

Lightweight Design of Electric Ships

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Outline

- About the project “Lätta Elfartyg”
- The basic ship design
- Hull weight optimization
- Concluding remark and next step

About the project “Lätta Elfartyg”

THE PROJECT “LÄTTA ELFARTYG”



Trafikverkets Branschprogram Hållbar Sjöfart som genomförs av LIGHTHOUSE



THE GOAL AND THE SCOPE

We aim to develop more energy- and cost-efficient vessels making use new technologies

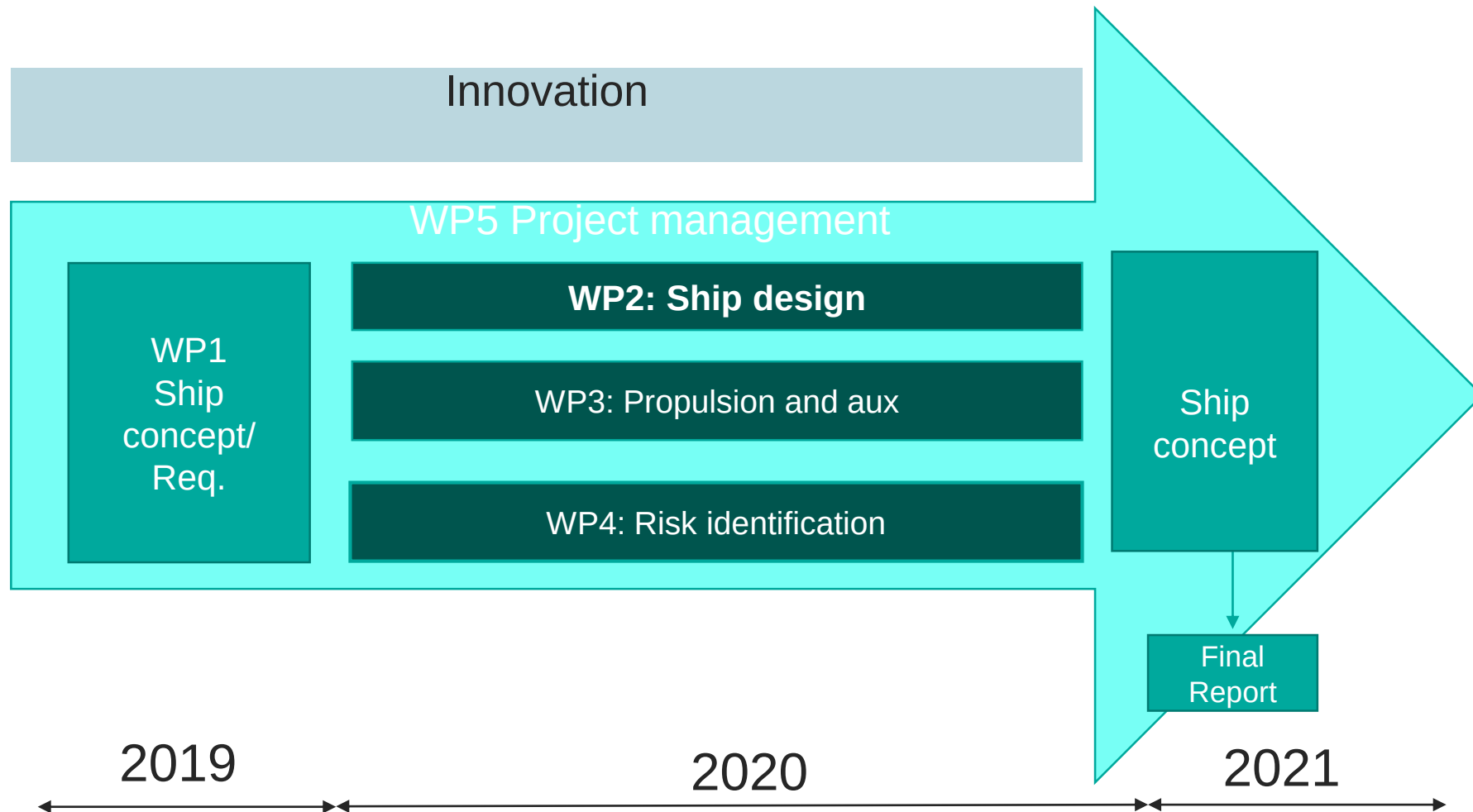
The target ship:

- RoRo / RoPax - Lightweight
- Fully electric propulsion, i.e., NOT hybrid

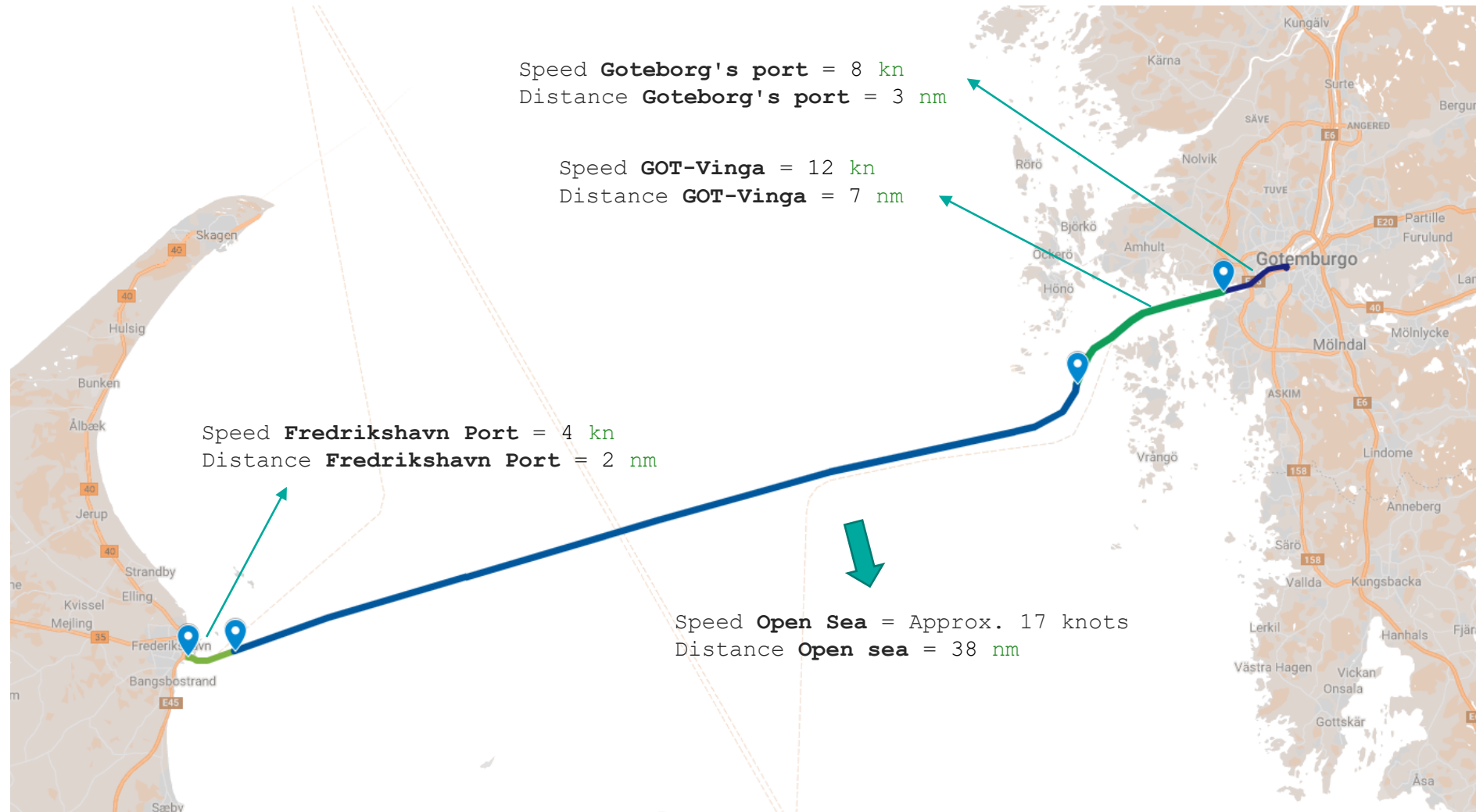
Questions to be addressed:

- Innovative concept design for an electric RoRo / RoPax ship
- How should the propulsion / auxiliary systems look like on an electric ship?
- How much weight can be saved with electric propulsion and with lighter materials?
- How to optimize systematically weight, range, speed requirements?
- Risk identification regarding electric operation (battery safety, charging, fire-safety, operational safety)

THE PROJECT OVERVIEW



ROUTE: Göteborg – Fredrikshavn, 2 turer per dag

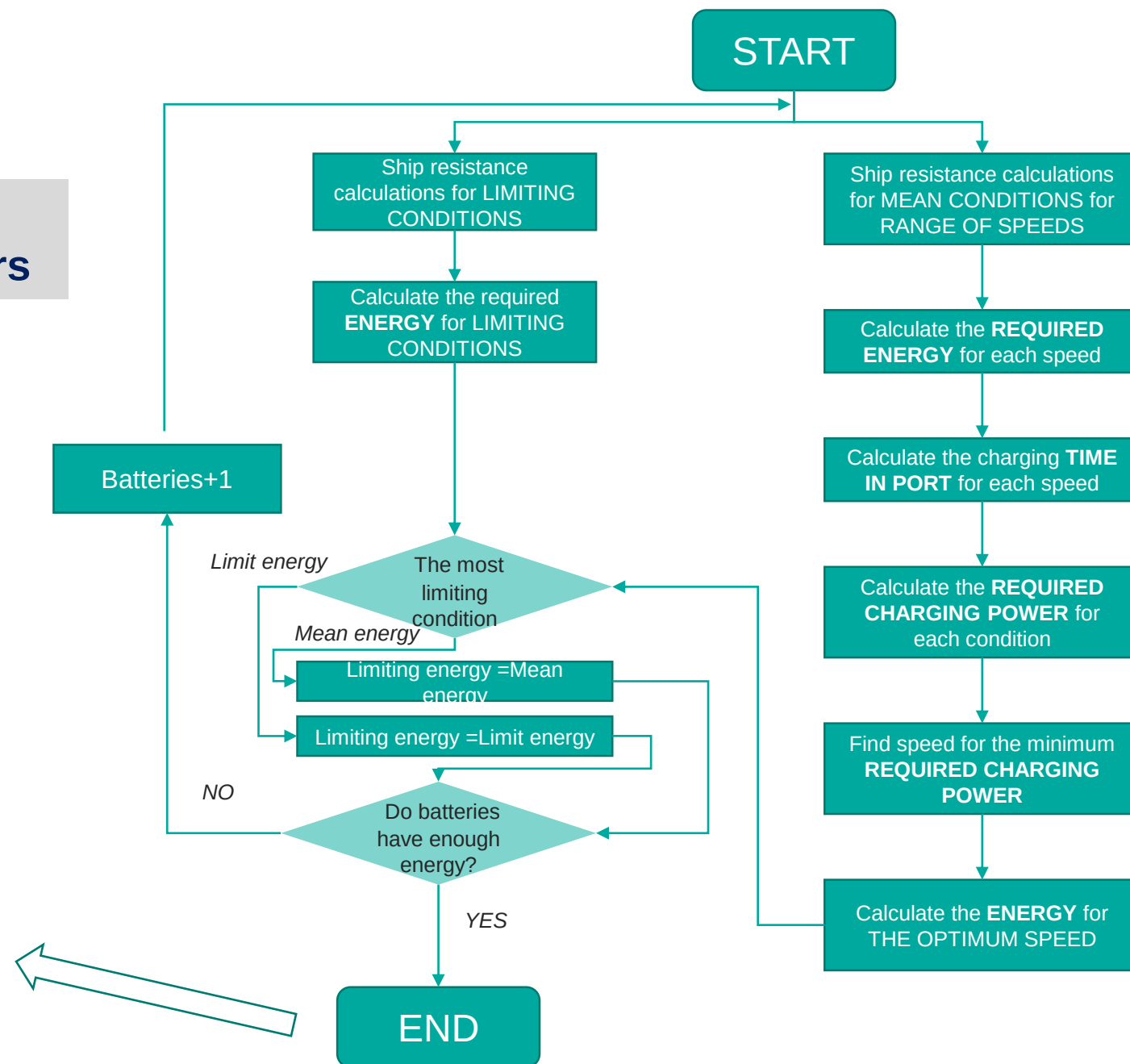


The basic ship design

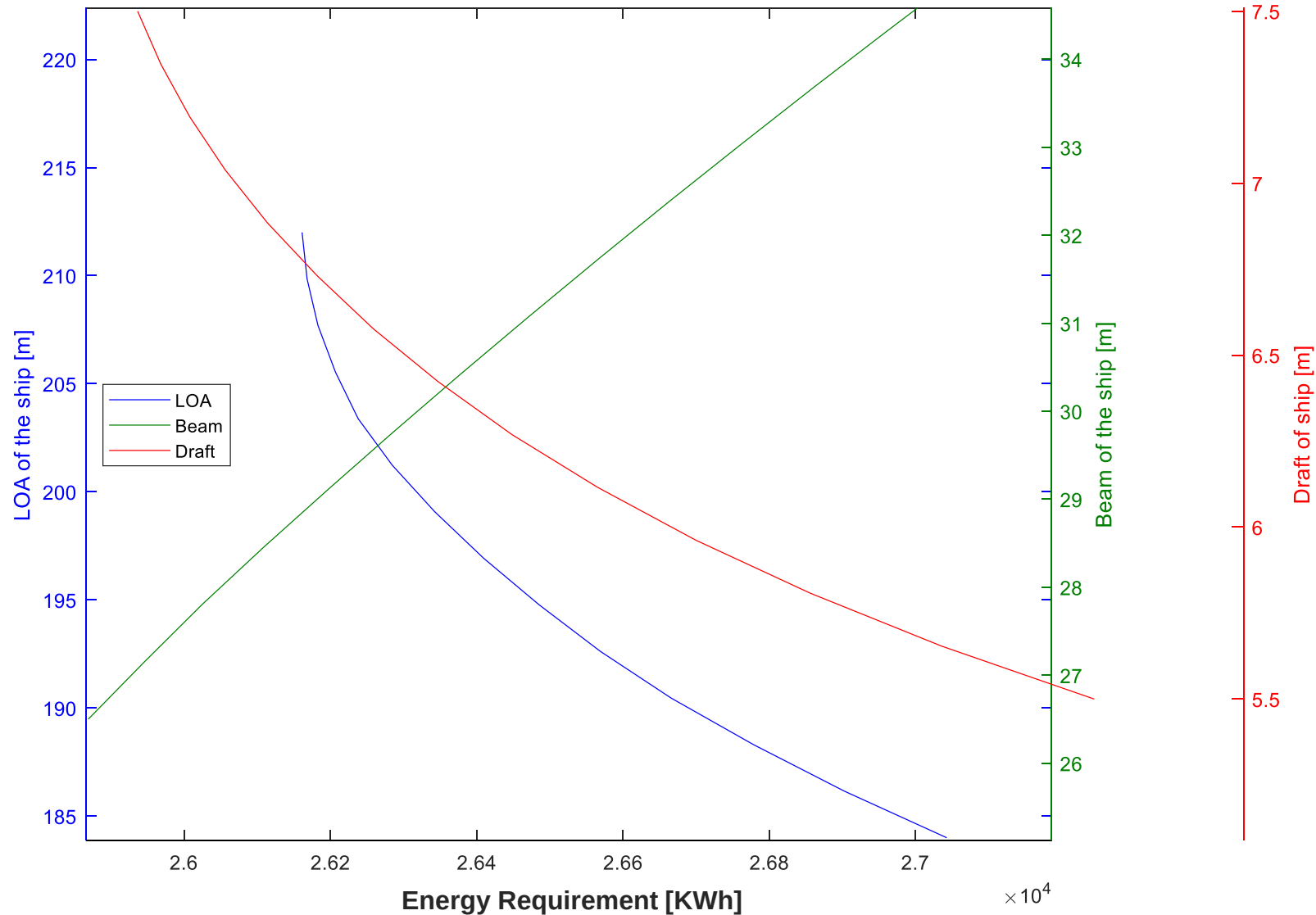
Flowchart of calculation of the basic design parameters

RESULTS:

- Energy required
- Number of batteries
- Charging power required
- Optimal average speed
- Block coefficient



VARIATION OF SHIP MAIN DIMENSIONS



Range of variations

LOA range = 184 - 212 [m]

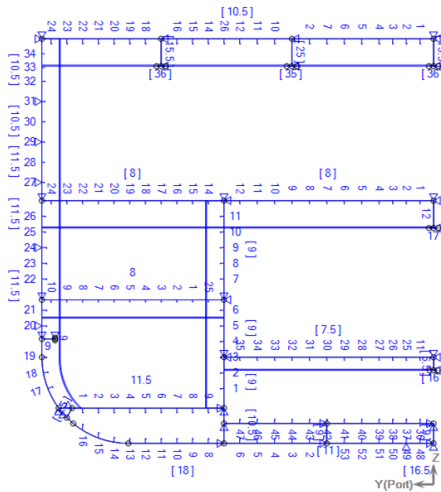
Beam range = 26.5 - 35 [m]

Draft range = 5.5 - 7.5 [m]

THE THREE SHIP DIMENSIONS

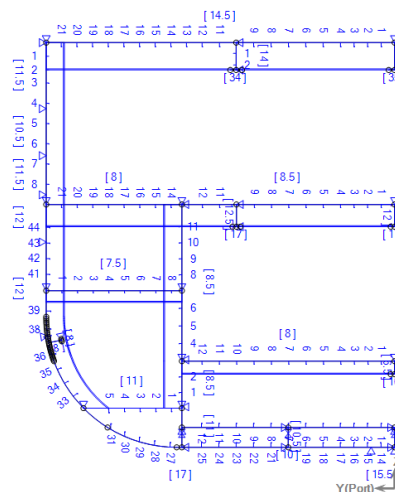
	“Wide”	“Long”	“Extra deck”	Unit
LOA	195.3	212.0	170.6	m
LPP	184.3	201.0	159.6	m
Draft	6.5	6.5	6.5	m
Breadth B	29.7	26.7	26.7	m
Lower hold	331	415	0 *	Lane meters
Main deck	1317	1278	947	Lane meters
Upper deck	1455	1410	1078	Lane meters
Extra deck	0	0	1078	Lane meters
Lane meters in total	3103	3103	3104	Lane meters
Optimal speed	17.1	17.2	17.0	knots
Ship displacement	20399.8	21228.7	19128.1	tons

THE MIDSHIP SECTIONS



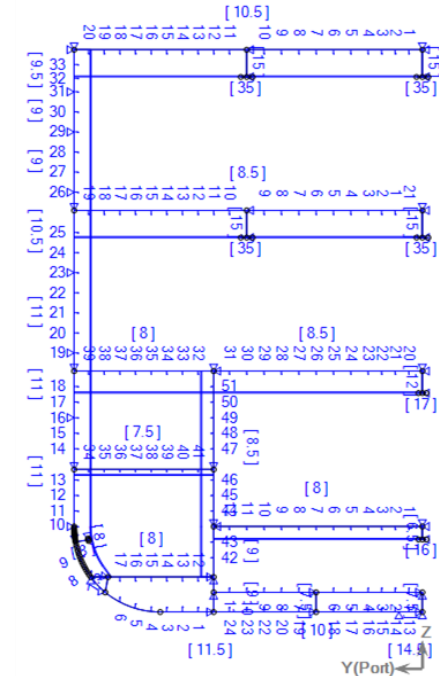
WIDE VERSION

Length Loa	195.3m
Beam B	29.7m
Draught T	6.5m
Depth D	15.5m



LONG VERSION

Length Loa	212.0m
Beam B	26.7m
Draught T	6.5m
Depth D	15.5m



EXTRA DECK VERSION

Length Loa	170.6m
Beam B	26.7m
Draught T	6.5m
Depth D	21.7m

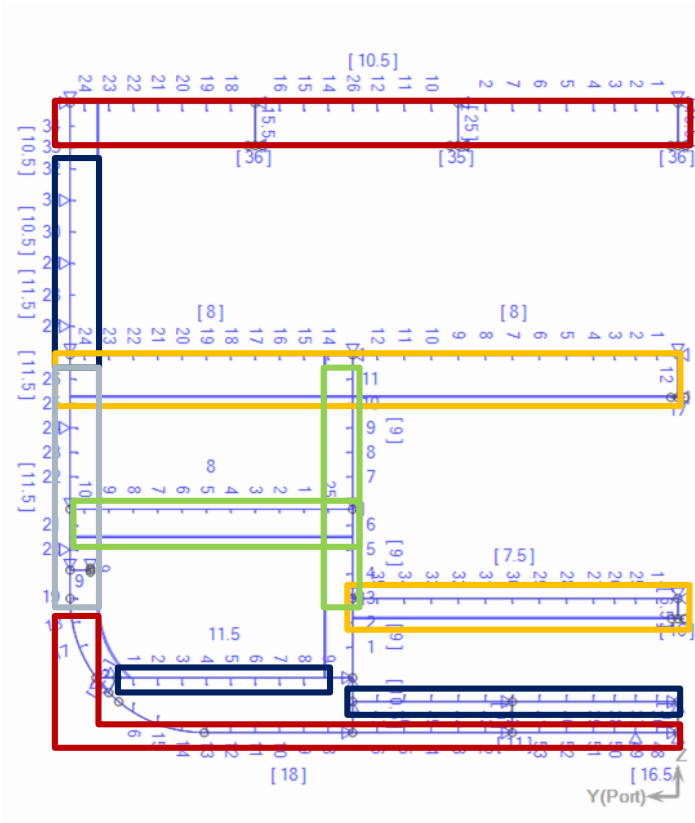
Hull weight optimization

Limiting factors for plates

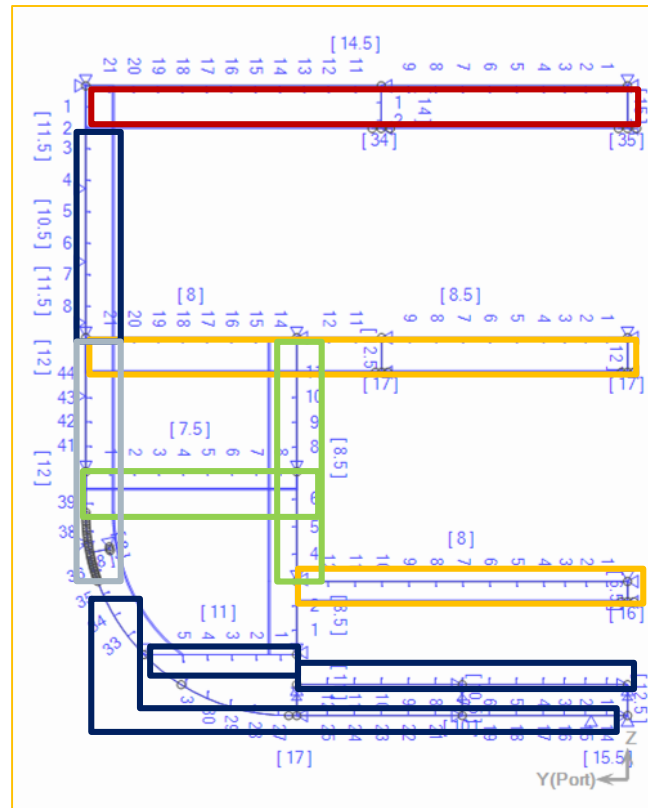
GROSS-SECTION MODULUS BUCKLING YIELDING MINIMUM THICKNESS



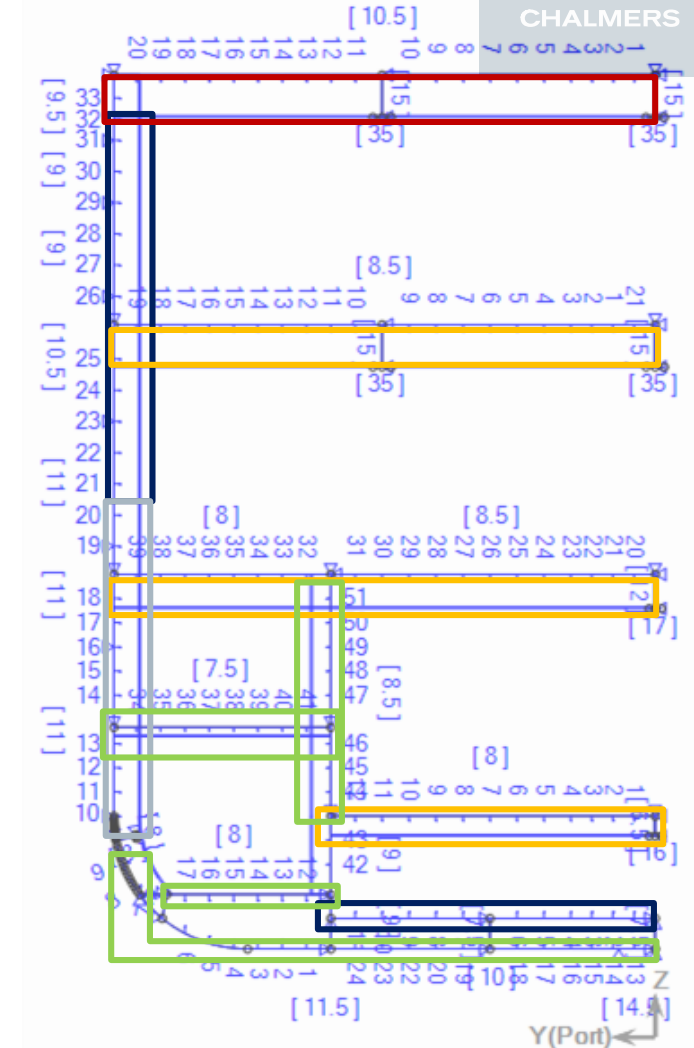
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WIDE VERSION



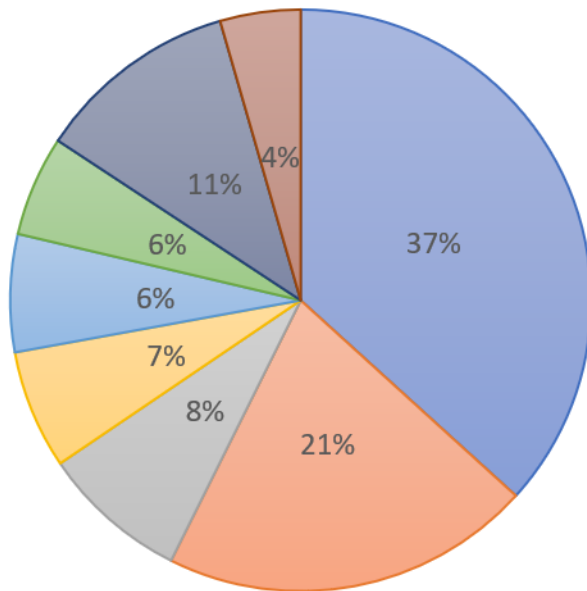
LONG VERSION



EXTRA DECK VERSION

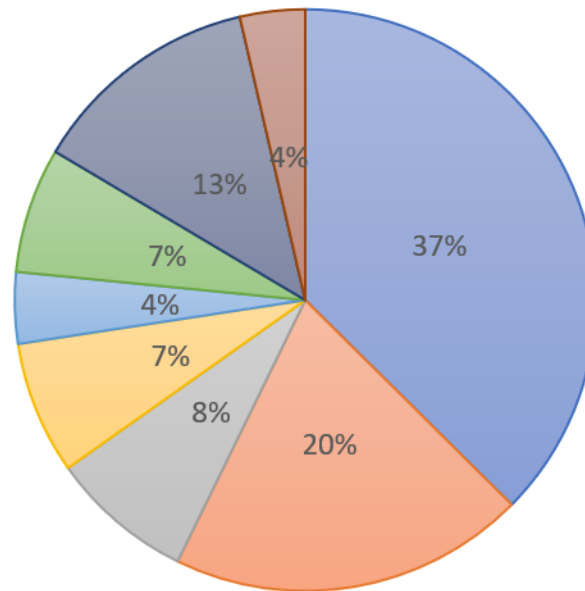
AREA / WEIGHT DISTRIBUTION

WIDE VERSION



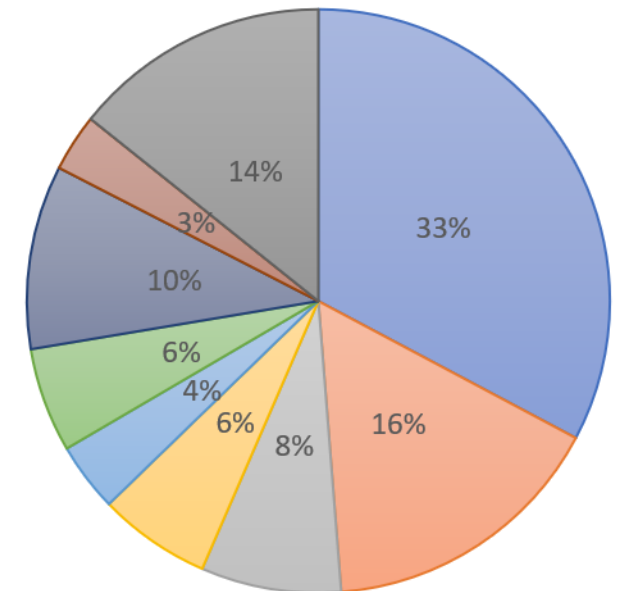
■ Outer shell ■ Strength deck
 ■ Inner bottom ■ Inner side
 ■ Bilge Structure ■ Deck 3300
 ■ Deck 9300 ■ Deck 5500

LONG VERSION



■ Outer shell Plate ■ Strength deck Plate
 ■ Inner bottom Plate ■ Inner side Plate
 ■ Bilge Structure Plate ■ Deck 3300 Plate
 ■ Deck 9300 Plate ■ Deck 5500 Plate

EXTRA DECK VERSION

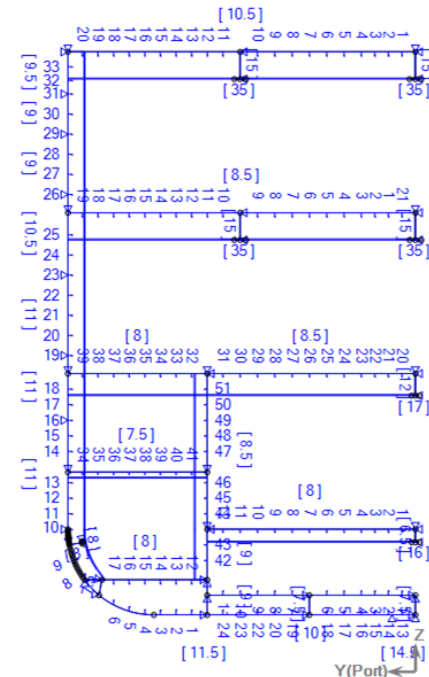
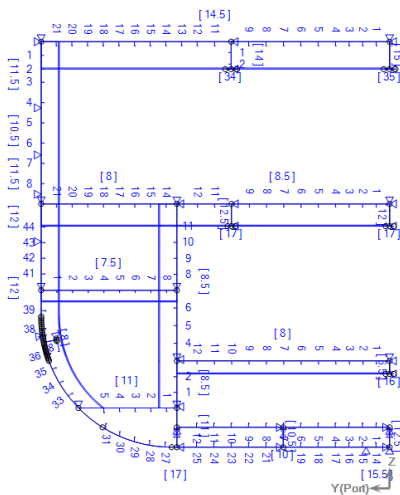
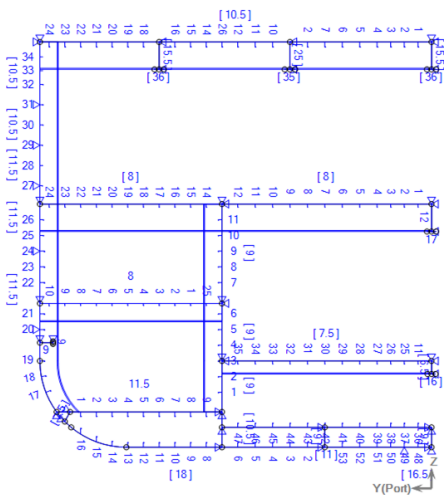


■ Outer shell ■ Strength deck
 ■ Inner bottom ■ Inner side
 ■ Bilge Structure ■ Deck 3300
 ■ Deck 9300 ■ Deck 5500
 ■ Deck 15500

TOTAL VOLUME OF TRANSVERSALS



Span between transversals = 2400mm



WIDE version Total volume for one transversal	1440671	mm ³
	1.44	m ³

LONG version Total volume for one transversal	1239522	mm ³
	1.24	m ³

EXTRA DECK version Total volume for one transversal	1732520	mm ³
	1.73	m ³

HULL WEIGHT & SHIP DISPLACEMENT

	Version	Wide	Long	Extra deck	Unit
Input value	Displacement	17753.0	18409.7	18001.4	t
		17320	17961	17562	m3
	Loa	195.2	212	163.4	m
	Beam	29.7	26.7	26.7	m
	Draft	6.3	6.3	6.3	m
	Depth	15.5	15.5	21.7	m
	Cross section area	28365.8	25160	28719	cm2
Process		2.8366	2.5160	2.8719	m2
	Volume per section	6.808	6.038	6.892	m3
	Transverse stiffeners	1.44	1.24	1.73	m3
	Volume per meter	3.44	3.03	3.59	m3
	Weight per meter	26.98	23.80	28.21	t
	W_steel	3511	3935	3584	t
Results	Additional weight	1300	1533	1476	t
	Hull weight	4811	5468	5059	t

SECTION VOLUME REDUCTION BY INTRODUCING HIGH TENSILE STEEL (HTS)

LONG version: section volume optimization				
Parts	Volume		Volume reduction	
	High Tensile Steel	Mild steel		
	[cm3]	[cm3]	[cm3]	[%]
Outer shell	287721.6	287721.6	0	0%
Strength deck	400500	428535	-28035	-7%
Inner side	86580	115440	-28860	-33%
Deck 3300	72543.9	76619.4	-4075.5	-6%
Deck 9300	234292.5	256987.5	-22695	-10%
Deck 5500	25423.11	27762.66	-2339.55	-9%
Floor transversal structure	132461.28	132461.28	0	0%
Total Volume	1239522.39	1325527.44	-86005.05	-7%
	1.23952239(m3)	1.32552744(m3)	-0.08600505(m3)	

HULL WEIGHT REDUCTION BY HTS

	Version	Wide – mixed steels	Long – mixed steels	Extra Deck – mixed steels	Unit
Input value	Displacement	17325.9	18157.6	17523.3	t
		16903	17715	17096	m3
	Loa	195.2	212	163.4	m
	Beam	29.7	26.7	26.7	m
	Draft	6.3	6.3	6.3	m
	Depth	15.5	15.5	21.7	m
	Cross section area	23985.1	22893	24493	cm2
Process		2.3985	2.2893	2.4493	m2
	Volume per section	5.756	5.494	5.878	m3
	Transverse stiffeners	1.44	1.24	1.48	m3
	Volume per meter	3.00	2.81	3.06	m3
	Weight per meter	23.55	22.04	24.05	t
	W_steel	3044	3627	3020	t
	Additional weight	1340	1588	1561	t
Results	Hull weight	4384 (-8.9%)	5216 (-4.6%)	4581 (-9.4%)	

CONCLUDING REMARK & NEXT STEP

- Innovative and realistic concept design of the electric ship
- Improvement and finalization of the “Lätta Elfartyg” inclusive of the propulsion / battery systems
- Hull weight optimization:
 - Further weight saving by introducing other type/combination of high tensile steels
 - Verification of hull strength using finite element analyses
 - A full consideration of hull weight reduction due to Service Area Restriction.



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