Gene-Hull Double-ended User Guide_En

Introduction

Gene-Hull Double ended makes possible the generation of double ended hulls for sailing yacht with their 2D views and their hydrostatic characteristics as output with keel and rudder included. It is based on a spreadsheet application (Open Office Calc 4.0.1) involving fit for purpose formulations of the polynomial type, able to generate the hull fairing lines. It needs a relatively small number of data to enter : basic geometrical data, parameters used in the formulations. This User Guide gives all definition and information on the role and influence of each data, with illustrations. Moreover, the User has the data of a reference hull allowing him to start his own project step by step.

For each new data introduced, all the computations and the drawings are updated automatically. Proposed parameters allow an infinity of combinations, so as many possible variants of a hull. Drawings and hydrostatic data, including ratios usually considered by naval architects, make possible to judge the hull and to converge towards the desired one. In section 6. of the results, the computation of the hull with heel angle is proposed (in hydrostatic condition, at iso displacement), and provide the righting moment due to the hull and the offset of its center of buoyancy.

Produced data allow either to continue the project with a 3D modeller (for that option, all necessary data are gathered in section 5.) or to draw any sections and frames needed for a building (data are provided in section 7.).

After an apprenticeship that I hope light thanks to this User Guide and mostly the hull of reference given to initiate a new project, it is very easy and even fun to create a great number of hulls within just few clicks, up to test unusual values of parameters to find out new style or shape of hulls : combinations are infinites and sometimes unpredictables (it is also a way to test the limits of this software). Of course at the end, the final choice is up to you, taking into account your experience as naval architect.

It is a free and open speadsheet application, on a support itself widespread (Open Office Calc), computations are done in the Administrator Space which is itself free of access. On request, a technical appendix can give you all the formulations involved and if necessary you can improve the tool yourself and share it with the community of amateurs of naval architecture. Or you can contact me with your remarks and improvement requests.

Jean-François Masset – August 2017 contact : jfcmasset@outlook.fr

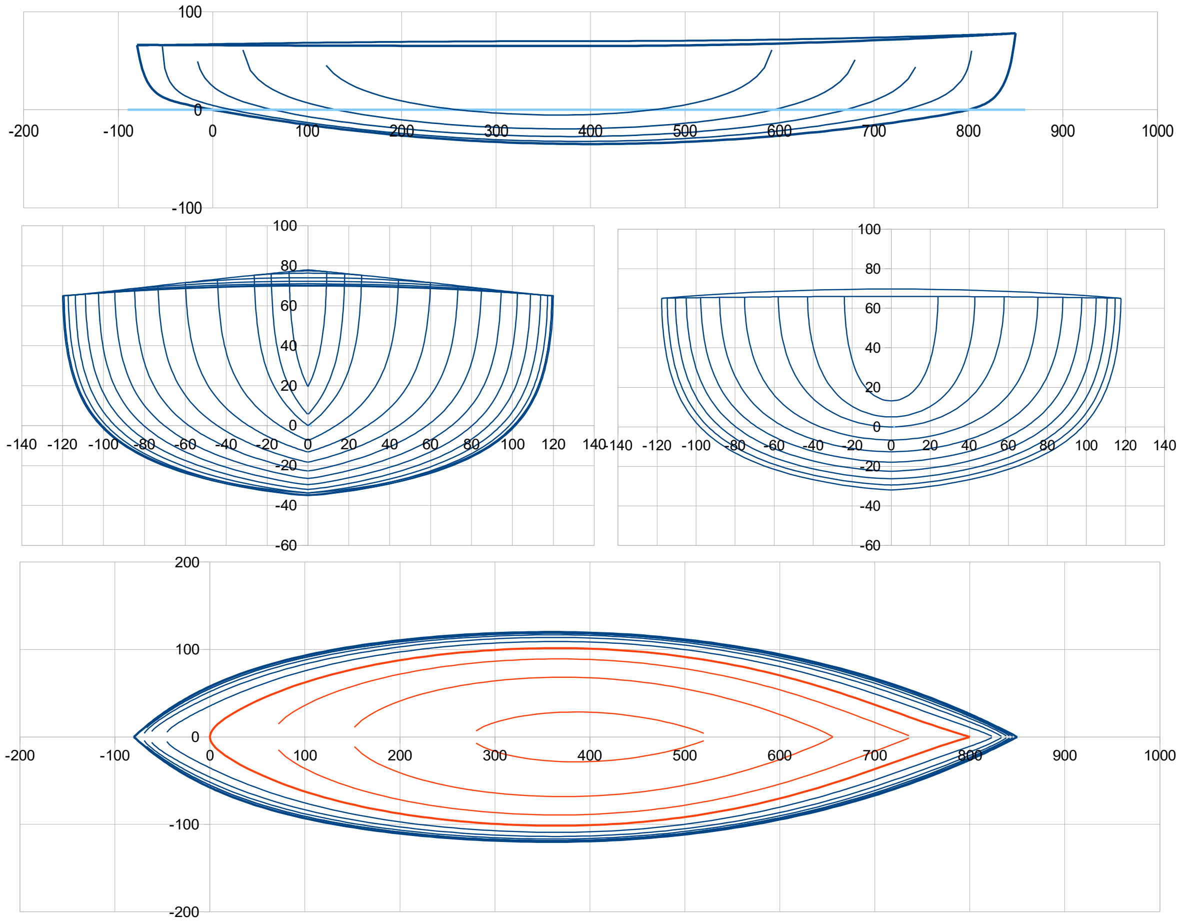
Summary presentation

The speadsheet application includes on the first sheet an User space (input & outputs) followed by an Administrator space where the computations are carried out. The User space includes 7 successive sections :

1. Data to enter
2. Data sum-up and results of hydrostatic and surfaces calculations
3. The 3 views 2D
4. Curves of control
5. Data for transfer to a 3D modeller
6. Hull with heel
7. Data for hull sections drawing at scale one, inc. hull frames and deck bars

The coordinates x,y,z used fo the views include :

- Origin 0,0,0 at the cross of the designed waterline surface (« H0 » level) and the perpendicular at the rear point of the waterline (section C0). The perpendicular at the front point of the waterline is section C10.
- x = longitudinal axis (positive towards front),
- y = transversal axis,
- z = vertical axis (positive towards up), Showed unities on the views are **cm**



Automatic scales are proposed for the views, with a main grid with a fixed pitch. Nevertheless, it is suggested for the User, as long as the main dimensions of the new project are fixed, to put the views at the right scale and to fix it.

Input

1. Data to enter

Data to enter are in column B, the ones of the hull of reference are in column D. Simplified views of the hull are showed opposite to the data so that one can see in real time the main effect of each data new value (sometimes about one second is necessary for the completion of the full computation). **Input unities are in m**, ***with conversion in feet in column C .***

Length of waterline

Lwl (m) : length of waterline at H0

Rear perpendicular crosses H0 plan at the coordinates origin (0, 0, 0). Front perpendicular crosses H0 at (Lwl, 0,0) point.

Hull body draft

Tc (m) : maximum draft of the hull body (positioned at 50% Lwl)

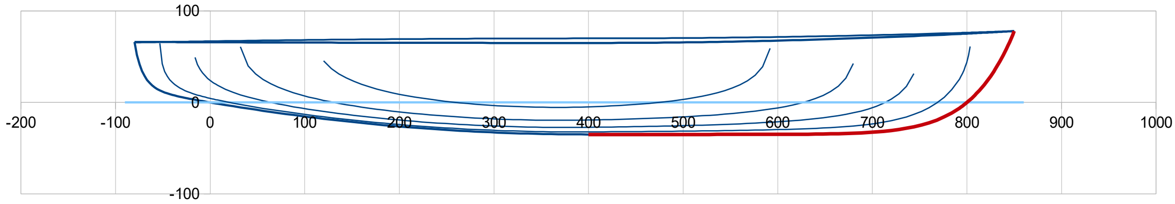
Nota : fixing the maximum draft at 50% Lwl is not really a restriction, as all other parameters to define front and rear part of the keel line are flexible enough to draw any kind of usual shape.

Keel line / front part (x > 50% Lwl)

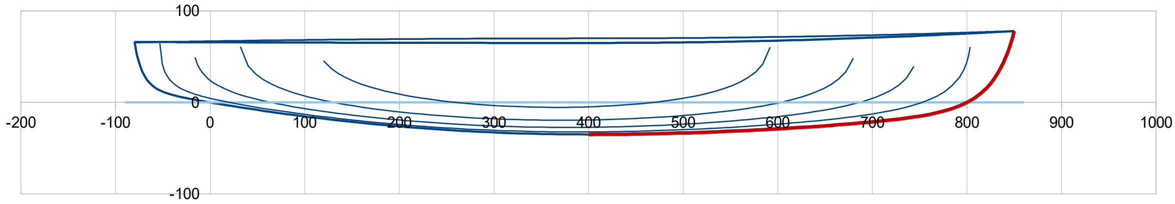
Bow end point :
Xbow (m) : should be > Lwl ; **Z bow (m) :** it is the front freeboard

Cet av : adimensional coefficient > 0, from 0,1 to 100 typically. This coefficient is involved in the polynomial formulation of the front part of the keel line and mostly influence the bow shape. Examples (at constant overhang) :

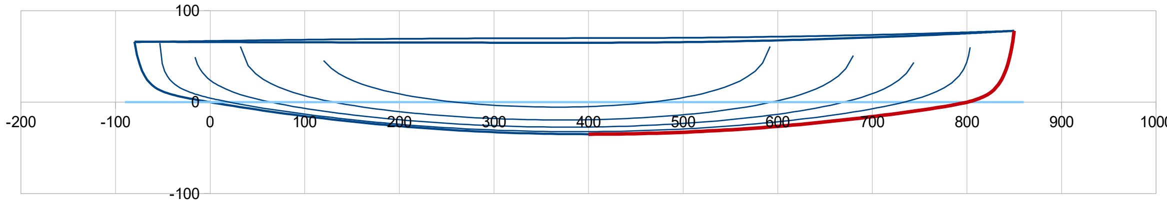
Cet av = 0,1 :



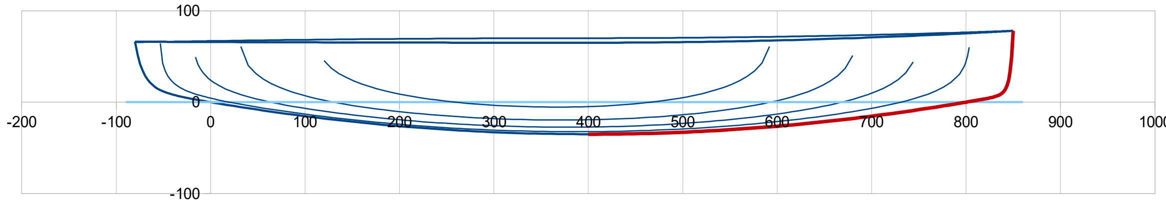
Cet av =10 :



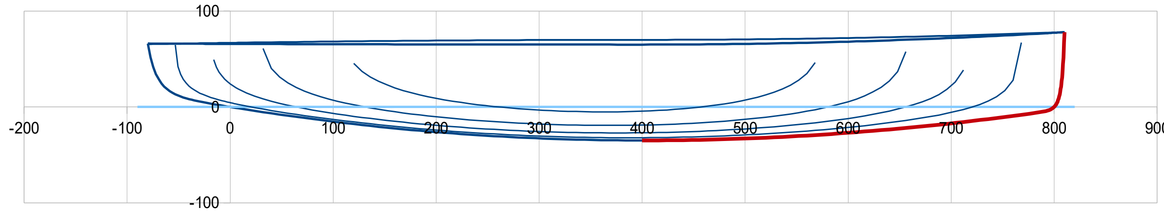
Cet av 30 :



Cet av 100 :



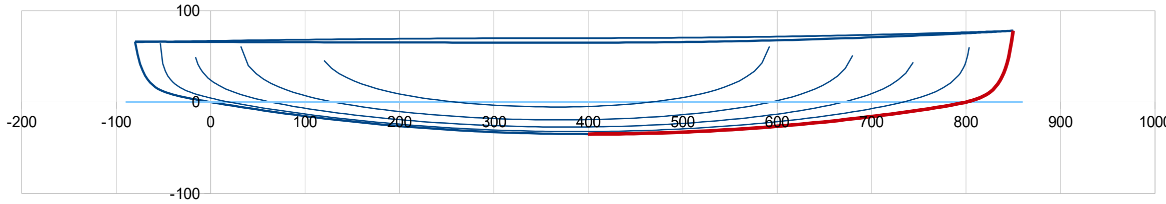
Cet av 100 with a short overhang (X bow close to Lwl) :



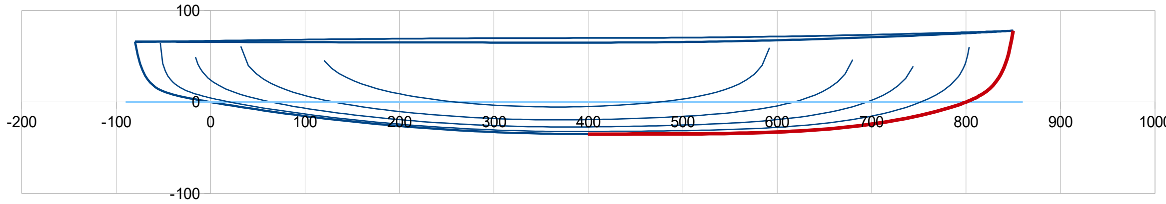
Important : Cet av being a sensible parameter for the system, it is recommended to put at first Cet av = 1 when beginning a new hull.

Pui q av : adimensional coefficient which figures the power factor of the front polynomial (details of the formulation in the technical appendix on request). Should preferably be ≥ 2, some examples :

Pui q av = 2 :



Pui q av = 4 :



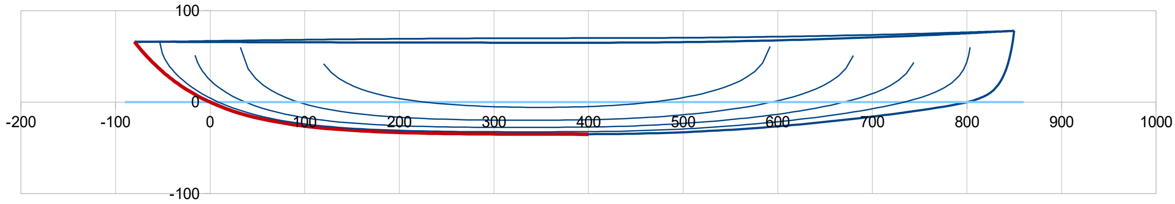
Nota : for the bow shape, eventually 3 data are of major influence : Xbow (acting on the front overlenght), Cet av (acting on the bow shape) and Pui q av (acting on the overall shape of the front keel line).

Keel line / rear part (x < 50% Lwl)

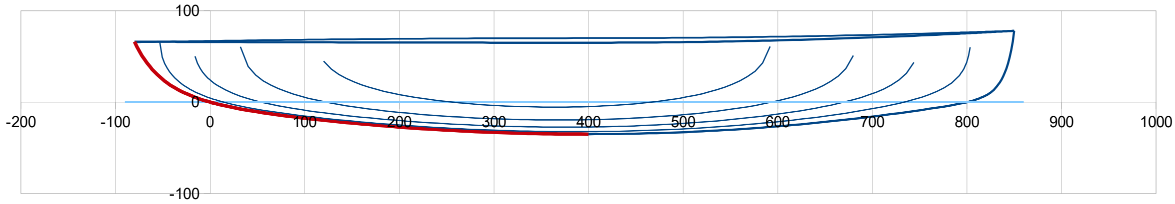
Rear end point : common to the keel line and the sheer line in the double ended configuration.
Xar (m) : X of the rear point overall, should be less than all other X ; **Zar (m) :** Z of the rear point

Cet ar : adimensional coefficient > 0, from 0,1 to 100 typically. This coefficient is involved in the polynomial formulation of the front part of the keel line and mostly influence the bow shape. Examples (at constant overhang) :

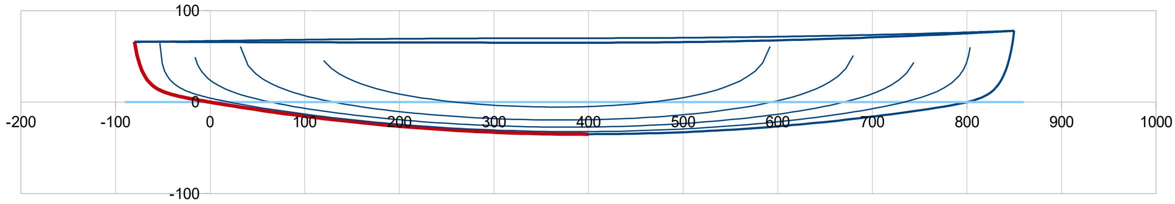
Cet ar = 1 :



Cet ar =10 :

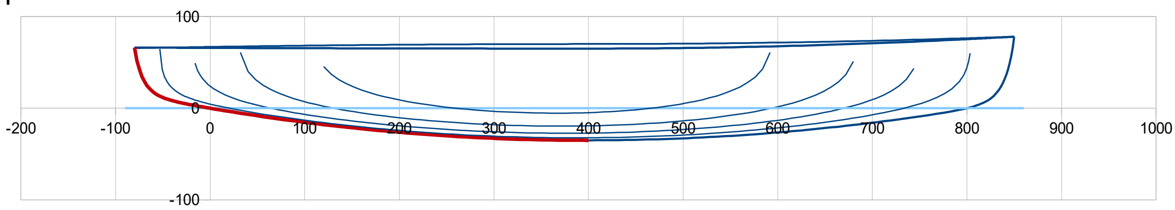


Cet ar 40 :

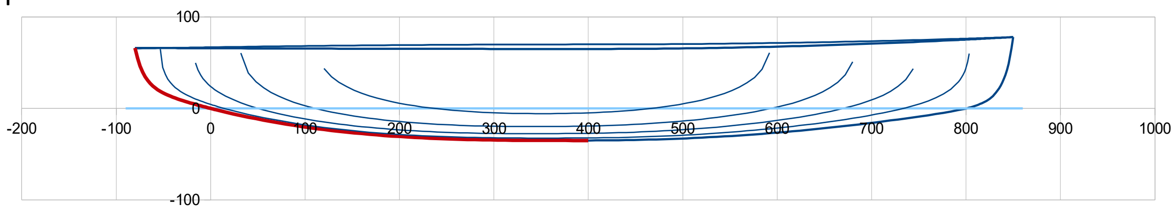


Pui q ar : adimensional coefficient which figures the power factor of the rear polynomial (details of the formulation in the technical appendix on request). Should preferably be ≥ 2 , some examples :

Pui q ar : 2



Pui q ar : 3



Nota : as for the bow shape, eventually 3 data are of major influence on the rear shape : Xar (acting on the rear overhang), Cet ar (acting on the rearshape) and Pui q ar (acting on the overall shape of the rear part of the keel line).

Sheer line in horizontal plan (plan xy)

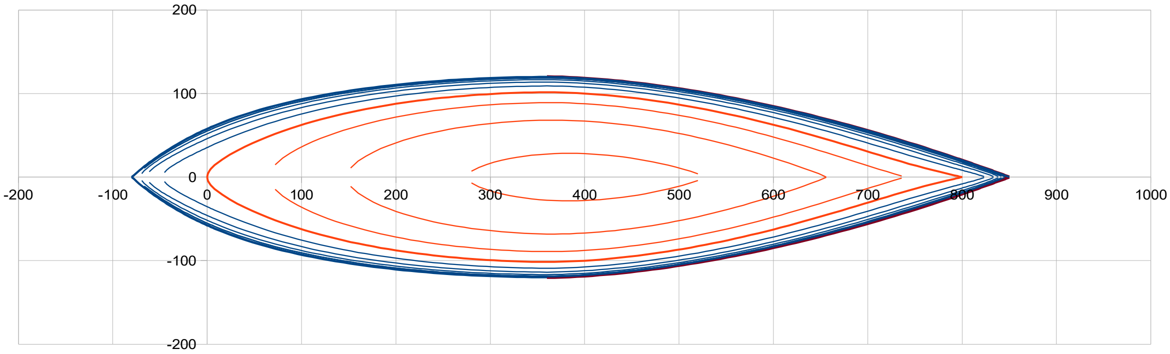
Bmax (m) : maximum beam, positioned at 43% lwl (this fixed position of the maximum beam could be seen as a restriction but actually, thanks parameters here below, a great variety of sheer line can be performed with various position of the maximum curvatures)

Sheer line fore part (> 42% Lwl) :

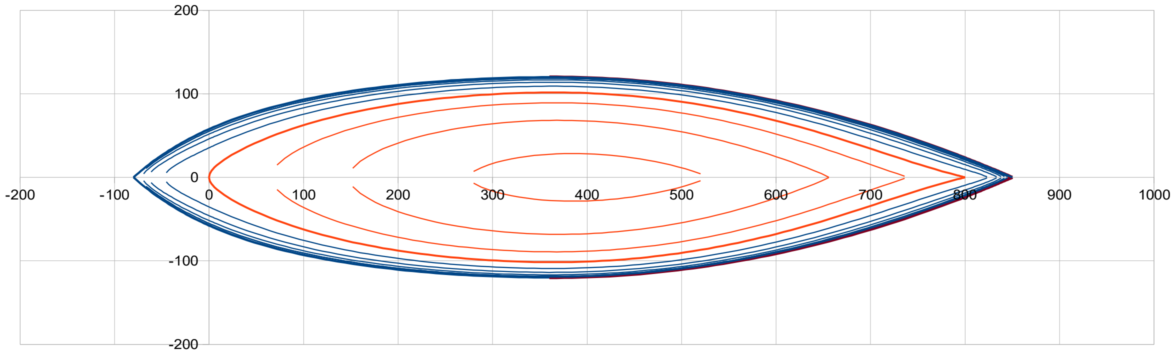
Pui livav, Cor Pui livav and Pui Cor Puiav : there are 3 adimensional coefficients for respectively the power of the sheer line polynomial fore part, its correction along with x and the power of the correction polynomial itself (formulation details in the technical appendix).

Pui livav = 2 gives the better curvature regularity in the midship zone, it is the recommended value. Pui livav < 2 lead to a more accentuated curvature (up to a folding when Pui liv < 1,5) and on the other hand a Pui livav > 2 lead to a flatenness in the midship zone. Examples :

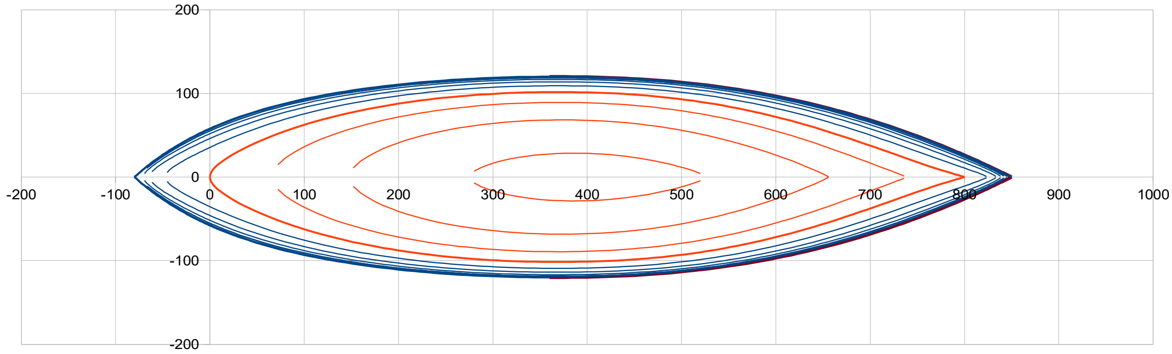
Pui livav = 1,7 :



Pui livav = 2 :

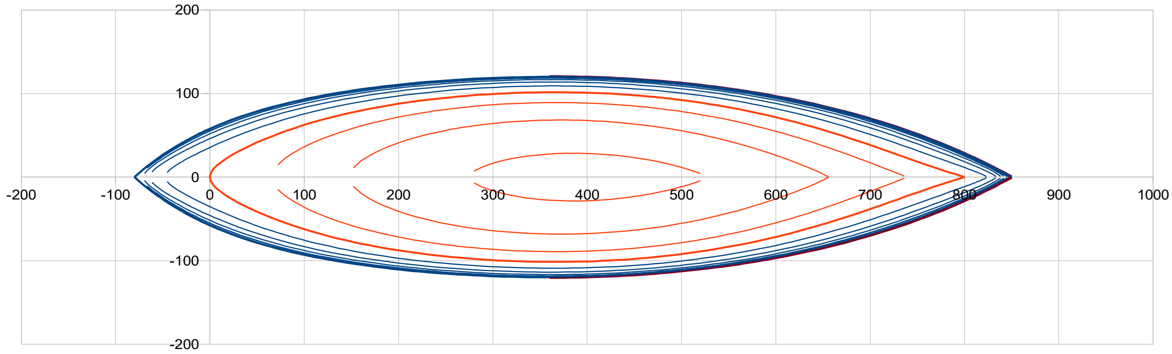


Pui livav = 2,3 :

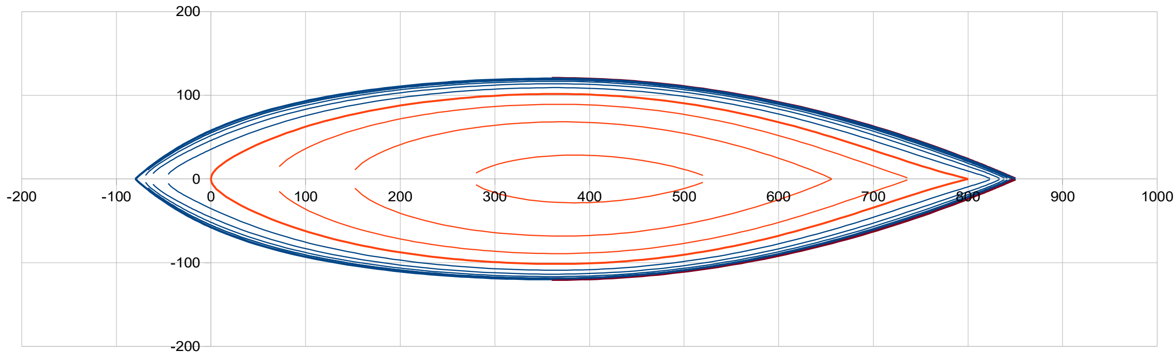


Cor Pui livav can add more or less tension towards the front end of the sheer line, meaning end with more or less curvature. Exemples :

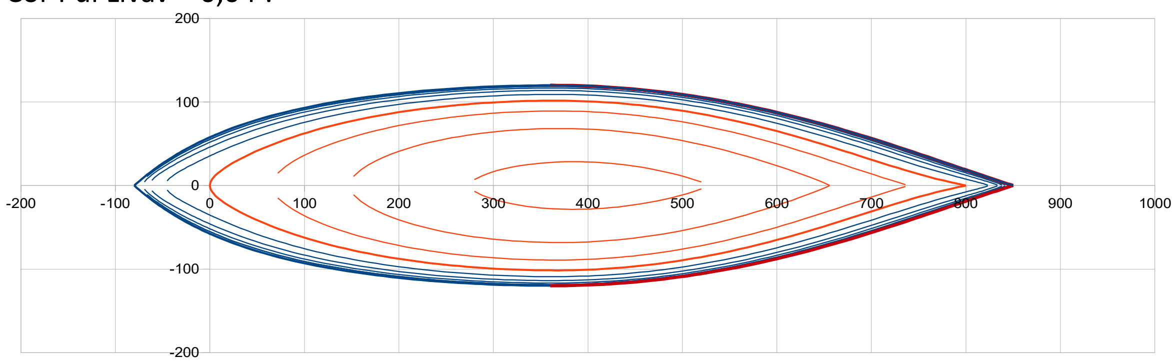
Cor Pui livav = -0,04



Cor Pui livav = 0,0

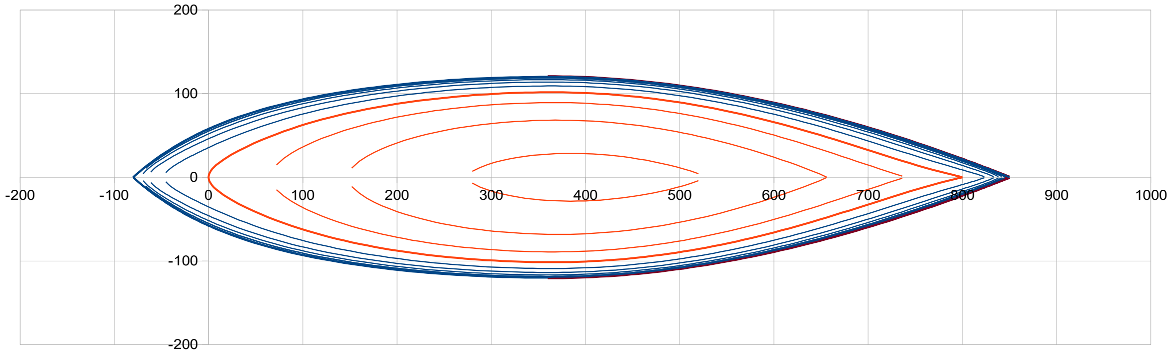


Cor Pui Livav = 0,04 :

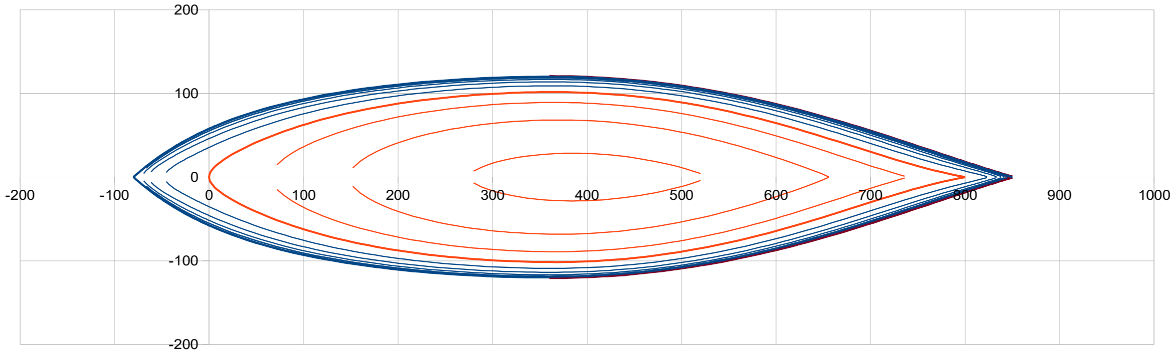


Pui Cor Puiav: acts on the application with x of the correction Cor Puiav.
Pui Cor Puiav =1 >>> correction application is linear. Pui Cor Puiav > 1 amplifies the correction application towards the end. Some examples :

Pui Cor Puiav = 1



Pui Cor Puiav = 4

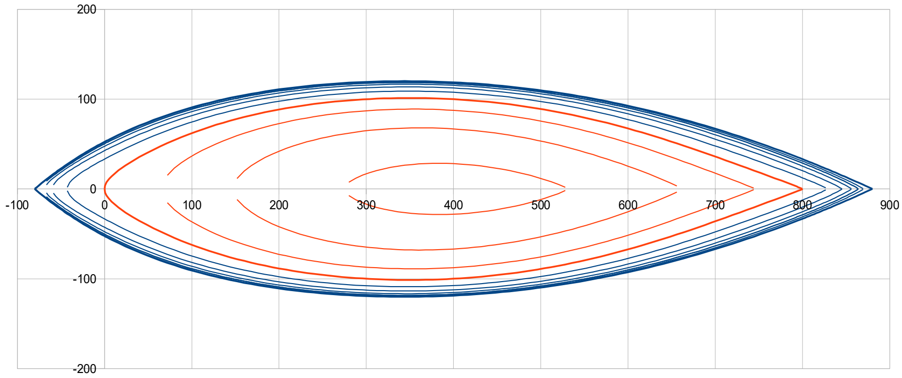


Nota : with recommended values of 1 to 4, Pui Cor Puiav acts as a fine tuning of the tensioning of the fore end of the sheer line triggered by Cor Puiav.

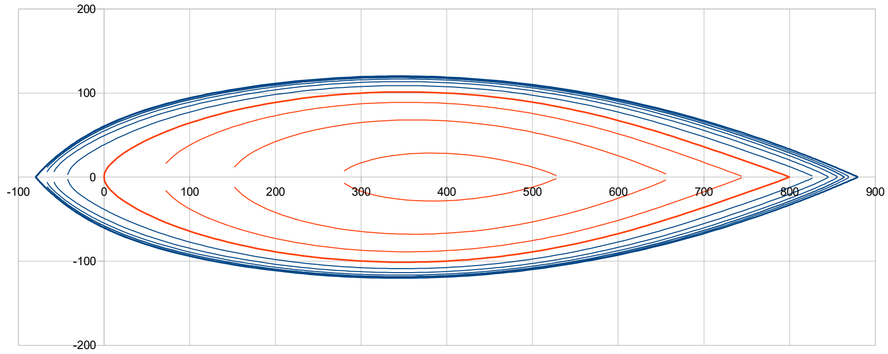
Sheer line rear part (< 43% Lwl) :

C liv ar : adimensional coefficient for a sheer line in continuity of curvature with the fore part and joining the rear point Xar with a roundness more or less important. The larger C liv ar, the more roundness in the rear body. Examples :

C liv ar = 2 :



C liv ar = 5 :



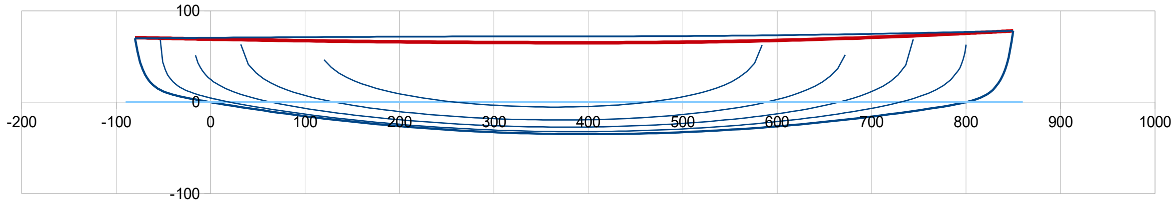
Sheer line in vertical projection (plan xz)

Z liv m (m) : it is the midship freeboard, specified at 50% Lwl

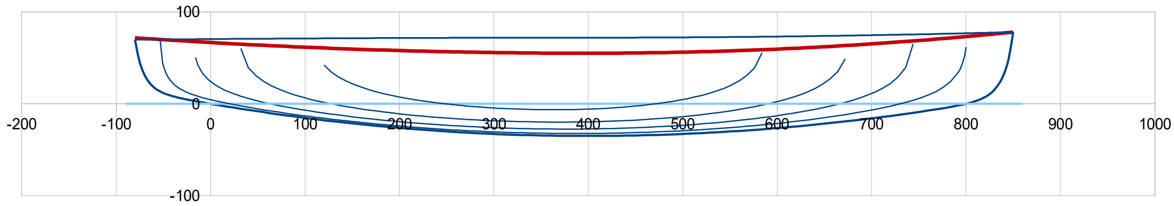
Together with Zbow and Zar defined here before, these are the 3 freeboards on which leans the xz polynomial for the sheer line.

Pui liv z : it is the power of this polynomial. Recommended values ≥ 2. Some examples with two different values of Z liv ar :

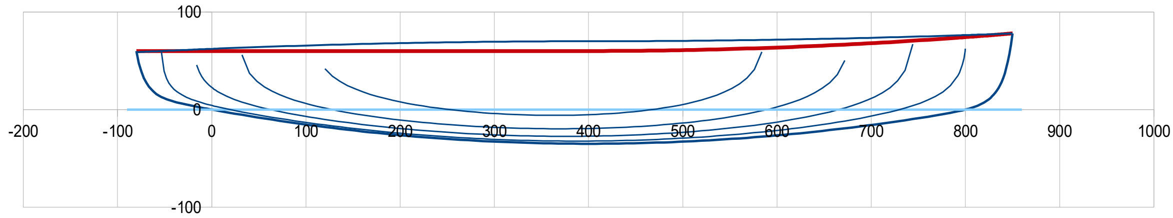
Z bow : 0,78 ; **Z liv m = 0,65** ; Zar = 0,70 ; Pui liv z = 2 :



Z bow : 0,78 ; **Z liv m = 0,55** ; Zar = 0,70 ; Pui liv z = 2 :



Z bow : 0,78 ; **Z liv m = 0,60 ; Zar = 0,60**; Pui liv z = 2 :

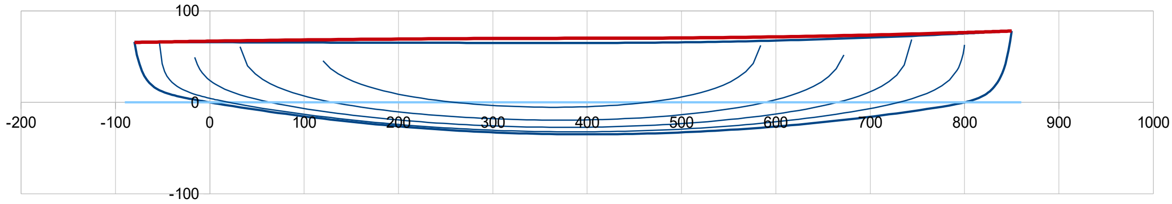


Deck / central line of symmetry

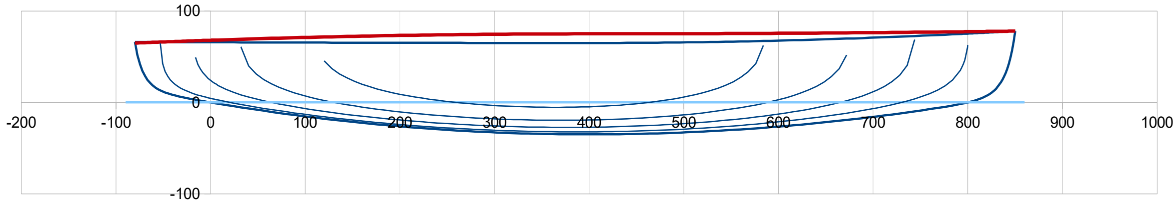
A deck surface, with standard circular curvature in the transversal sections, is defined from both the sheer line definition and the central line one (at y = 0) going from the front end of the hull (X bow, Z bow) to the rear end (Xar, Zar) with an additionnal data **Zp m (m)** at X = 50% Lwl

Pui z pont : it is the power of the polynomial defining this deck central line. Recommended value : 2 à 3. Some examples :

Zp m : 0,70 ; Pui z pont = 2



Zp m : 0,75 ; Pui z pont = 2



VE Sections (combination of « V » and « E » sections (E for Elliptic))

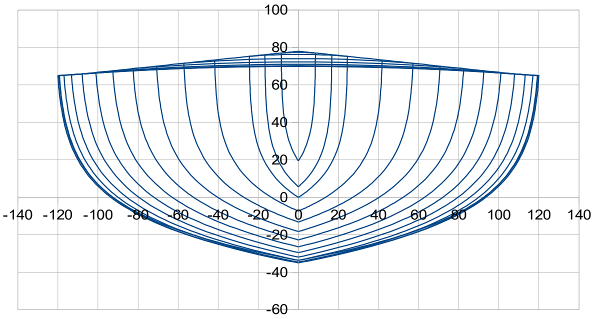
Sections are defined as a combination of 2 polynomials, one representative of a V shape section and the other one representative of a E shape section. Data to enter concern respectively the V parameters, the E ones and their combination all along X, from front to aft end of the hull.

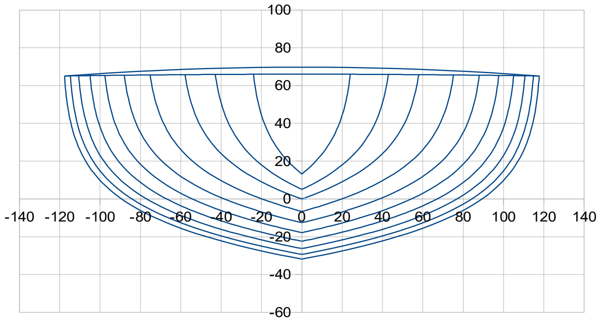
<u>**Parameters for V sections**</u> **:**

Hv av (m) ; Hv ar (m) ; Hv m (m) ; Pui Hv

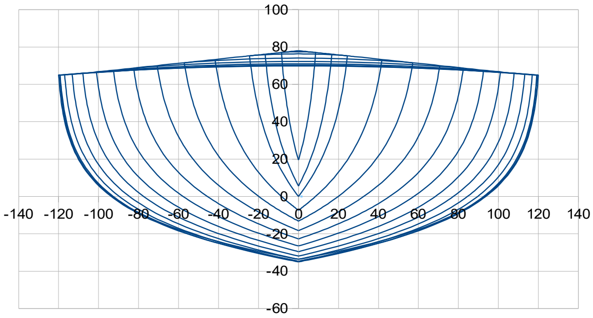
These parameters deal with the height H of the polynomial tangential vertical point as a function of the x position of the section (formulation details in the technical appendix). **Hv av** is the front height, **Hv ar** is the rear height and **Hv m** is the midship height, should be greater than respectively Z bow, Zar and Z liv m. <u>The larger Hv, the more the V shape is open</u>. **Pui Hv** is adimenssional, it is the power of the polynomial computing the evolution of Hv from front to rear. Some examples (V sections only, without the combination with E sections) :

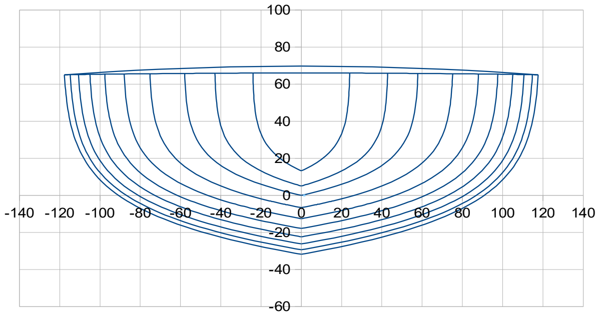
Hv av = 2 m ; Hv ar = 6 m ; Hv m = 4,5 m ; Pui Hv = 2





Hv av = 6 m ; Hv ar = 3 m ; Pui Hv = 4,5 ; Pui Hv = 2

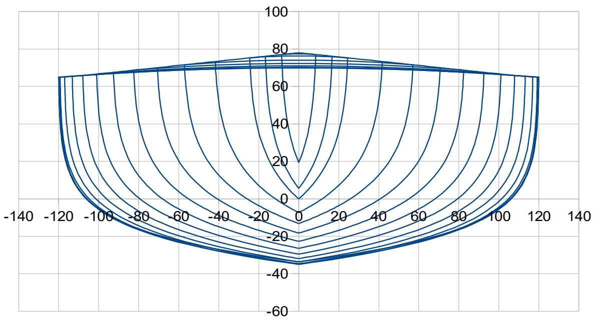


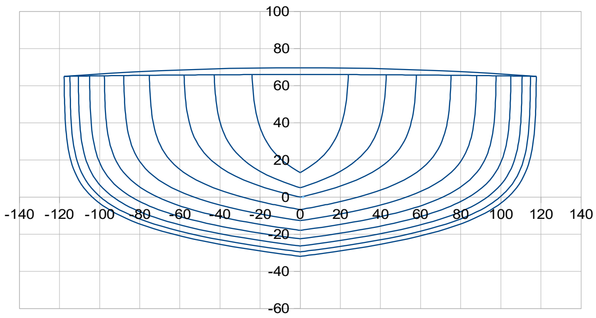


Pui V av ; Pui V ar ; Pui Pui V ; Cor Pui Pui

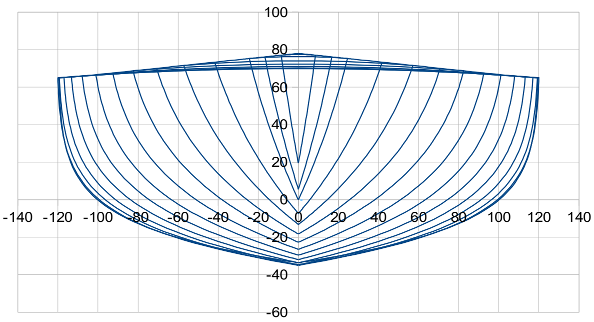
These are adimensionals parameters dealing with the power of the polynomial with position x of the section (formulation details in technical appendix). **Pui V av** front power ; **Pui V ar** rear power. The larger Pui V, the more the V shape shows a rounded chine. **Pui Pui V** is the power of the polynomial computing the evolution from Pui V ar to Pui V av, and **Cor Pui Pui** is a variation with x of this power. Cor Pui Pui can be considered as a fine tuning. Some examples (V sections only, without the combination with E sections) :

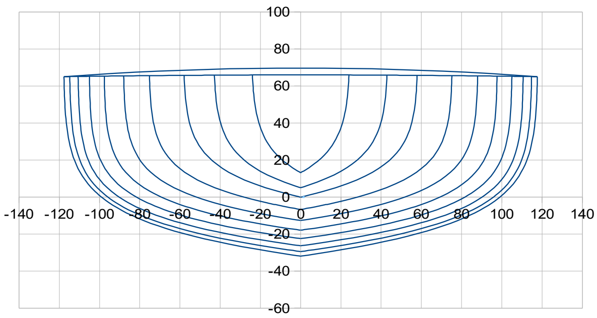
Pui V av = 13 ; Pui V ar = 28 ; Pui Pui V = 1,5 ; Cor Pui Pui = 0,5



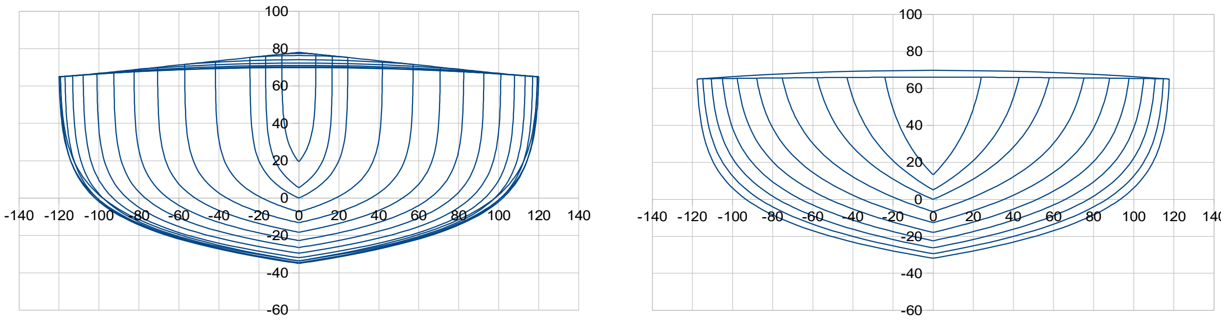


Pui V av = 2 ; Pui V ar = 28 ; Pui Pui V = 1,5 ; Cor Pui Pui = 0,5





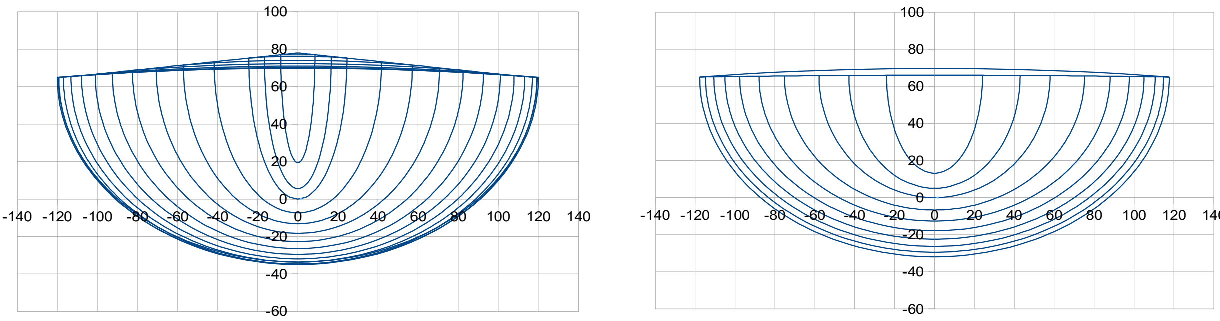
Pui V av = 28 ; Pui V ar = 13 ; Pui Pui V = 1,5 ; Cor Pui Pui = 0,5



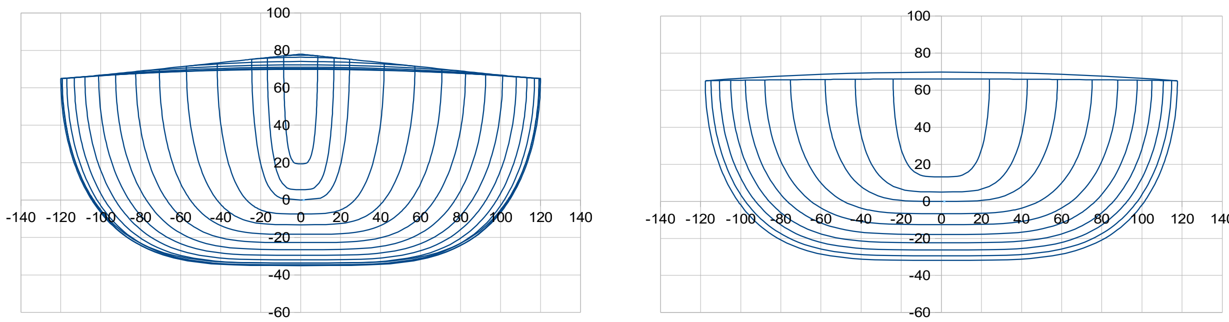
<u>E sections parameter</u> :

Pui E : adimenssional, power of the elliptic function. Some examples (E sections only, without combination with V sections). Examples :

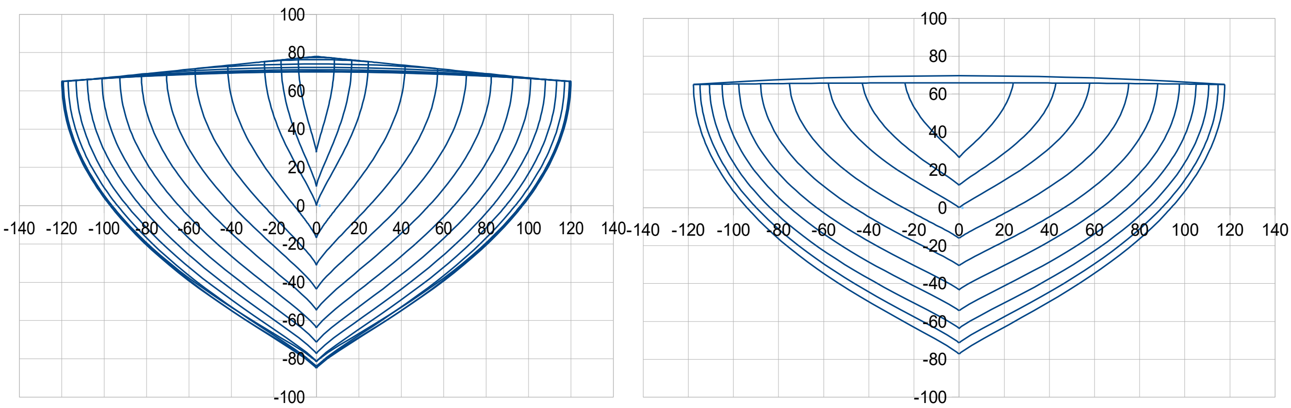
Pui E = 2



Pui E = 4



One can also generate very classic hull shape by using unusual values of Pui E < 1 :
Pui E = 0,75



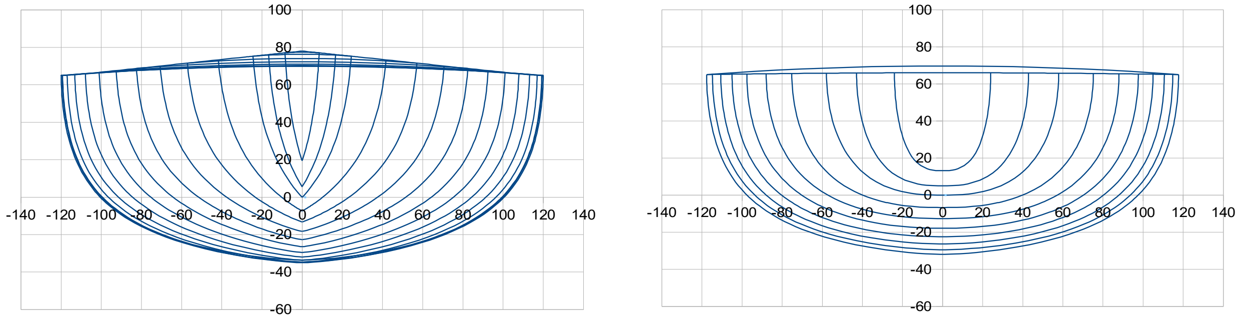
V and E sections combination :

V et E sections are combined in function of x, with :

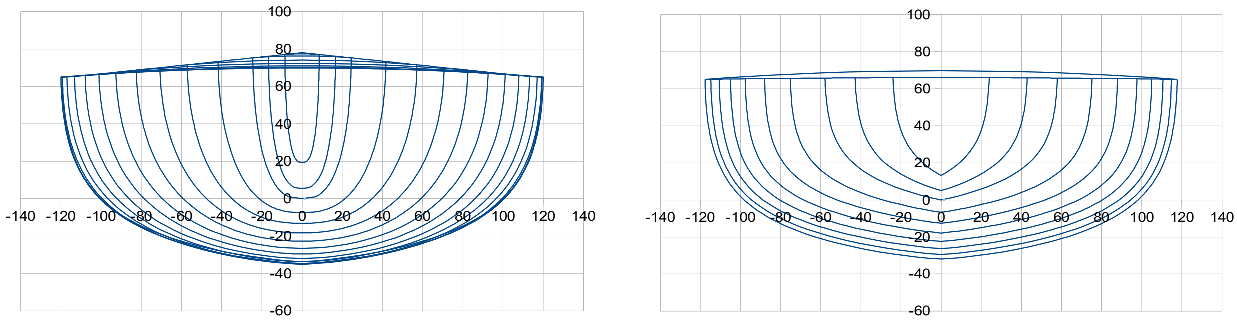
mix VE av ; mix VE ar : adimensionals between 0 to 1. 1 is representative of V and 0 representative of E.

mix VE av = 1 and mix VE ar = 0 >>> Evolution from V sections at the front to E sections at the rear of the hull , it is the usual case.
mix VE av = 0 et mix VE ar = 1 >>> It is the exact contrary, evolution from E sections at the front to V sections ath aft of the hull.

Examples :
mix VE av = 1 et mix VE ar = 0 (the usual case)



mix VE av = 0 et mix VE ar = 1 (the exact reverse case)



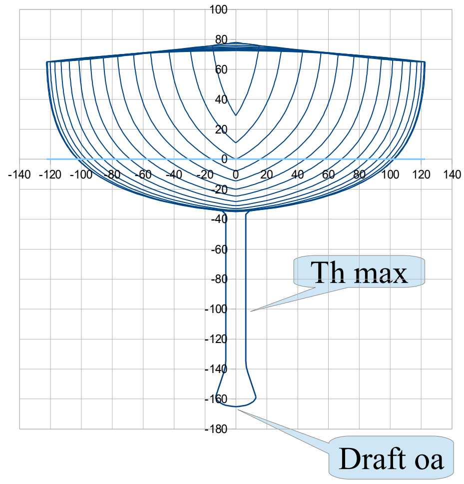
Nota : All intermediate cases, between 0 and 1, of course are also possibles.

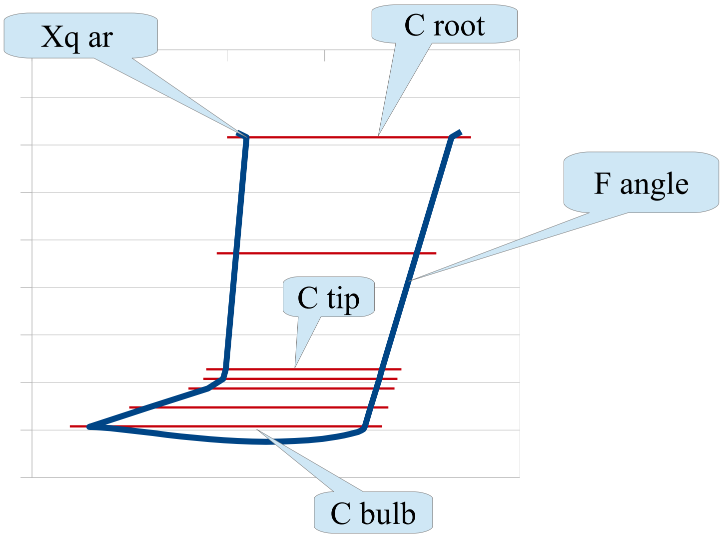
Pui mix VE : adimensional, it is the power of the polynomial function with x from **mix VE av** at front end to **mix VE ar** at rear end of the hull.

A last advice on input : probably that the use of the polynomial parameters are not very intuitive, but the hull of reference data is there to guide in your first steps and moreover you can test the effect of each parameter and this « learning by testing » process will help you to progress rapidly.

1.2 Keel data

The type of keel for this pre-design stage is the usual « inverted L » fin keel with a bulb at the tip end. Data to enter include the definition of the longitudinal profile and of the naca profiles of the various horizontal sections.



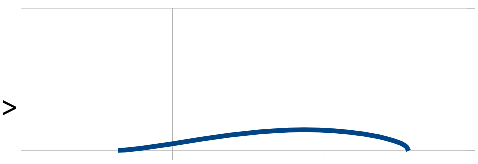


Xq ar (m) : X of the rear upper point
C root (m) : lenght of the root profile (see Nota herebelow)
C tip (m) : lenght of the tip profile before enlargement for the bulb
Th keel (cm) : Maximum thickness of the keel profile, constant between C root and C tip.
F angle (°) : leading edge angle / horizontal, usually between 45° and 90°
C bulb (m) : lenght of the bulb profile
Th bulb (cm) : Maximum thickness of the bulb,
Draft oa (m) : draft overall

Type of Naca profile : put 1 for the selected profile, 0 for the 2 others

Naca 00xx	Naca 63-0xx	Naca 65-0xx
0	**1**	0

Ex : Profil Naca 63-0xx with Th max at 35% c >>>

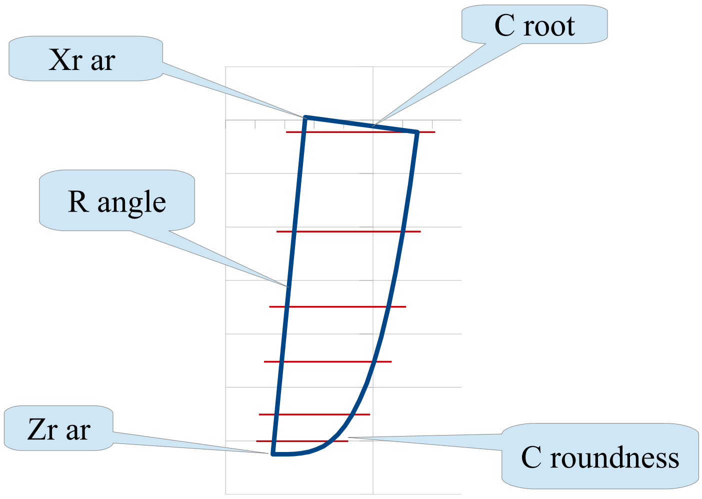


Nota : Profiles are calculated and drawn with a cut-off at 97,5% c so to avoid trailing edges too tapered and unfeasible. Chords Croot, Ctip and C bulb here above are the real lenghts taking into account the cut-off, computed chord c being C/0,975.

Density keel : wing part of the keel, from C root to C tip ; Font 7,3 ; Steel 7,85 ; Lead 11,35, …
Density bulb : Bulb part, below C tip level.

1.3 Rudder data

As for the keel, data to enter allow the geometrical definition of the longitudinal profile of the rudder and the naca profiles used at various horizontal sections.

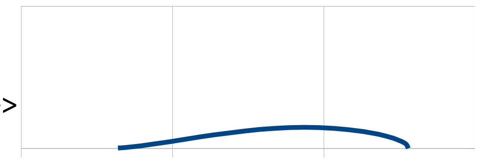


Xr ar (m) : X of the rear upper point
C root (m) : X lenght of the upper profile
t/c (%) : relative thickness of the horizontal Naca profiles, constant for the rudder.
R angle (°) : trailing edge / horizontal, usually between 75° to 85°
Zr ar (m) : Z of the rear lower point
C roudness : roundness coefficient of the mlower part of the rudder, usually 2,5 to 5,5

Type de profil Naca : put 1 for the selected profile, 0 for the two others

Naca 00xx	Naca 63-0xx	Naca 65-0xx
0	**1**	0

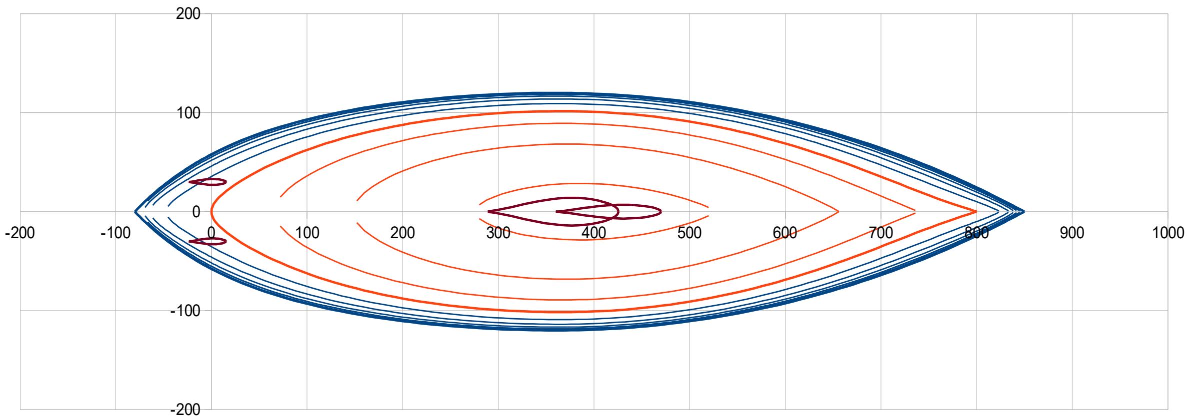
Ex : Profil Naca 63-0xx with Th max at 35% c >>>



Nota : Profiles are calculated and drawn with a cut-off at 97,5% c so to avoid trailing edges too tapered and unfeasible. Computed chord c are equal to C/0,975, C being the geometrical chords.

Nb of rudders : Number of rudders, 1 ou 2 ***(for double ended configuration, it is usually 1 rudder)***

Offset y (m) : when Nb = 2, y offset of each rudder axis / ship axis (put 0 when Nb = 1) . Example with Offset y = 0,3 m :



Output :

A hull with fairing lines and hydrostatic characteristics is automatically produced as long as all data are fulfilled with one consistent value. Modification of one value leads in real time to an updated version of the hull.

These output are divided into several sections 2 to 7, the User should act in some of them for either change and fix the scale of the views or introduce some complementary data for specific study (the heel angle, etc …)

2. Data sum-up and results of hydrostatic and surfaces calculations

These data and results are autmatically produced, no intervention by the User.

They include parameters and ratios usually considered by naval architects to judge the consistence of the hull design, like :

- Lwl / D^(1/3)
- Bwl / B
- Displacements for 3 waterlines : H0, H0-3cm, H0+3cm,
- Xc, Zc position of the center of buoyancy
- Displacements of the keel and of the rudder, their X,Z center of buoyancy
  >>> Displacement and buoyancy position of the total hull + keel + rudder
- Cp (Prismatic coefficient) of the hull
- Sf (floatation aera) and its longitudinal center
- Sw (hull wetted surface) and ratio Sw / D^(2/3) for hull, keel and rudder.

… + the curve of the sections aeras, for 3 waterlines : H0, H0+3cm, H0-3cm

… + to contribute to the mass balance data :

- Shull (surface of the hull) , its center of gravity position X,Z
- Sdeck (surface of the deck), its center of gravity position X
- Keel weight and position of the center of gravity X,Z

...+ center of resistance LCR of the keel (according to Larsson-Eliasson method for fin keel).

Example

2.1 Hull									
Loa (m)	**9,60**	**Lwl (m)**	**8,00**	> Lwl/D^(1/3)	6,27				
>> ft	*31,50*		*26,25*						
B (m)	**2,40**	**at X (% Lwl)**	**43,0**						
>> ft	*7,87*								
Bwl (m)	**2,03**	**at X (% Lwl)**	**44,0**	> Bwl / B	0,844				
>> ft	*6,64*				**Freeboards (m) >**	**Aft**		**Midship**	**Fore**
Tc (m)	**0,35**	**at X (%Lwl)**	**50**			**0,66**		**0,65**	**0,78**
>> ft	*1,15*				*>> ft*	*2,17*		*2,13*	*2,56*
Displacement at H0 (m3)	**2,07962**	**at Xc (m)**	**3,771**	**Xc (%Lwl)**	**47,14**		**Zc (m)**	**-0,12**	
>> lbs	*4699*	*w. seawater*	*1025*	*kg/m3*			*>> ft*	*-0,39*	
Displacement at H-3cm (m3)	1,75434	at Xc (m)	3,783	Xc (%Lwl)	47,29		Zc (m)	-0,11	
Displacement at H+3cm (m3)	2,42551	at Xc (m)	3,759	Xc (%Lwl)	46,98		Zc (m)	-0,13	
Cp (%)	**53,76**								
Sf (m2)	**11,22**	**at Xf (m)**	**3,691**	**Xf (%Lwl)**	**46,14**		>>> Xc – Xf (%Lwl)	1,00	
>> ft2	*120,72*	*>> ft*	*12,11*						
Angle immersed sheer Ii (°)	**28,5**	at section C4 (40% Lwl)							
Sw (m2)	**11,98**	>Sw/D^(2/3)	7,35						
>> ft2	*128,92*								
Shull (m2)	**25,76**	**at X (m)**	**382,17**	**Z (m)**	**0,07**				
>> ft2	*277,31*	*>> ft*	*1253,83*	*>> ft*	*0,24*				
Sdeck (m2)	**15,97**	**at X (m)**	**372,93**						
>> ft2	*171,95*	*>> ft*	*1223,54*						
2.2 Keel Bulb									
Vol. Keel (m3)	**0,07628**	**at X (m)**	**3,936**	**X (%Lwl)**	**49,20**	**Z (m)**	**-0,80**		
Mass keel(kg)	**556,8**	*>> ft*	*12,91*			*>> ft*	*-2,61*		
>> lbs	*1228*								
Vol. Bulb(m3)	**0,04284**	**at X (m)**	**3,625**	**X (%Lwl)**	**45,31**	**Z (m)**	**-1,50**		
Mass bulb(kg)	**486,2**	*>> ft*	*11,89*			*>> ft*	*-4,92*		
>> lbs	*1072*								
Draft oa (m)	**1,65**	**Sw (m2)**	**3,20**			**Sxz (m2)**	**1,18**		
>> ft	*5,41*	*>> ft2*	*34,44*			*>> ft2*	*12,71*		
LCR (m)	**4,11**	method : keel profile extended to the waterline, 25% c at 45% draft oa							
>> ft	*13,50*								
2.3 Rudder(s)									
Number	**1**								
Volume (m3)	**0,01315**	**at X (m)**	**-0,077**	**X (%Lwl)**	**-0,96**	**Z (m)**	**-0,54**		
Sw (m2)	**0,85**					**Sxz (m2)**	**0,41**	per rudder	
>> ft2	*9,12*					*>> ft2*	*4,39*		

2.4 Hull + Keel Bulb + Rudder(s)							
Displacement at H0 (m3)	**2,21189**	**at Xc (m)**	**3,751**	**Xc (%Lwl)**	**46,89**	**Zc (m)**	**-0,17**
(kg)	**2267**	*>> ft*	*12,31*			*>> ft*	*-0,56*
>> lbs	*4998*						
Ballast (kg)	**1043**	**at Xg (m)**	**3,791**	**Xg (%Lwl)**	**47,39**	**Zg (m)**	**-1,13**
>> lbs	*2299*	*>> ft*	*12,44*			*>> ft*	*-3,69*
>> % Ballast	46,0						
Sw (m2)	**14,47**	>Sw/D^(2/3)	8,53				
>> ft2	*155,80*						

3. The 3 views 2D

The views are automatically redrawn after every input data modification.

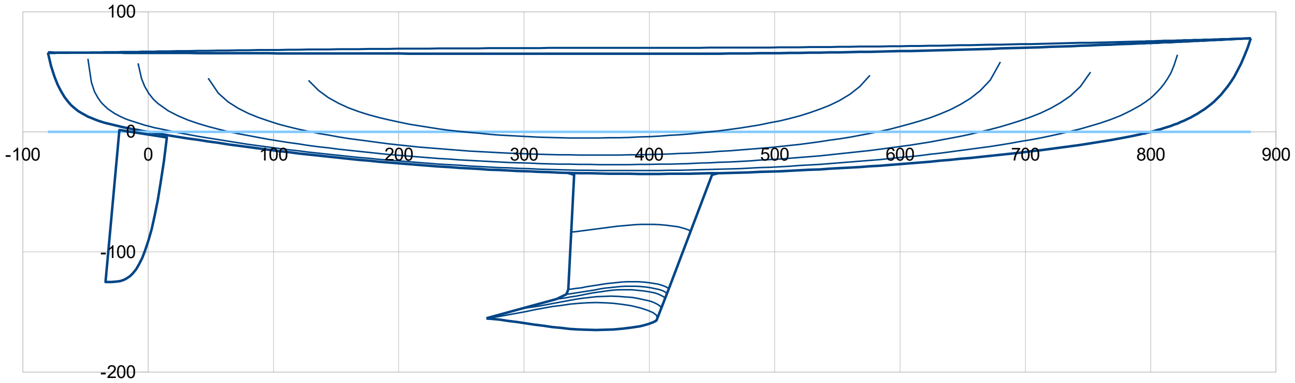
View of the front sections include sections ≥ C4 (= 40% Lf), with a half section pitch : C4, C4,5, C5, ... In front of C10 (Front perpendicular), 2 complementary sections Cav1 and Cav2 are drawn, at 1/3 and 2/3 of the bow overhang.

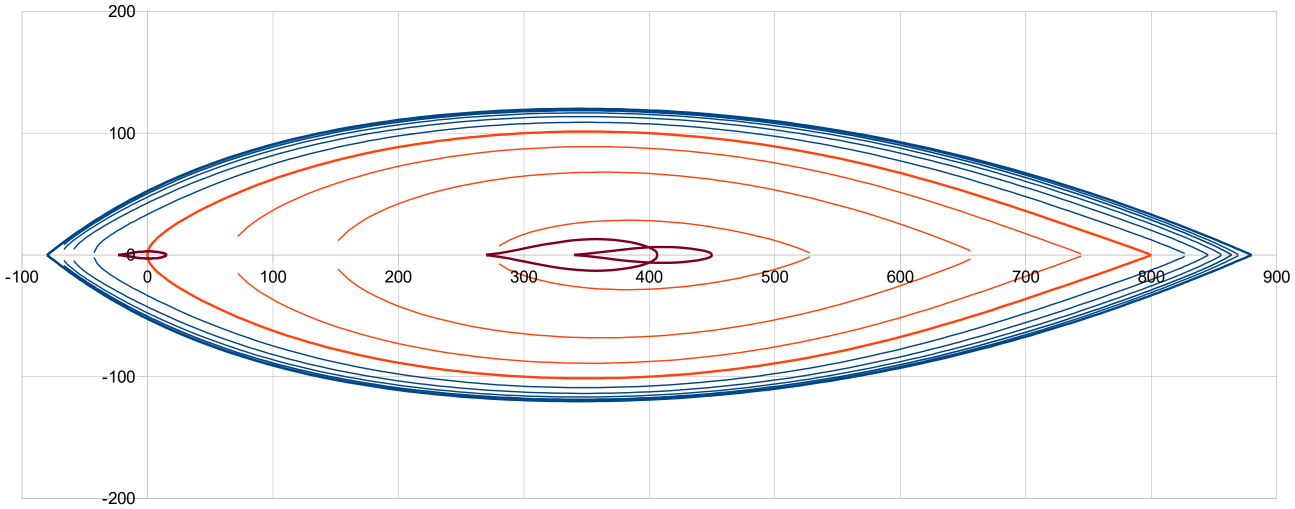
View of the rear sections includes sections ≤ C4, with a half section pitch : C4, C3,5, C3, C2,5, ... Behind C0, 2 complementary sections Car1 and Car2 are drawn, at 1/3 and 2/3 of the rear overhang.

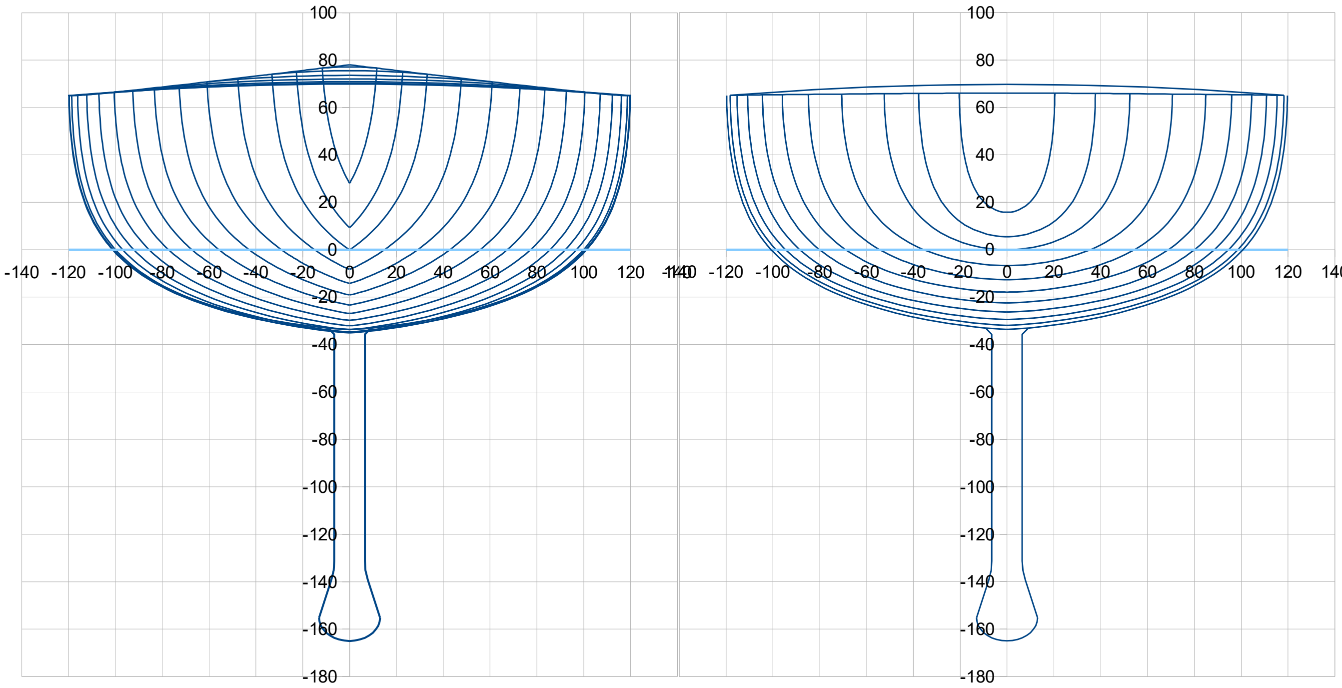
In the plan view of the bottom, waterlines in red are the wetted ones, the thick red line being the waterline H0.

Intervention of the User :
Axis scales are proposed automatic, grid pitch fixed and equal for the 2 coordinates. As long as the project dimensions are fixed , it is recommended to modify (if necessary) and to fix the scale of the views for orthonormal views (i.e. square grid).

Example :







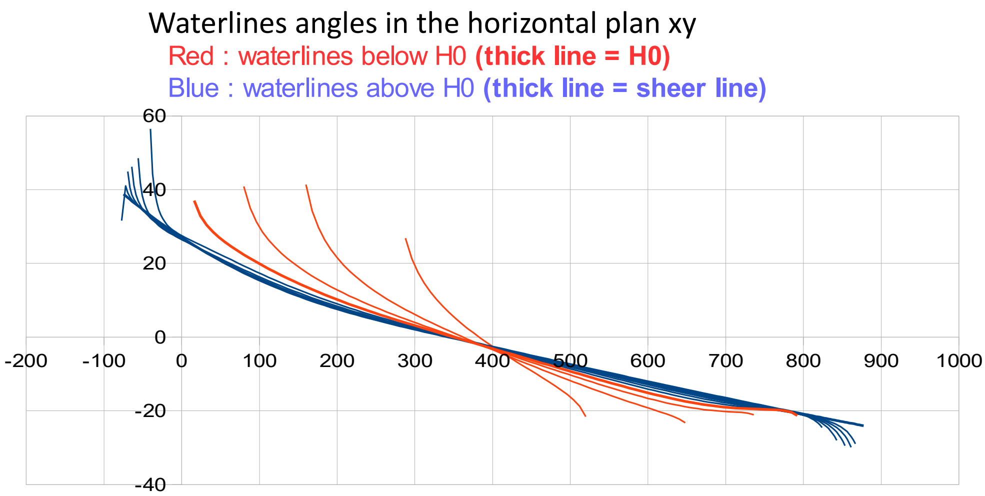
4. Curves of control

These curves are proposed to assess some complementary characteristics of the hull :

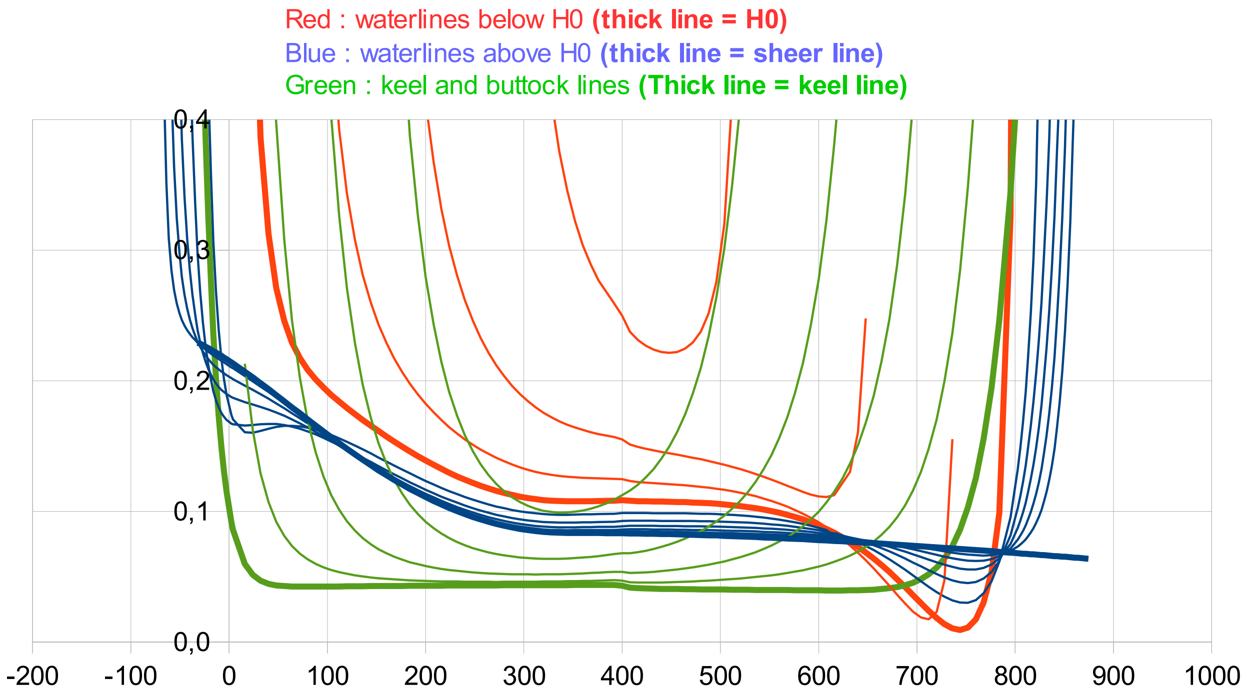
- Waterlines angles in the horizontal plan xy, with the same color code blue/red as for the bottom view.
- Curvature 1/R of :
  - Waterlines and sheer line (in the horizontal plan xy) with idem color code blue/red,
  - Keel line and Buttocks lines (vertical longitudinal cuts) in green, keel line being the thick one
- Some parameters curves, H and Pui (for sections V or U) and the combination law (for VE or UE).

User intervention :

As long as the project lenght is fixed, it is recommended to fix the scale of the X coordinates in the views.



Curvature 1/R :



5. Data for transfer to a 3D modeller

These data are also automatically produced are provided to facilitate a transfer towards a 3D modeller like Multisurf or equivalent. It includes :

- x,y,z data for each section : Car1, C0, C0,5, ...etc ..., C9,5, C10, Cav1, Cav2.
- x,z data of the keel line including the bow,
- x,y,z data of the sheer line,
- x,z data of the deck central line of symmetry,
- x,z data of the longitudinal profile of the keel, data of the naca profiles in various horizontal sections
- x,z data of the longitudinal profile of the rudder, data of the naca profiles in various horizontal sections

6. Hull with heel

This section is for the computation and draw of the hull with heel, in hydrostatic condition at constant displacement and fixed trim. The User should introduce 2 data :

- Heel angle (°) (typically 0 to 30°)
- the small elevation (cm) necessary to maintain constant the hull displacement : the user should iterate on the value up to the exact equality of the dispacements (Disp. = Disp. Heel 0° at H0) :

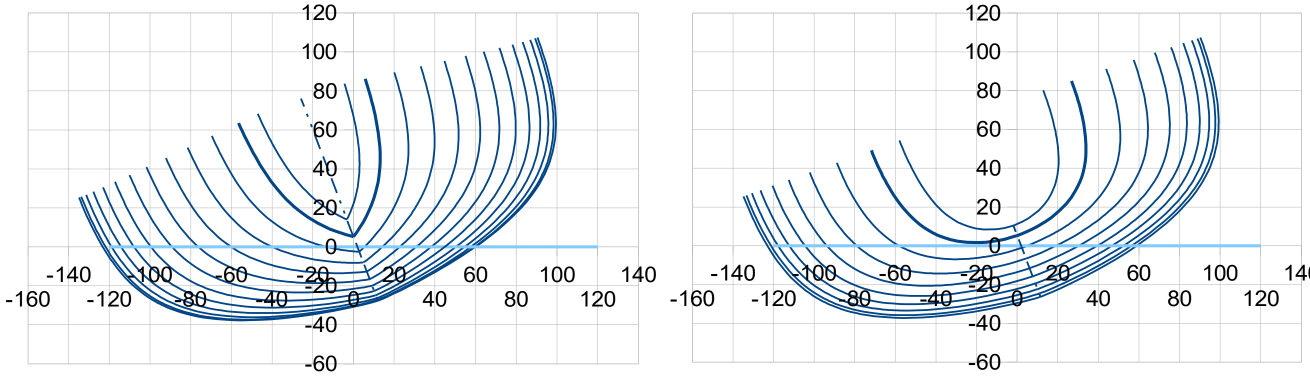
Data to enter		**Results**	
Heel (°)	**20,0**	Disp. Heel 0°	**2,07292**
Height (cm)	**5,6229**	**> Disp. (m3)**	**2,07292**

Drawings and results are then automatically produced, including :

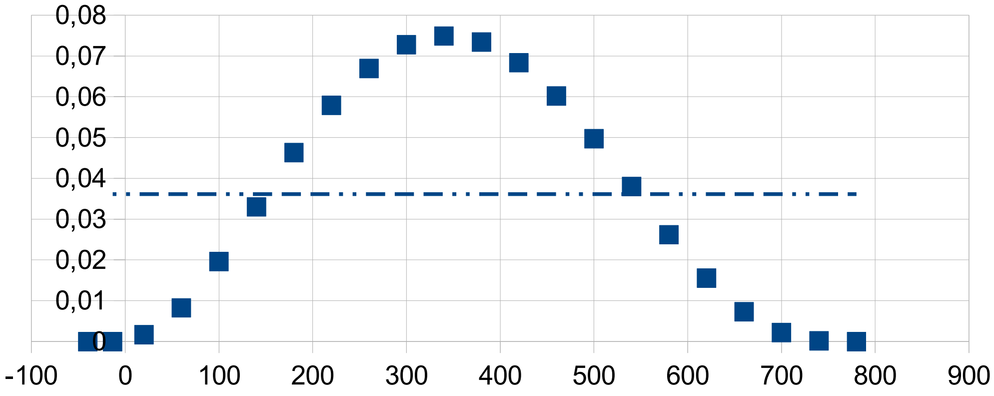
- center of buoyancy position and comparison with its initial position,
- righting moment (m4),
- wetted surface and comparison,

A plot shows the righting moment per volumes inter sections, so that to assess the hull balance with heel.

Data to enter		Results						
Heel (°)	**20,0**	Disp. Heel 0°	**2,07292**					
Height (cm)	**5,6229**	**> Disp. (m3)**	**2,07292**	Mom (m4)	0,722	Mom (kN.m)	7,26	
		Xc (m)	3,72	/ Xc Heel 0°	3,78	>>> Xc 0° - Xc 20° (% Lwl)		0,69
		Yc (m)	-0,35	/ Yc Heel 0°	0,00			
		Zc (m)	-0,13	/ Zc Heel 0°	-0,12			
		Sw (m2)	11,17	/ Sw Heel 0°	11,91			



Righting Moment (m4) per volumes inter sections



7. Data for hull sections drawing at scale one, inc. hull frames and deck bars

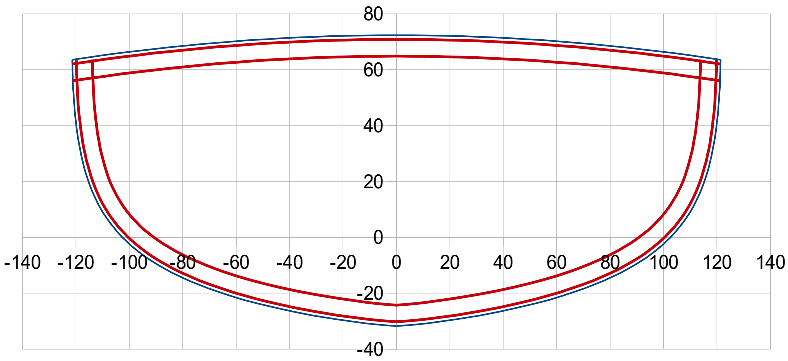
This section provides the data which can be used for a scale one drawing of any section at a given X position, inc. a hull frame or a deck bar when necessary. This section is divided in 2 sub-sections 7.1 and 7.2 for respectively sections behind or in front of C5 (midship).

The User should enter the X value of the section, the current thickness of the hull, the height of the hull frame, the current thickness of the deck, the height of the deck bar. **Unities : cm** .

Example :

Data to enter	x (cm)
>	600,0

Hull thickness (cm) >	1,5	Frame H >	6
deck thickness (cm) >	1,5	Bar H >	[illegible]



y hull	z hull
94,18	**65,99**
94,08	63,89
93,96	61,79
93,82	59,69
93,65	57,59
93,46	55,49
93,25	53,39
93,01	51,30
92,74	49,20
92,44	47,10
92,11	45,00
91,74	42,90
91,34	40,80
90,89	38,70
90,39	36,60
89,85	34,50
89,26	32,40
88,61	30,30
87,90	28,20
87,12	26,10
86,27	24,00
85,35	21,90
84,34	19,80
83,24	17,70
82,04	15,60
80,73	13,50
79,31	11,40
77,76	9,30
76,07	7,20
74,23	5,10
72,23	**3,00**
71,21	**2,00**
70,15	**1,00**
69,05	**0,00**
67,89	**-1,00**
66,69	**-2,00**
65,44	**-3,00**
63,86	-4,21
62,20	-5,41
60,44	-6,62
58,60	-7,83
56,66	-9,04
54,61	-10,24
52,44	-11,45
50,16	-12,66
47,75	-13,87
45,19	-15,07
42,49	-16,28
39,62	-17,49
36,56	-18,70
33,30	-19,90
29,82	-21,11
26,06	-22,32
22,00	-23,53
17,55	-24,73
12,57	-25,94
6,78	**-27,15**
4,52	**-27,55**
2,61	**-27,85**
1,08	**-28,05**
0,17	**-28,14**
0,00	**-28,15**