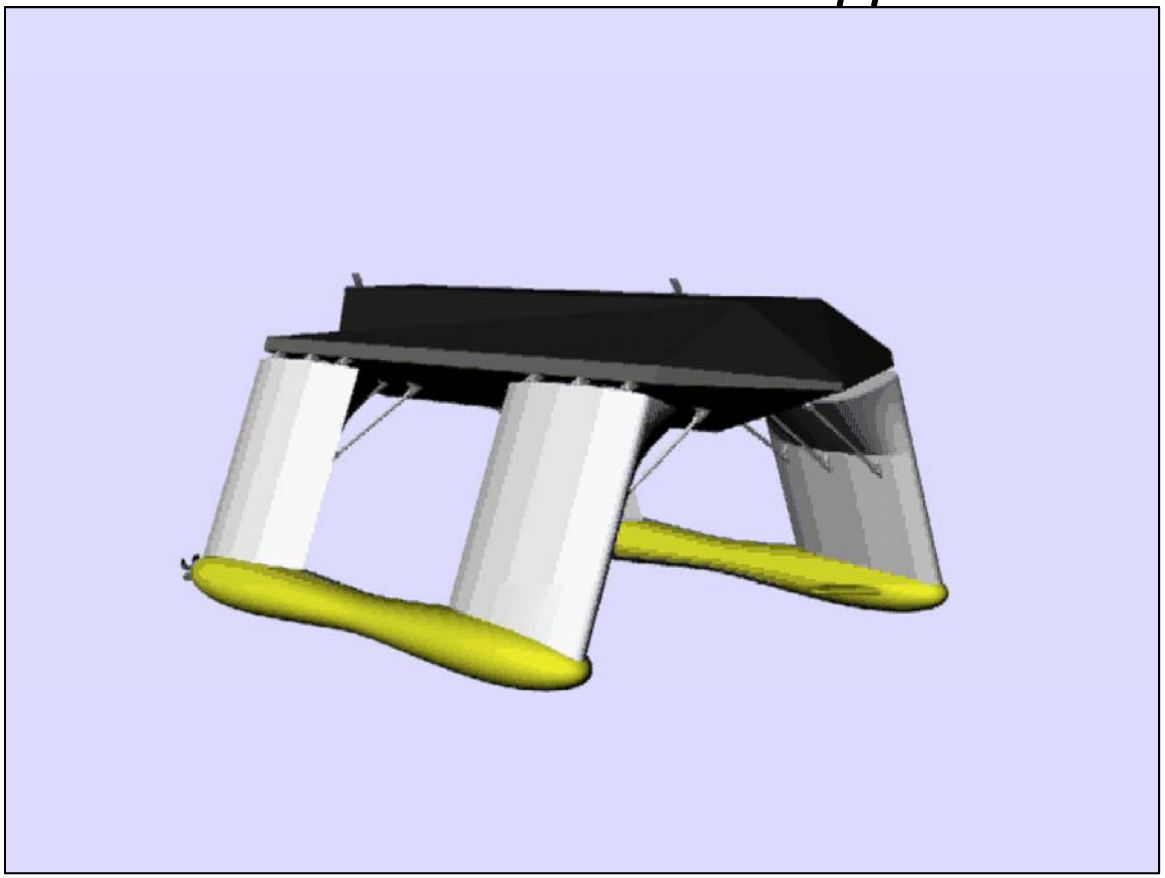
NURC SWATH-USV

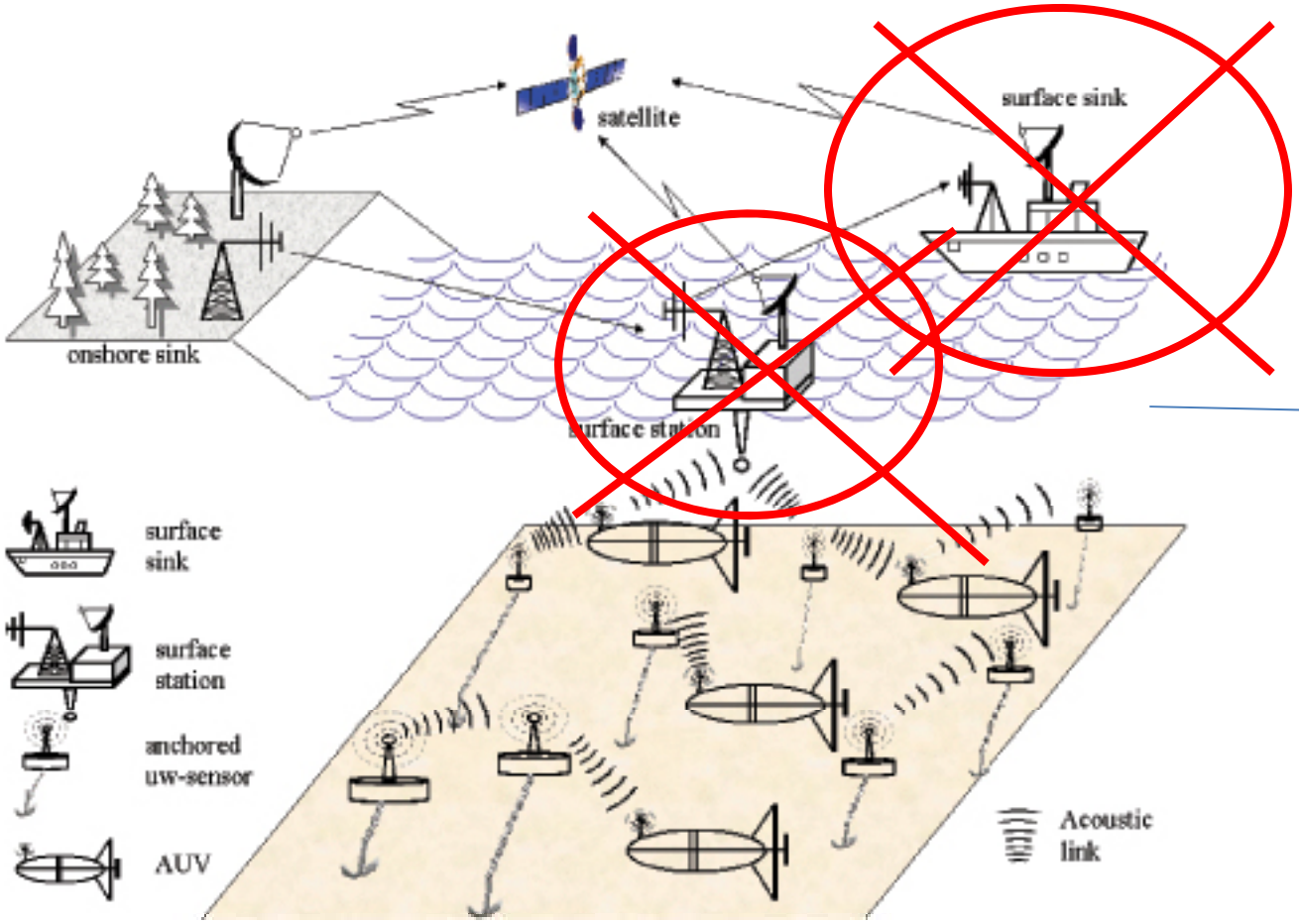
Innovative USV with SWATH Hull for Superior Operability in Sea States and AUV Support



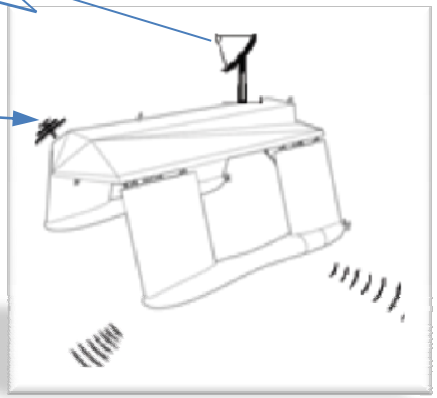
NATO Undersea Research Centre
University of Genoa

Chief Scientist: Dr. Ing. Stefano Brizzolara
Research Assistants: PhD Ing. Giuliano Vernengo
Ing. Marco Bovio

Integrated Cooperative UUV-USV-Network



Persistant Surveillance/Monitoring System

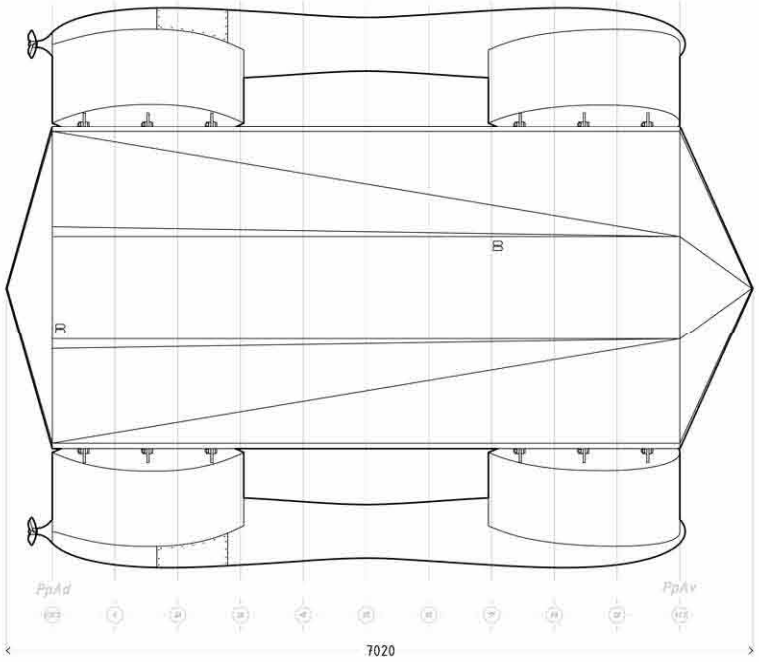


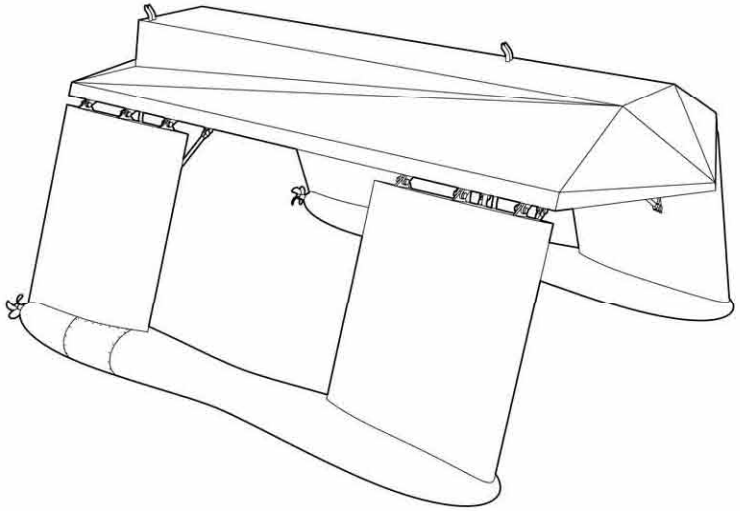
Aim and Features:

- To develop the ***concept design*** and ***feasibility assessment*** of an innovative USV (Unmanned Surface Vehicle) of the SWATH (Small Waterplane Area Twin Hulls) type, but with unconventional shape of underwater hulls to minimize total resistance.

- Advantages of the designed SWATH hull form:
  - Inherent superior seakeeping ability w.r.t. equivalent monohulls and catamaran vehicles:
    - More operability in rough sea states (relative to the actual hull dimension)
    - Very stable platform for better underwater measuring capabilities
    - Smaller vehicle with same seakeeping performance of a much larger vessel

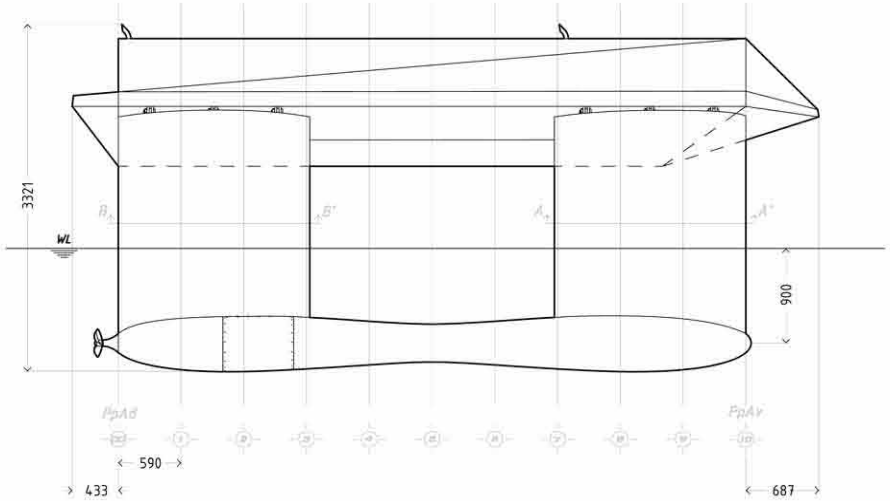
  - Particularly Suitable for AUV launch and recover
  - Advanced stabilizing system (based on dynamic fins devices)

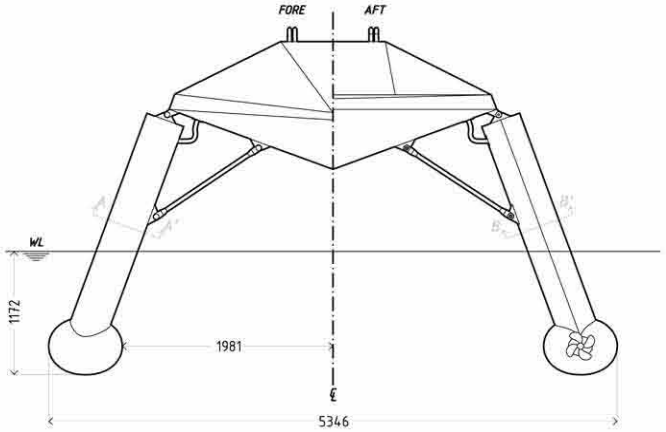


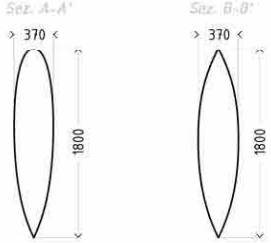


Technical Data:

Lenght Over All	7.02m
Length at WL	5.90m
Beam max.	5.35m
Draft	1.17m
Height	3.32m
Displacement Full	4.120t
Engine Power	2x 22kW
Max Speed	12kn







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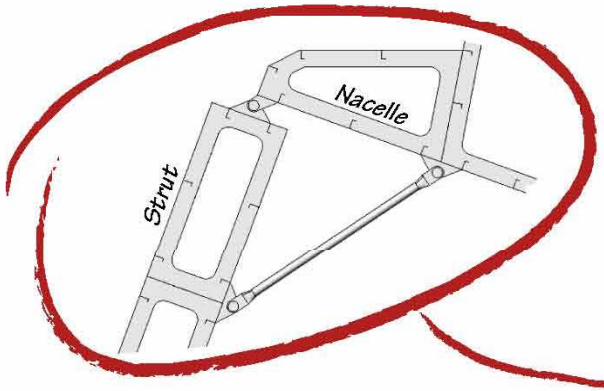
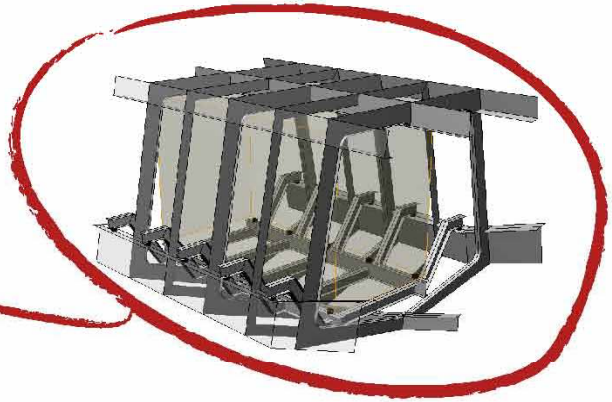
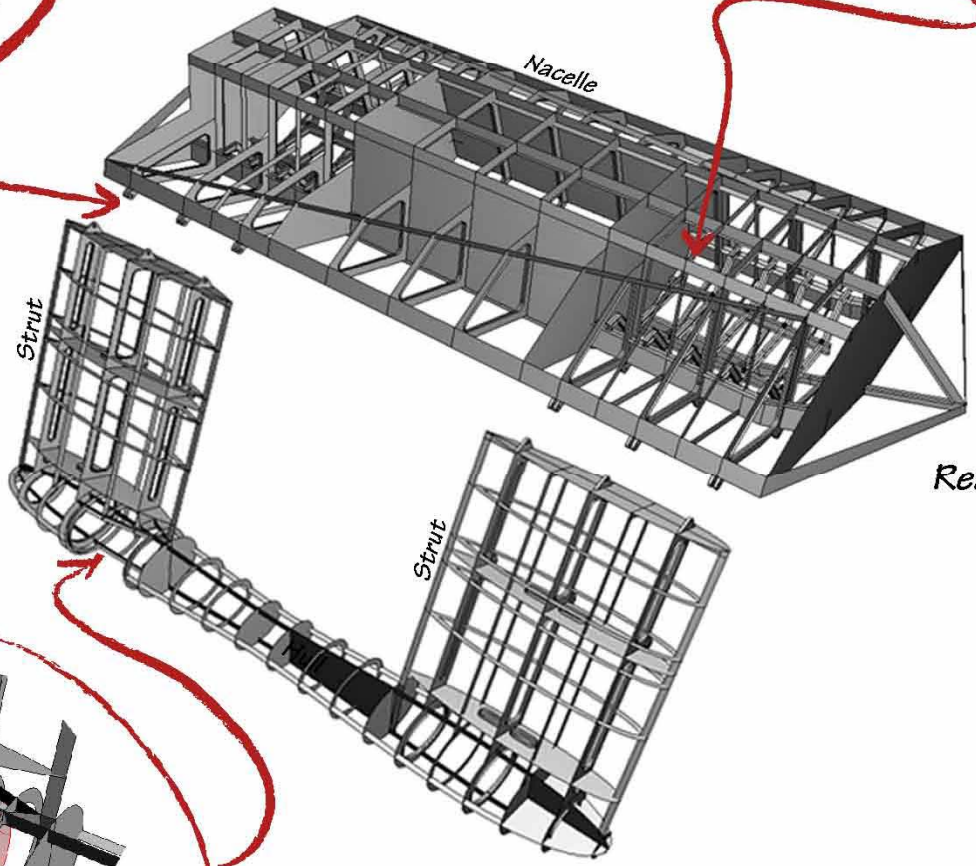
DRAWING: LINES PLAN	TITLE: SWATH - USV
PROJECT: Hydrodynamic Design and Optimization of an Innovative SWATH-USV by CFD Methods	FILE: 02/08/2010_SWATH_Strut 5 Tav. 1
	DATE: 03/08/2010
	UNITS: mm SCALE: 1:25@A1
	CHECKED BY: Prof. Ing. Stefano Brizzolara
	DESIGNED BY: Marco Bovio

Dismountable joint concept

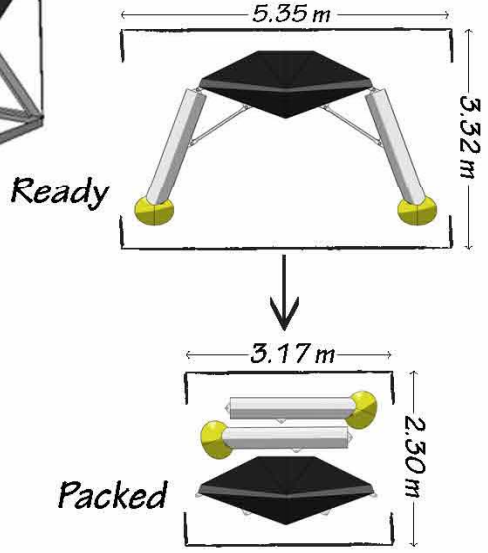


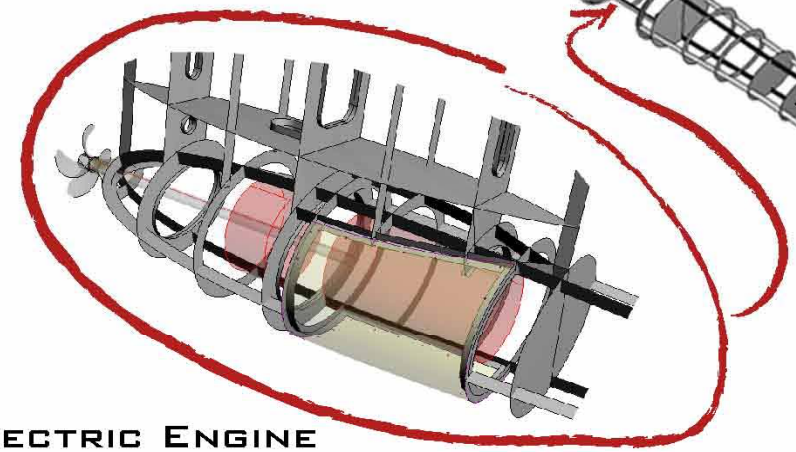


Diesel Generator Cradle



material:
Marine Aluminium Alloy 5083 H 321





Electric Engine Housing

NURC	N.A.T.O. Undersea Research Centre
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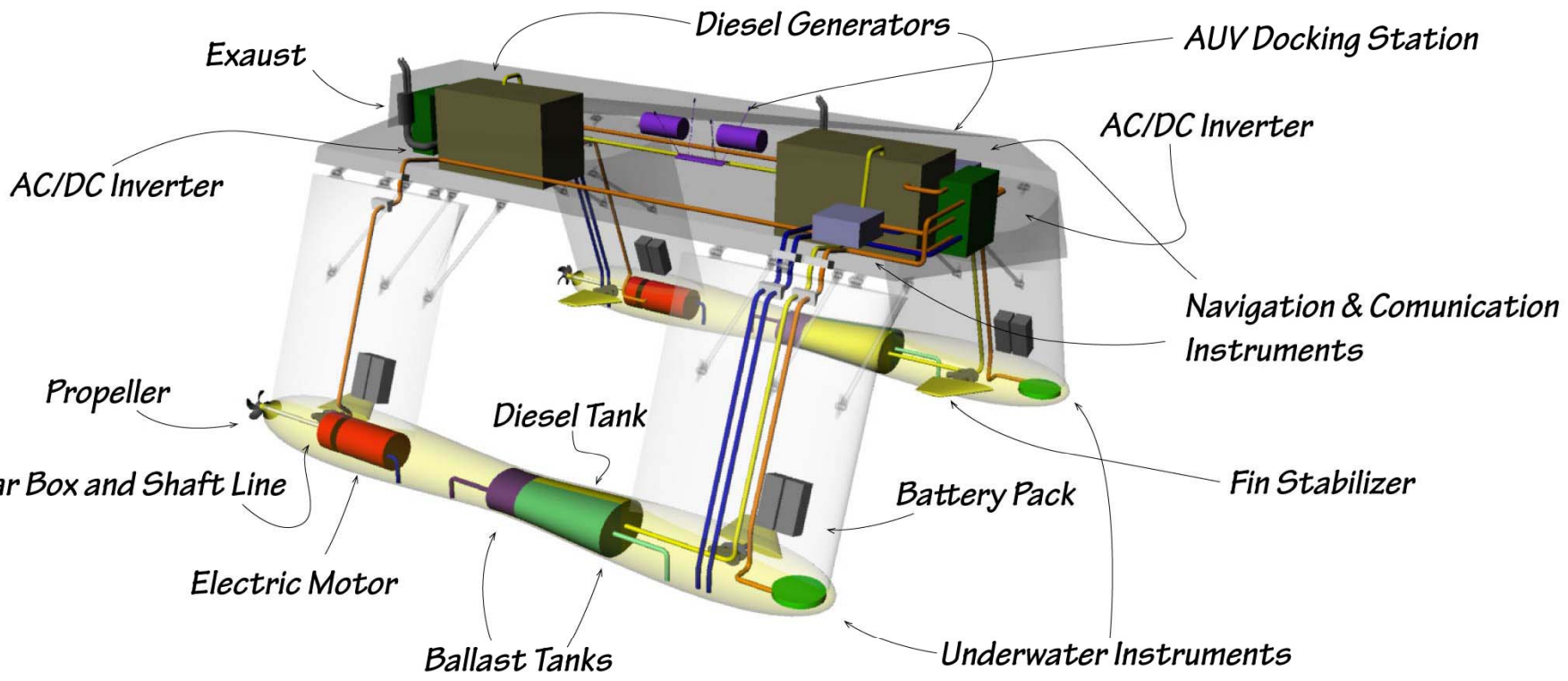
DRAWING: STRUCTURES & CONSTRUCTION DETAILS	TITLE: SWATH - USV
PROJECT: Hydrodynamic Design and Optimization of an Innovative SWATH-USV by CFD Methods	FILE: 02/08/2010_SWATH_Strut 5 — Tav.: 2
	DATE: 03/08/2010
	UNITS: mm SCALE: 0.0 @A1
	CHECKED BY: Prof. Ing. Stefano Brizzolara
	DESIGNED BY: Marco Bovio



DETAILS:

- 2x Diesel Generator 22 kW
- 2x AC/DC Inverter
- 2x Gearbox - about 1:5 reduction (to be defined)
- 2x Electric Motor - (to be defined)
- 2x Propeller - (to be defined)
- 4x Fin Stabilizer
- 8x Battery Pack Li-ion 120 Ah
- Diesel Tanks capacity up to 190 lt
- Trim Water Ballasts capacity up to 95 lt

- Cooling Water
- Electric Line
- Fuel Line
- Water Ballast (Trim)
- Water Ballast (Diesel)

N.A.T.O. Undersea Research Centre

University of Genoa

DRAWING: GENERAL ARRANGEMENT & PIPING LINES

PROJECT: Hydrodynamic Design and Optimization of an Innovative SWATH-USV by CFD Methods

TITLE: SWATH - USV

FILE: 02/08/2010_SWATH_Strut 5 | Rev: 3

DATE: 03/08/2010

UNITS: mm | SCALE: 0.0 @A1

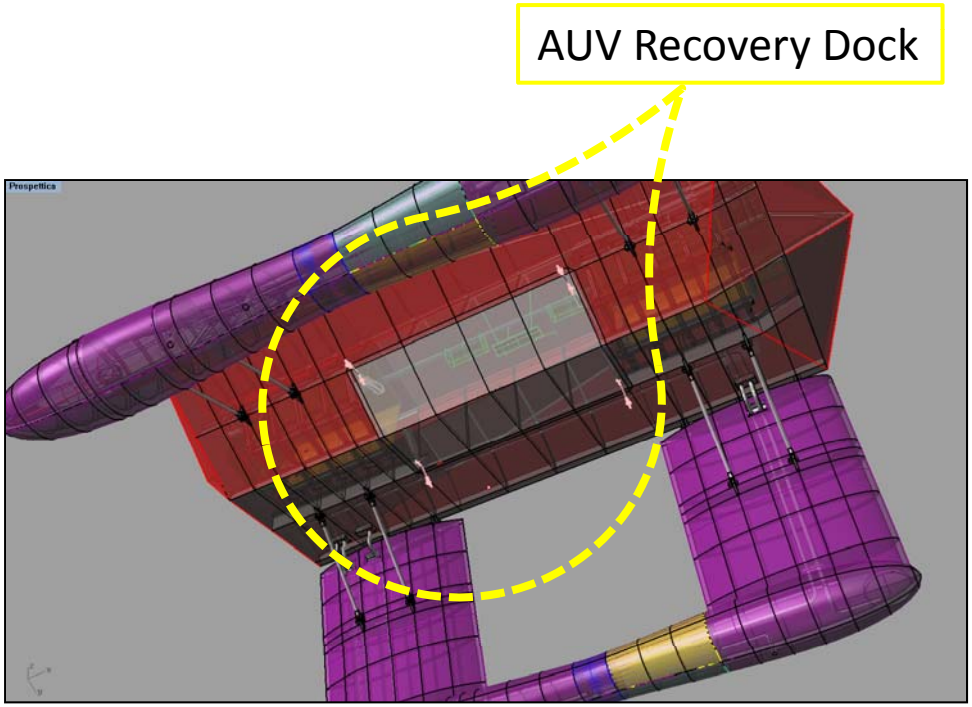
CHECKED BY: Prof. Ing. Stefano Brizzolara

DESIGNED BY: Marco Bovio

AUV recovery feature

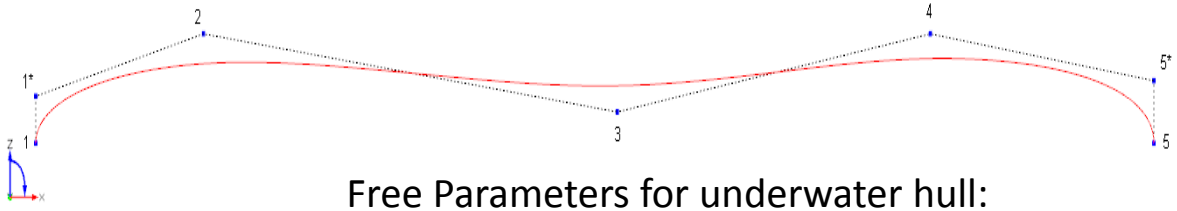
- Recovering and launching dock for small AUV (up to 100kg of weight and 2.2m in length)

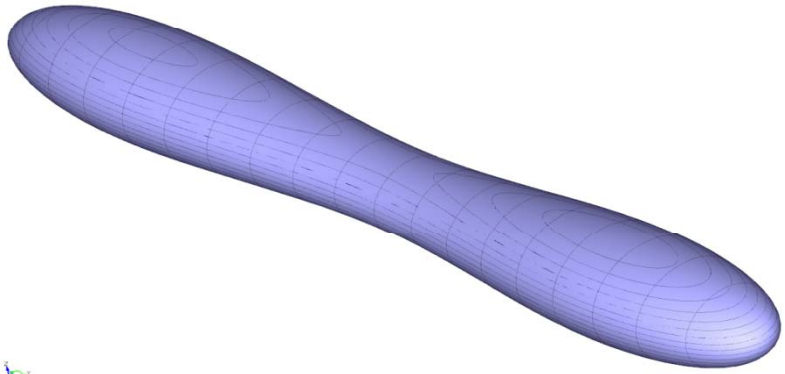
- Connections and power for downloading data and recharging batteries



Parametric Hull form Optimization

- **New FULLY PARAMETRIC HULL SURFACE DEFINITION Approach (just tested with success for frigate type of hulls of the Italian Navy):**
  For lower hulls (ellipsoidal shape):

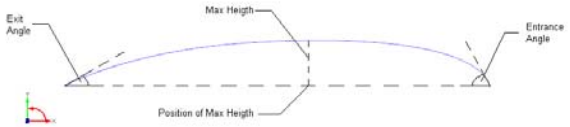


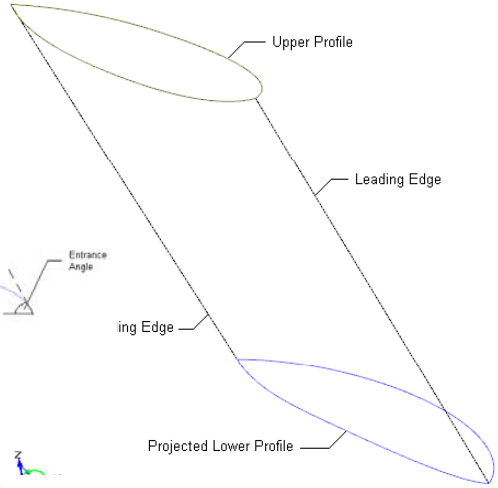


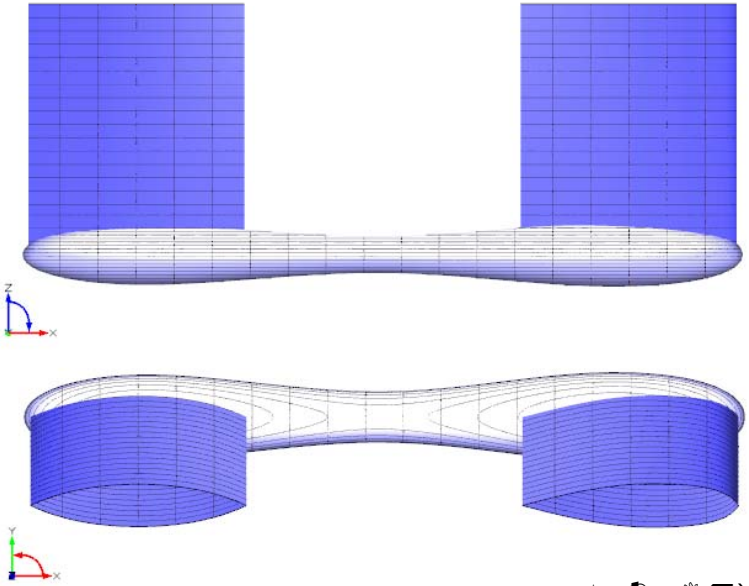
Free Parameters for underwater hull:

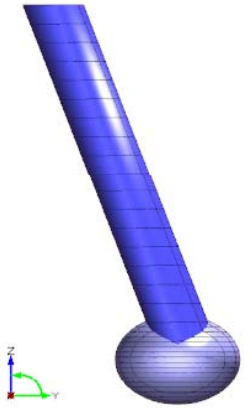
Point	1	1’	2	3	4	5’	5
X Coordinate	0	0	X_Pos_2	X_Pos_3	X_Pos_4	Length	Length
Z Coordinate	0	Z_Pos_1’	Z_Pos_2	Z_Pos_3	Z_Pos_4	Z_Pos_5’	0

- **And struts (profile shape):**



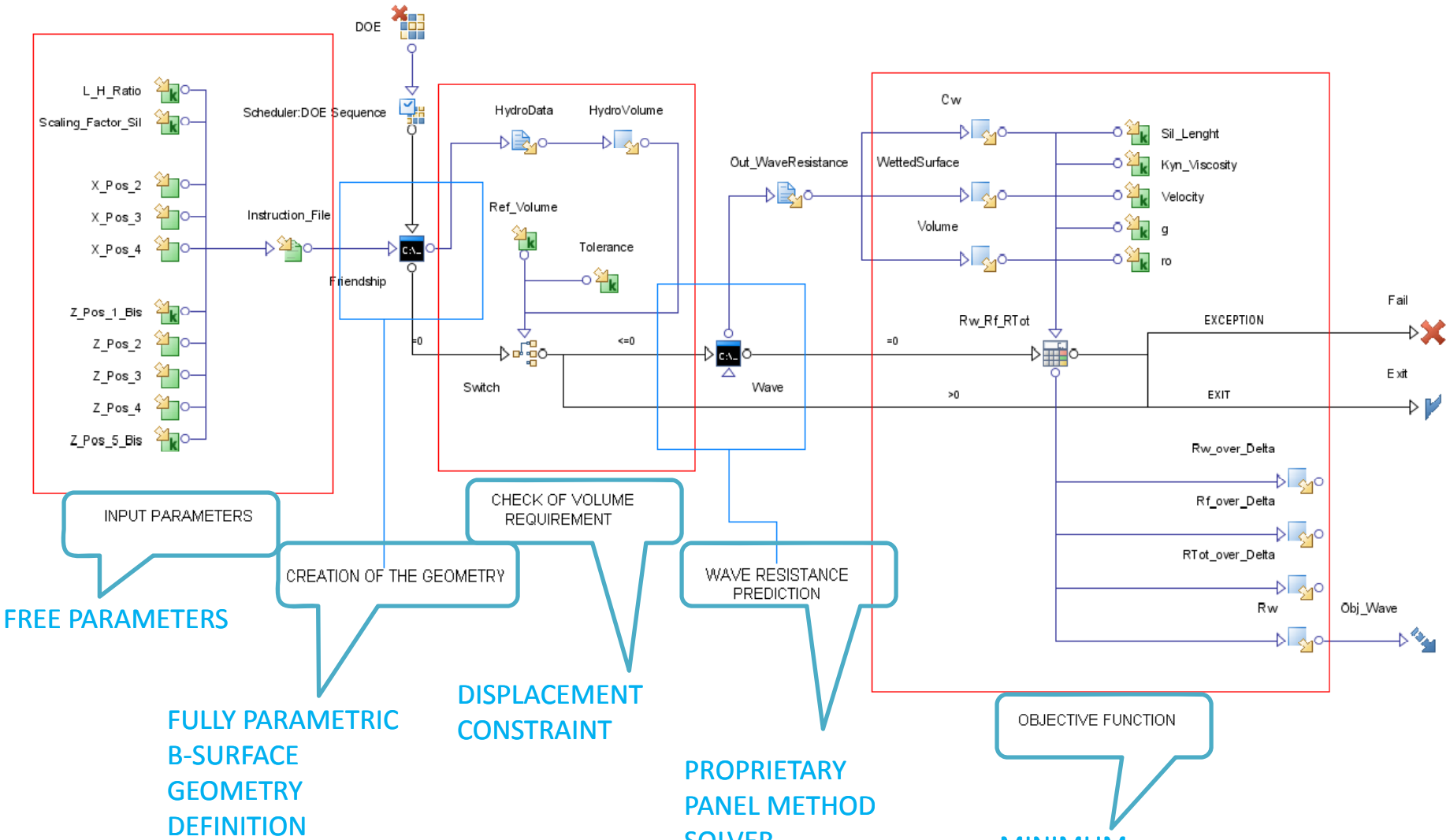




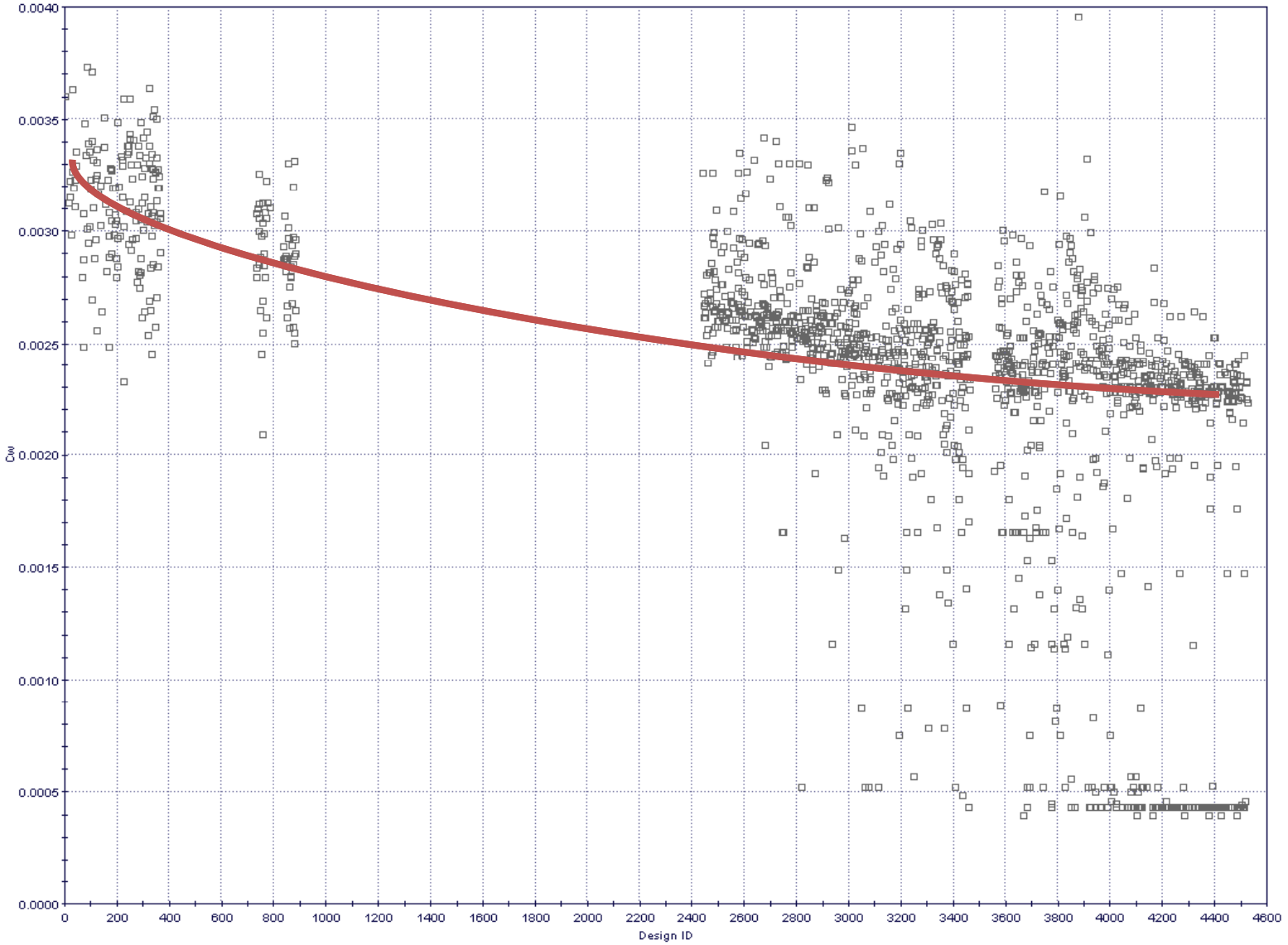


Flowchart of the devised optimization system

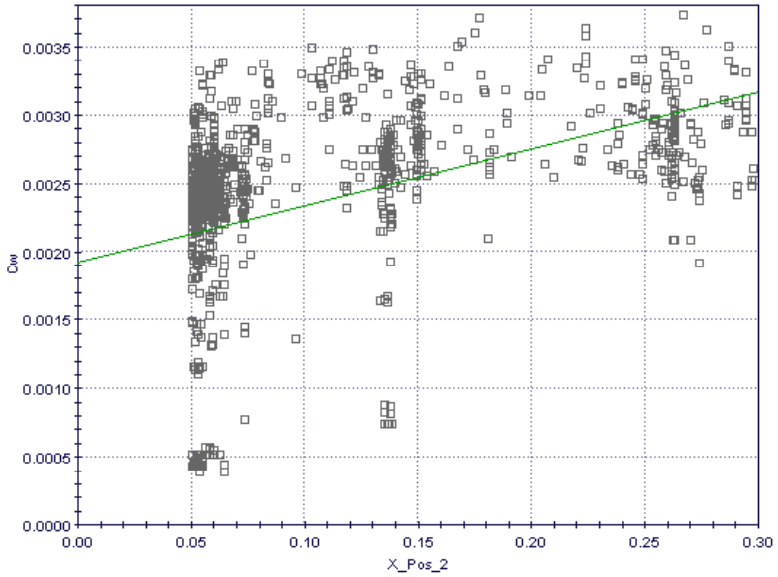
(opt. env.: ModeFrontier)

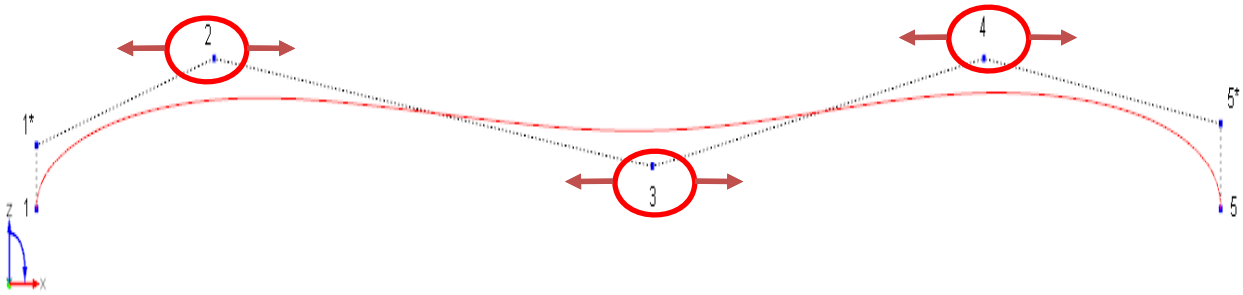


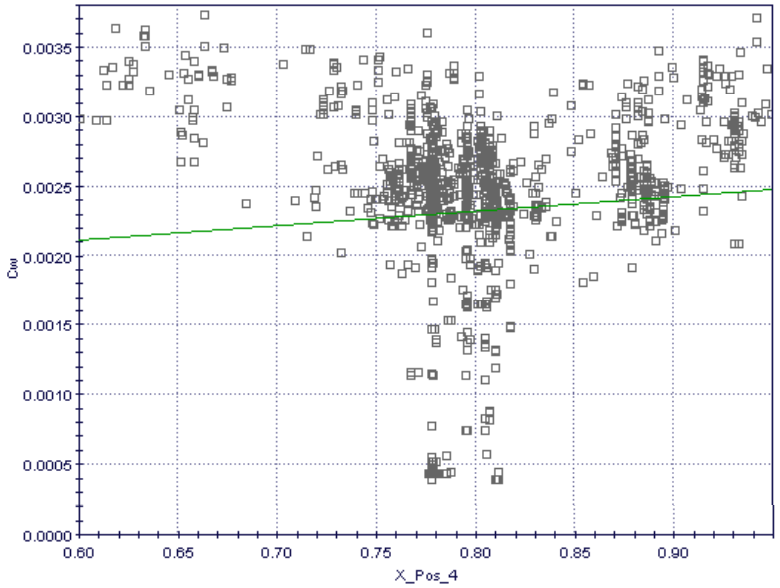
Convergence of Wave Resistance during Optimization

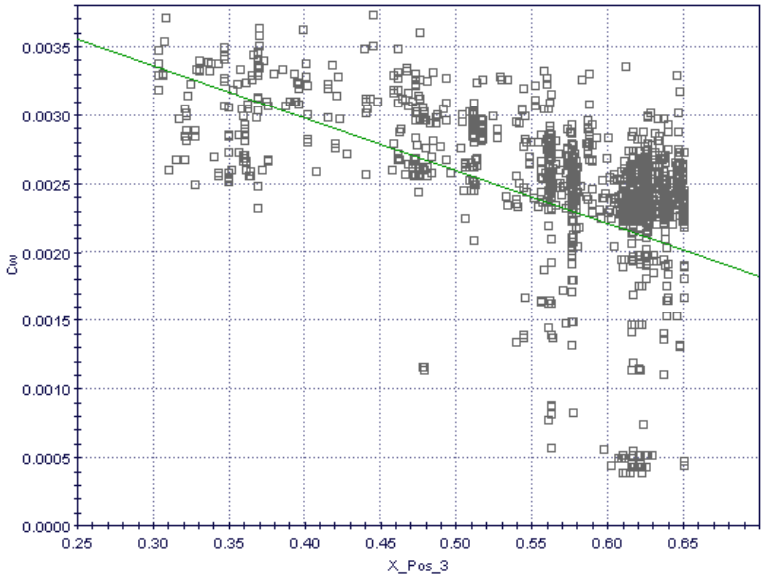


Trends for free variable: Abscissae of internal control points

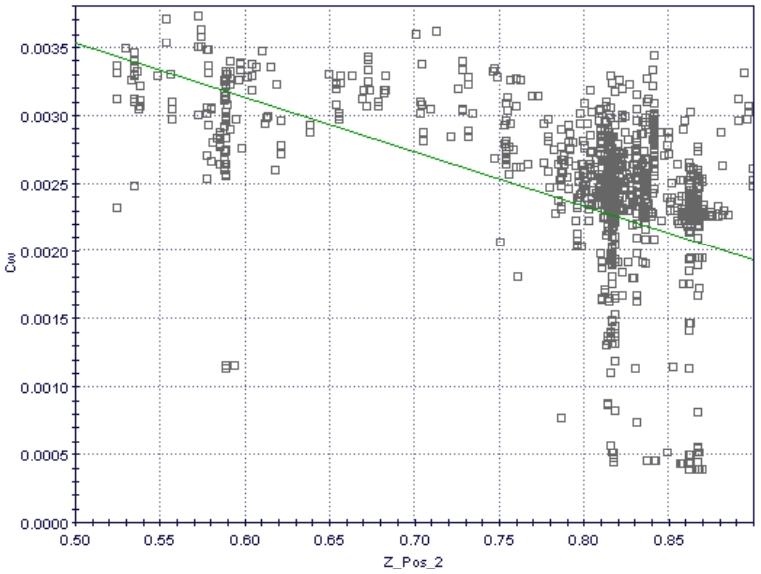


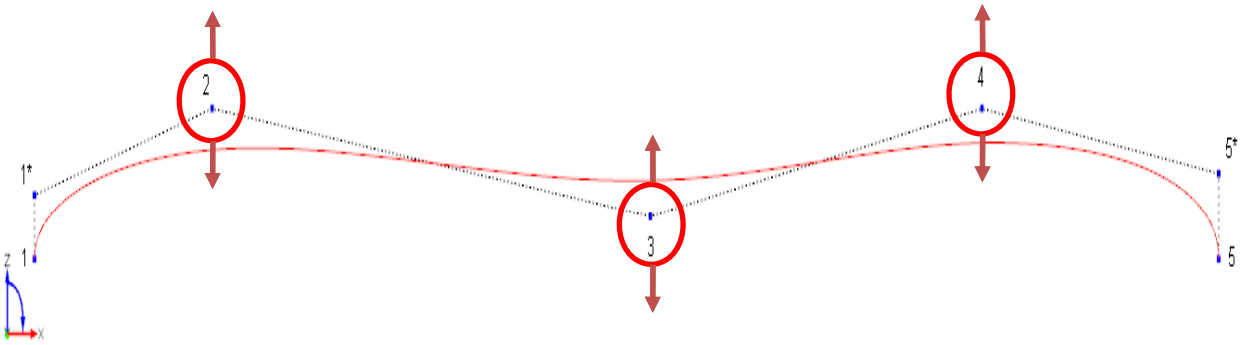


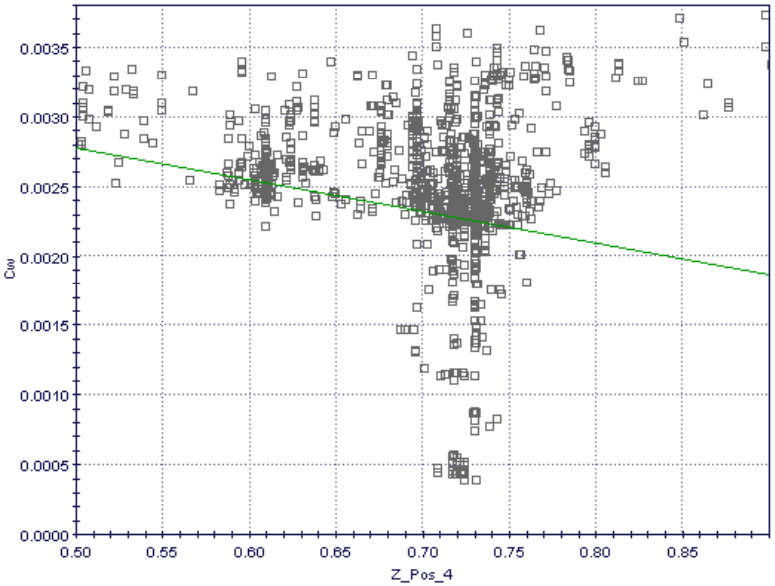


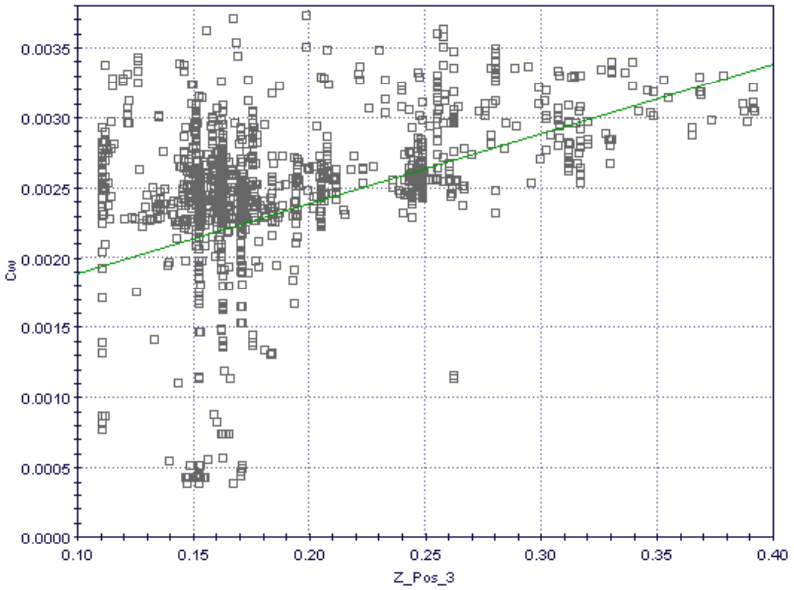


Trends for free variable: Ordinates of internal control points

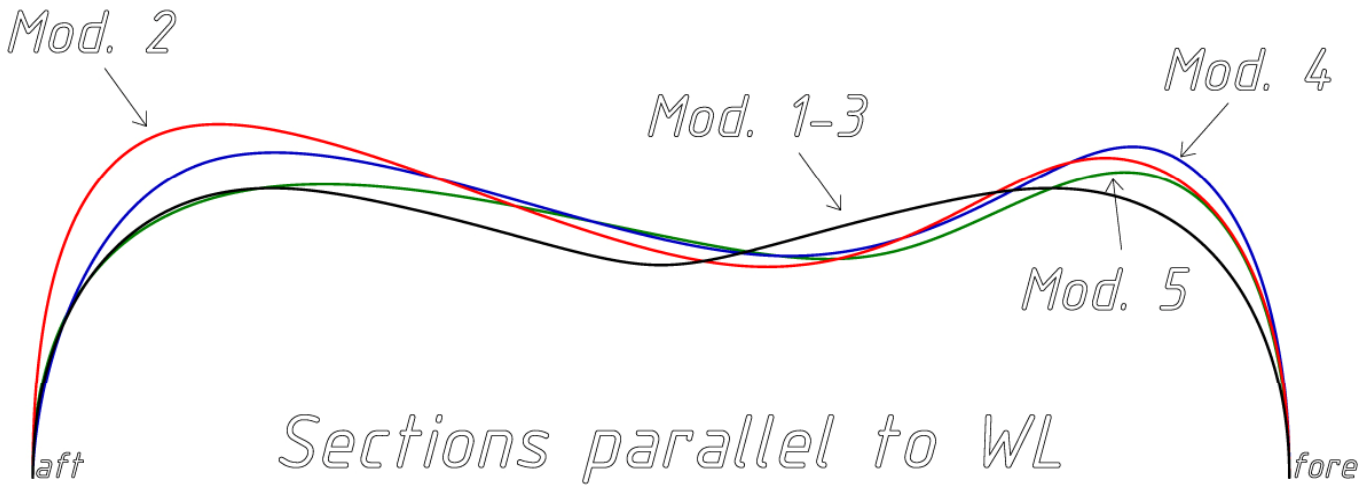


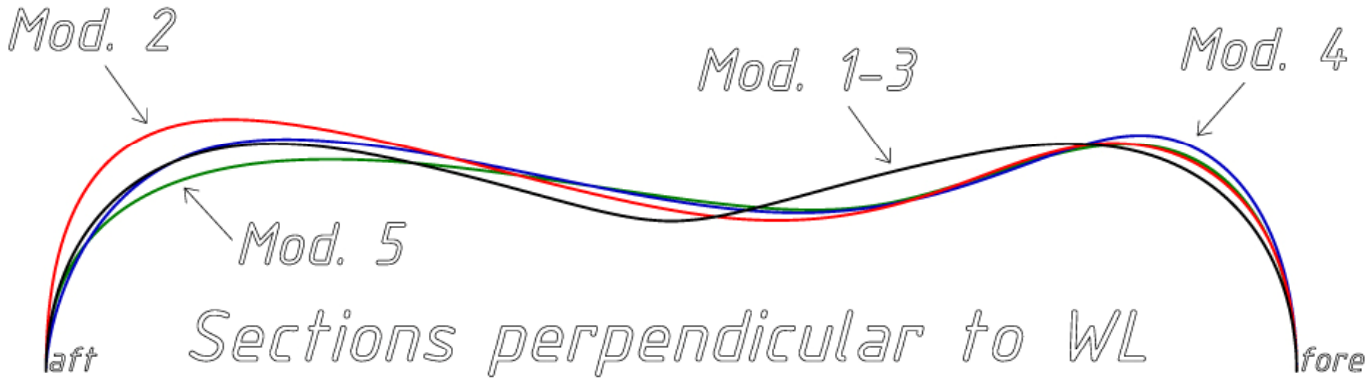






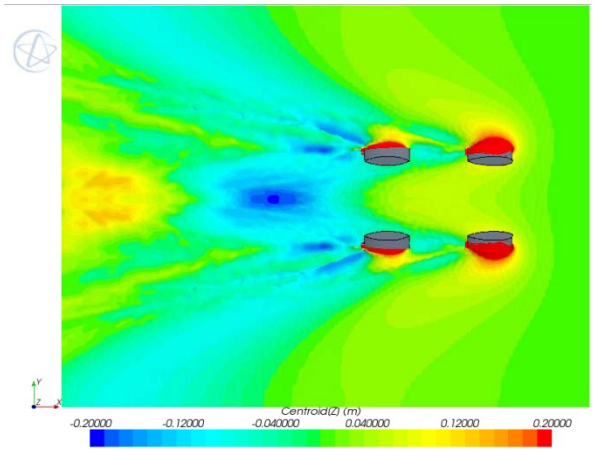
Preliminary CFD calculation: Verified Hull geometries



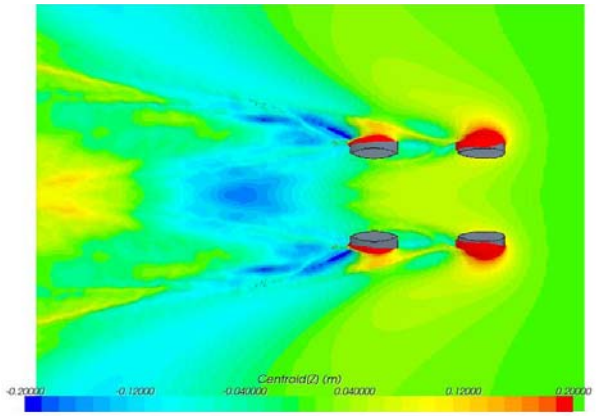


Wave Pattern generated at speed v = 12kn

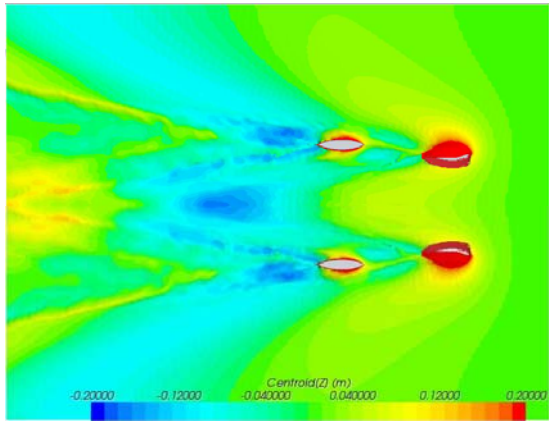
(fully turbulent unsteady RANSE calculations)



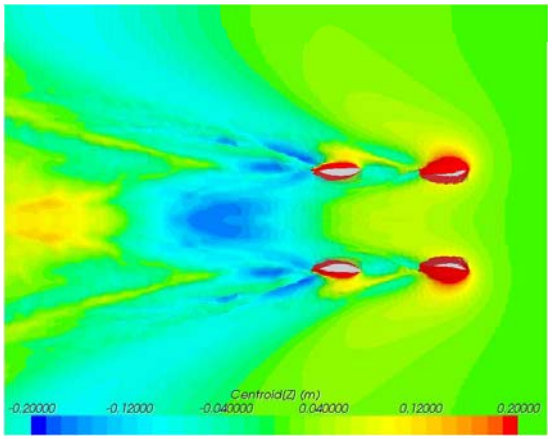
Model 1: Rt = 2038.9 N



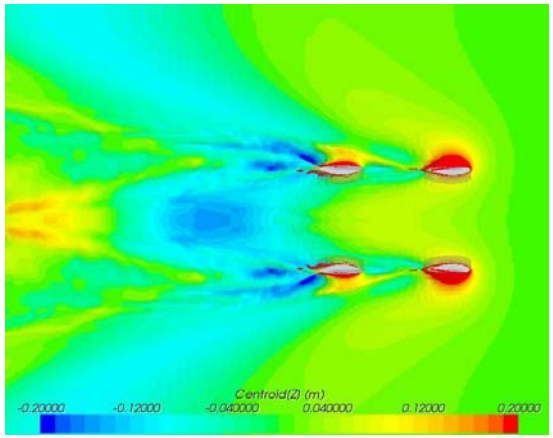
Model 2: Rt = 2146.1 N



Model 3: Rt = 1869.6 N



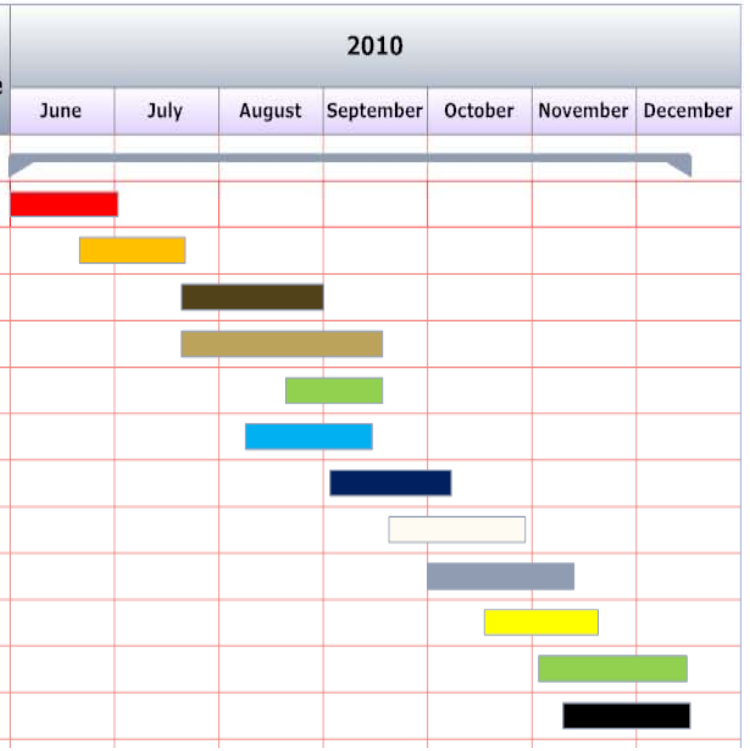
Model 4: Rt = 2078.6 N



Model 5: Rt = 1884.8 N

Time schedule:

Number	Task	Resource	Start	End	Duration	% Complete
1	SWATH SUV Concept Design		1/6/2010	16/12/2010	143	
1.1	Hull design		1/6/2010	1/7/2010	23	
1.2	CFD hull form optimization		21/6/2010	21/7/2010	23	
1.3	CFD Resistance calculation		21/7/2010	31/8/2010	30	
1.4	General Arrangements		21/7/2010	17/9/2010	43	
1.5	Weights		21/8/2010	17/9/2010	20	
1.6	Structure basic layout		9/8/2010	14/9/2010	27	
1.7	Ballast system (active)		3/9/2010	7/10/2010	25	
1.8	Main auxiliary plants		20/9/2010	29/10/2010	30	
1.9	Stability (static and dynamic)		1/10/2010	12/11/2010	31	
1.10	Propulsion system design		18/10/2010	19/11/2010	25	
1.11	Propeller(s) Design		3/11/2010	15/12/2010	31	
1.12	Dynamic appendages design		10/11/2010	16/12/2010	27	



To do:

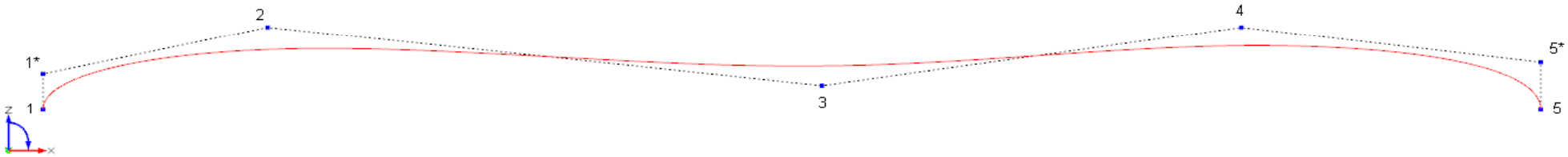
- dynamic stability to be designed

- main propeller to be dimensioned and final estimation of propulsion power

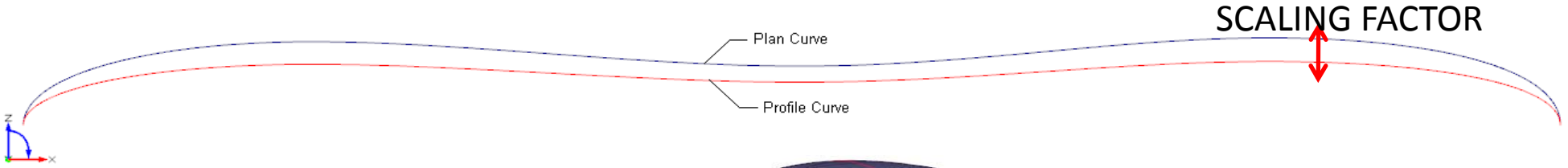
- active ballast and stabilizing system to be dimensioned and finilized

Parametric definition of the model

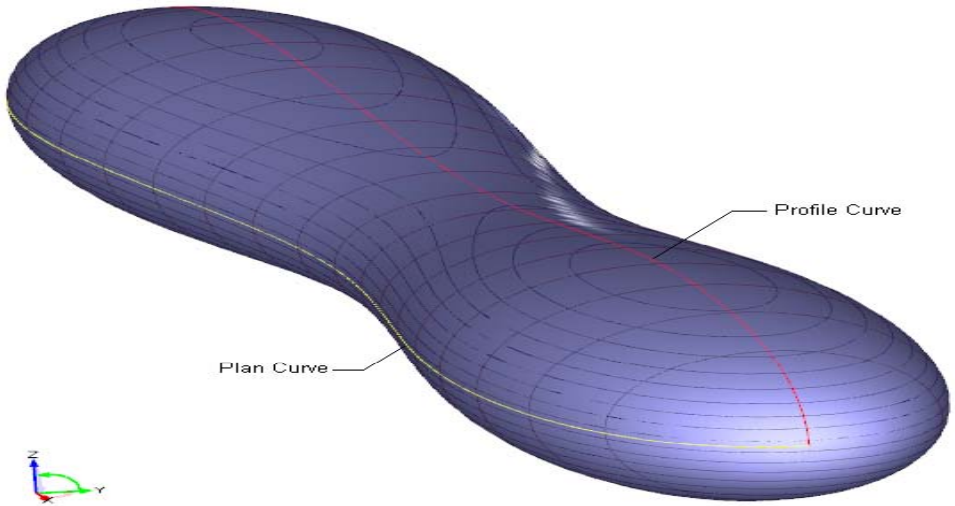
PROFILE CURVE: BSPLINE CURVE
7 CONTROL POINTS 9 PARAMETERS (X AND Z COORDINATES)



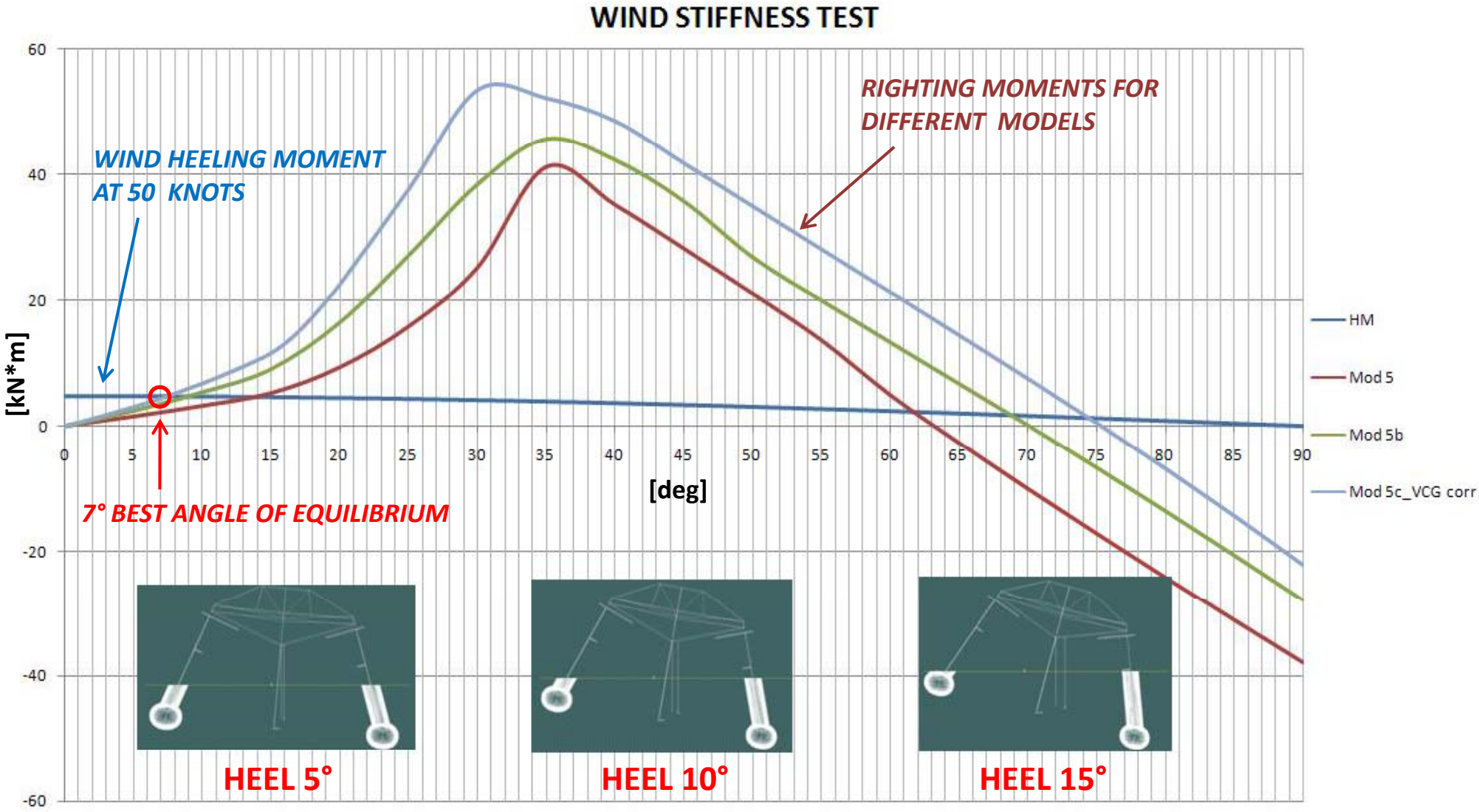
PLAN CURVE: SCALED COPY OF PROFILE CURVE
1 PARAMETER (SCALING FACTOR)



SUBMERGED HULL
10 PARAMETERS
(Elliptic section)

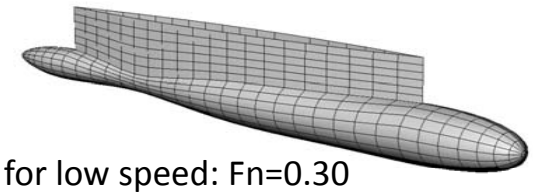


Stability check: Wind Stiffness Test



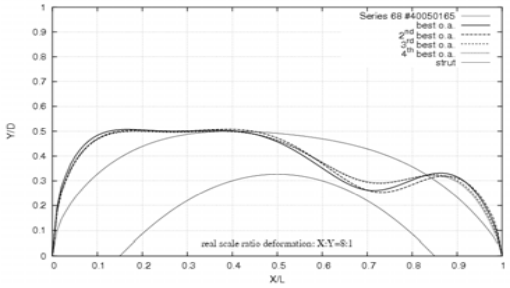
Optimum Geometries for a conventional SWATH

S. Brizzolara (2004), 25th Symposium on Naval Hydrodynamics, St. John's, Newfoundland

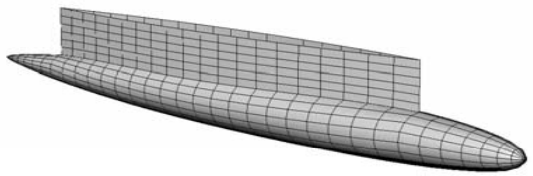


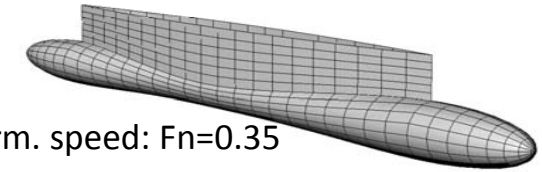
Optimum for low speed: Fn=0.30

O30



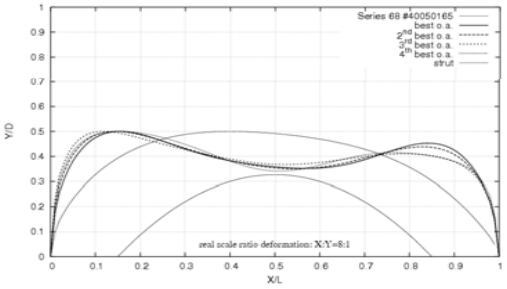
Conventional S-58

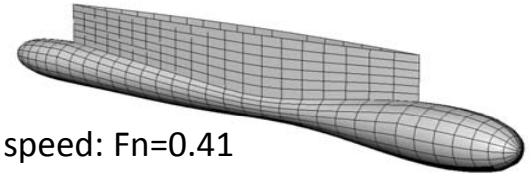




Optimum for interm. speed: Fn=0.35

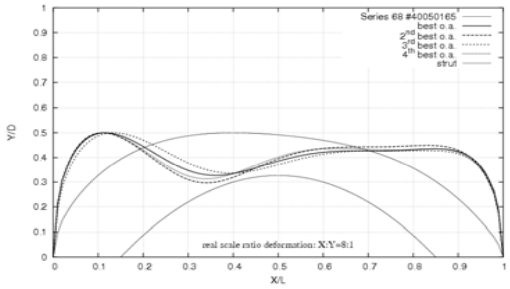
O35

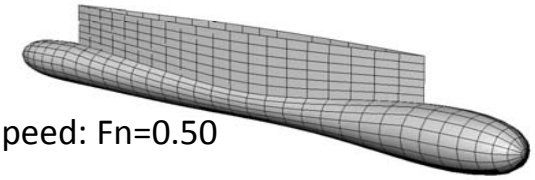




Optimum for high speed: Fn=0.41

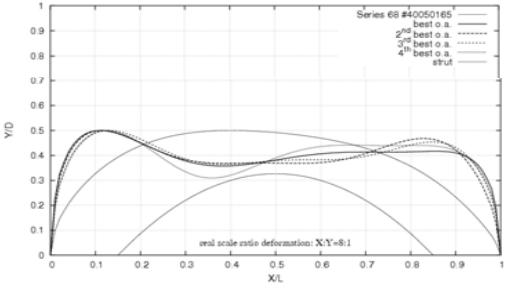
O41





Optimum for high speed: Fn=0.50

O50



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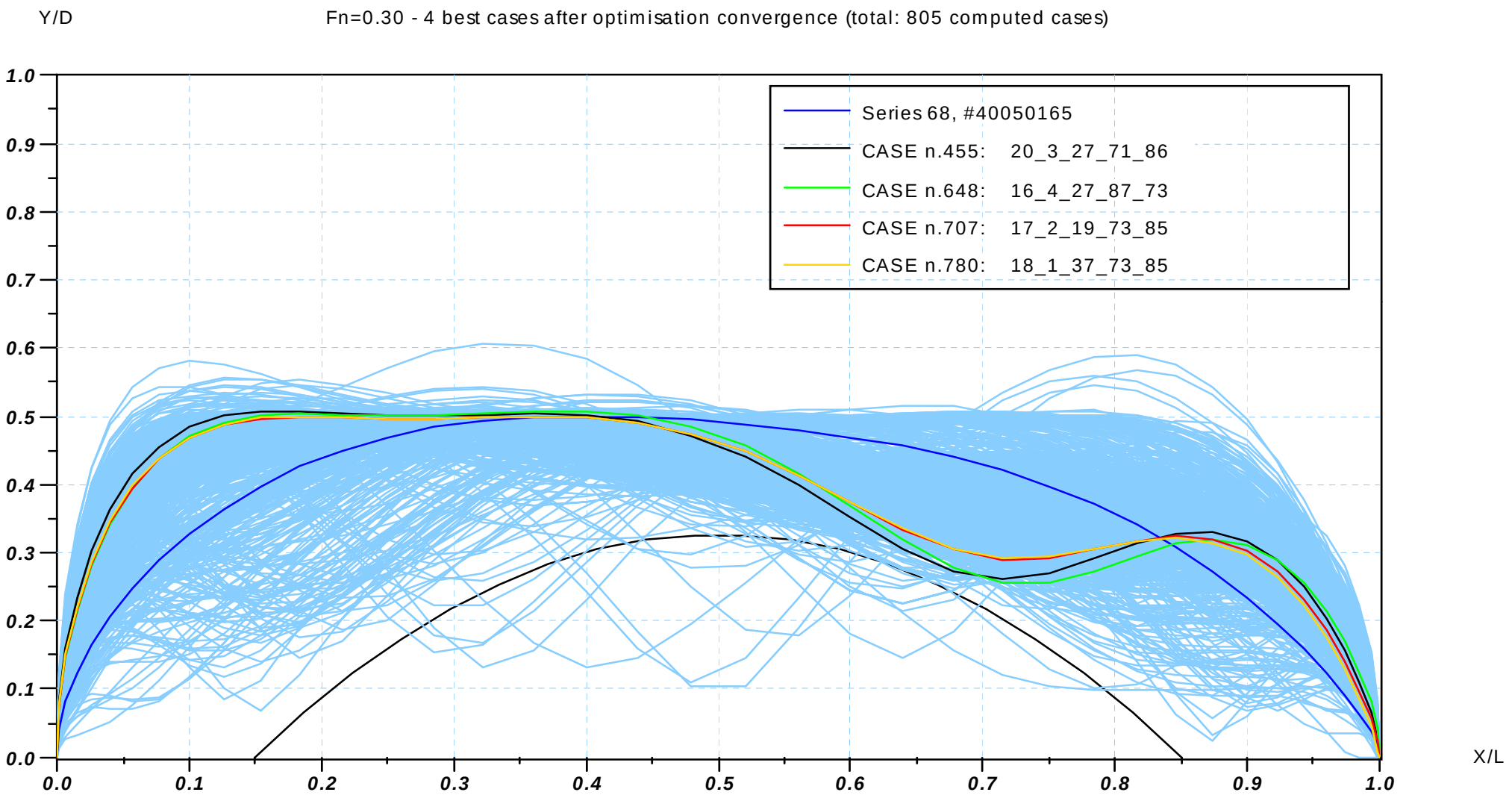
Example of examined individuals



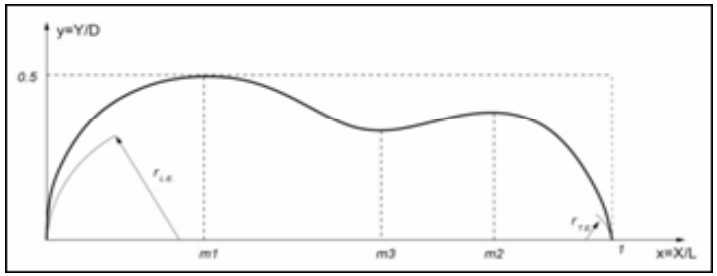
Optimum Geometries for a conventional SWATH

"Parametric Optimization of SWAT-Hull Forms by a Viscous-Inviscid Free Surface Method Driven by a Differential Evolution Algorithm",

S. Brizzolara

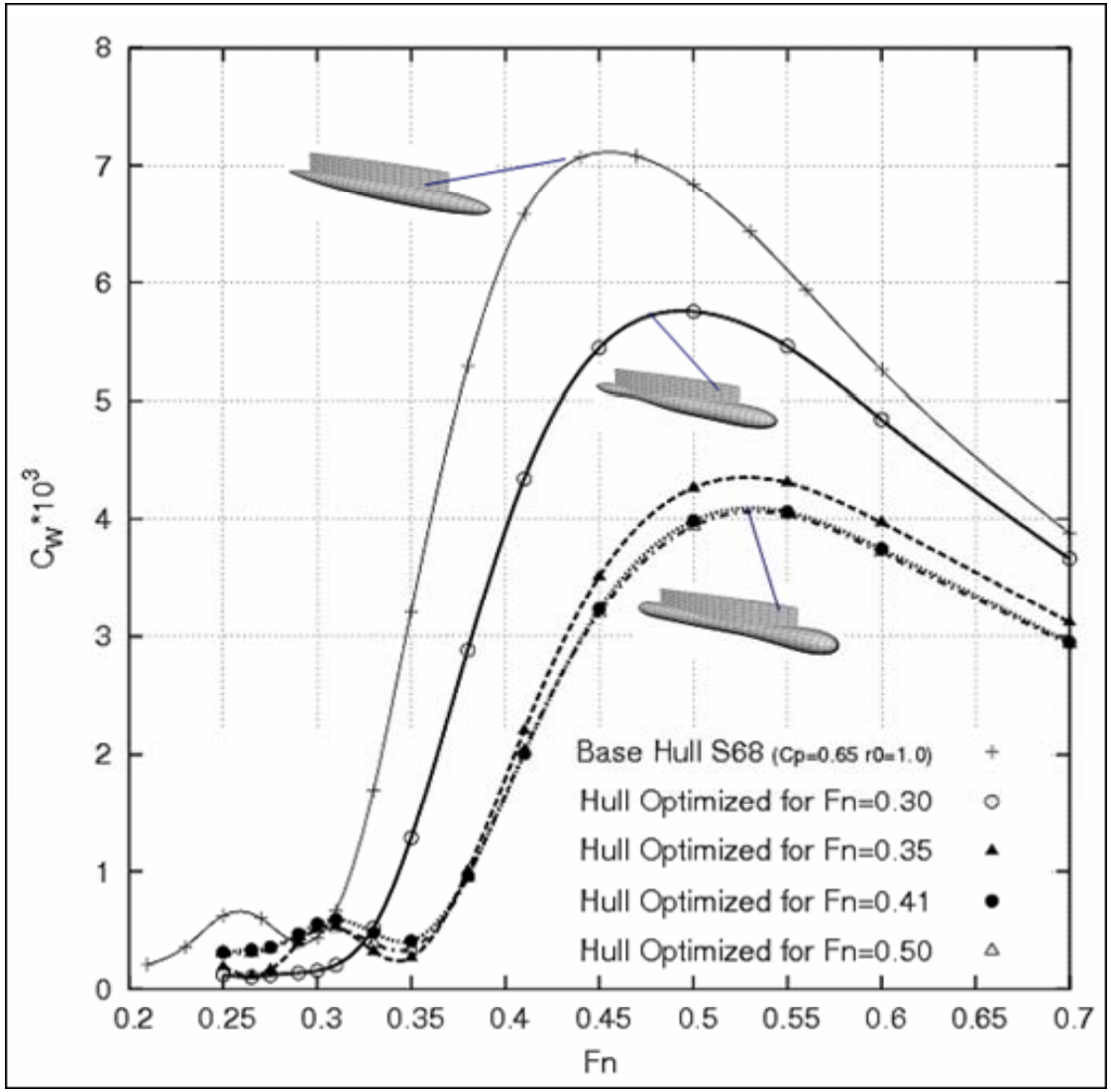
25th Symposium on Naval Hydrodynamics
St. John's, Newfoundland and Labrador, CANADA,
8-13 August 2004

Parametric definition of hull geometry



$$y^2(x) = \sum_{k=1}^{8} a_k \cdot x^k$$

CONSTRAINTS:
- fixed volume
- fixed max diameter
- curvature at L.E.and T.E.



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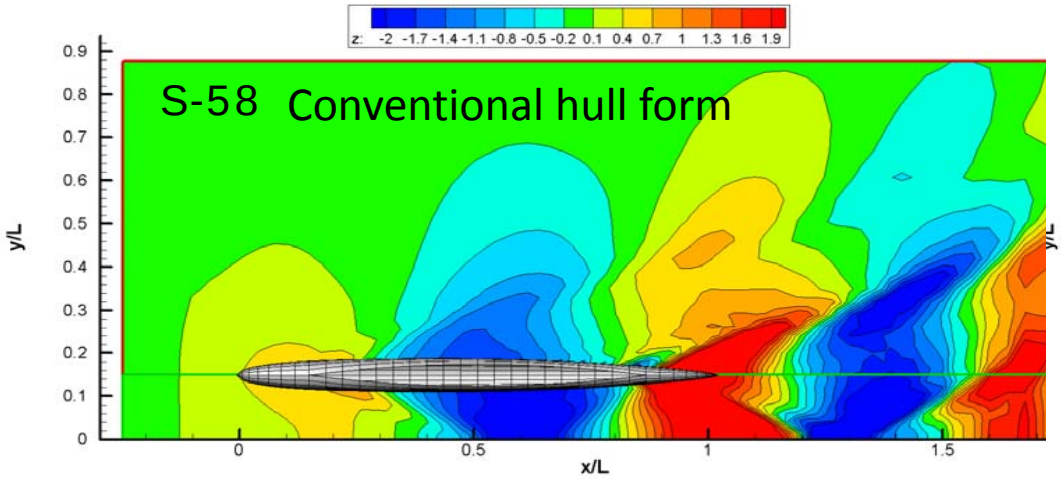
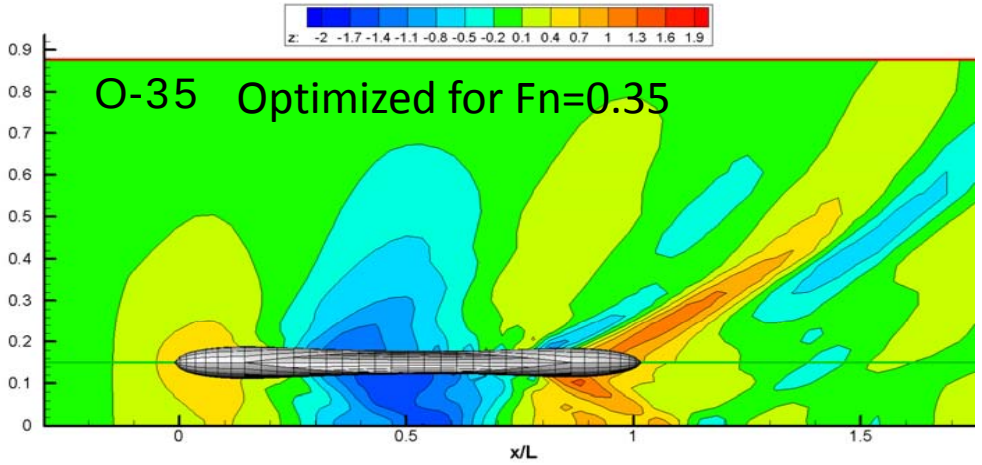
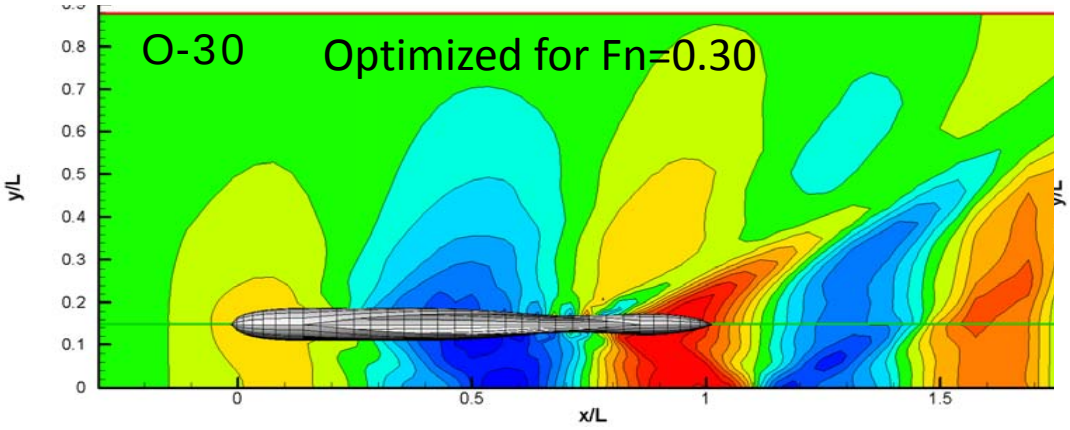
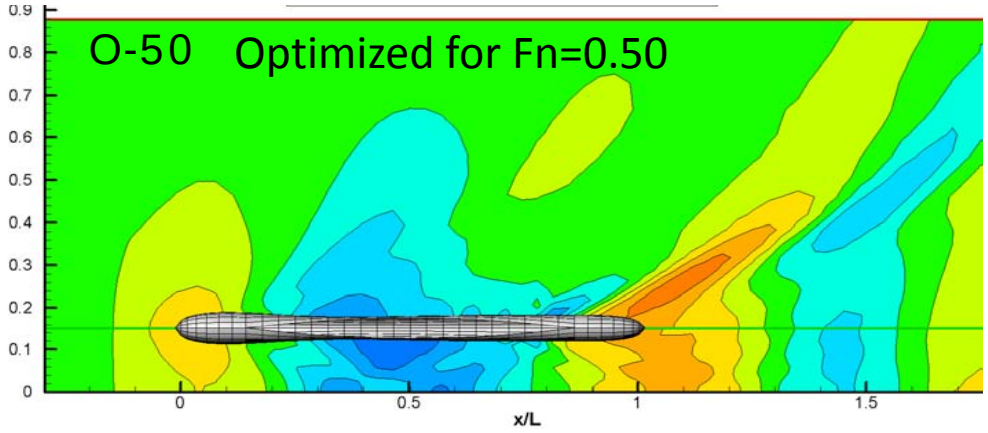
Fn=0.50: Wave Patterns of different Optimum hulls









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Predicted Performance at Full Scale