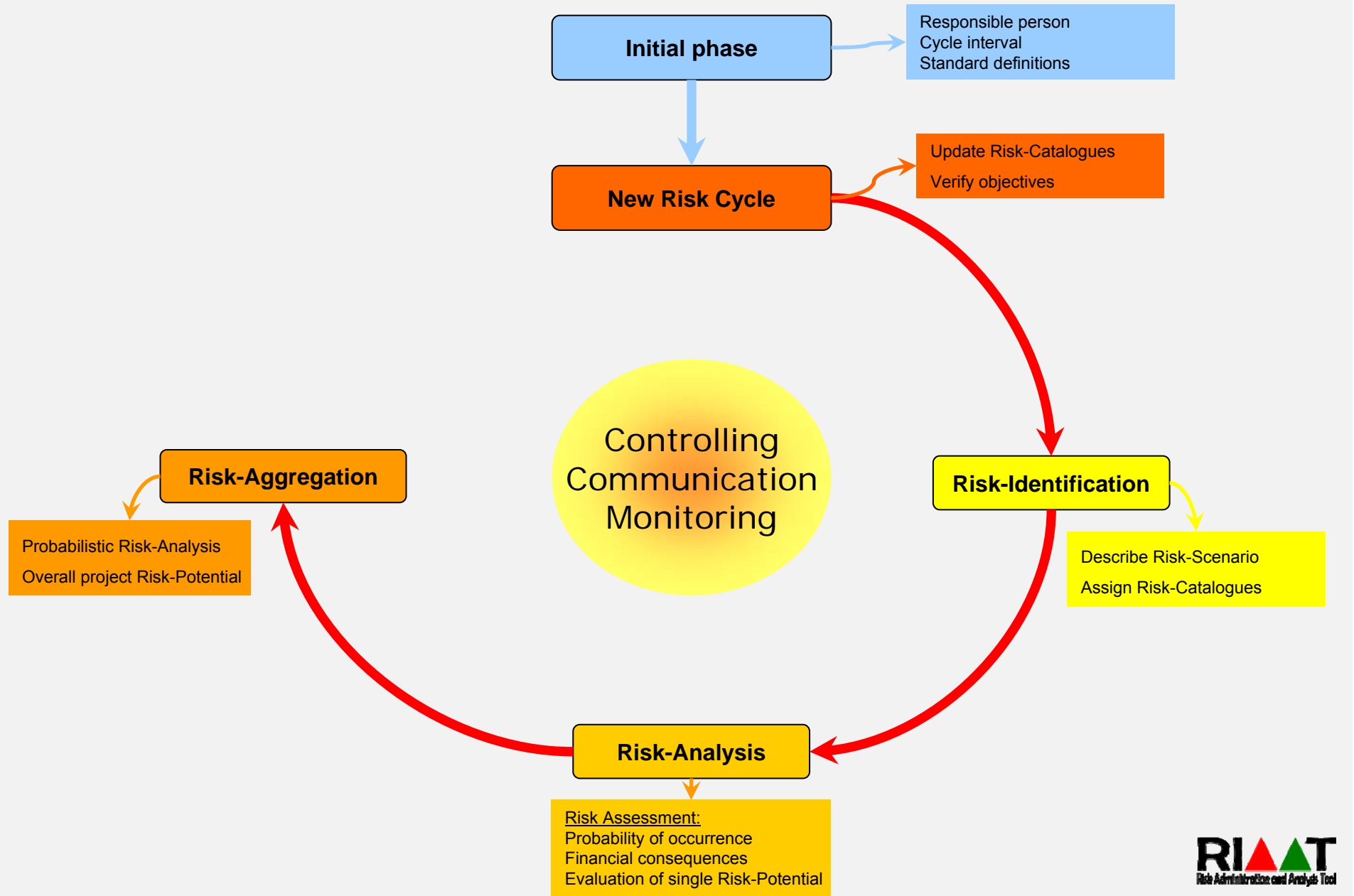
Risk-Assessment

Probability Distribution

Lorenz Curve

Correlation: Quantities correlated, Prices indep.

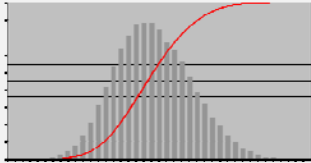
3. Structuring the Risk-Management-Process



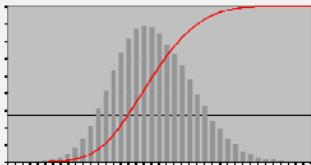
3. Structuring the Risk-Management-Process

Aggregation to overall Risk-Potential

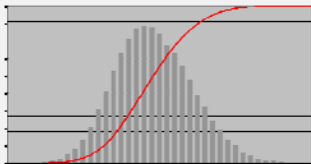
Excav. Pits



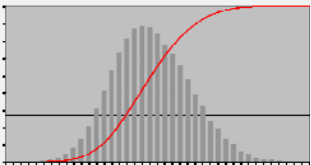
TBM



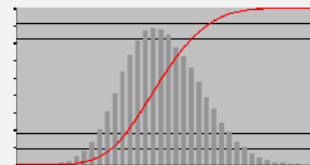
NATM



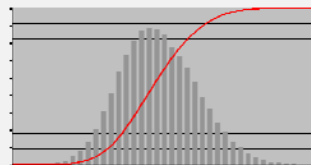
Ground risks



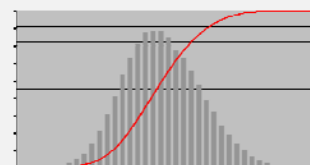
Client risks



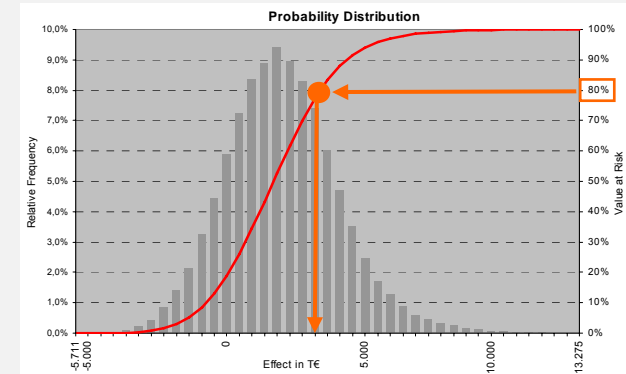
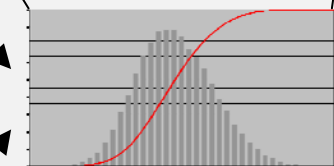
Other client risks



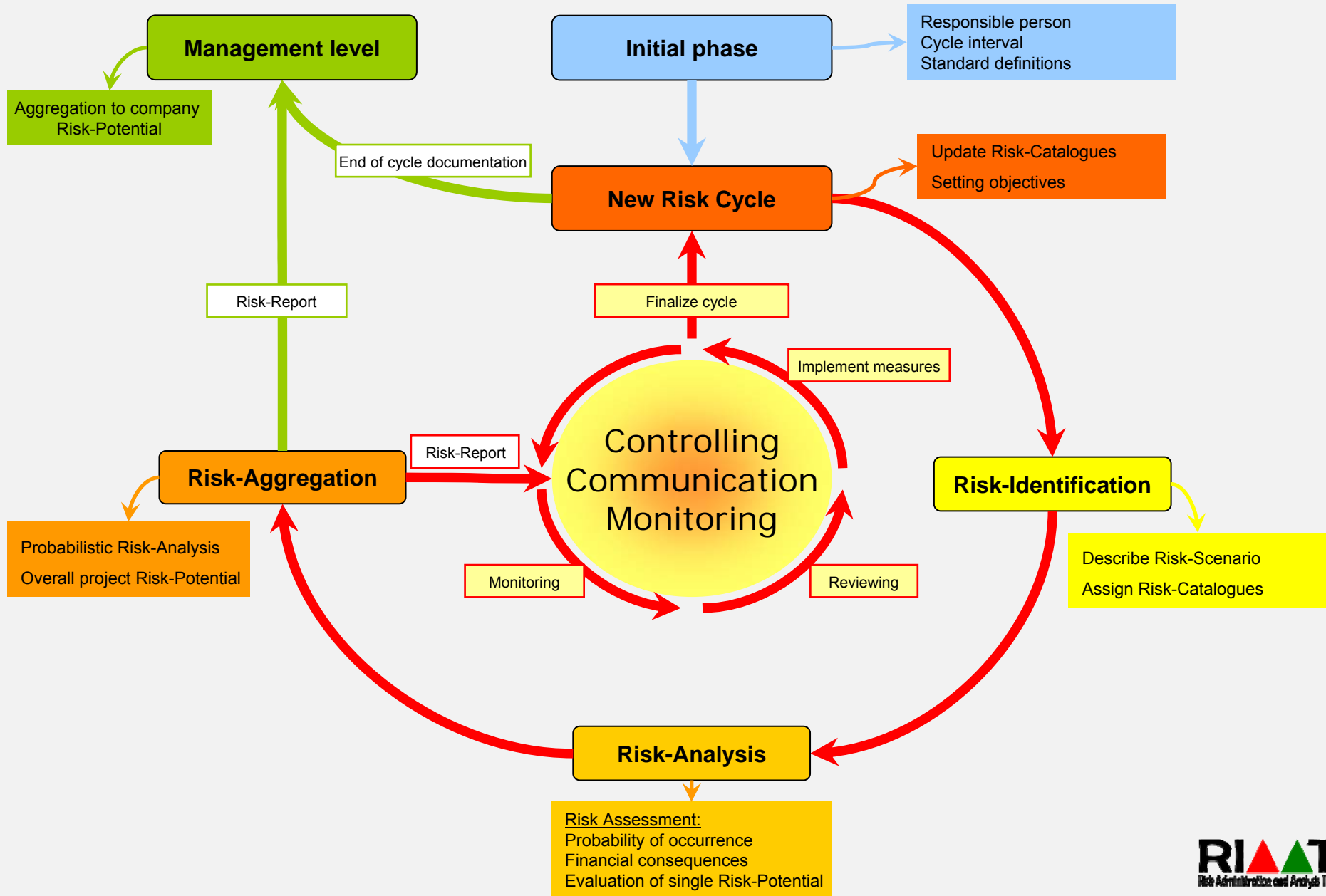
Contractor risks



Overall Risk-Potential



3. Structuring the Risk-Management-Process



Event Tree Analysis

Scenario:

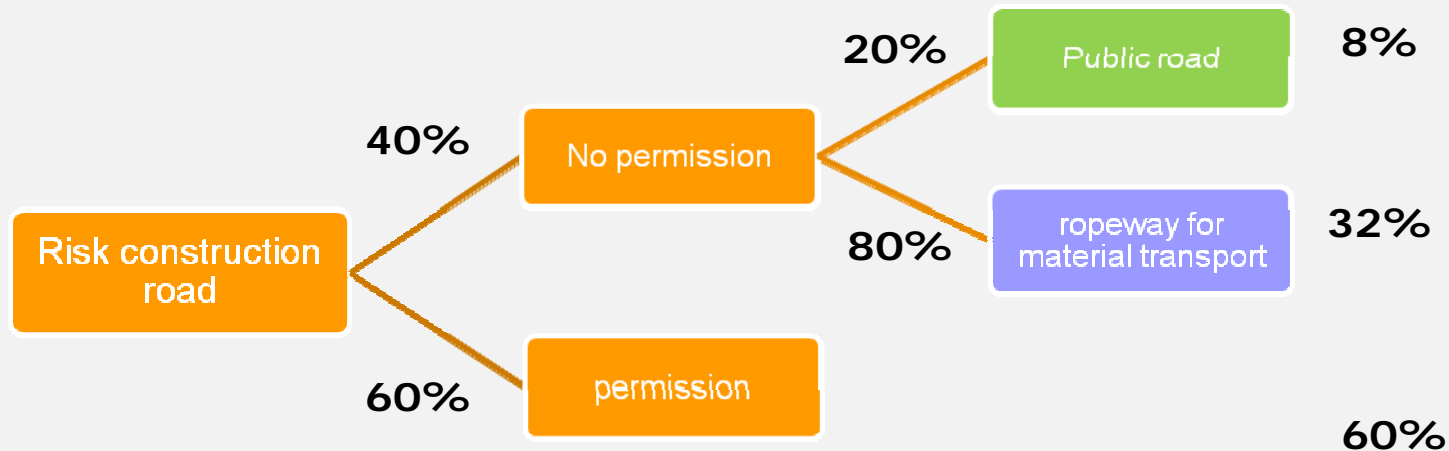
- construction road to a reservoir of a hydro-electric power plant
- 40% risk that the construction road will not be permitted (nature reserve)

→ in this case (risk does occur) → 2 alternatives:

1. extension of the existing public road to the reservoir
estimated probability for permission only 20%
2. no permission for the public road → new ropeway for material transport
most expensive scenario

The whole scenario can be modelled by an event tree.

4. Example



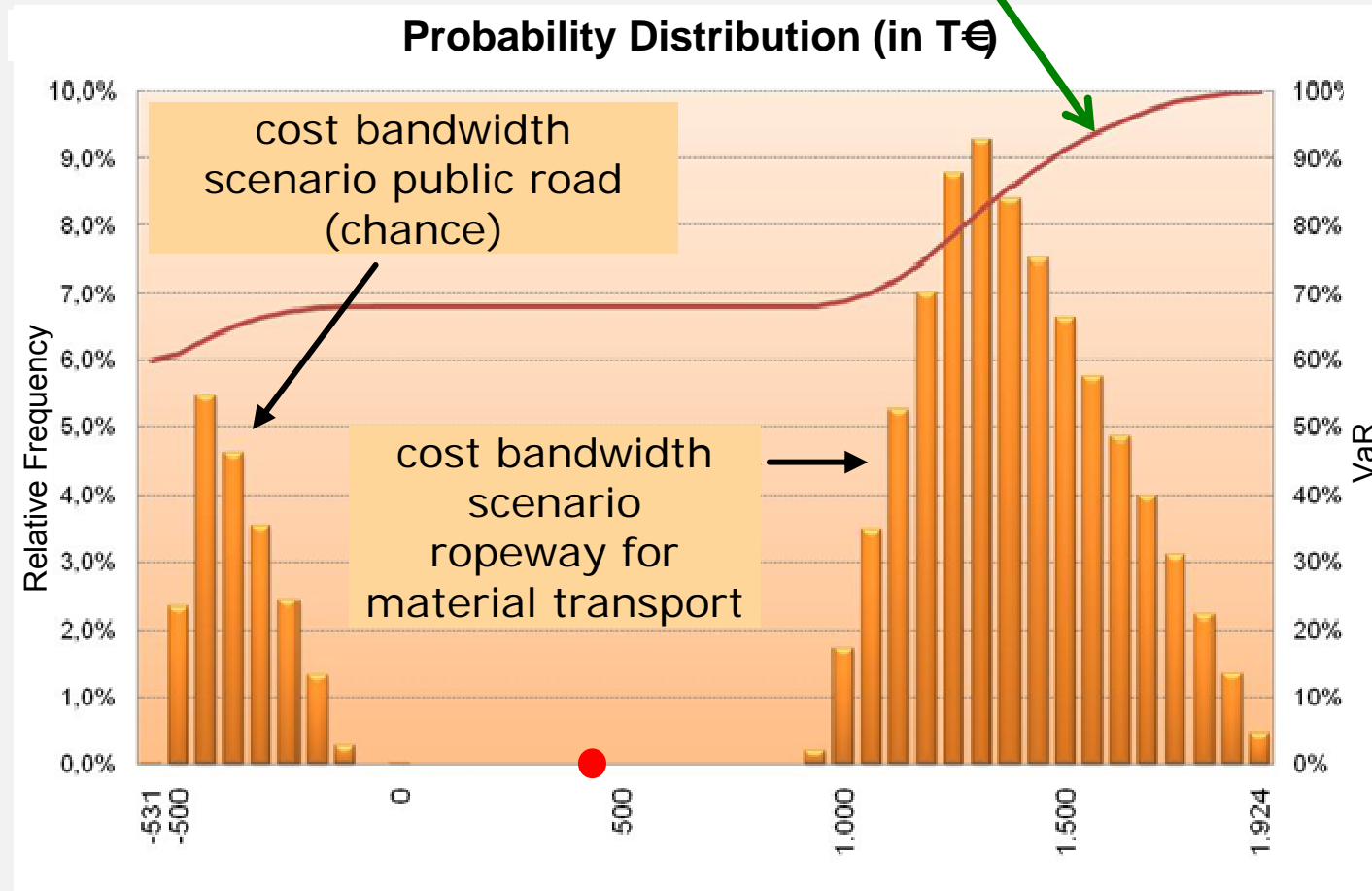
The costs of the construction road are estimated with 1.000.000 €.

If there will be no permission the costs for the construction road can be saved in the first step.

		triangle		
		min	ml	max
Omitted construction road	8%	-1.000.000	-1.000.000	-1.000.000
Extension of public road		467.500	550.000	880.000
Omitted construction road	32%	-1.000.000	-1.000.000	-1.000.000
ropeway for material transport		1.912.500	2.250.000	2.925.000

4. Example

After simulation the result is a probability distribution that displays the overall risk potential. There is a probability of 60% that the risk will not occur (see red distribution function).



deterministic approach:

$$8\% \times (-1.000.000\text{€} + 550.000\text{€}) + 32\% \times (-1.000.000\text{€} + 2.250.000\text{€}) + 60\% \times 0\text{€} \\ = 36.000\text{€} + 425.000\text{€} + 0\text{€}$$

461.000 € → won't occur in reality

5. Summary

Probabilistic Risk-Analysis:

- Modeling of reality: better by distributions densities than by a deterministic figure
- More information is transported if a range of values is not condensed into a single figure

Support through software Tool:



provides

- Standard for project structuring
- Standard for risk assessment und analysis
- Risk aggregation “Bottom-Up” → form project to company level
- Standard for structuring risk reports
- Revision control

5. Summary



- Developed particularly for the needs of construction projects
- Practically proofed

Applied in major projects:

- Koralm base tunnel – RA cost estimation stage (32km long tunnel)
- Hydro-electric power plants
 - Spullersee
 - Tauernmoos
- New rail corridor lower Inn valley (TEN 1)
RA – construction stage