



## Mathematical Evaluation of Risks/Chances

## General Contractor

- MAN Ferrostaal offers Industrial Services worldwide
- Specialised in the Design, Management and Turnkey Delivery of major Industrial Facilities
- Customised Industrial Project Development and Financing Concepts
- Sales, Service and Logistics for the Transport, Automotive, Print and other Industries
- Sales and Service Platform of the MAN Group



# I. How to evaluate a risk in the most simple way ?



**Through indication of a certain percentage of the calculation value:**

**Example:**

**Calculation value: 54,9 Mio €**

**Evaluation: 3,1% of 54,9 Mio € = 1,7 Mio € shall be calculated as risk provision.**

**=> Sales price: 56,6 Mio €**

## II. How can we do better ?



### Advantage:

Quantification of single risks is easier.

### Disadvantage:

Quantification of single risks is very imprecise and subjective.

Chances are not considered.

Item to be calculated	calculation value in €	possible risk percentage in €	possible risk amount in €	degree of probability in €	Risk evaluation in €
	1	2	3 = 1 * 2	4	5 = 3 * 4
132 kV cable	200.000,00	15,00%	30.000,00	70,00%	21.000,00
aux. Transformer 2,5 MVA	60.000,00	15,00%	9.000,00	70,00%	6.300,00
Bank Garantien	150.000,00	10,00%	15.000,00	100,00%	15.000,00
CAR	600.000,00	15,00%	90.000,00	100,00%	90.000,00
Electrical Equipment: Step up Tranformer / Generator circuit breaker, 6 kV Switchgear	2.850.000,00	15,00%	427.500,00	10,00%	42.750,00
Engineering	1.220.800,00	100,00%	1.220.800,00	15,00%	183.120,00
Erection Supervision, Commis	788.920,00	80,00%	631.136,00	20,00%	126.227,20
⋮	⋮	⋮	⋮	⋮	⋮
Gasturbinengenerator	35.840.000,00	10,00%	3.584.000,00	10,00%	358.400,00
⋮	⋮	⋮	⋮	⋮	⋮
Hermes / ECA	1.235.000,00	10,00%	123.500,00	100,00%	123.500,00
⋮	⋮	⋮	⋮	⋮	⋮
Transportation	1.621.220,00	15,00%	243.183,00	50,00%	121.591,50
⋮	⋮	⋮	⋮	⋮	⋮
<b>Subtotal:</b>	<b>54.891.063,00</b>				<b>2.024.741,60</b>

# III. How does the Monte Carlo Method work - Input



For all Elements of the cost control, the following assumptions are made:

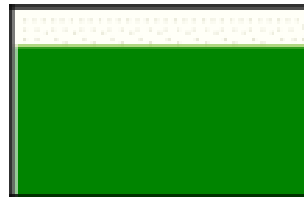
- Best Case
- Worst Case
- Inter-dependence between individual risks
- Determination of the appropriate distribution function for all values between Best and Worst Case



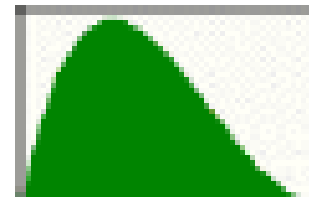
Normal



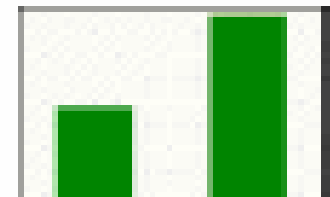
Triangular



Uniform



Beta



Yes-No

### III. How does the Monte Carlo Method work - Definition



#### Definition:

A random generator selects values between Best and Worst Case in accordance with the pre-determined distribution function for each individual risk.

Thousands of „Trials“ are calculated and thus produce a statistical picture of risks and chances.

### III. The Monte Carlo Method Example model



item to be calculated	Base case (calculated)	Best Case	Worst Case
	€	€	€
132 kV cable	200.000,00	150.000,00 €	250.000,00 €
aux. Transformer 2,5 MVA	60.000,00	30.000,00 €	90.000,00 €
Bank Garantien	150.000,00	100.000,00 €	200.000,00 €
CAR	600.000,00	500.000,00 €	700.000,00 €
Electrical Equipment: Step up Tranformer / Generator circuit breaker, 6 kV Switchgear	2.850.000,00	2.500.000,00 €	3.100.000,00 €
Engineering	1.220.800,00	1.100.000,00 €	2.400.000,00 €
Erection Supervision, Commissioning	788.920,00	600.000,00 €	1.500.000,00 €
Gasturbinengenerator	35.840.000,00	35.000.000,00 €	37.000.000,00 €
Hermes / ECA	1.235.000,00	150.000,00 €	1.400.000,00 €
Transportation	1.621.220,00	1.500.000,00 €	2.600.000,00 €
<b>Subtotal:</b>	<b>54.891.063,00</b>	<b>50.560.000,00</b>	<b>64.360.000,00</b>
Contingency	1.700.000,00		
<b>Total</b>	<b>56.591.063,00</b>		

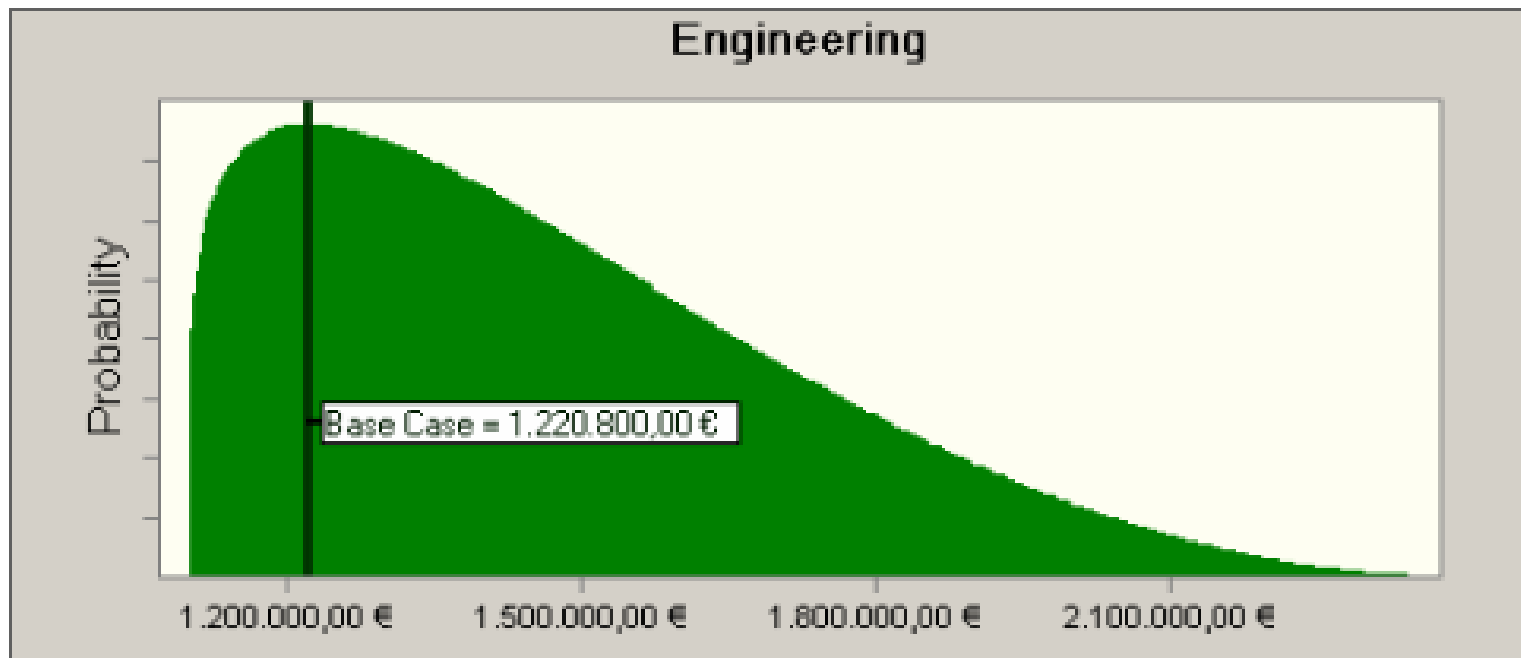
# III. The Monte Carlo Method

## 1. Example: Engineering



### Beta distribution with parameter

<b>Minimum</b>	<b>1.100.000,00 €</b>
<b>Maximum</b>	<b>2.400.000,00 €</b>
<b>Alpha</b>	<b>1,21512815</b>
<b>Beta</b>	<b>3,099992676</b>



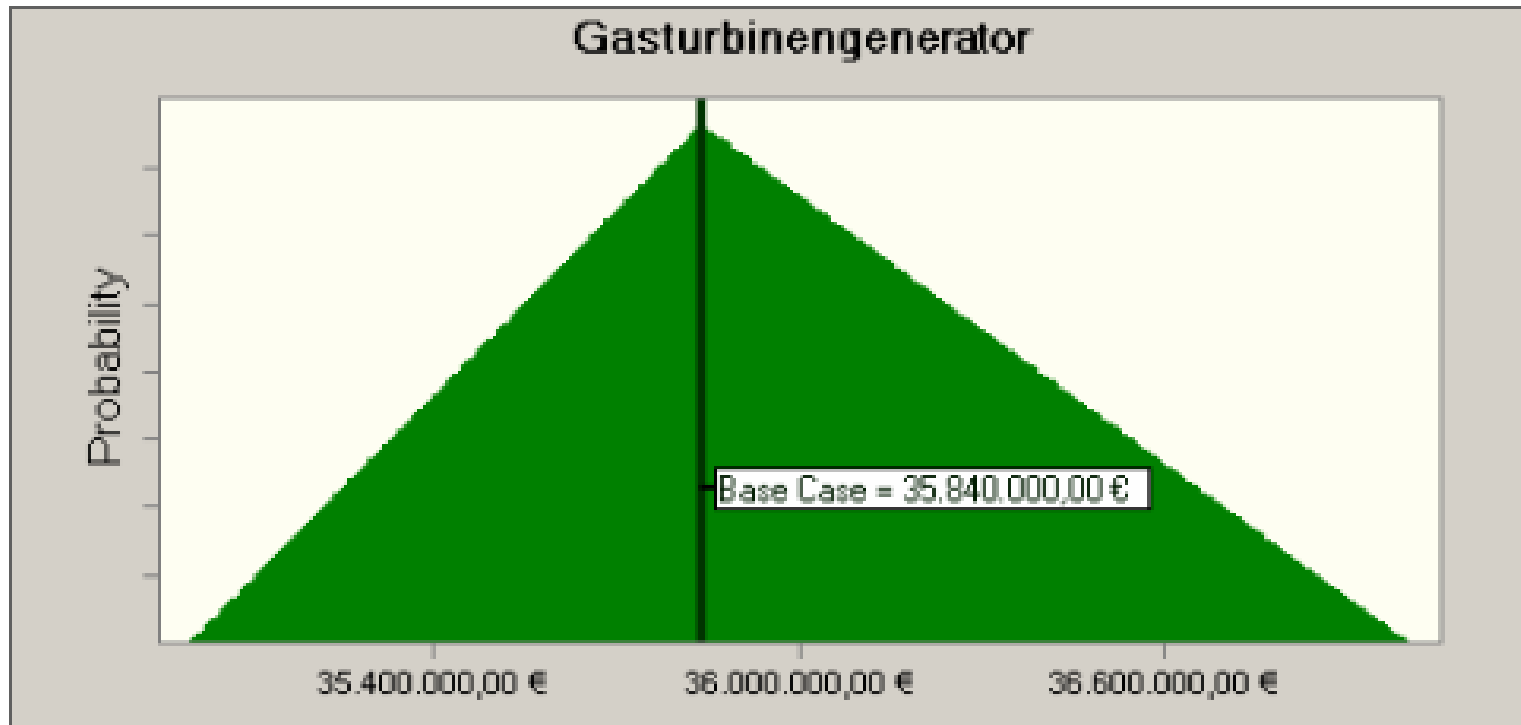
# III. The Monte Carlo Method

## 2. Example: Gas turbine



Triangular distribution with parameter

<b>Minimum</b>	<b>35.000.000,00 €</b>
<b>Likeliest</b>	<b>35.840.000,00 €</b>
<b>Maximum</b>	<b>37.000.000,00 €</b>



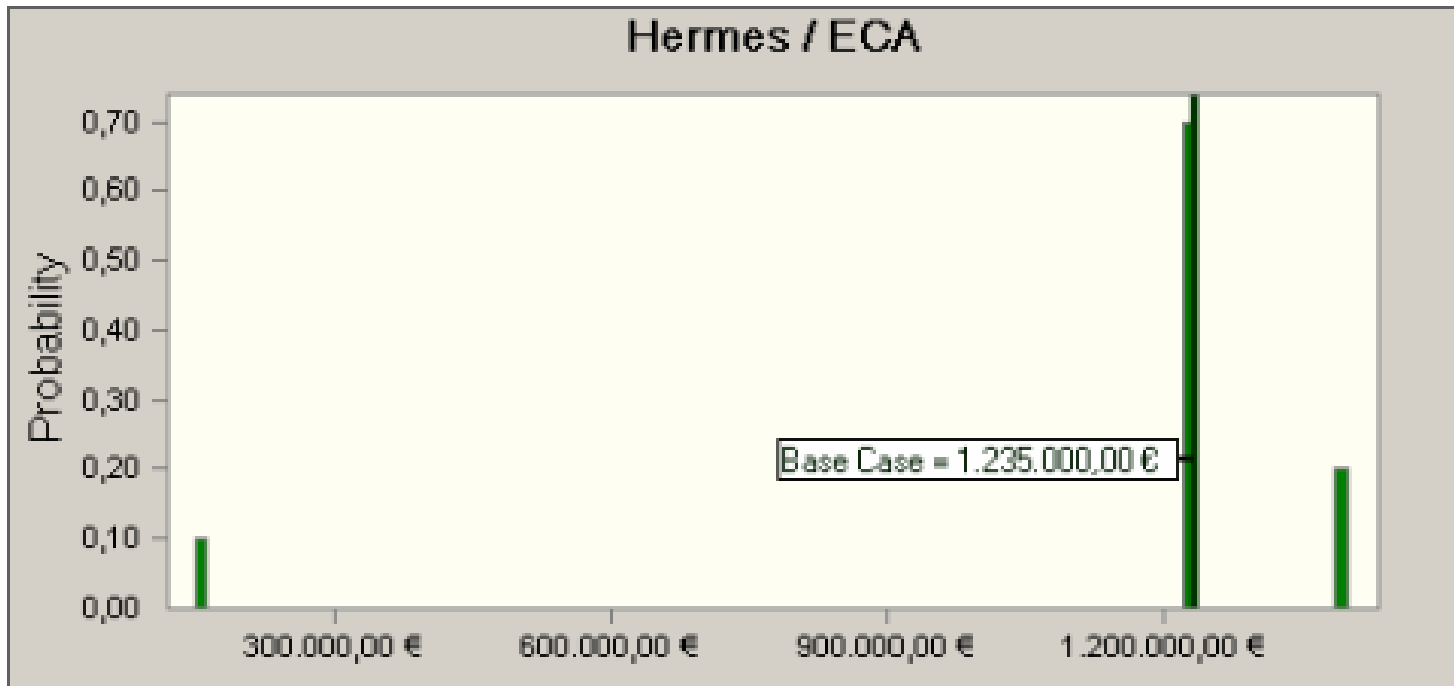
# III. The Monte Carlo Method

## 3. Example: Hermes export credit insurance costs



Custom distribution with parameter

<i>Value</i>	<i>Probability</i>
150.000,00 €	10%
1.235.000,00 €	70%
1.400.000,00 €	20%



# III. The Monte Carlo Method

## Result: 80% exactitude/safety factor



Traditional Method

Calculation value = 54,9 Mio €

Contingency 1,7 Mio €

Sales value = 56,6 Mio €

Median = 55,75 Mio €

**Minimum:**

55,24 Mio €

=>Calculation value is not achievable

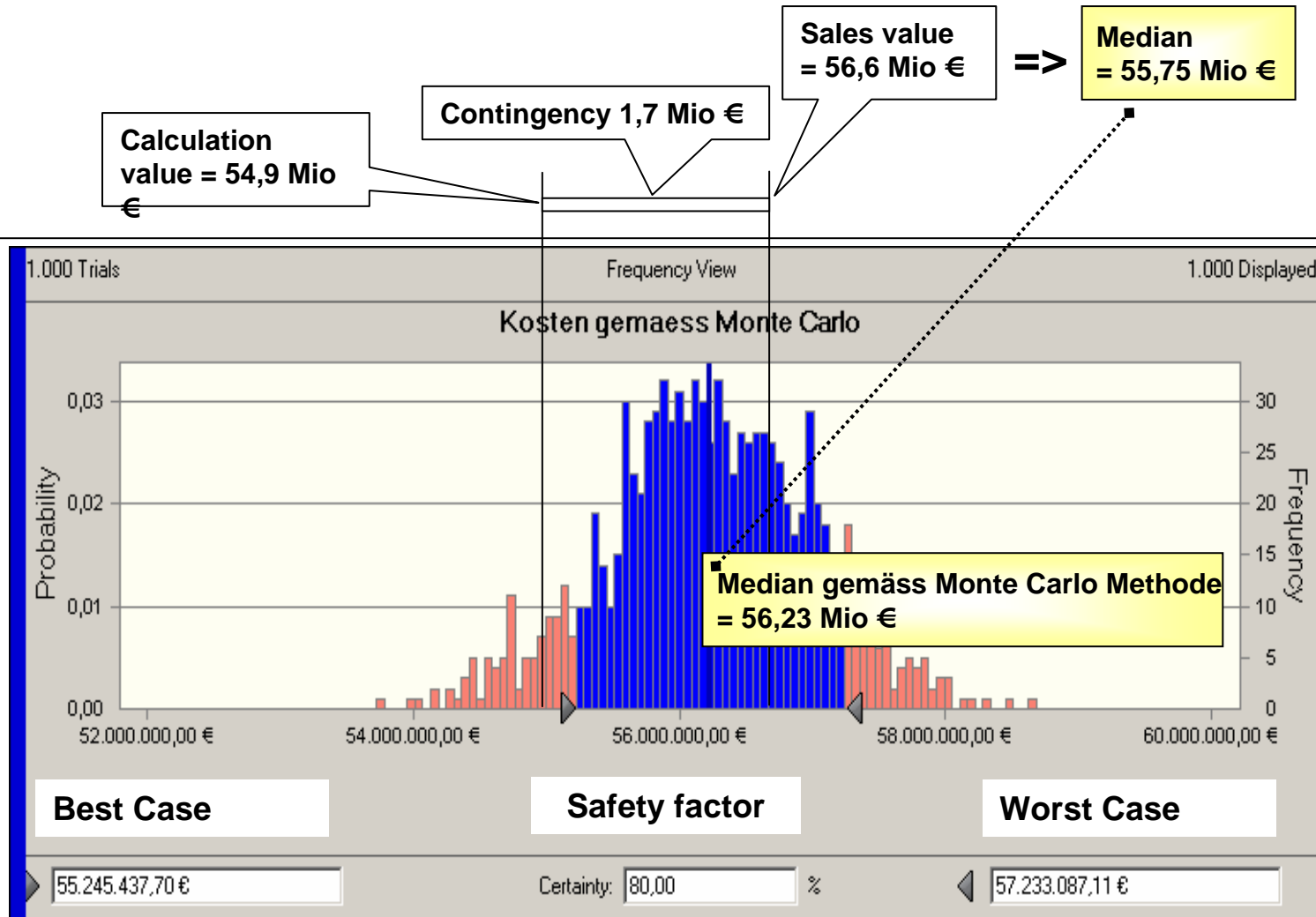
Monte Carlo Method

**Maximum:**

57,23 Mio €

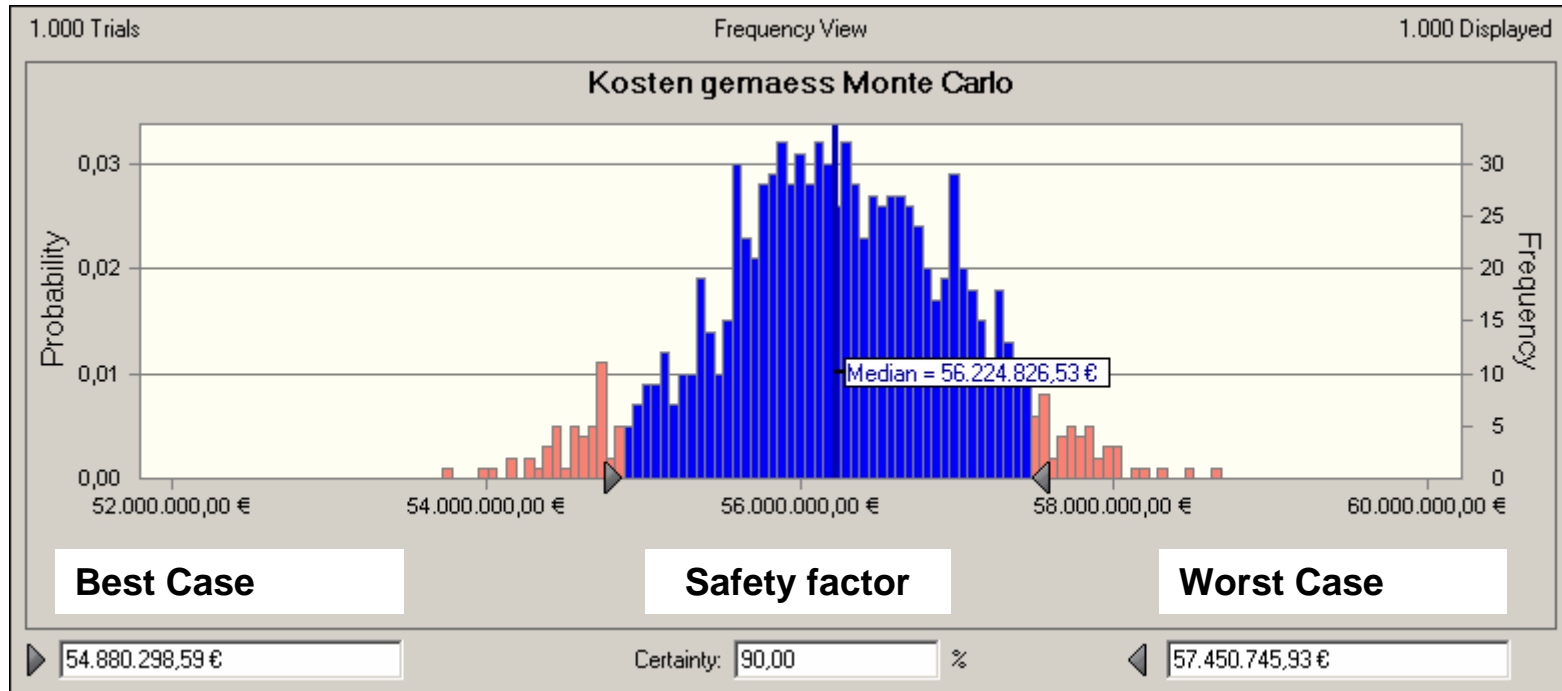
=>Contingency insufficient;

2,3 Mio € are required



# III. The Monte Carlo Method

## Result: 90% exactitude/safety factor



**Costs : 56,22 Mio €**

**-1,34 Mio €**

**+ 1,23 Mio €**

**Minimum: 54,88 Mio €**

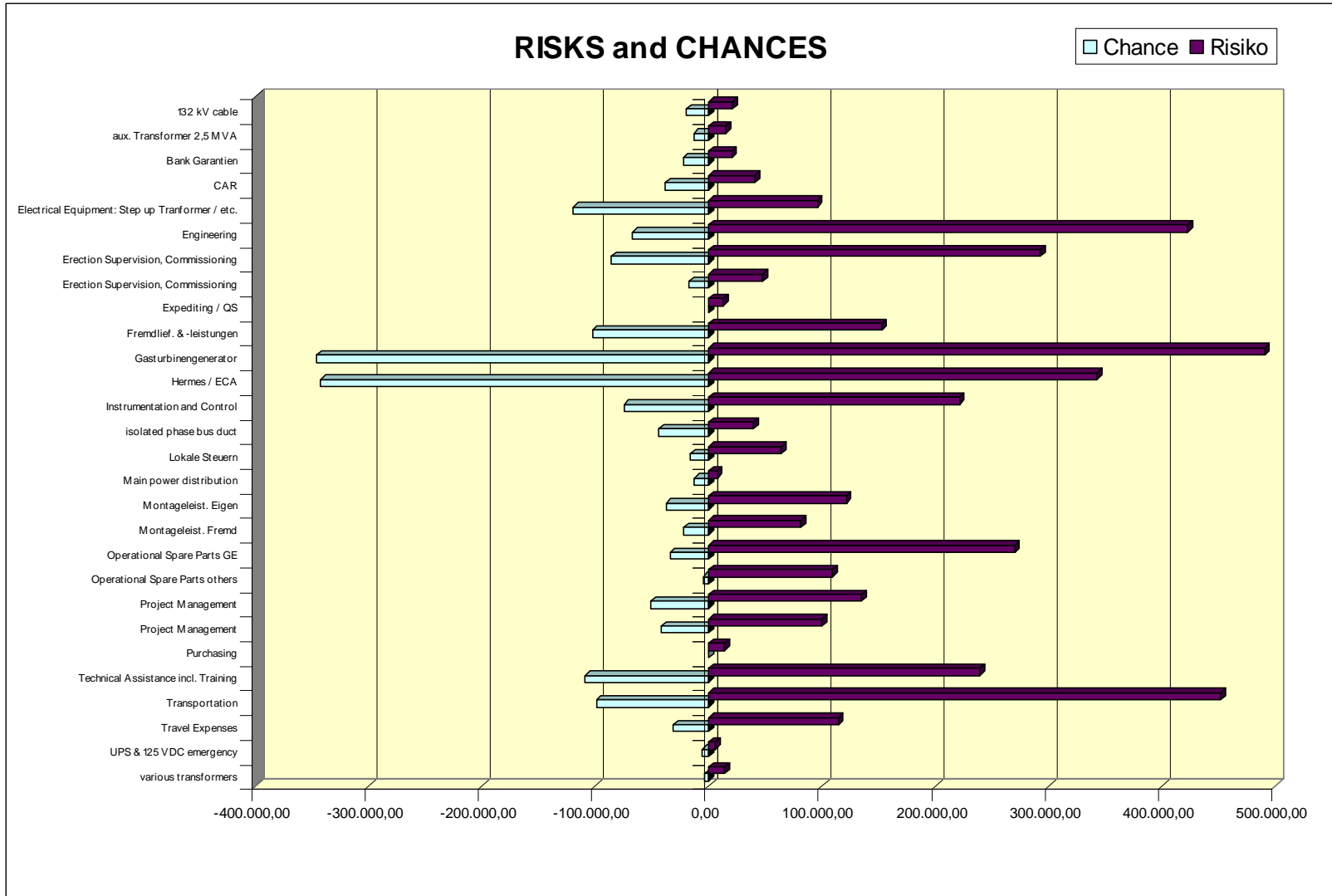
**=> Calculation value only achievable as Minimum!**

**Maximum: 57,45 Mio €**

**=> Contingency of 1,7 Mio € insufficient**

**=> De facto a Contingency of 2,5 Mio € required**




# III. The Monte Carlo Method Risk and Chances



# IV. The Monte Carlo Method






## possible distributions 1/2

**Table C.1 List of Crystal Ball distributions**

<i>Distribution</i>	<i>Conditions</i>	<i>Applications</i>	<i>Examples</i>
 Normal	<ul style="list-style-type: none"> <li>• Mean value is most likely.</li> <li>• It is symmetrical about the mean.</li> <li>• More likely to be close to the mean than far away.</li> </ul>	Natural phenomena.	People's heights, reproduction rates, inflation.
 Triangular	<ul style="list-style-type: none"> <li>• Minimum and maximum are fixed.</li> <li>• It has a most likely value in this range, which forms a triangle with the minimum and maximum.</li> </ul>	When you know the minimum, maximum, and most-likely values, <i>useful with limited data.</i>	Sales estimates, number of cars sold in a week, inventory numbers, marketing costs.
 Lognormal	<ul style="list-style-type: none"> <li>• Upper limit is unlimited; lower limit is zero.</li> <li>• Distribution is positively skewed, with most values near lower limit.</li> <li>• Natural logarithm of the distribution is a normal distribution.</li> </ul>	Situations where values are positively skewed, but <i>cannot</i> be negative.	Real estate prices, stock prices, pay scales, oil reservoir size.

# IV. The Monte Carlo Method possible distributions 2/2

**Table C.1 List of Crystal Ball distributions (Continued)**

 <p>Uniform</p>  <p>Discrete Uniform</p>	<ul style="list-style-type: none"> <li>• Minimum is fixed.</li> <li>• Maximum is fixed.</li> <li>• All values in range are equally likely to occur.</li> <li>• Discrete Uniform is the discrete equivalent of the Uniform distribution.</li> </ul>	<p>When you know the range and all possible values are equally likely.</p>	<p>A real estate appraisal, leak on a pipeline.</p>
 <p>Binomial</p>  <p>Yes-No</p>	<ul style="list-style-type: none"> <li>• For each trial, only 2 outcomes are possible; usually, success or failure.</li> <li>• Trials are independent.</li> <li>• Probability is the same from trial to trial.</li> <li>• The Yes-No distribution is equivalent to the Binomial distribution with one trial.</li> </ul>	<p>Describes the number of times an event occurs in a fixed number of trials, also used for Boolean logic (true/false or on/off).</p>	<p>Number of heads in 10 flips of a coin, likelihood of success or failure.</p>
 <p>Beta</p>	<ul style="list-style-type: none"> <li>• Minimum and maximum range is between 0 and a positive value.</li> <li>• Shape can be specified with two positive values, alpha and beta.</li> </ul>	<p>Represents variability over a fixed range, describes empirical data.</p>	<p>Representing the reliability of a company's devices.</p>

## **What is your experience with mathematical method versus**

**Considerations such as technology, quantities,  
prices, volatility, etc. and relatively little information  
regarding:**

- **Reliability of Technology**
- **Quantities – derived from engineering**
- **Prices – derived from quantities and number of quotations**
- **Volatility of project – in its particular environment (country, local, etc.)**

# MAN Ferrostaal AG

