

Independent Cost Estimate for Development & Production of Rotterdam class ships

Soesterduinen, 4 March 2010

TNO | Knowledge for business



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DACE-ISPA seminar on Parametric Analysis



Outline



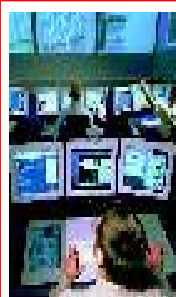
- TNO
- NATO RTO
- Cost Analysis improvements
- Practicing guideline with Independent Cost Estimates
- Model Regression Trees
- Summary



TNO is active in five core areas



TNO Quality of Life



TNO Defence, Security and Safety



TNO Science and Industry



TNO Built Environment and Geosciences



TNO Information and Communication Technology

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TNO Defence, Security and Safety



Three locations

- The Hague
- Rijswijk
- Soesterberg

Employees: 1065

Turnover 2006: 140 M€

- Defence 64 %
- Other 36 %

Defence research programmes: 85

- 66% international collaboration

Good to excellent technology position



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TNO Defence, Security and Safety 5 Business Units



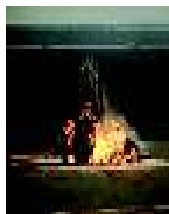
Observation Systems

- Integrated systems
- Transceivers and real-time signal processing
- Radar and electronic warfare
- Electro-optics and under-water technology



Information and Operations

- Operational analysis
- Command, control and information management
- Modelling and simulation
- Policy studies and strategy



Protection, Munitions and Weapons

- System performance and survivability
- Explosions, ballistics and protection
- Energetic materials, electric power technology



Biological and Chemical Protection

- Threat and protection
- Detection and identification
- Diagnosis and therapy



Human Factors

- Human interfaces
- Human in command
- Human performance
- Training and instruction

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TNO cost analysis



- BU Information and Operations
 - Acquisition & in-service Support
 - Cost Analysis
- Products
 - Life Cycle Cost Analysis
 - Business Case analysis
 - Asset Management studies
 - Strategic Cost Analysis
 - Courses on Cost Analysis
- Customers
 - Defence
 - Other government agencies
 - Industry
 - Medium and Small Businesses
 - Other TNO departments
 - International cooperation

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NATO RTO: Research & Technology Organization



Mission RTO:

To conduct and promote co-operative research and information exchange within NATO and with its "Partners".

Goal Task Group:

Allow researchers in different nations to work together in order to solve a particular R&T problem.



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NATO RTO work in Cost Analysis



- More international cooperation in acquisition projects.
- NATO was lacking a common approach for Life Cycle Costing.
 - No common definitions
 - National guidelines
- Framework required to generate realistic and consistent LCC estimates.
- Steps in Framework:
 1. Definitions and Generic Cost Breakdown Structure
 2. Methods and models for LCC
 3. Development guideline
 4. Development code of practice
 5. Exercise guideline

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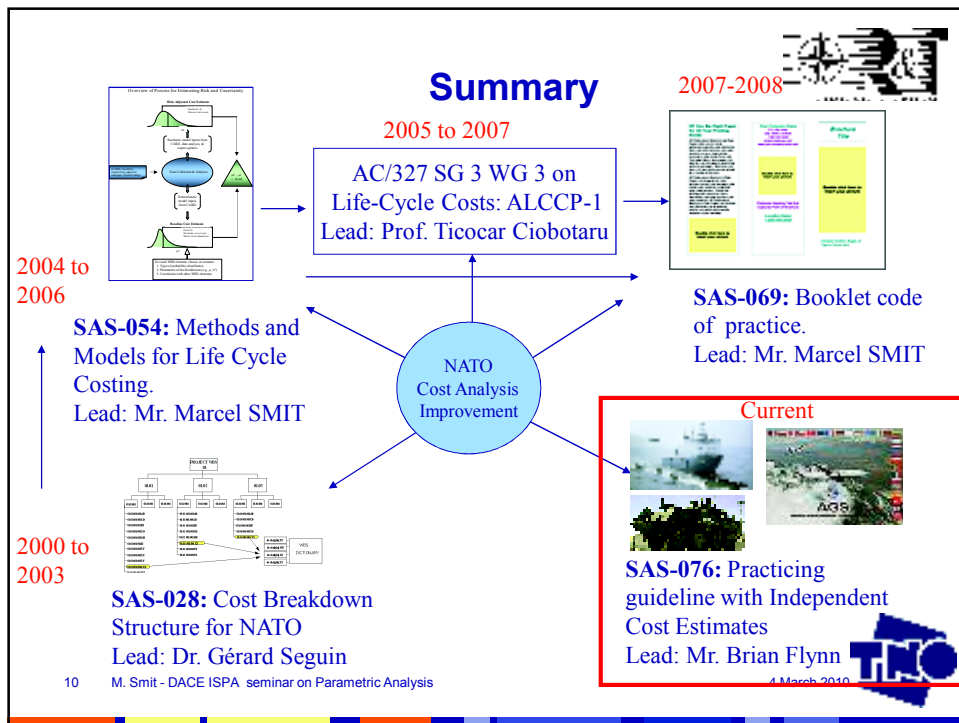
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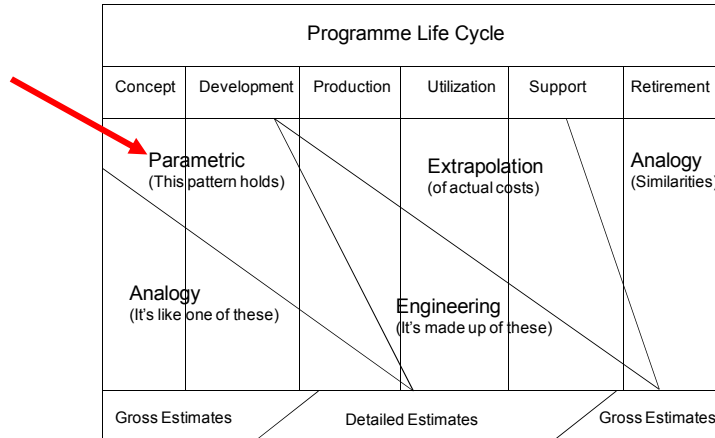


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SAS-054: Cost estimating methods in Programme Life Cycle



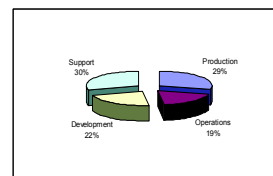
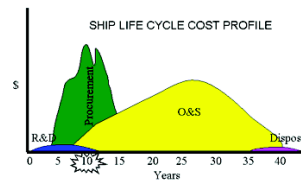
SAS 076: Practicing guideline with independent cost estimates



Objective

Test guideline from SAS-054, SAS-069 and ALCCP-1.

- Demonstrate proof of concept
 - Independent life-cycle cost estimates (ICEs)
 - Generate three ICEs
 - Over the life cycle
 - Fully documented
 - With risk and uncertainty analysis
- Suggestions for improvement guideline



SAS-076: Practicing guideline with independent cost estimates



Netherlands Landing Platform Docks

- Ex-post testing
 - Estimate development and production cost using data from similar ships.
 - Obtain true costs from program office.
 - Compare estimates with actual costs after ICE and compute delta.



HMS Rotterdam



HMS Johan de Witt



Short description LPD



- Built to conduct amphibious operations
- Large Multirole capacity
- Main role amphibious support (world wide)
- Tasks: embark, transport and disembark Marine Corps battalion
- Helicopter operations in high sea states
- Operations with landing craft, docking max 6.

- Length hull (RDM- JdW): 162,2 m - 176,4 m
- Beam: 25m
- Max draught 5,9 m – 5,9 m
- Max displacement: 12,750 t – 16,800 t
- Speed: 19 kts
- Crew: 124
- Hospital facilities upto 100 patients



Data collection



- Database of military and civilian auxiliary vessels of similar size to Rotterdam class ships covering a span of years from 1954 to 2009
- 64 ships in 17 classes from 7 nations (excluding Rotterdam class)
 - Min required cost data for **59** ships in 17 classes from 6 nations
 - Full ANEP-41 ESWBS cost category data for 10 U.S. ships and 1 French Ship
- Number of attributes: 133
- Sources:
 - Country-submitted data
 - Public information:
 - Jane's Fighting Warships (jfs.janes.com)
 - Wikipedia (www.wikipedia.com)
 - Federation of American Scientists
 - Friedman, N., "U.S. Amphibious Ships and Illustrated Design History", Naval Institute Press, Annapolis, Maryland, USA.
 - Forecast International (www.forecastinternational.com)
 - Navy Matters (www.navy-matters.beedall.com)



Example ships in database



Overview of attributes



- Dimensions
- Performance
- Propulsion
- Electrical power generation
- Lift capacity
- Flight deck
- Armament
- Countermeasures
- Radars
- Other capabilities (e.g. hospital)



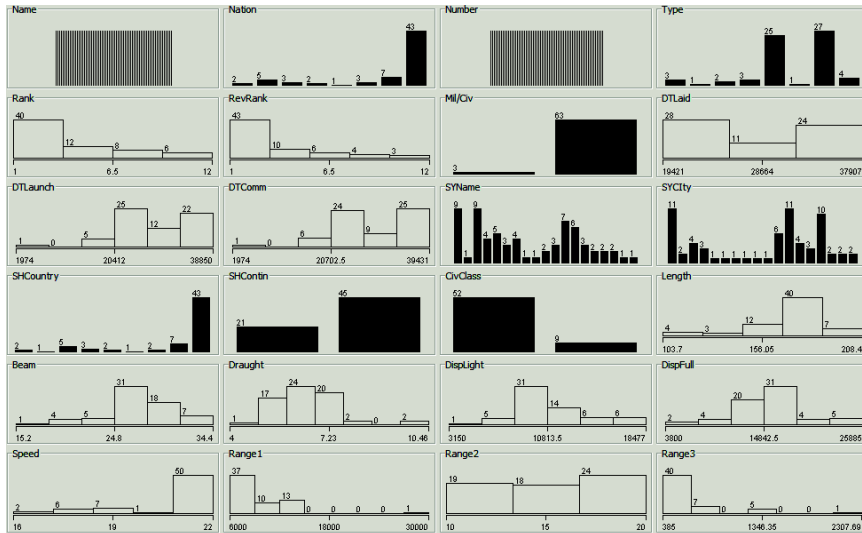
Data populated in Excel sheet



Attribute	Value 1	Value 2	Value 3	Value 4	Value 5	Value 6	Value 7
Dimensions
Performance
Propulsion
Electrical power generation
Lift capacity
Flight deck
Armament
Countermeasures
Radars
Other capabilities (e.g. hospital)



Data visualization



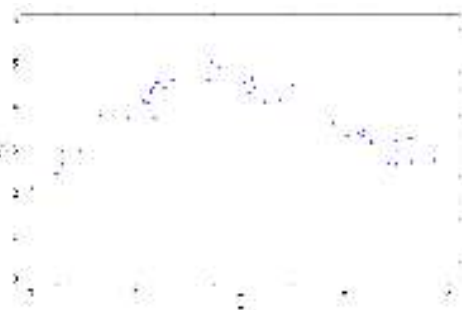
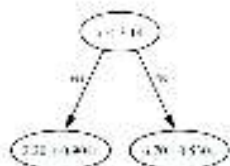
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Methodology

- Model Regression Trees for numeric prediction
 - Combination of **decision trees & linear regression**:
 - Data set partitioned using a decision tree type structure
 - Linear regression applied independently to each distinct subset of the data

Linear regression model tree



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Model (Regression) Trees



- M5 model tree system developed by J.R. Quinlan (1992)

Quinlan, J.R., Learning with continuous classes, *In Proceedings AI'92 (Adams & Sterling Eds)*, 343-348, Singapore: World Scientific, 1992.

- Very well accepted in scientific community
- Free, easy-to-use implementation:
WEKA: Waikato Environment for Knowledge Analysis



Open source collection of machine learning/data mining algorithms implemented in JAVA

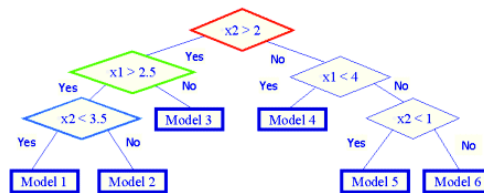
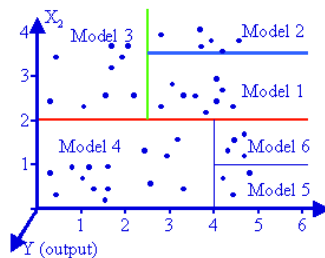
<http://www.cs.waikato.ac.nz/~ml/weka/index.html>



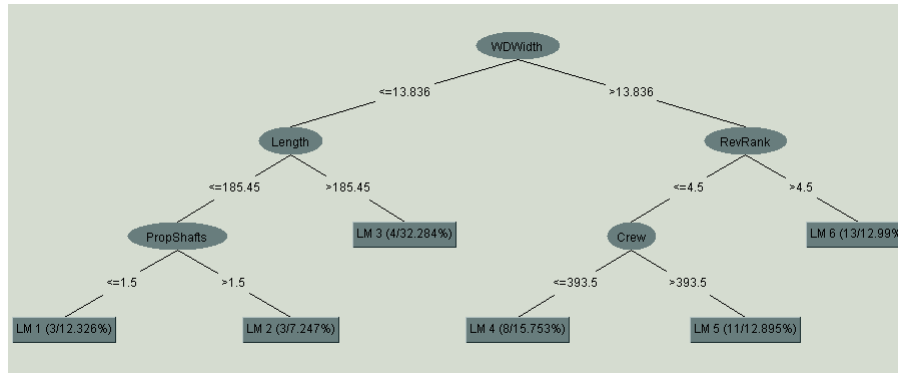
Estimation using Model Trees



- Model (Regression) Trees for numeric prediction
- net result is a tree type structure in which each leaf of the tree is a different regression model with a Cost Estimating Relationship



Estimation using Model Trees



Estimation using Model Trees



LM num: 1

$$\text{\$DevProdUSDLog} = -0.0151 * \text{RevRank} + 0.0063 * \text{Length} + 0.0123 * \text{Beam} - 0.0101 * \text{PropShafts} + 0.0128 * \text{WDWidth} + 7.0323$$

LM num: 2

$$\text{\$DevProdUSDLog} = -0.0151 * \text{RevRank} + 0.0063 * \text{Length} + 0.0123 * \text{Beam} - 0.0101 * \text{PropShafts} + 0.0128 * \text{WDWidth} + 7.0261$$

LM num: 3

$$\text{\$DevProdUSDLog} = -0.0151 * \text{RevRank} + 0.0552 * \text{CivClass=N} + 0.0066 * \text{Length} + 0.0123 * \text{Beam} + 0.0128 * \text{WDWidth} + 7.0271$$

LM num: 4

$$\text{\$DevProdUSDLog} = -0.0222 * \text{RevRank} + 0.0061 * \text{Length} + 0.0133 * \text{Beam} + 0.0016 * \text{Crew} + 0.0068 * \text{WDWidth} + 6.5856$$

LM num: 5

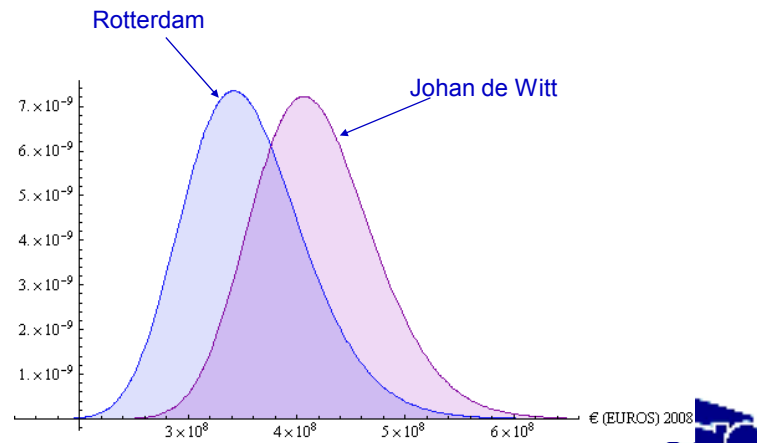
$$\text{\$DevProdUSDLog} = -0.0287 * \text{RevRank} + 0.0056 * \text{Length} + 0.0133 * \text{Beam} + 0.0015 * \text{Crew} + 0.0068 * \text{WDWidth} + 6.7562$$

LM num: 6

$$\text{\$DevProdUSDLog} = -0.0176 * \text{RevRank} + 0.0042 * \text{Length} + 0.0197 * \text{Beam} + 0.0008 * \text{Crew} + 0.0068 * \text{WDWidth} + 7.0202$$



Estimation using Model Trees



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Current status and still to be done



- Validation technique: selecting attributes by SMEs
- Validation results by using second methodology Cluster Analysis
- Some issues to be implemented: normalization of costs
- Comparison with real costs and explain differences.
- Ex-ante estimate for Operation & Support Costs

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Summary



- NATO RTO has developed very useful framework, consisting of a number of documents to conduct Cost Analysis in all phases of the product life cycle.
- Currently a working group applies model regression trees to estimate development and production costs.
- Model regression trees is a very useful methodology, requiring relatively easy accessible data.
- WEKA-tool supports this methodology.



More information ?



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Department: Acquisition & In-service Support

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QUESTIONS

