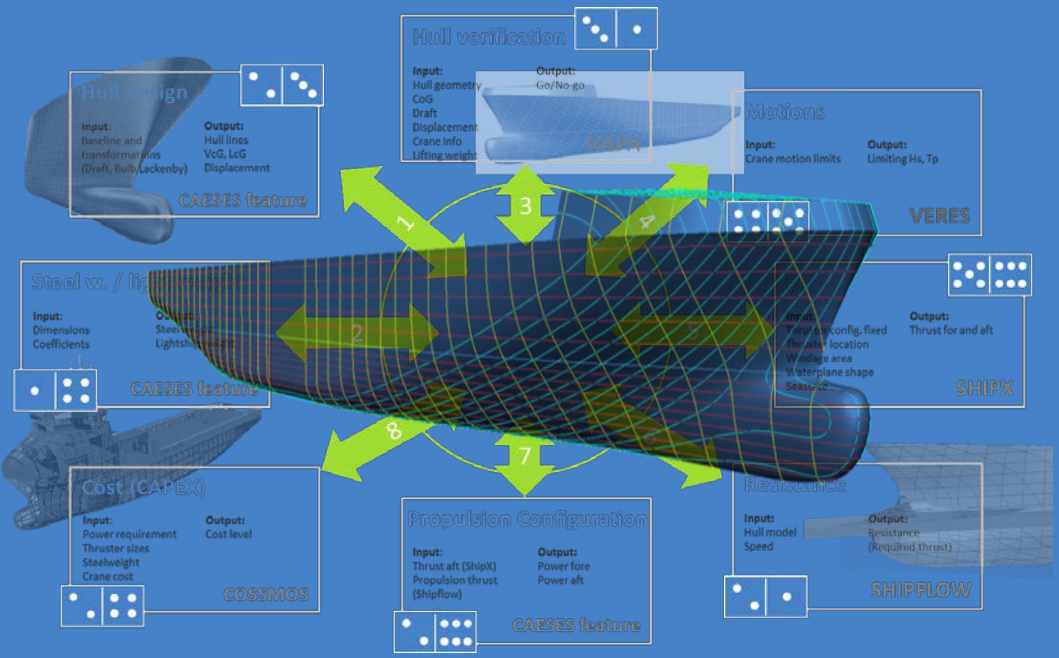

Methods and Case Studies
for Holistic Ship Design and Optimization

HOLISHIP

FRIENDSHIP SYSTEMS

Introduction

- HOLISHIP
  - *HOLI*stic optimisation of *SHIP* design and operation for life cycle
  - European R&D project
  - 40 partners
  - Funded within the European Union's Horizon 2020 Transport Research Programme
  - Develop the next generation ship design system for the European maritime industry

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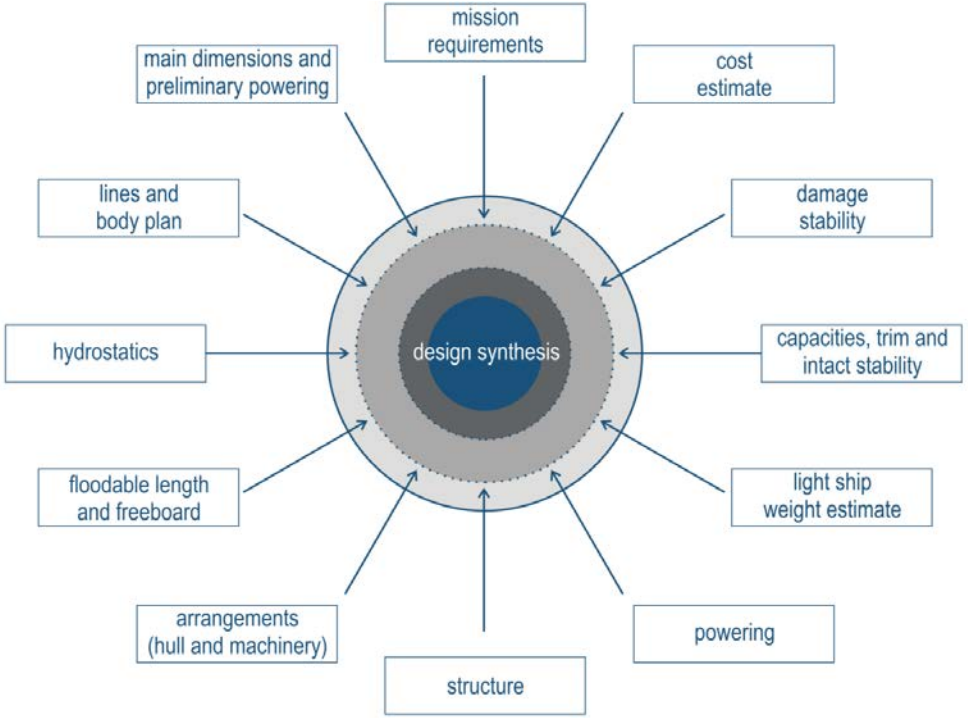
Motivation



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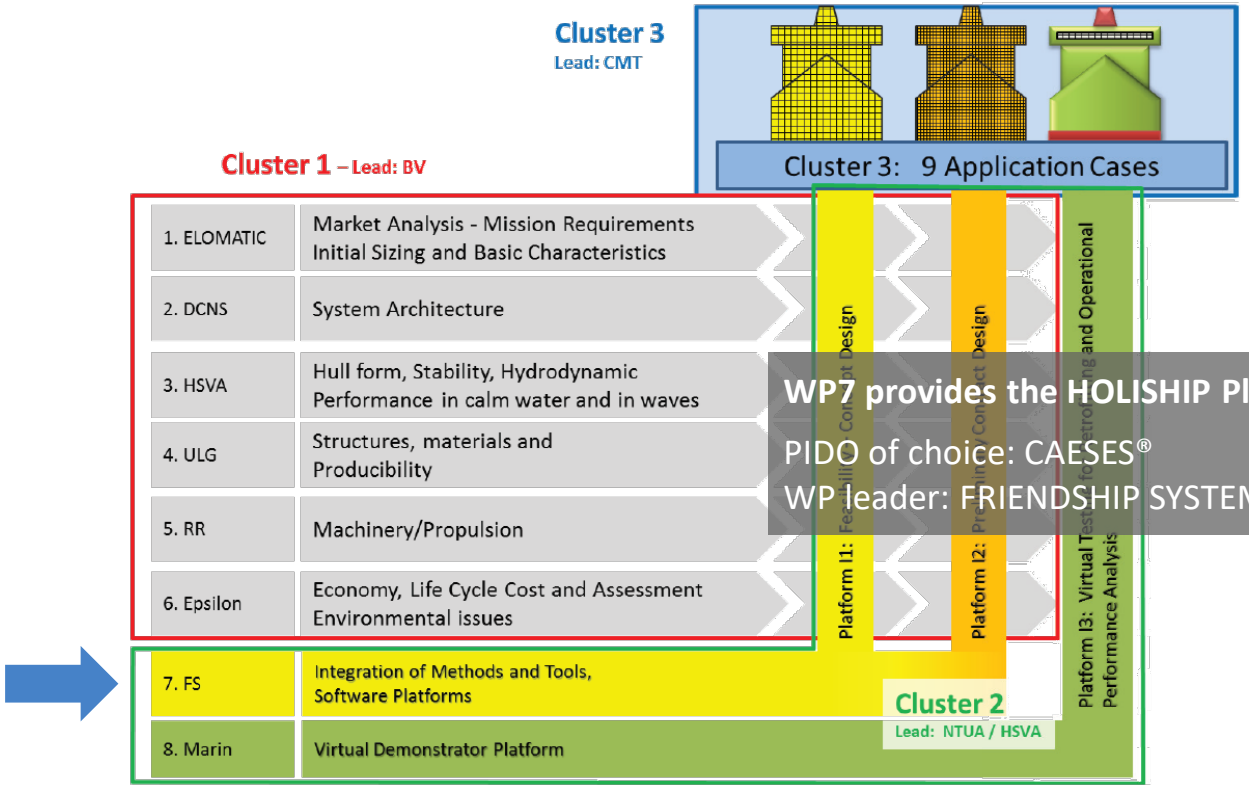
Project Setup



WP7 provides the HOLISHIP Platform for design

PIDO of choice: CAESES®

WP leader: FRIENDSHIP SYSTEMS

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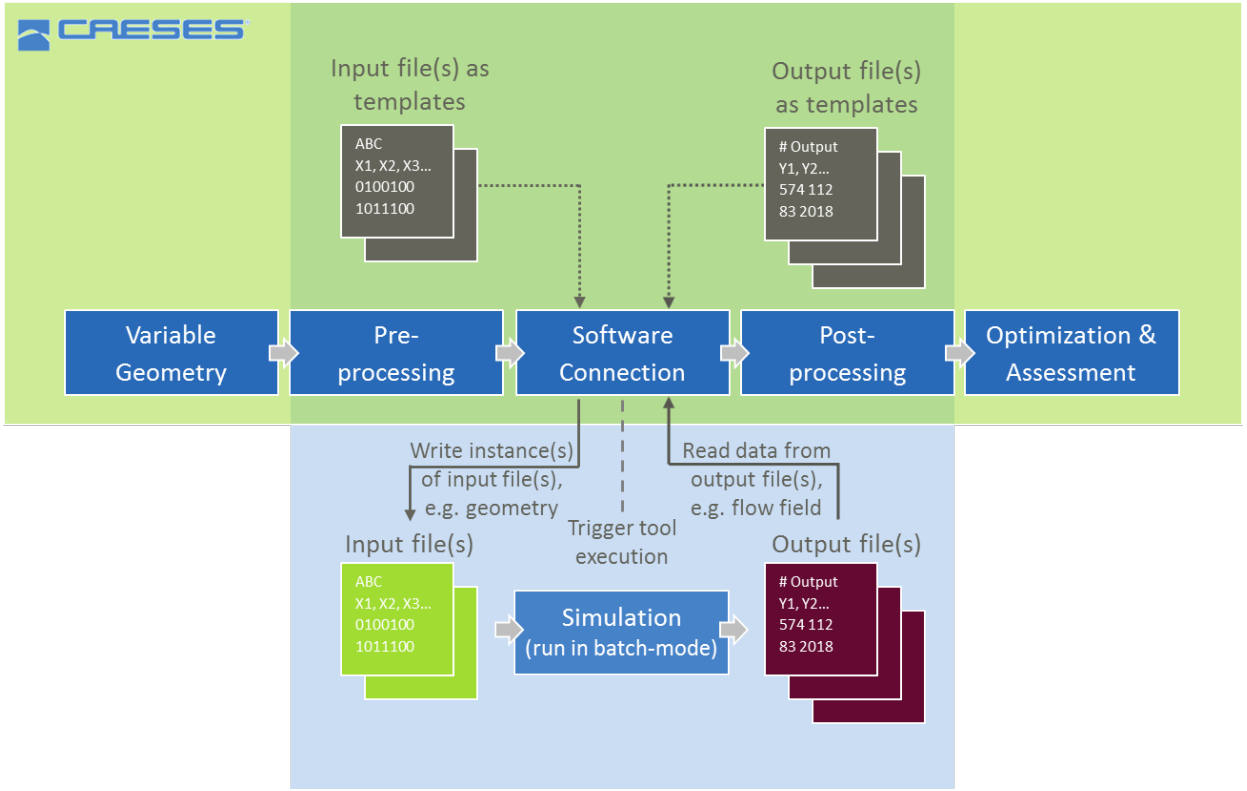
Tool Integration



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Case Studies

Case Study | Double-ended Ferry

1h return trip in Scandinavian waters

10 nm at a service speed of 13 kn

Length from 110 m to 135 m and beam from 17.5 m to 22 m

Conventional and electric propulsion as alternatives

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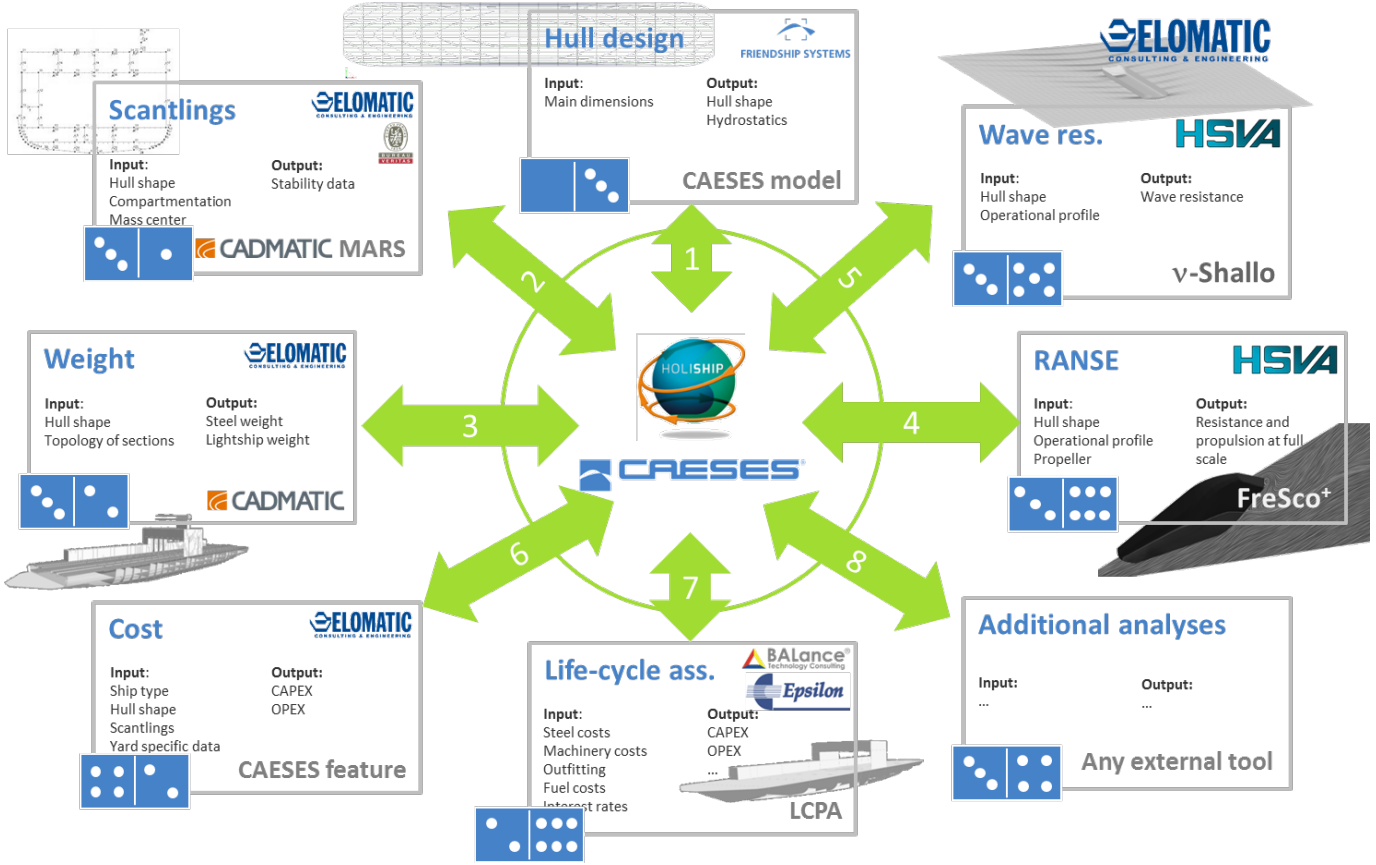
Case Study | Double-ended Ferry



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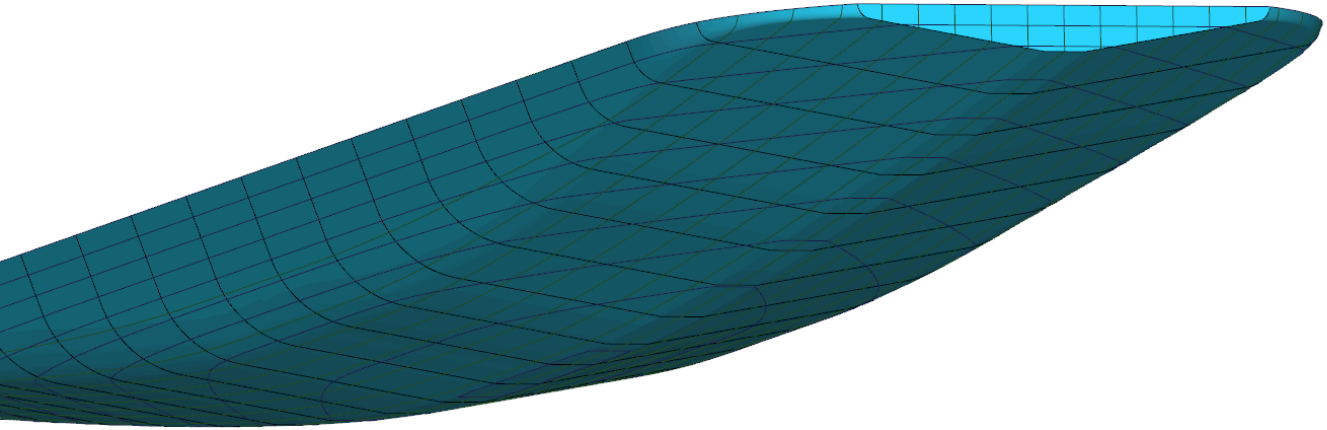
Parametric Model



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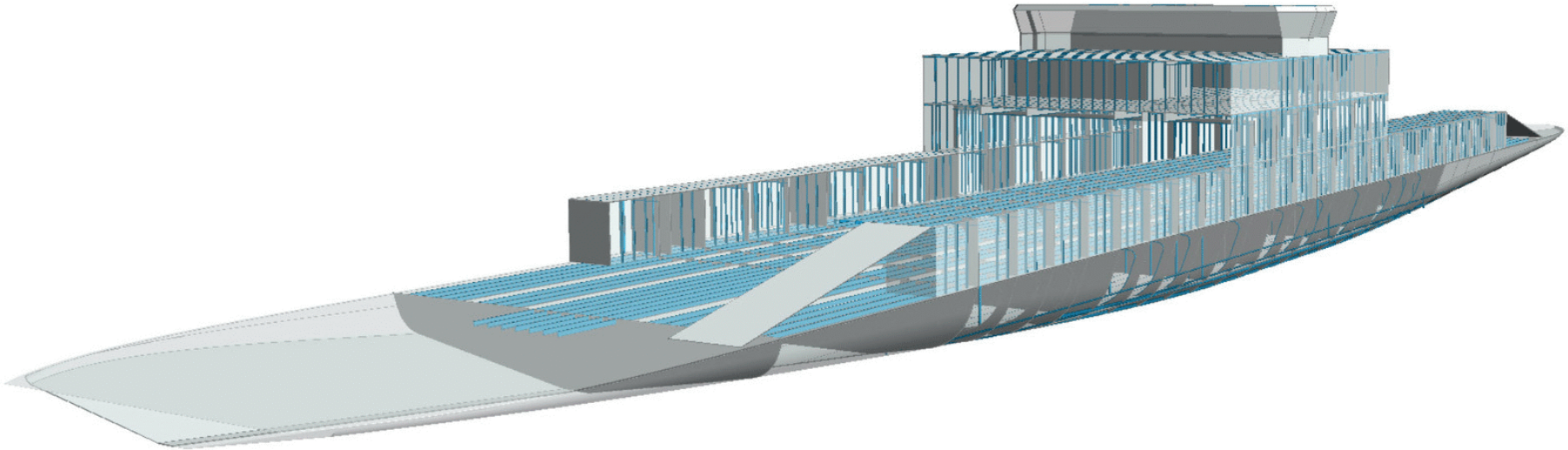
Parametric Model for Steel Weight

ELOMATIC
CONSULTING & ENGINEERING
CADMATIC



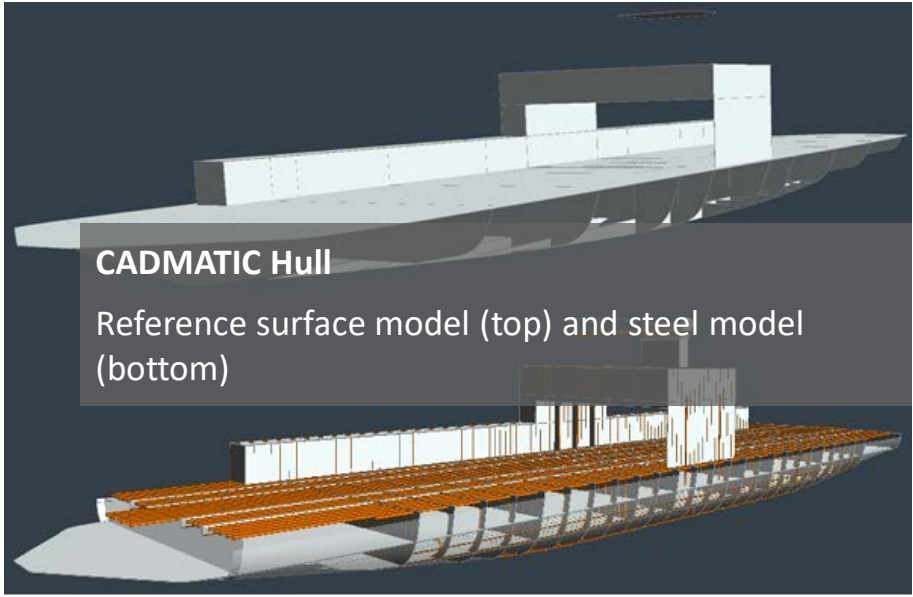
FRIENDSHIP SYSTEMS © 2019

Parametric Model for Steel Weight

Index	Type	Name	Expression	Value	Comment
1	length	frame	700	700	
2	length	MFB1	-48*frame	-33600	
3	length	MFB2	MFB1+16*frame	-22400	
4	length	MFB3	MFB2+16*frame	-11200	
5	length	MFB4	MFB3+8*frame	-5600	
6	length	MFB5	-1*MFB4	5600	
7	length	MFB6	-1*MFB3	11200	
8	length	MFB7	-1*MFB2	22400	
9	length	MFB8	-1*MFB1	33600	
10	length	TBH040101	MFB4-4*frame	-8400	Sewage tank TBH on deck 01, MVZ4
11	length	TBH050101	MFB4+2*frame	-4200	MDO tanks on deck 01, MVZ5
12	length	TBH050102	TBH050101	-4200	Waste oil tank on deck 01, MVZ5
13	length	TBH050103	MFB4+2*frame	-4200	Sea chest on deck 01, MVZ5
14	length	TBH050104	TBH050101+6*frame	0	TBH between MDO, bilge & lubrication tanks on deck 01, MVZ5
15	length	TBH050105	TBH050104+4*frame	2800	Bilge & lubrication tank TBH on deck 01, MVZ5
16	length	TBH060101_P	MFB6-4*frame	8400	Fresh water tank on deck 01, MVZ6
17	length	TBH010201	MFB1-4*frame	-36400	Fire station on deck 02, MVZ1
18	length	TBH020201	MFB1+1*frame	-32900	TBH between fire station & Escape room on deck 02, MVZ2
19	length	TBH020202	TBH020201+3*frame	-30800	Store TBH on deck 02, MVZ2
20	length	TBH030201	MFB3	-11200	TBH between Embarkation area & Pax inva area on deck 02, MVZ3
21	length	TBH040201	MFB4	-5600	TBH between Pax area inva & staircase on deck 02, MVZ4
22	length	TBH050201	MFB5	5600	TBH between staircase & Embarkation area on deck 02, MVZ5
23	length	TBH060201	MFB6	11200	TBH between Pax area inva & Embarkation area on deck 02, MVZ6
24	length	TBH070201	MFB7	22400	Pax area inva TBH on deck 02, MVZ7
25	length	TBH080201	TBH070201+8*frame	28000	Toilet TBH on deck 02, MVZ8
26	length	TBH080202	TBH080201+4*frame	30800	TBH between toilet & Escape room on deck 02, MVZ8
27	length	TBH080203	TBH080202+3*frame	32900	TBH between Escape room & store & chain box on deck 02, MVZ8
28	length	TBH090201	MFB8+4*frame	36400	Store & chain box TBH on deck 02, MVZ9
29	length	TBH040301	MFB4	-5600	Staircase TBH on deck 03, MFB4
30	length	TBH050301	MFB5	5600	Staircase TBH on deck 03, MFB5
31	length	TBH040401	TBH040301	-5600	Pax area TBH on deck 04
32	length	TBH050401	TBH040401+3000	-2600	TBH between Pax area & Apparatus room
33	length	TBH050402	0*frame	0	TBH between toilet & staircase on deck 04, MVZ5
34	length	TBH050403	-1*TBH050401	2600	TBH between Pax area & Apparatus room
35	length	TBH050404	TBH050301	5600	Pax area TBH on deck 04, MVZ5
36	length	FLOOR0	0*frame	0	Floor at frame 0
37	length	FLOOR4	4*frame	2800	Floor at frame 4
38	length	FLOOR8	8*frame	5600	Floor at frame 8
39	length	FLOOR12	12*frame	8400	
40	length	FLOOR16	16*frame	11200	
41	length	FLOOR20	20*frame	14000	
42	length	FLOOR24	24*frame	16800	
43	length	Apparatus_rm	25	25	Area [m2] required by apparatus room
44	length	Car_lane_width	1900	1900	
45	length	Truck_lane_wi	2600	2600	
46	length	Margin	600	600	Margin between cars and trucks in width direction
47	length	Superstr._dk02	2300	2300	Double stairs including handrails

ELOMATIC CONSULTING & ENGINEERING

CADMATIC



CADMATIC Hull

Reference surface model (top) and steel model (bottom)

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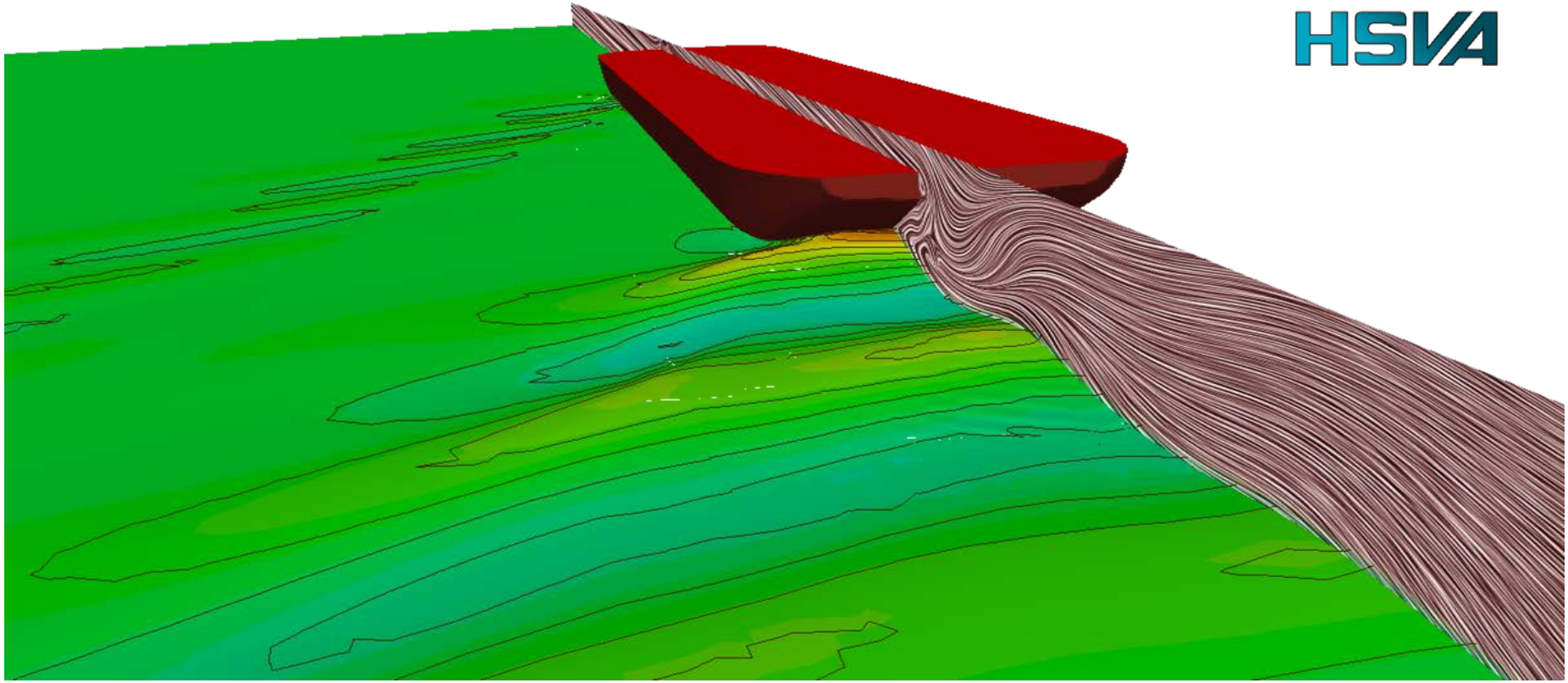
Resistance Calculation



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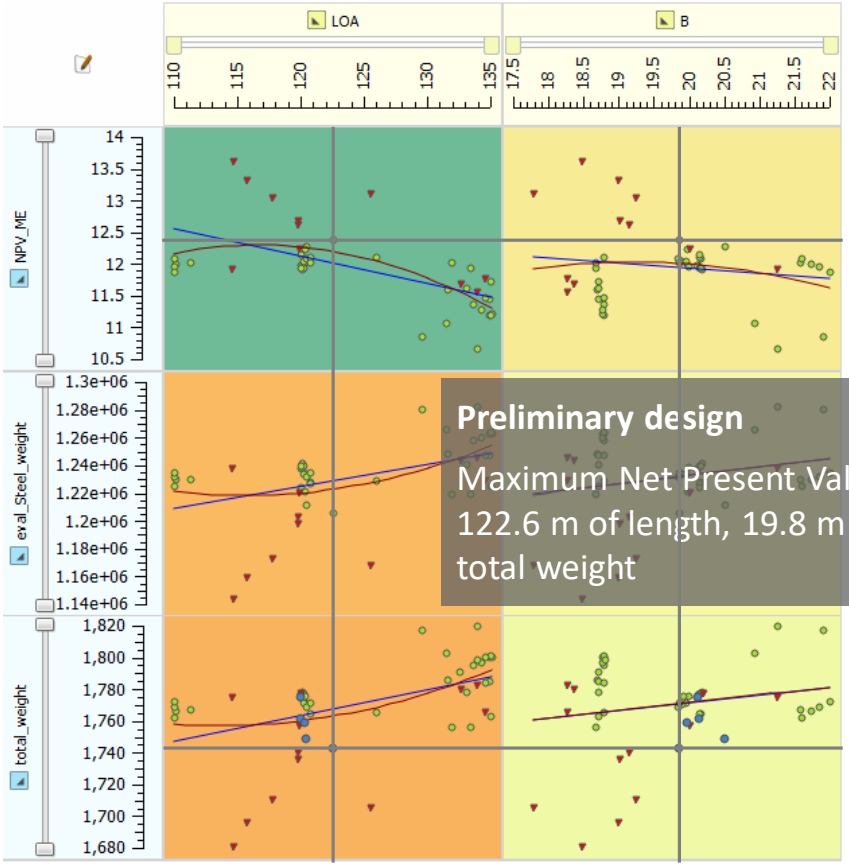
Selected Results

	LOA	B	NPV_ME	eval_Steel_weight
DakotaNPV_45_des0008	133.83019	20.818265	10.693516	1282251
DakotaNPV_45_des0009	131.41931	20.537008	11.089807	1265263
DakotaNPV_45_des0010	129.56609	21.394106	10.870721	1279599
DakotaNPV_45_des0011	134.87564	18.583422	11.727946	1225628
DakotaNPV_45_des0012	133.36497	18.554445	11.943248	1219256
DakotaNPV_45_des0013	131.86499	18.554445	12.027549	1219256
DakotaNPV_45_des0014	120.03525	19.822581	11.989082	1238096
DakotaNPV_45_des0015	120.03525	19.809122	11.986977	1237576
DakotaNPV_45_des0016	120.31297	19.681539	12.037256	1234182
DakotaNPV_45_des0017	134.78942	18.649617	11.219011	1262798
DakotaNPV_45_des0018	133.51604	18.649617	11.374218	1258099
DakotaNPV_45_des0019	131.56438	18.554857	11.610872	1248255
DakotaNPV_45_des0020	120.1619	19.881497	11.92362	1241141
DakotaNPV_45_des0021	120.1619	19.70983	11.969609	1238949
DakotaNPV_45_des0022	120.4442	19.622349	12.059072	1233629
DakotaNPV_45_des0023	134.98627	18.623386	11.231876	1262737
DakotaNPV_45_des0024	134.15769	18.623386	11.302323	1259685
DakotaNPV_45_des0025	110.16938	21.251259	12.002067	1229729
DakotaNPV_45_des0026	120.25956	19.83961	11.944304	1239916
DakotaNPV_45_des0027	120.25956	19.676595	12.040897	1234060
DakotaNPV_45_des0028	120.40757	19.583758	12.095168	1231510
DakotaNPV_45_des0029	111.34281	21.10596	12.020061	1230431
DakotaNPV_45_des0030	114.59532	20.827311	11.929995	1237649
DakotaNPV_45_des0031	125.96042	18.64687	12.109788	1228923
DakotaNPV_45_des0032	134.51399	18.18955	11.776789	1228923
DakotaNPV_45_des0033	133.82427	18.18955	11.567696	1245183
DakotaNPV_45_des0034	132.59438	18.274285	11.68784	1243120
DakotaNPV_45_des0035	110.06638	21.121204	12.089381	1225381
DakotaNPV_45_des0036	119.82696	18.963698	12.609877	1203073
DakotaNPV_45_des0037	119.82696	18.85548	12.686416	1198800
DakotaNPV_45_des0038	120.76159	19.870922	12.097435	1228014
DakotaNPV_45_des0039	120.76159	19.840846	12.11217	1227269
DakotaNPV_45_des0040	119.87121	19.719581	12.248568	1220301
DakotaNPV_45_des0041	134.82376	18.573122	11.458615	1247674
DakotaNPV_45_des0042	134.43083	18.643574	11.47709	1247254
DakotaNPV_45_des0043	133.01706	18.573122	11.632661	1241027
DakotaNPV_45_des0044	120.04975	19.851421	12.163529	1224719
DakotaNPV_45_des0045	120.3412	19.698843	12.231218	1221633
DakotaNPV_45_des0046	120.75396	19.594195	12.035982	1234400
DakotaNPV_45_des0047	134.94201	18.642476	11.203426	1263376
DakotaNPV_45_des0048	110.13962	21.345882	11.957126	1231968
DakotaNPV_45_des0049	110.13962	21.488571	11.892787	1235132
DakotaNPV_45_des0050	120.05966	19.868313	11.943547	1240039



Preliminary design

Maximum Net Present Value (NPV) of 12.4M€ at 122.6 m of length, 19.8 m of beam and 1741 tons of total weight

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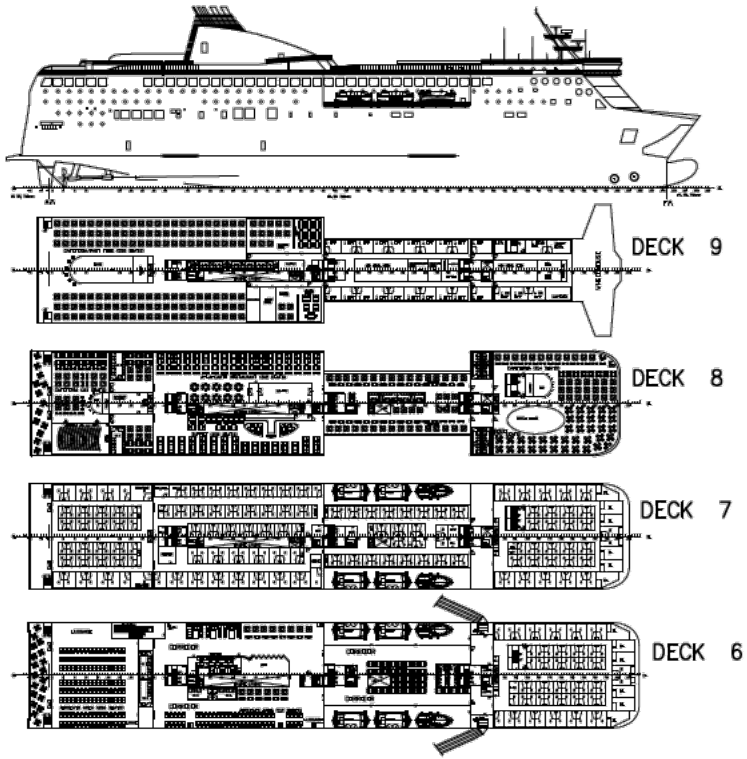
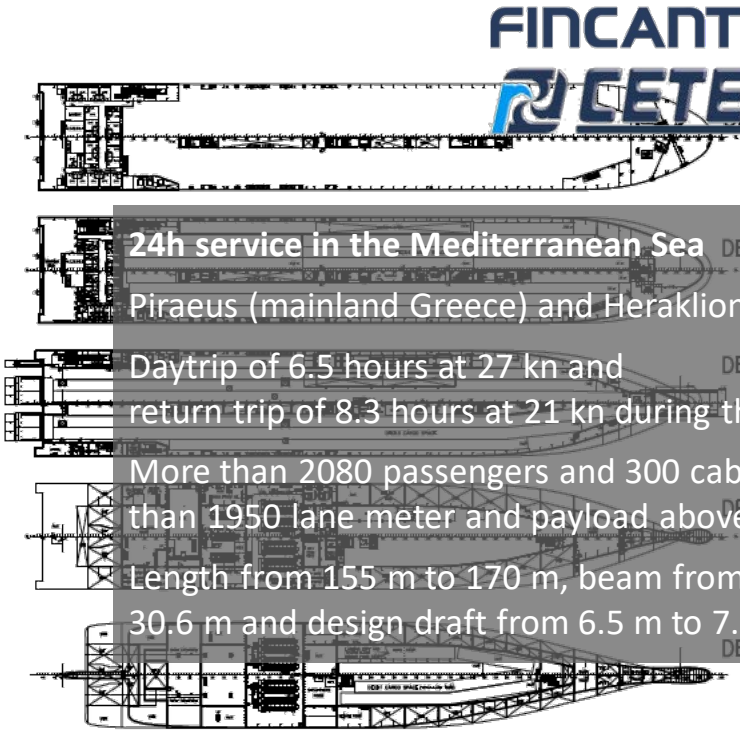
Case Study | RoPax





FINCANTIERI
CETENA S.P.A.

24h service in the Mediterranean Sea

Piraeus (mainland Greece) and Heraklion (Crete)

Daytrip of 6.5 hours at 27 kn and return trip of 8.3 hours at 21 kn during the night

More than 2080 passengers and 300 cabins, more than 1950 lane meter and payload above 3500 t

Length from 155 m to 170 m, beam from 27.6 m to 30.6 m and design draft from 6.5 m to 7.1 m

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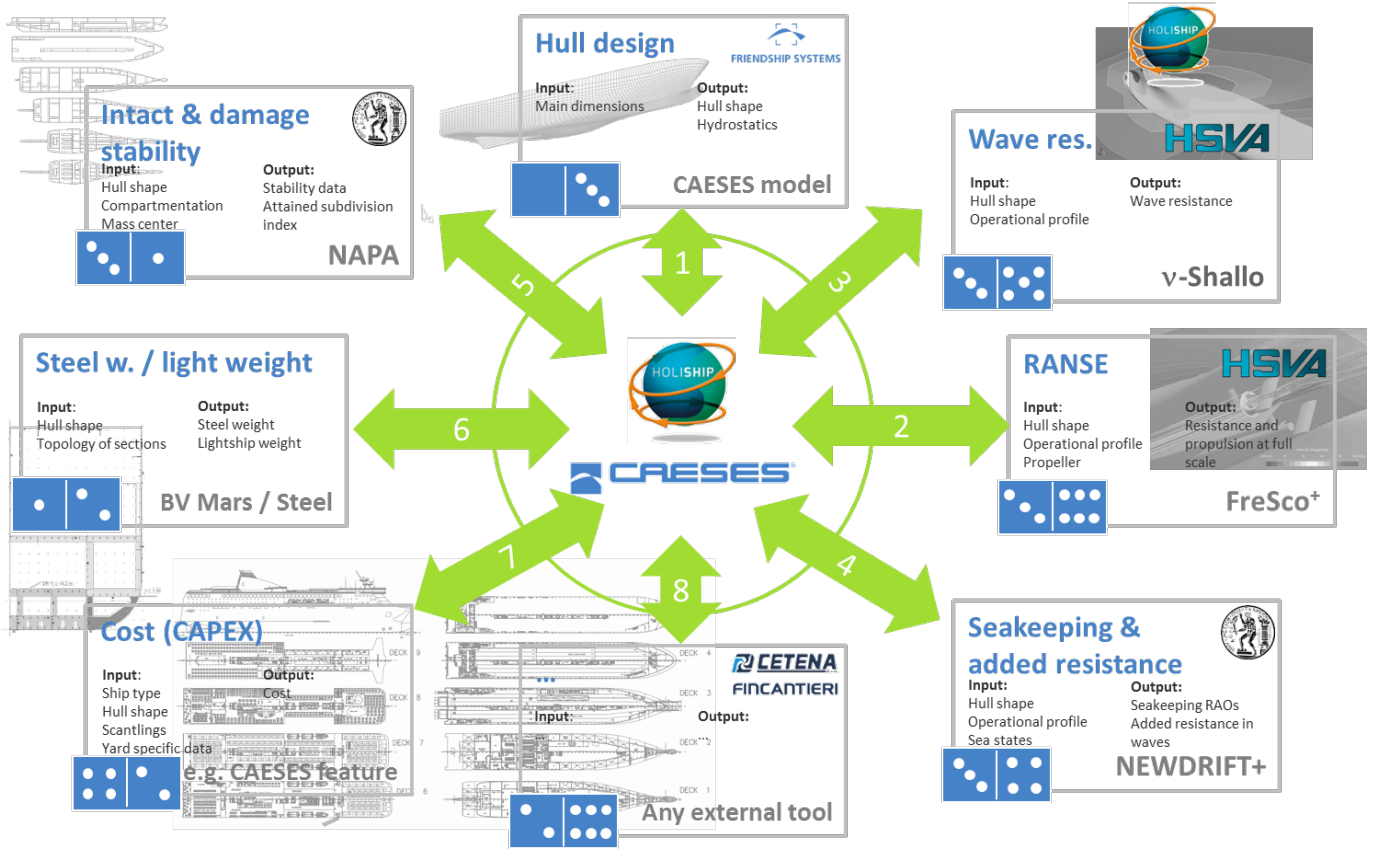
Case Study | RoPax



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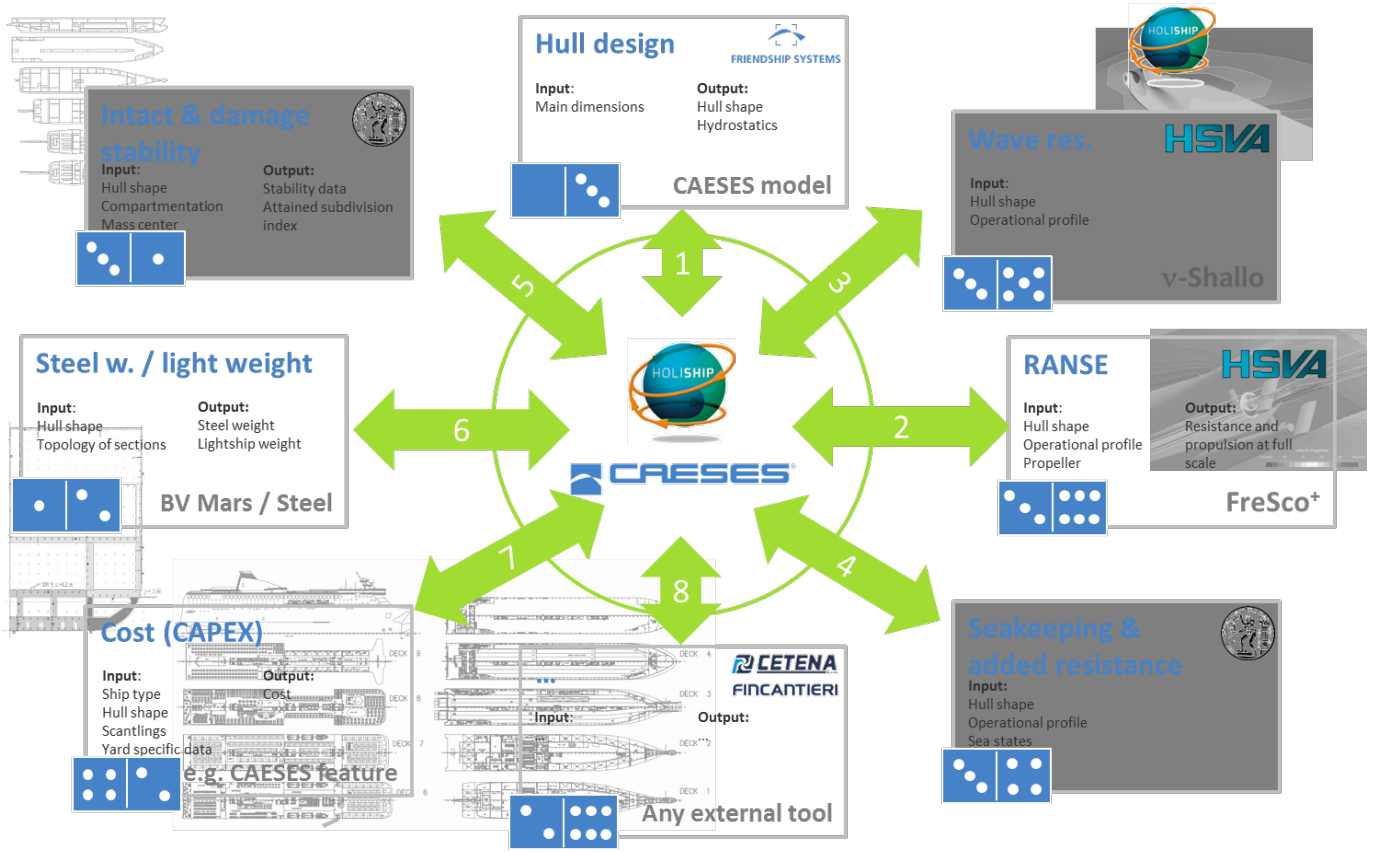
Surrogate Models



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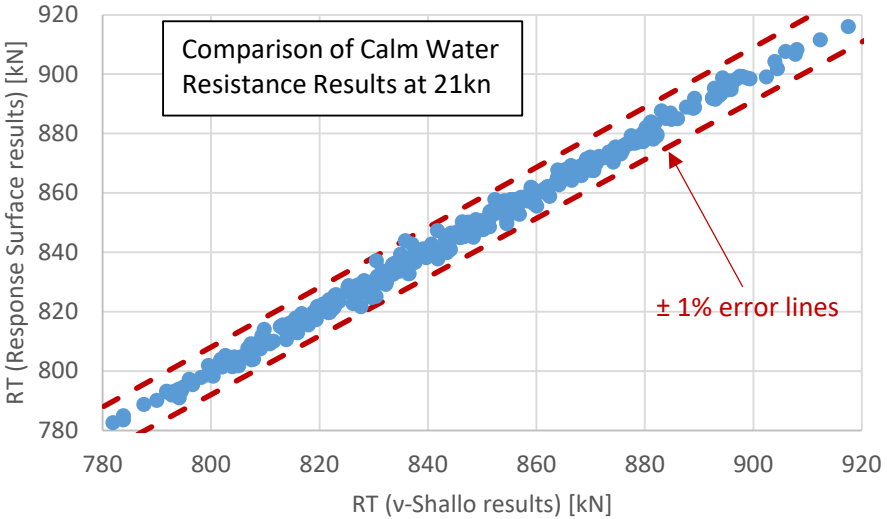
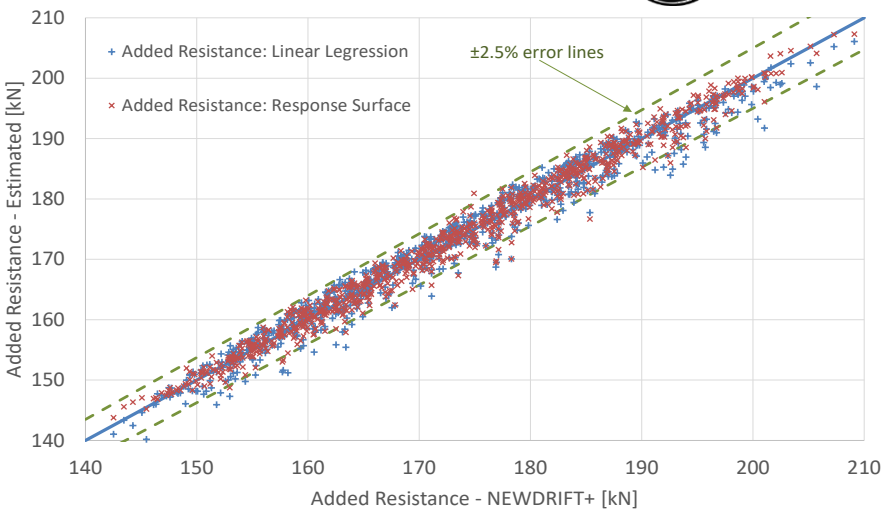
Surrogate Models





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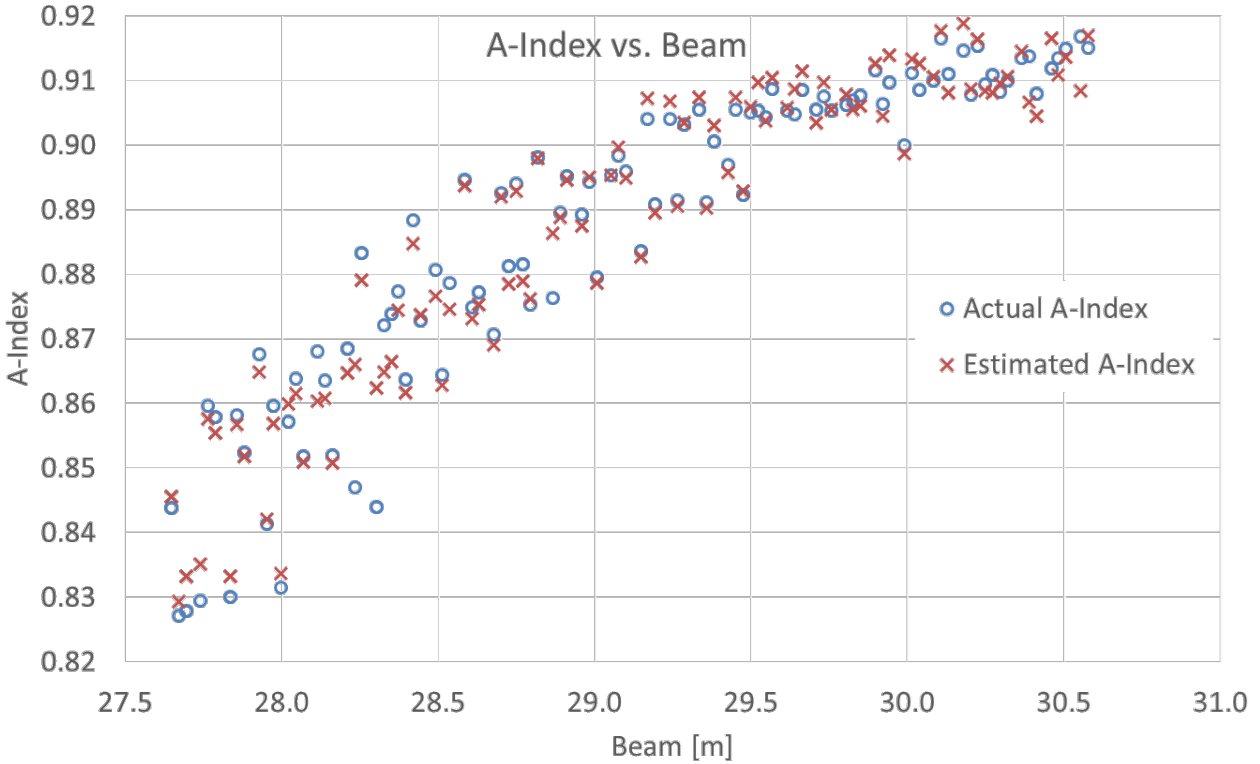
Surrogate Models



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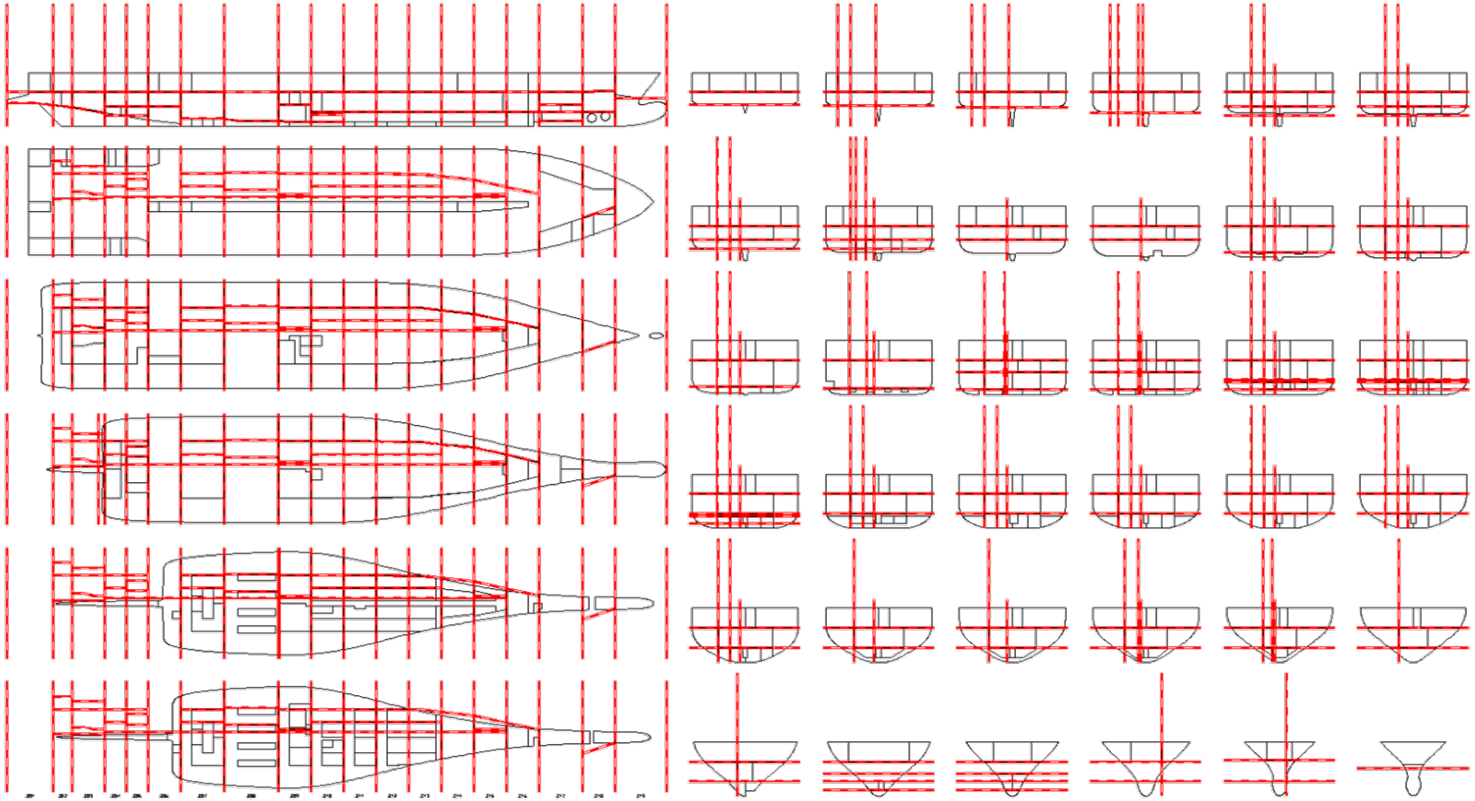
Parametric Model of Compartmentation



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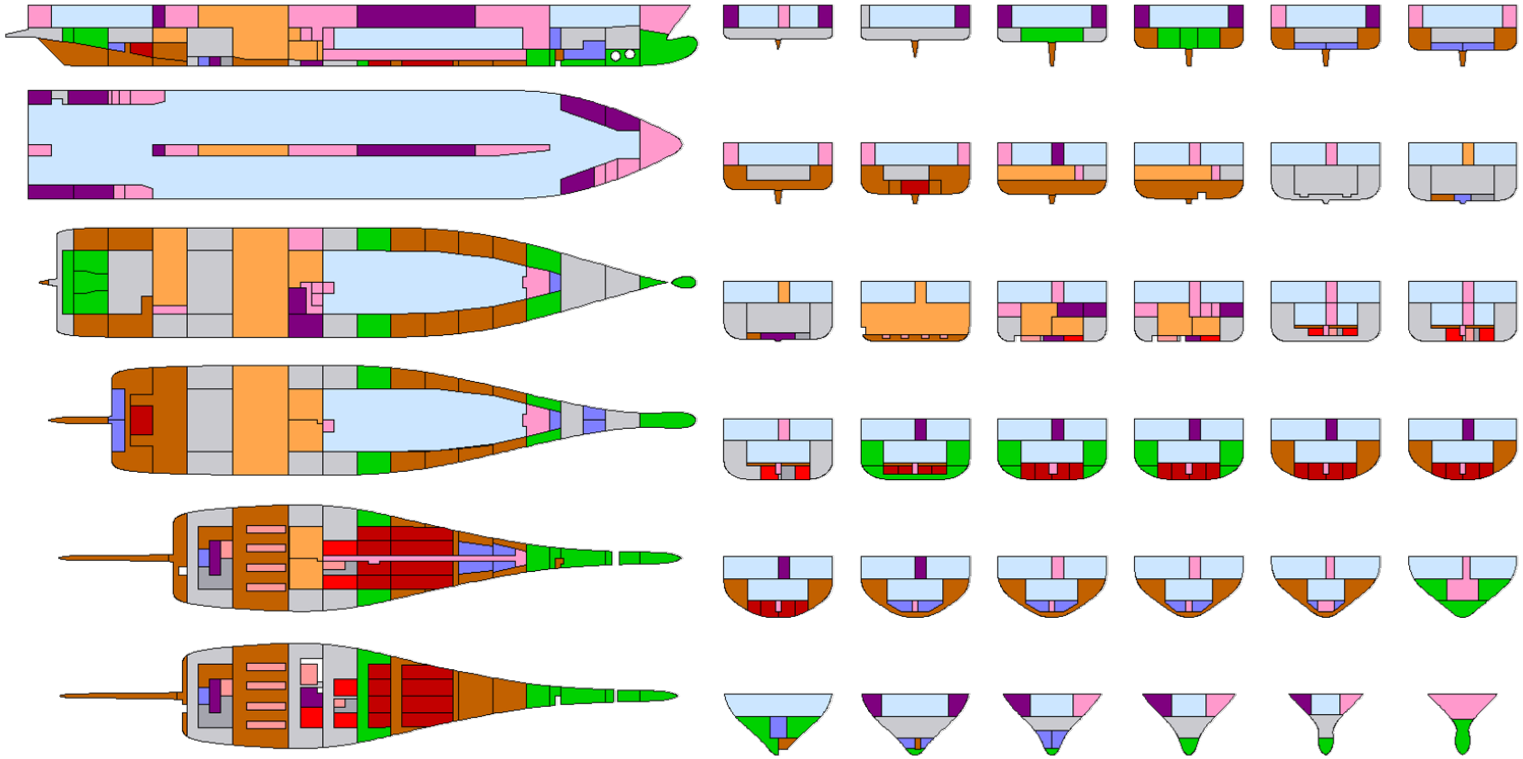
Parametric Model of Compartmentation



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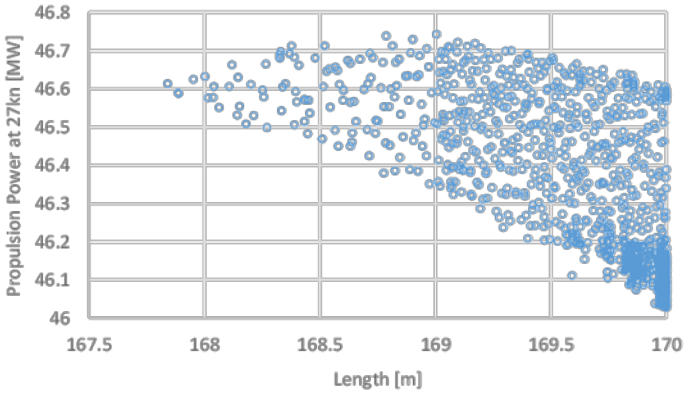
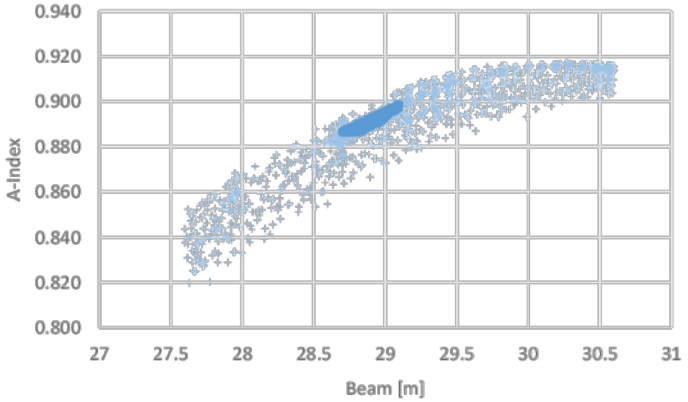
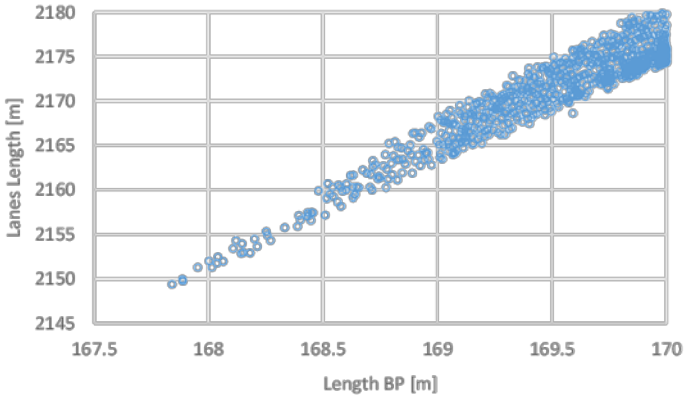
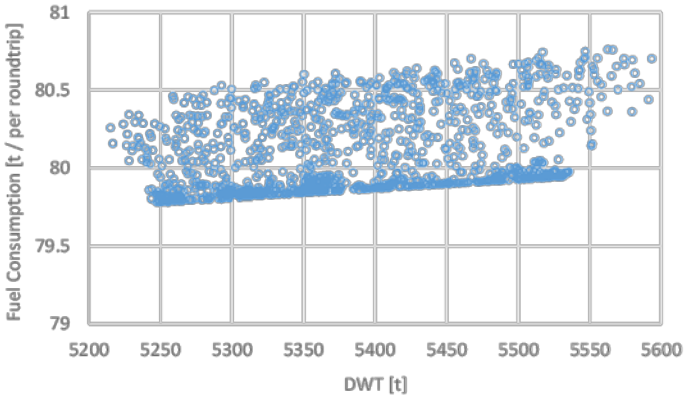
Selected Results









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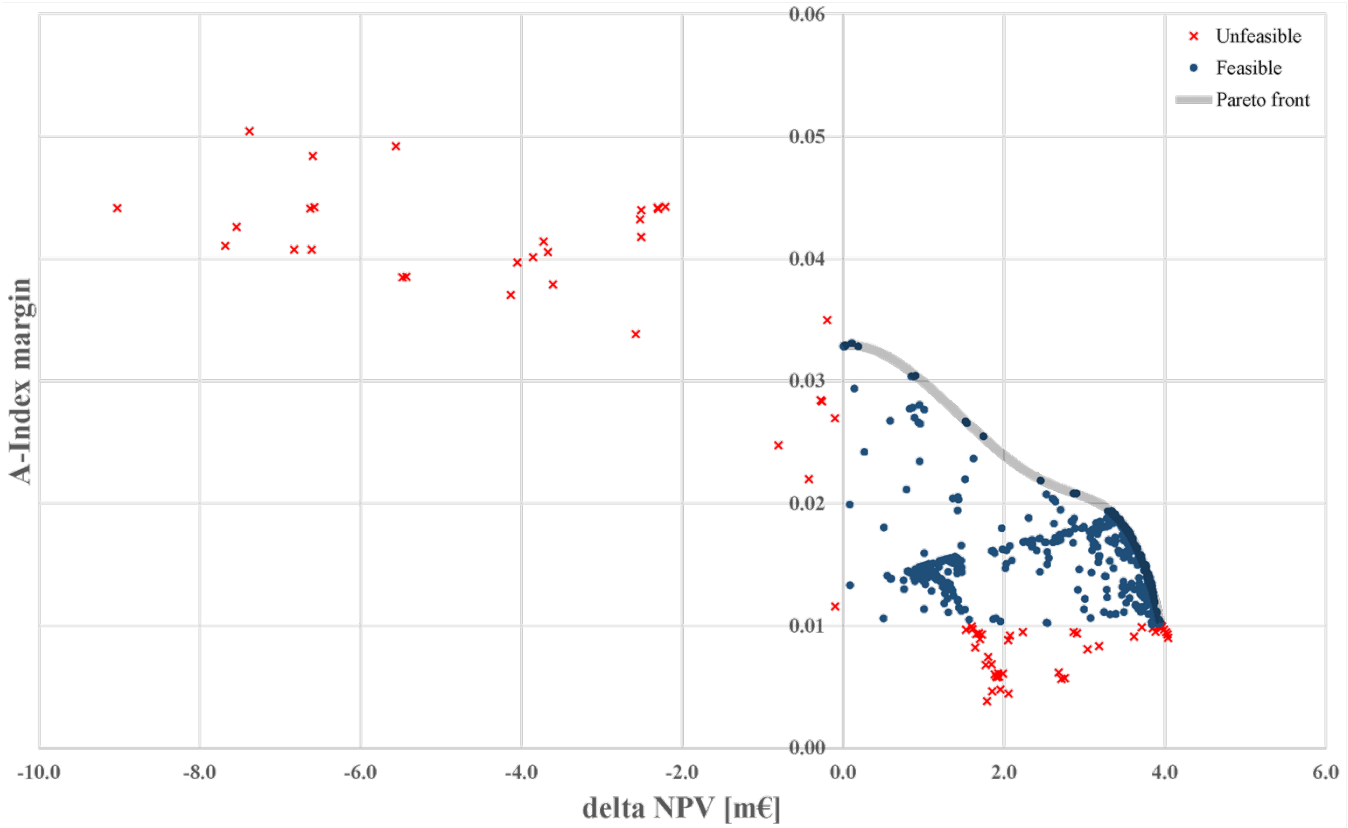
Selected Results



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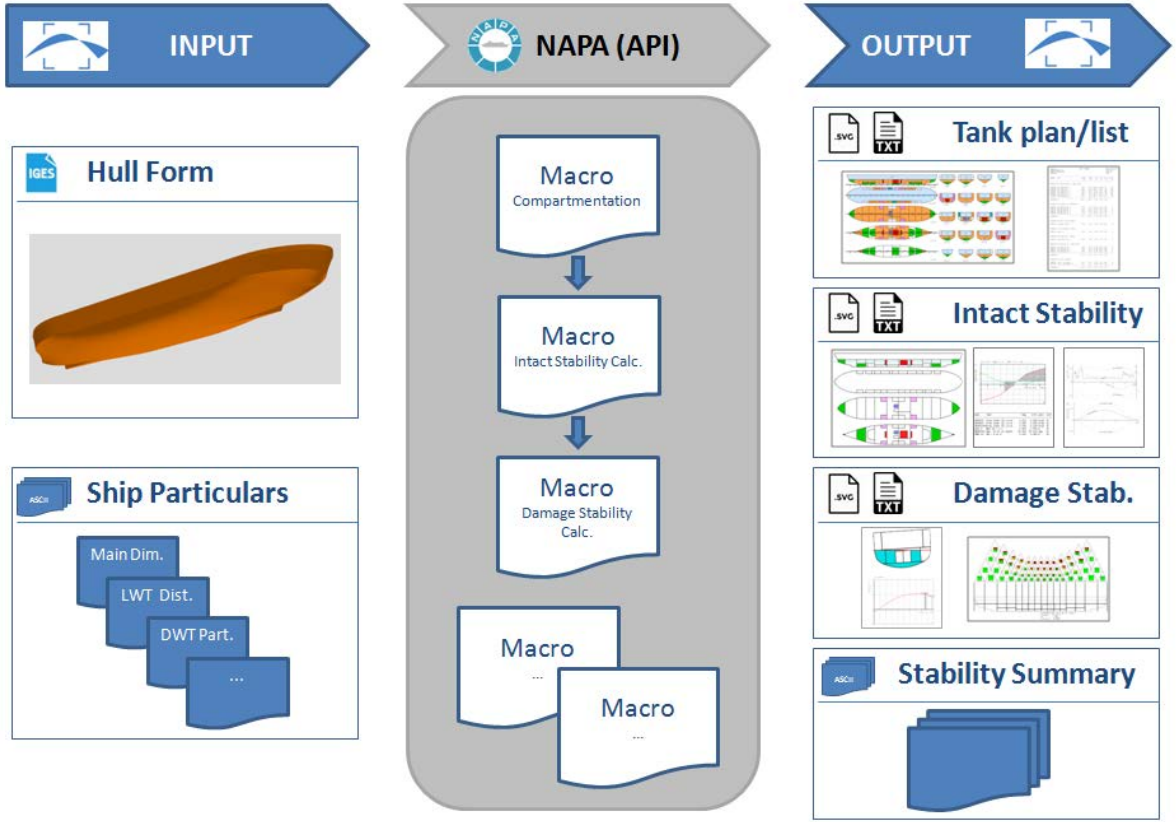
Connection of CAESES and NAPA

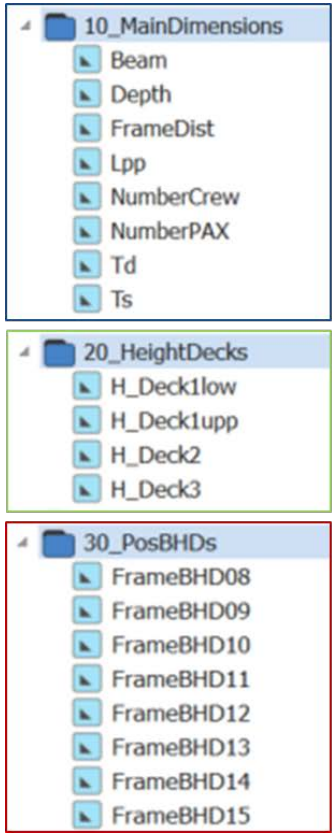
Overview

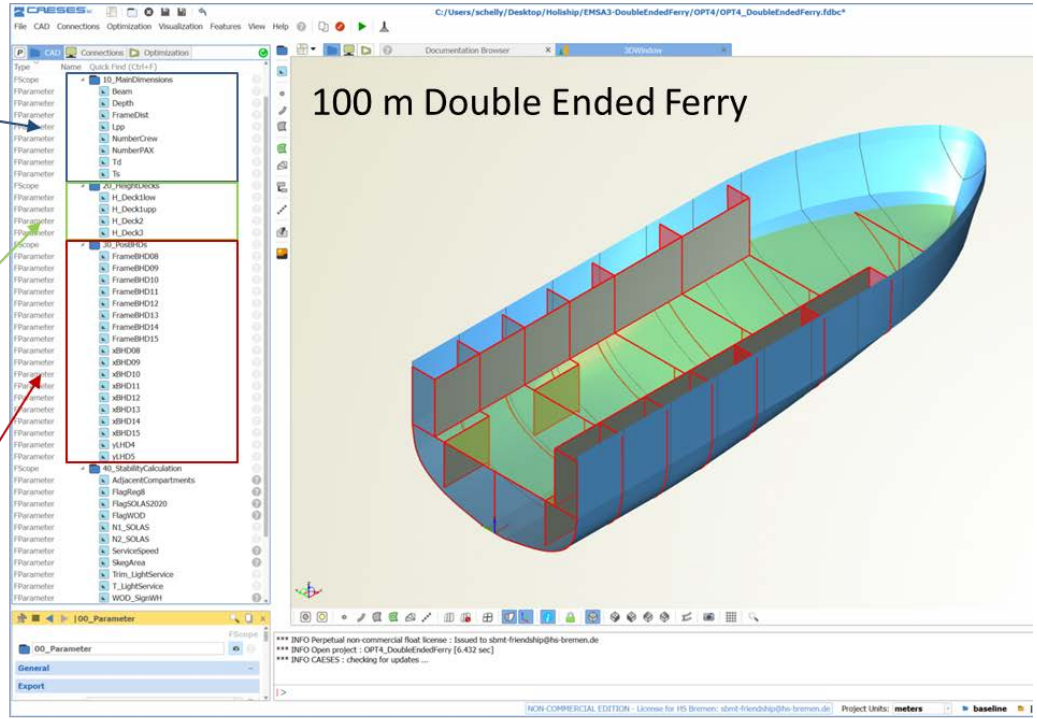
- Stability calculations based on:
  - Intact Stability Code (IS-Code 2008)
  - SOLAS Chap. II-I, Reg. 6, 7, 8 (SOLAS 2009)
  - MSC Circ. 421(98), Reg. 6, 7, 8 (SOLAS 2020)
  - Directive 2003/25/EC (Stockholm Agreement)



FRIENDSHIP SYSTEMS © 2019

Parameters





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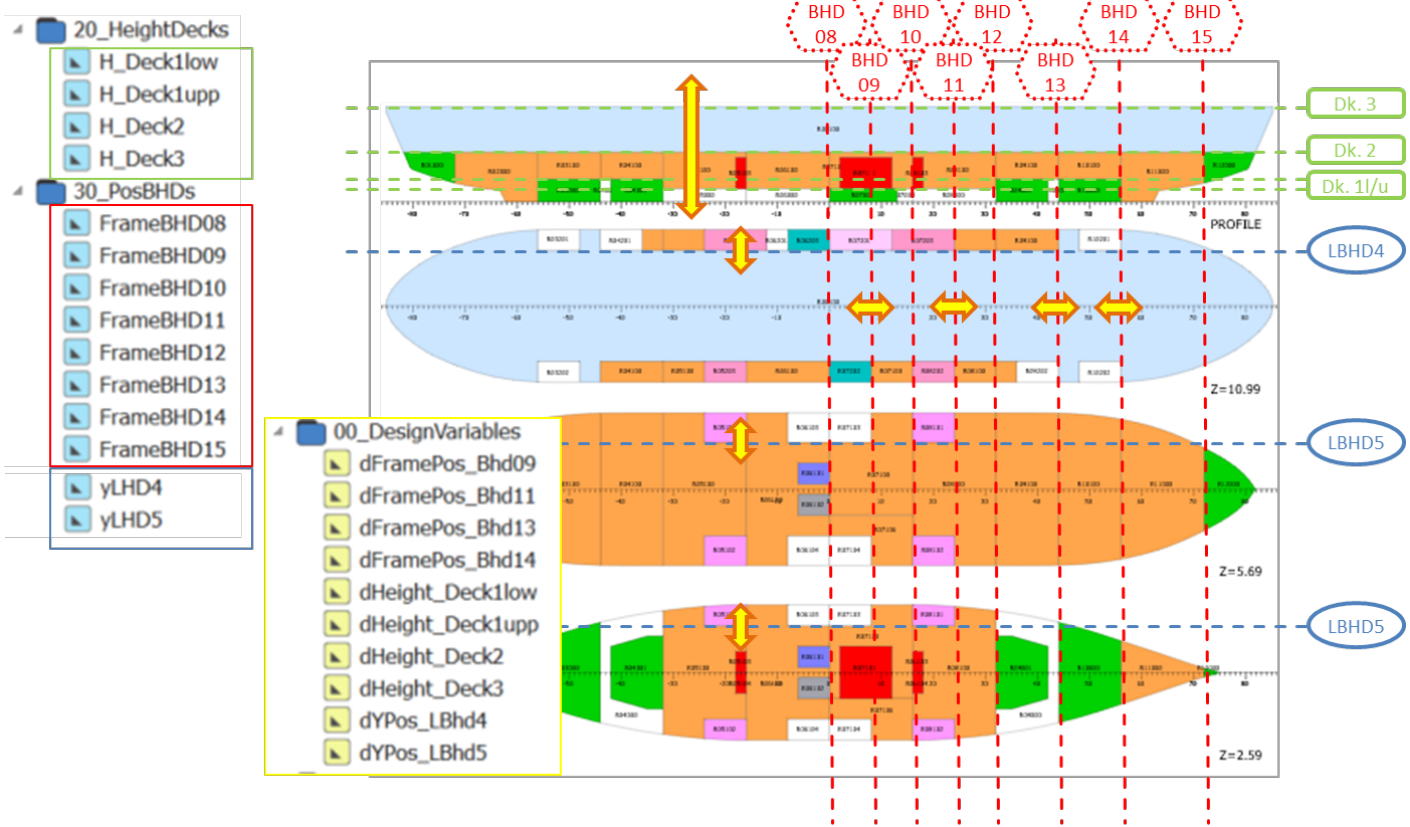

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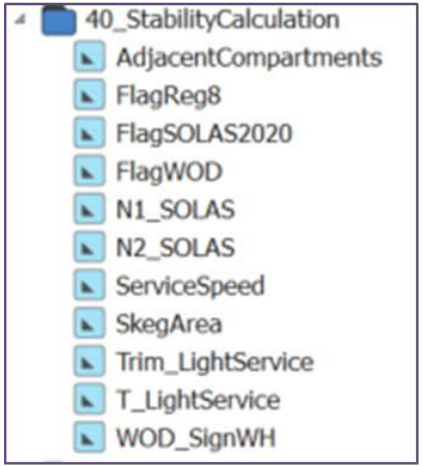
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FlagSOLAS2020
FlagWOD
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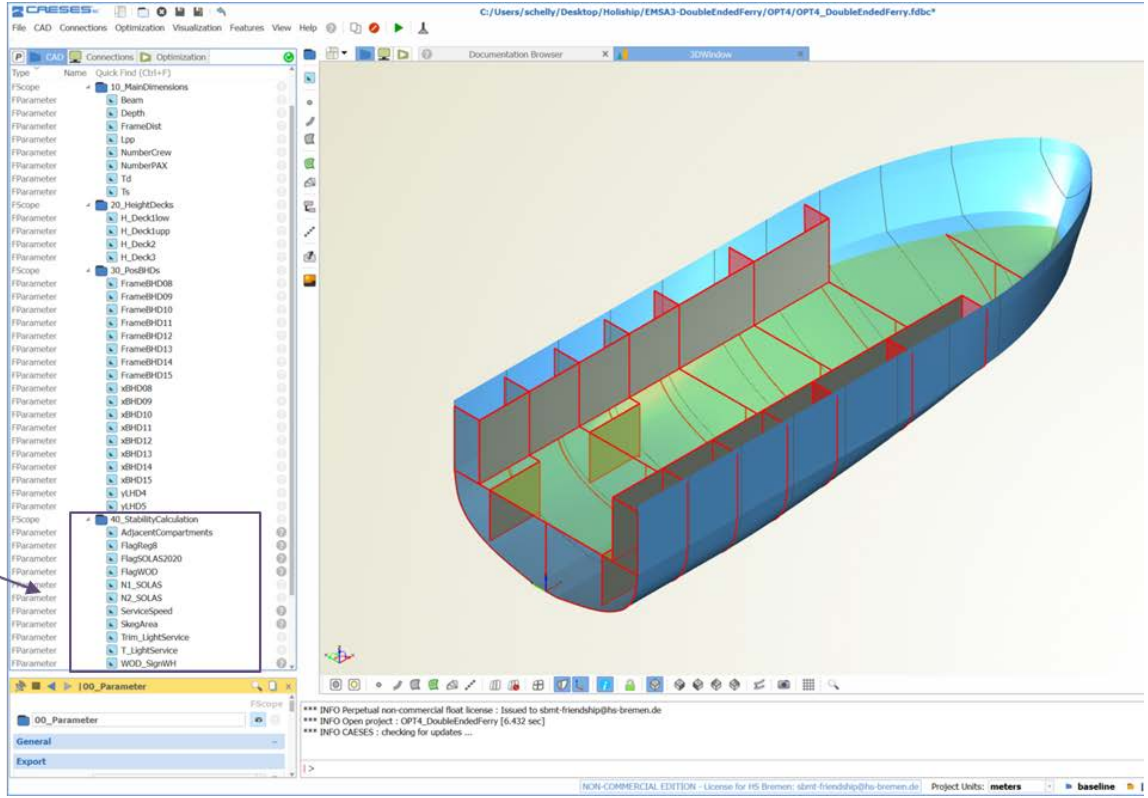
N2_SOLAS
ServiceSpeed
SkegArea
Trim_LightService
T_LightService
WOD_SignWH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File CAD Connections Optimization Visualization Features View Help
Documentation Browser
3DWindow
10_MainDimensions
Beam
Depth
FrameDist
Lpp
NumberCrew
NumberPAX
Td
Ts
20_HeightDecks
H_Deck1low
H_Deck1upp
H_Deck2
H_Deck3
30_PosBHDs
FrameBHD08
FrameBHD09
FrameBHD10
FrameBHD11
FrameBHD12
FrameBHD13
FrameBHD14
FrameBHD15
xBHD08
xBHD09
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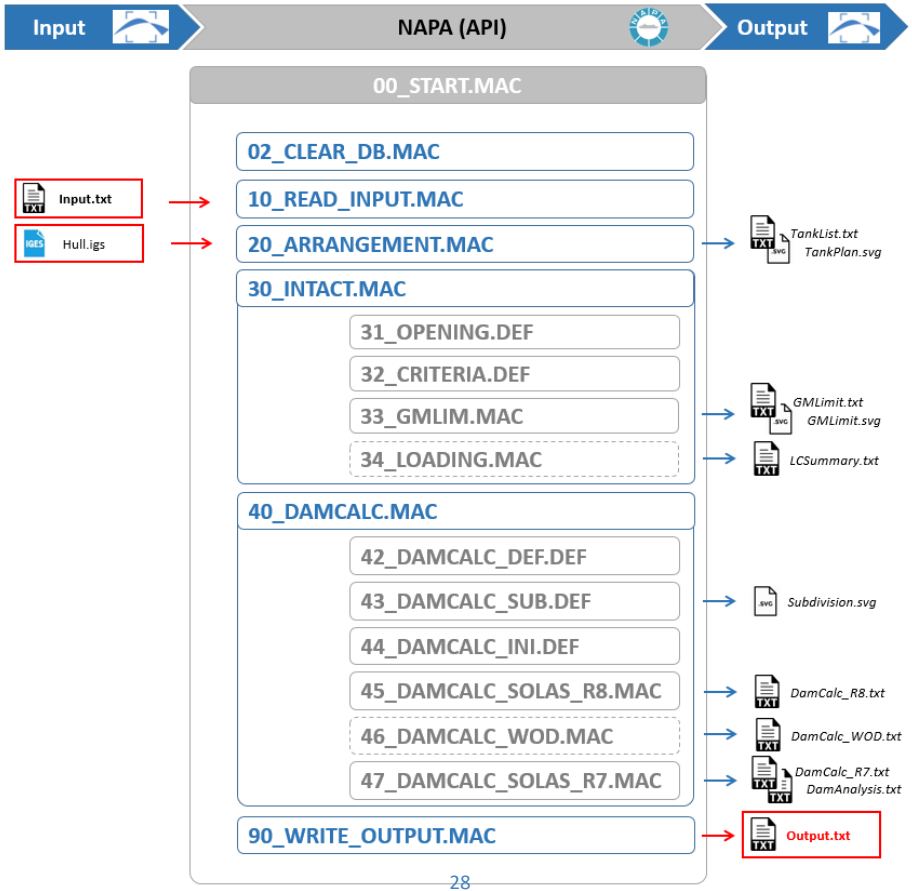
xBHD13
xBHD14
xBHD15
yLHD4
yLHD5
40_StabilityCalculation
AdjacentCompartments
FlagReg8
FlagSOLAS2020
FlagWOD
N1_SOLAS
N2_SOLAS
ServiceSpeed
SkegArea
Trim_LightService
T_LightService
WOD_SignWH
00_Parameter
General
Export
*** INFO Perpetual non-commercial float license : Issued to sbmt-friendship@hs-bremen.de
*** INFO Open project : OPT4_DoubleEndedFerry [6.432 sec]
*** INFO CAESES : checking for updates ...
NON-COMMERCIAL EDITION - License for HS Bremen; sbmt-friendship@hs-bremen.de
Project Units: meters
baseline

NAPA Macros



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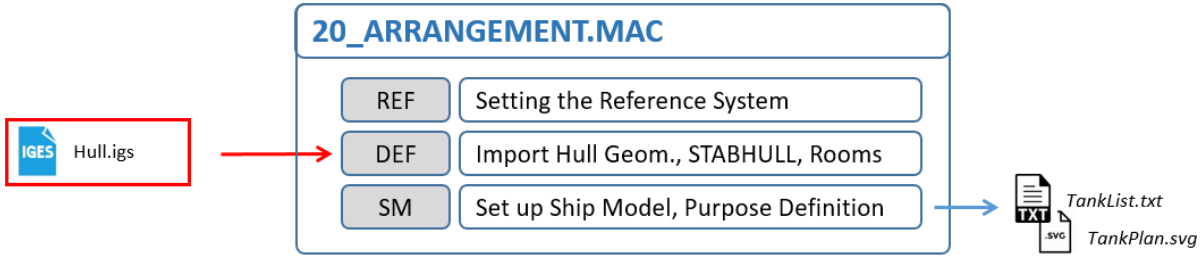
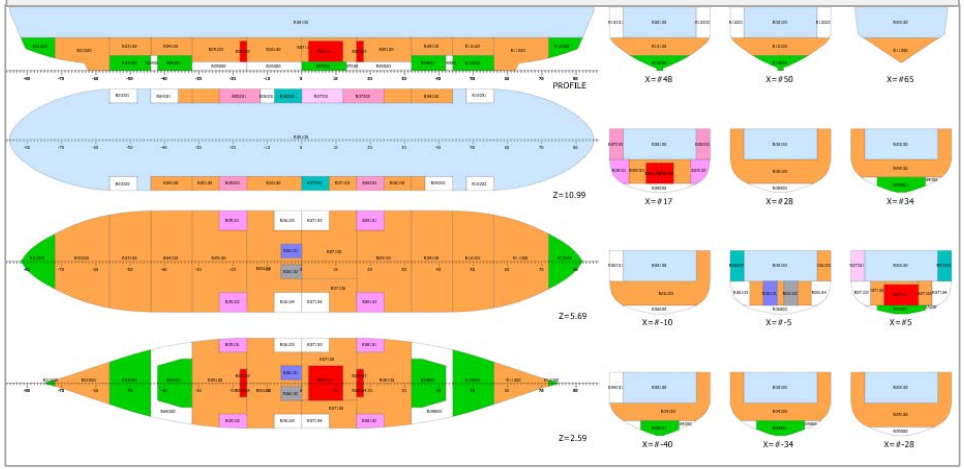
General Arrangement



Tankplan.svg



Tanklist.txt

DEF_tankarr.txt - Editor

Datei Bearbeiten Format Ansicht ?

NAME	DES	VOLM m3	VNET m3	CGX m	CGY m	CGZ m
CAPACITY OF Ballast Water (RHO=1.025)						
R01000	Aft Peak BW Tk.	42.1	41.2	-45.10	0.00	4.77
R03000	No.1 BW DB Tk. C	89.3	87.6	-29.57	0.00	1.74
R04001	No.2 BW DB Tk. C	98.9	97.0	-22.01	0.00	1.48
R07001	No.3 BW DB Tk. C	82.4	80.7	3.90	0.00	0.85
R09001	No.4 BW DB Tk. C	98.9	97.0	22.01	0.00	1.48
R10000	No.5 BW DB Tk. C	89.3	87.6	29.57	0.00	1.74
R12000	Fore Peak BW Tk.	42.1	41.2	45.10	0.00	4.77
SUBTOTAL		543.1	532.3	0.59	0.00	1.98
NAME	DES	VOLM m3	VNET m3	CGX m	CGY m	CGZ m
CAPACITY OF Diesel Oil (RHO=0.86)						
R05103	Aft MDO Day Tk. P	10.4	10.2	-10.20	1.20	3.30
R05104	Aft MDO Day Tk. S	10.4	10.2	-10.20	-1.20	3.30
R07101	MDO Storage Tk. C	129.6	127.0	4.20	0.00	3.30
R08103	Fwd MDO Day Tk. P	10.4	10.2	10.20	1.20	3.30
R08104	Fwd MDO Day Tk. S	10.4	10.2	10.20	-1.20	3.30
SUBTOTAL		171.1	167.7	3.18	0.00	3.30

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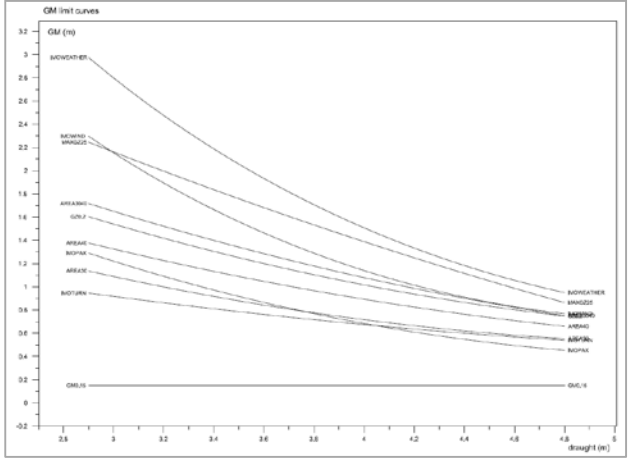
Intact Stability

30_INTACT.MAC

- **31_OPENING.DEF**
  - CR — Definition of Openings (intact & damage)
- **32_INT_CRITERIA.DEF**
  - CR — Definition of Intact Stab. Criteria
- **33_INT_GMLIM.MAC**
  - CR — Generation of GM Limit Table and Plot → *GMLimit.txt*, *GMLimit.svg*
- **34_LOADING.MAC**
  - LD — Loading Cases for Draughts DL, DP & DS → *LCSummary.txt*

GMLimit.svg



GMLimit.txt

```
LIMIT CURVE

-------------------------------------------
      T      TR    MINGM    MAXKG DCRI
      m       m       m        m
-------------------------------------------
  3.390   0.000   2.204    8.508 IMOWEATH.
  3.936   0.000   1.570    8.728 IMOWEATH.
  4.300   0.000   1.257    8.821 IMOWEATH.
-------------------------------------------
```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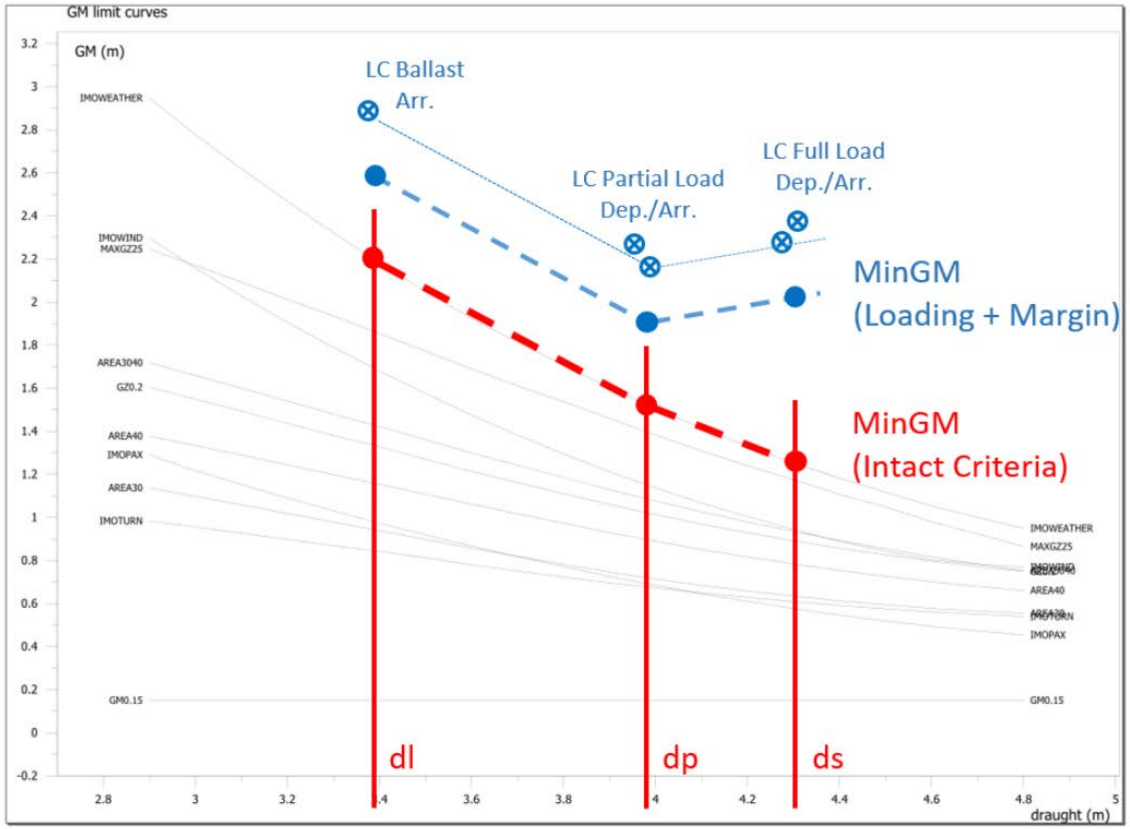
Intact Stability



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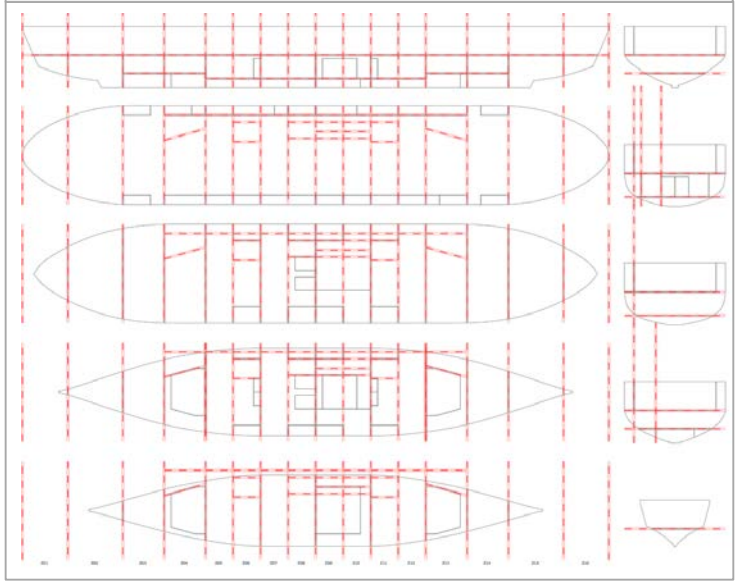
Damage Stability

40_DAMCALC.MAC

- **42_DAMCALC_DEF.DEF**
  - DAM — Settings for Damage Stability Calc.
- **43_DAMCALC_SUB.DEF**
  - DAM — Definition of Subdivision → *Subdivision.svg*
- **44_DAMCALC_INI.DEF**
  - DAM — Initial Conditions (T, Trim, GM)
- **45_DAMCALC_SOLAS_R8.MAC**
  - DAM — Analysis of Minor Damages → *DamCalc_R8.txt*
- **46_DAMCACL_WOD.MAC**
  - DAM — Analysis of Water on Deck Damages → *DamCalc_WOD.txt*
- **47_DAMCALC_SOLAS_R7.MAC**
  - DAM — Calc. of A-Index and Analysis of Results → *DamCalc_R7.txt*, *DamAnalysis.txt*

Subdiv.svg



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Damage Stability

```
##################################################################################
#                          Damage Stability Calculation                          #
#                         (Regulation 7, 8 of SOLAS 2009)                        #
##################################################################################

MIN. GM ACC. TO IS-CODE, SOLAS Reg. 8.1 and SOLAS Reg. 8.2/3
------------------------------------------------------------

                   Min. GM    Min. GM     Min. GM      Min.GM     GM applied
Inital      T      IS-Code    Reg. 8.1   Reg. 8.2/3      WOD        Reg. 7
 Cond.     [m]       [m]        [m]         [m]          [m]          [m]
-------------------------------------------------------------------------------
  DL      3.390      2.195      0.968       1.754       0.000       2.195
  DP      3.936      1.567      0.805       1.677       0.000       1.677
  DS      4.300      1.254      0.859       1.785       0.000       1.785


RESULTS OF DAMAGE STABILITY CALCULATION:
----------------------------------------

Required Subdivision Index     R = 0.72792
Attained Subdivision Index     A = 0.84290


PROBABILITY OF OCCURENCE

WPV      SFAC=1      0<SFAC<1      SFAC=0         WPV
-------------------------------------------------------
DL     0.1759820    0.0077738    0.0000000    0.1837558
DP     0.3009800    0.0579482    0.0085833    0.3675116
DS     0.2999564    0.0442802    0.0232749    0.3675116
-------------------------------------------------------
WPV    0.7769184    0.1100022    0.0318583    0.9187789

PROBABILITY OF SURVIVAL

WPVS     SFAC=1      0<SFAC<1      SFAC=0         A         A(rel)
-------------------------------------------------------------------
DL     0.1759820    0.0047156    0.0000000    0.1806976     124,1%
DP     0.3009800    0.0337238    0.0000000    0.3347038     115,0%
DS     0.2999564    0.0275390    0.0000000    0.3274955     112,5%
-------------------------------------------------------------------
A      0.7769184    0.0659784    0.0000000    0.8428969        ok
```

DamCalc_R8.txt

```
Damage Length [Reg. 8.1: 0.08L from FP at 85%H]: l =    7.826 m

Damage Length [Reg.8.2/3: max(0.03L,3.0 m)]    : l =    3.067 m
Damage Penetr.[Reg.8.2/3: max(0.1B,0.75 m)]    : b =    1.716 m


MIN. GM ACC. TO SOLAS II-1, Reg. 8.1 & 8.2/3
--------------------------------------------

                    Min. GM      Min. GM
Inital      T       Reg. 8.1    Reg. 8.2/3
 Cond.     [m]        [m]          [m]
-------------------------------------------
  DL      3.390      0.969        1.758
  DP      3.936      0.805        1.672
  DS      4.300      0.859        1.781
```

DamCalc_WOD.txt

```
Length acc. to SOLAS 90:                : L    = 97.058 m
Min. damage length acc. to SOLAS90:     : lmin =  5.912 m

Shortest zone length:                   : lmin =  4.800 m
Max. number of zones in nzone damages:  : n    =  3

Sign. wave height                       : Hsw  =  4.000 m


MIN. GM ACC. TO EC2003/25 (Stockholm)
-------------------------------------

                        1-Comp.     Multi-Comp.
Inital         T        Min. GM      Min. GM
 Cond.        [m]          [m]          [m]
-----------------------------------------------
  DL         3.390        1.795        2.654
  DP         3.936        1.704        3.151
  DS         4.300        1.822        3.240
```

HSB
Hochschule Bremen
City University of Applied Sciences

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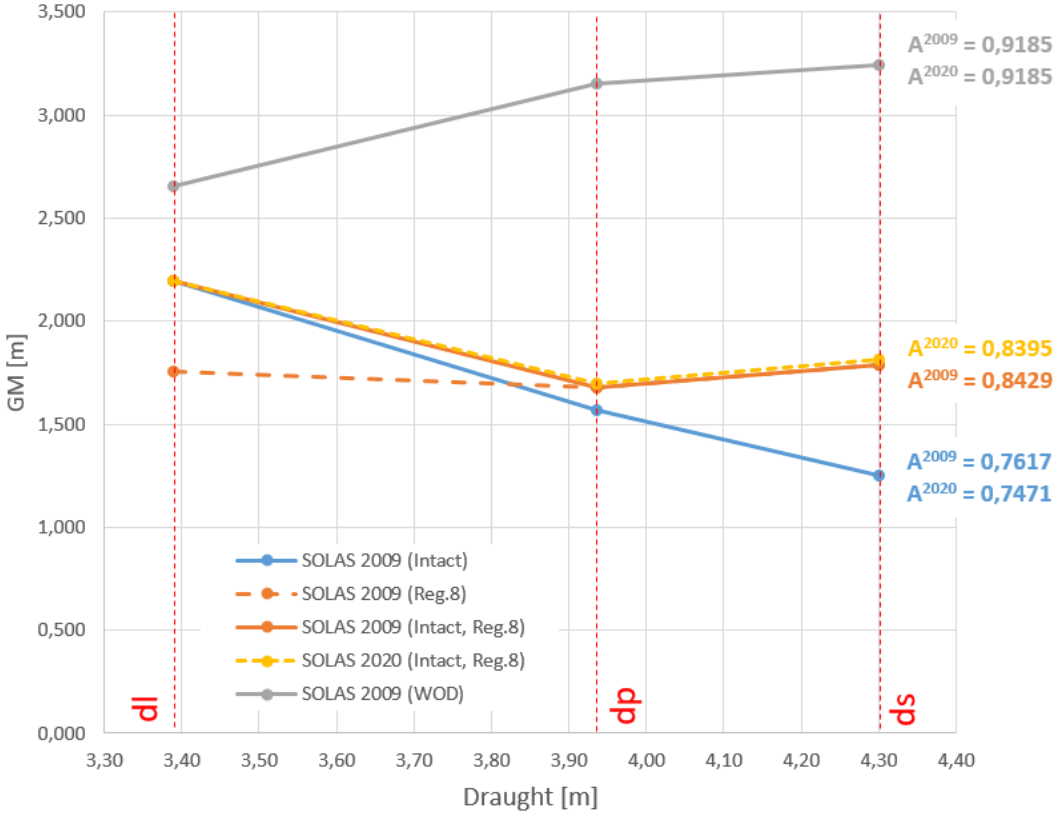
Damage Stability



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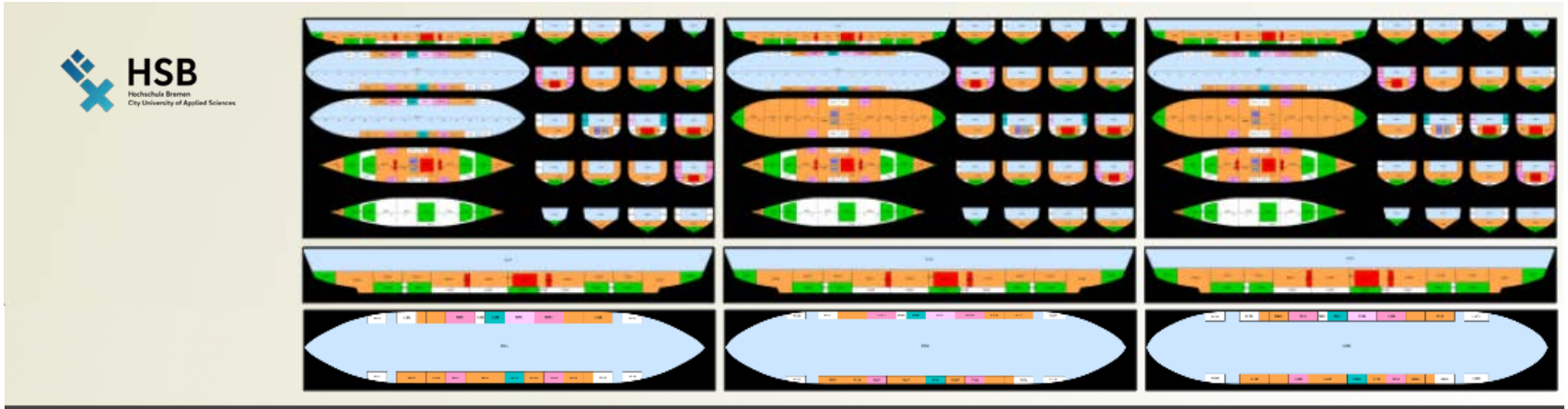
Selected Results



Name	EnsembleInvestigation_01_des0000	EnsembleInvestigation_01_des0057	EnsembleInvestigation_01_des0090
dHeight_Deck2	-0.4	0	0.4
dYPos_LBhd5	-0.5	0.5	0
dFramePos_Bhd14	0	1	2
eval_SOLAS_A	0.667679	0.7574003	0.8172983
eval_SOLAS_A_s0to1	0.5578171	0.6531604	0.7490322
eval_SOLAS_A_s1	0.1098619	0.1042399	0.0682661
eval_SOLAS_WPRV	0.9187789	0.9193434	0.9198653
eval_VOL_DieselOil	152.1	171.1	190.1
eval_VOL_Garage	6998.6	7199.6	6363.2

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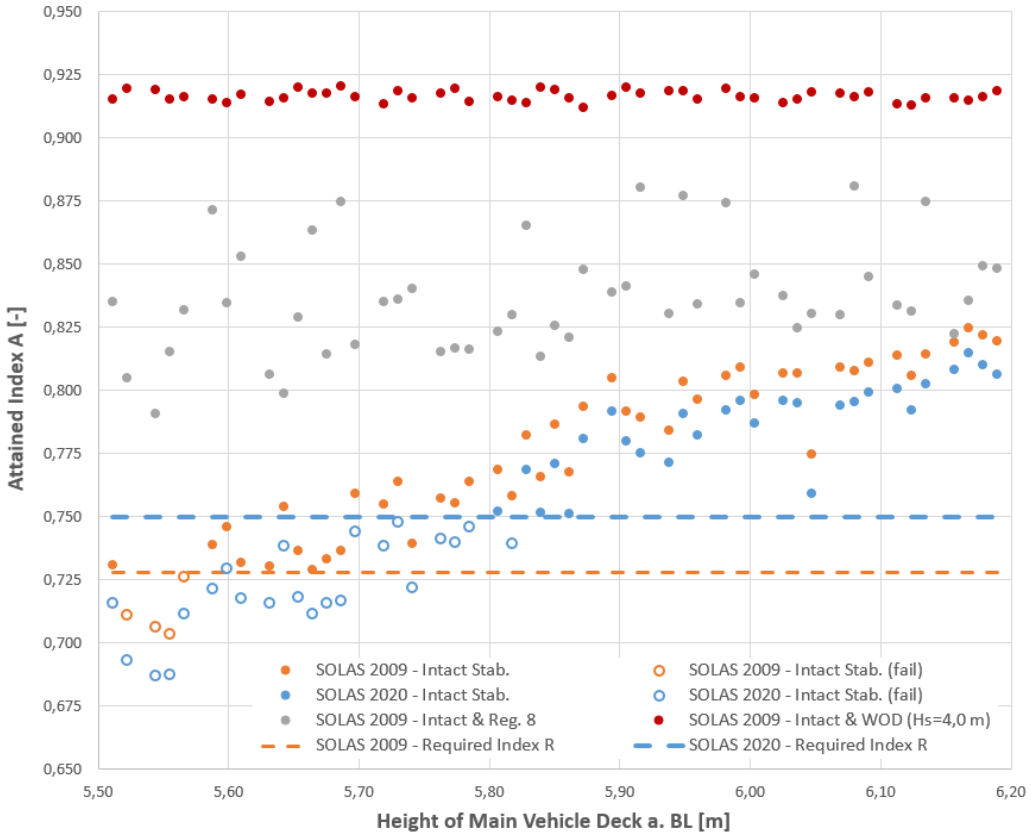
Selected Results



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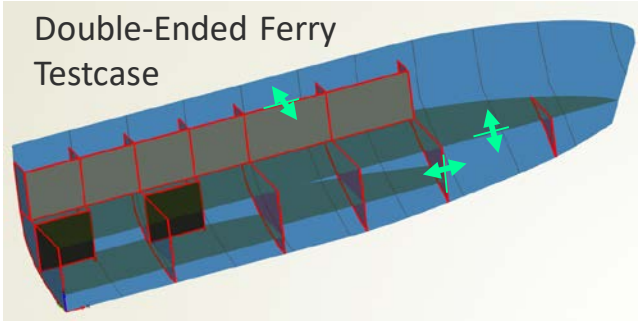

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