Modeling & Simulation for Evaluating Whole Life Cycle Cost of New Vessels and Related Complex Systems

SimonLuca Poggi

Advisor: A.Bruzzone
Tutor: M.Furolo

Research Objectives

To develop models for analyzing the life cycle of complex vessels by using Simulation considering:

- **Stochastic Behavior of Maintenance Operations & Breakdowns**
- **Stochastic Behavior in Utilization and Workloads**
- **Stochastic in General Parameters**

Development of a framework for approaching these issues in a specific case:

CALYPSO Project

NUMA Carrier

Carrier Life cYcle Period Simulation & Optimization

Goals of the Project

- The main goal of the Project is to develop a framework for analyzing the whole life cycle cost a big vessels.
- This Project is focusing on the construction of model with special attention to the case of Airmobile carriers
- The model allows to correlate vessels parameters and characteristics for completing comparisons

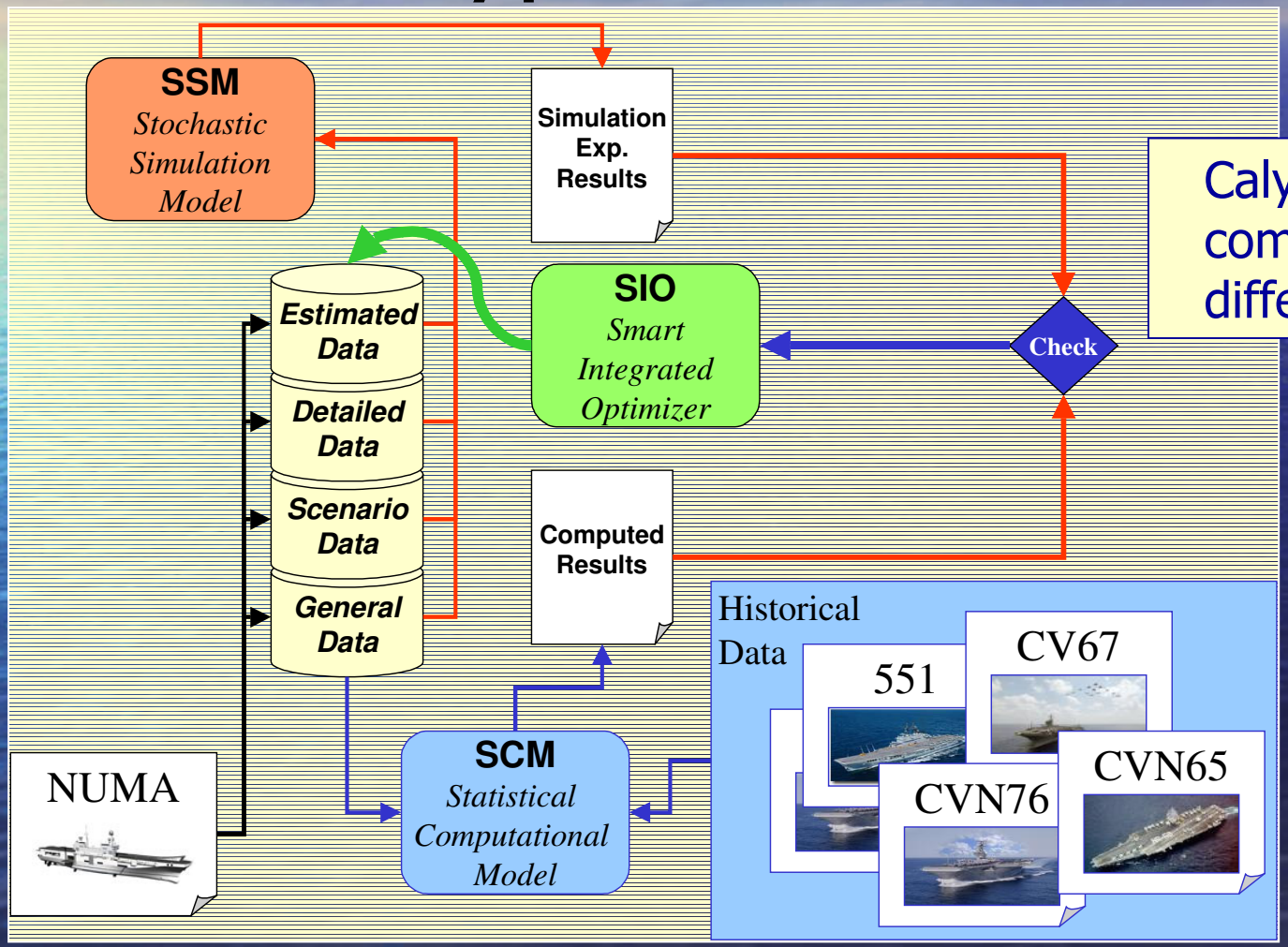
Simulation Project Planning

- Task 1: CALYPSO SCM
  - Phase 1:
    - ☒ *Tailoring CALYPSO SCM*
    - ☒ *CV Data Collection*
    - ☒ *CALYPSO SCM Preliminary Tests & Results*
  - Phase 2
    - ☒ *Similar Ship SS Data Acquisition*
    - ☒ *SCM Statistical Validation on SS*
    - ☒ *Additional Parameters (Optional)*
- Task 2: CALYPSO SSM
  - Phase 1:
    - *Tailoring CALYPSO SSM*
    - *Detailed Data/Maint.Profiles*
    - *Scenario Definition/Operative Profiles*
  - Phase 2:
    - *Test on New Ship*
    - *Statistical Verification and Validation*
    - *Design of Experiments*
- Task 3: CALYPSO Integration
  - Integration and Optimization
  - Model Execution and Results Synthesis

Life Cycle Cost (LCC)

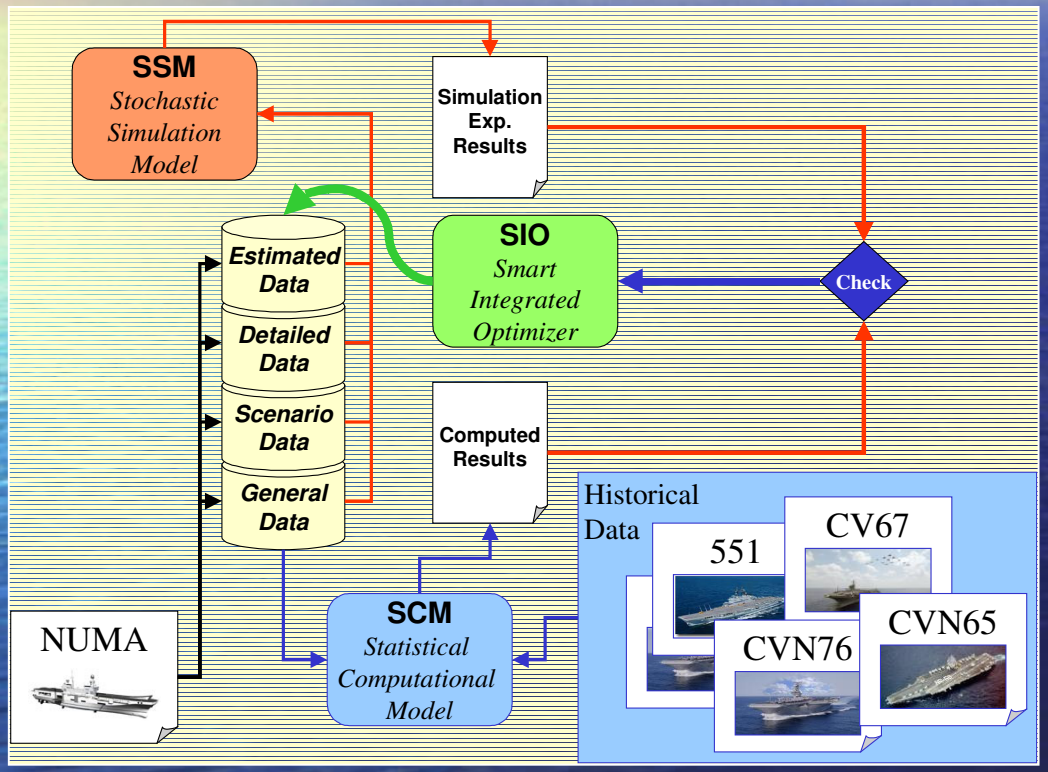
- LCC is the total costs of ownership of machinery and equipment
- LCC include acquisition, operation, maintenance and decommission costs
- LCC is used in different case such as
  - Project engineering
  - Maintenance engineering
  - Reliability engineering

Calypso Architecture



Calypso is composed by different modules

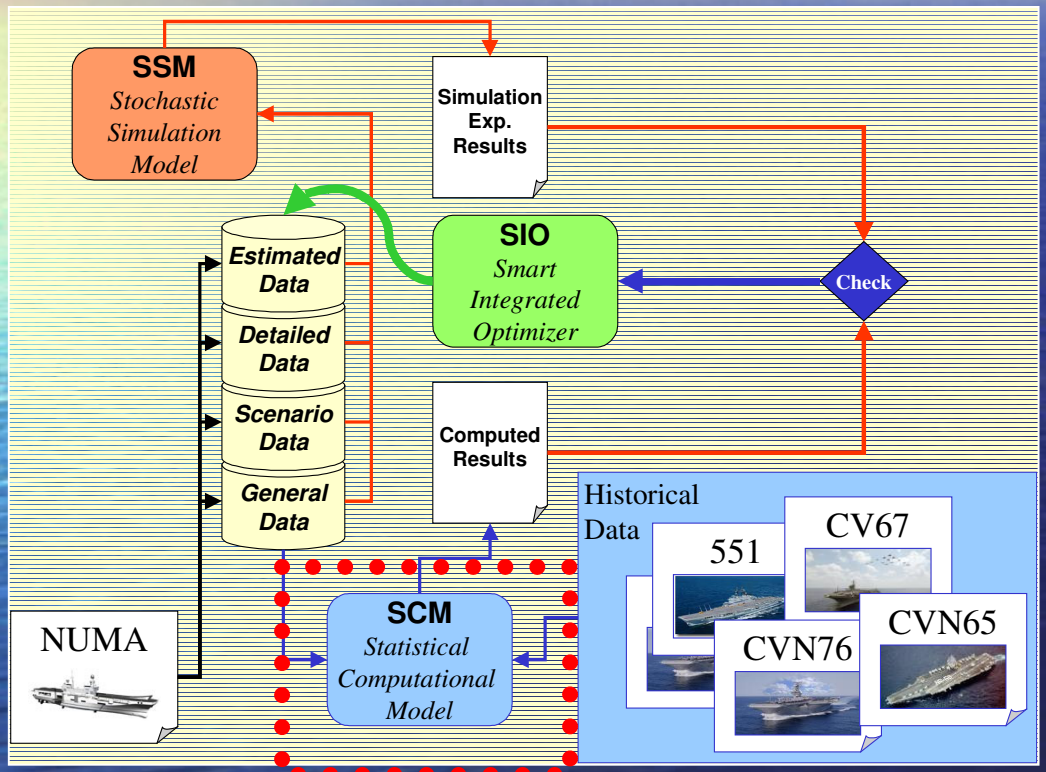
CALYPSO Architecture



Calypso framework include three major components:

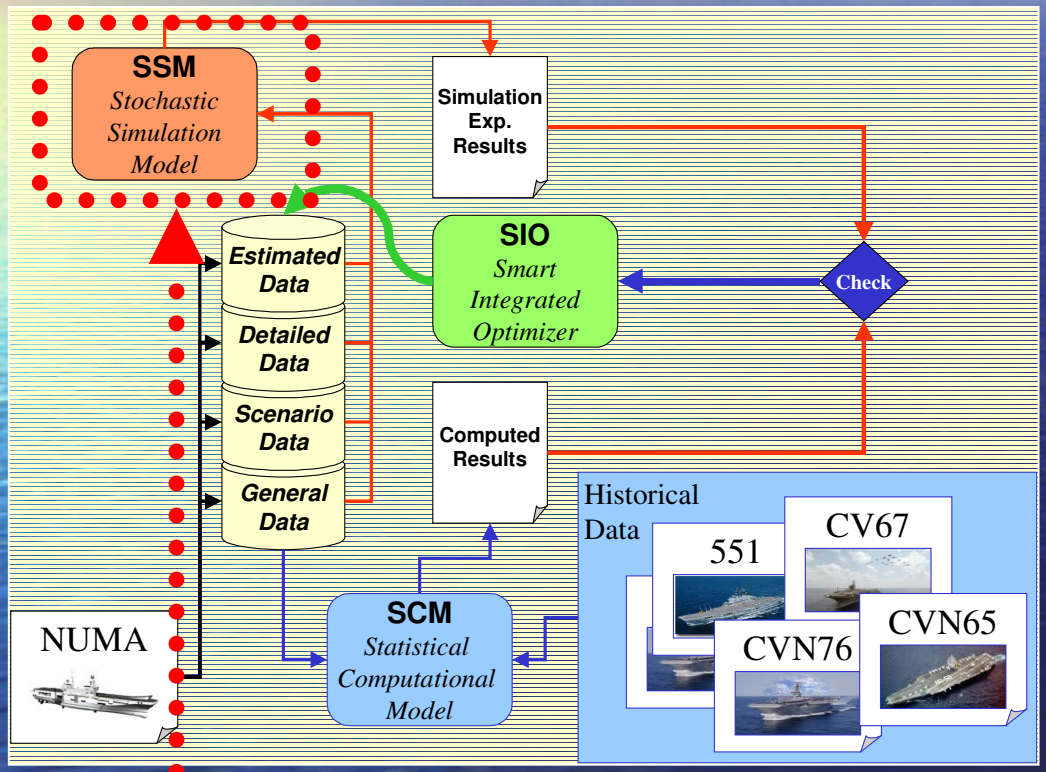
- SCM statistical computational model
- SSM stochastic simulation model
- SIO smart integrated optimizer

CALYPSO Architecture



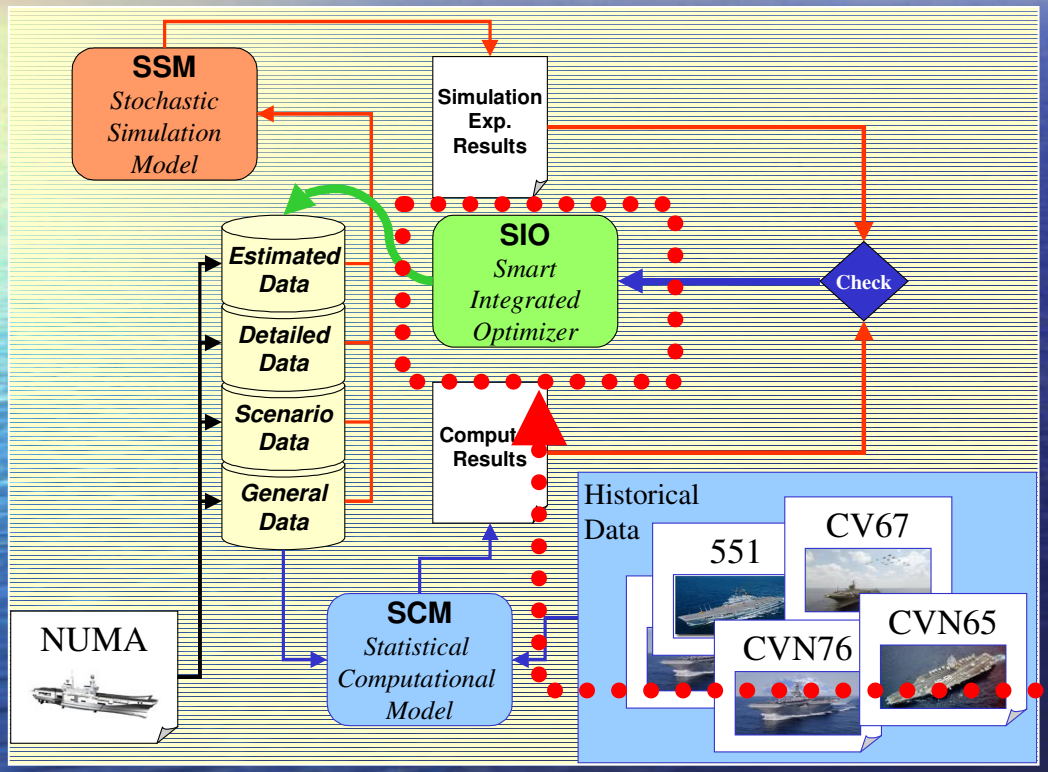
The SCM extrapolates, from historical data related to similar ship types, the costs related to the different activities. By this approach it's possible obtain an estimation of the overall LCC

CALYPSO Architecture



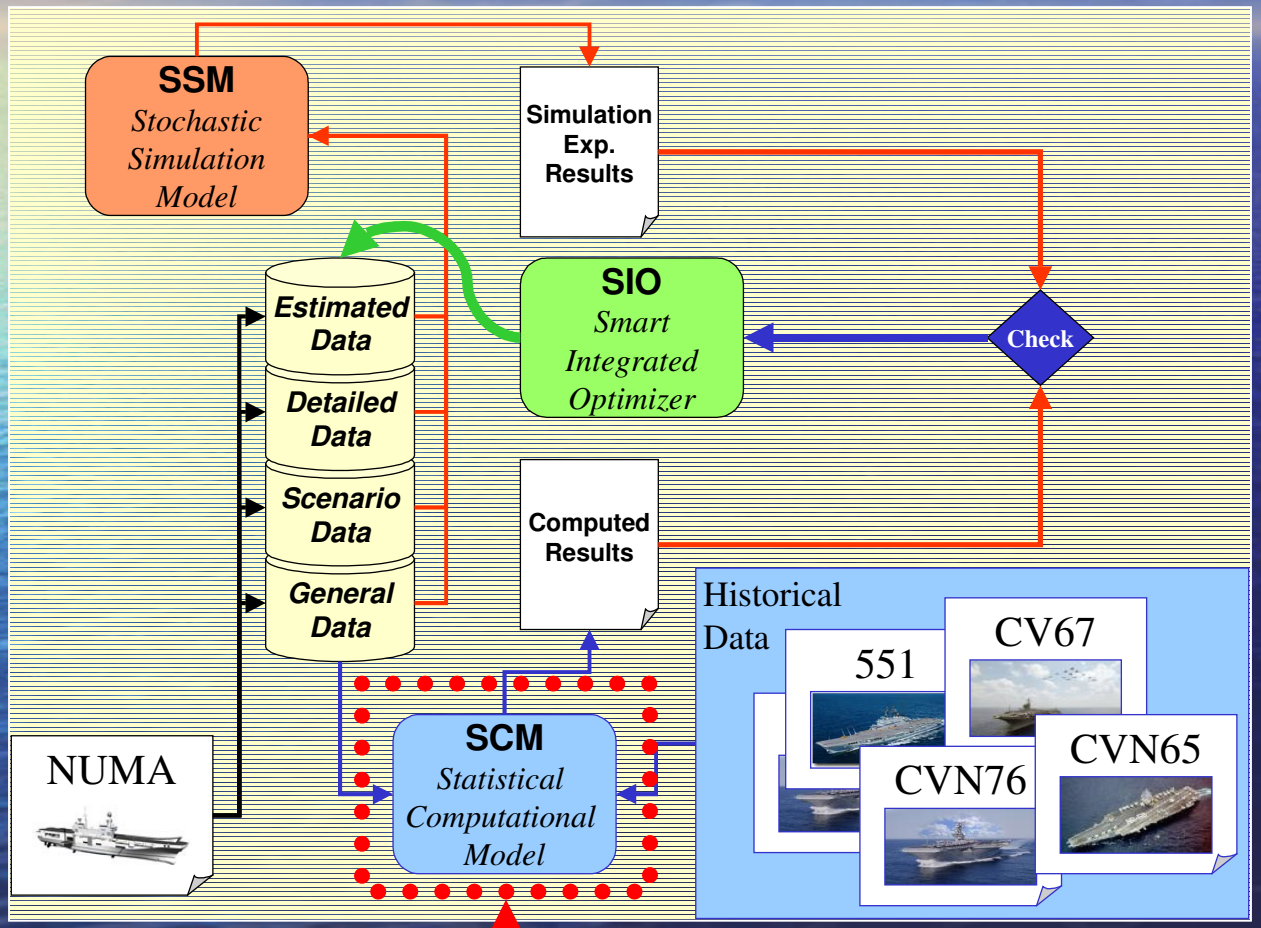
The SSM is a stochastic simulator that reproduce Carrier operation during whole life cycle considering different expected scenario; the results obtained by this model on traditional operative scenario can be compared with the SCM

CALYPSO Architecture



SIO proceeded to an automates optimization devoted to obtain a best fit setting of detailed parameters based on the comparison between SCM and SSM

CALYPSO Architecture



Calypso architecture can be used in a real case study

At the moment we developed and personalized SCM on a real case study

Statistical Computational Model

SCM – Main menu

SCM allows to correlate the new vessels with existing ships of same type

SCM – Historical & Technical Data

Historical Data

cost category	data	value	CV 67 (97 fiscal yea	CVN 68 (97 fiscal yea	Garibald	NUM
	$/l					
	Inflaction 97-05					
	years					
	years					
	today barrel cost					
Investiment cost						
	cost per tons					
	ship displacement					
	midlife modernization					
Direct operating and support cost						
	annual personnel cost					
	annual accrued retirement					
	fuel barrels/year					
	barrel cost					
	SRA (30 years)					
	SRA (30 years)					
	cost per SRA					
	COH (30 years)					
	COH (30 years)					
	cost per COH					
	Others (spare parts, supplies) (year)					
Indirect operating and support cost						
	Initial training cost (year)					
	Special training cost (year)					
	barrel delivery cost					
	year nuclear support activities					
	Others (pubblications, technical services) year					
cost category	data	value	CV 67 (97 fiscal yea	CVN 68 (97 fiscal yea	Garibald	NUM

Technical Data

tecnical data	CV 67 (Kenne	CVN 68 (Nim	GARIBAL	NUM	France	Uk
Dimension						
Lengh [m]						
Breadth [m]						
Draft [m]						
Full load displacement [tons]						
Tonnes light						
Personnel [ship]						
Propultion						
Reactor						
Boiler						
shafts						
Maximum power [Hp]						
Maximum power [Mw]						
Performance						
Maximun speed [knots]						
Range at average speed [nm]						
Acquisition cost [Ml]						
Cost per tons [l]						
Average Sailing [Nm]						
Availability in Sea						
Availability in Port						
Exercise Time [h/year]						
Real Operations [h/year]						
Direct operating and support cost coefficent						
Personnel coefficent	1	1	1	1		
Fuel coefficent	1	1	1	1		
Depot maintenance coefficent	1	1	1	1		
Other coefficent	1	1	1	1		
Indirect operating and support cost coefficent						
Training coefficent	1	1	1	1		
Fuel delivery coefficent	1	1	1	1		
Other coefficent	1	1	1	1		

SCM includes Parameters about costs, capacities and profiles

VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

SCM – Coefficents Menu




Ref-Comparison: Nimiz-Cavour

Direct operating and support cost

Personnel coeff	N° personnel	0,313
Fuel coeff	Hp	0,421
Depot maintenance	Full load displacement	0,335
Others	Acquisition cost	0,670

Results direct operating and support cost coeff

Indirect operating and support cost

Training coeff	N° personnel	0,313
Fuel delivery	Hp	0,421
Other	(1:1)	1,000

Result indirect operating and support cost coeff

Click for final estimation

Main menu | Historical data | Tecnical data | LCC fiscal year 05 (30 years)

2005 © Copyrights DIPTEM University of Genoa

Correlation are defined by users based on different possibilities

VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

SCM –Comparison

Comparative Analysis with Historical Data

Fiscal year 2005

Cost category	Subcost category	CV 67	Coeff	NUMA	
Investiment cost					
	ship acquisition cost	1879			[M€]
	midlife modernization cost				
Total investiment cost		1879			[M€]
Operating and support cost					
Direct operating and support cost					
	Personnel	2556			[M€]
	Fossil fuel	578			[M€]
	Depot maintenance	2460			[M€]
	Other	513			[M€]
	Total direct operating and support cost	6107			[M€]
Indirect operatating and support cost					
	Training	88			[M€]
	Fossil fuel delivery	258			[M€]
	Nuclear support activities				
	Other	32			[M€]
	Total indirect operating and support cost	378			[M€]
Total operating and support cost		6485			[M€]
Inactivation/Disposal cost					
	Inactival/Disposal cost	41			[M€]
	Spent nuclear fuel storage cost				
Total inactival/Disposal cost		41			[M€]
Total life cycle cost	Total life cycle cost	8405			[M€]

VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

Different Fiscal Year and Currencies

Possibility to valorize the costs in reference to different FY

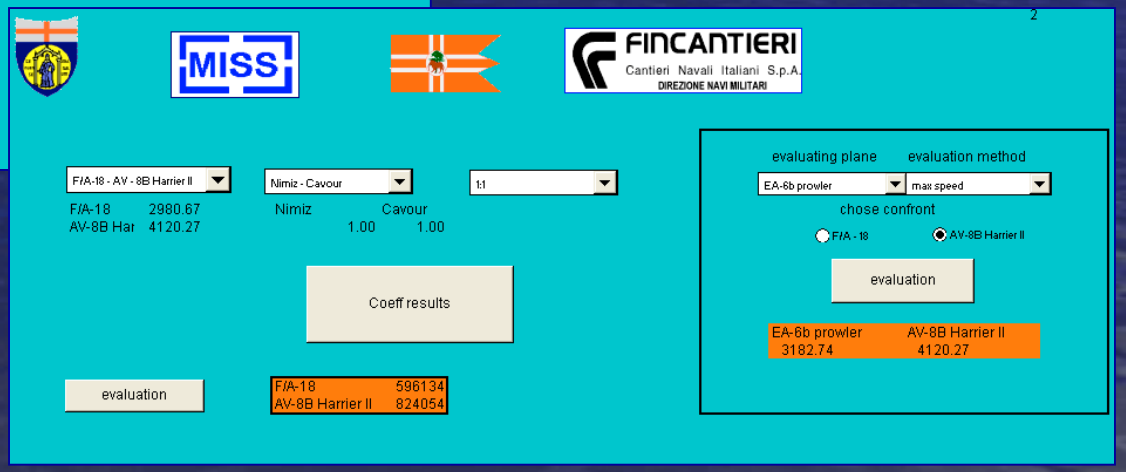
Fiscal year 98 [M$]

		Ship 1		Ship 2
Cost categorg	Subcost categorg	CY 67	Coeff	C: NUMA
Investiment cost				
	ship acquisition cost	2099		
	midlife modernization cost			
Total investiment cost		2099		
Operating and support cost				
Direct operating and support cost				
	Personnel	2856		
	Fossil fuel	645		
	Depot maintenance	2748		
	Other	573		
	Total direct operating and support cost	6822		
Indirect operatating and support cost				
	Training	99		
	Fossil fuel delvery	288		
	Nuclear support activities	0		
	Other	36		
	Total indirect operating and support co	422		
Total operating and support cost		7244		
Inactivation/Disposal cost				
	Inactival/Disposal cost	46		
	Spent nuclear fuel storage cost	0		
Total inactival/Disposal cost		46		
Total life cycle cost	**Total life cycle cost**	9388		

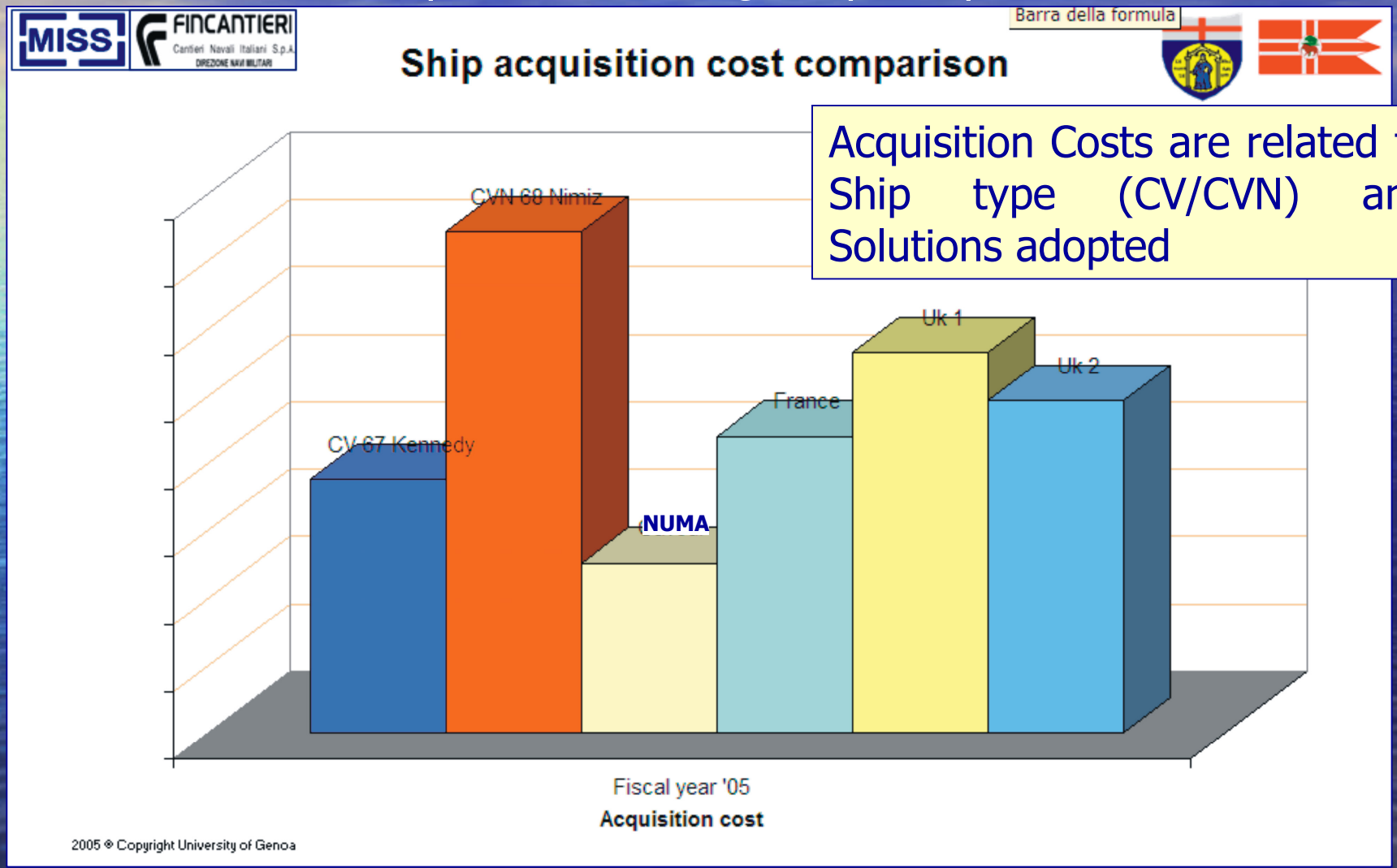
VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

SCM Module for Wing Costs

SCM allows to estimate the cost of aircraft and airmobiles on the carrier



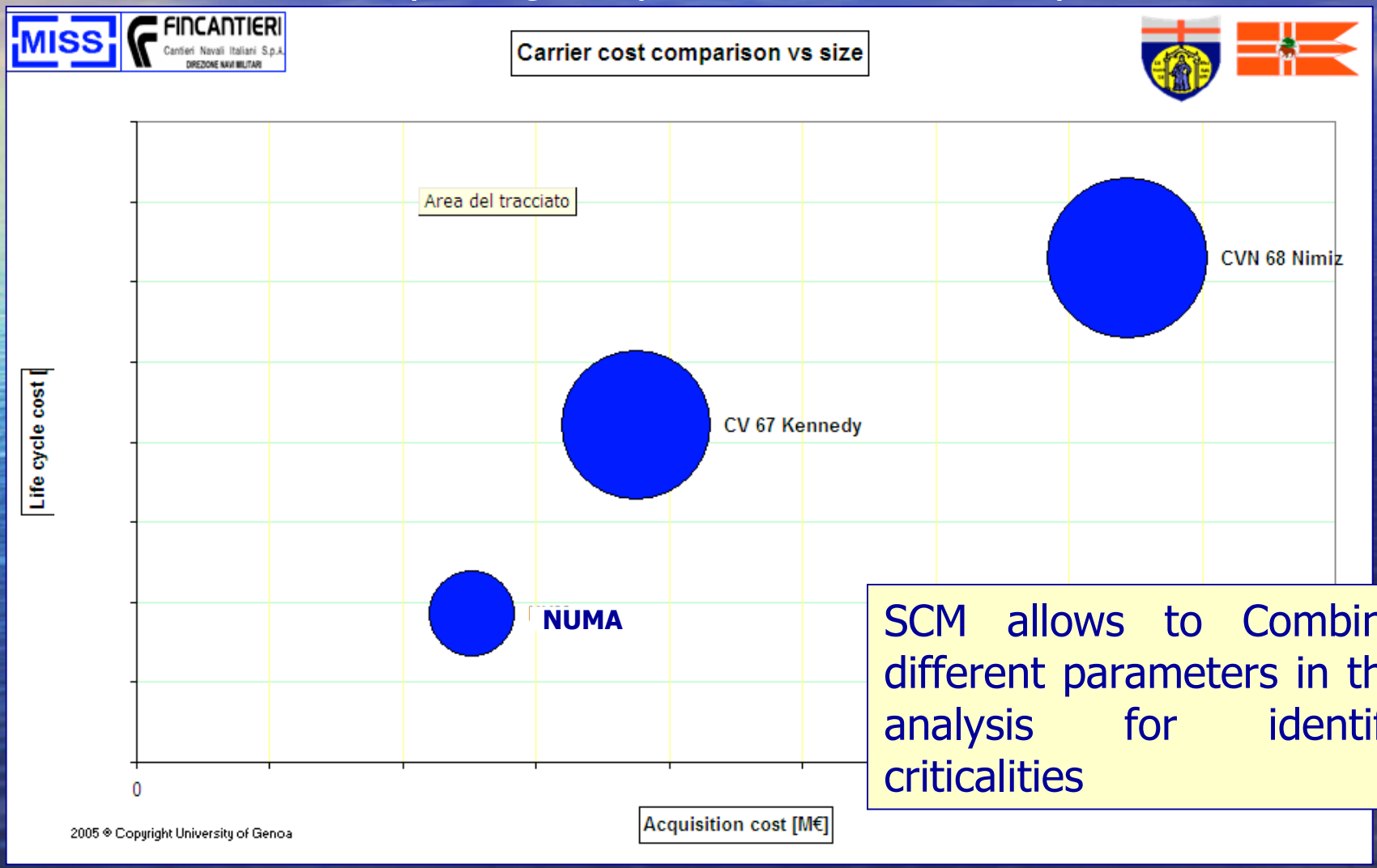
SCM –Comparison Among Ship Acquisition Cost



Acquisition Costs are related to Ship type (CV/CVN) and Solutions adopted

VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

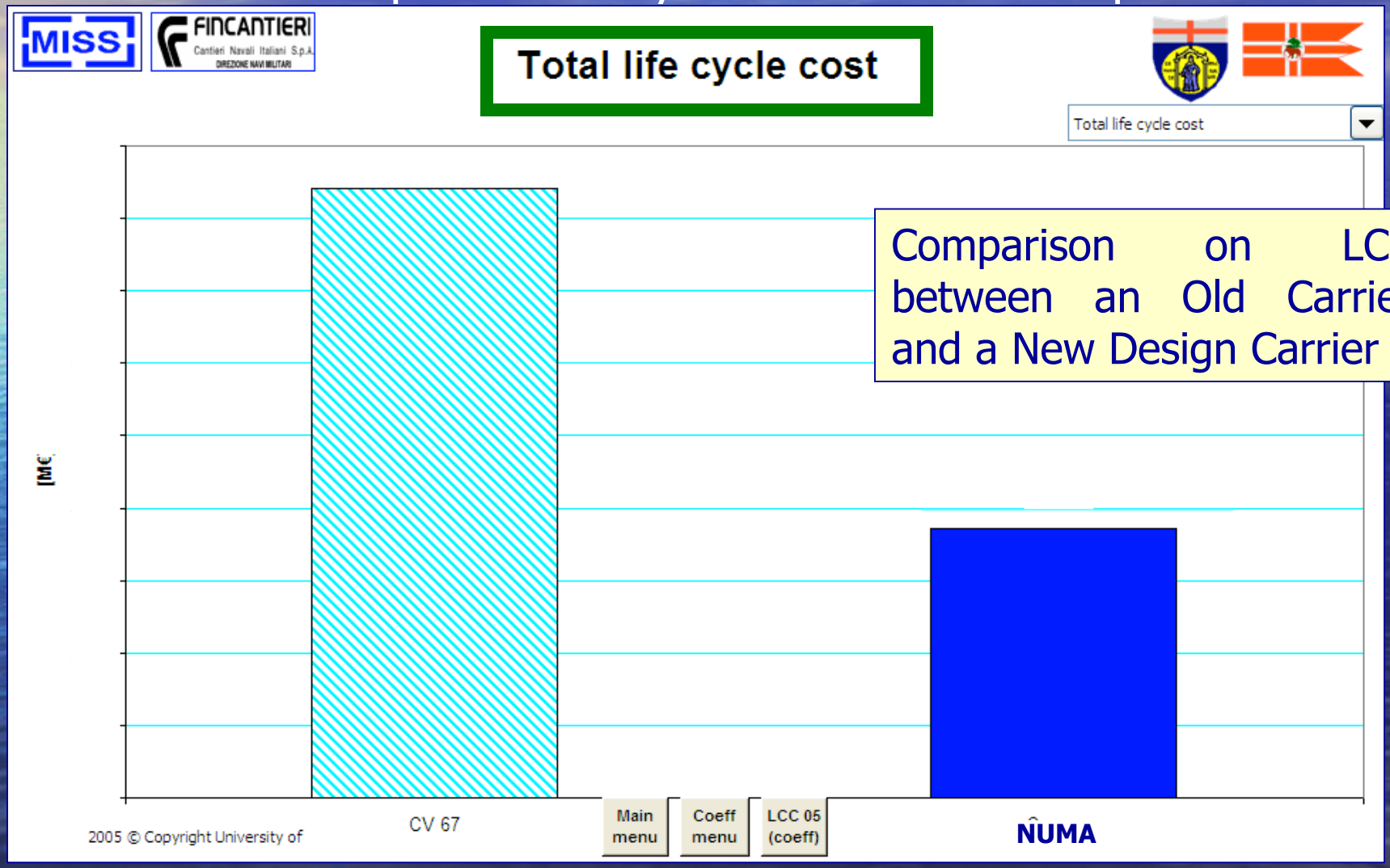
SCM –Comparing Acquisition / LCC / Displacement



SCM allows to Combine different parameters in the analysis for identify criticalities

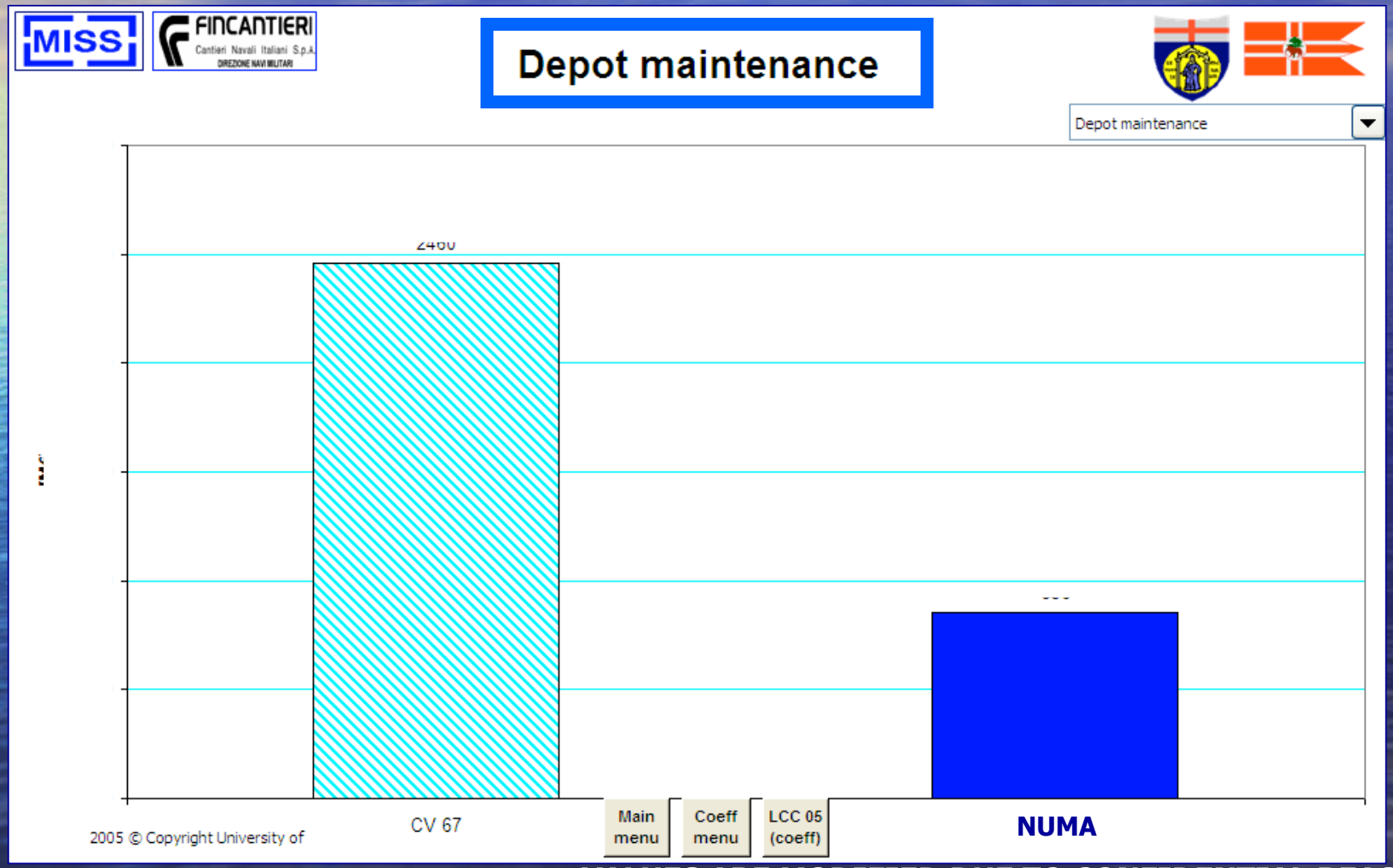
VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

SCM – Example: Kennedy-NUMA Overall Comparison



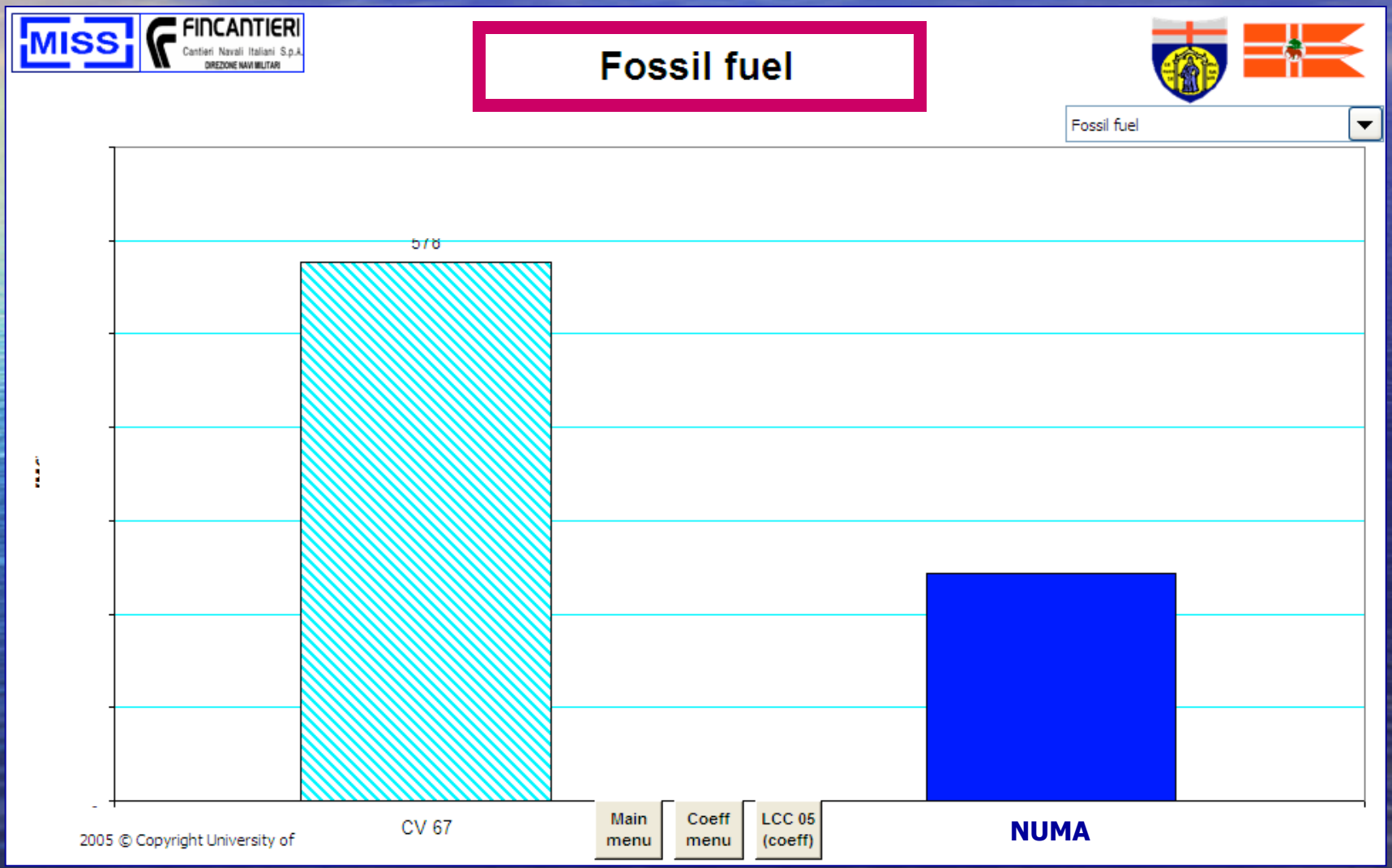
VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

SCM – Example: Kennedy-NUMA Maintenance Comparison



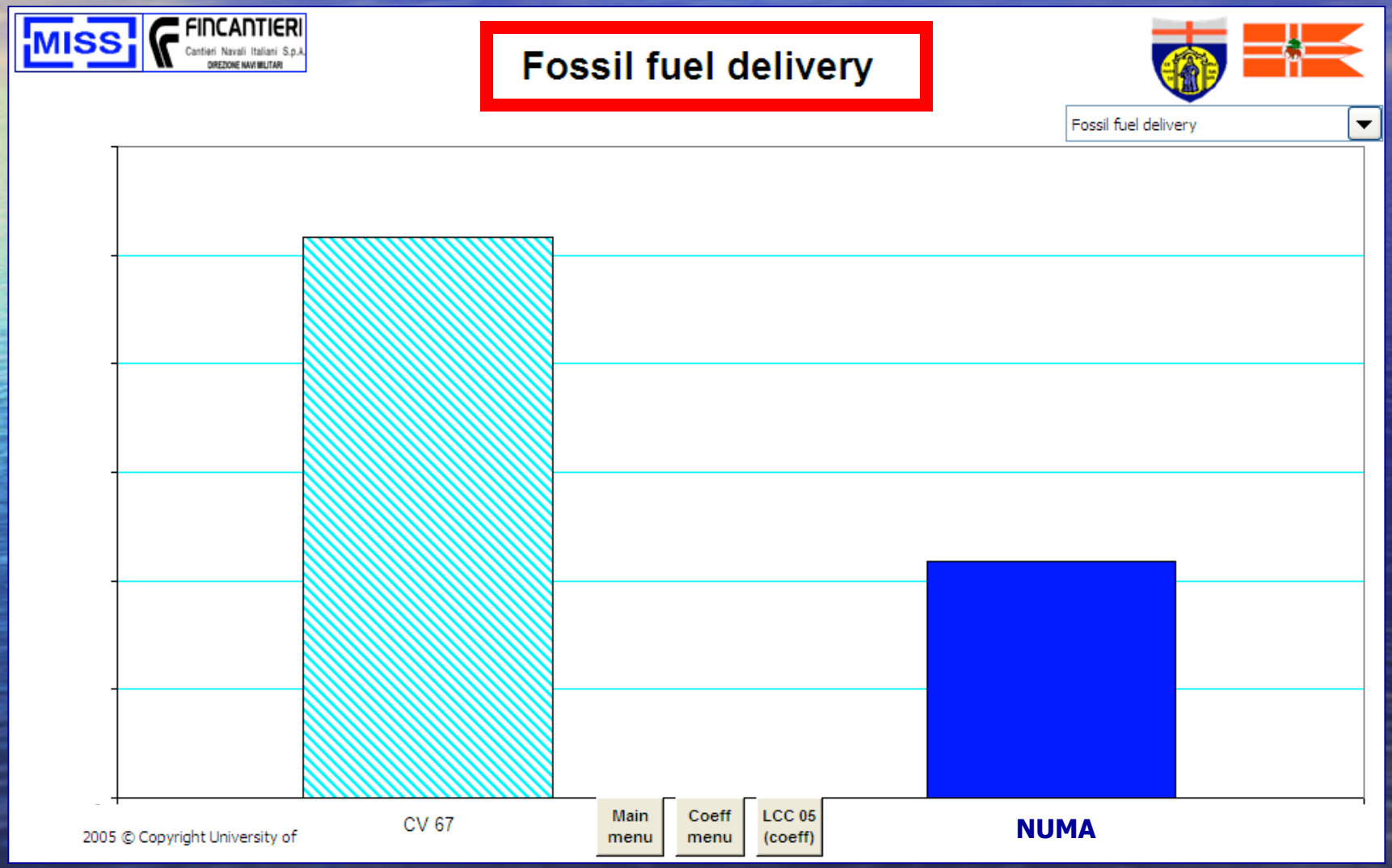
VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

SCM – Example: Kennedy-NUMA Fuel Cost Comparison



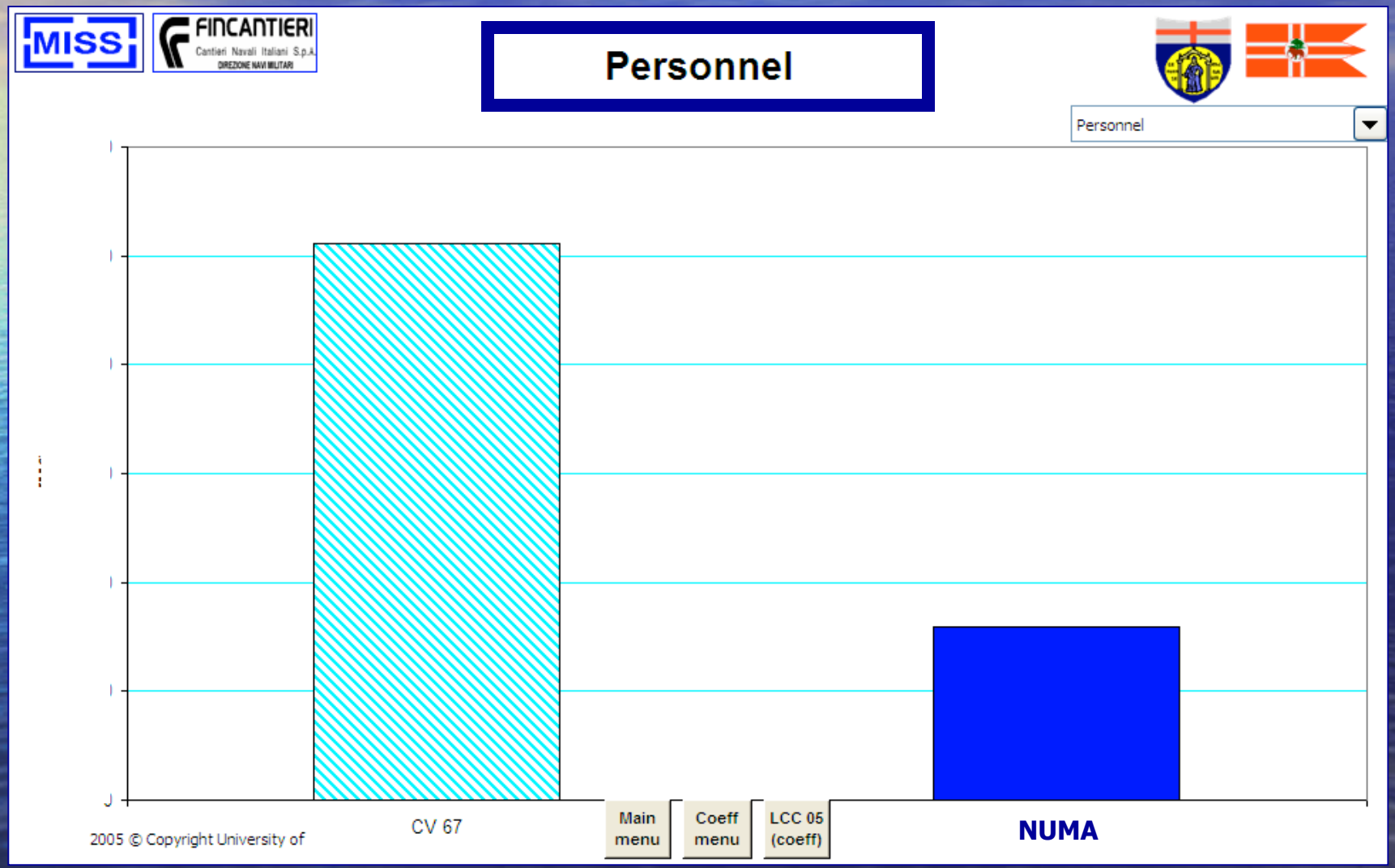
VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

SCM – Example: Kennedy-NUMA Delivery Bunker



VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

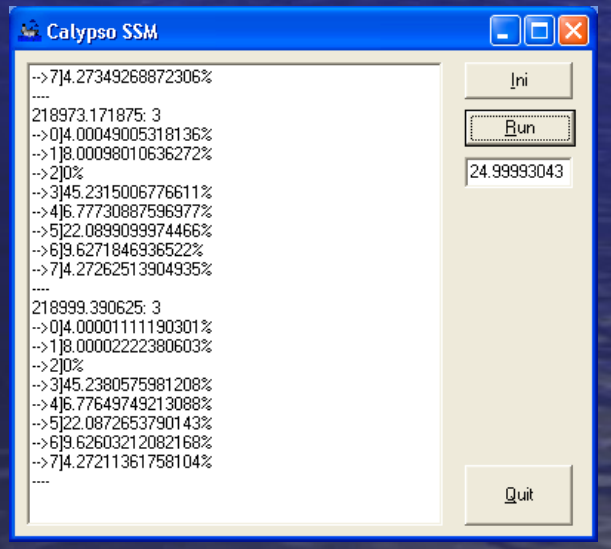
SCM – Example: Kennedy-NUMA Personnel Cost Comparison



VALUES ARE MODIFIED DUE TO CONFIDENTIAL REASONS

Conclusions

- The correlation among different ships by SCM allowed to identify values for estimating costs factors and maintenance impact
- Interesting Correlation are evident from data analysis provided by SCM
- Currently we are working on the development SSM and SIO based on the results provided by the SCM



References

Development of Innovative Projects Consortium

http://st.itim.unige.it

DIPTEM University of Genoa
via Opera Pia 15
16145 Genova
agostino@itim.unige.it

DIP
Office Tower, Voltri Port
16145 Genova
info@brbstudio.com