



CONGRESO INTERNACIONAL DE  
**IV DISEÑO E**  
INGENIERÍA  
**NAVAL**

11 - 13 DE MARZO DE 2015

# COST ESTIMATION AND COST RISK ANALYSIS IN EARLY DESIGN STAGES OF NAVAL PROJECTS

Michael Rudio



INDEPENDENT  
NAVAL CONSULTANTS



# MTG | VORGES methodology



- Naval Design Agency for the consultancy of the contracting authority
- Planning and conception of surface naval vessels
- Independent consultancy without manufacturer interests
- Year of foundation: 1966



# Cooperation COTECMAR | ARC | MTG

Plataforma Estratégica de Superficie (PES)

Req.-Workshop → harmonized list of req's (2013)

Concept design PES V1  
incl. cost estimation (2014)

Calculation of numerical variants /  
development of an effectiveness model  
incl. cost estimation (2014/2015)

Comparison of results of different  
tools (2014/2015)

Selection of a numerical variant  
by ARC (2015)

Concept design PES V2 based on ARC's  
selection and modified req's  
incl. Cost estimation and cost risk  
analysis (2015)

Way ahead:

- Development of further conceptual designs in order to finalize functional requirements
- Transfer of technology and Know-How

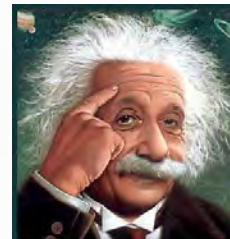


# Definition of Cost Estimation

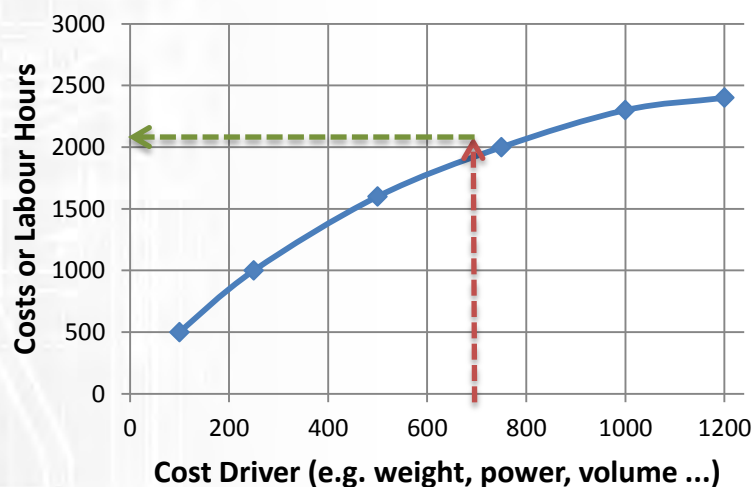
- Cost estimation is the **systematic elaboration** of costs based on the **available data** and the **most probable** costs at the time of estimation.
- Cost estimation is challenging in early stages of the project due to:
  - Lack of technical and cost data
  - New/undefined technologies
  - Unclear/changing requirements
  - Volatility of prices (oil, materials, labour rates...)
  - Inherent uncertainty in forecasts

# Famous Costing Techniques

**Expert opinion:**

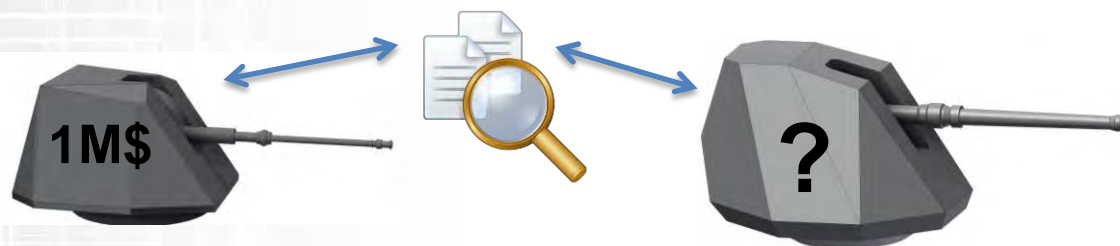


## Cost Estimating Relationship



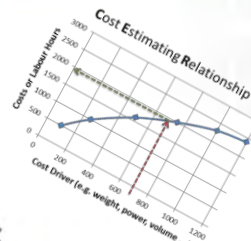
**Parametric:**

**Analogy:**

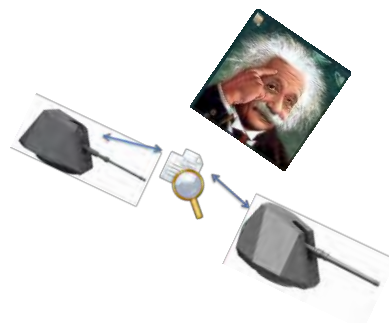


# Estimating Acquisition Costs

## 1. Platform



## + 2. Payloads



## + 3. Related costs

- Construction
- Management
- Software
- Logistic support
- ...

$$\int_a^b f(x) dx \approx \sum_{k=1}^{N-1} \frac{h}{2} [f_k + f_{k+1}] = h \left[ \frac{f(a) + f(b)}{2} + \sum_{k=1}^{N-1} f_k \right]$$

## = 4. Total costs

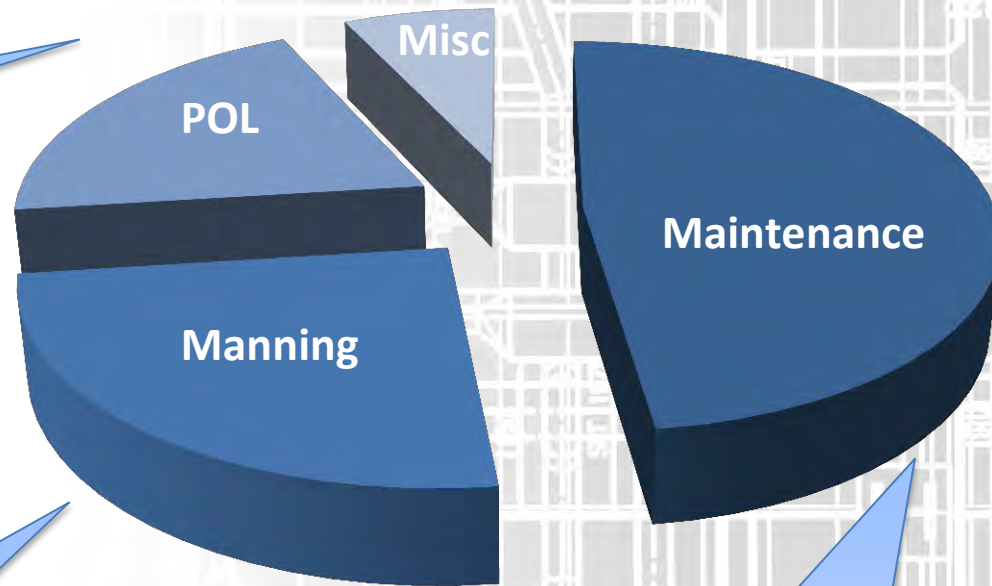




# Estimating In-service Costs

1. Use operational profile
2. Use technical data from main engines and electrical plant
3. Calculate fuel consumption
4. Combine results with actual and forecasted fuel prices

1. Use/establish manning concept
2. Use/define operational concept
3. Identify salaries and additional payments
4. Apply bottom-up calculation



1. Collect data from existing ships
2. Use regression techniques to discover relationships
3. Use analogies to compare old/new systems
4. Extrapolate data



# Cost Risk Analysis - Motivation

## Cost estimates are:

- required in (very) early project stages
- based on multiple assumptions and data sources
- **uncertain!**

→ Outcome of a cost estimation produces just one possible result.

***“Never try to walk across a river just because it has an average depth of four feet.”***

(Milton Friedman, American Economist/Statistician)

→ Don't believe in mean values or point estimates.

# Cost Risk Analysis - Goals

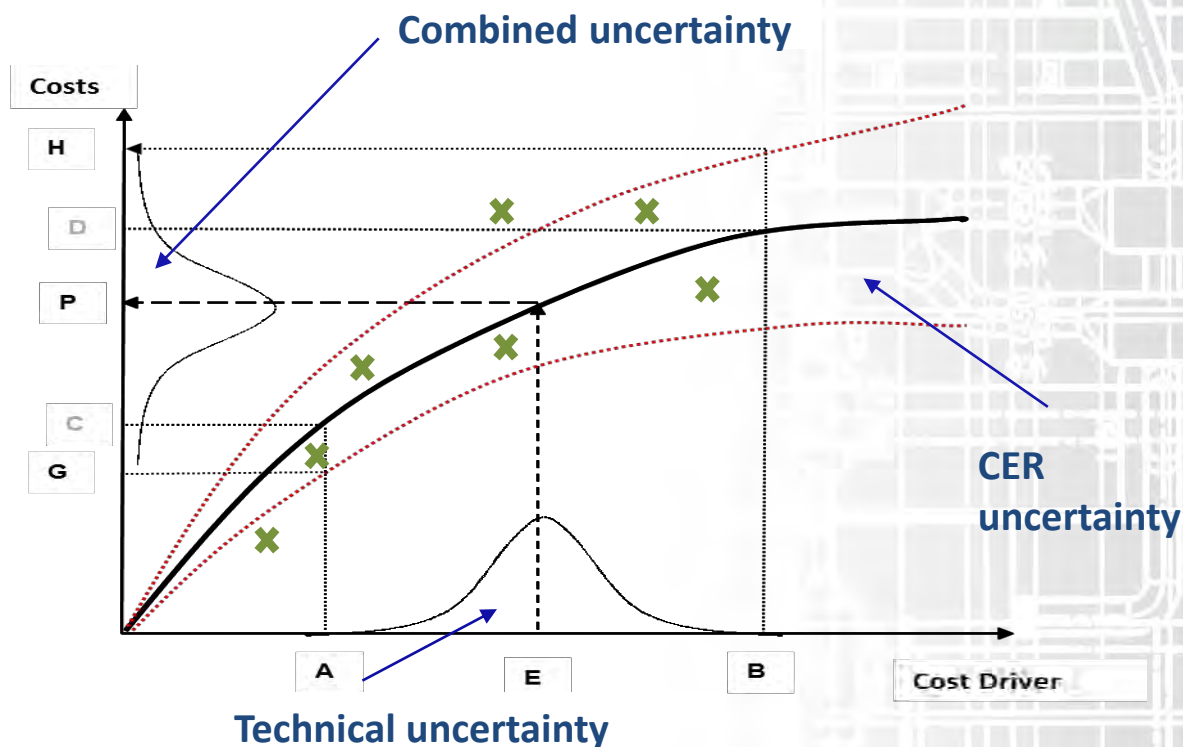
- **Need for an instrument to quantify uncertainties → identify cost risks of the project**
- **Goals of Cost Risk Analysis are to:**
  - estimate cost margins and confidence intervals
  - approximate probability of exceeding certain values
  - identify “risk drivers”

“We can be 90% sure that costs are between 90 and 120 millions.”

“The probability of overrunning the project’s budget is 25%.”

“Systems A, B and C contribute mostly to the total uncertainty of the project.”

# Modelling Uncertainty



**Twofold uncertainty:**

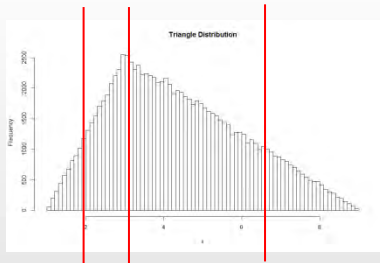
- “technical”
- “financial”

→ **Combined uncertainty [G; H]**

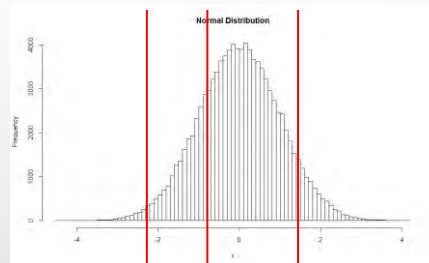
# Monte Carlo Simulation

- Stochastic simulation method relying on random experiments
- Statistical distributions in order to model uncertainty

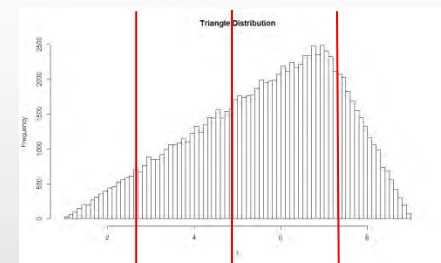
$u_1$ :



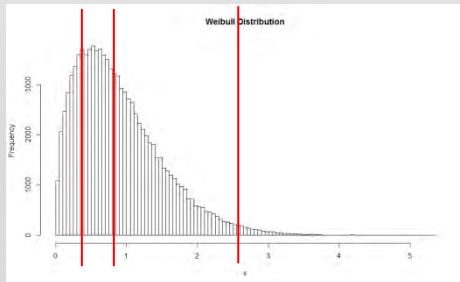
$u_2$ :



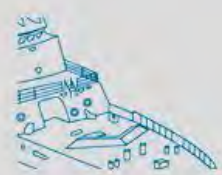
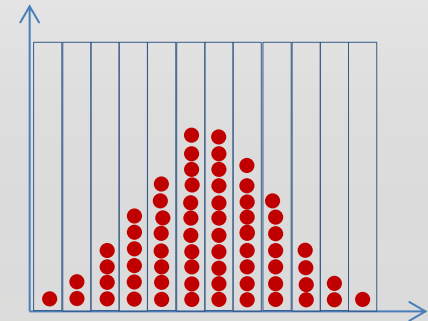
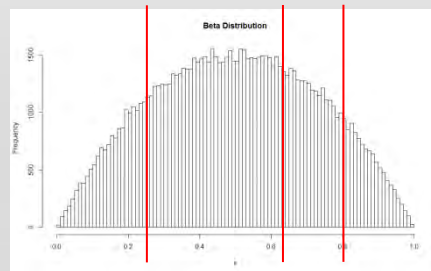
$u_3$ :



$u_4$ :

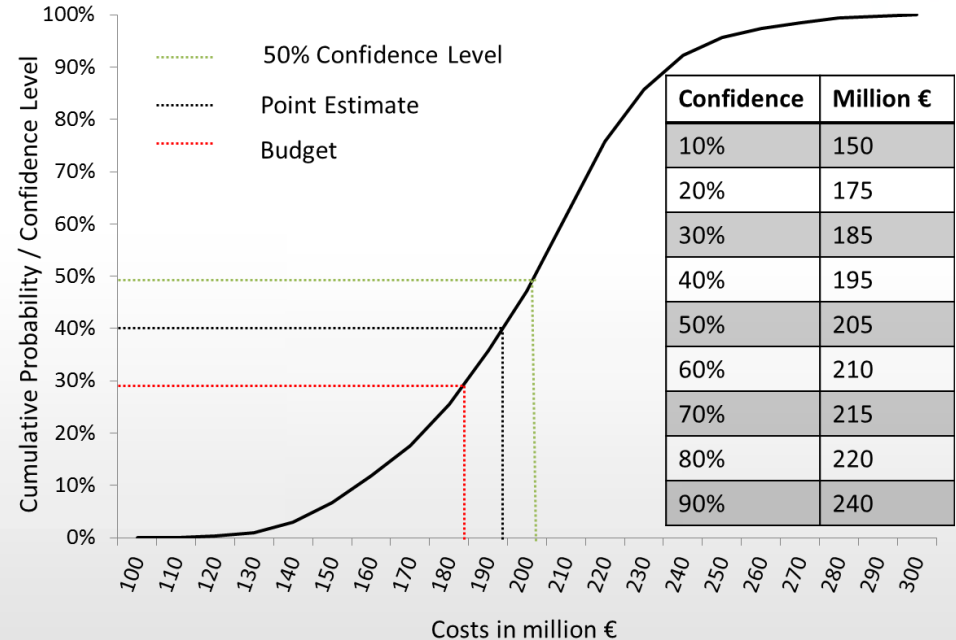
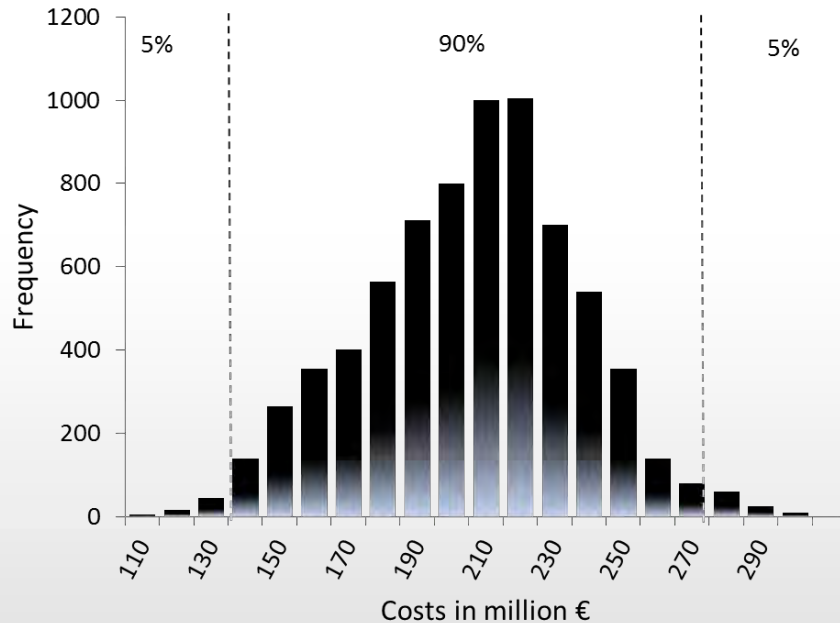


$u_5$ :





# Results of Cost Risk Analysis



- 90%-Interval
- Mean
- Median
- Standard deviation

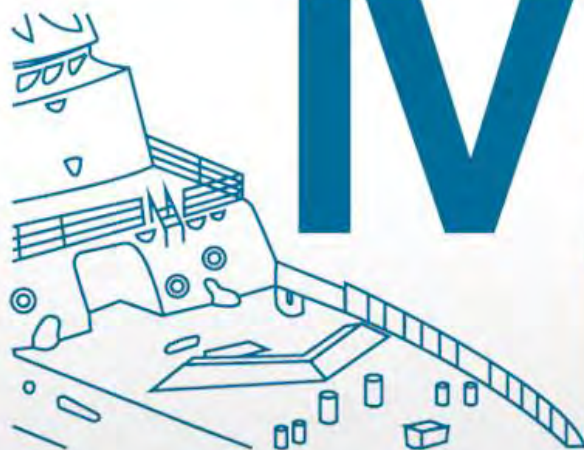
- Percentiles
- Probability of exceeding point estimate / budget
- "Risk Dollars"



# Summary

- Naval ships are highly complex and sophisticated systems
- It's a core issue to:
  - Identify requirements and
  - translate them to technical solutions
- Based on this it's another core issue to
  - Develop technical solutions in line with the budget
  - Identify cost risks as early as possible
- MTG has accepted this challenge
- MTG has proven to be a valuable partner for a wide range of customers



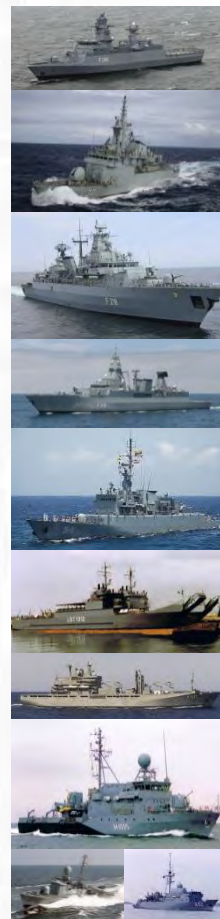


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## Governmental References

Country	Reference Design and services
Germany	<ul style="list-style-type: none"> <li>• F122/F123/F124/F125/MKS180</li> <li>• T404/T702 (EGV)</li> <li>• S143/S143A</li> <li>• M332/M343</li> <li>• FD423; FS751 Planet (SWATH)</li> </ul>
Colombia	<ul style="list-style-type: none"> <li>• FS1500 (design, setting to work and acceptance testing, post delivery tests, building management)</li> <li>• PES requirements generation</li> <li>• PES initial conceptual design</li> </ul>
Brazil	<ul style="list-style-type: none"> <li>• Inhaúma (design, project planning, tender management and evaluation, design training)</li> </ul>
Nigeria	<ul style="list-style-type: none"> <li>• LST1300 (design and construction management)</li> <li>• Acceptance of MEKO</li> </ul>
Malaysia	<ul style="list-style-type: none"> <li>• FS1500 (design and building management)</li> </ul>
India	<ul style="list-style-type: none"> <li>• Engineering and maritime training courses</li> </ul>
Greece	<ul style="list-style-type: none"> <li>• Surveillance Street of Crete (Feasibility study underwater detection system (UWDS))</li> </ul>
Australia	<ul style="list-style-type: none"> <li>• Project management support services (ANZACS)</li> <li>• Anti ship missile defense study</li> <li>• Design standards and procedures</li> </ul>
Oman	<ul style="list-style-type: none"> <li>• Tender assessment, design assessment, contract negotiation</li> <li>• Engineering assessment and modification design</li> <li>• Surveillance System Street of Hormuz (Feasibility study)</li> </ul>
Sweden	<ul style="list-style-type: none"> <li>• Sensor analysis and integration concept</li> </ul>



Company	Reference Design and services
Advanced Marine Enterprises Inc. Arlington, Va., USA	<ul style="list-style-type: none"> <li>• Hull girder load predictions for frigate type ship</li> </ul>
AMEC (Australian Marine Engineering Cooperation)	<ul style="list-style-type: none"> <li>• Assessment of shipbuilding capability of Williamstown Naval Dockyard</li> </ul>
Bird- Johnson Co. Inc., USA	<ul style="list-style-type: none"> <li>• Propeller shaft design</li> </ul>
DCNS, France	<ul style="list-style-type: none"> <li>• Cost estimation for ship component optimization and evaluation</li> </ul>
Hollandse Signaalapparaten B.V., Netherlands	<ul style="list-style-type: none"> <li>• Investigating radar multiple path propagation</li> </ul>
ISDEFE, Spain	<ul style="list-style-type: none"> <li>• Cost estimation for frigate programs</li> </ul>
Mc Mullen, USA	<ul style="list-style-type: none"> <li>• Whipping analysis of corvette type ship</li> </ul>
Mitas, Brazil	<ul style="list-style-type: none"> <li>• AAW effectiveness study</li> </ul>
Singapore Shipbuilding & Engineering Ltd., Singapore	<ul style="list-style-type: none"> <li>• Landing craft, forward design</li> <li>• Design FPB communication system</li> </ul>
Boeing, Naval System Division, USA	<ul style="list-style-type: none"> <li>• Design PHM, metrification, combat system, naval architecture and marine engineering</li> <li>• Fleet effectiveness study</li> </ul>
Verolme do Brazil, Brazil	<ul style="list-style-type: none"> <li>• Naval dockyard planning, build strategy, proposal consulting, work planning and control</li> </ul>

## Industry References