# The Impacts of Design Change on Reliability, Maintainability, and Life Cycle Cost

## Case study: Combat Vehicle 90 - Rubber versus steel tracks?

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# Presentation outline

- Bottom-up engineering approach to Cost Analysis – An important complement to the Parametric Approach
- Modeling and Simulation of Systems' Operation and Logistics Support – A great way to generate data for cost analysis

  (In addition to providing invaluable decision support for Life Cycle Management)
- Case study example – LCC evaluation of a CV90 design change
- Conclusions

# SYSTECON –

## Solutions for Optimal Balance between  Performance and Cost

- Consultancy in systems  and logistics engineering.
- The Opus Suite: software for logistics support optimization and life cycle system management used by defense authorities and industry leaders worldwide.
- Founded in 1970, an independent, partner owned company with offices in:
  - Washington DC, Florida, and Colorado
  - Stockholm, Sweden and Weymouth, UK

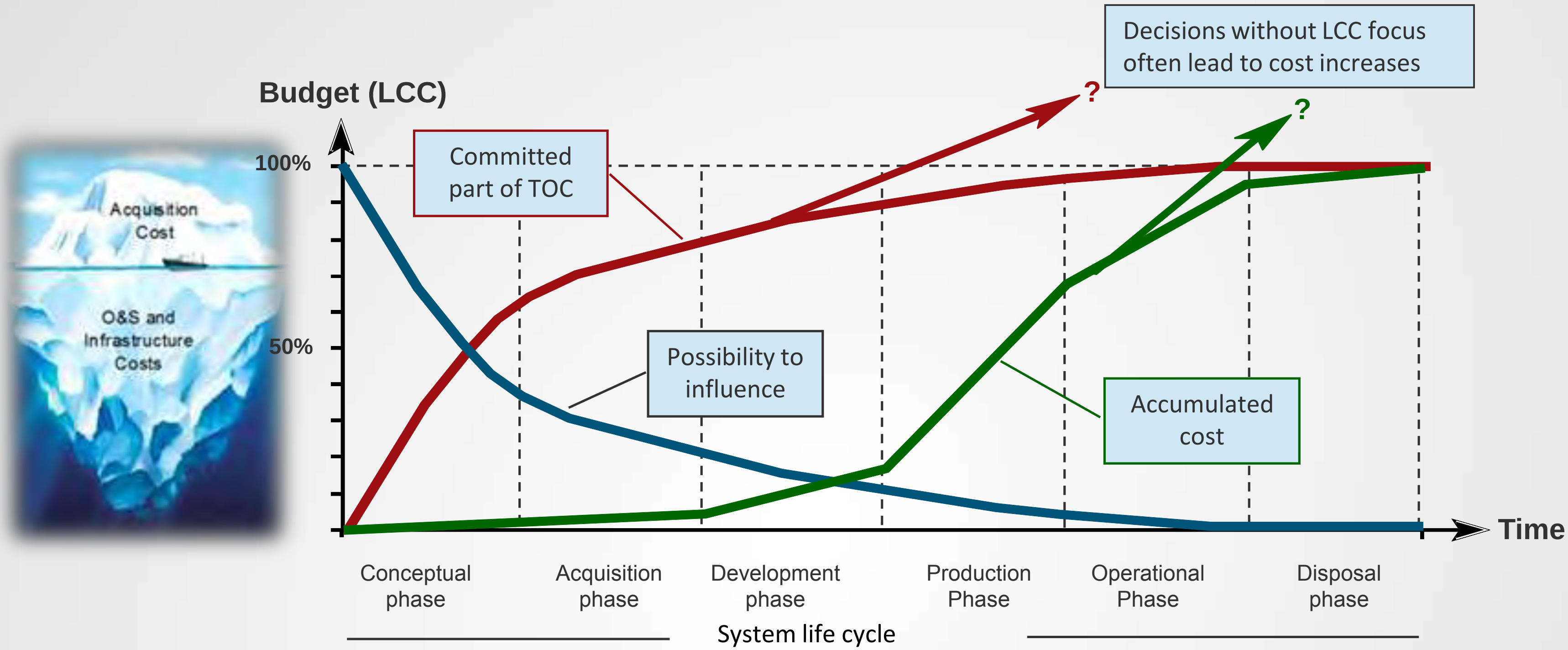
# Customers

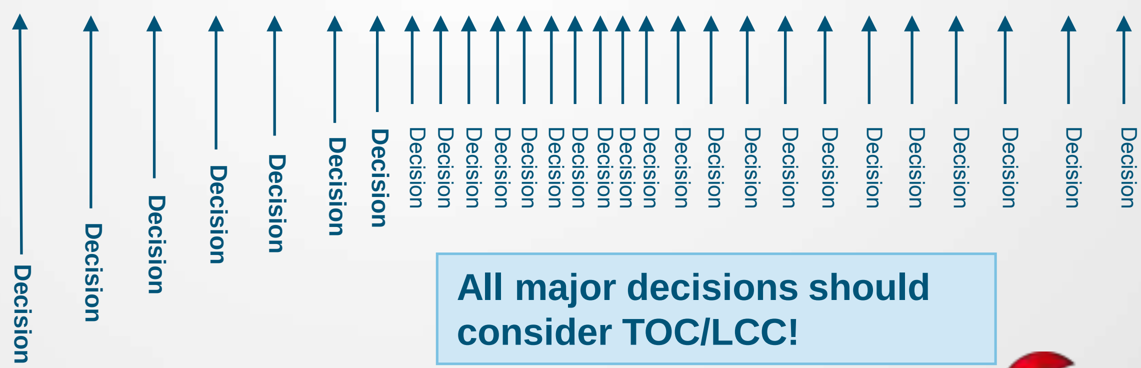
Australian DMO
Belgian Army
Brazilian Air Force
Danish DoD (DALO)
Dutch DoD
French Air Force
Italian Navy
NATO Heli PO (NAHEMA)
Norwegian MoD (FLO)
OCCAR
Singapore DoD (DSTA)
South Korean Army
South Korean Navy
Spanish Air Force
Swedish MoD (FMV)
Thai Air Force
Turkish Air Force
UK MoD
US Air Force
US Navy (NAVSEA)
US Navy (NAVAIR)

Agusta Westland
Airbus Defense and Space
Airbus Helicopters
Alenia Aermacchi
BAE Systems
Boeing
CAE
Dassault Aviation
FFG
Finmeccanica
GKN Aerospace
Hanwha
Israel Aerospace Industries
Kongsberg
Krauss-Maffei Wegmann
LIG Nex1
Lockheed Martin
Marshall Aerospace
MBDA
Nexter
Northrop Grumman

Qinetic
Raytheon
Rheinmetall Landsystem
Rockwell Collins
Samsung Thales
SAS Selex
Saab AB
ST Electronics
Textron
Thales Defence
Turbomeca
Turkish Aerospace Industries
Alstom
Bombardier Transportation
Heli-One / CHC
Maersk Drilling
Nokia
ST Aerospace Solutions
SuperJet International
Telstra

# Reducing Total Cost of Ownership




**All major decisions should consider TOC/LCC!**

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# Approaches to Cost Estimation and Analysis
## (NATO RTO Tech report TR-SAS-076)

EARLY PHASES OF THE PROCUREMENT CYCLE

- **Analogy Approach**
  Top-down cost estimation that forecasts the cost of a new system based on the historical cost of one or several similar systems. Selected "complexity factors" are often used to adjust the estimate.

- **Parametric Approach**
  Top-down cost estimation where linear regression models are typically used to forecast the cost of a new system based on a multitude of selected cost driving variables.

ALL PHASES OF THE SYSTEM LIFE CYCLE

- **Engineering Approach**
  Bottom-up cost estimation starting from a low level of definable cost elements within the cost breakdown structure and building up to estimate the total cost of a new system.

# Comments on the Engineering Approach (TR-SAS-076)

- “It is the most detailed of all the techniques and the most costly to implement.”
- *However*, “ it provided some key advantages”:
  - [It] is highlighting the critical aspects in the design and its logistical organization, which makes it a tool for project management and systems engineering.
  - It provides a structured way of weighing significant technical and cost inputs.
  - It shows the economical consequences of the technical system properties over time, which provides the means of evaluating the cost implication of a proposed system solution
  - [It]allows the user to determine the cost efficiency of the system.
  - Cost drivers can be identified and more detailed analysis on costs can be started.
- “The engineering method is trying to minimize the need of input data taking into consideration only those costs and related parameters which influence the decision making process.”
- Look at the engineering method as an on-going enterprise during the system life time, i.e., “from cradle to grave”. Applied properly and consistently, the method not only implicitly leads to improvement of the system efficiency, but also gives the system operator after a period of time, access to a database similar to VAMOSC which will substantially improve the future Life Cycle Cost estimations.

# Life Cycle Management

## Decisions that call for thorough analyses:

- What types of systems do we need?
  - requirements definition

- Which logistic concept should be implemented?
  - Optimized logistics support

CONCEPT → PROCUREMENT → PRODUCTION → OPERATION → TERMINATION

- Which technical system (vendor) should we choose?
  - LCC/TOC-based procurement

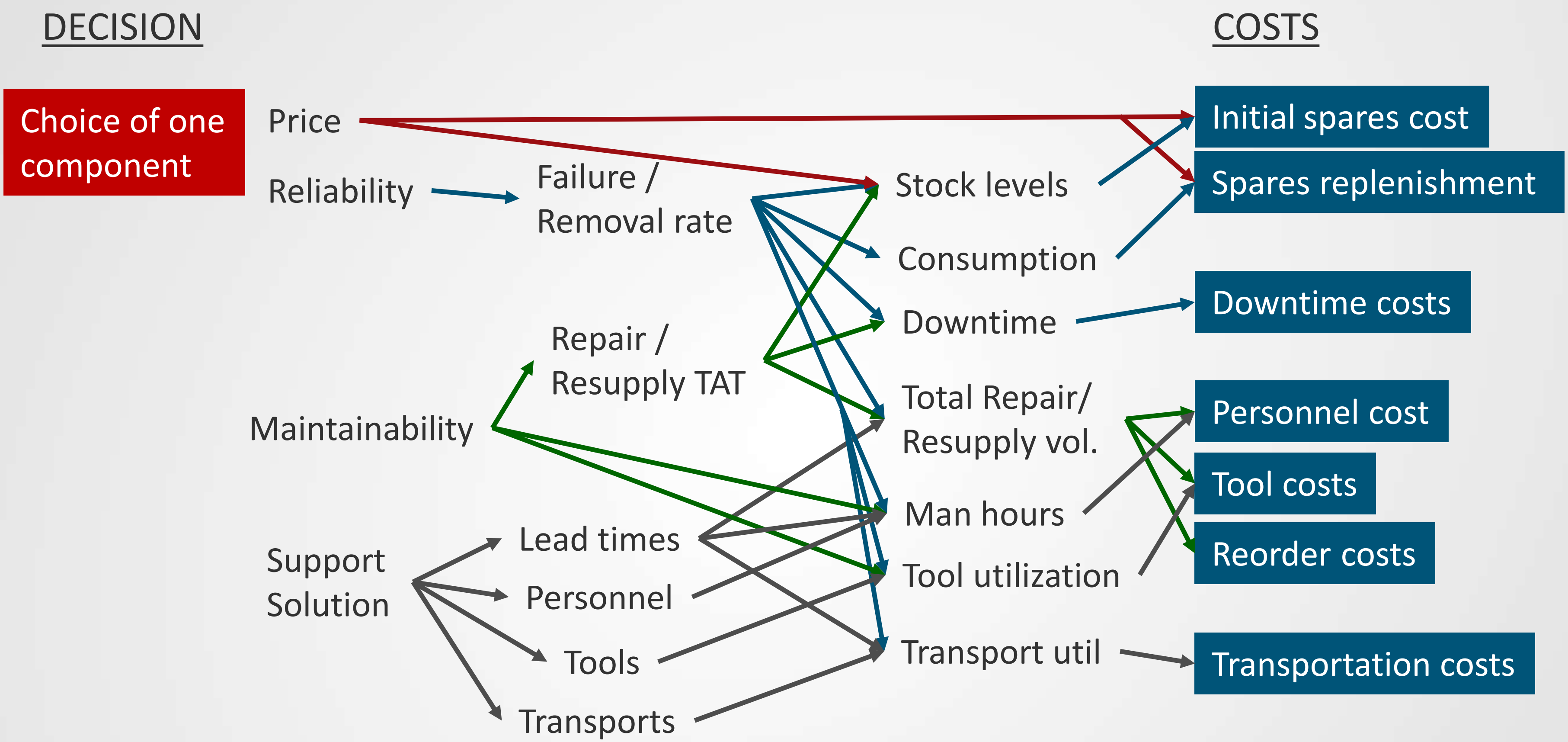
- Status and possible improvements of the system?
  - Monitoring + cost effective improvements

**MAIN OBJECTIVE:** Ensure that operational requirements are fulfilled at the lowest cost throughout the system's life cycle.

# Key Decisions Requiring Analysis

- What requirements should be put on a new system?
- What is our budget?
- Which system should we purchase?
- What kind of supply solution is optimal?
- What investments in logistic support, spares, and other resources do I need to make, and where should they be located?
- Can we handle the planned operations with the current support solution?
- What improvements are most cost-effective to enhance my operations?
- How much do we have to lower the failure rate of a certain system or component to reach target availability?
- When the operational profile or the environment changes, how does that impact my solution?
- When should I replace the existing fleet of systems?

# Parameters that affect costs




**Complex and interdependent!**



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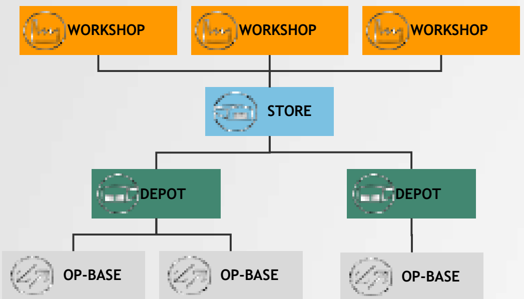
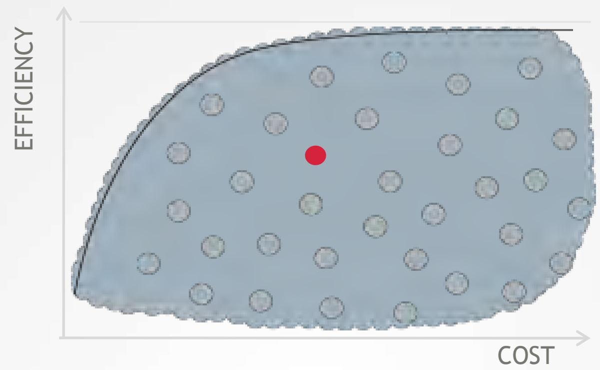
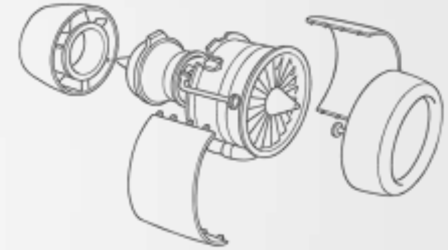
# OPTIMAL BALANCE BETWEEN OPERATIONAL PERFORMANCE AND OVERALL COST

SUPPORT SOLUTION

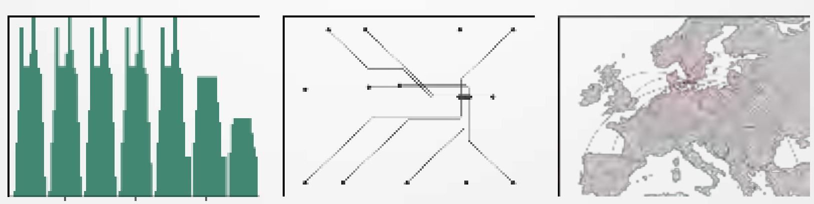



TECHNICAL SYSTEM



OPERATION



# Case Study:
# LCC Analysis of Track Alternatives
# Combat Vehicle 90



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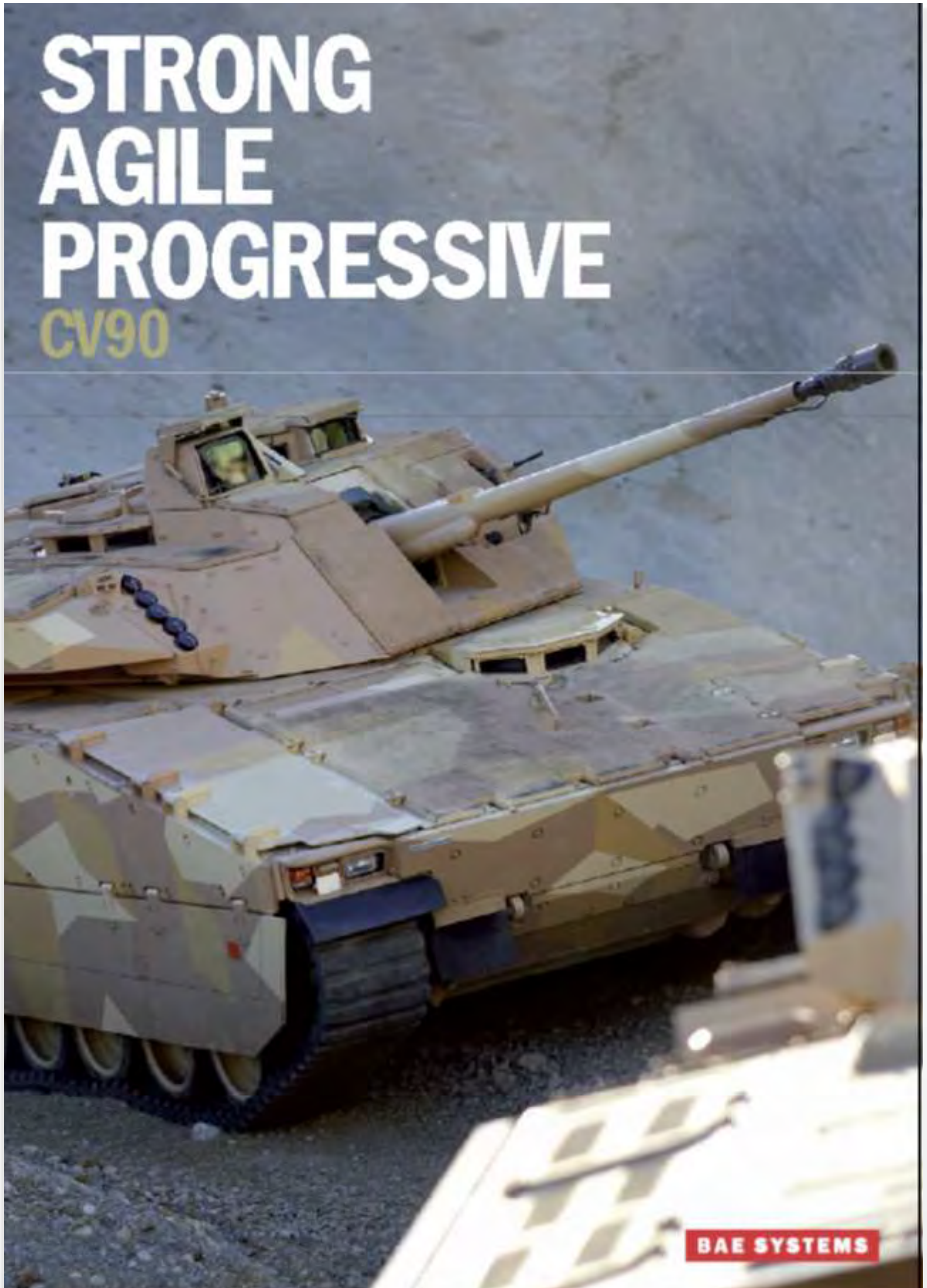


# Combat Vehicle 90

- Producer: BAE Systems
- Users: Sweden, Norway, Finland, Denmark, Switzerland, and the Netherlands
- Deployed in Afghanistan and Liberia
- More than 1,000 vehicles produced
- Weighs up to 35 tons

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# Track alternatives project background

- CV90 originally comes with steel tracks
- In the Middle East operations - problems with crew fatigue due to vibrations
- Rapid development of rubber tracks for heavy vehicles
- Several existing and potential CV90 customers have shown interest to use CV90 with rubber tracks

# Rubber Tracks Investment - Effects on LCC?

| Steel tracks | Rubber tracks |
|---|---|
| Well proven | Reduced vibrations |
| Longer lifespan | Reduced noise |
| Repairable | Increased mobility |
| Cheaper | Reduced weight |
| **For old customers with steel tracks** | |
| Existing maintenance organisation | New maintenance organization |
| (Aquisition cost) | Aquisition cost |

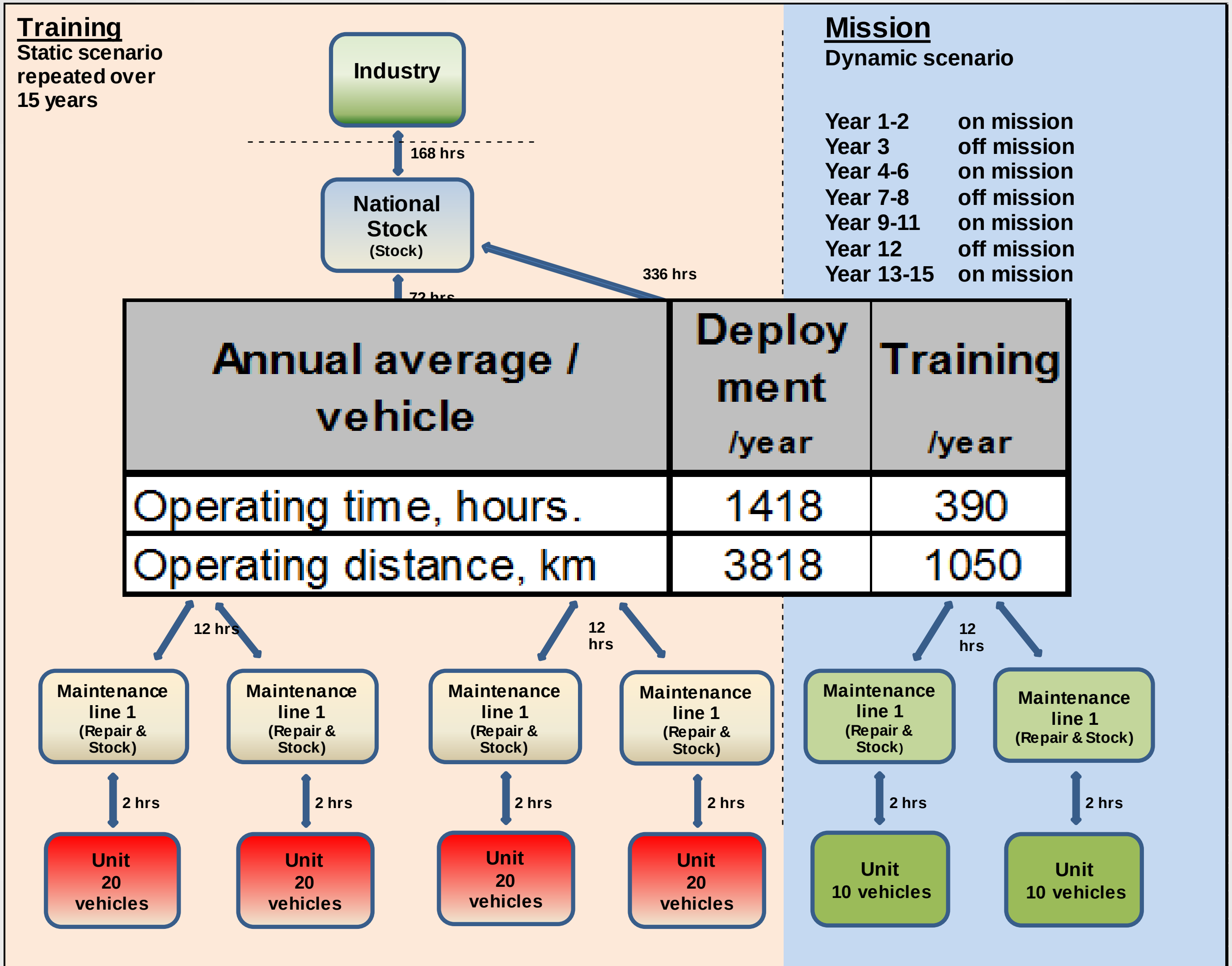
| Reduced vibrations means |
|---|
| Longer lifespan for system and components |
| Crew fatigue decreases |
| Less ammunition discarded due to vibrations |
| Less damage on roads |

# Project Approach

- BAE Systems and Systecon worked together on the project.
- Three weight classes were analyzed:
  - 25, 30, and 35 tons (6 types of CV90)
  - Opus Suite was used for the analysis.
- Data and results are confidential - this presentation focus on the method.

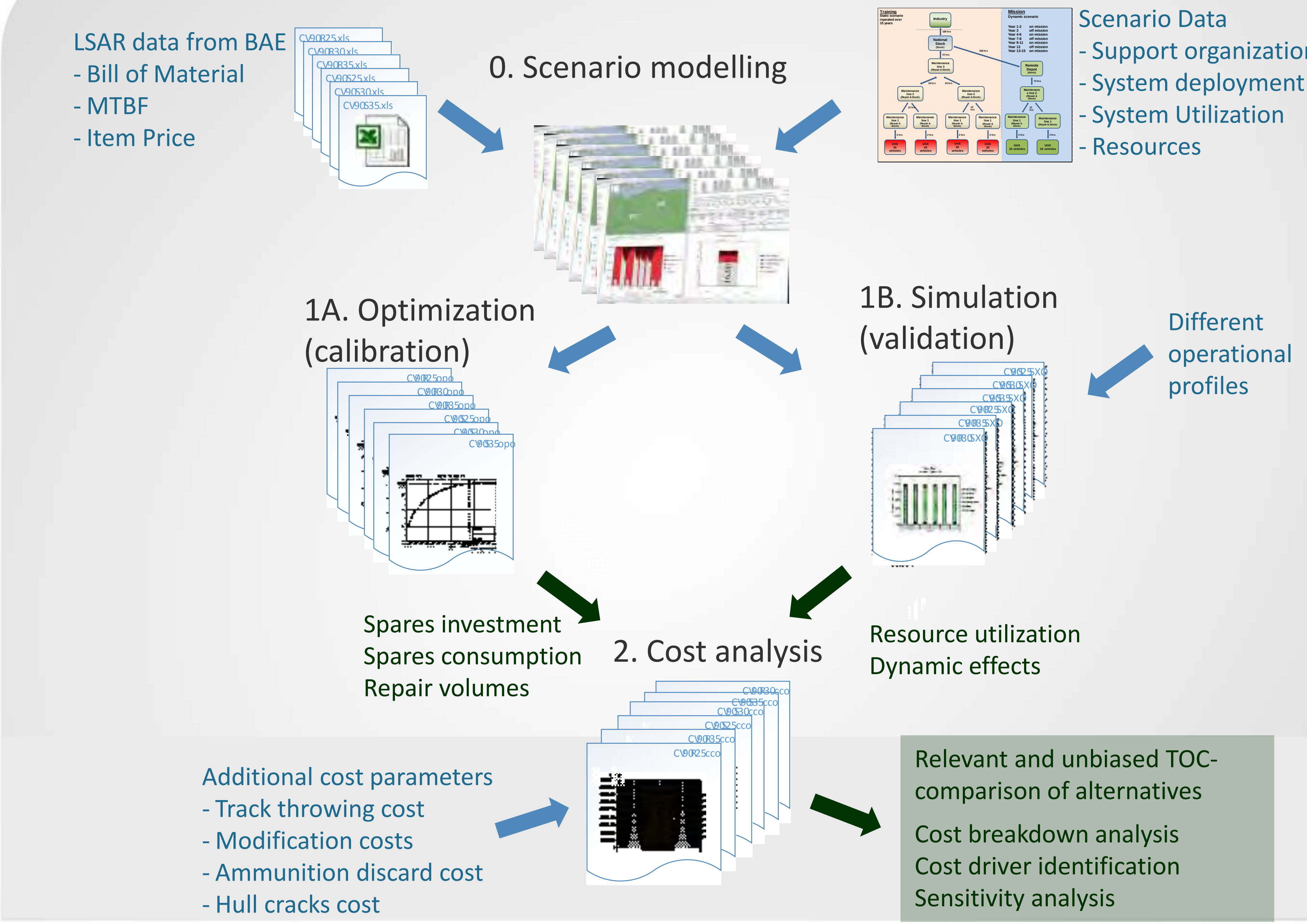


# Organization and Operational Profile

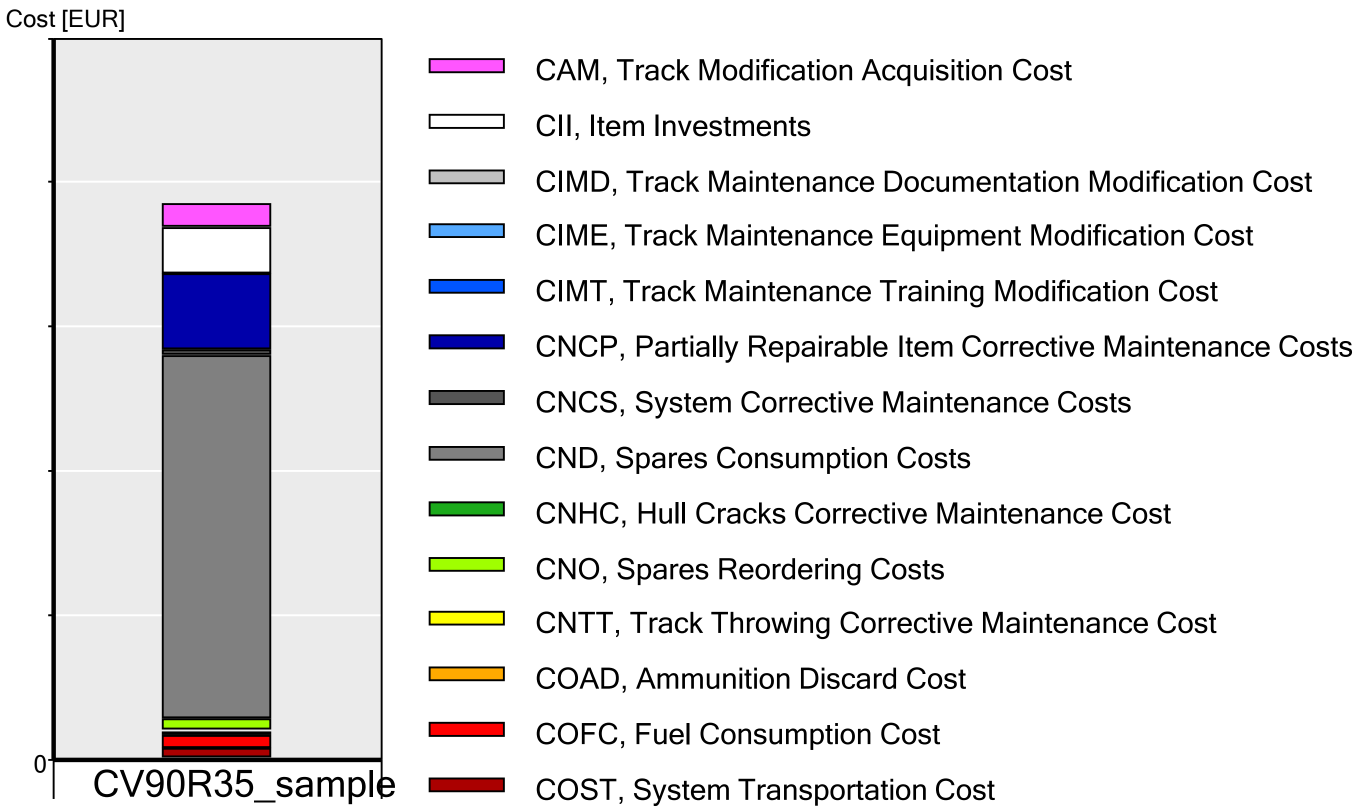



| Annual average / vehicle | Deployment /year | Training /year |
|---|---|---|
| Operating time, hours. | 1418 | 390 |
| Operating distance, km | 3818 | 1050 |

# Modelling and Analyses workflow



# Cost Breakdown Example



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# Conclusions CV90 LCC-project

- The approach was successful
- The member countries could base their decision regarding rubber tracks on an objective comparison of how System Life Cycle Cost was affected by the differences in design, reliability and maintainability for the two alternatives.
- We could easily identify the cost drivers to determine which parameters to focus on.
- We could determine how much lower failure rates the systems and components must be in the rubber tracked vehicles to get pay back. This “backwards calculation” is very effective when you do not have all data!
- The project result views the differences and similarities in LCC for the different track systems.

# Conclusions - General

- Successful Life Cycle Management of technical systems requires an ability to understand and influence the parameters that have impacts on operational performance and Life Cycle Cost.
- Engineering “bottom-up” cost analysis can provide powerful decision support for cost effective systems engineering and life cycle management.
- Modeling and Simulation can be used to provide objective leveled-off data for bottom-up cost analysis.
- With a baseline model in place, it is easy to perform “what if” analyses and to adapt to new operational scenarios, changes in the logistic prerequisites, etc.

# IN SEARCH FOR THE OPTIMUM

## THANK YOU FOR LISTENING!