Cost-benefit analysis for the “Intelligent Vessel”: The case of the ATOMOS IV project

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ATOMOS IV project

- “Advanced Technologies to Optimize Maritime Operational Safety: Intelligent Vessel”
- Contract No. 1999-CM.10540 (DG-TREN, 5th FP)
- Duration: 1999-2003
- 12 partners from 8 EU countries

Previous related projects

- ATOMOS
- ATOMOS II
- DISC (Demonstrators for Integrated Ship Control)
- DISC II/ATOMOS III

ATOMOS IV partners

- FORCE-DMI (DK) -Coordinator
- Lloyds Register of Shipping (UK)
- STN Atlas (D)
- Lyngsoe Marine (DK)
- Logimatic A/S (DK)
- National Technical University of Athens (GR)
- D' Appolonia SpA (I)
- CETEMAR (E)
- ISSUS (D)
- TNO (NL)
- Swedish Maritime Administration (S)
- Aalborg University (DK)

Main Objectives

- Bring the benefits of advanced computer and control technology to the European fleet.
- Perform a trial retrofit of an advanced control system on a trial vessel.
- Perform a full verification and validation of the retrofit
- Perform a full evaluation of the retrofit from a safety and cost-benefit viewpoint

Other aspects

- Compliance to SOLAS V/15 (bridge and navigation equipment design and procedures)
- Human-centered development for ship control centers and interfaces
- Risk-based development applying safety assessment techniques
- Principles-based assessment for programmable systems
- Computer-based training tools

Rationale

ATOMOS-type technologies would

- reduce manning and other costs
- increase EU ship and fleet competitiveness
- reduce risk of accidents and pollution
- increase maritime safety

Possible contexts

- Newbuilding: Build a new ship based on ‘ATOMOS platform’
- Retrofit: Convert an existing ship by implementing the ‘ATOMOS platform’

- Focus of ATOMOS IV project: Retrofit

ATOMOS IV project retrofit

- Implemented on “Frej”, a Swedish ice-breaker
- Vessel to be equipped with all necessary hardware and software
- ATOMOS bridge and integrated ship control
- Extensive tests and sea trials conducted
- Full verification, validation and evaluation
- Final demonstration (the ‘big switch’)


FREJ

Retrofit Strategy Tool (RTS)

- Helps ship owner assess if retrofit is worth pursuing
- Goes over complete list of retrofit equipment
- Evaluates all costs and benefits from retrofit
- General context: applies to any ship, provided data is available

Cost-benefit issues in RST

- Compare original ship to converted (ATOMOS) ship
- Evaluate all cost and benefit components
- Use appropriate cost-benefit criteria
- Perform sensitivity analysis
- Draw conclusions

Cost benefit contexts in ATOMOS IV

- Specific: just for the ‘Frej’
- Generic: for any ship type

Generic Cost Benefit Flow

ATOMOS Concept

Generic ATOMOS System Architecture

ATOMOS Retrofit – Decision

ATOMOS Subsystems

Safety Evaluation

Costs & Benefits

Criterion

Results

Main Criterion: Net Present Value (NPV)

$$NPV = \sum_{n=1}^{RFL} \frac{B_{CRn} + B_{MNTn} + B_{INSn} + B_{FUEn} - C_{TRAn} - C_{OTHn}}{(1+i)^n} - (C_{ATI} + C_{NAT} + C_{CAB} + C_{EXT})$$

Benefits:

- Manning
- Maintenance
- Insurance
- Fuel
- Safety

Initial Costs:

- ATOMOS Platform
- Non–ATOMOS Equipment
- Cabling
- Extra

Recurring Costs (for year "n"):

Training,Maintenance, Upgrading, Service

Cost Benefit Components (RST)

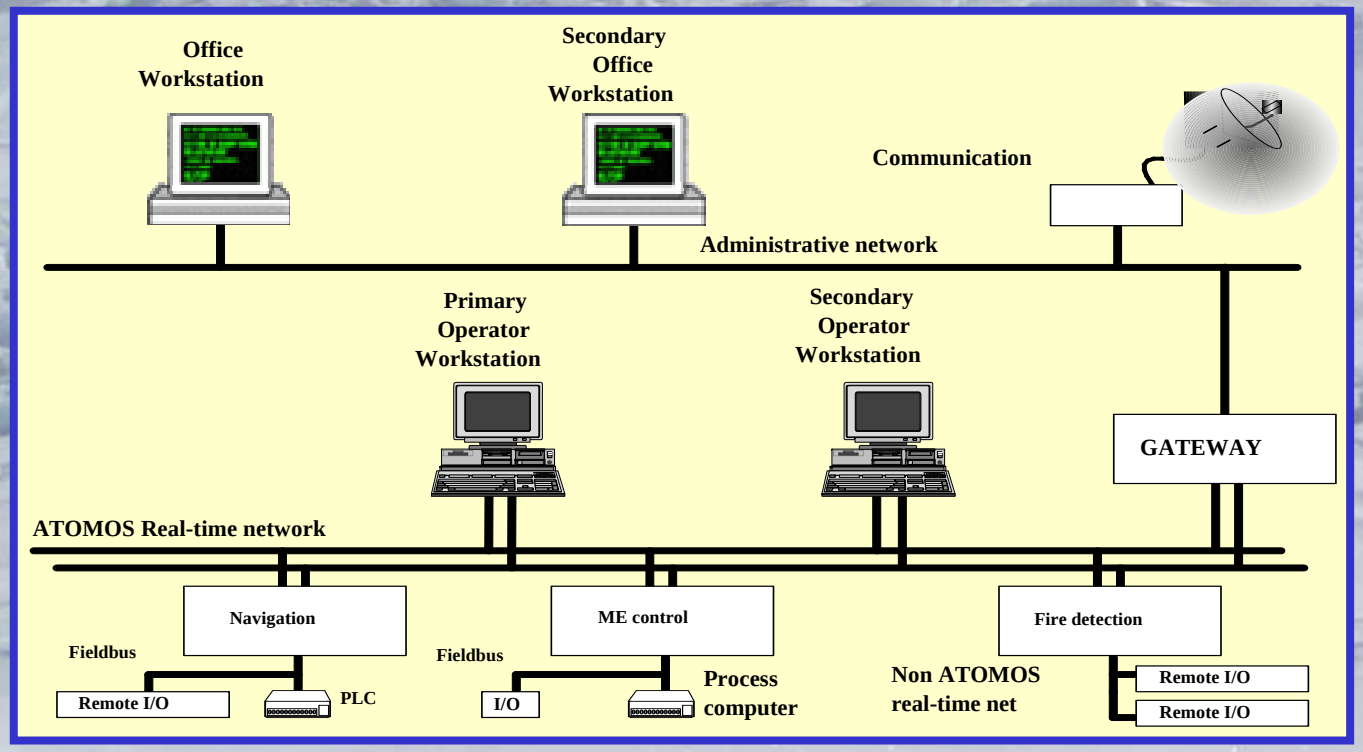
Costs

ATOMOS Platform
Non-ATOMOS Equipment
Cabling
Extra

Benefits

Manning
Safety
Maintenance
Insurance
Fuel

ATOMOS Platform



Software

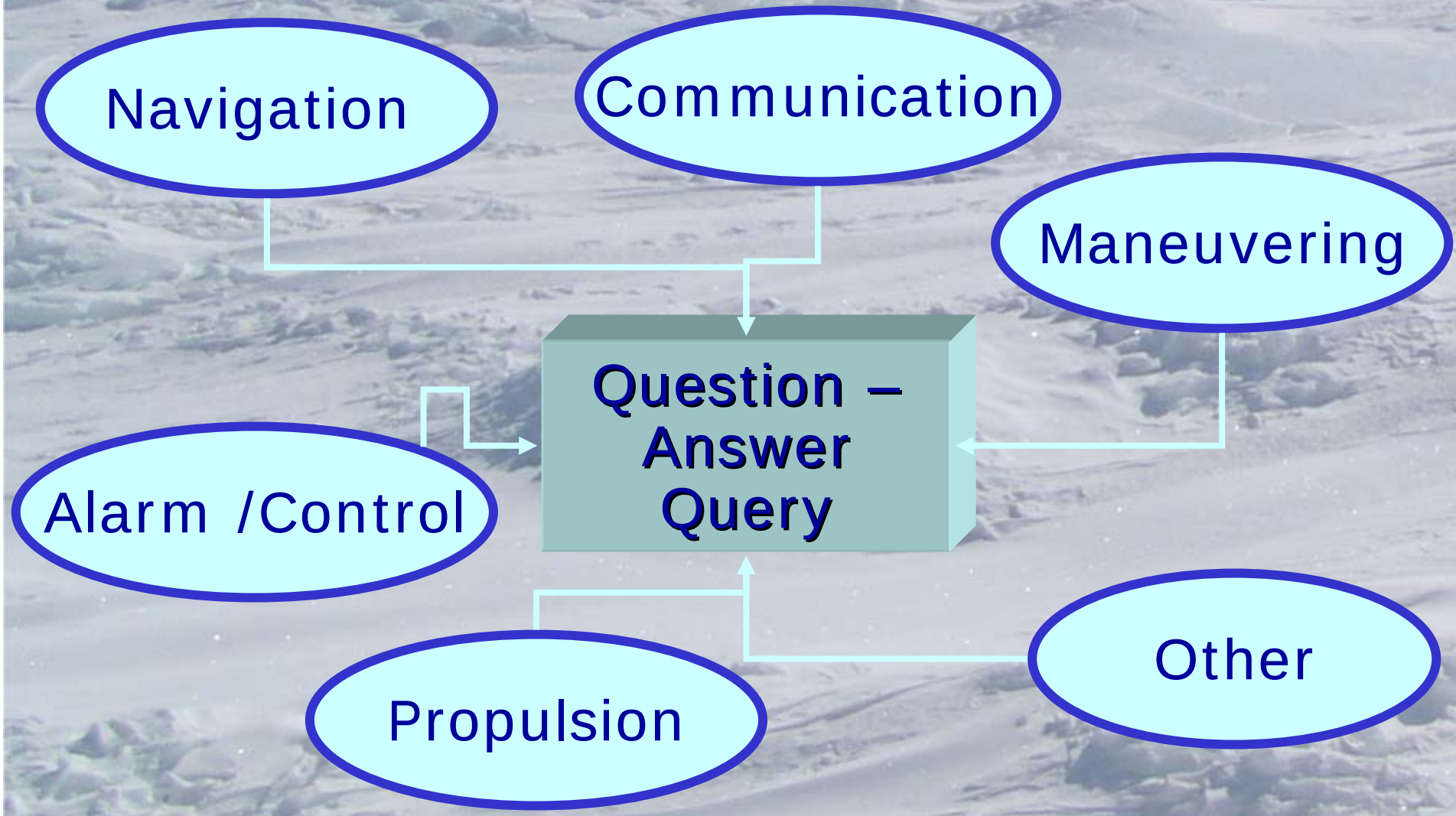
Navigation Equipment / Bridge Systems

Alarm Monitoring and Control Systems

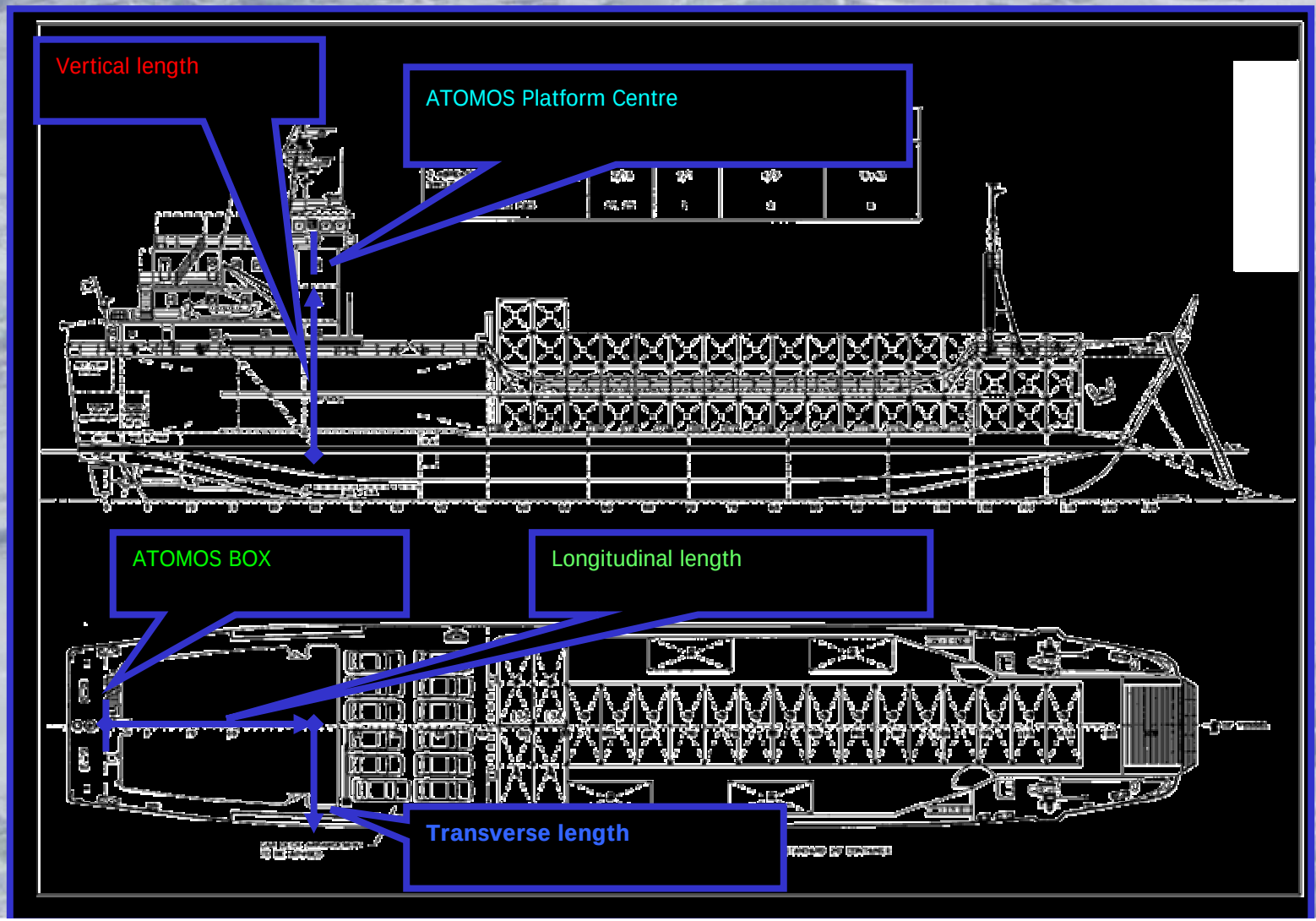
ATOMOS Platform Cost

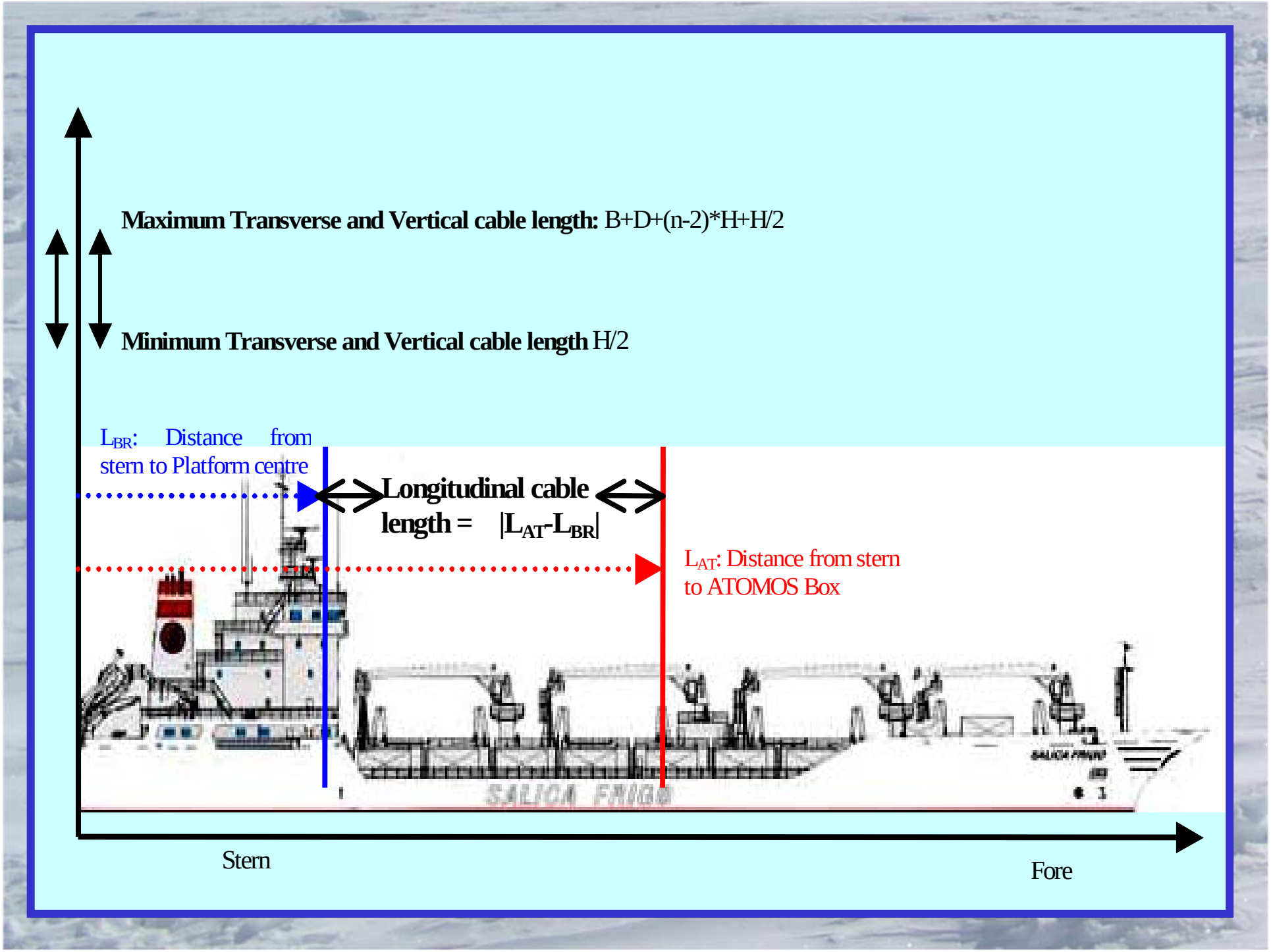
	COSTS (euros)		*COSTS (euros / year)*				
	PURCH.	INSTAL.	TRAIN.	OPER.	MAINT	UPGR.	SERV.
NAVIGATION EQUIPMENT	345,970	14,300	6,700	0	0	0	24,800
ALARM MONITORING and CONTROL	283,500	168,500					
SOFTWARE	21,756	154,743	4,597	2,758		919	
EXTRA	8,000						
TOTAL/ Category	659,226	337,543	11,297	2,758		919	24,800
TOTAL	**996,769**		**11,297**	**28,477**			

Non – ATOMOS Equipment



Cabling Cost




Maximum Transverse and Vertical cable length: B+D+(n-2)*H+H/2
Minimum Transverse and Vertical cable length H/2
L_{BR}: Distance from stern to Platform centre
Longitudinal cable length = $|L_{AT}-L_{BR}|$
L_{AT}: Distance from stern to ATOMOS Box
Stern
Fore

Extra Costs

$$C_{EXTRA} = T_R \times (C_{OP} + C_{RET}) + T_{TR} \times (C_{TR} + C_{OP})$$

T_R : time duration of ATOMOS retrofit

C_{RET}: vessel's operational cost per unit time during retrofit

T_{TR}: travel time to the shipyard

C_{TR}: vessel's operational cost per unit time during voyage to the shipyard

C_{OP} : vessel's opportunity cost (lost income) per unit time

Manning cost reduction: most important benefit

- Compare conventional crew with ATOMOS vessel crew
- Question: What is the crew composition of an ATOMOS-type vessel?
- No previous results available
- Developed ‘crew synthesis tool’

Manning:
Crew Synthesis Tool

- Indicative Vessel's Crew Synthesis Estimation
- Possible Modification by the Ship Owner
- Reasonable Results (*Classification*)
- Operational Approach

Input :Database (480 Records: 60 vessels)

Output : Set of Derived Rules and Trees

Automation levels

L0 : Manual
L1 :Remote Monitoring
L2 : UMS
L3 : Automation of Individual Systems
L4 : CCS
L5 : Interconnected System
L6 : IBS – as defined by IEC (1999)
L7 :Watch 1 (ATOMOS vessel)

Crew Synthesis Tool (2)

5 Major Greek Shipping companies - Interviews

→ Flags: Greek, Panama, Liberia, Malta, Norway

4 Automation Levels Selected : L0, L2, L4, L7

→ 14 Selected Vessels

Crew Synthesis Tool (3)

ATOMOS IV

Data Mining Techniques 

Class Approximation with Classification Trees

Y : Dependent Variables → **Crew Number per Rank**

X_1, X_2... X_m : Independent Variables →

- **Automation / Integration Levels**
- **Ship Types**
- **GRT**
- **BHP**

Manning:
Illustrative Example

Calculations for *Able Bodies*

Rule-Leaf 7:

if

AUTOMATION LEVEL is L5 or L6

GRT > 3435

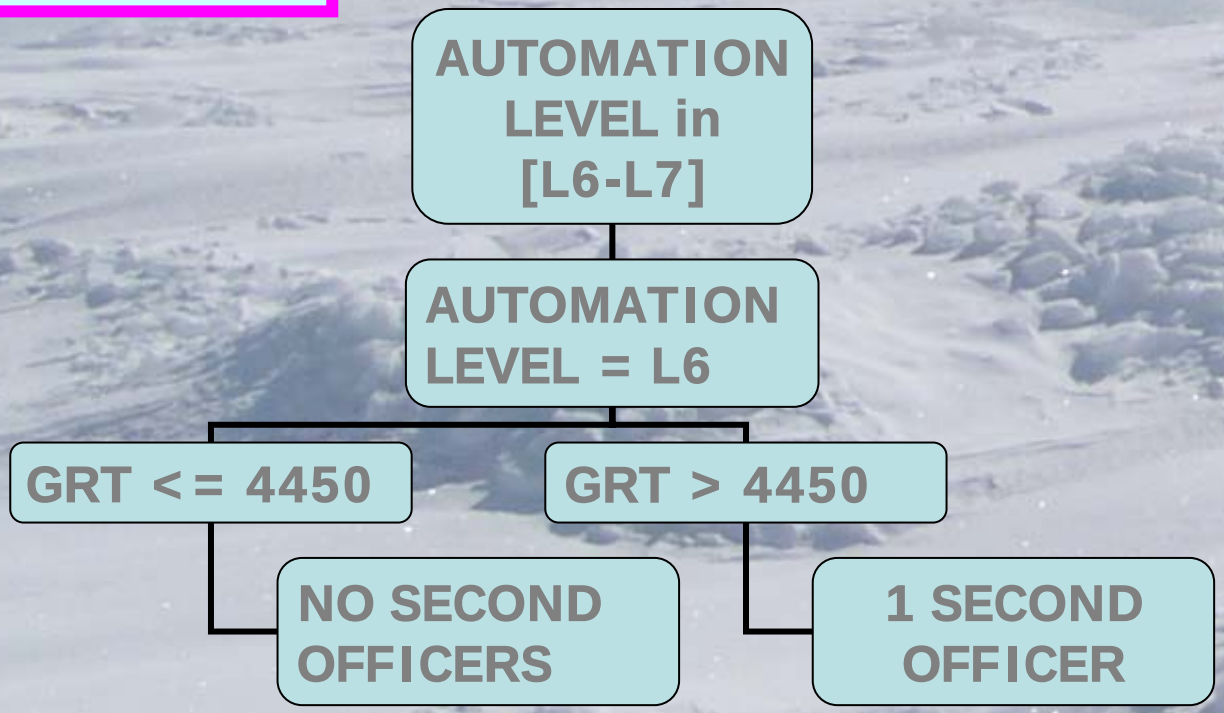
GRT <= 8500

then

AB= 2

Illustrative Example (2)

Sub-Tree:
Graphical View



Cross Validation Test (1)

Test Results:

TYPE	FLAG	LEVEL	REAL	PRED	DIFF	%DIFF
TANKER	UK	UMS	12	11	-1	-8.3
GC	Cyprus	CONV	22	22	0	0.0
TANKER	Portugal	CONV	26	27	1	3.8
TANKER	Italy	CONV	20	23	3	15.0
RORO	Sweden	CONV	20	21	1	5.0
BC	Spain	CONV	24	25	1	4.2
GC	Netherlands	CCS	7	8	1	14.3
GC	UK	CONV	23	22	-1	-4.3
CONT	Denmark	UMS	17	19	2	11.8
CONT	Denmark	UMS	17	19	2	11.8
RORO	Cyprus	CCS	12	11	-1	-8.3
TANKER	France	CONV	21	24	3	14.3
BC	Italy	CONV	22	25	3	13.7
TANKER	Spain	UMS	17	19	2	11.8

Cross Validation Test (2)

Case Driven Results (Container, Danish Flag):

	UMS REAL	UMS PRED	CCS PRED	ATOMOS PRED
Total	17	19	15	11
Captain	1	1	1	1
Chief Officer (Mate)	1	1	1	1
2nd Officer	2	2	1	0
3rd Deck Officer	0	0	0	0
Chief Engineer	1	1	1	1
2nd Engineer	2	1	1	1
3rd Engineer	1	2	1	0
Electrician	1	1	0	0
Bosun	1	1	1	1
Deck or Able Body	4	5	5	4
Wiper / Oiler	1	1	0	0
Cook	1	1	1	1
Steward	1	2	2	1

Illustrative Example (1)

Vessel's Type	: Tanker
DWT	: 90,000 t
GRT	: 39,283 t
L	: 205 m
B (Breadth)	: 37 m
D	: 21.5 m
BHP	: 16,681

4-Parts Calculations

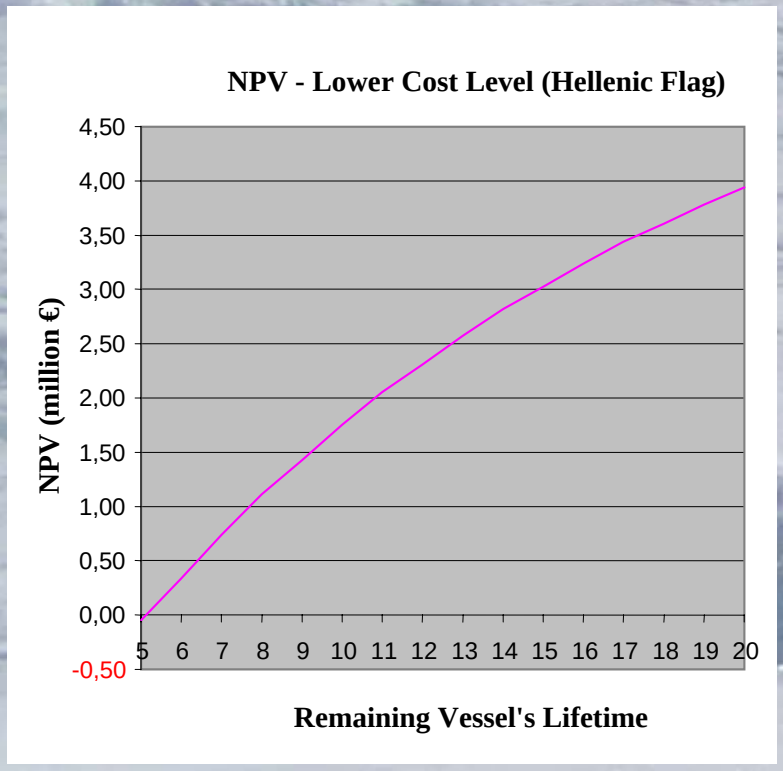
Illustrative Example (2)

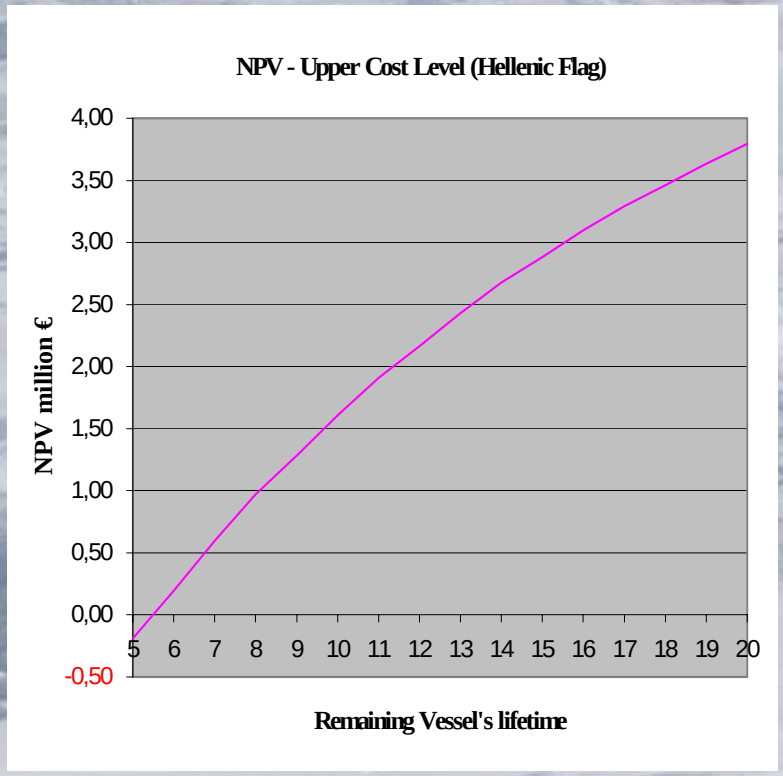
	Annual Operating Cost: € 28,477
ATOMOS Cost	Purchase/Installation : € 996,769
	Training : € 11,297
Non- ATOMOS Cost	Lower Value : € 77,257
	Upper Value : €226,842
Cabling Cost	€46,169
Extra Cost	€1,627,500

Illustrative Example (3)

Manning Benefits	€39,707 per month
Maintenance Benefits	€15,881 per year
Insurance benefits	€ 500 per year
Safety Benefits	€248,792
Fuel Benefits	0

Sample results



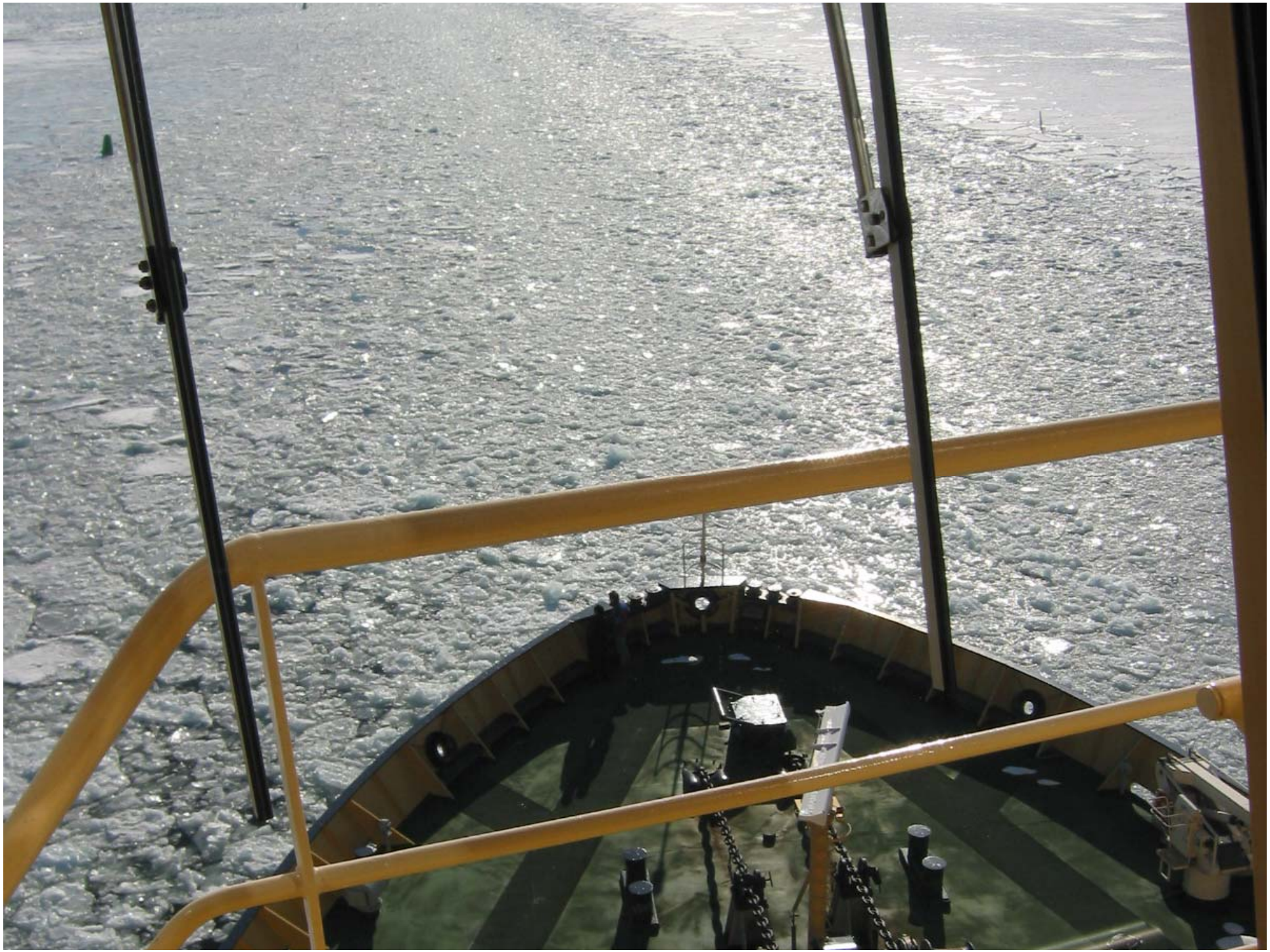


Lower Cost Level

Upper Cost Level

Conclusions (summary)

- Real-world retrofit a success
- Project objectives fully realized
- Significant benefits realized




FREJ

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