12m2 du Havre

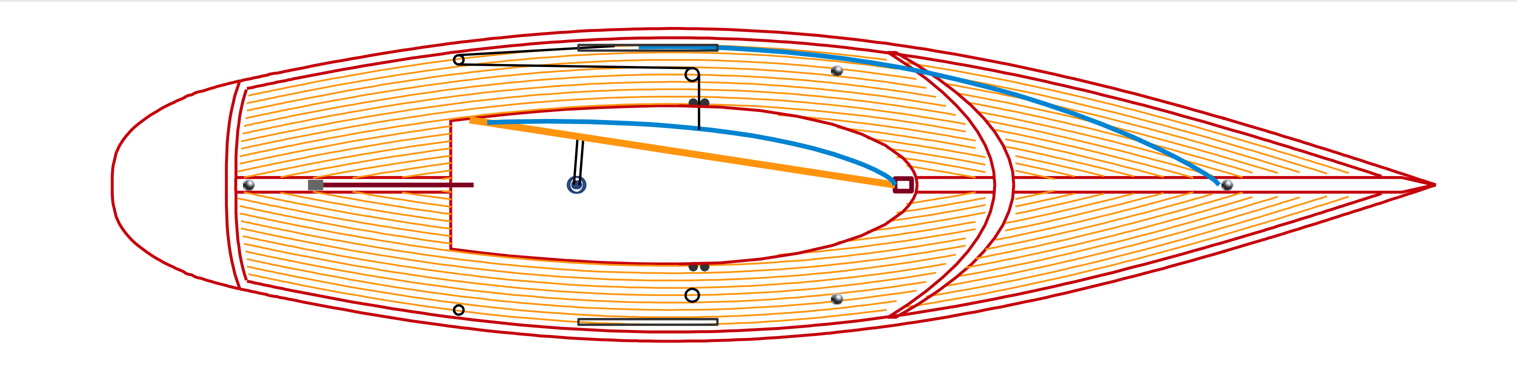
DOLFINO 2019

Loa :	6,96 m	(22,83 ft)
Lwl :	5,20 m	(17,06 ft)
Boa :	1,70 m	(5,58 ft)
Bwl :	1,37 m	(4,49 ft)
Draft :	0,93 m	(3,05 ft)
Displacement :	680 kg	(1499 lbs)
Lead ballast :	334 kg	(736 lbs)
Wetted surface :	7,61 m2	(81,9 sqft)

Surface de voilure :

Main :	9,26 m2	(99,7 sqft)
Jib :	8,77 m2	(94,4 sqft)
Total :	18,0 m2	(193,8 sqft)
Spi :	~ 20 m2	(215,3 sqft)

Jean-François Masset – November 2019



Summary

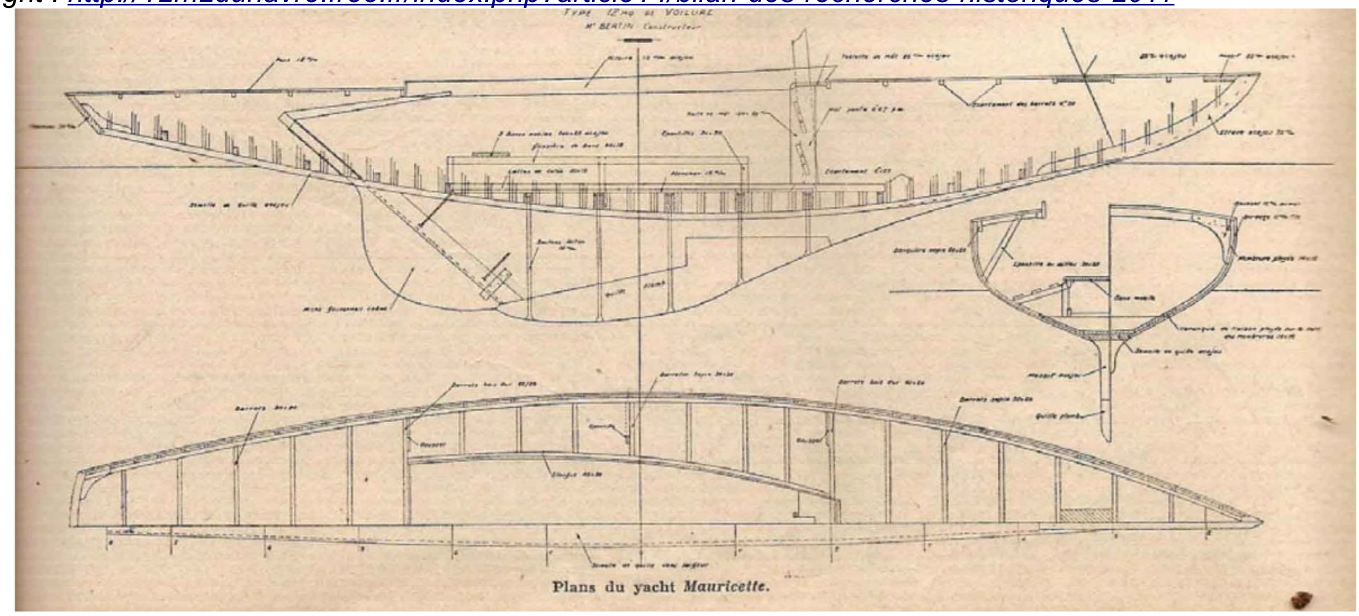
Introduction

The « 12 m2 du Havre » is an old french rule dated 1924, based on a very simple formula :

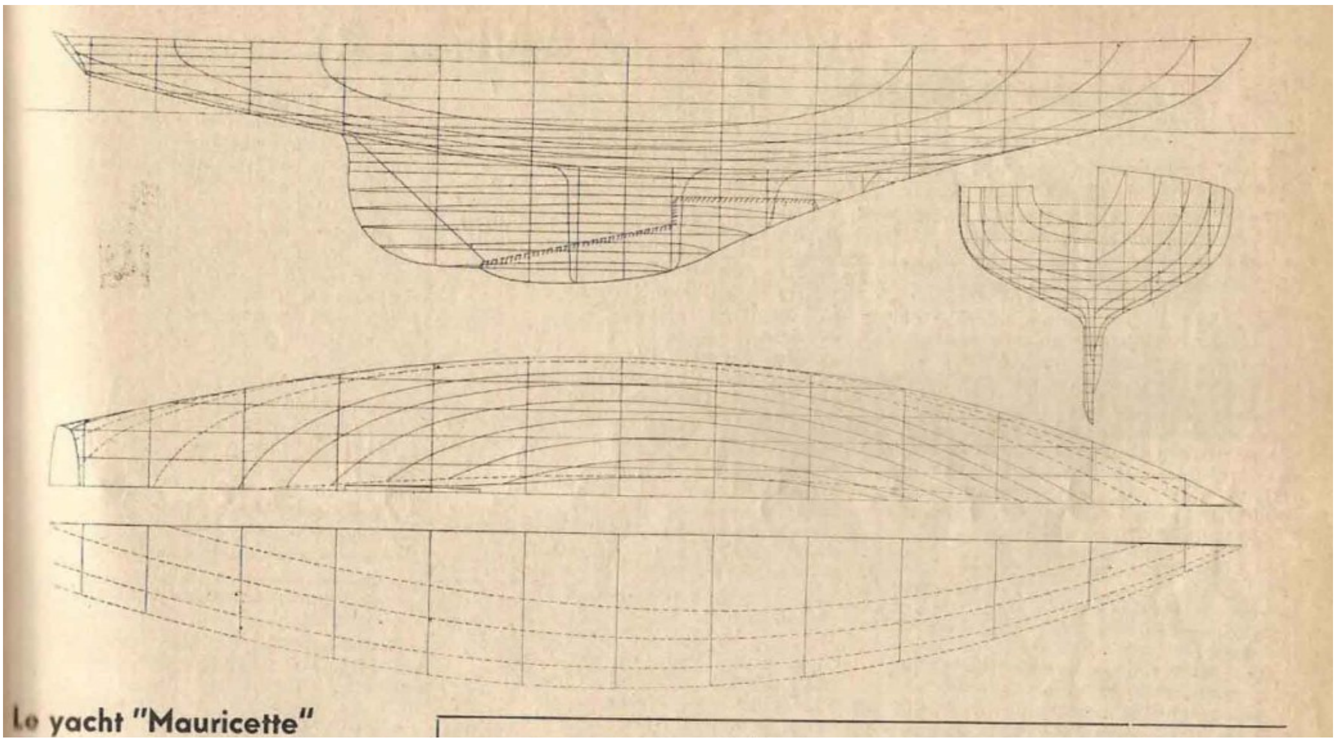
Sails surface according to fore + main triangles ≤ 12 m2

, + some constraints guided by safety reasons (inc. Beam > 1,4 m, Midship quarter beam hull depth > 0,45 m, Ballast > 200 kg, …), leading to small and quite cheap (for those days) keelboats of about 6 to 7 m for a crew of 2 or 3.

The class started slowly but had a peak activity from 1935 to 1939 in France / Le Havre and Seine bay waters (Honfleur, Deauville), with up to 30 units and more than 180 regattas recorded. One of the most regular in performance was then *Mauricette*, designed by architect-builder Maurice Bertin :



Plans du yacht *Mauricette.*



Le yacht "Mauricette"

Loa : 6,35 m ; Lwl : 4,5 m ; Beam : 1,46 m ; Draft 0,87 m ; Light weight : 550 kg ; Ballast 287 kg

After the WW2 and the destruction of a large part of the fleet, the class failed to renew its success, besides naval architecture evolving on other more modern directions. It was only around 2009 that a renaissance of the class took place, driven by the growing interest in classic yachting : an association was created and the class rules was slightly updated in 2013, in particular concerning the scantlings and the keel geometry in order to preserve a certain style and to not outclass the few remaining historical boats. For example, a maximum concavity of the keel fin front line in order to avoid modern fin keel. On the other hand, separate rudder are authorized as it was already the case from the beginning. The current rule (in French) : http://12m2duhavre.free.fr/Jauge/Jauge%202013.pdf

Pictures of old and new designs :

Françoise – Maurice Bertin design 1935

Caol Ila - Bruno Jeanson design, launched in 2013

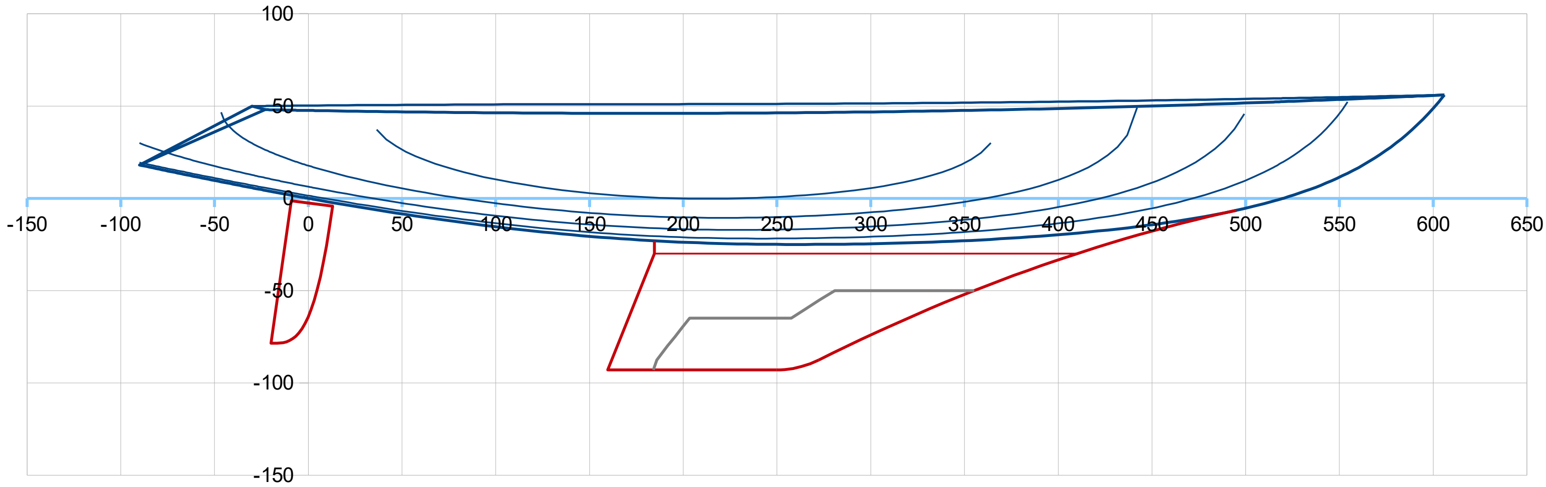
Members of this association are both happy owners of historical boats and amateur architect and/or builders of new ones. Their web site : http://12m2duhavre.free.fr/

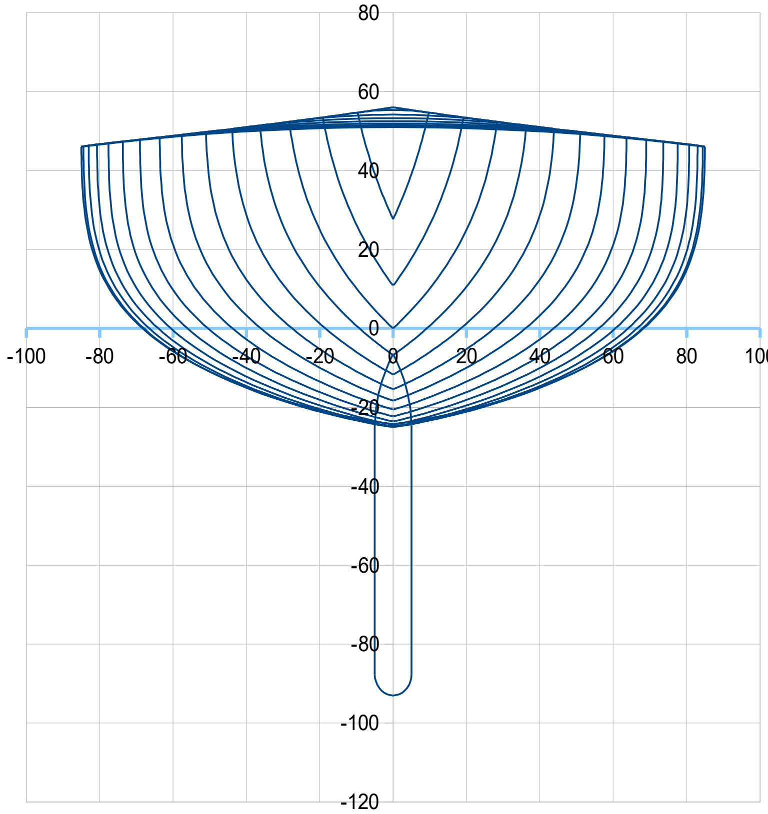
Dolfino 2019 project is so proposed to the association and/or towards the amateur builders who can be interested, among the other designs already available (see « Boîte aux plans » in their web site).

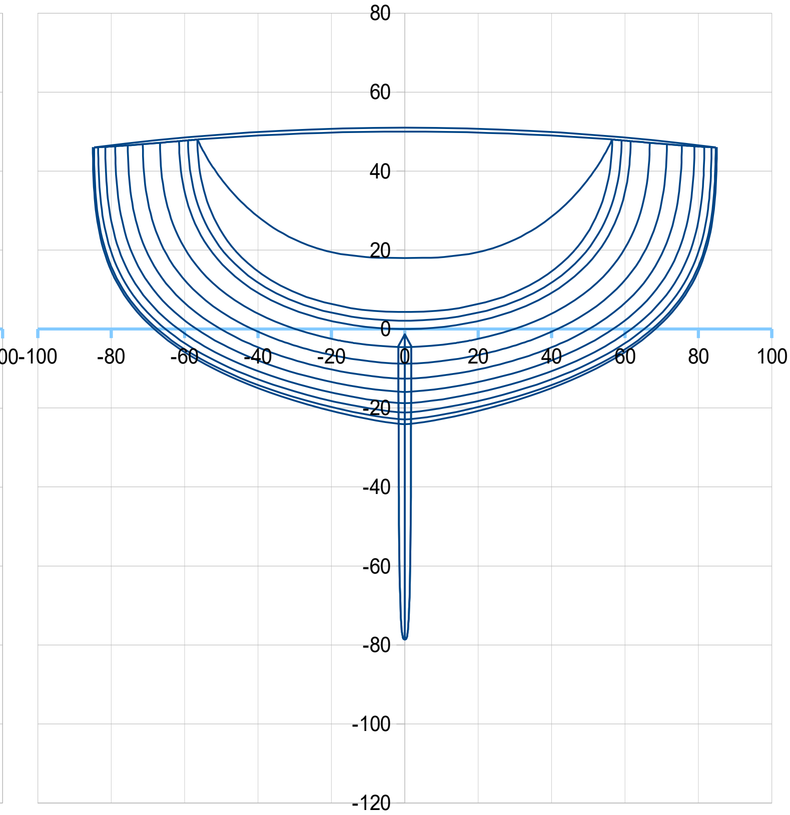
« Dolfino 2019 » Brochure

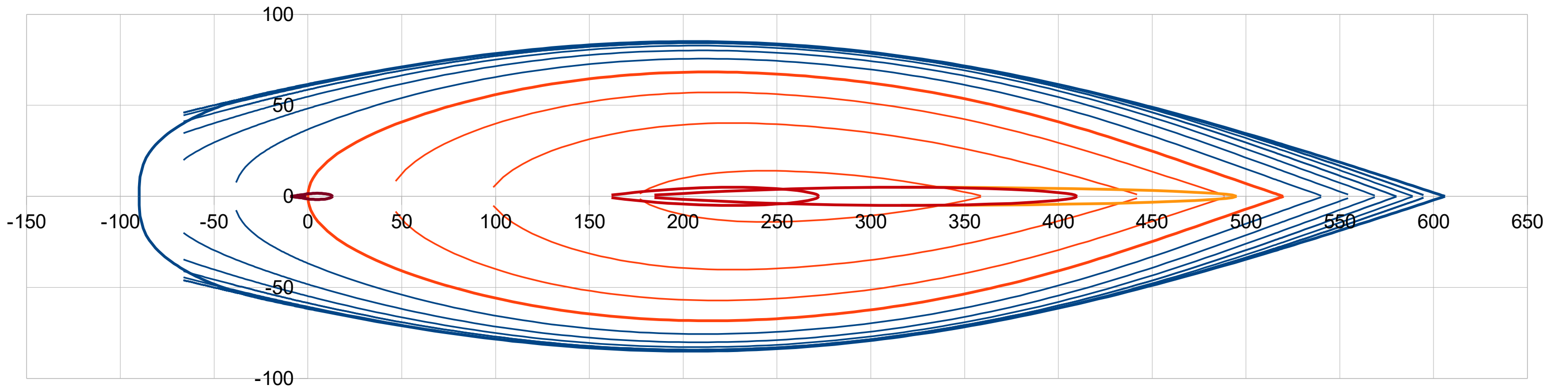
1. **Hull**

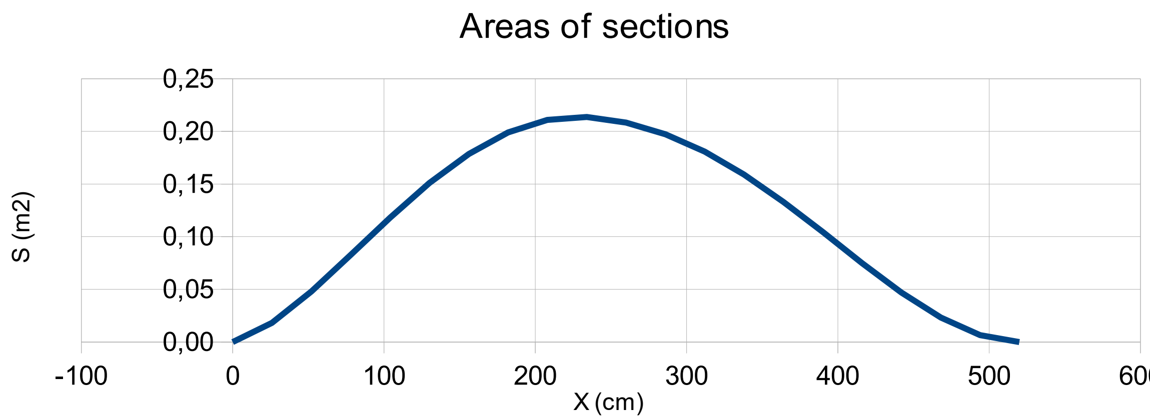
Loa : 6,96 m (22,83 ft) ; Boa : 1,70 m (5,58 ft)
Lwl : 5,20 m (17,06 ft) ; Bwl : 1,37 m (4,49 ft) *(with here below waterline corresponding to displacement 718 kg)* ; *drawing units : cm*











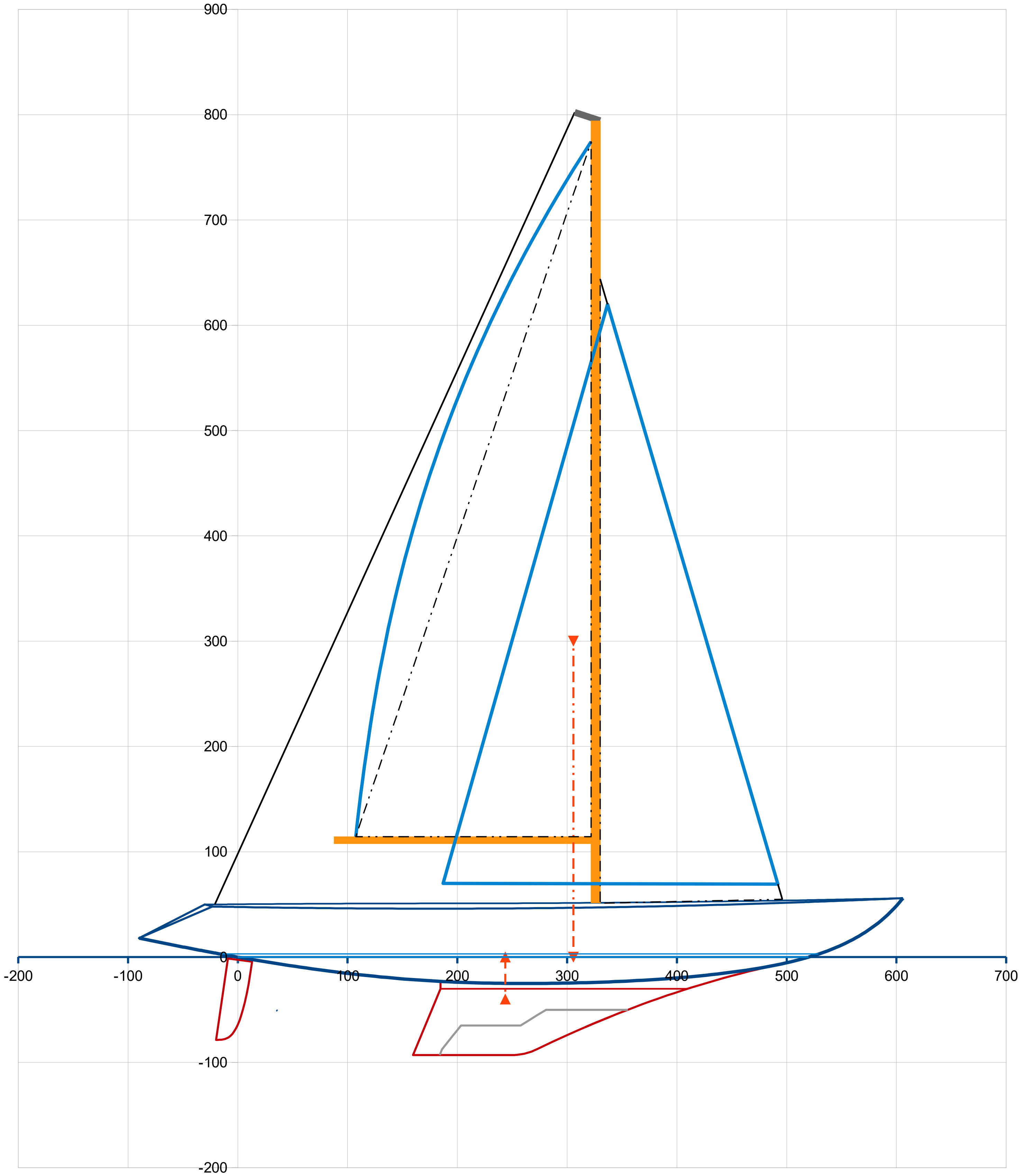
Some comments in complement of the hydrostatics data given in chapter 4., compared to a classic 1935 design like *Mauricette* :

- overall width is increased to 1.70 m with a more regular rounded chine to facilitate the slats installation,
- the fore sections show a more accentuated V for a better passage in choppy waves,
- the freeboard at bow end is raised to 56 cm, and at midship to 46 cm,
- towards the rear, the V shape becomes rounded and even slightly U-shaped at the end of a more developed vault.
- the concavity rule for the keel fore line is still respected : 9.5 cm < 10 cm (detailed in Annex 7)

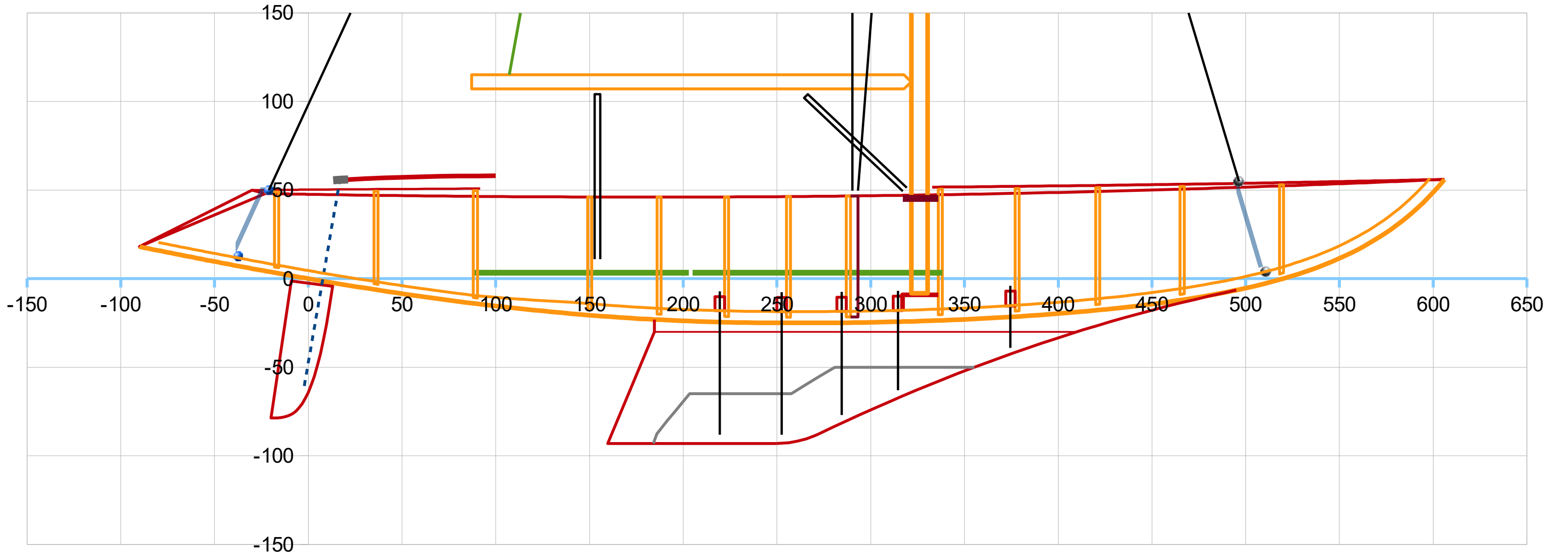
2. Sailplan

Surface triangles St (m2)	**12,0**	S main (m2) >	9,26	**Xmast (m)**	**3,26**
I (m)	**5,92**	S jib (m2) >	8,77	**Zboom(m)**	**1,11**
J (m)	**1,66**	**SA (m2) >**	**18,0**		
P (m)	**6,60**				
E (m)	**2,15**				

Lead (long keel method, in %Lwl) **10,8**



3. Structure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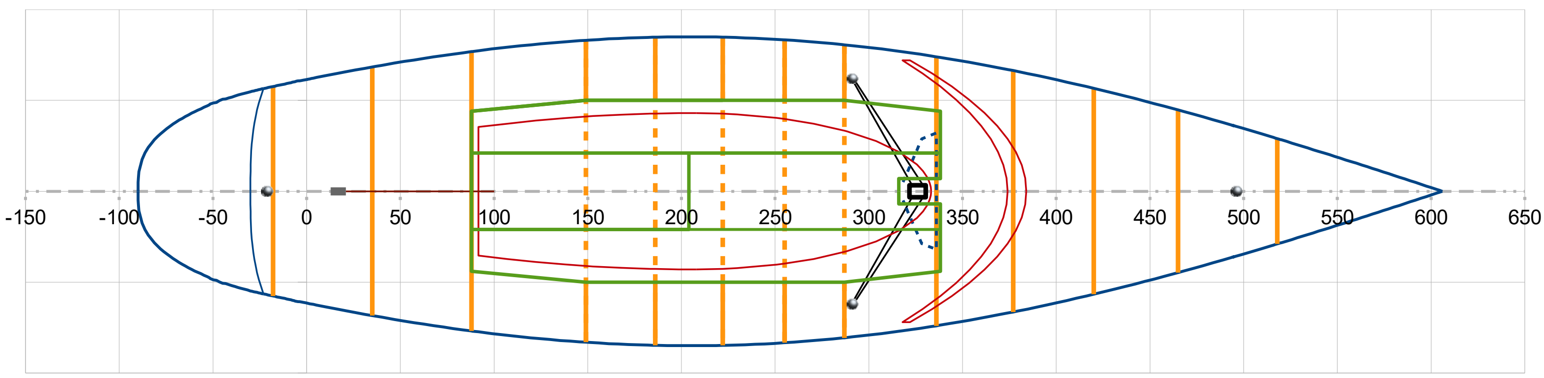
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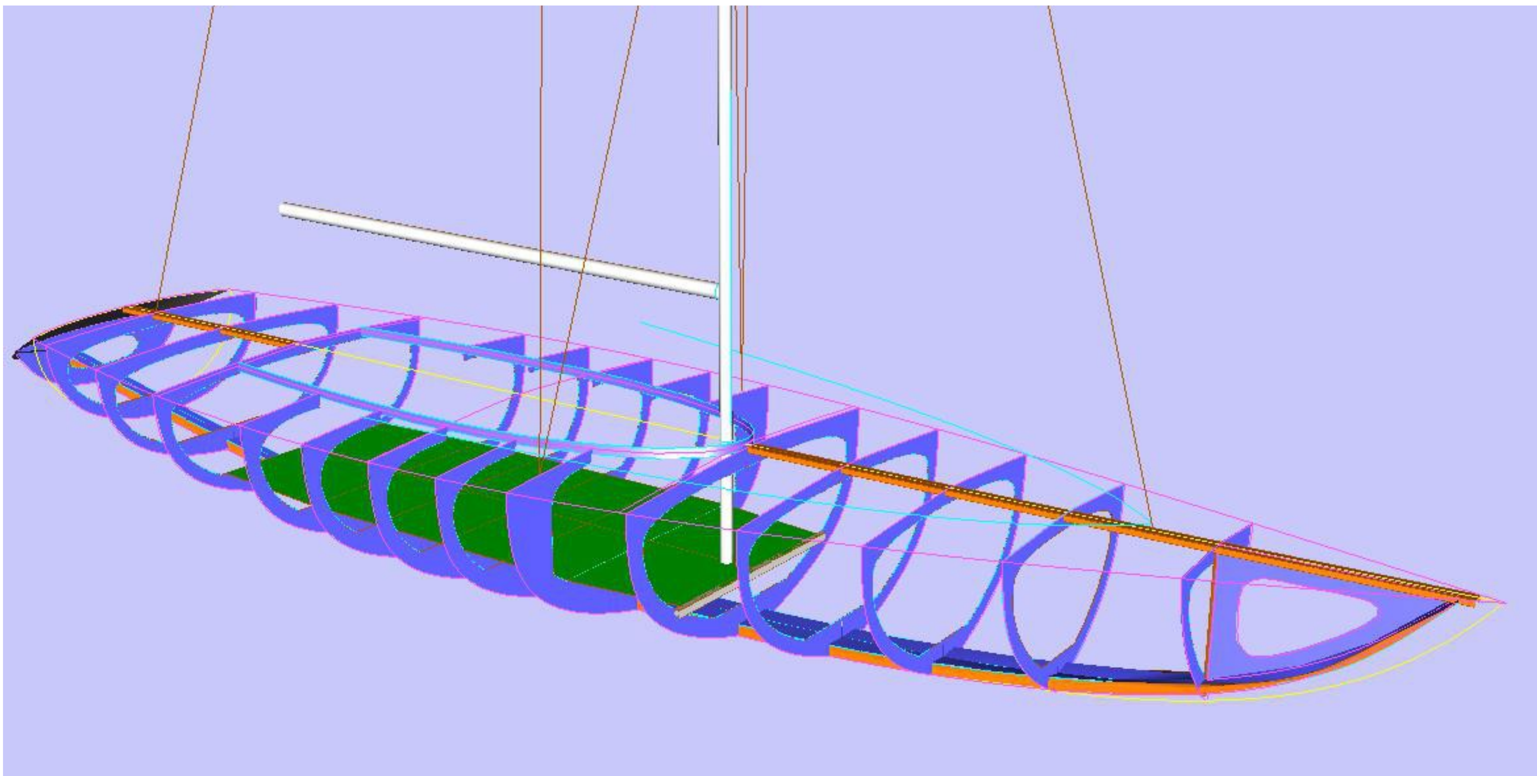
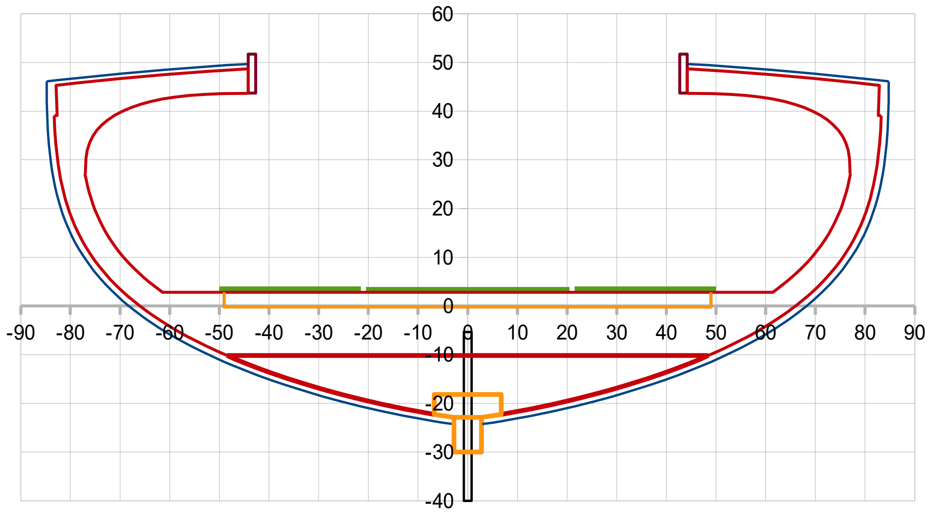




The hull plating and the frames :
The structure design is fit for a strip-planking construction with Red Cedar strakes of net thickness 14 mm (0,551 inches) and width 30 mm (1,181 inches). The first two upper strakes (under the deck) are 20 mm thick, made of Oregon pine laminate, and act as longitudinal stringers. In the sections views showed in Appendix A1 here after, the 22 mm marine plywood frames are drawn with taking into account this 14 mm plating thickness.

The deck and the cockpit :
Each section frame includes its sub-deck bar. The half-beams of the cockpit area are made after turning the hull, by sawing each concerned beam at the necessary dimension. The deck structure is completed with two central front and rear flat stringer. The cockpit perimeter is dressed with a 15 mm thick Sipo coaming. The width of the half-decks is 42 cm, allowing to have, besides a comfortable seat, a safety extra margin with regard flooding in case of an overheel angle (> 30°) due to a gust of wind. The floor of the cockpit is made of a foam/plywood sandwich of thickness 20 mm (5/10/5), in 4 removable panels allowing access for the scooping and/or the pumping, and for the boat lifting using the eyebolts of the threaded rods fastening the lead ballast. The floor / boom height is 103 cm, allowing to tack without having to bend excessively.

Keel line, wing and its ballast, one successively considers :
- a keel piece going from the bow end to the rear transom, built of Iroko bonded laminate or equivalent.
- a massive interface, intermediate piece between the keel and the fin, including in the horizontal lower plan (at z-30 cm) a Naca profile interface with the fin itself. Made of bonded laminated, and secured (initially by gluing, then maintained in compression by bolting the ballast) to the underside of the keel piece.
- a fin as an extension of the z-30 interface profile of the massif,
- a ballast integrated in the volume of the fin (without specific outgrowth).

The mast foot is supported on a wooden base integral with the keel and the frame at X336. A piece acting as a reinforcement for the transverse maintenance of the mast, is integral with the bar of the frame X336.

4. Hydrostatics data

2.1 Hull

Loa (m)	**6,96**			**Lwl (m)**	**5,20**										
>> ft	*22,83*				*17,06*										
B (m)	**1,70**			**at X (% Lwl)**	**39,0**										
>> ft	*5,58*														
Bwl (m)	**1,37**			**at X (% Lwl)**	**41,0**			> Bwl / B	0,804						
										Freeboards (m) >	**Aft**		**Midship**		**Fore**
Tc (m)	**0,25**			**at X (%Lwl)**	**50**						**0,48**		**0,46**		**0,56**
>> ft	*0,82*									*>> ft*	*1,57*		*1,51*		*1,84*
		Displacement at H0 (m3)	**0,61185**			**at Xc (m)**	**2,443**			**Xc (%Lwl)**	**46,97**			**Zc (m)**	**-0,081**
		>> lbs	*1383*			*w. seawater*	*1025*		*kg/m3*					*>> ft*	*-0,27*
Disp at h (cm)	-2,85		0,47842			at Xc (m)	2,463			Xc (%Lwl)	47,37			Zc (m)	-0,070
Disp at h (cm)	2,85		0,75905			at Xc (m)	2,423			Xc (%Lwl)	46,59			Zc (m)	-0,093
Cp (%)	**55,07**														
Sf (m2)	**4,93**			**at Xf (m)**	**2,350**			**Xf (%Lwl)**	**45,20**					>>> Xc – Xf (%Lwl)	1,77
>> ft2	*53,09*			*>> ft*	*7,71*										
Angle immersed sheer li (°)			**28,4**	at section C4 (40% Lwl)											
Sw (m2)	**5,05**			>Sw/D^(2/3)	7,01										
>> ft2	*54,37*														
Shull (m2)	**12,54**			**at X (m)**	**2,408**			**Z (m)**	**0,061**						
>> ft2	*135,03*			*>> ft*	*7,90*			*>> ft*	*0,20*						
Sdeck (m2)	**7,75**			**at X (m)**	**2,385**										
>> ft2	*83,43*			*>> ft*	*7,82*										

2.2 Massive and Fin

Massive (m3)	**0,01380**			**at X (m)**	**3,406**			**X (%Lwl)**	**65,51**			**Z (m)**	**-0,248**		
				>> ft	*11,18*							*>> ft*	*-0,81*		
Fin (m3)	**0,07219**			**at X (m)**	**2,623**			**X (%Lwl)**	**50,45**			**Z (m)**	**-0,496**		
				>> ft	*8,61*							*>> ft*	*-1,63*		
Draft oa (m)	**0,93**					**Sw (m2)**	**2,40**					**Sxz (m2)**	**1,18**		
>> ft	*3,05*					*>> ft2*	*25,84*					*>> ft2*	*12,73*		
CLR (m)	**2,493**			**CLR (%Lwl)**	**47,95**	*CLR = Center of Lateral Resistance*									
>> ft	*8,18*					method : geometry of hull, daggerboard and rudder									

2.3 Rudder(s)

Number	**1**														
Volume (m3)	**0,00294**			**at X (m)**	**-0,016**			**X (%Lwl)**	**-0,32**			**Z (m)**	**-0,353**		
Sw (m2)	**0,31**			*>> ft*	*-0,05*							**Sxz (m2)**	**0,15**		per rudder
>> ft2	*3,31*											*>> ft2*	*1,62*		

2.4 Total : Hull + Massive & Fin + Rudder(s)

		Displacement at H0 (m3)	**0,70078**			**at X CB (m)**	**2,470**			**X CB(%Lwl)**	**47,50**			**at Z CB (m)**	**-0,128**
		(kg)	**718**			*>> ft*	*8,10*							*>> ft*	*-0,42*
		>> lbs	*1584*												
		Lead ballast (kg)	**334**			**at X CG (m)**	**2,558**			**X CG(%Lwl)**	**49,19**			**at Z CG (m)**	**-0,720**
		>> lbs	*736*			*>> ft*	*8,39*							*>> ft*	*-2,36*
		>> % Ballast	46,4												
		Sw (m2)	**7,76**			>Sw/D^(2/3)	9,83			Lwl/D^(1/3)	5,85				
		>> ft2	*83,52*							*DLR*	*142*	*M(lbs/2240)/(Lwl(ft)/100)^3*			

2.5 Data from the mass spreadsheet

Light boat:		**M (kg)**	**680**			**at X CG (m)**	**2,518**			**X CG(%Lwl)**	**48,42**			**at Z CG (m)**	**-0,154**
Avec crew 1		**M (kg)**	**780**			**at X CG (m)**	**2,392**			**X CG(%Lwl)**	**46,01**			**at Z CG (m)**	**-0,066**
Avec crew 2		**M (kg)**	**880**			**at X CG (m)**	**2,396**			**X CG(%Lwl)**	**46,07**			**at Z CG (m)**	**0,002**

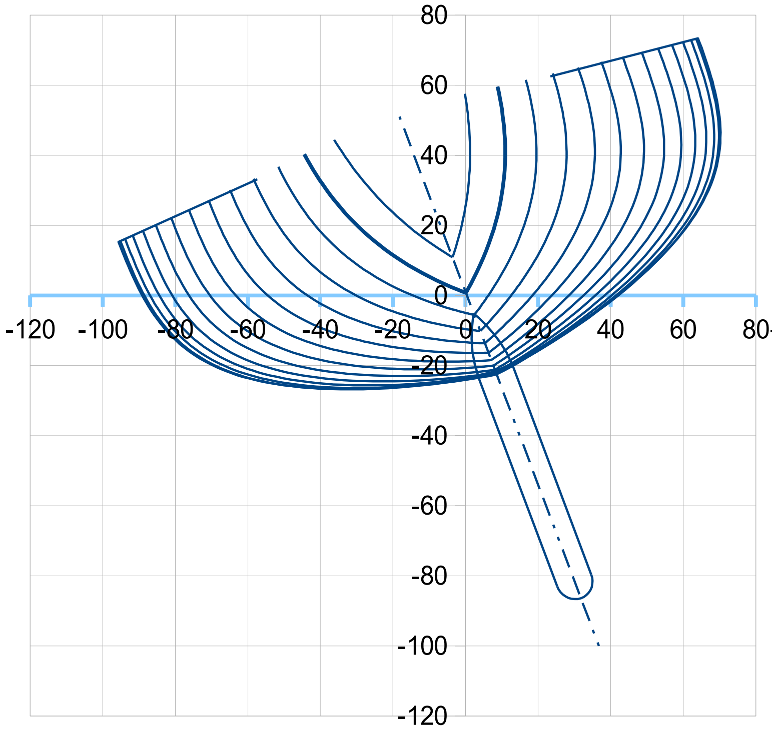
	Mass	Mean immersion / H0	Trim
Light weight	680 kg (1499 lbs)	-0,7 cm (-0,3")	-0,2°
With light crew 100 kg	780 kg (1720 lbs)	1,1 cm (+0,4")	0,4°
With heavy crew 200 kg	880 kg (1940 lbs)	3,0 cm (+1,2")	0,3°

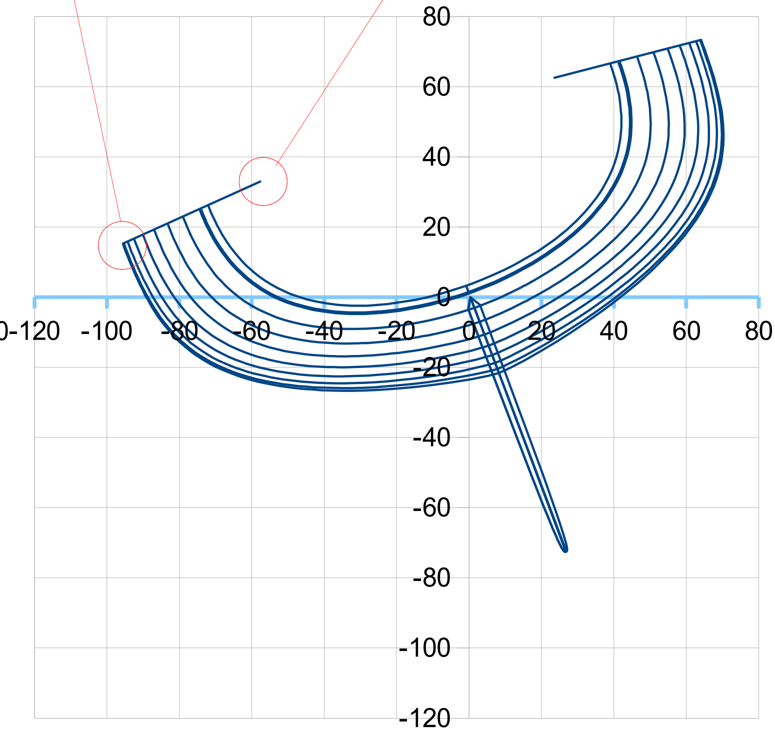
5. Equilibrium and hydrostatics data at 20° heel angle

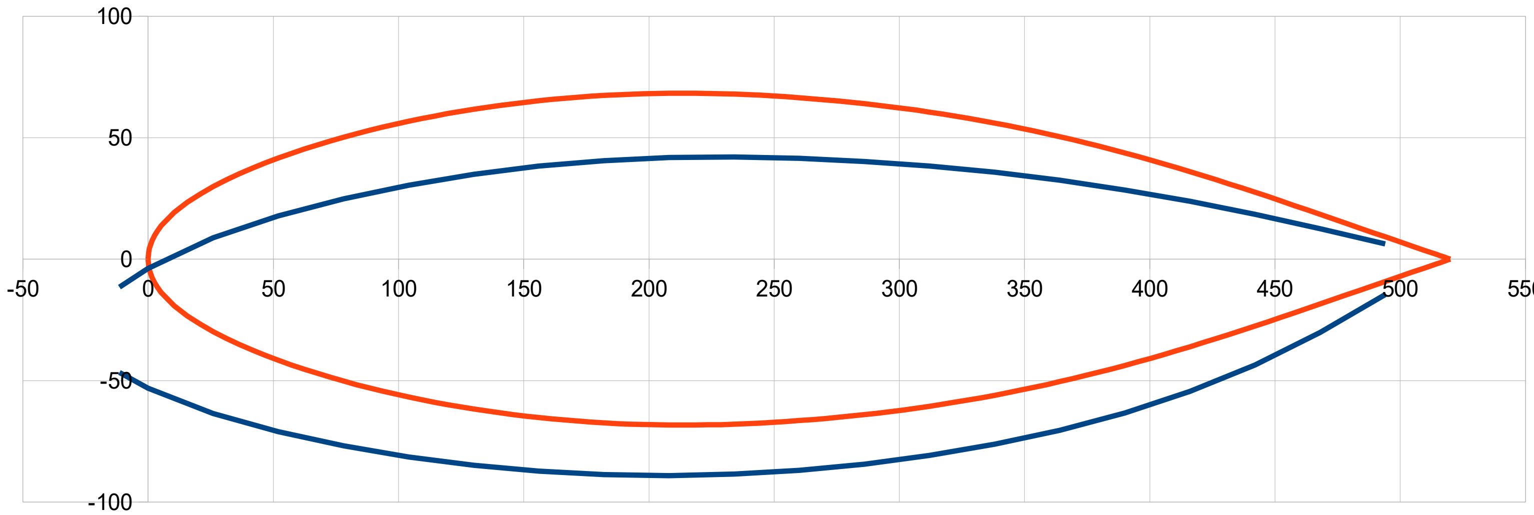
The heeled equilibrium is approached through Mass = Buoyancy and Longitudinal Center of Gravity (X CG) = Longitudinal Center of Buoyancy (X CB) conditions, and here computed with a payload of 200 kg of which 160 kg (2 crew) seated to windward, so with a total displacement of 880 kg.

>>> Righting Moment RM = 2,88 kN.m Wetted surface Sw = 8,08 m2

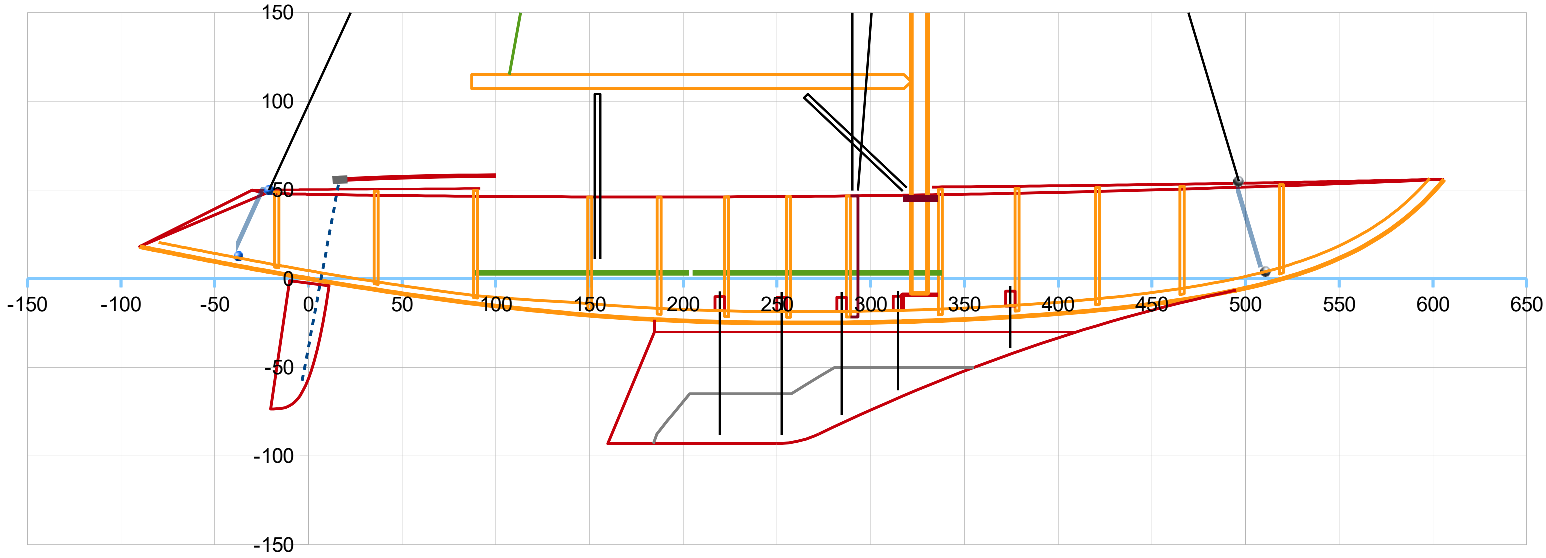
Free-board mini = 15,2 cm Half-deck height = 33,1 cm

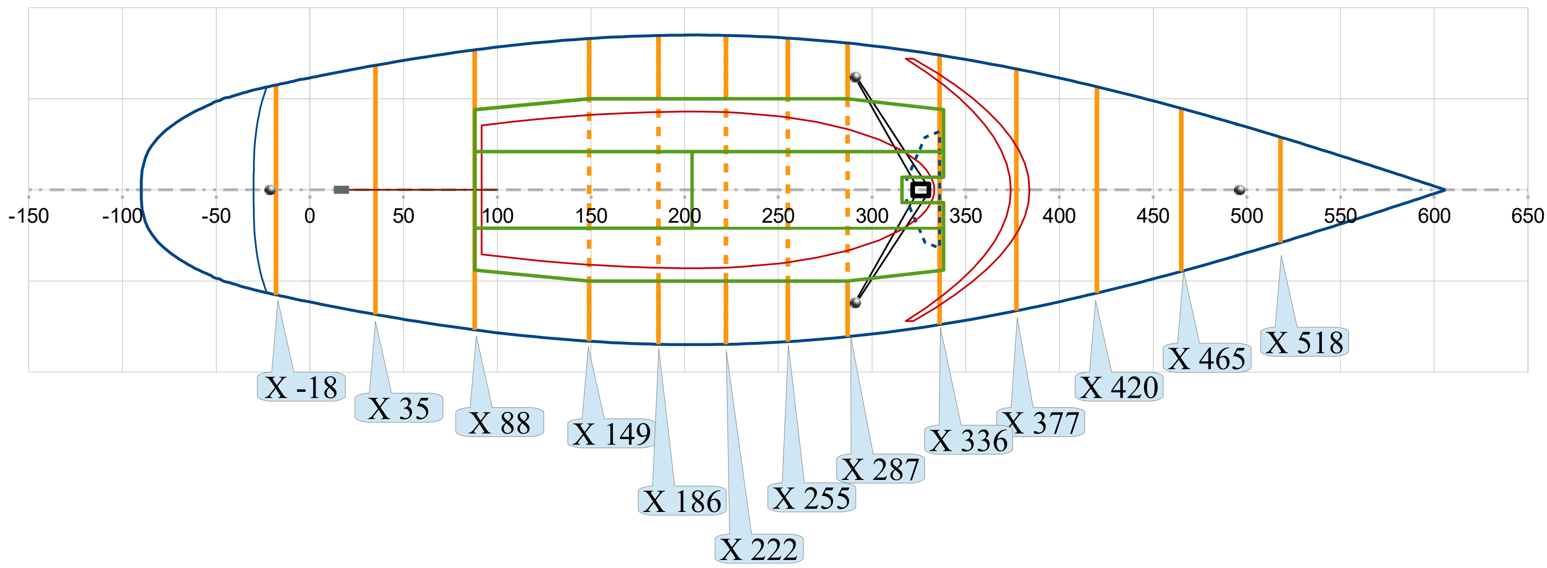




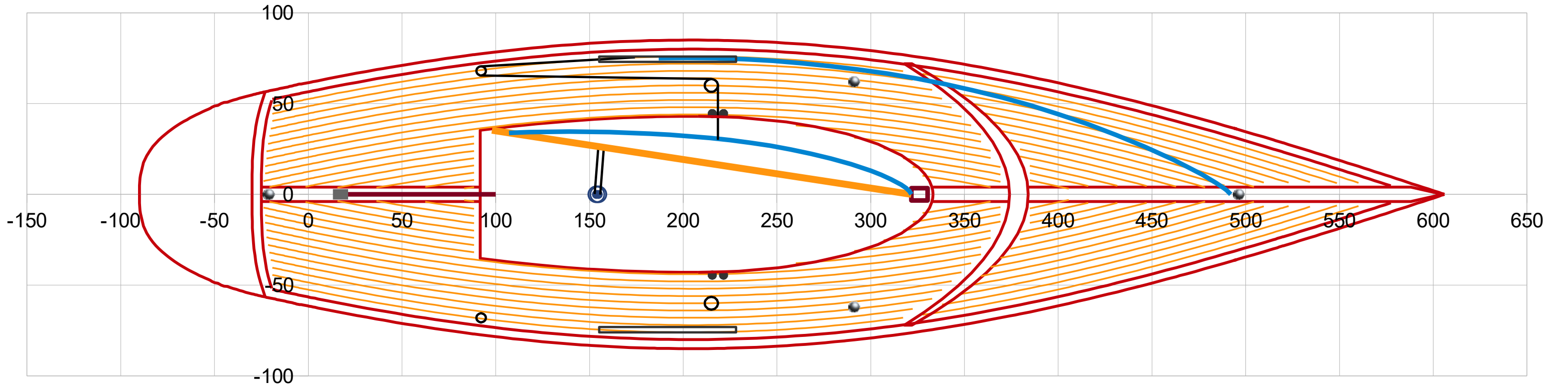


Annex A1 : Structure drawings



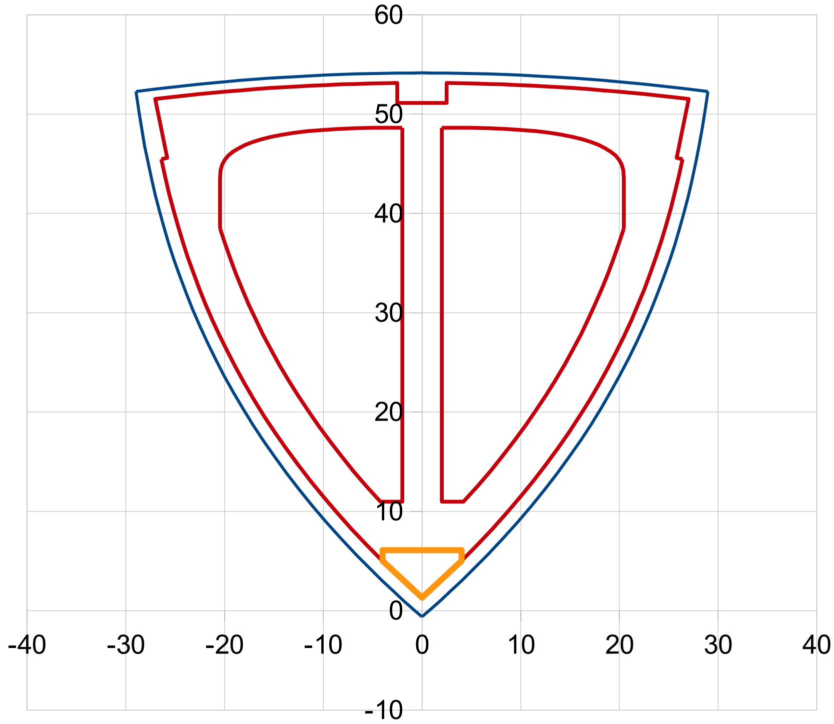


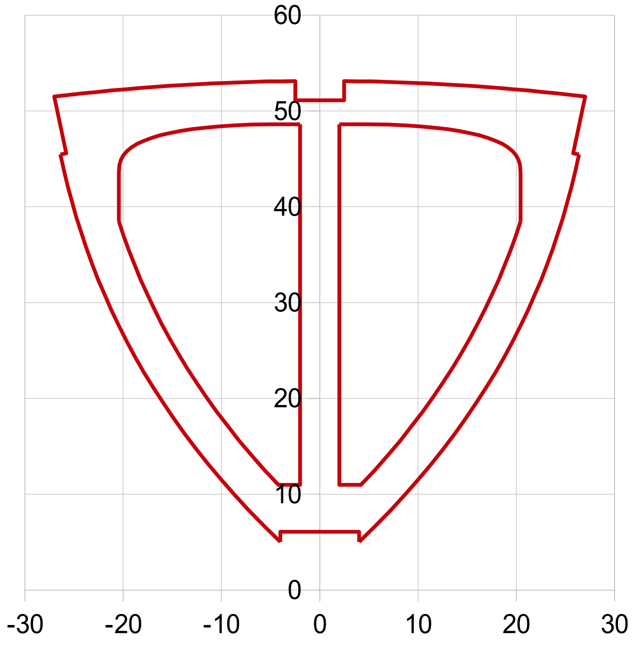
Transversal frames are made of marine plywood thickness 22 mm, the above X positions are given backside.



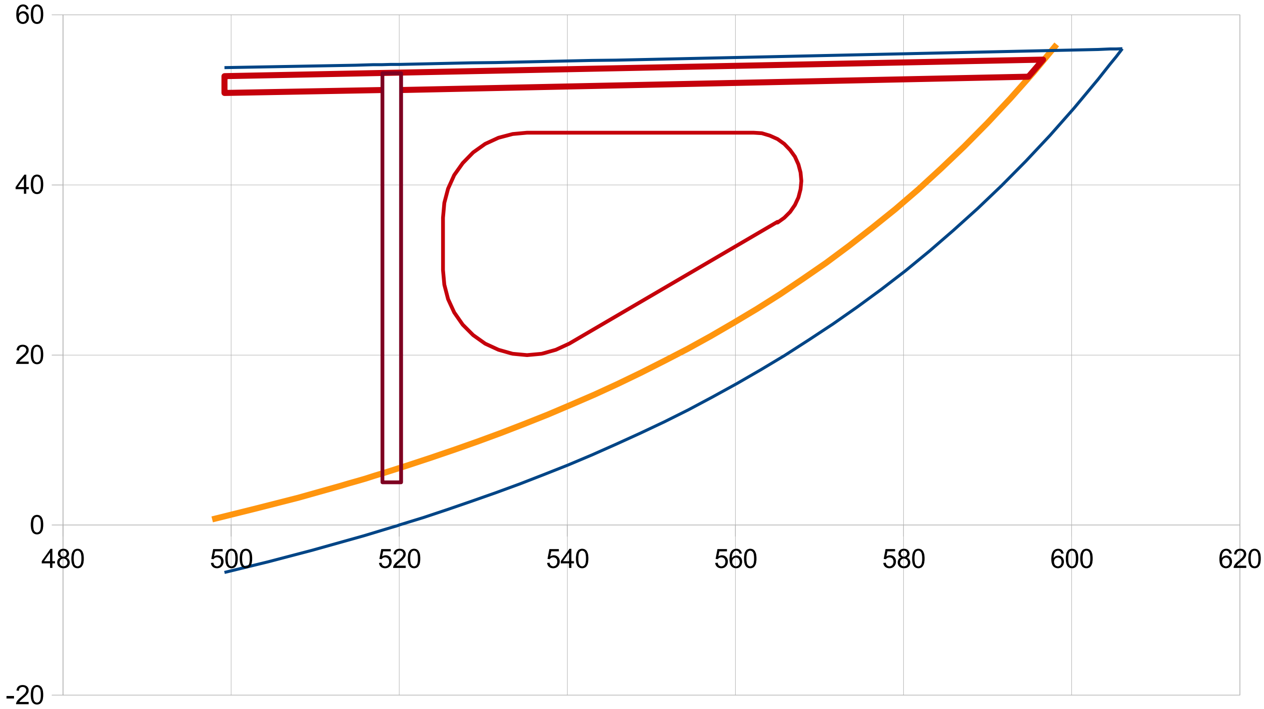
The deck is made of marine plywood thickness 6 mm covered with Teak slats of thickness 7,5 mm / width 35 mm (typically). A lighter alternative would be to make the deck with a plywood of thickness 12 mm, then leading to a weight reduction of about 13 kg.

Transversal frame X518 and its fore longitudinal frame :

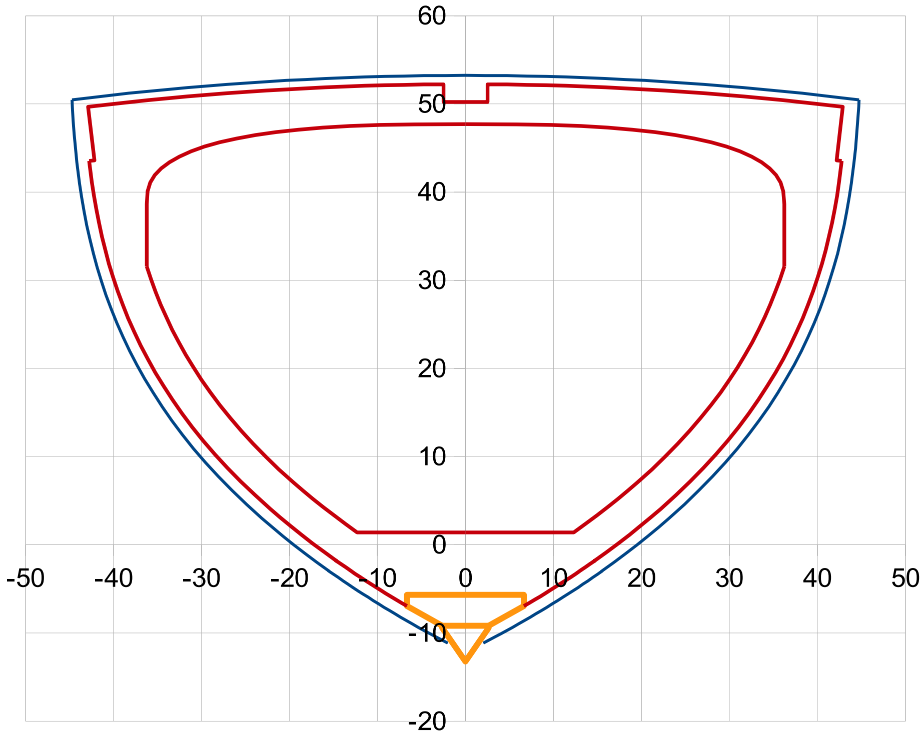


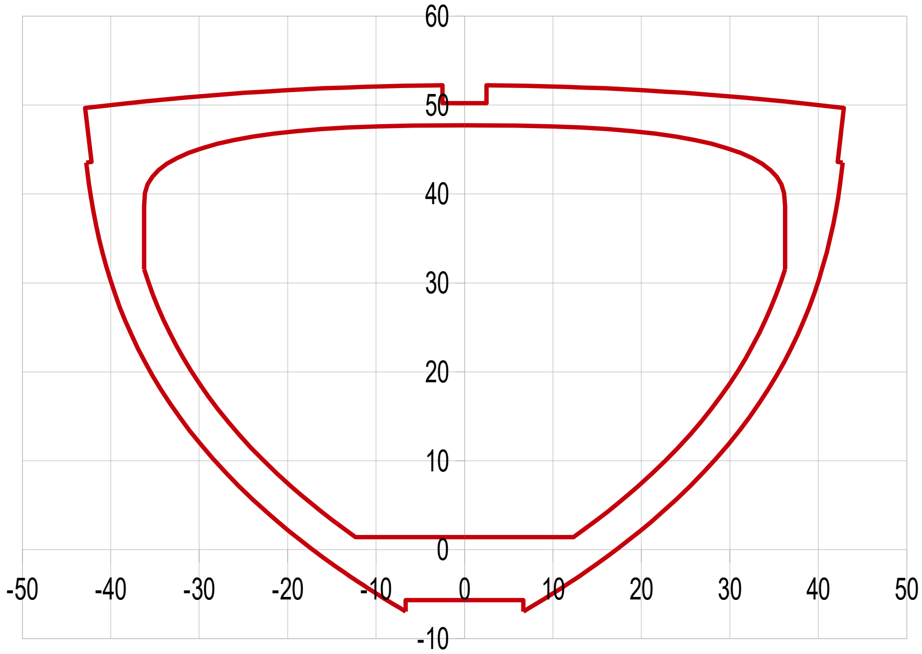


Fore longitudinal frame (in front of X518 frame)

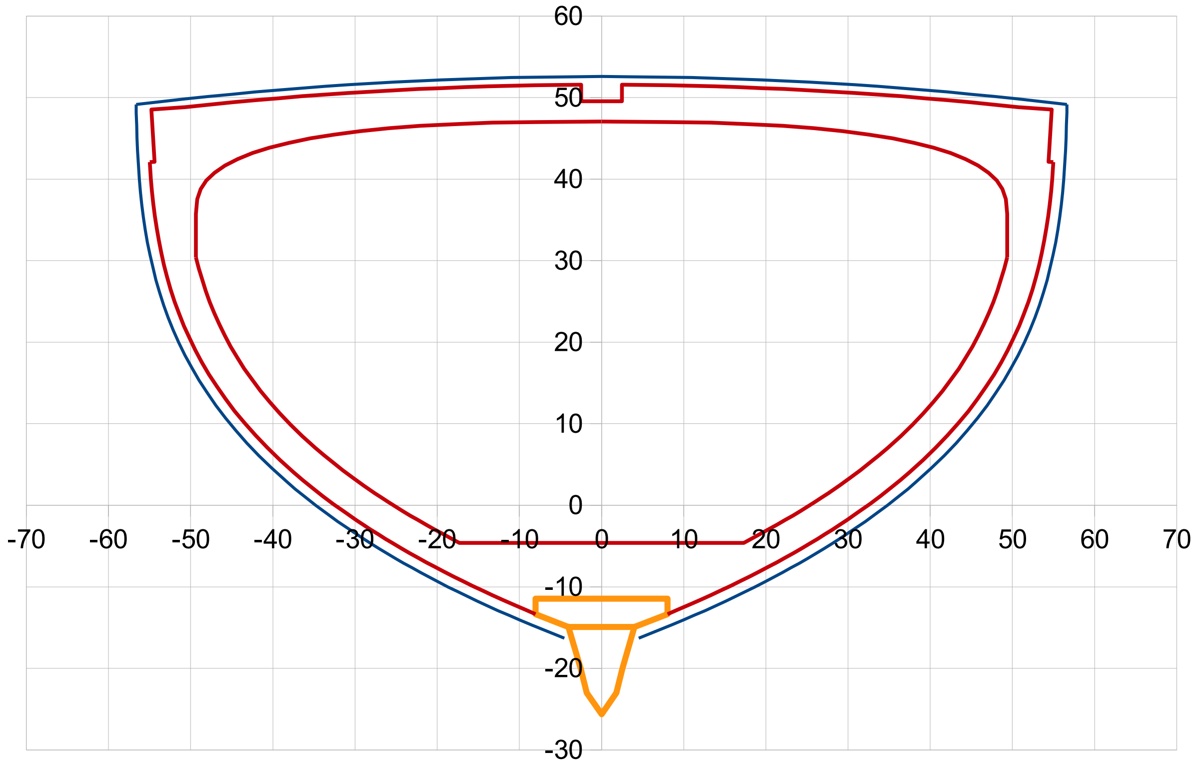


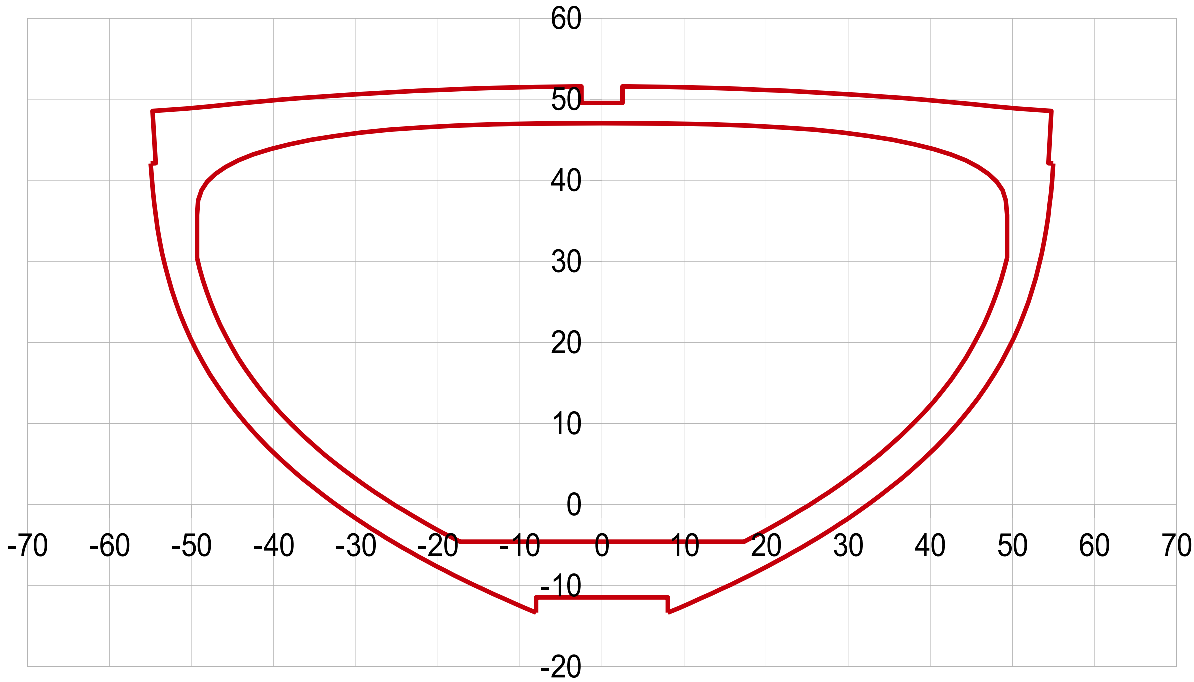
Transversal frame X465



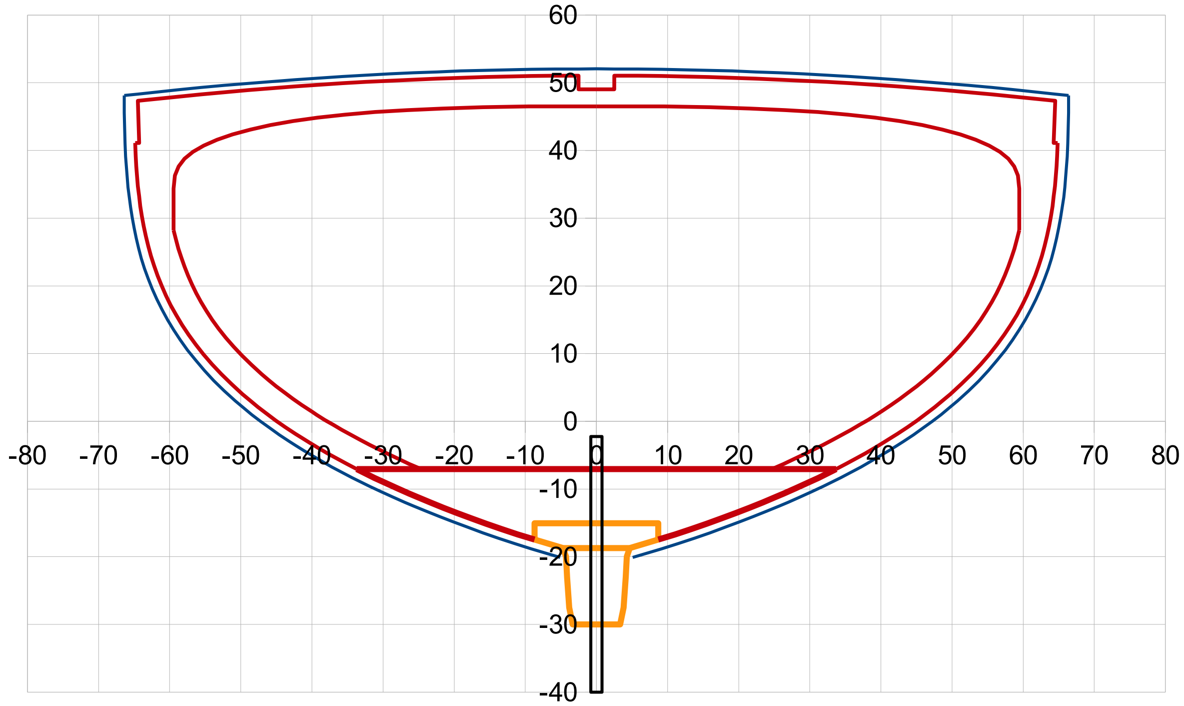


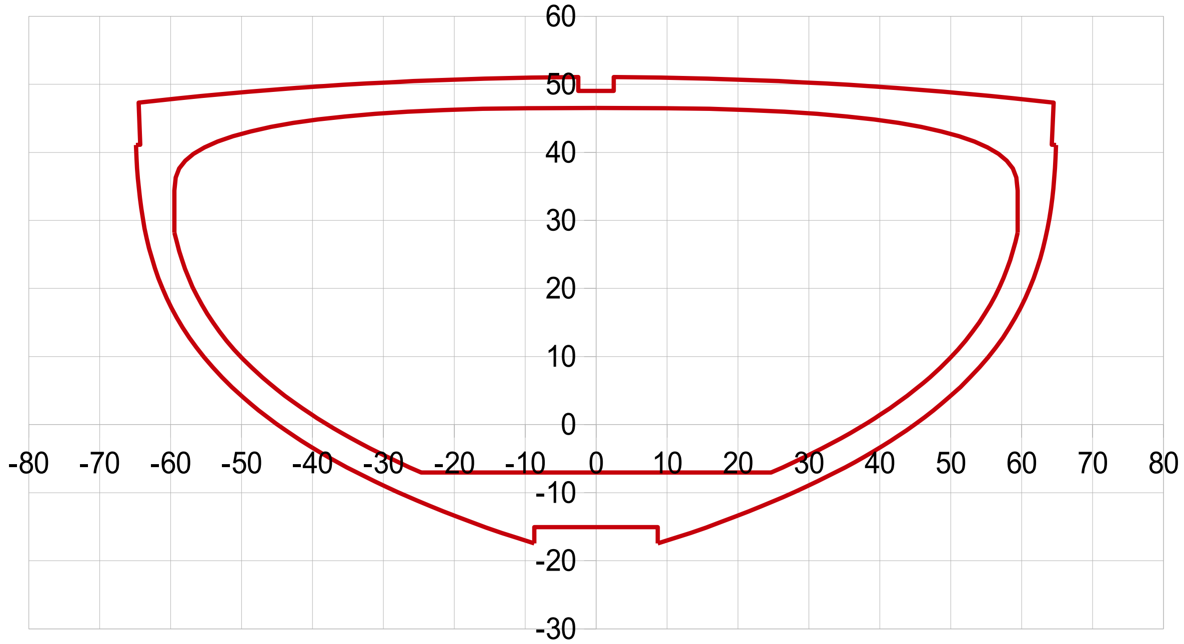
Transversal frame X420



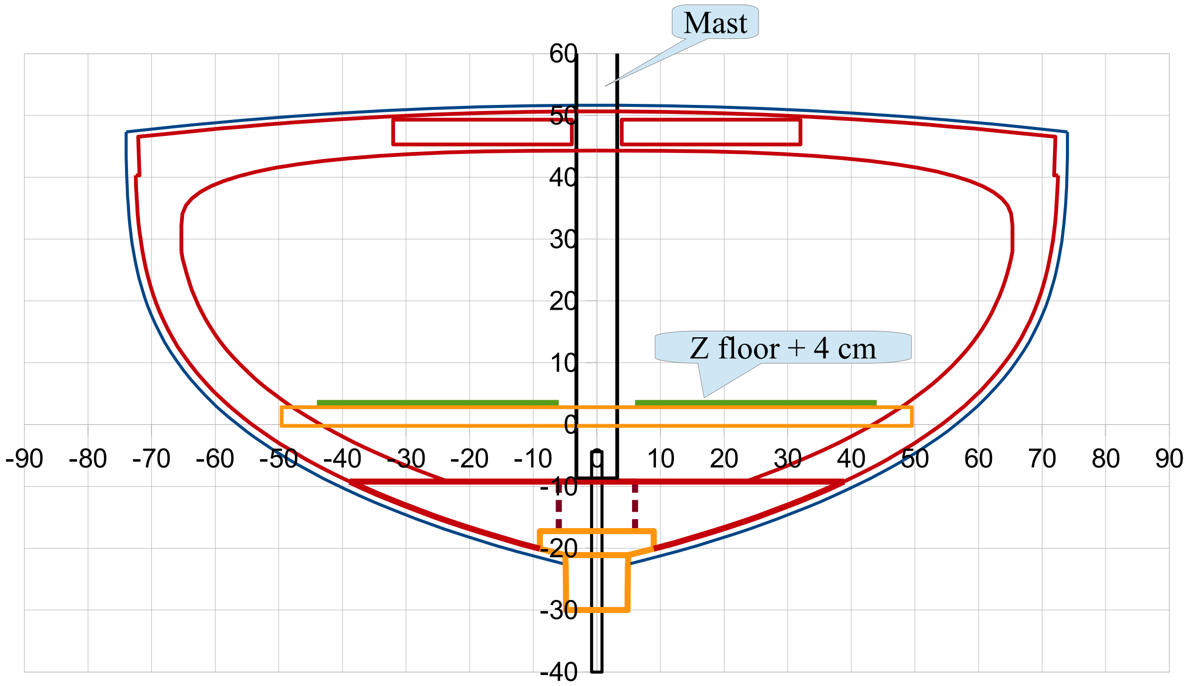


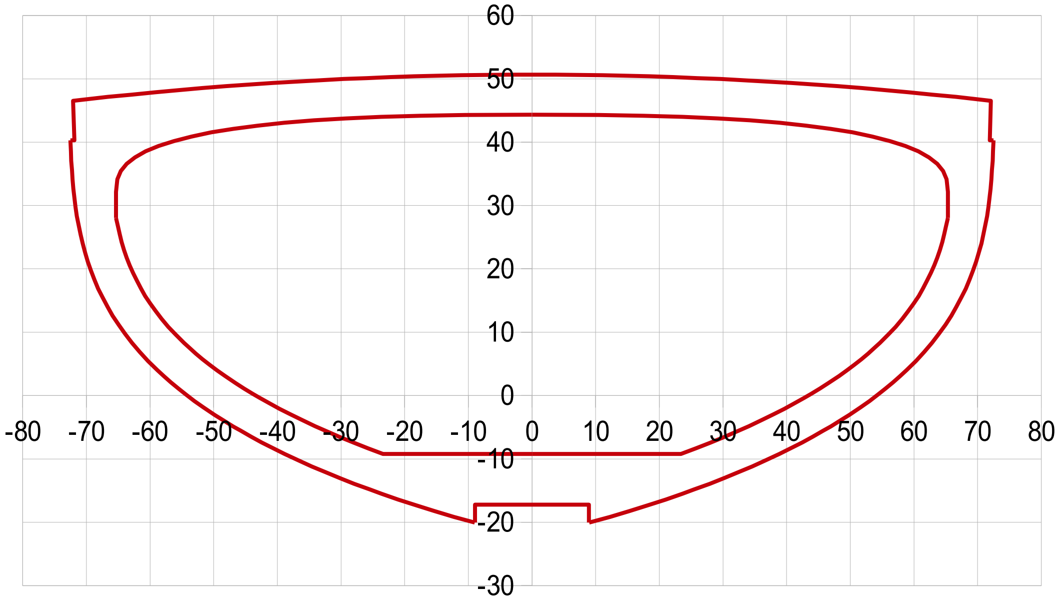
Transversal frame X377



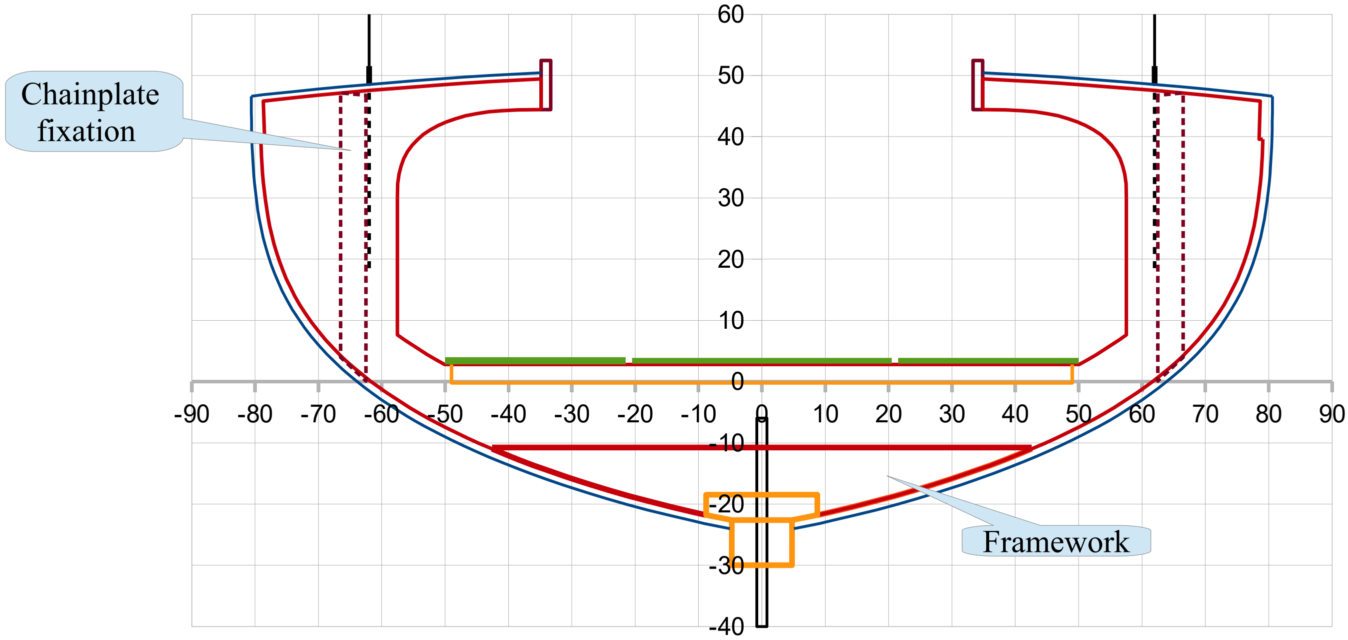


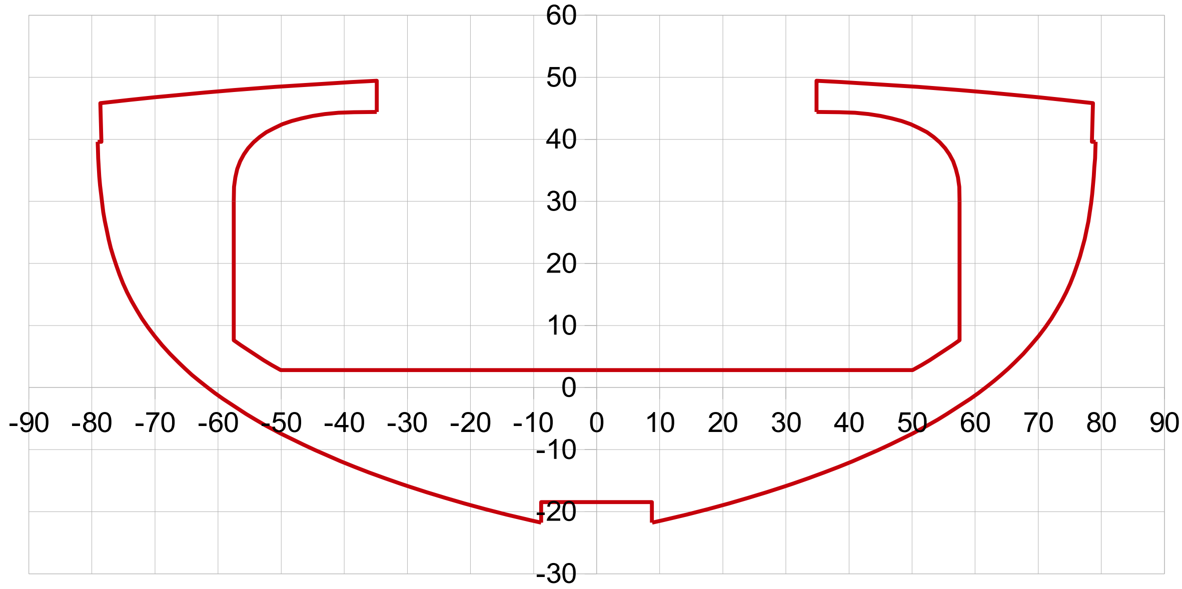
Transversal frame X336



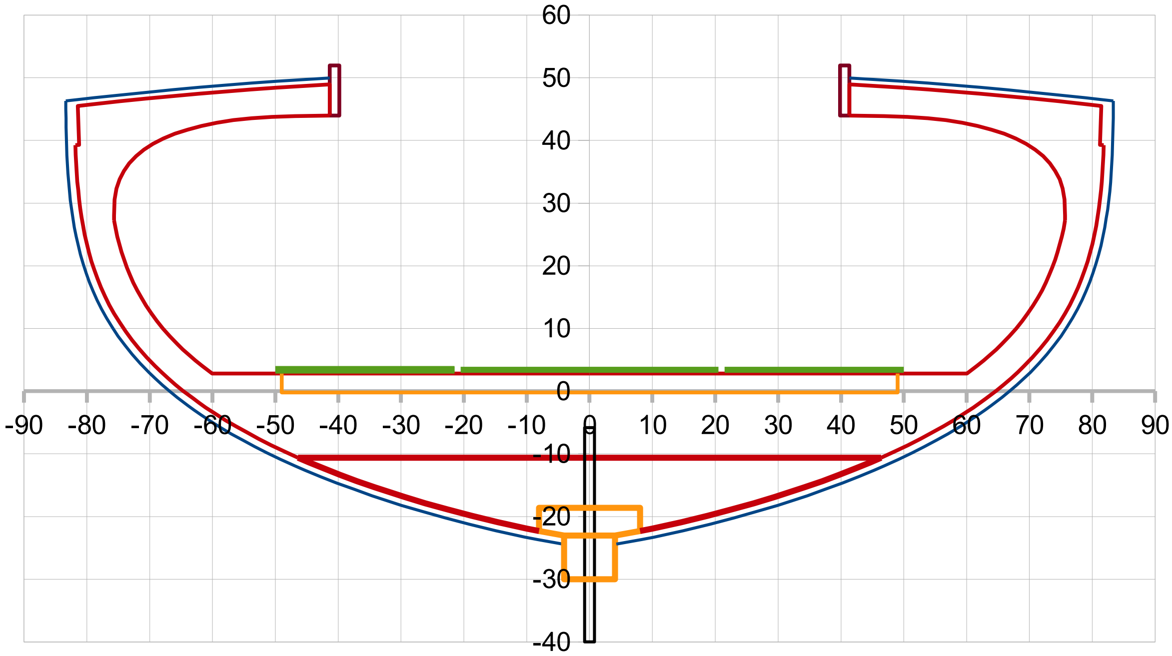


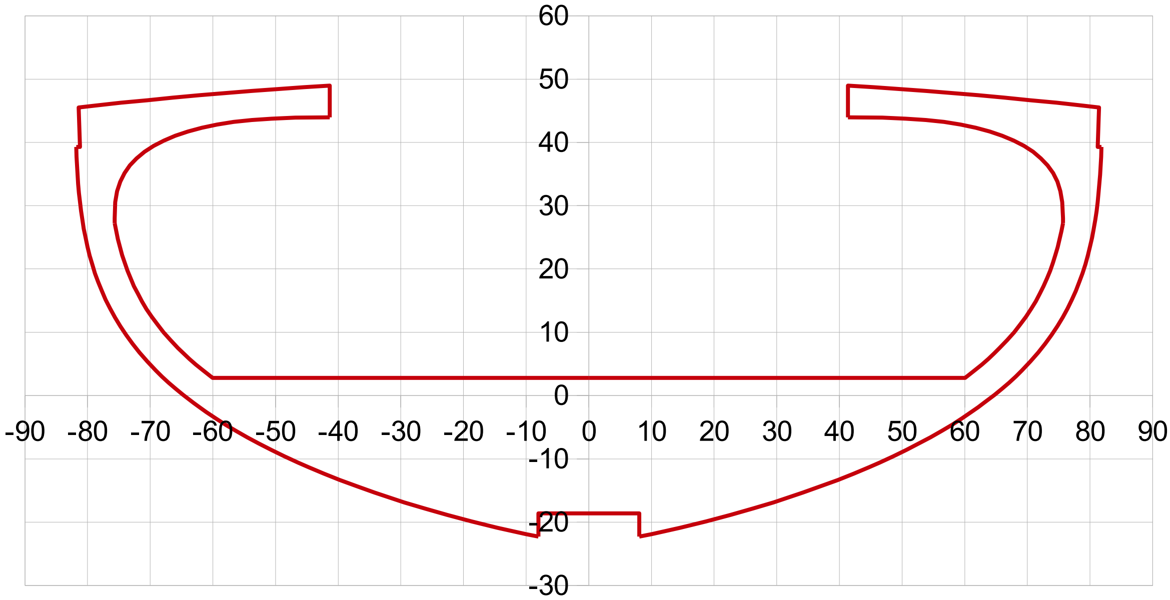
Transversal frame X287



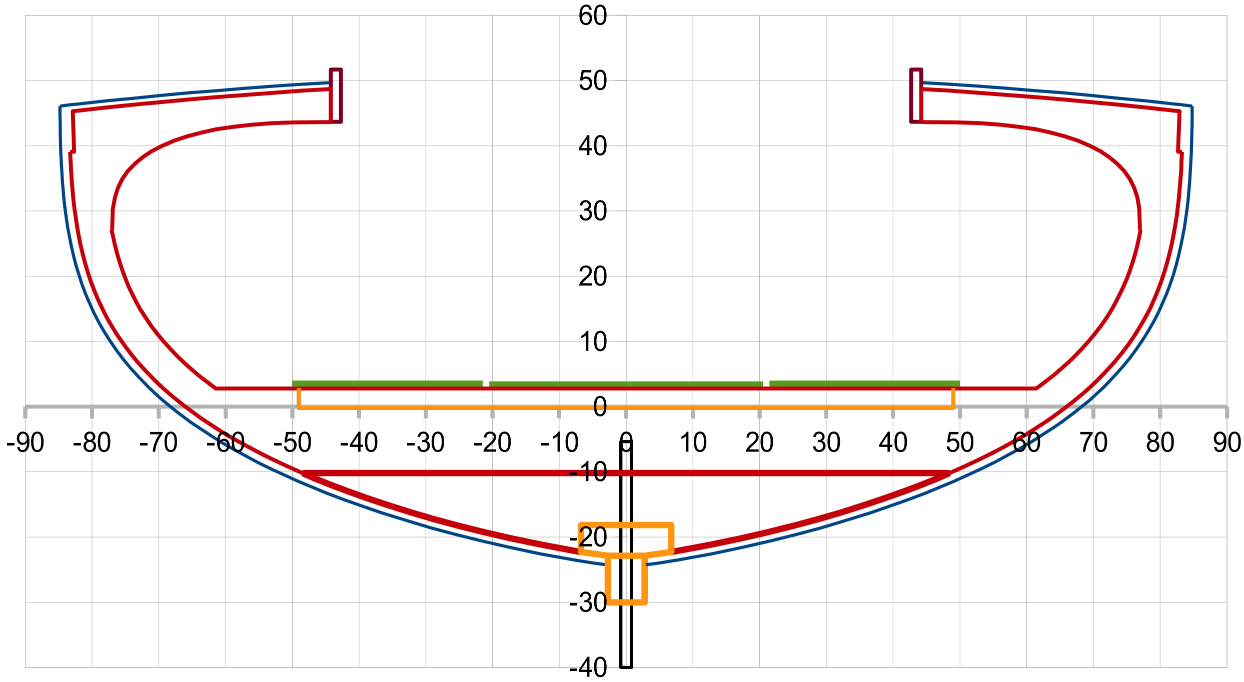


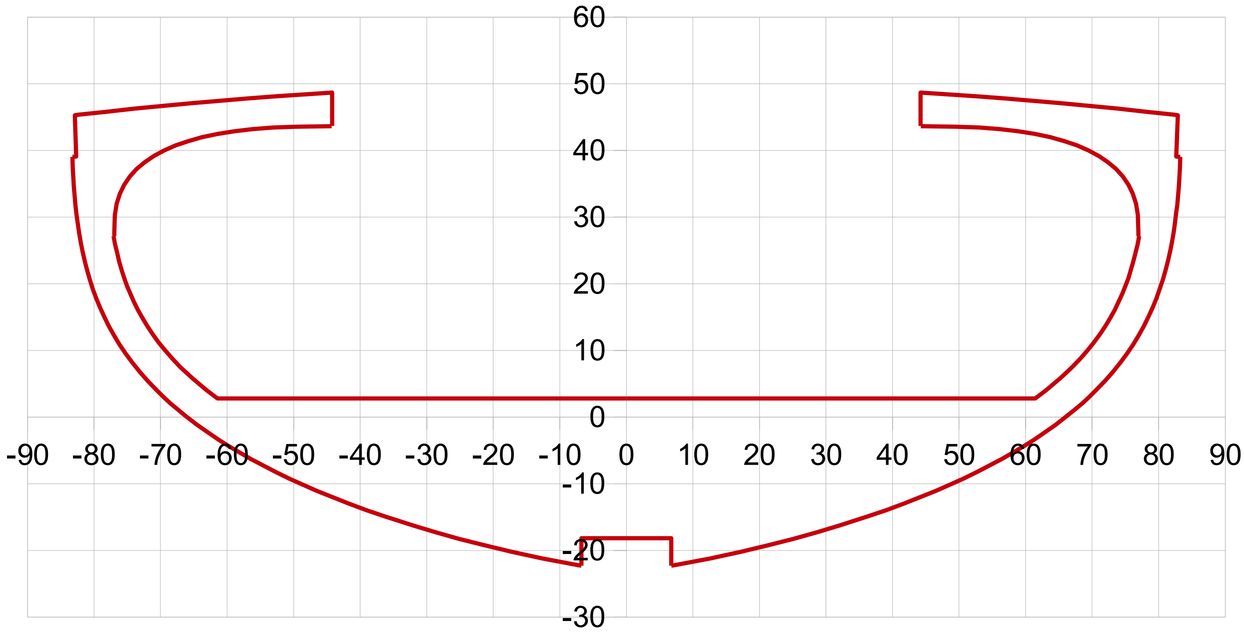
Transversal frame X255



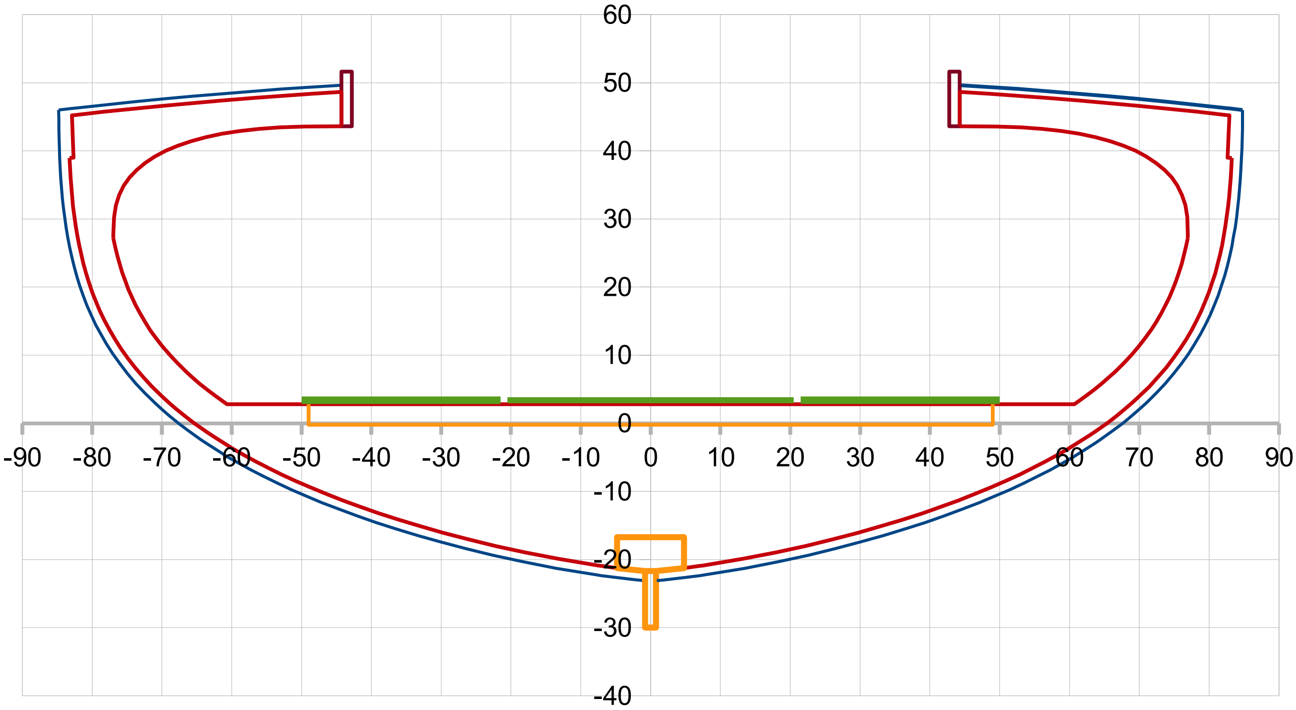


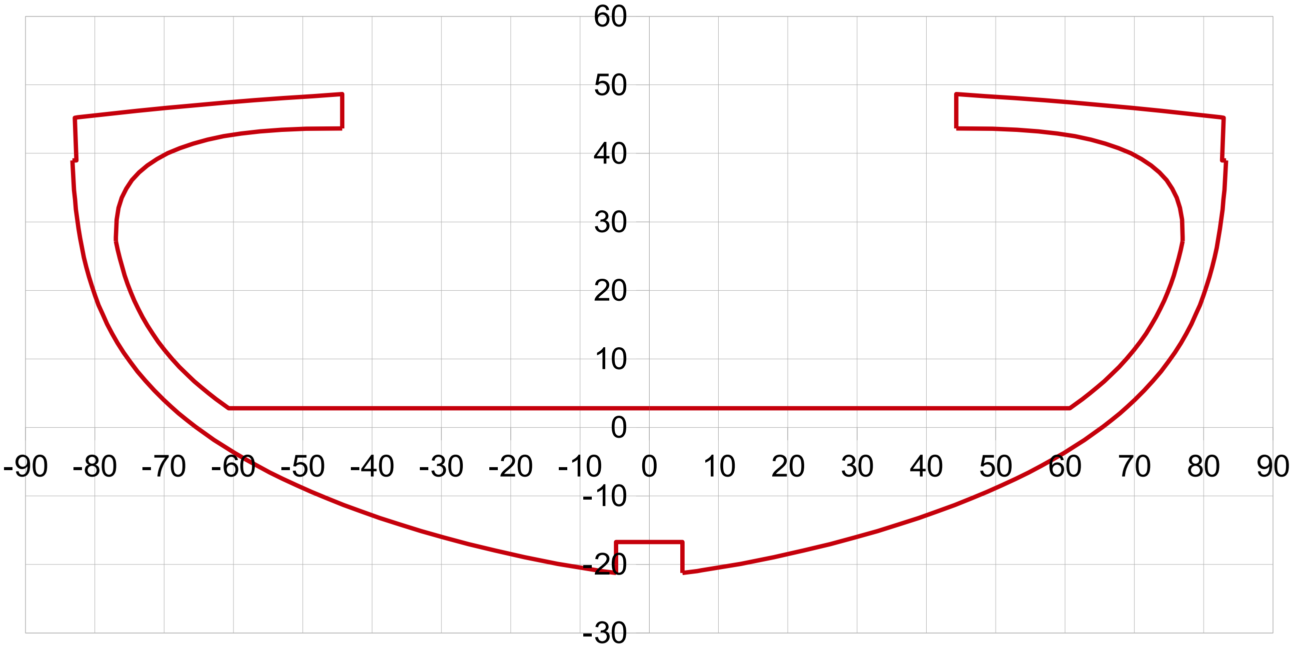
Transversal frame X222



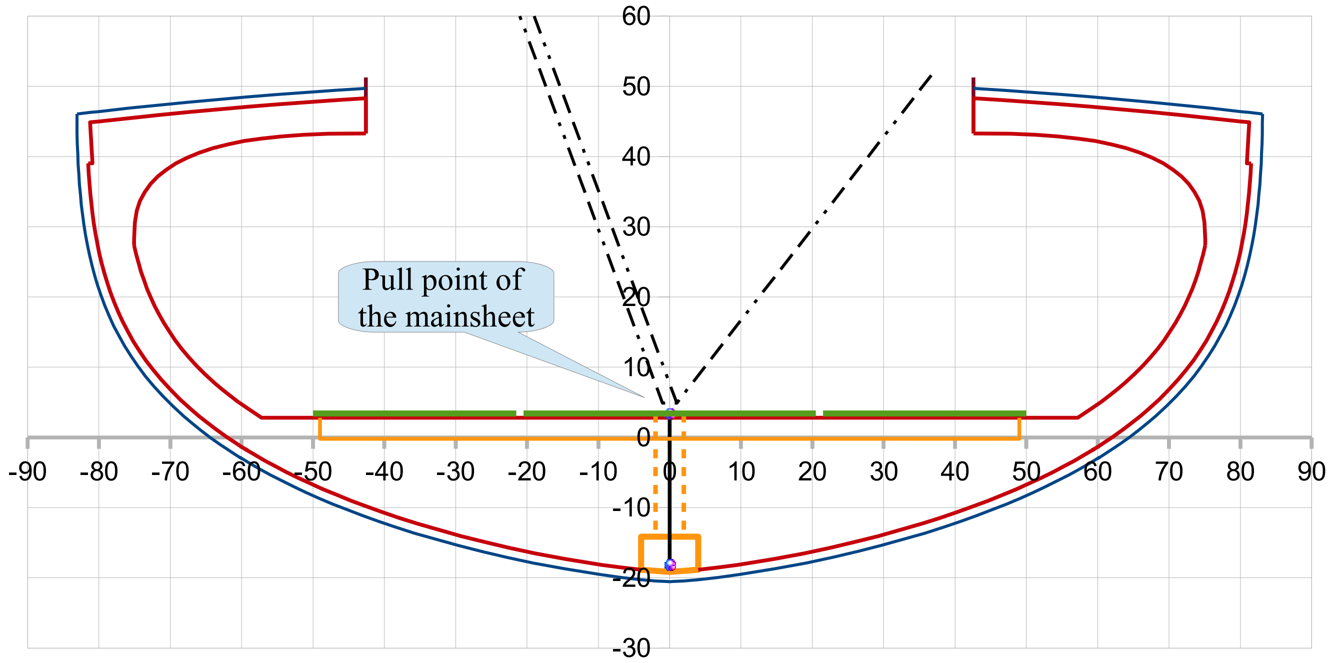


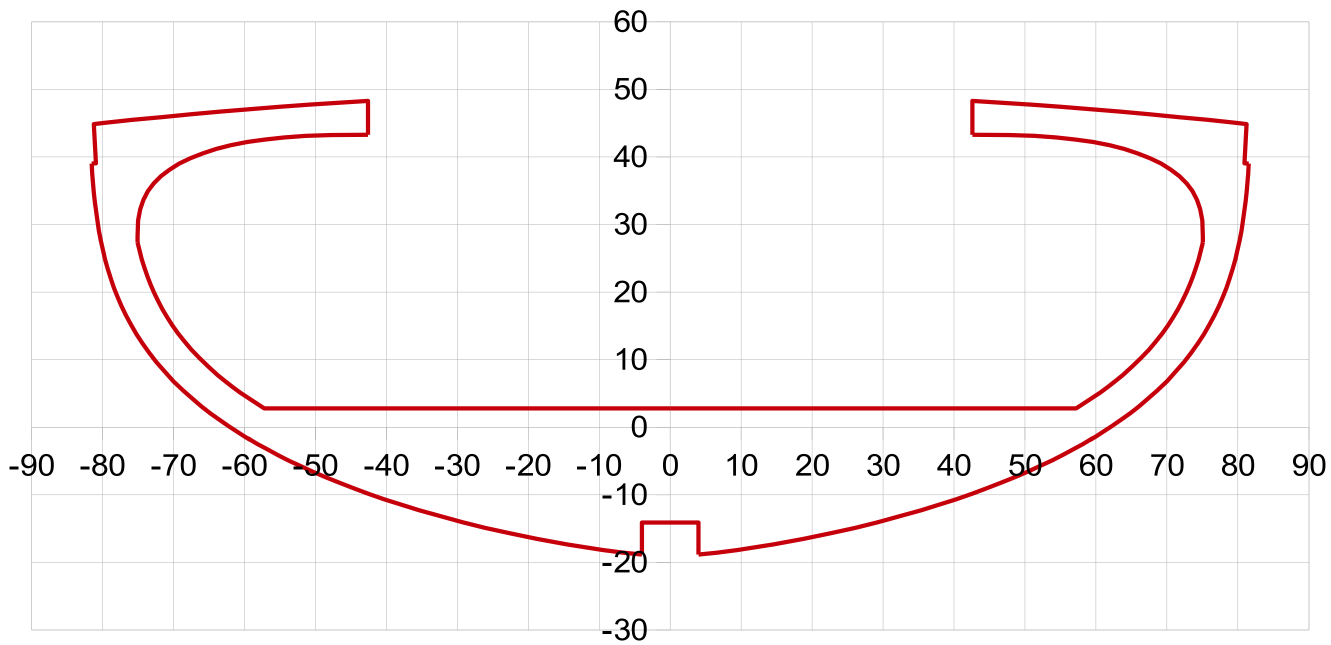
Transversal frame X186



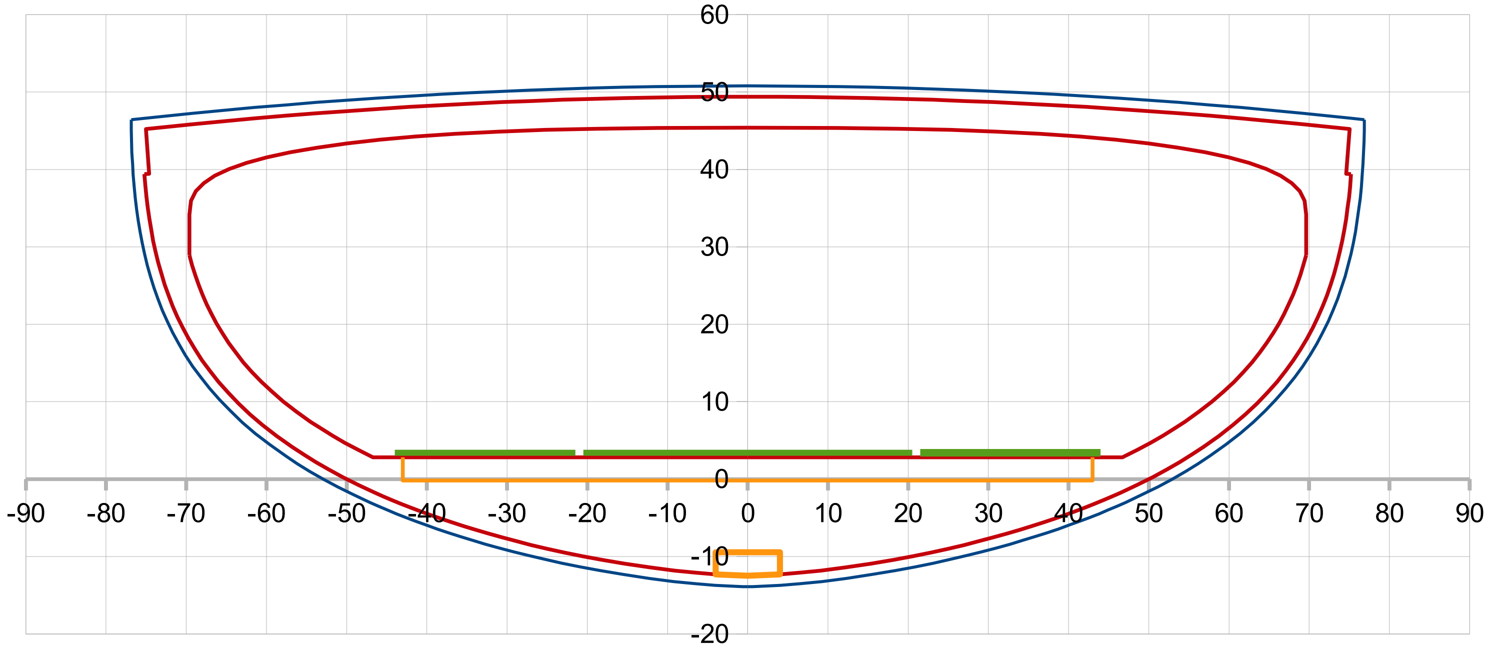


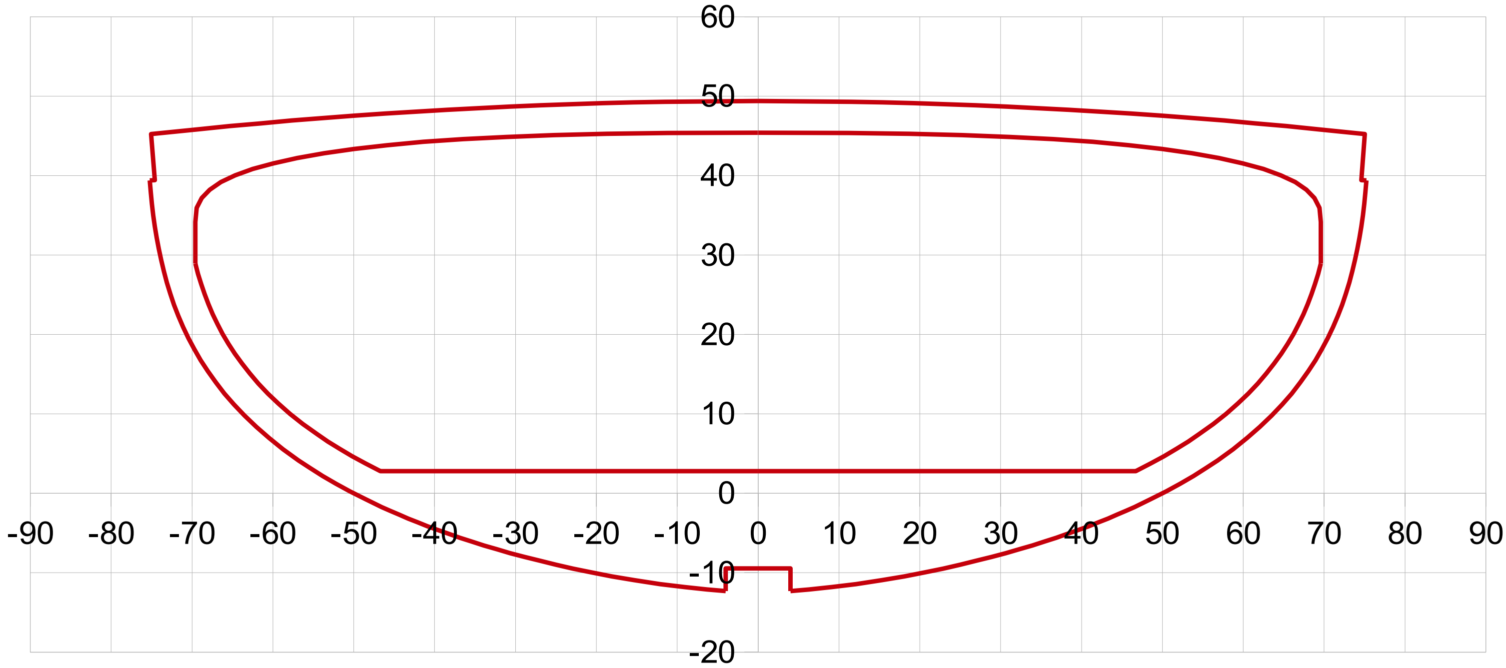
Transversal frame X149



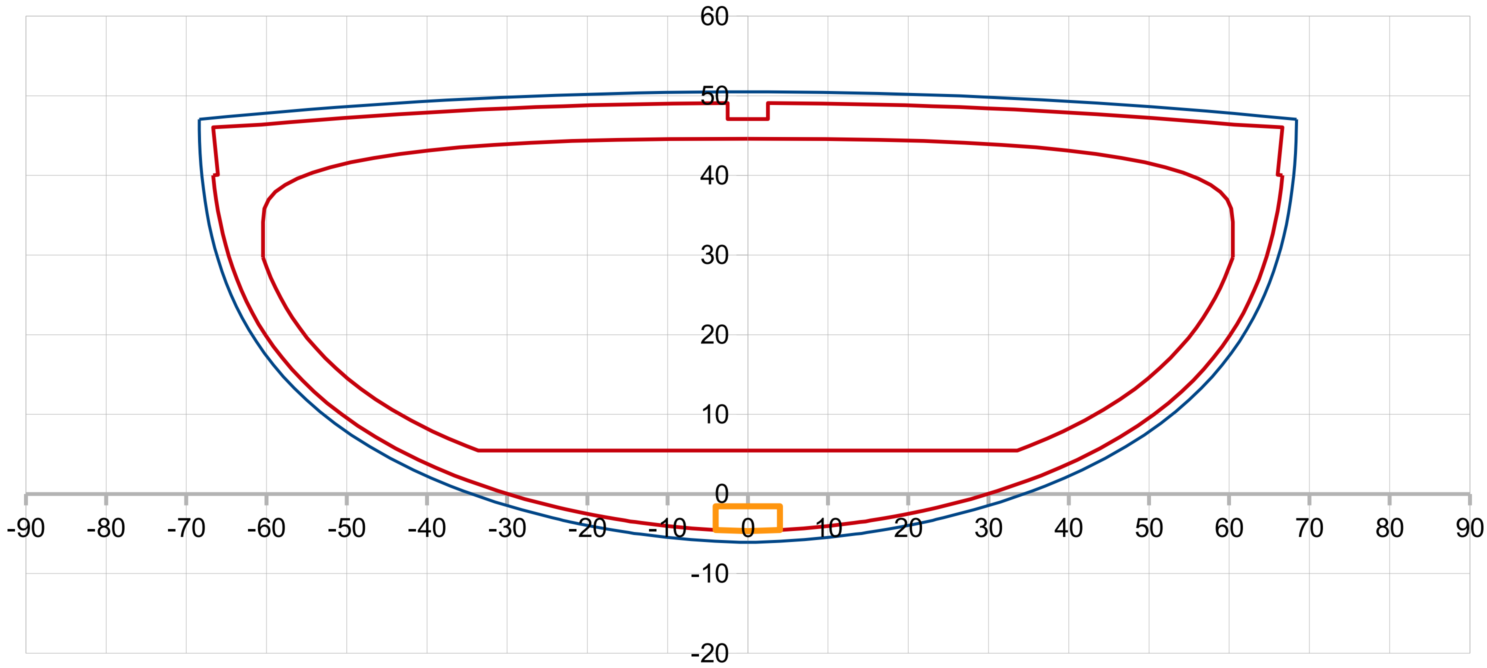


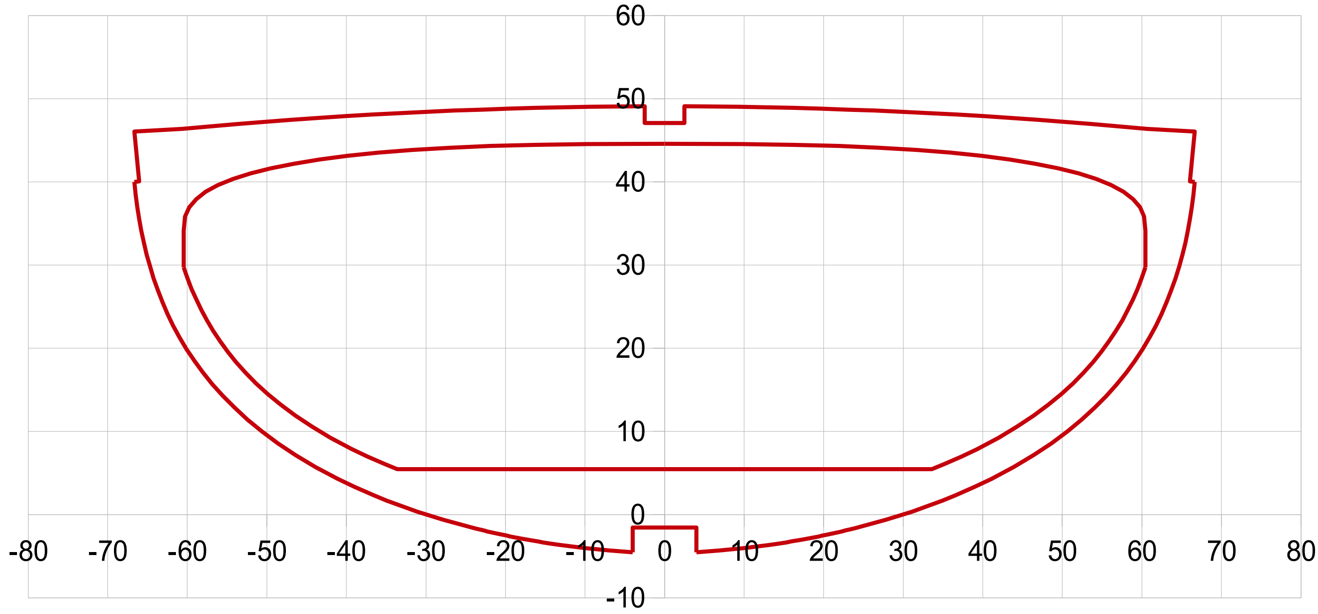
Transversal frame X88



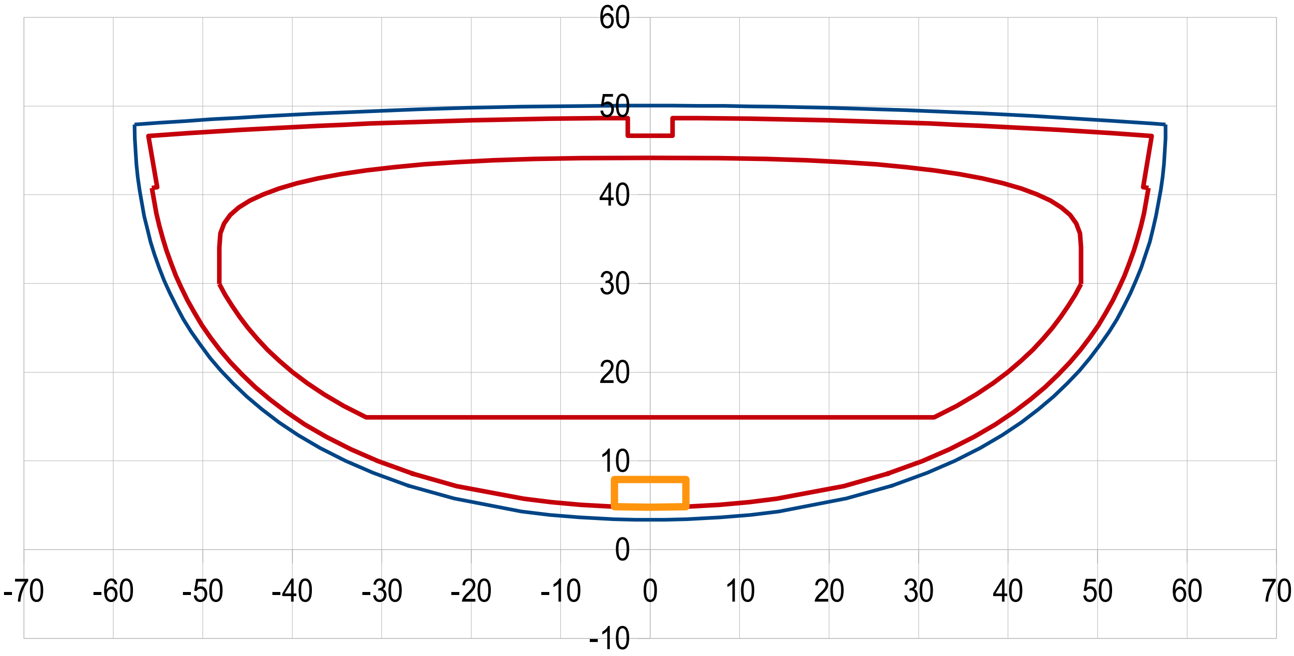


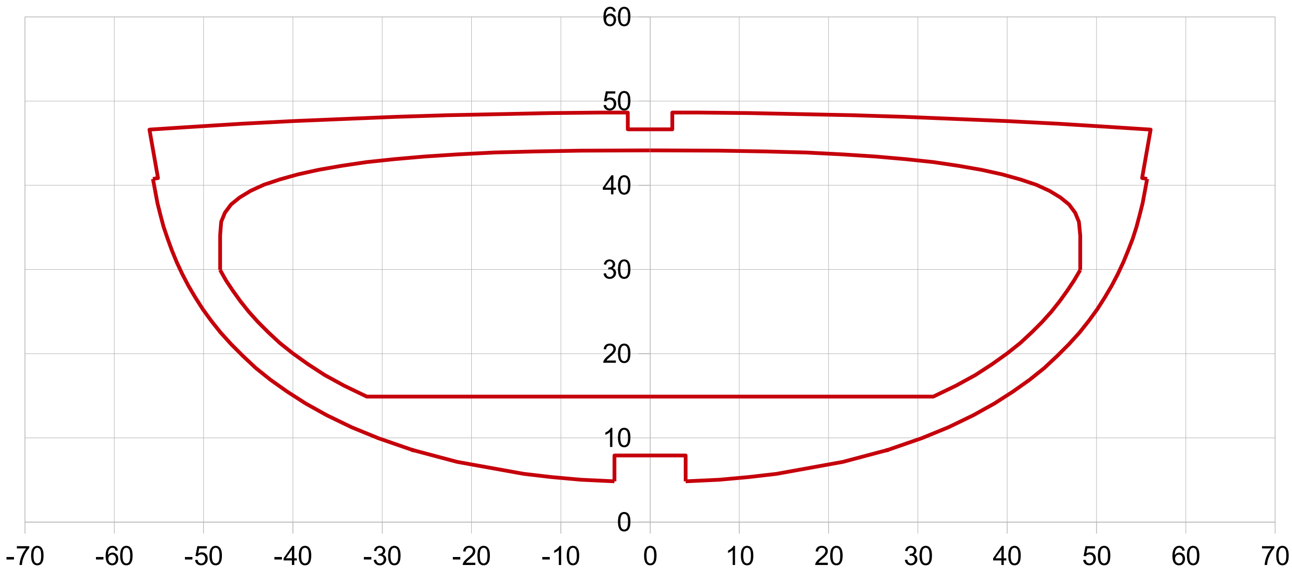
Transversal frame X35





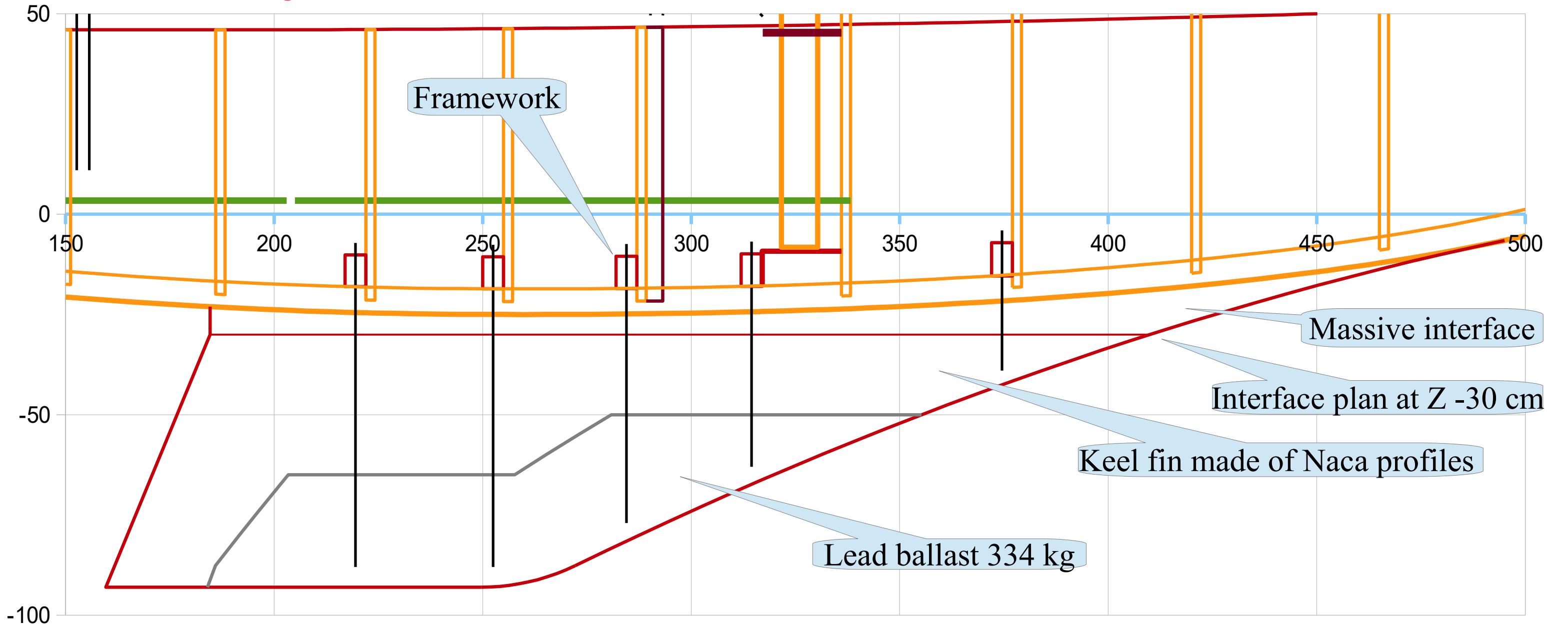
Transversal frame X-18

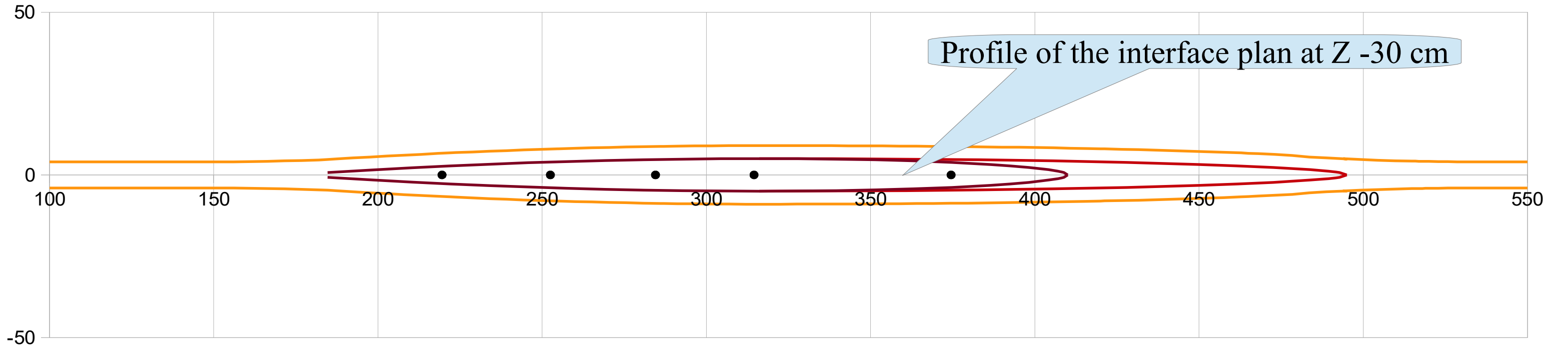


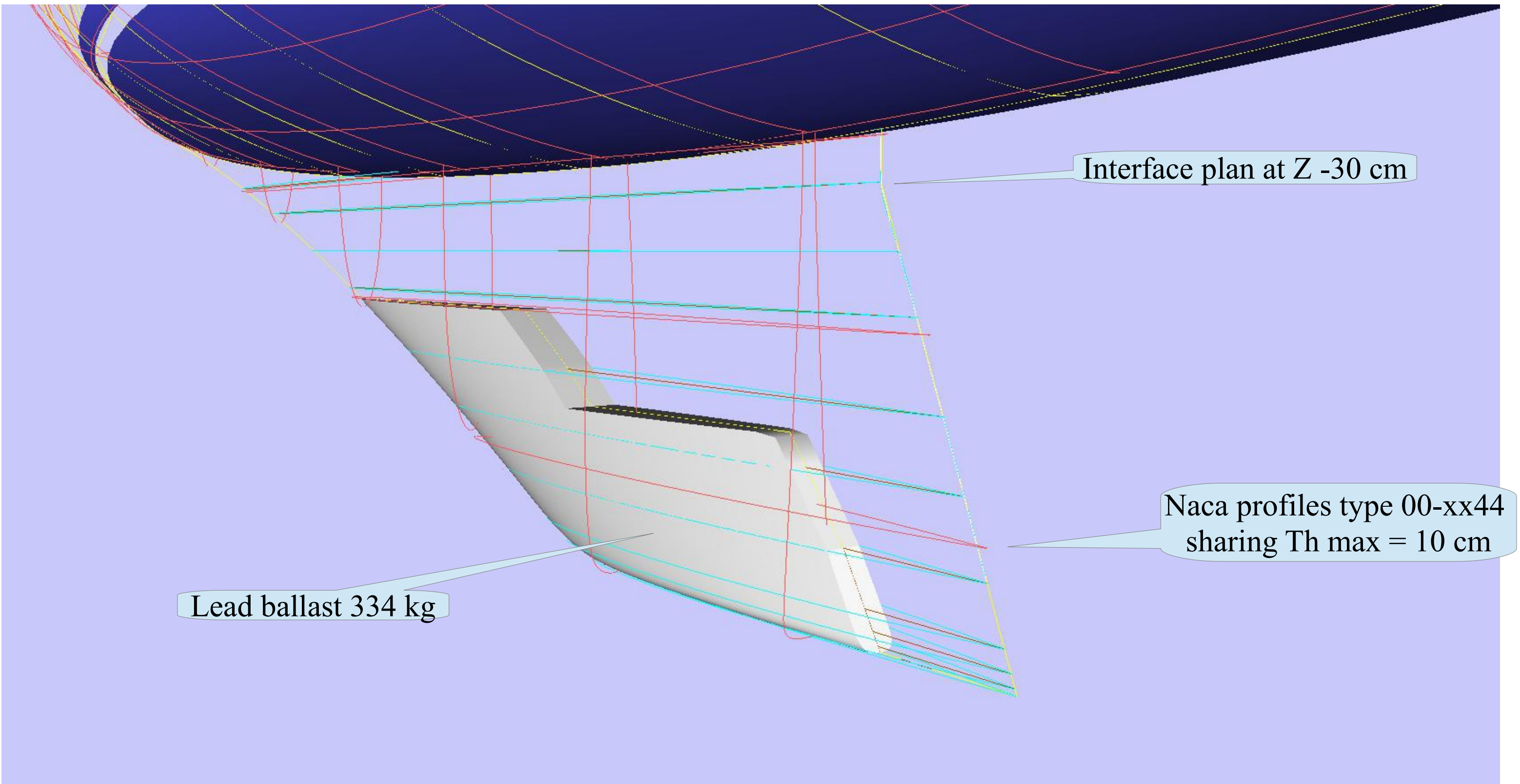


Annex A2 : Keel fin and rudder

Keel fin with its integrated ballast :



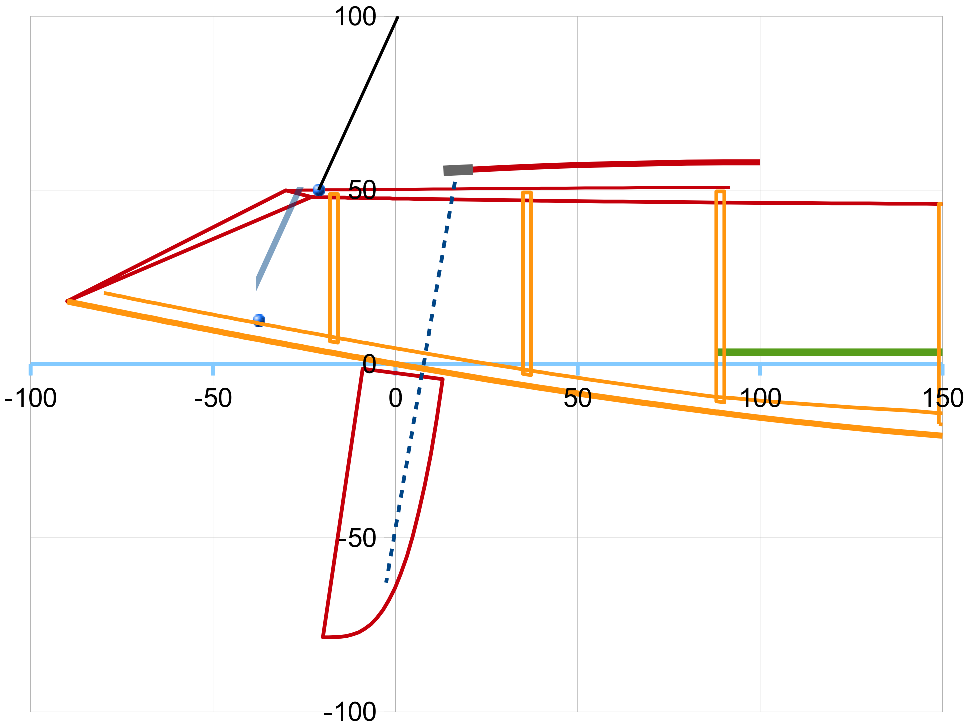




The massive interface, an intermediate piece between the keel and the fin, has a Naca profile on the lower horizontal face (at -30 cm), allowing the interface with the fin. It is made of bounded laminated Iroko and secured, by gluing first and then kept in compression by bolting the ballast, to the underside of the keel piece.

The fin is also made of laminated Iroko according to a geometry based on horizontal Naca profiles of type 00-xx44 and sharing maximum thickness 10 cm, with a truncature at 96% of the theoretical chord. The volume dedicated to lead ballast is taken from that fin geometry without any particular outgrowth. 5 rods of diameter 20 mm typically and threaded at their upper end allow the attachment of the assembly to the structure of the ship, via 5 frameworks glued/attached to the frames.

The suspended rudder :



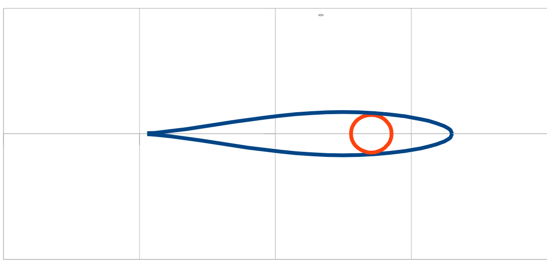
The rudder geometry is based on Naca profile type 63-015 and relative thickness 15% and with a troncature at 97,5 % of the theoritical chord.

Estimation of the lift F and of maxi flexure moment M at the level of the lower bearing (keel line level) :

- F = Cz ½ Rho S V² with S ~ 0,15 m2 , Cz max ~ 1,2 and V ~3,5 m/s => F ~ 113 daN
- M = 113 x 351 ~ 39 700 daN.mm

With a steel pipe Diameter 30 mm x Th 2,5 mm (>> flexure inertia modulus I/v = 1372 mm3), grade S420MC of yield stress 42 daN/mm2 :

>>> σf = M/(I/v) = 28,9 daN/mm2 (so 69% of the yield stress)



Annex A3 – Masses and CG spreadsheet

Mass and Xg, Zg position	Input data		Results				
	L or S or V	mass unit	Mass	Xg	M Xg	Zg	M Zg
	m or m2 or m3	or % Disp.	(kg)	(m)		(m)	
Bordé (+5% epoxy, marge , ...)							
Lattes en Red Cedar Ep 14 mm d 0,4	10,97	400	**64,52**	2,34	151,11	0,05	3,01
Serres 2xH30xEp20 pin d'Orégon d5,5	0,78	550	**8,99**	2,92	26,23	0,46	4,10
Tableau ar CP 6,5 mm d0,5	0,63	500	**2,03**	-0,52	-1,05	0,35	0,72
Stratif. Ext. 2 couches 160g/m2 + epoxy ~ 0,8 kg/m2	13,17	0,80	**10,54**	1,93	20,30	0,06	0,59
Stratif. Int. 1 couche 160g/m2 + epoxy ~ 0,4 kg/m2	13,17	0,40	**5,27**	1,93	10,15	0,06	0,29
Eléments transversaux (+5% epoxy, marge, ...)							
Membrure X518 (CP Ep 22, d 0,5)	0,113114	500,00	**1,31**	5,19	6,78	0,35	0,46
Membrure X465 (CP Ep 22, d 0,5)	0,117774	500,00	**1,36**	4,66	6,34	0,30	0,41
Membrure X420 (CP Ep 22, d 0,5)	0,145899	500,00	**1,69**	4,21	7,10	0,27	0,45
Membrure X377 (CP Ep 22, d 0,5)	0,174806	500,00	**2,02**	3,78	7,63	0,23	0,47
Varangue X377 (Ep 50, Chêne d 0,71)	0,047454	710,00	**1,77**	3,75	6,62	-0,10	-0,18
Cloison X336 (CP Ep 22, d 0,5)	0,246456	500,00	**2,85**	3,37	9,60	0,23	0,64
Pied de mât lamellé collé Iroko d 0,65	0,001825	650,00	**1,25**	3,27	4,07	-0,13	-0,16
Varangue X336 (Ep 50, Chêne d 0,71)	0,064636	710,00	**2,41**	3,15	7,58	-0,12	-0,29
Tasseau 30x30 chêne 0,71	0,000892	710,00	**0,66**	3,35	2,22	0,01	0,01
Membrure X287 (CP Ep 22, d 0,5)	0,398801	500,00	**4,61**	2,88	13,27	0,13	0,61
Varangue X287 (Ep 50, Chêne d 0,71)	0,069586	710,00	**2,59**	2,85	7,38	-0,14	-0,36
Tasseau 30x30 chêne 0,71	0,000882	710,00	**0,66**	2,86	1,88	0,01	0,01
Carré 40 reprise cadènes	0,001437	710,00	**1,07**	2,91	3,12	0,25	0,27
Membrure X255 (CP Ep 22, d 0,5)	0,334403	500,00	**3,86**	2,54	9,81	0,07	0,25
Varangue X255 (Ep 50, Chêne d 0,71)	0,082869	710,00	**3,09**	2,53	7,80	-0,14	-0,42
Tasseau 30x30 chêne 0,71	0,000882	710,00	**0,66**	2,54	1,67	0,01	0,01
Membrure X222 (CP Ep 22, d 0,5)	0,340057	500,00	**3,93**	2,23	8,76	0,06	0,26
Varangue X222 (Ep 50, Chêne d 0,71)	0,082869	710,00	**3,09**	2,20	6,78	-0,14	-0,42
Tasseau 30x30 chêne 0,71	0,000882	710,00	**0,66**	2,21	1,45	0,01	0,01
Membrure X186 (CP Ep 22, d 0,5)	0,328931	500,00	**3,80**	1,87	7,11	0,08	0,31
Tasseau 30x30 chêne 0,71	0,000882	710,00	**0,66**	1,90	1,25	0,01	0,01
Membrure X149 (CP Ep 22, d 0,5)	0,304844	500,00	**3,52**	1,50	5,28	0,11	0,38
Tasseau 30x30 chêne 0,71	0,000882	710,00	**0,66**	1,48	0,97	0,01	0,01
Pied central support plancher et point de tire-Chêne 0,71	0,000280	710,00	**0,21**	1,53	0,32	0,09	0,02
Cloison X88 (CP Ep 22, d 0,5)	0,252966	500,00	**2,92**	0,89	2,60	0,20	0,57
Tasseau 30x30 chêne 0,71	0,000774	710,00	**0,58**	0,92	0,53	0,01	0,01
Membrure X40 (CP Ep 22, d 0,5)	0,181879	500,00	**2,10**	0,36	0,76	0,27	0,56
Membrure X-18 (CP Ep 22, d 0,5)	0,160696	500,00	**1,86**	-0,17	-0,31	0,30	0,57
Cadre tableau ar (CP Ep 22, d 0,5)	0,115000	500,00	**1,33**	-0,51	-0,68	0,30	0,40
Eléments longitudinaux (+5% epoxy, marge, ...)							
Cloison ajourée avant CP 22 d 0,5	0,114484	500	**1,32**	5,47	7,23	0,33	0,44
Quille lamellé collé Iroko d0,65 ou acajou	0,028867	650	**19,70**	2,77	54,62	-0,07	-1,45
Lisse centrale avant L50xEp20 pin d'Orégon d0,55	2,58	550	**1,49**	4,67	6,97	0,48	0,72
Lisse centrale arriere H50xEp20 pin d'Orégon d0,55	1,17	550	**0,67**	0,33	0,22	0,45	0,30
Plancher cockpit CP 12 ou 5/10/5 = 20 > 6 kg/m2	2,40	6	**15,14**	2,26	34,30	0,03	0,51
Plat bord Sipo 50x14 d 0,62	14,97	620	**6,82**	2,27	15,46	0,51	3,48
Fougère avant L80 Ep 7,5 Sipo d 0,62	2,58	620	**1,01**	4,67	4,72	0,50	0,51
Fougère arrière L80 Ep 7,5 Sipo d 0,62	1,17	620	**0,46**	0,33	0,15	0,47	0,22
Pont CP Ep 6,5 d 500	5,26	500	**17,94**	2,53	45,37	0,51	9,15
Lattes de teck L35 epoxy 5 Ep 7,5 d 0,72	4,96	720	**28,11**	2,48	69,74	0,52	14,54
Hiloire de cockpit H80 Ep 15 Sipo d 0,62	5,49	620	**4,29**	1,95	8,35	0,48	2,04
Autres éléments de structure, d'aménagement							
Brise-lame en CP 6,5 mmd 0,5	0,17	500	**0,58**	3,67	2,13	0,53	0,31
Cadènes de haubans inox L330x40x2,5	0,000066	7850,00	**0,52**	0,25	0,13	0,35	0,18
Cadène de pataras L500	0,41	7850,00	**0,32**	-0,29	-0,09	0,31	0,10
Cadène d'étai L500	0,53	7850,00	**0,41**	5,04	2,09	0,29	0,12
Etambrai Ep30 Chêne 0,71	0,081355	710,00	**1,73**	3,28	5,69	0,45	0,79
Provision pour autres renforts ou stratification			**3,00**	2,60	7,80	0,36	1,07
Flottabilité							
Réserve de flottabilité arrière (polystyrène d 0,02)		0,400	**8,00**	0,30	2,40	0,20	1,60
Réserve de flottabilité avant (polystyrène d 0,02)		0,500	**10,00**	4,30	43,00	0,20	2,00
Gréement							
Mât alu type Selden C087 (87/64) 1,67 kg/ml	8,04	1,67	**13,43**	3,26	43,78	3,93	52,77
En tête de mât, pied de mât, barres de flèches : +15%			**2,01**	3,26	6,57	3,93	7,92
Bôme alu type Selden B087 (087/60) 1,55 kg/ml	2,35	1,55	**3,63**	2,04	7,43	1,11	4,03
Vit de mulet, embout : +10%			**0,36**	2,04	0,74	1,11	0,40
Tangon alu type Selden S050 (050) 0,84 kg/ml	1,65	0,84	**1,39**	2,26	3,14	0,30	0,42
Etai-Pataras-Haubans 8,1 kg / 100 m	40,00	0,081	**3,24**	3,26	10,56	3,93	12,73
Voiles , type Dracon 240 g/m2	20,00	0,24	**4,80**	3,06	14,67	3,01	14,42
Drisses, palan de GV, hale-bas, poulies, ... : 4 kg			**4,00**	3,06	12,23	1,00	4,00
Massif interface et platine / P lest	0,013803	650,00	**8,97**	3,41	30,56	-0,25	-2,23
Aileron sans lest	0,042792	650,00	**27,81**	2,67	74,22	-0,34	-9,52
Lest plomb	0,029395	11350,00	**333,63**	2,56	853,43	-0,72	-240,22
Safran et gouvernail							
Safran en CP +GRP d0,65	0,002943	650,00	**1,91**	-0,02	-0,03	-0,35	-0,68
Tubes mèche et jaumière, paliers, boulonneries, barre, .			**5,00**	0,12	0,61	0,27	1,34
	Lest ratio (%)	*49,05*					
		Results : Light weight boat >>>	**680,23**	**2,518**	1712,63	**-0,154**	-104,43
2 équipiers			80	1,3	104,00	0,64	51,20
amovibles			20	2,5	50,00	0,10	2,00
		Results : boat in charge>>>	**780,23**	**2,392**	1866,63	**-0,066**	-51,23
2 équipiers			160	1,85	296,00	0,64	102,40
amovibles			40	2,5	100,00	0,10	4,00
		Results : boat in charge>>>	**880,23**	**2,396**	2108,63	**0,002**	1,97

Annex A4 – Rig, sails and equilibrium (lead)

Reminder of the definitions for the 12m2 du Havre :

Measured as the sum of the surfaces of the two triangles defining the mainsheet and the fore triangle, shall not be greater than 12m².

From P,E,I,J dimensions >> Mainsheet triangle = P*E/2 ; Fore triangle = I*J/2

=> S = G*B/2 + I*J/2 ≤ 12 m2

Proposed sailplan :

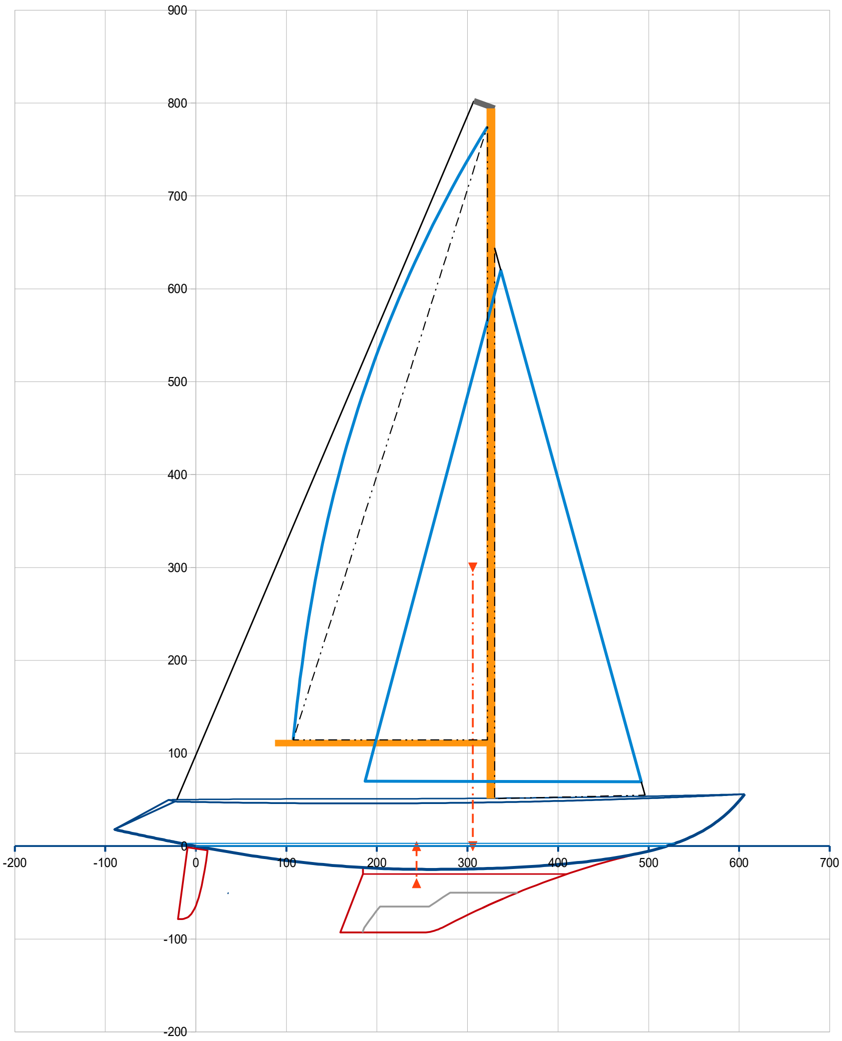
P = 6,60 m
E = 2,15 m
I = 5,92 m
J = 1,66 m => S = 12 m2

Mast height / H0 : ~ 8,0 m
Xmast at deck level : 3,26 m
Mast inclination : 0°
Boom lenght : ~ 2,35 m
Boom height / cockpit floor : ~ 1,03 m
Pole lenght : 1,65 m (< J)

Sailplan geometrical center (according to main and fore triangles) : Xv 3,06 m
Hull body, fin and rudder geometrical center : Xd 2,49 m
>> Xv – Xd : 10,8 %Lwl

Sails expected surface :
Mainsheet : 9,26 m2 (99,7 sqft)
Jib : 8,77 m2 (94,4 sqft)
>> Total Sv : 18 m2 (194 sqft)

Ratio Sv / Sw light weight : 2,37
(Sw 7,61 m2)
Ratio Sv / Sw with 200 kg payload : 2,14
(Sw 8,41 m2)



Rig :

Typical dimensioning :

Alloy mast 87mm/64mm type Selden C087 or equivalent, mass 1,67 kg/ml, inertia moments xz/yz 49,8 / 27,5 cm4

Alloy boom 87mm/60mm type Selden B087 or equivalent, mass 1,55 kg/ml

Alloy pole Diameter 50mm, type Selden S050 or equivalent, mass 0,84 kg/ml

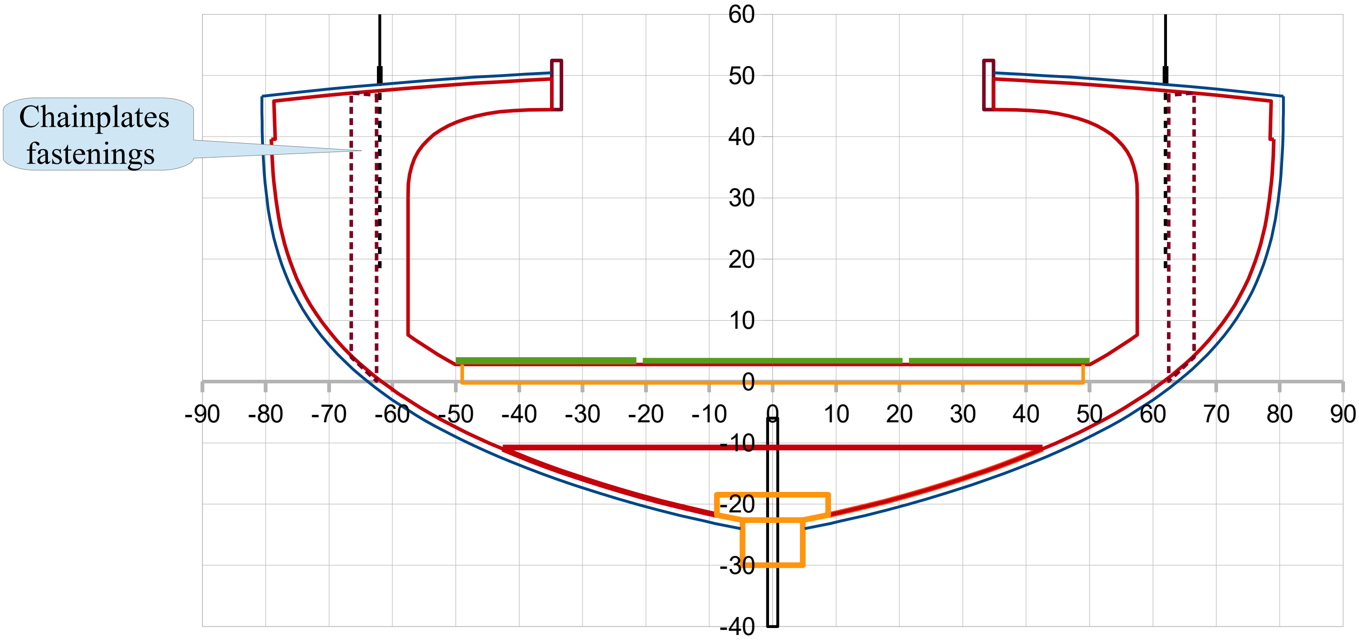
Frontstay-Backstay-Shrouds : steel cable Diameter 4 mm

The rigging plan :

Details of the rigging plan, including the angle of the spreaders, the position of the chainplates and the front sail sheet tracks in connection with the front sails cutting, are to be defined with both the rig supplier and the sailmaker.

Forestay and backstay efforts are taken back under the deck by fixations on the keel piece.

Chainplates are fastened to dedicated reinforcements under the deck and integrated to the frame X287, allowing the transmission of forces to the hull structure.



Annex A5 – Stability and righting moment

For this study, we consider the equipped boat and a reference payload of 200 kg distributed as follows (in the ship reference):

	Mass (kg)	X (cm)	Y (cm)	Z (cm)
2 crew	160	185	0 (au centre) 80 (au rappel)	64
Removable and personal equipement	40	250	0	10

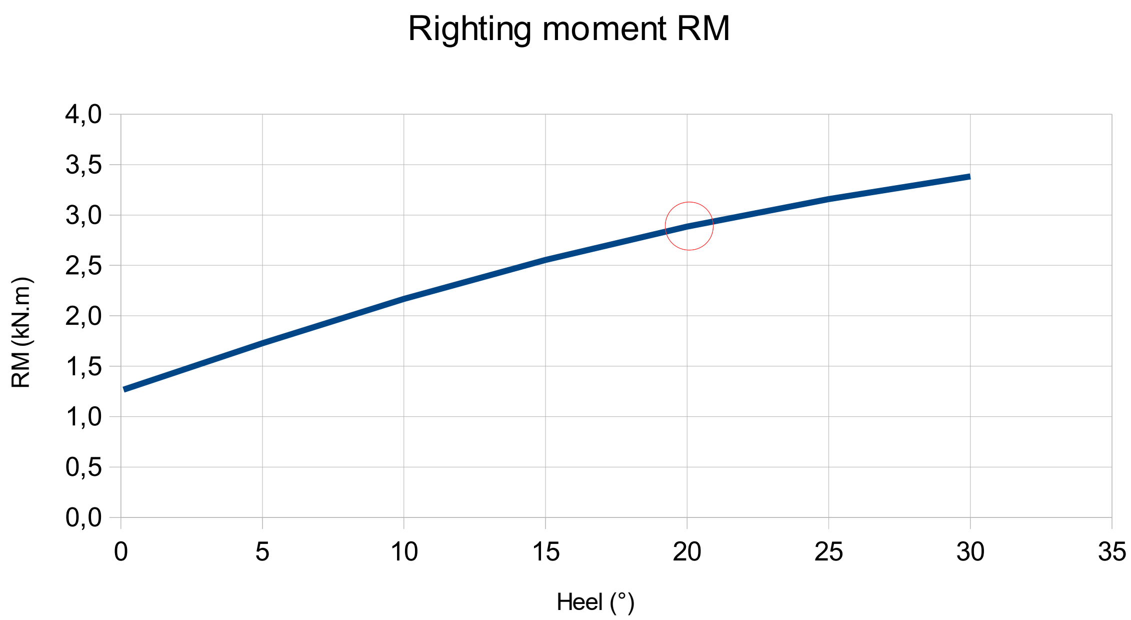
, which leads to the following weight data for the calculation:

Data from mass spreadsheet

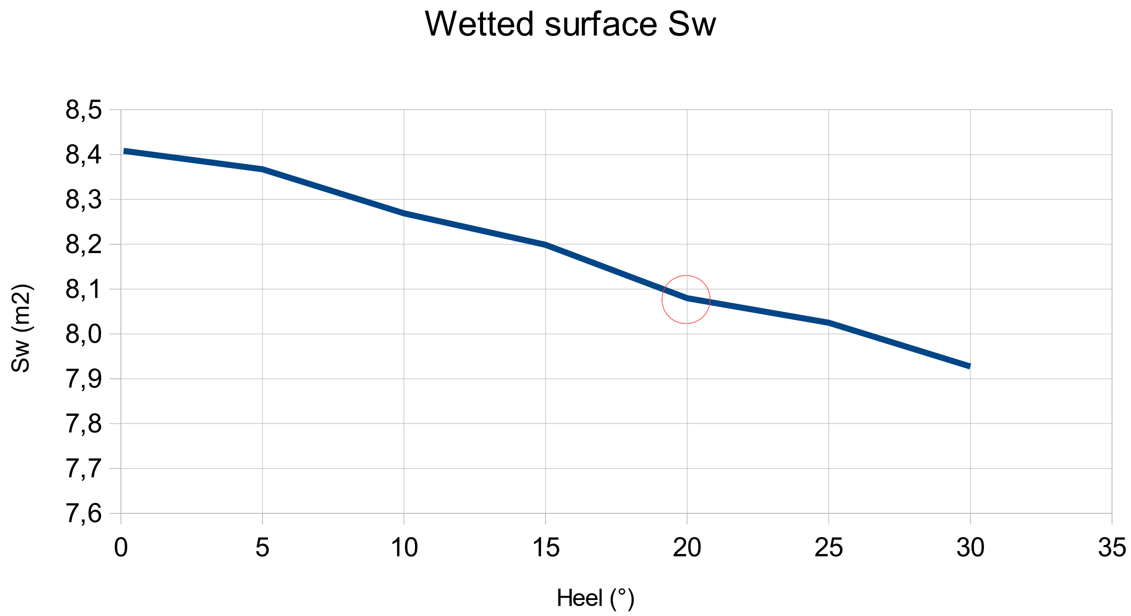
M tot (kg)	*880,2*	
Xg tot (m)	*2,396*	
Zg tot (m)	*0,002*	
Yg tot (m)	*0,145*	*Crew at hiking*
Yg tot (m)	*0,000*	*Crew at center*

>>> Stability with this payload and 2 crew at center (Y=0) >>> **GM(0,1°) : 64,1 cm**

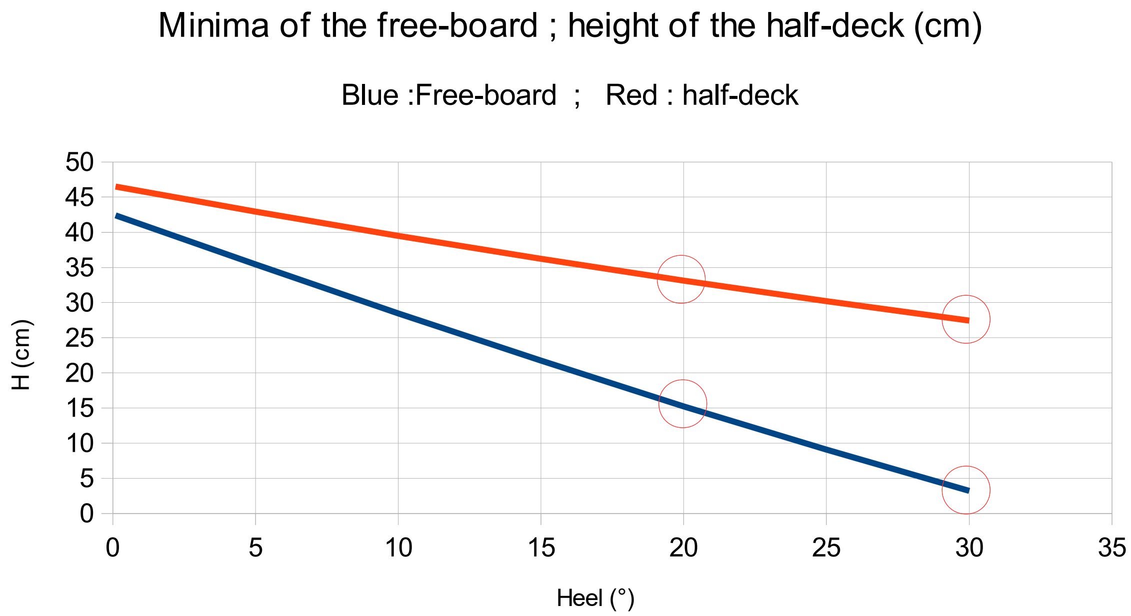
>>> Righting moment when the 2 crew are sit windward (Y ~ 80) :



>>> at **20° heel angle : RM = 2,88 kN .m**

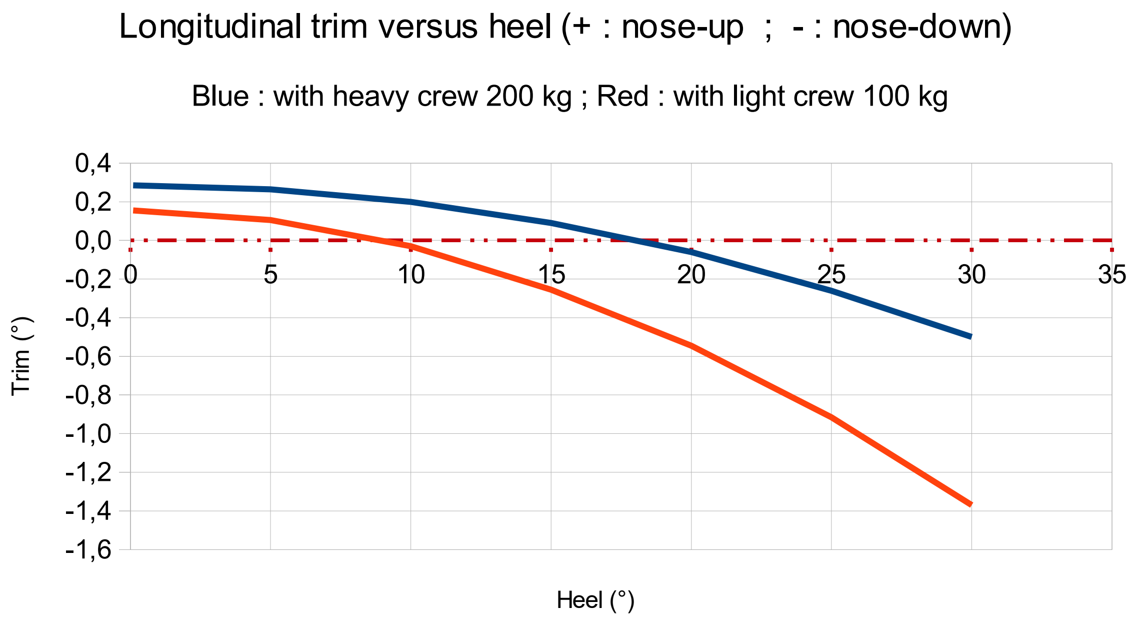


>>> at **20° heel angle : Sw = 8,08 m2**



>>> at **20° heel angle : Minimum free-board = 15 cm ; Height of half-deck = 33 cm**

>>> at 30° heel angle : Minimum free-board = 3 cm ; Height of half-deck = 27 cm


Longitudinal trim versus heel (+ : nose-up ; - : nose-down)
Blue : with heavy crew 200 kg ; Red : with light crew 100 kg
0,4
0,2
0,0
-0,2
-0,4
-0,6
-0,8
-1,0
-1,2
-1,4
-1,6
Trim (°)
0
5
10
15
20
25
30
35
Heel (°)

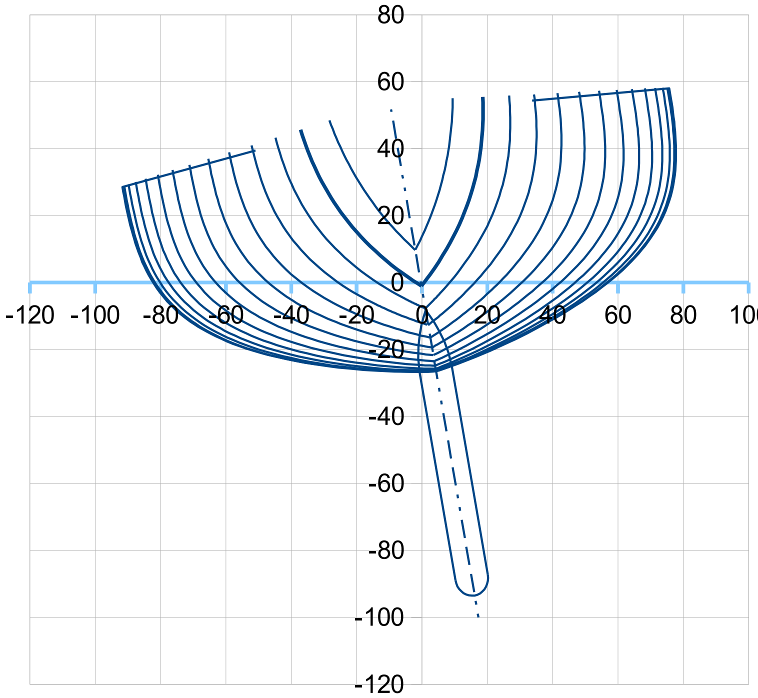
At 10° heel angle

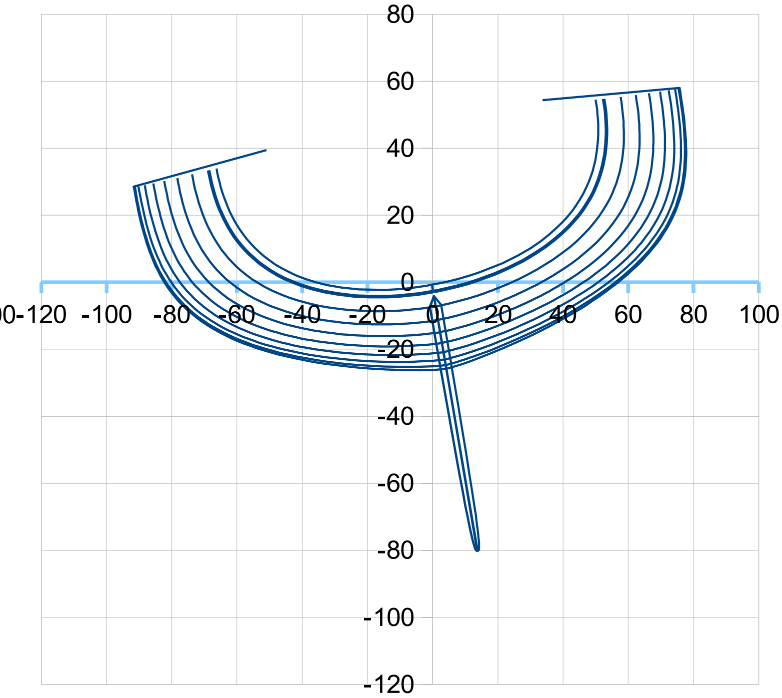
Data to enter	
Heel (°)	10,0
Height (cm)	-1,9577
Trim (°)	0,200

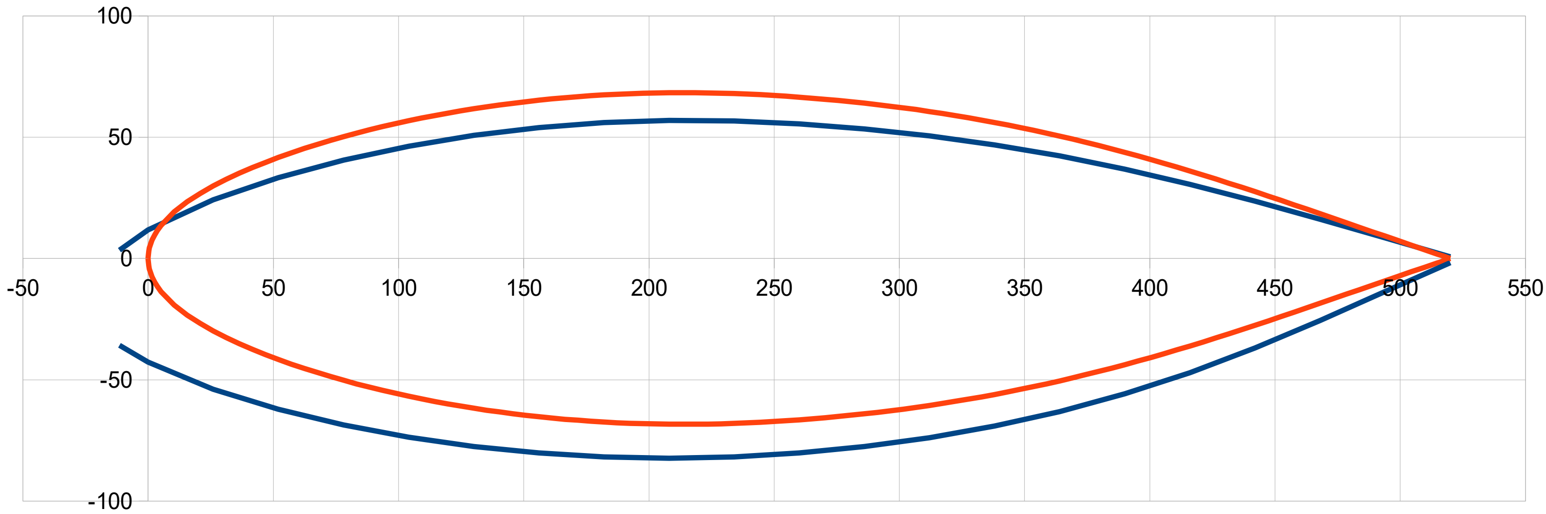
Results for iteration on height and trim	
Disp. (m3)	0,85876
Xc heel (m)	2,396
Other results	
Yc heel (m)	-0,108
Zc heel (m)	-0,131
Sw heel (m2)	8,89

Data to compare with :	
Mass (kg)	880,23
/ Disp. (m3)	0,85876
/ Xg (m)	2,396
Xc Heel 0°	2,470
Yc Heel 0°	0,000
Zc Heel 0°	-0,128
Sw Heel 0°	8,38

Other results for RM , GM (when Yg =0) obliquity and minimum freeboard		
Yg heel (m)	0,143	
>> GZ (m)	0,251	
RM (kN.m)	2,167	Crew at hiking
GM (cm)	*62,1*	*Crew at center (Yg=0)*
Obliquity (°)	1,34	
FB mini (cm)	28,4	
Hdeck mini (cm)	39,5	

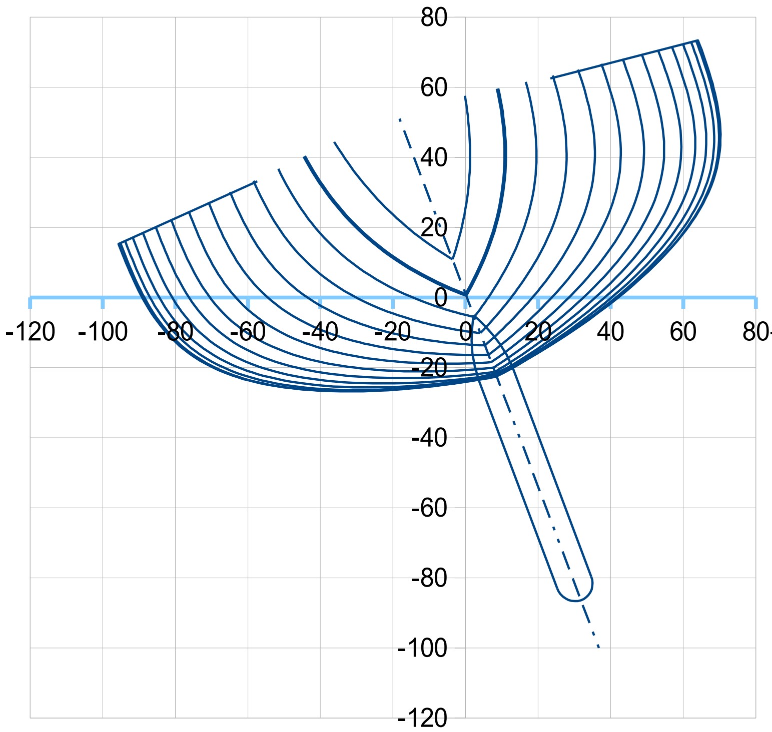


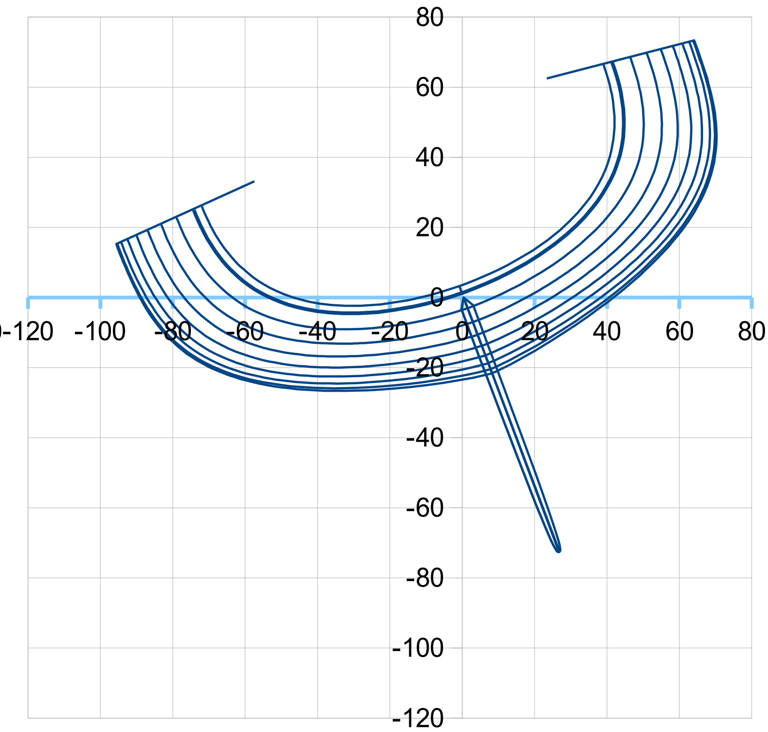


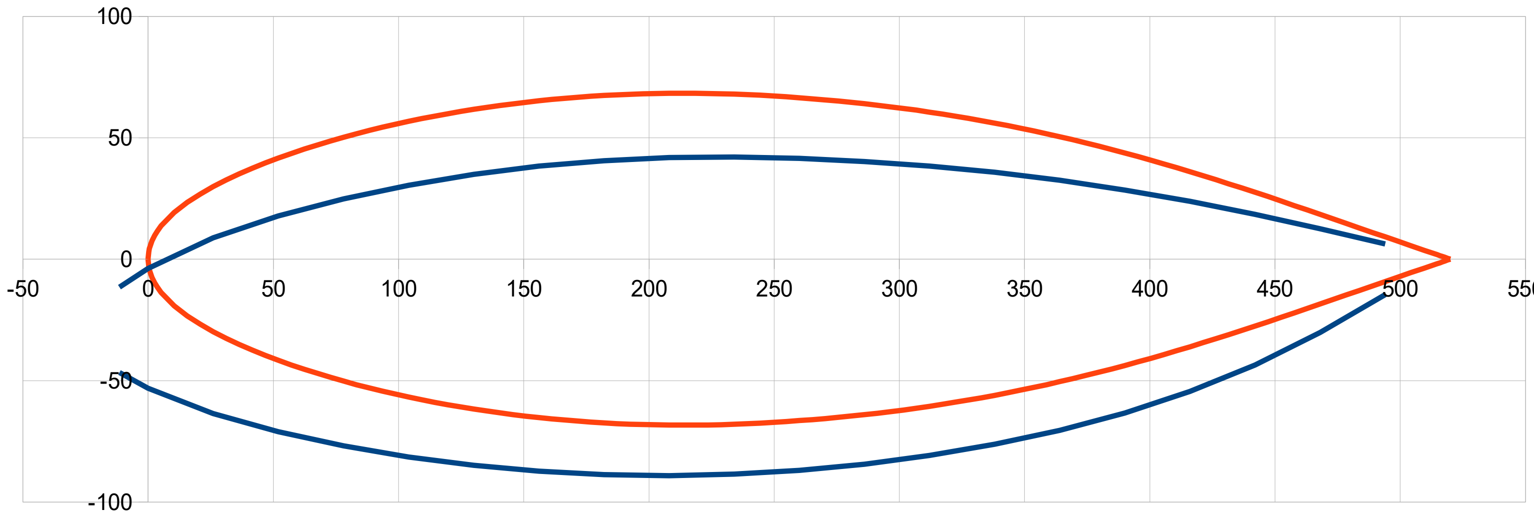


At 20° heel angle

Data to enter		**Results for iteration on**		**Data to compare with :**		**Other results for RM , GM (when Yg =0)**		
Heel (°)	**20,0**	**height and trim**		Mass (kg)	880,23	**obliquity and minimum freeboard**		
Height (cm)	**1,0804**	**Disp. (m3)**	**0,85876**	**/ Disp. (m3)**	**0,85876**	**Yg heel (m)**	**0,136**	
Trim (°)	**-0,060**	**Xc heel (m)**	**2,396**	**/ Xg (m)**	**2,396**	**>> GZ (m)**	**0,334**	
		Other results		Xc Heel 0°	2,470	**RM (kN.m)**	**2,883**	**Crew at hiking**
		Yc heel (m)	**-0,198**	Yc Heel 0°	0,000	***GM (cm)***	***57,7***	***Crew at center (Yg=0)***
		Zc heel (m)	**-0,129**	Zc Heel 0°	-0,128	**Obliquity (°)**	**2,46**	
		Sw heel (m2)	**8,70**	Sw Heel 0°	8,38	**FB mini (cm)**	**15,2**	
						Hdeck mini (cm)	**33,1**	

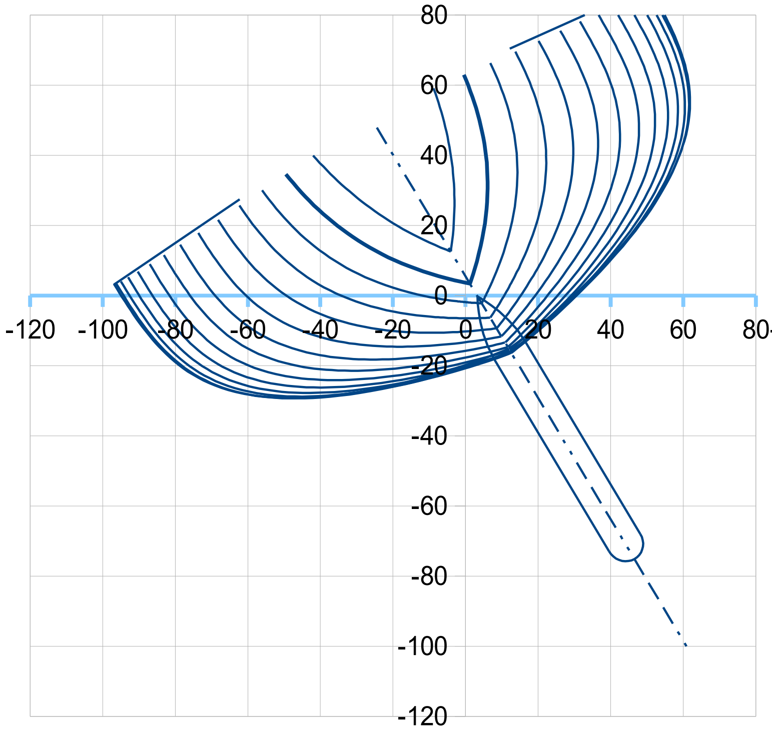


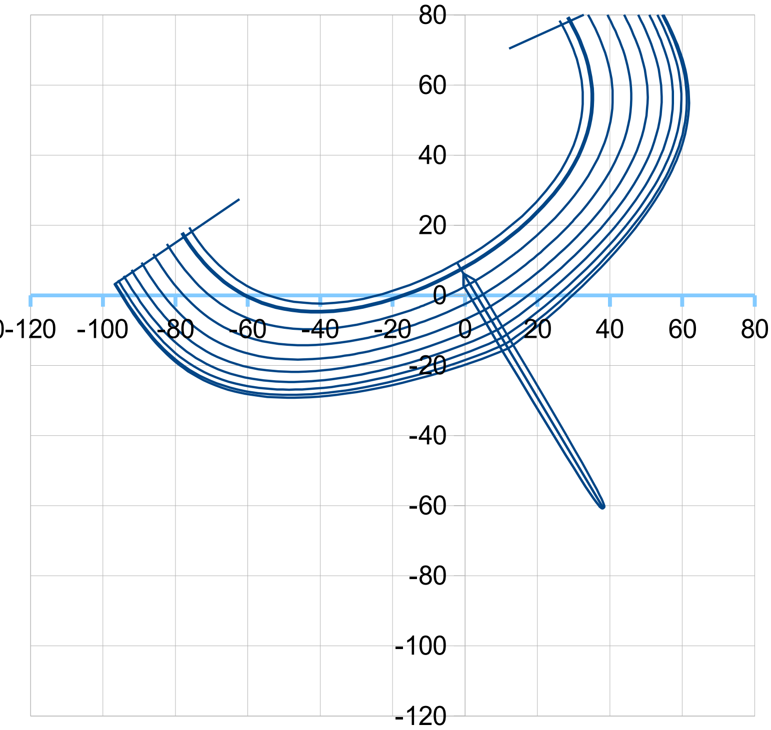


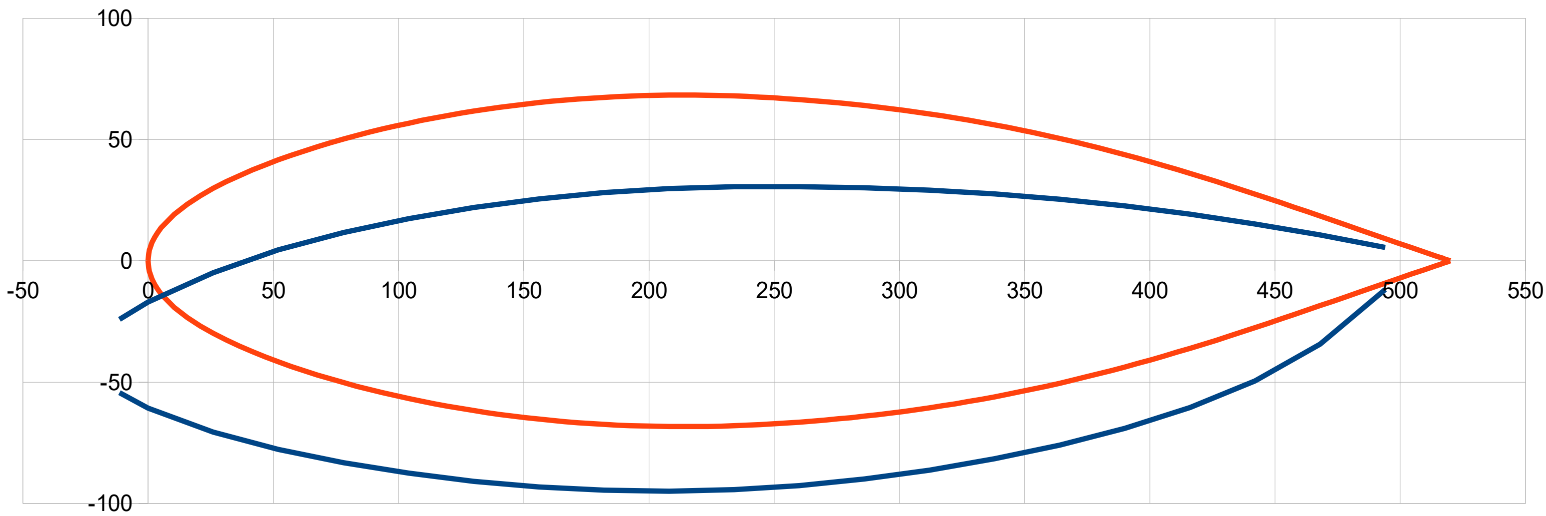


At 30° heel angle

Data to enter		**Results for iteration on height and trim**		**Data to compare with :**		**Other results for RM , GM (when Yg =0) obliquity and minimum freeboard**		
Heel (°)	**30,0**			Mass (kg)	880,23			
Height (cm)	**6,3583**	**Disp. (m3)**	**0,85876**	**/ Disp. (m3)**	**0,85876**	**Yg heel (m)**	**0,125**	
Trim (°)	**-0,500**	**Xc heel (m)**	**2,396**	**/ Xg (m)**	**2,396**	**>> GZ (m)**	**0,392**	
		Other results		Xc Heel 0°	2,470	**RM (kN.m)**	**3,382**	**Crew at hiking**
		Yc heel (m)	**-0,267**	Yc Heel 0°	0,000	***GM (cm)***	***53,2***	***Crew at center (Yg=0)***
		Zc heel (m)	**-0,125**	Zc Heel 0°	-0,128	**Obliquity (°)**	**3,40**	
		Sw heel (m2)	**8,54**	Sw Heel 0°	8,38	**FB mini (cm)**	**3,2**	
						Hdeck mini (cm)	**27,4**	







Annex A6 – Flooded equilibriun and buoyancy

Flottability reserves :
" When the boat is filled with water, buoyancy reserves must be sufficient to keep the boat afloat and to provide sufficient stability with the crew on board."

The front and rear inside volumes of the boat allow the installation of buoyancy reserves of respectively 500 and 400 liters, made from blocks of expanded low density polystyrene (~ 20 kg / m3). In the following flooding study, these buoyancy volumes are assumed to be linearly distributed with the height, from z + 0 to z +50 cm :

Estimation of the maximum weight to consider :
Light weight (680 kg) with a crew of 3 with their personal cloths and food (270 kg) = 950 kg

Masses and buoyancies for the flooding study	Mass (kg)	Rho (kg/m3)	Buoyancy (kg)
Fin-ballast, massive interface, rudder	372		91
Wood hull and structure from Z -30 cm à +50cm >>	251	700	108
Rig and equipment above Z +50 cm >>	39		0
Flottability from Z 0 à Z +50	18	20	882
Total light weight	***680***		
Mass crew 3 + personal	270		0
Total in charge	***950***		

z immersion (cm)	**Masses (kg)**	**Buoyancies (kg)** Fin-ballast Massif,Rudder	Hull Structure	Rig Equipement	Crew 3	Flottability	**Balance net buoyancy**
-30	-950	91	0	0	0	0	-859
-25	-950	91	7	0	0	0	-852
-20	-950	91	13	0	0	0	-846
-15	-950	91	20	0	0	0	-839
-10	-950	91	27	0	0	0	-832
-5	-950	91	34	0	0	0	-825
0	-950	91	40	0	0	0	-819
5	-950	91	47	0	0	88	-724
10	-950	91	54	0	0	176	-629
15	-950	91	61	0	0	265	-534
20	-950	91	67	0	0	353	-439
25	-950	91	74	0	0	441	-344
30	-950	91	81	0	0	529	-249
31	-950	91	82	0	0	547	**-230**
35	-950	91	87	0	0	617	-154
40	-950	91	94	0	0	706	-59
43	**-950**	**91**	**98**	**0**	**0**	**759**	**-2**
45	-950	91	101	0	0	794	36
50	-950	91	108	0	0	882	**131**

In this extreme case where the 3 people do not bring any buoyancy in their own, the waterline is + 43 cm and the net buoyancy reserve is 131 kg.

If 3 people "bathe" at zero apparent weight in the invaded cockpit, reducing the acting weight by ~ 225 kg, the waterline is then + 31 cm, so a minimum freeboard of + 15 cm.

Annex A7 - Compliance with the « 12m2 du Havre » rules

Sailplan parameters :

G = 6,60 m
B = 2,15 m
I = 5,92 m
J = 1,66 m **=> S rule = 12 m2**

Ballast :

A volume of 0,02940 m3, integrated to the fin, is made of lead (11350 kg/m3) :

>>> 334 kg > 200 kg

Beam overall :

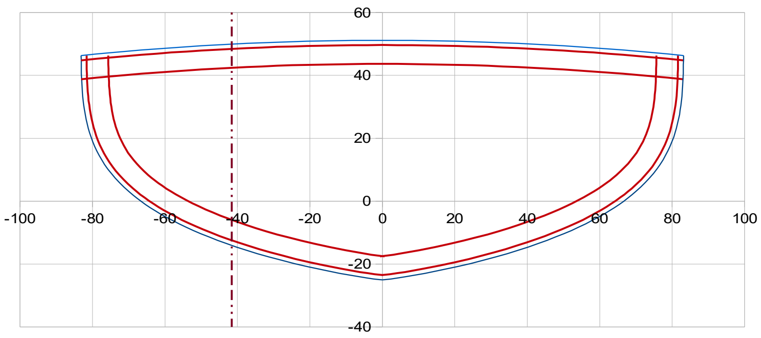
>>> 1,70 m > 1,40m

Midship quarter beam hull depth , measured at the middle of the lenght overall between the inside of the hull plating and the underside of the gunwales, should be > 0,45 m :

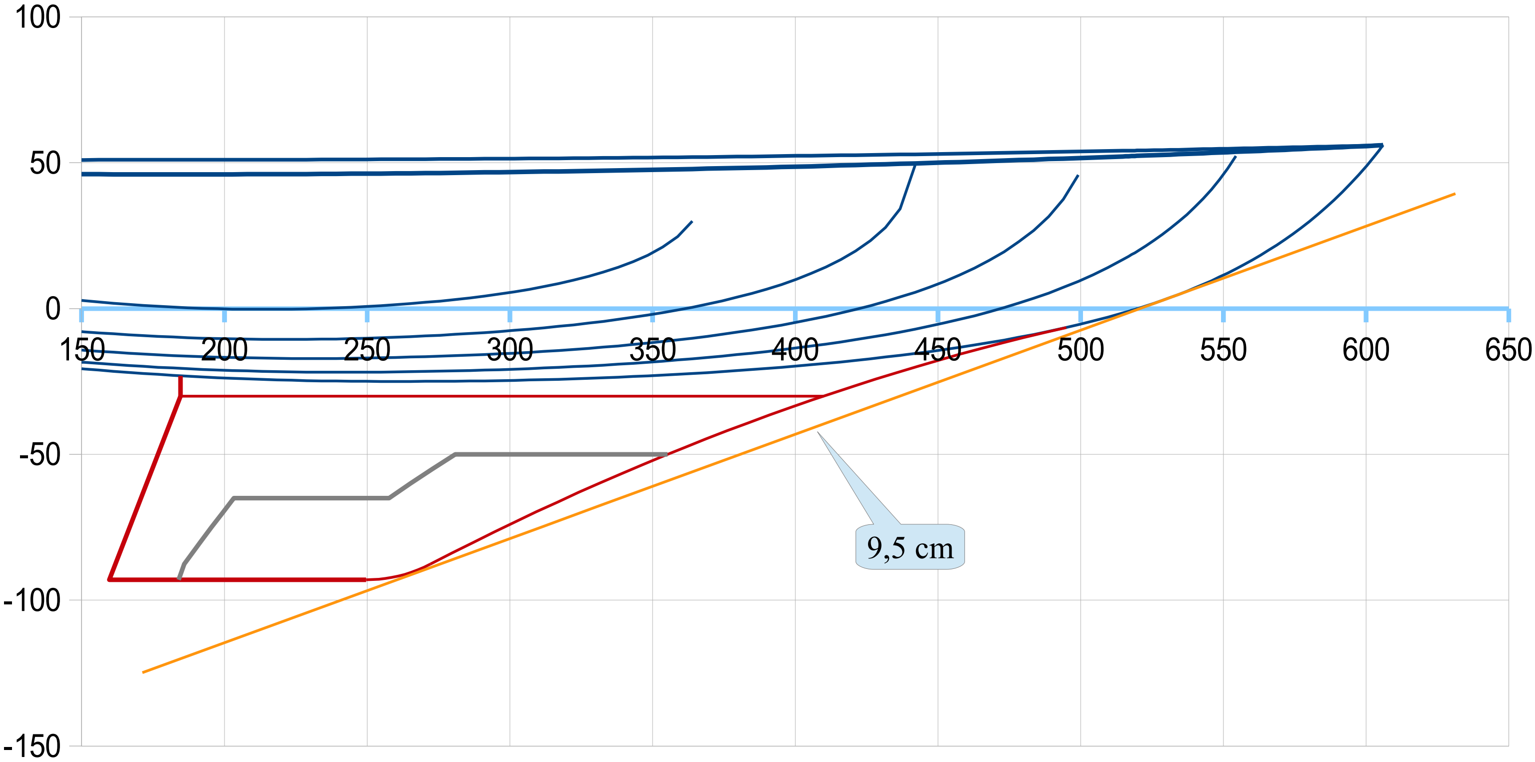
The middle of the lenght overall corresponds to the section X 318

Hull beam at X 318 : 166,26 cm
=> quarter beam : y = 41,56 cm
z inside plating = -12,1 cm (with slats Th. 14 mm)
z inderside the gunwales = + 49,95 cm

>>> quarter beam hull depth : 62 cm > 45 cm



Concavity rule : 9,5 cm < 10 cm



Hull construction :

>>> classic strip-planking construction on frames, with slats Th. 14 mm

Flottability reserves :

" When the boat is filled with water, buoyancy reserves must be sufficient to keep the boat afloat and to provide sufficient stability with the crew on board."

>>> 900 liters of buoyancy in the form of plates or blocks of low density expanded polystyrene are installed in the volumes available in front of the X336 and behind the X88 frames, and provide a net buoyancy of 131 kg in case of full flooding with a net load of 270 kg (3 persons at max), see details in Annex A6

Acknowledgement

My warm thanks to Alain Lebeau who encouraged me and supported me in my approach, who brought me all his experience of sailor and owner of an historical 12 m2 Le Havre ("*Françoise*") to guide me in this design process, who made all the beautiful 3D views that illustrate this brochure.