Design Process for Composite Ships

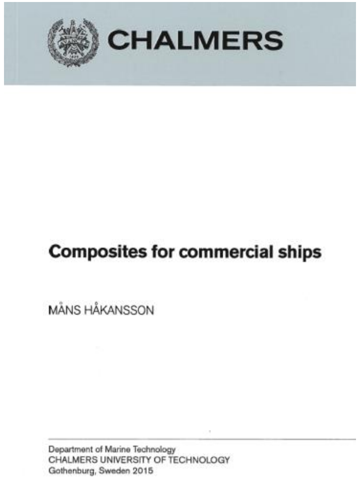
Måns Håkansson

Composite Specialist, Saab Kockums

Background

- Måns Håkansson
- Employed At Karlskronavarvet since 1998
- Composite materials all the time
- Lic. Eng. at Chalmers 2015

Minesweeper "Viksten" (1974)

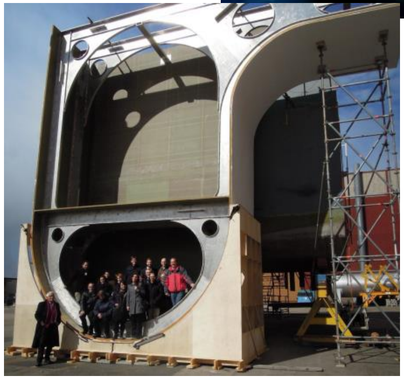


CHALMERS

Composites for commercial ships

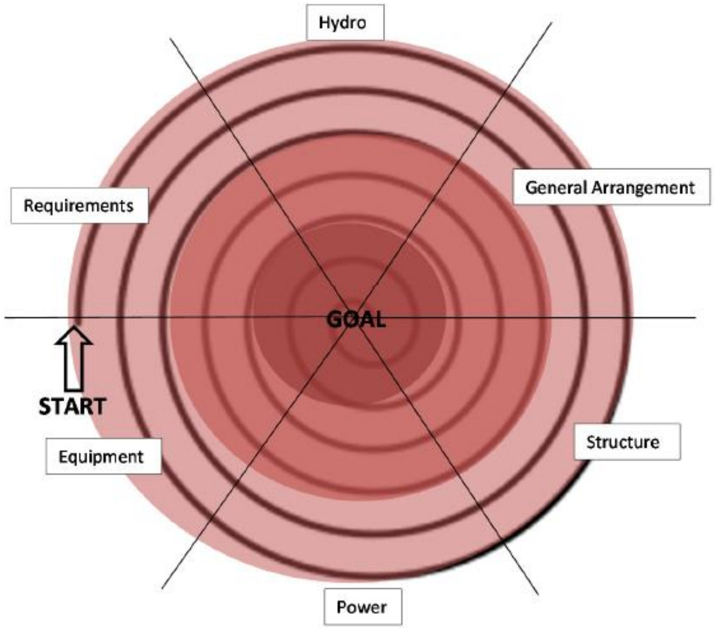
MÅNS HÅKANSSON

Department of Marine Technology
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2015



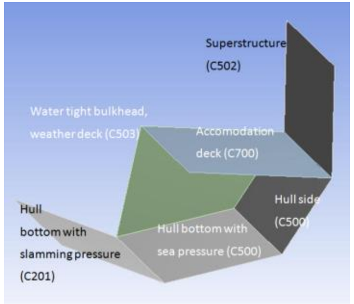
Composite Materials Light but Expensive

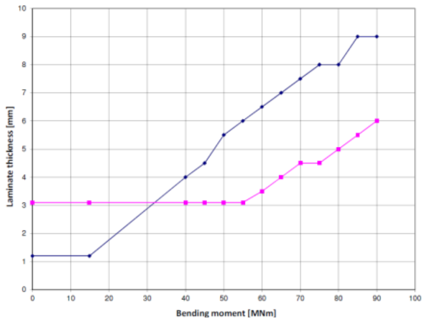
- Increase in fuel costs
- Lighter vessels due to environmental concern
- Life cycle cost analysis necessary
  - Higher acquisition cost and risk balanced by lower operational cost
- Systems engineering and structural design
  - Several loops in the design spiral
  - Tools and knowledge
- “New material”
  - Composite ships must excel in cost comparisons with steel or aluminium



Investigations

- Panel Optimization
- Longitudinal Bending
- Miscellaneous Requirements
  - Fire, noise and production aspects
- Ship's Superstructure
- Life-cycle Cost Analysis (LCCA)

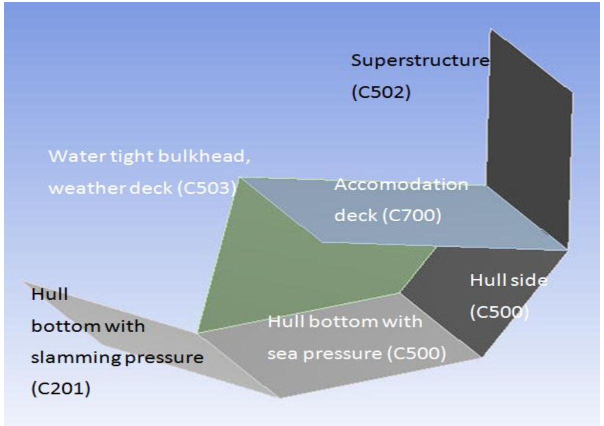




Panel Optimization

Input

PARAMETERS	NUMBER OF VALUES	VALUES
Material	2	Carbon fibre; glass fibre
Structure	2	Single-skin; sandwich
Ship length	3	10 m; 50 m; 100 m
Structural part	6	See figure
Panel size	4	1×1; 2×2; 4×4; 8×8 m
Design pressure	10	Evenly distributed in specific intervals
Objective function	2	Cost; weight



Output

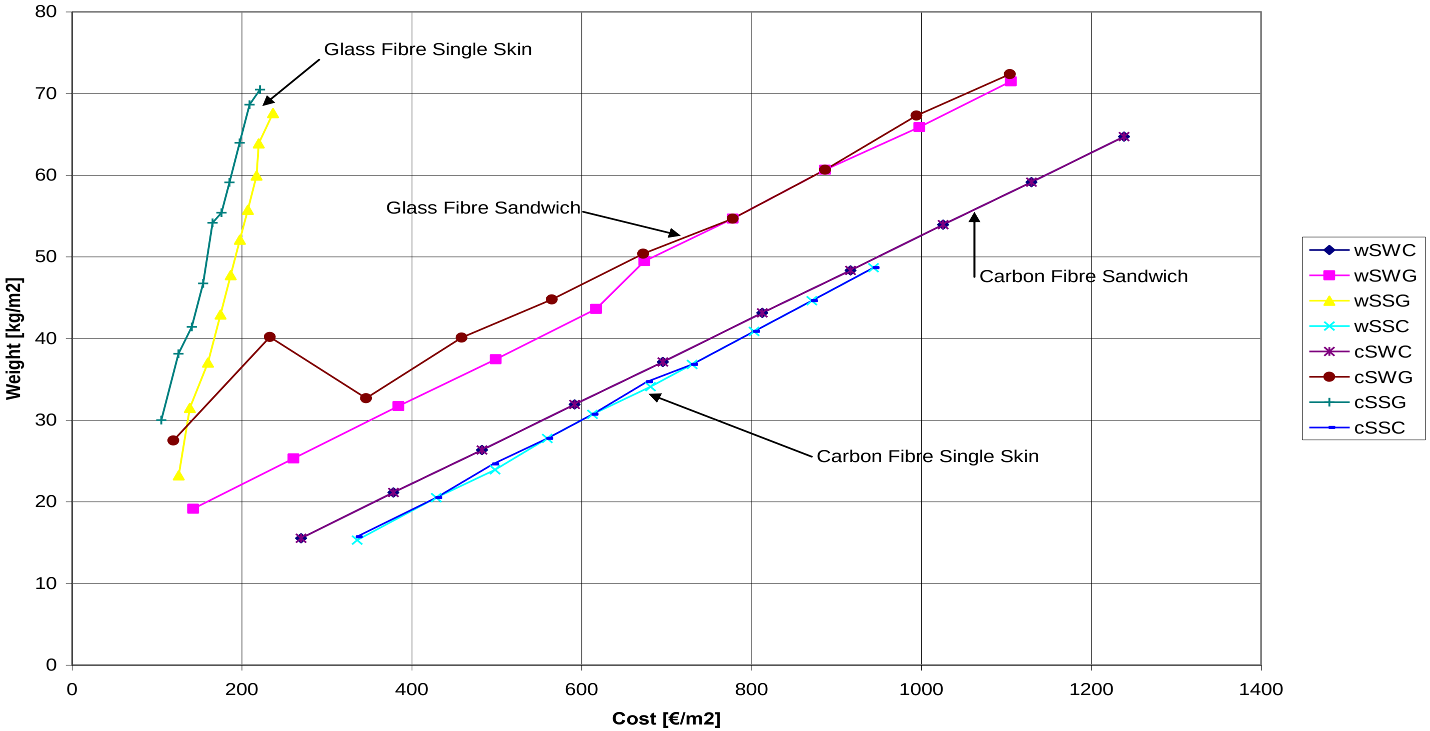
3000 set of data

Weight, Cost

Material, geometry

Calculations according to DNV Rules

Results: Panel Optimization



Hull Bottom

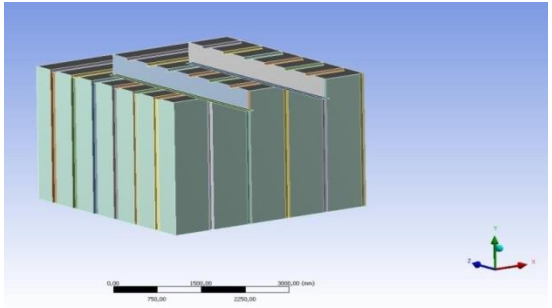
50 m ship

2x2 m

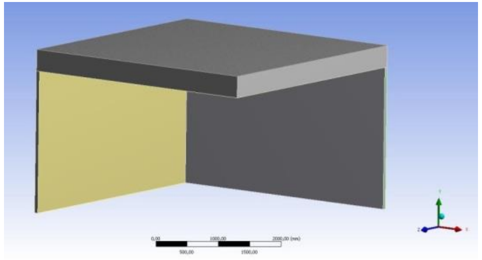
50 – 500 kPa

Complex Design Superstructure

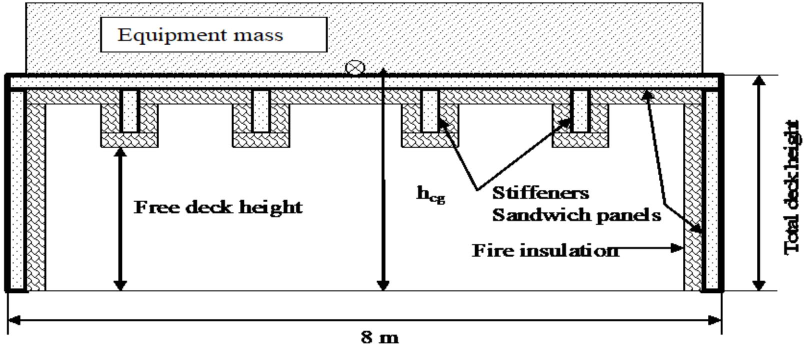
- Large, open spaces – panel size: 8x8 m
- Fire requirements: fire insulations according to rules
- Resonance frequency > 11 Hz
- Defined free deck height: 2.2 m
- Equipment's mass: 80 kg/m^2



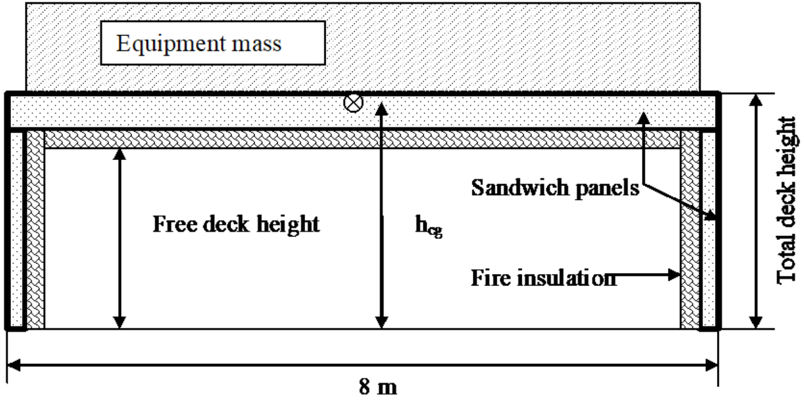
- Objective functions and examples of design requirements:
  - Weight and "ship stability"
- Input:
  - Results from panel optimizations
- Output:
  - Comparison of objective functions for steel, aluminium, CFRP and GFRP



Superstructure



Panel with girders



Panel without girders

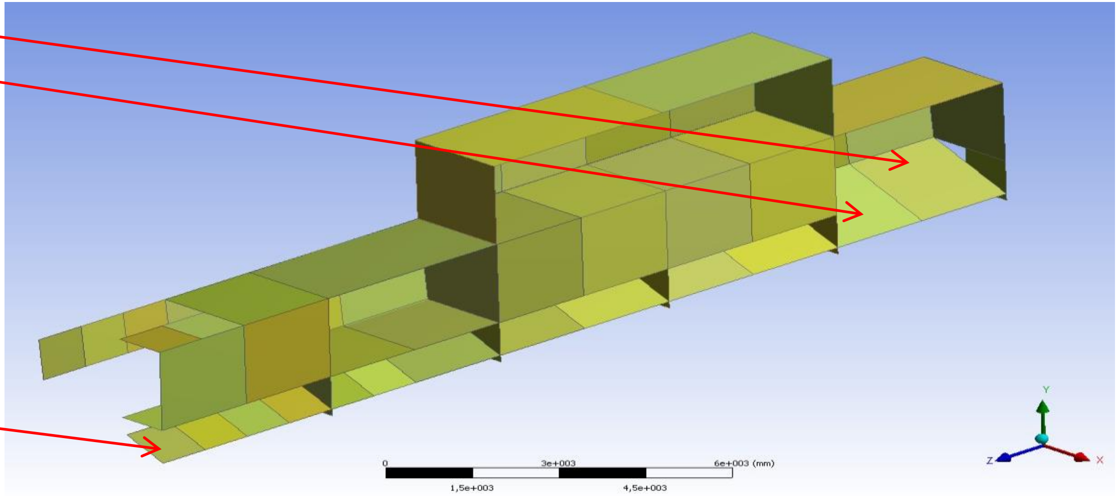
- Higher weight
- Higher material cost
- Lower CG
- Less fire insulation

Superstructure

	MATERIAL/STRUCTURE					
	Steel	Al	CFRP	GRP	CFRP	GRP
Objective function	-	-	Weight	Weight	CG	CG
Structural weight [kg]	6340	3318	2028	3055	2596	3688
Total weight [kg]	12207	9410	8508	9718	8681	9805
No of girders	4	4	3	3	0	0
Deck height [mm]	2654	2756	3046	3569	2656	2780
hCG [mm]	2564	2829	3147	3437	2813	2842
Moment [tonm]	31.3	26.6	26.8	33.6	24.4	27.9
Frequency [Hz]	11.2	11.3	11.2	11.1	11.3	11.1

Production Aspects

Location [m]	Design pressure [kPa]	Panel size [mxm]
AP-2	50	2x2
2-4	60	2x2
4-6	70	2x2
6-8	80	2x2
8-10	90	2x2
10-12	100	2x2
12-14	90	2x2
14-16	70	1x1
16-18	70	1x1
18-FP	80	1x1



20 m ship Carbon Fibre Sandwich

Production Aspects

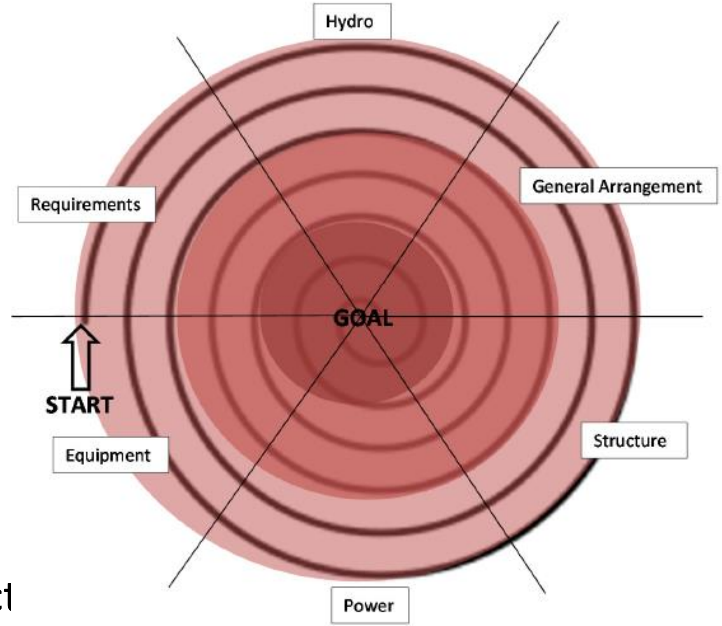
Location	Core thickness [mm]	Laminate thickness [mm]	Core type	Weight [kg/m^2]	Cost [€/m^2]
AP-2	29	1.9	PVC130	16.7	127
2-4	35	1.9	PVC130	18.3	150
4-6	41	1.9	PVC130	19.6	167
6-8	47	1.9	PVC130	20.9	187
8-10	53	1.9	PVC130	22.6	205
10-12	59	1.9	PVC130	23.9	224
12-14	53	1.9	PVC130	22.6	205
14-16	18	2.0	PVC200	12.5	93
16-18	18	2.0	PVC200	12.5	93
18-FP	23	1.9	PVC200	13.1	112

Total weight: 1308 kg

1 type of core and 1 laminate thickness → +2 kg
2 core thicknesses → +62 kg
1 core thickness → +210 kg

Simplified LCCA

- Fuel life cost dominates
  - High speed
  - Many operating hours
- Impact of displacement changes
  - Resistance – speed – displacement diagrams
  - Statement: “2% fuel save from 1% weight reduct
- Cost/Weight Relationship



Thank You!