Gene-Hull VE Canoe 2.3_User Guide_English version

This new Gene-Hull version is dedicated to Canoe early stage project.

Gene-Hull VE Canoe makes possible the **generation of hulls for canoe** with their 2D linesplan and their hydrostatic characteristics as output. 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. **An additional sheet is devoted to a Velocity Prediction Program (VPP)**. This User Guide gives all definition and information on the role and influence of each data, with illustrations. Moreover, the User has the input data of a reference hull allowing him to start his own project step by step, and a « Hulls storage » sheet where other examples of inputs are archived and can be copy/paste.

For each new data introduced, all computations and drawings are updated automatically. Proposed parameters allow an infinity of combinations, so as many possible variants of a hull. Drawings, hydrostatic data including ratios usually considered by naval architects, intial stability GM, drag and speed prediction, … make possible to judge the hull and to converge towards the desired one.

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

In the present state of this development, no tumblehome can be generated, but that can be developed if requested.

After an apprenticeship that should be light thanks to this User Guide and the hull of reference given to initiate a new project, it is 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 the User, taking into account his experience as naval architect.

It is a free and open source speadsheet application, on a support itself free and widespread (Open Office Calc 4.0.1) : if any problem are faced to open and use an ods file, you can download Open Office or Libre office according to : http://www.openthefile.net/extension/ods

A technical appendix give you the main 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.

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Summary presentation

The application includes 3 sheets :

- Gene-Hull
- Hulls storage
- VPP

Gene-Hull : includes an User space (input & outputs) followed by an Administrator space where the computations are carried out. The User space includes 7 successive sections :

Gene-Hull input :

1. Data to enter

Gene-Hull output :

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 stability at total displacement (with its specific inputs)
7. Data for hull sections drawing at scale one, inc. hull frames and deck bars

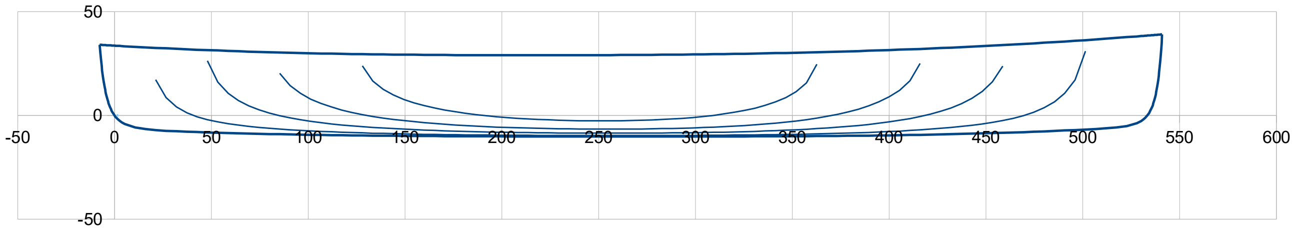
Hulls storage : is the storage space for hulls input data

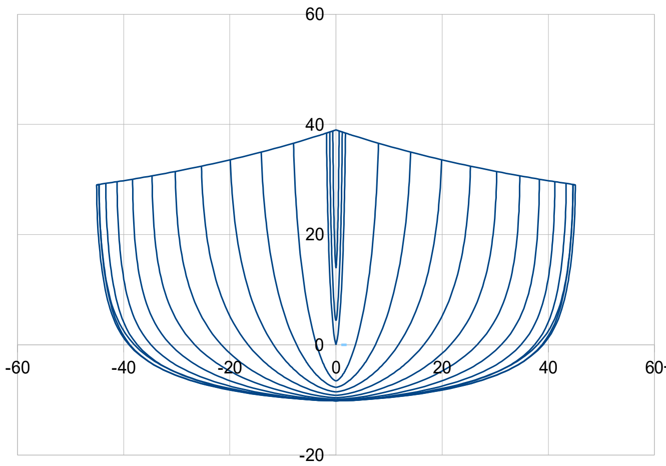
VPP : is the sheet devoted to the drag computation (flat sea, no wind) and the speed prediction for a given propulsion net power (flat sea, head wind), with its complementary inputs

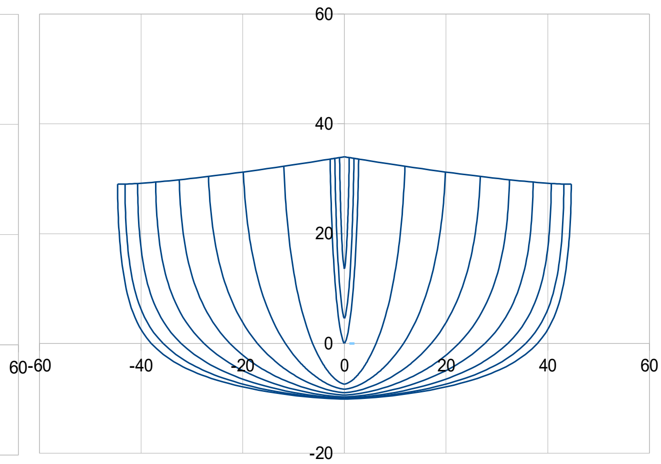
+ in annex of the present User Guide : main formulations involved in Gene Hull

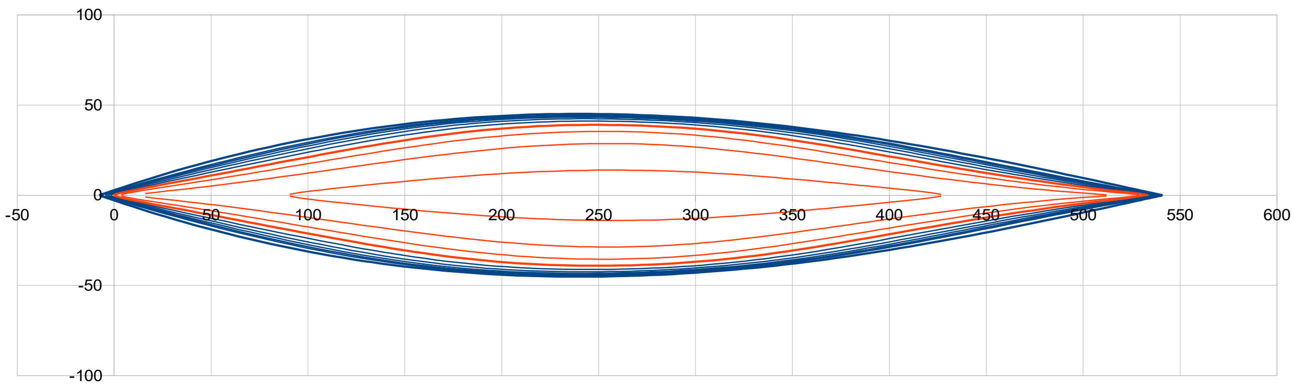
The coordinates x,y,z used fo the views include :

- Origin 0,0,0 at the cross of the designed waterline surface (« H0 » level) and the perpendicular at the rear point of the waterline (station C0). The perpendicular at the front point of the waterline is station 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 a right scale and to fix it.

Gene-Hull sheet / Input

1. Data to enter for the hull body

Data to enter are in column B (cells B12 to B50), the ones of a hull of reference are in column D, in pink. Simplified views of the hull are showed opposite to the data so that one can see on them, as well as on the complete views some lines below, the effect of each data new value *(sometimes these small views do not update instantly, in that case go directly to the complete views that are in the output space). **Data are in metric units,*** with automatic conversion in US customary units in column C *(in italic blue in the file).*

1. Data to enter			
1.1 Hull data	metric	>> feet	Hull of ref.
Lenght of waterline :			
Lwl (m)	5,134	16,84	5,134
Maximum draft of the hull body :			
Tc (m)	0,1016	0,33	0,1016
Keel line front part :			
Xbow (m)	5,310	17,42	5,310
Zbow (m)	0,400	1,31	0,400
Pui q av	3,30		3,30
Cet av	40,0		40,0
Keel line, rear part :			
Xar (m)	-0,176	-0,58	-0,176
Zar (m)	0,34	1,12	0,34
Pui q ar	3,30		3,30
Cet ar	30,0		30,0
Sheer line, in horizontal projection xy :			
Bmax (m)	0,9017	2,96	0,9017
at X (% Lwl)	45,0		45,0
Pui livav	2,00		2,00
Cor Pui livav	0,035		0,035
Pui Cor Puiav	2,00		2,00
Pui livar	2,06		2,06
Cor Pui livar	0,000		0,000
Pui Cor Puiar	2,00		2,00
Sheer line, in vertical projection xz :			
Z liv m (m)	0,300	0,98	0,300
Pui liv z	2,00		2,00
Sections : as a combination of « V » shape and « E » sh			
Sections V :			
C Hv av	7,00		7,00
C Hv m	1,130		1,130
C Hv ar	6,70		6,70
Pui Hv	2,00		2,00
Pui V av	6,00		6,00
Pui V ar	12,00		12,00
Pui Pui V	3,00		3,00
Sections E and combination VE :			
Pui E	3,90		3,90
mix VE av	0,51		0,51
mix VE ar	0,51		0,51
Pui mix VE	1,00		1,00

Lenght of waterline

Lwl (m) : lenght of waterline at H0 **(cell B12)**

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. **(cell B14)**

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, as demonstrated here after.

Bow and keel line front part (X > 50% Lwl)

Xbow (m) : should be > Lwl (inverted bow is not possible) **(cell B16)**

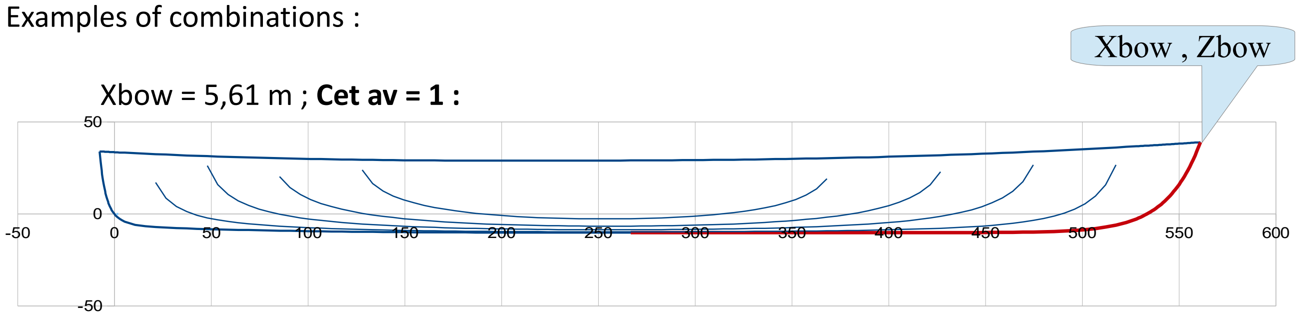
Zbow (m) : it is the front freeboard **(cell B17)**

In addition to the above geometrical data, 2 adimensional parameters are used to shape this front keel line : **Cet av** (acting more specifically on the bow shape) and **Pui q av** (acting on the overall shape of the line).

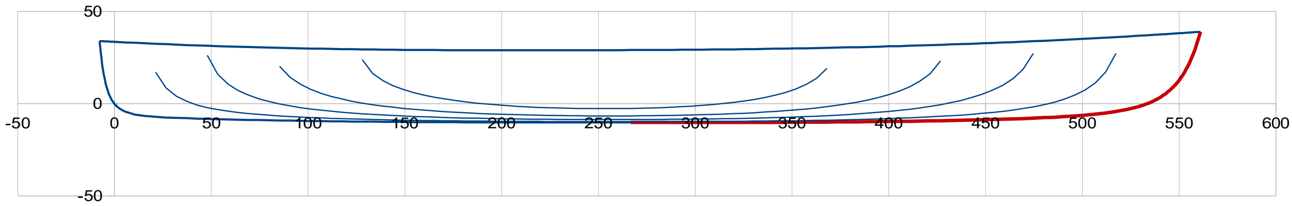
Cet av : adimensional coefficient > 0, from 0,1 to 100 typically **(cell B 19)**
This coefficient is involved in the polynomial formulation of the front part of the keel line and mostly influence the bow shape.

Examples of combinations :

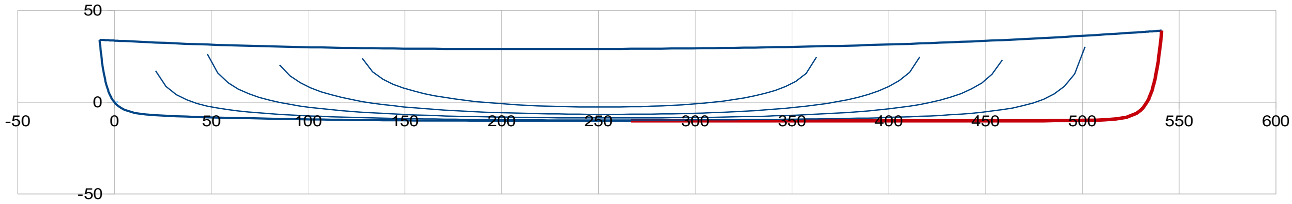
Xbow = 5,61 m ; **Cet av = 1 :**



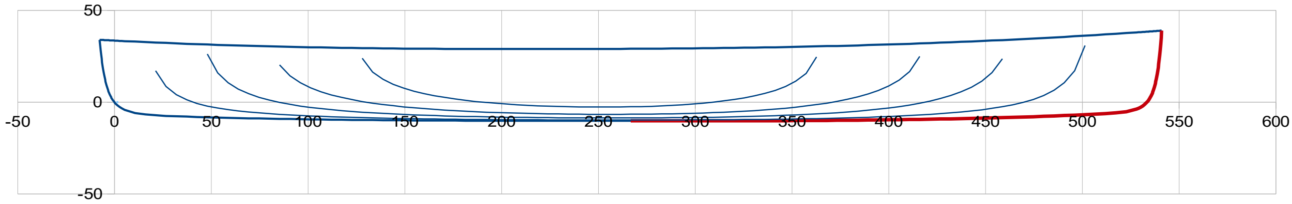
Xbow = 5,61 m ; **Cet av =10 :**



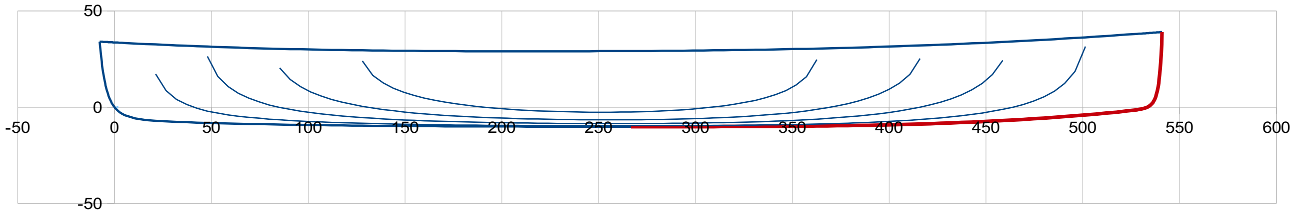
Xbow = 5,41 m ; **Cet av = 10 :**



Xbow = 5,41 m ; **Cet av = 40 :**



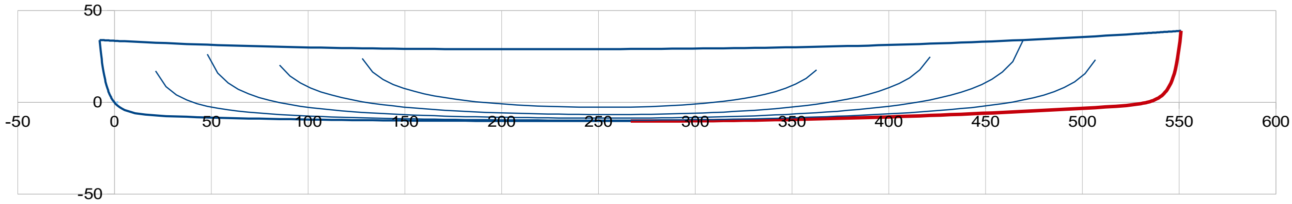
Xbow = 5,41 m ; **Cet av = 100 :**



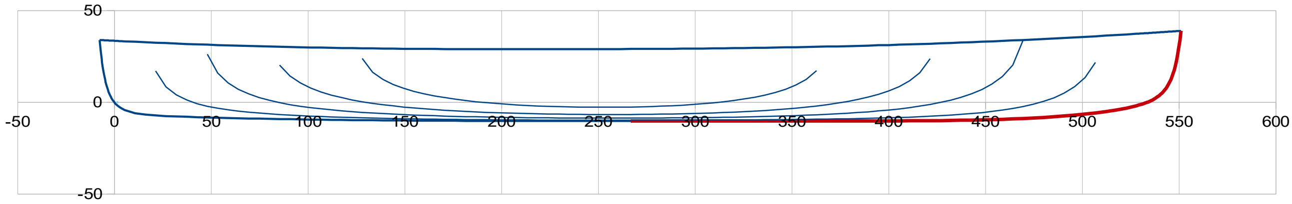
Pui q av : adimensional coefficient which figures the power factor of the front polynomial. Should preferably be ≥ 2. **(Cell B18)**

Some examples :

Xbow 5,51 m ; **Pui q av = 2 :**



Xbow 5,51 m ; **Pui q av = 7 :**



Stern and keel line rear part (X < 50% Lwl)

As for the front part, input of 2 geometrical data and 2 adimensional parameters.

Xar (m) : should be **<** 0 **(cell B21)**

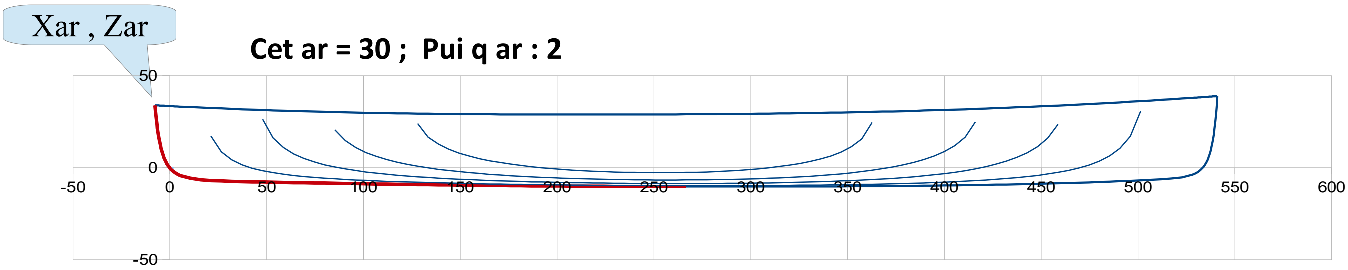
Zar (m) : it is the rear freeboard **(cell B22)**

In addition to the above geometrical data, 2 adimensional parameters are used to shape this rear keel line : **Cet ar** (acting more specifically on the stern shape) and **Pui q ar** (acting on the overall shape of the line).

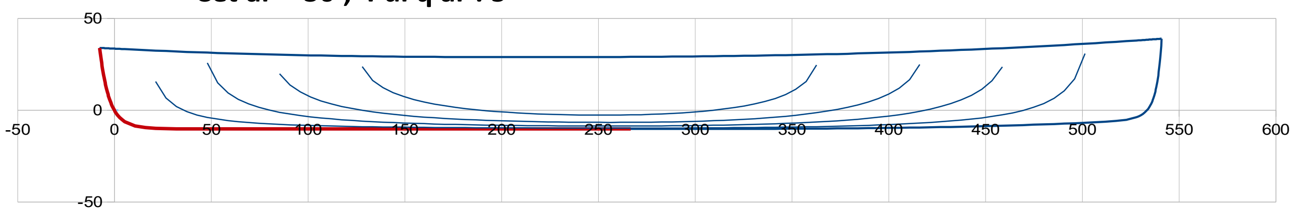
Cet ar : adimensional coefficient > 0, from 0,1 to 100 typically **(cell B 24)**
This coefficient is involved in the polynomial formulation of the rear part of the keel line and mostly influence the stern shape.
Pui q av : adimensional coefficient which figures the power factor of the rear polynomial. Should preferably be ≥ 2 **(Cell B23)**

Examples of combinations :

Cet ar = 30 ; Pui q ar : 2



Cet ar = 30 ; Pui q ar : 5



Sheer line, its definition in horizontal projection (xy plan)

Bmax (m) : hull maximum beam **(Cell B26)**

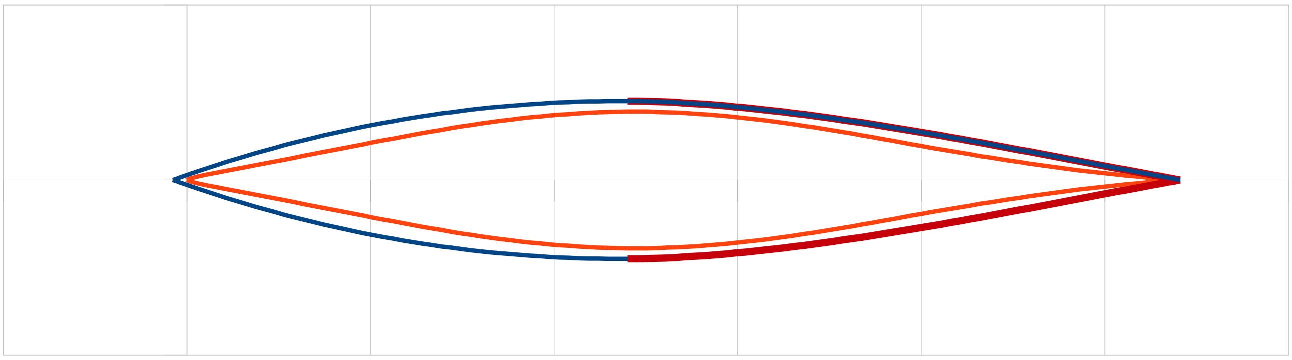
at X (% Lwl) : longitudinal position of Bmax **(Cell B27)**

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

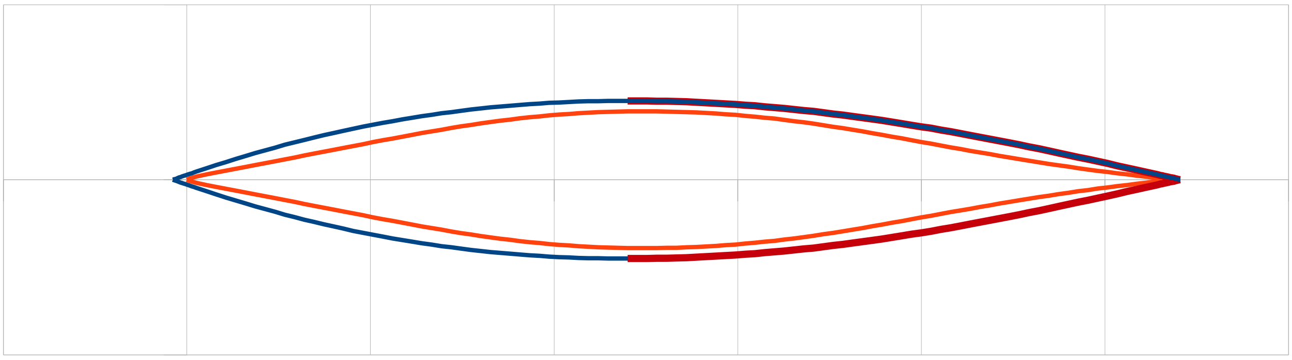
Pui livav (cell B28) :
Pui livav = 2 gives the better curvature regularity in the midship zone, it is the recommended value. Pui liv < 2 lead to a more accentuated curvature (up to a folding when Pui liv < 1,5) and on the other hand a Pui liv > 2 lead to a flattening in the midship zone.

Examples :

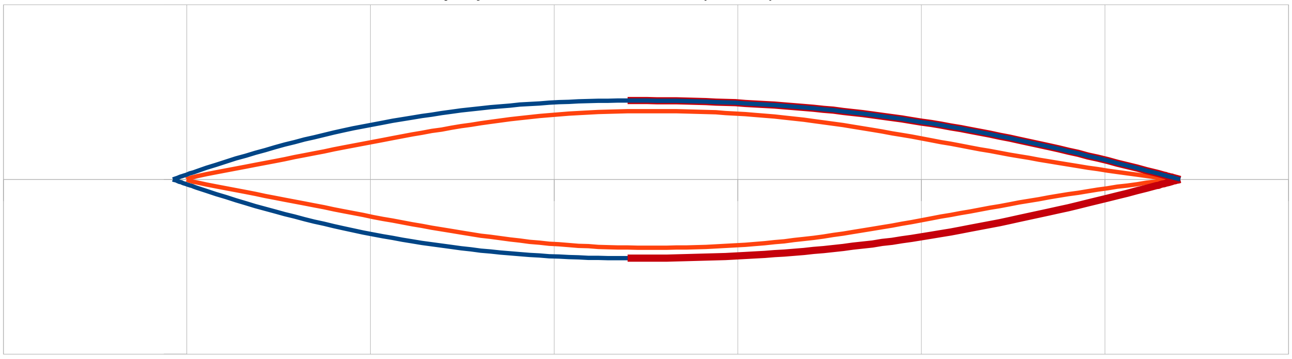
Pui livav = 1,7 ; Cor Pui livav = 0,035 ; Pui Cor Puiav = 2



Pui livav = 2,0 ; Cor Pui livav = 0,035 ; Pui Cor Puiav = 2

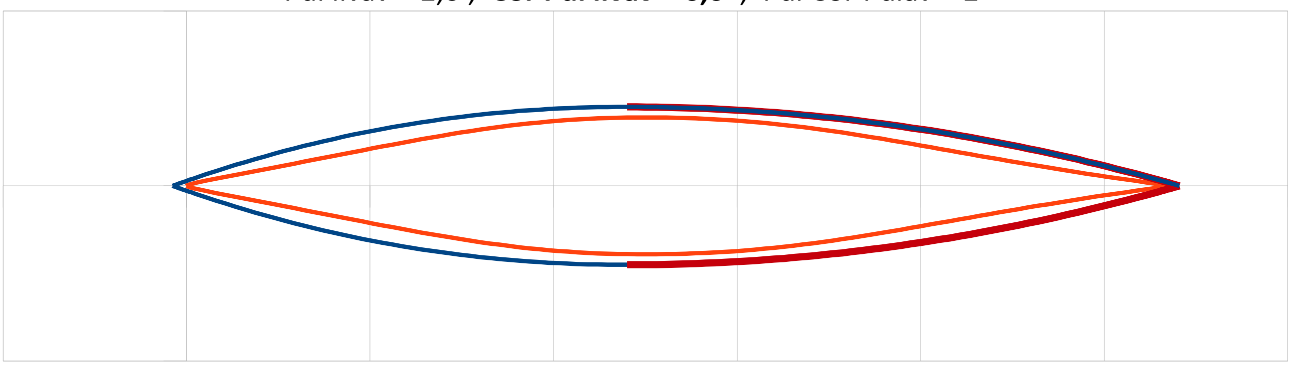


Pui livav = 2,3 ; Cor Pui livav = 0,035 ; Pui Cor Puiav = 2

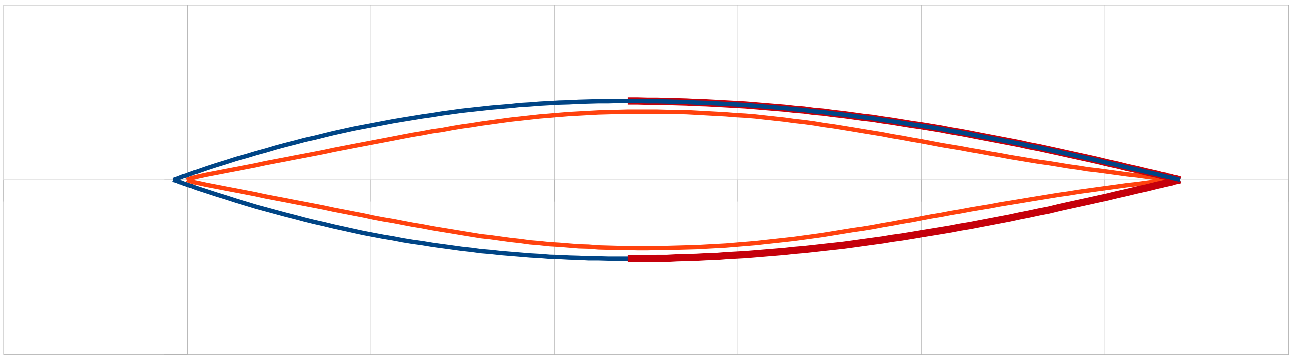


Cor Pui livav (cell B29) can add more or less tension towards the front anf aft ends of the sheer line, meaning ends with less curvature. Examples :

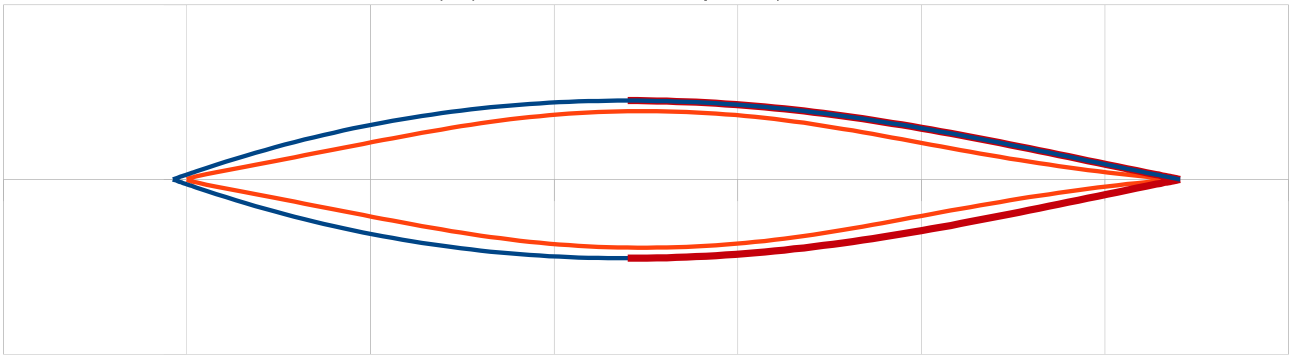
Pui livav = 2,0 ; **Cor Pui livav = 0,0** ; Pui Cor Puiav = 2



Pui livav = 2,0 ; **Cor Pui livav = 0,025** ; Pui Cor Puiav = 2

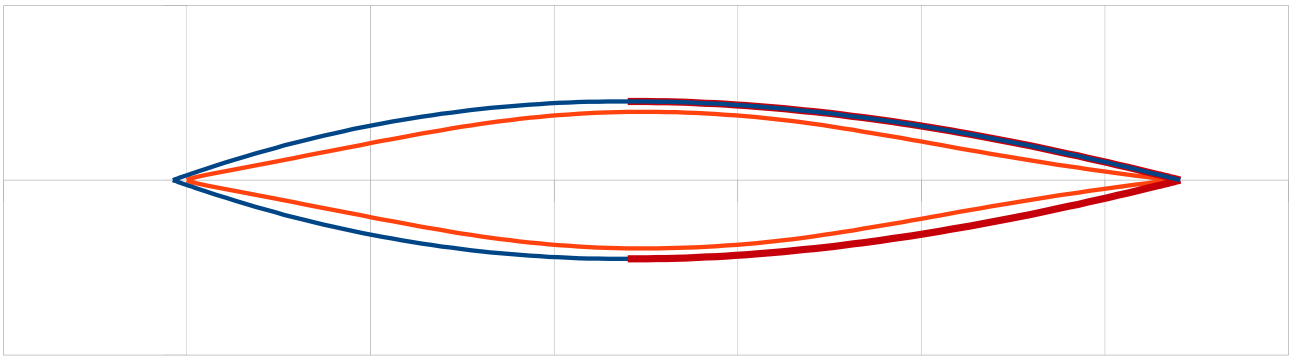


Pui livav = 2,0 ; **Cor Pui livav = 0,050** ; Pui Cor Puiav = 2

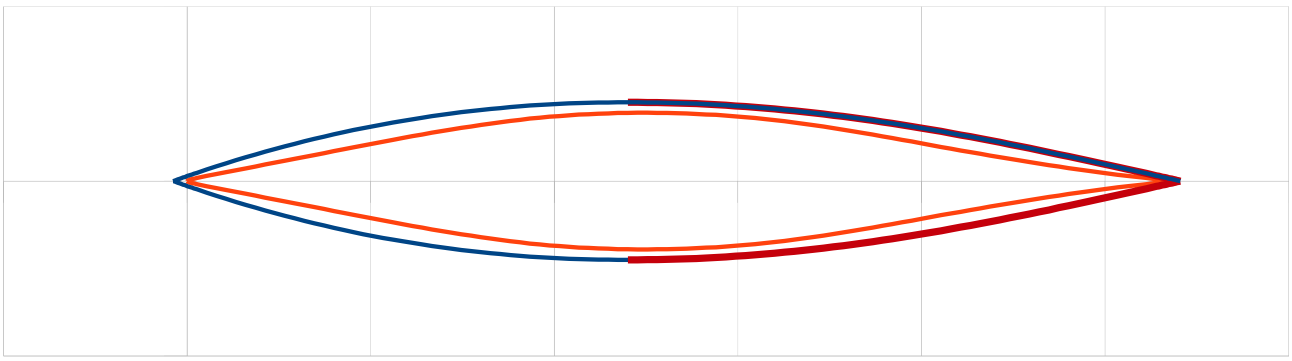


Pui Cor Puiav (cell B30) acts on the application with x of the correction Cor Pui liv.
Pui Cor Puiav =1 >>> correction application is linear.
Pui Cor Puiav > 1 >>> amplifies the correction application towards the ends. Some examples :

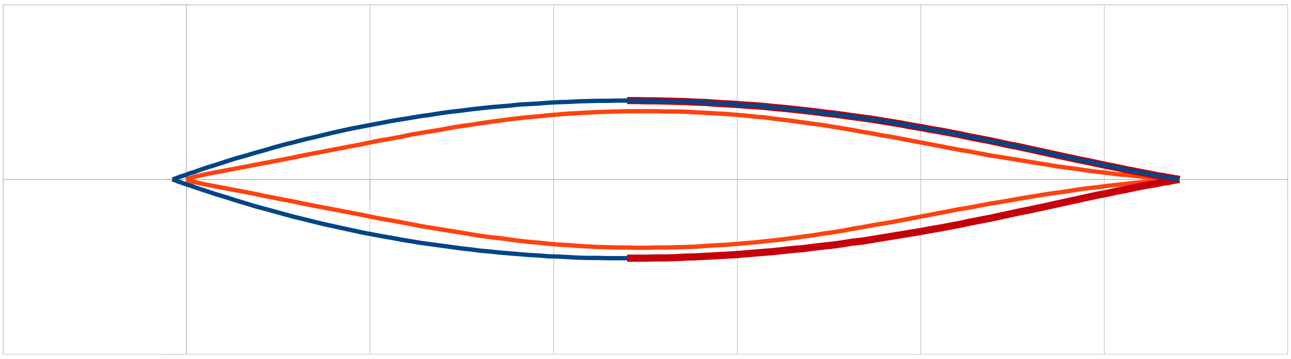
Pui livav = 2,0 ; Cor Pui livav = 0,035 ; **Pui Cor Puiav = 1**



Pui livav = 2,0 ; Cor Pui livav = 0,035 ; **Pui Cor Puiav = 2**



Pui livav = 2,0 ; Cor Pui livav = 0,035 ; **Pui Cor Puiav = 4**



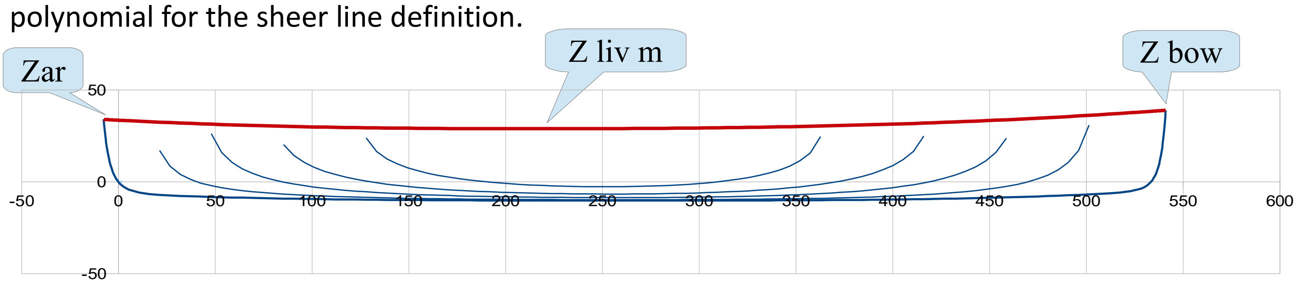
Nota : Pui Cor Puiav acts as a fine tuning of the tensioning of the ends of the sheer line triggered by Cor Pui livav.

For the aft sheer line : Pui livar (Cell B31) , Cor Pui livar (Cell 32) and **Pui Cor Puiar (Cell B33)** are 3 adimensional coefficients acting in a similar way as the ones above for the Fore sheer line, for respectively the power of the aft sheer line polynomial, its correction along with x and the power of the correction polynomial itself (formulation details in the technical appendix).

Sheer line, its definition in vertical projection (xz plan)

Z liv m (m) : it is the freeboard at 40% Lwl **(cell B35)**

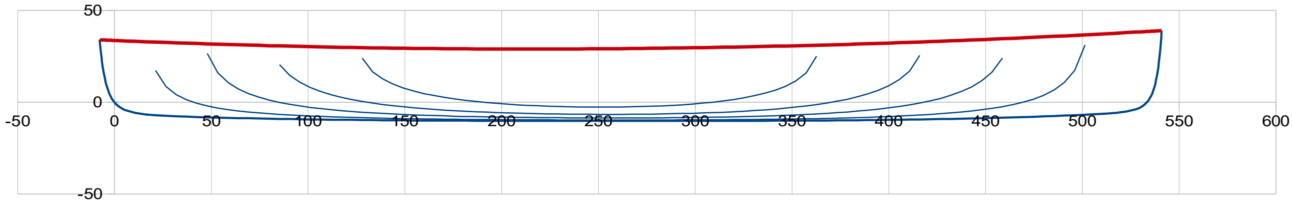
Together with **Z bow** and **Zar** defined here before, these are the 3 freeboards on which leans the xz polynomial for the sheer line definition.



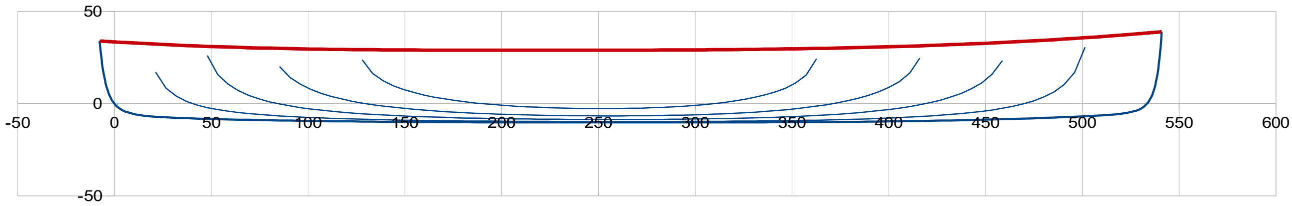
Pui liv z : it is the power of this polynomial line. **(cell B36)**
Recommended value : >2 ; Usual values : 2 to 3.

Examples :

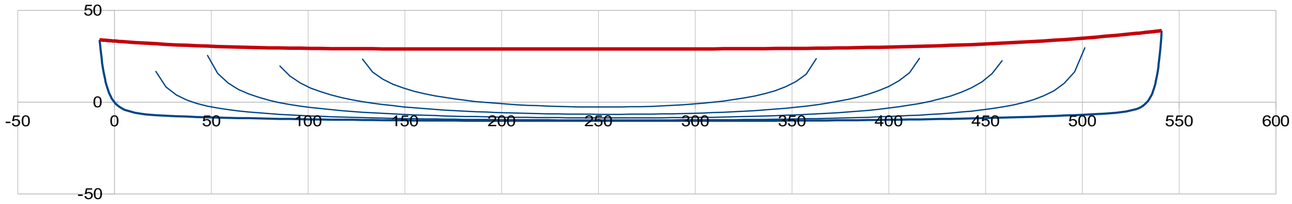
Pui liv z = 2 :



Pui liv z = 3 :



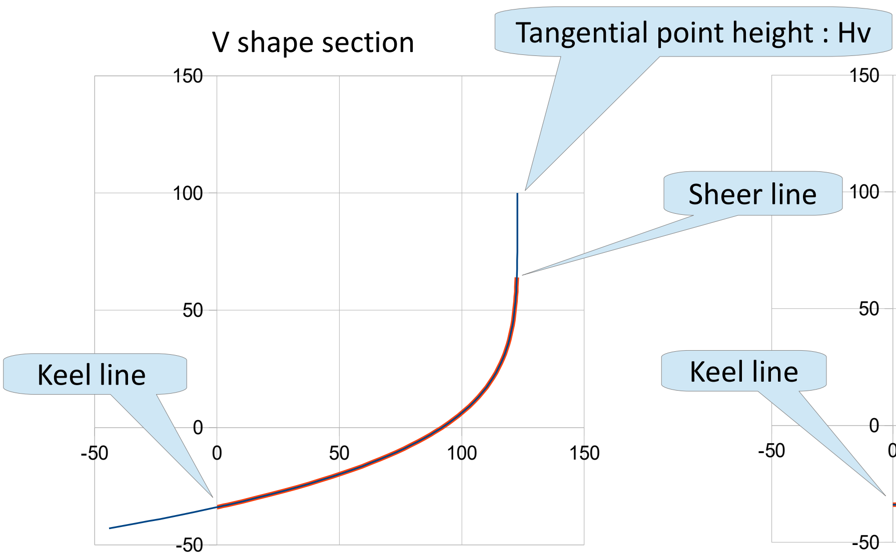
Pui liv z = 4 :

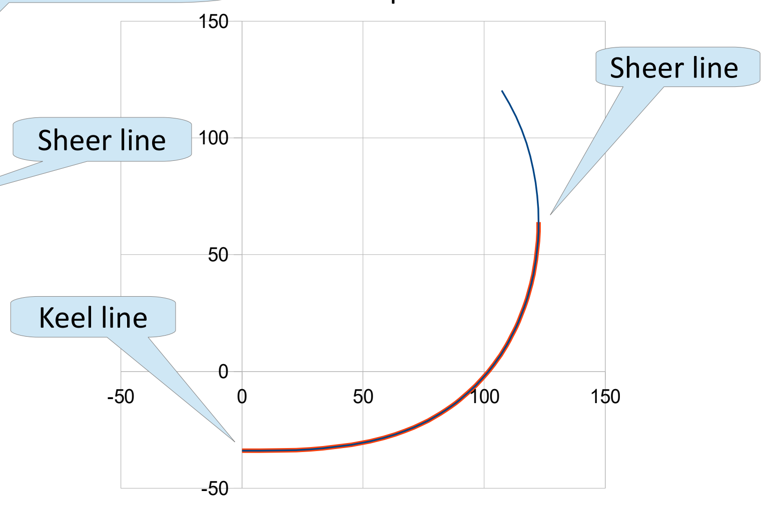


VE Sections (as a combination of « V » and « E » transversal shapes)

The transversal sections are defined as a combination of 2 polynomials, one representative of a V shape section and another one representative of a E shape section (E for Elliptic). In the « UE » application, combination of U shape section and of E shape section. Before describing each input parameters, some more explanation and illustration of these combinations are probably helpful.

VE sections are combination of these two shapes sketched here below. The adimensionnal parameters to enter concern the height of the tangential point Hv, the degree and the coefficients of the polynomials V and E, and for all their variation with x.





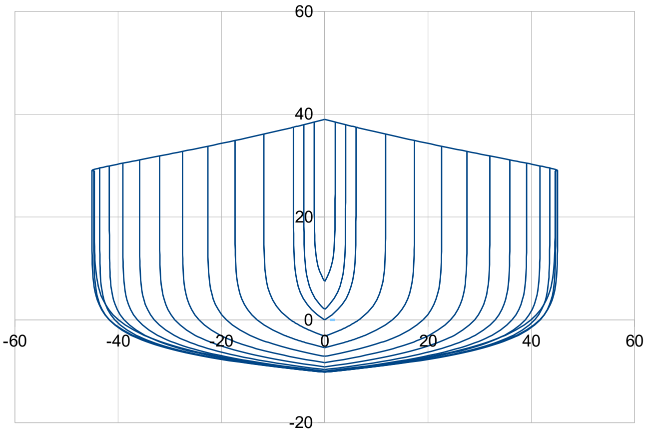
Parameters to shape the V of the sections :

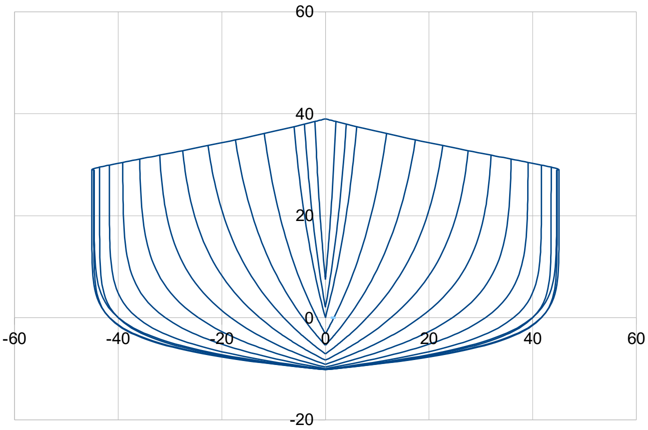
C Hv av ; C Hv m ; C Hv ar ; Pui Hv (cells B39, B40, B41, B42)

These parameters deal with the height Hv of the polynomial tangential vertical point, function of the x position of the section (formulation details in the technical appendix).
C Hv av at bow end , **C Hv m** at midship and **C Hv ar** at rear end, are the relative heights Hv to respectively Z bow, Z liv m and Z liv ar and **should be > 1** (in case of numerical issues, take > 1,1) .
What is the influence of these parameters : the larger C Hv, the more the V shape is sharp ; the smaller C Hv, the more the V shape includes a rounded bilge.
Pui Hv is the power of the polynomial computing the evolution of C Hv from front to rear of the boat.

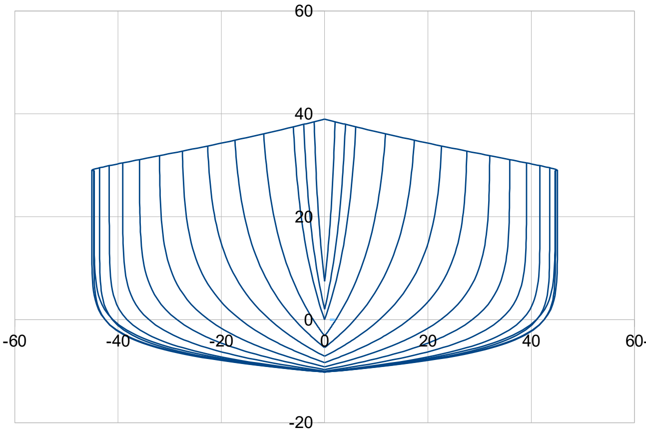
Some examples (V sections only, without the further combination with E sections) :

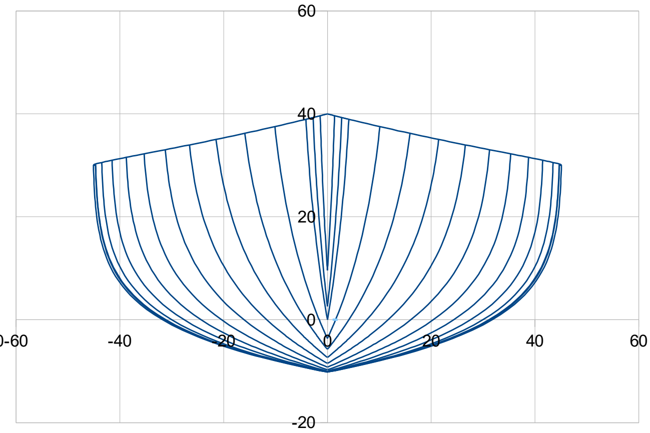
Example with **C Hv av** acting mostly on the fore sections :
C Hv av = 1 ; C Hv m = 1,13 ; C Hv ar = 6 >> **C Hv av = 10** ; C Hv m = 1,13 ; C Hv ar = 6





Example with **C Hv m** acting mostly on the midship sections :
C Hv av = 6 ; **C Hv m= 1 ;** C Hv ar = 6 >> C Hv av = 6 ; **C Hv m= 3 ;** C Hv ar = 6





Idem, **C Hv ar** acts mostly on the rear sections.

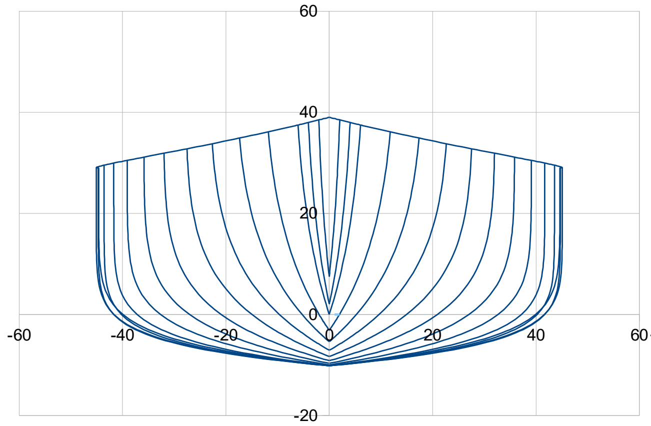
Pui Hv is the power of the polynome connecting the 3 C Hv following x.

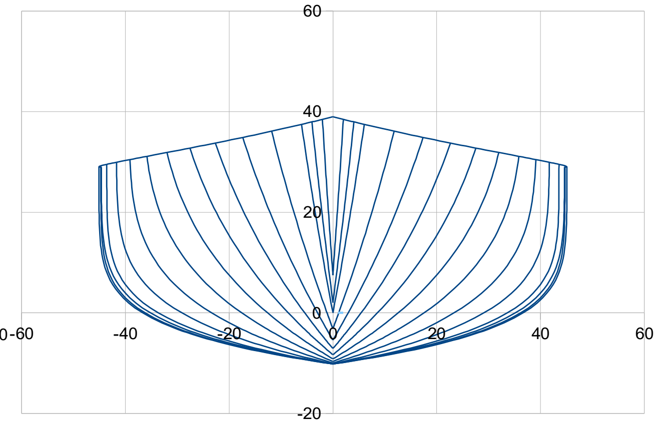
Pui V av ; Pui V ar ; Pui Pui V (cells B43, B44, B45)
These parameters deal with the power of the polynomial, function of the x position of the section (formulation details in technical appendix). **Pui V av** is the power of the fore sections; **Pui V ar** is the power of the rear sections. The larger Pui V, the more the V shape is rounded. **Pui Pui V** is the

power of the polynomial computing the evolution with x from Pui V ar to Pui V av. Some examples (V sections only, without the combination with E sections) :

Example for **Pui V av** acting mostly on fore sections :

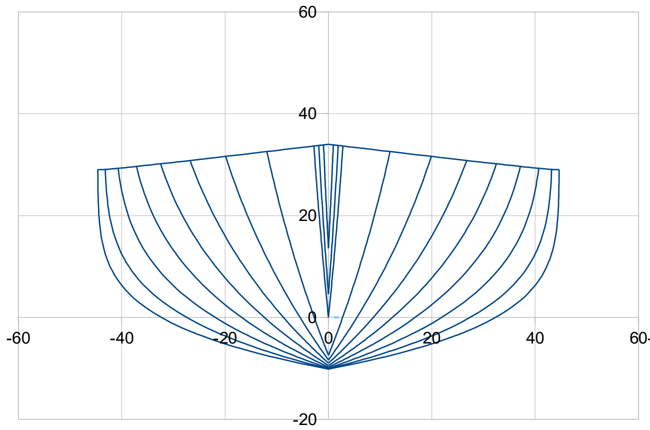
Pui V av = 10 ; Pui V ar = 10 ; >> **Pui V av = 2** ; Pui V ar = 10 ;

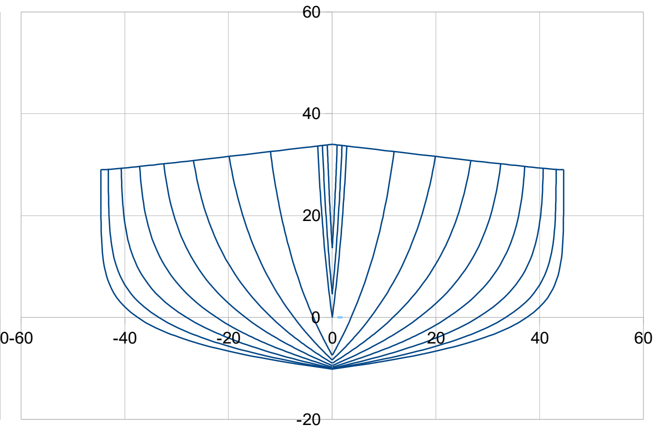




Example for Pui V ar acting mostly on rear sections :

Pui V av = 10 ; **Pui V ar = 3** >> Pui V av = 10 ; **Pui V ar = 7**

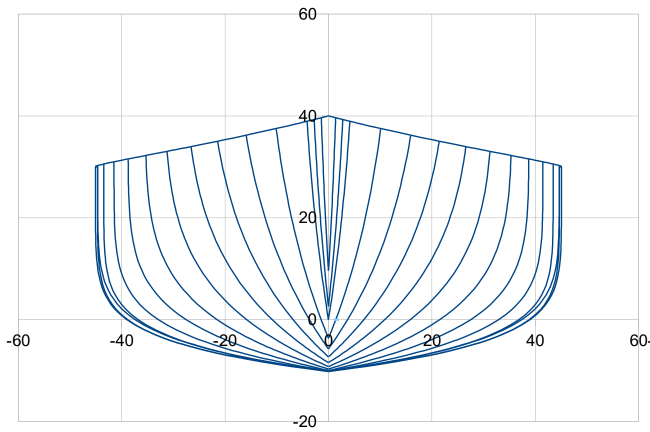


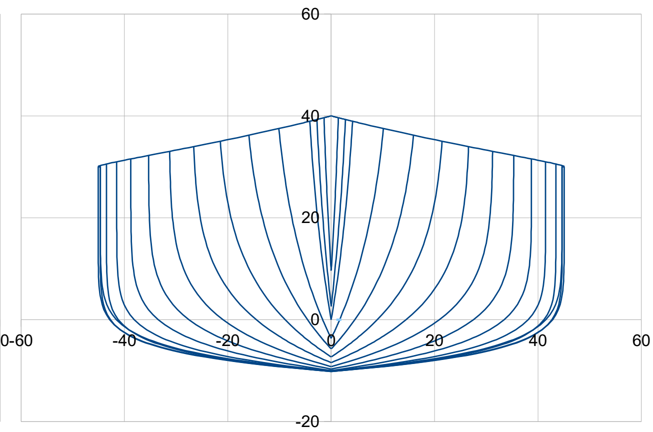


Pui Pui V is the polynomial power adressing the evolution with x of Pui V ar to Pui V av., so its influence is mostly visible for midship sections.

Example (with Pui V ar = 12 and Pui V av = 6) :

Pui Pui V = 0,5 >>> **Pui Pui V = 6**



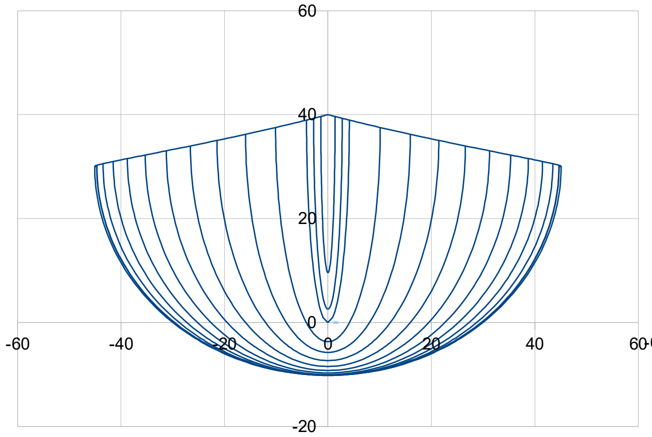


E shapes adimensional parameters :

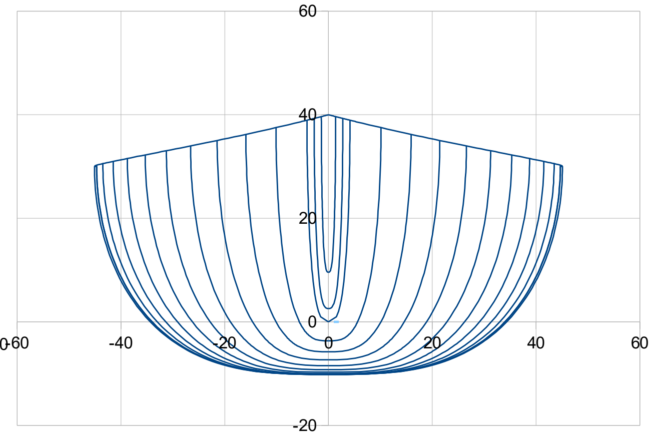
Pui E : power of the E function. **(cell B47)**

Some examples (E sections only, without combination with V sections). Examples :

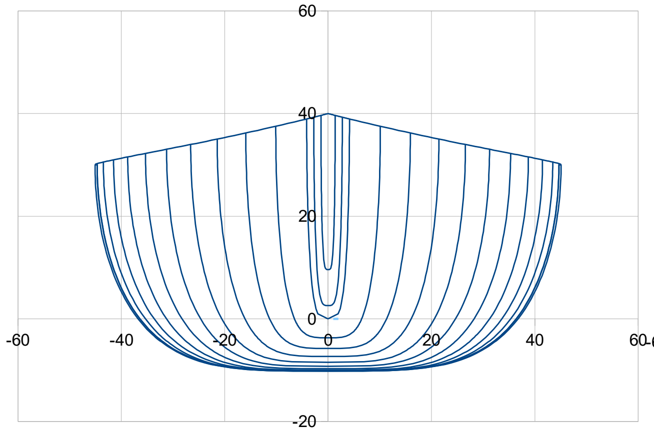
Pui E = 2



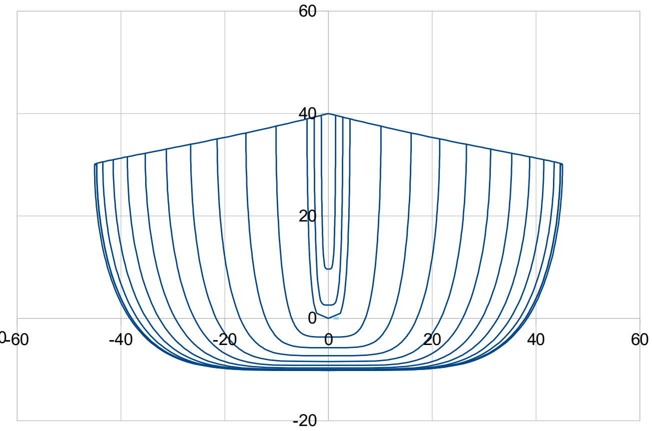
Pui E = 3



Pui E = 4



Pui E = 5



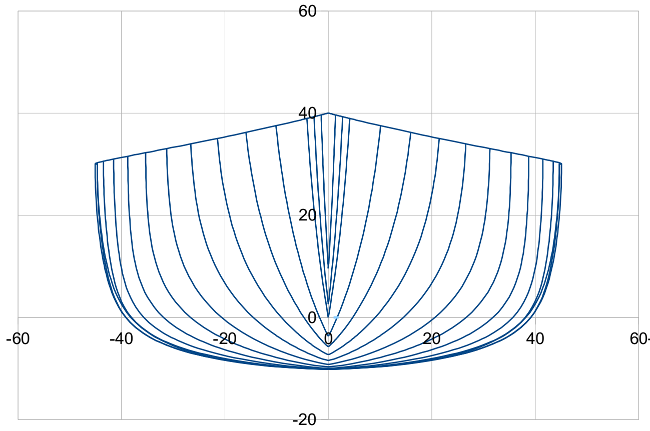
V and E sections combination :

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

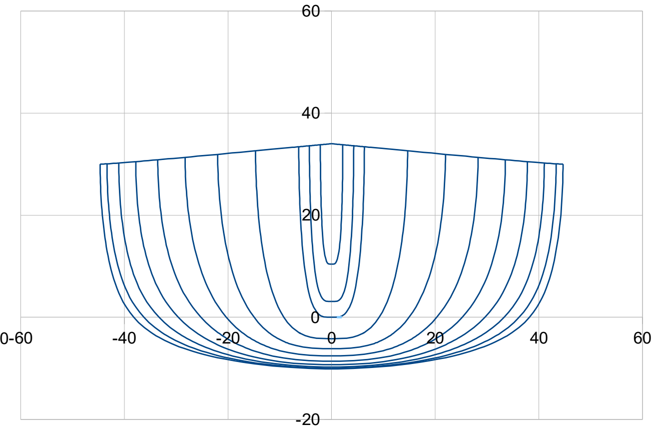
mix VE av ; mix VE ar : adimensionals between 0 to 1. **(cells B48 and B49)**
1 means 100% V shape and 0 means 100% E shape.

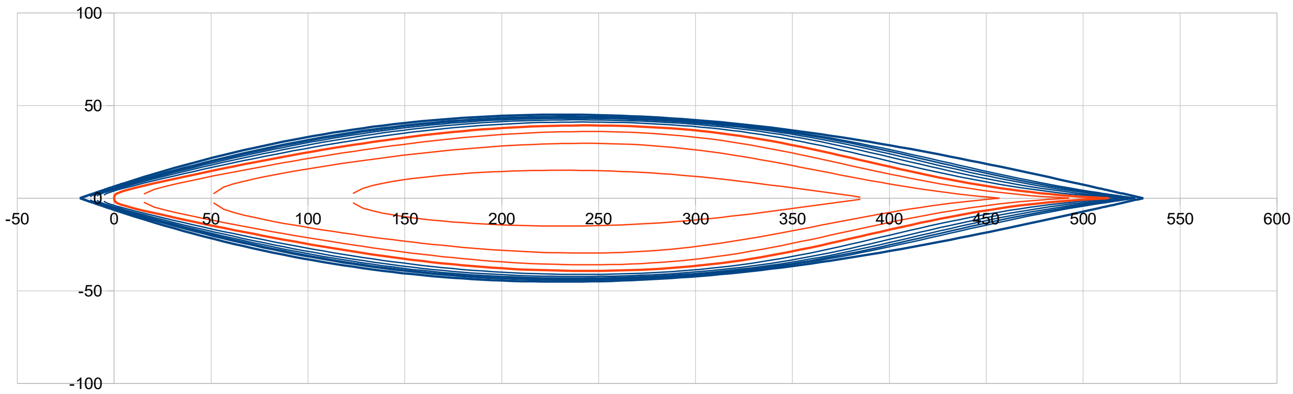
Examples :
mix VE av = 1 and mix VE ar = 0 >>> Evolution from V sections at the front to E sections at the rear of the hull

Front view



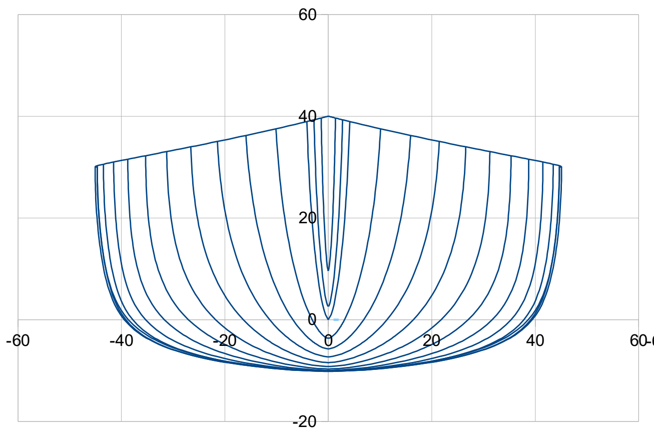
Rear view



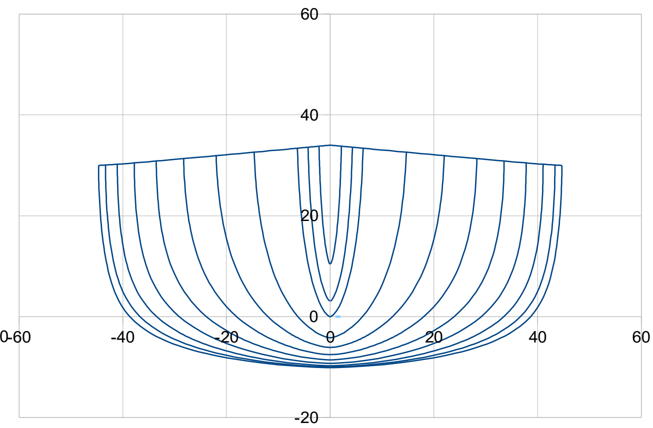


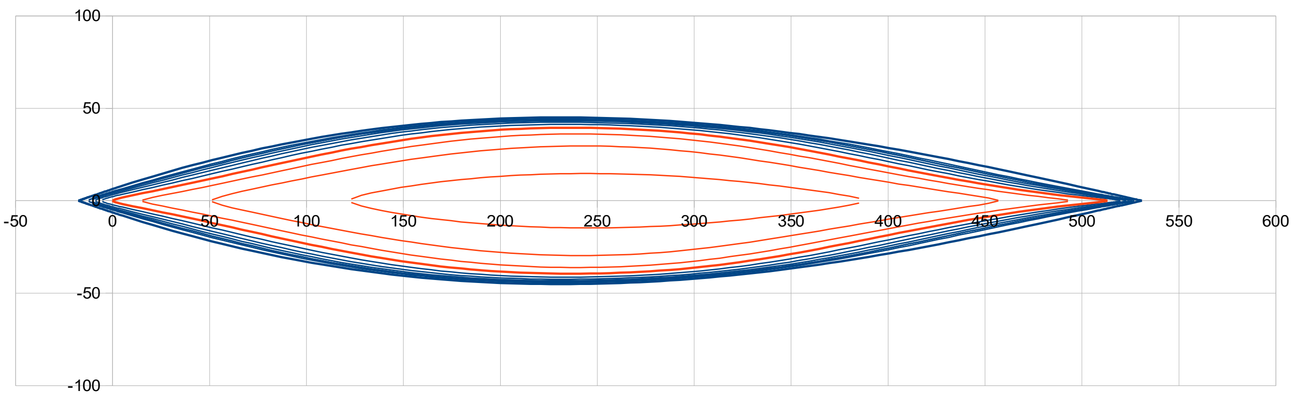
mix VE av = 0,5 et mix VE ar = 0,5 >>> a uniform mix of V and E sections

Front view



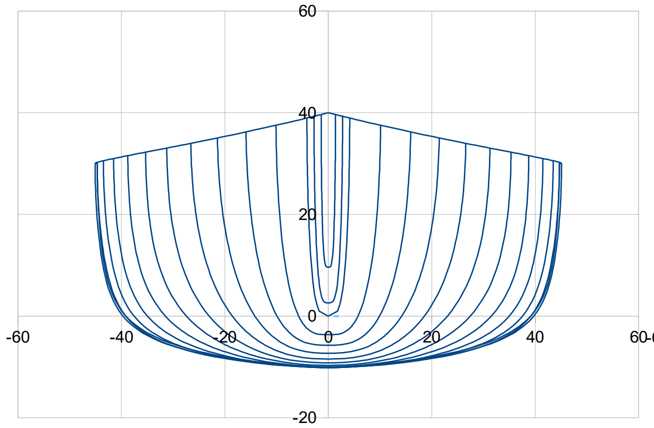
Rear view



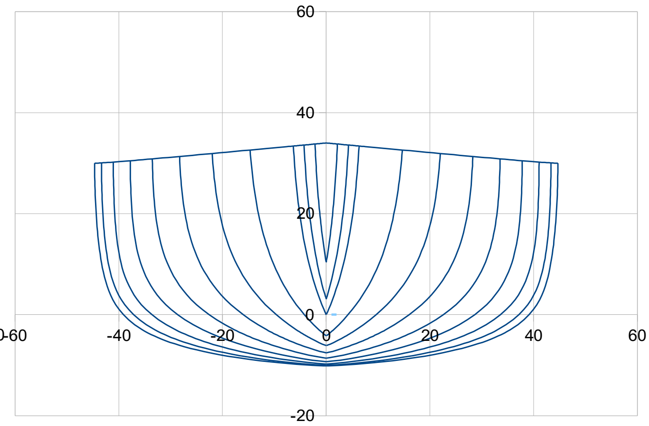


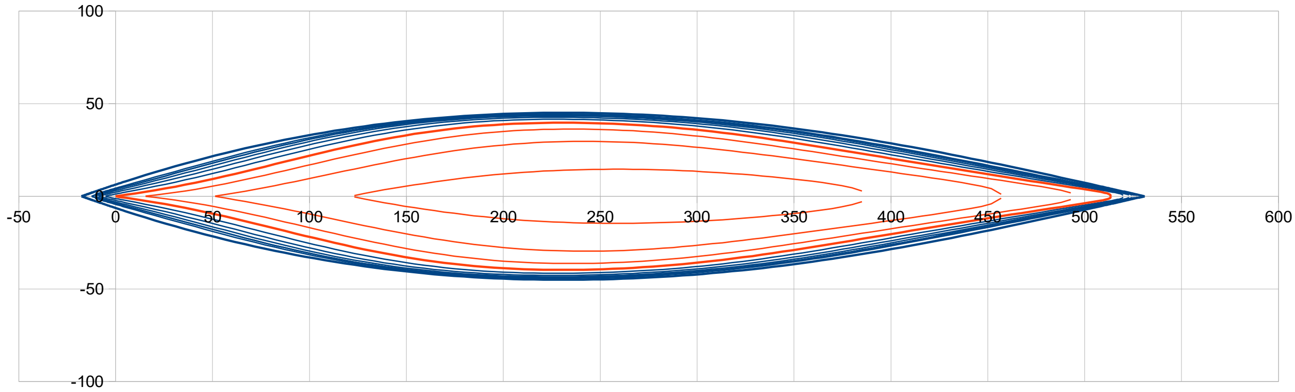
mix VE av = 0 et mix VE ar = 1 *>>> It is the exact contrary, evolution from E sections at the front to V sections at the aft of the hull.*

Front view



Rear view





Pui mix VE (cell B50) : adimensional, it is the power of the polynomial function with x wich pilots the evolution from **mix VE av** at front end to **mix VE ar** at rear end of the hull. For example, Pui mix VE means a linear variation with x from **mix VE av** to **mix VE ar** .

Gene-Hull sheet / output

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

These output are divided into several sections 2 to 7, the User should act in some of them for either to change and fix the scale of the views, or to introduce some complementary data for specific study (e.g. Section 6. Hull Stability at total displacement).

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) in metrics unit and DLR in US unit.
- Froude Fn at Speed 5 mph
- Bwl/B and Bwl/Lwl
- Xc (= LCB) and Zc : position of the center of buoyancy
- Cp (Prismatic coefficient) of the hull
- Sf (floatation aera) and its longitudinal center position
- Sw (hull wetted surface) and ratio Sw / D^(2/3)

… + the curve of the sections aeras

… + to contribute to the mass balance data :

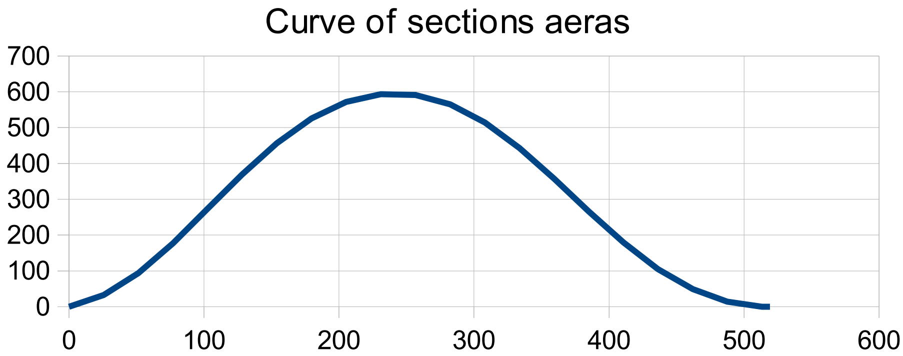
- Shull (surface of the hull) , its center of gravity position X,Z

Example :

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

Hull

Loa (m)	**5,486**	**Lwl (m)**	**5,13**	> Lwl/D^(1/3)	9,49	Fn at 5 mph	0,315	
>> ft	***18,00***	***>> ft***	***16,84***	*DLR*	*33*	*M(lbs/2240)/(Lwl(ft)/100)^3*		
B (m)	**0,902**	**at X (% Lwl)**	**45,0**					
>> inch	***35,50***							
Bwl (m)	**0,7903**	**at X (% Lwl)**	**46,0**	> Bwl / B	0,876	**Bwl/Lwl**	**0,14406**	
>> inch	***31,11***			**Freeboards (m) >**		**Aft**	**Midship**	**Fore**
Tc (m)	**0,1016**	**at X (%Lwl)**	**50**			**0,34**	**0,30**	**0,40**
>> inch	***4,00***				***>> inch***	***13,39***	***11,81***	***15,75***
Displacement at H0 (m3)		**0,15851**	**at Xc (m)**	**2,446**	**Xc (%Lwl)**	**47,65**	**Zc (m)**	**-0,039**
	(kg)	**158,51**	*>> ft*	*8,03*			*>> inch*	*-1,53*
	>> lbs	***349,5***	*with water mass / vol. of*		*1000*	*kg/m3*		
Cp (%)	**52,05**							
Sf (m2)	**2,41**	**at Xf (m)**	**2,429**	**Xf (%Lwl)**	**47,32**		>>> Xc – Xf (%Lwl)	0,33
>> ft2	*25,91*	*>> ft*	*7,97*					
Angle immersed sheer Ii (°)		**33,9**	at section C4 (40% Lwl)					
Sw (m2)	**2,61**	>Sw/D^(2/3)	8,90					
>> ft2	*28,07*							
Shull (m2)	**6,26**	**at X (m)**	**255,06**	**Z (m)**	**0,06**			
>> ft2	*67,38*	*>> ft*	*836,80*	*>> ft*	*0,21*			



3. The 3 views 2D

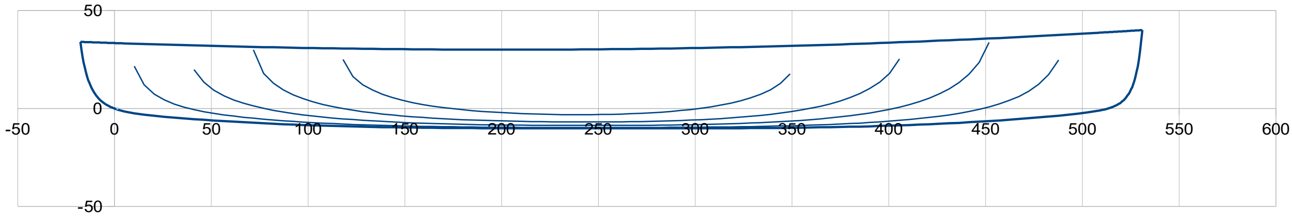
The views are automatically redrawn after every input data modification.

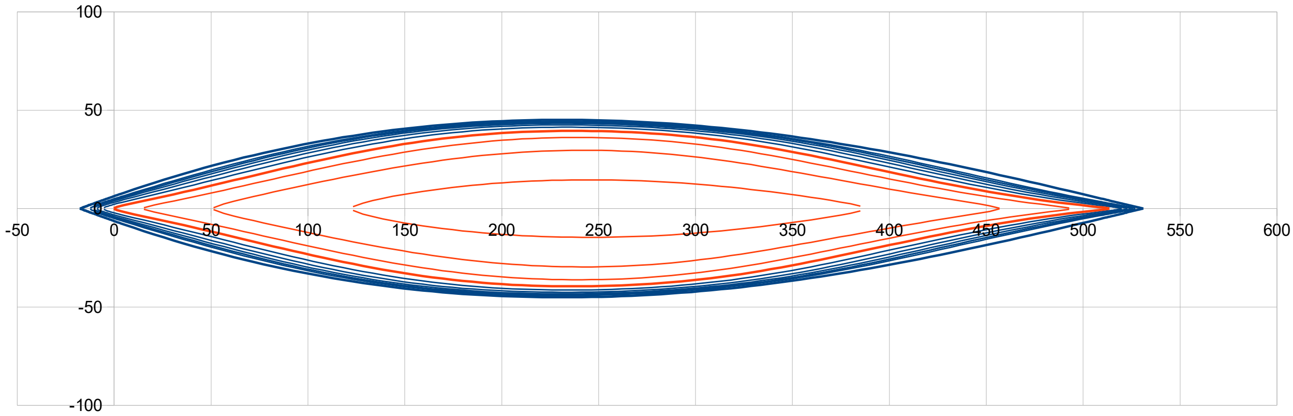
View of the front sections include sections ≥ C4 (= 40% Lwl), with a half section pitch : C4, C4,5, C5, ... In front of C10 (Front perpendicular), 2 complementary sections Cav1 and Cav2 are drawn, at 1/3 and 2/3 of the bow overhang.
View of the rear sections includes sections ≤ C4, with a half section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

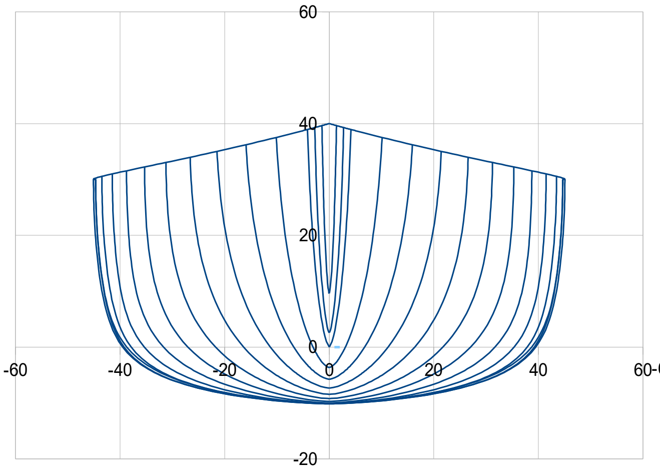
In the plan view of the bottom, waterlines in red are the wetted ones, the thick red line being the waterline H0.

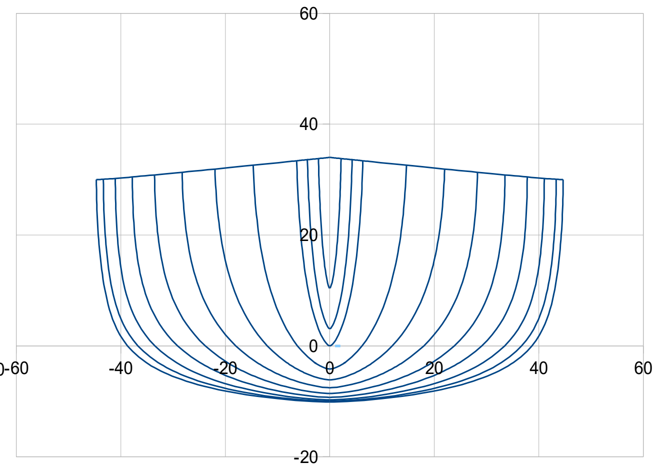
User intervention if necessary : *a*xis scales are proposed « automatic », grid pitch « fixed » and equal for the 2 coordinates. As long as the project dimensions are fixed , it is recommended to modify (if necessary) and to fix the scale of the views for orthonormal drawings (i.e. square grid).

Example :









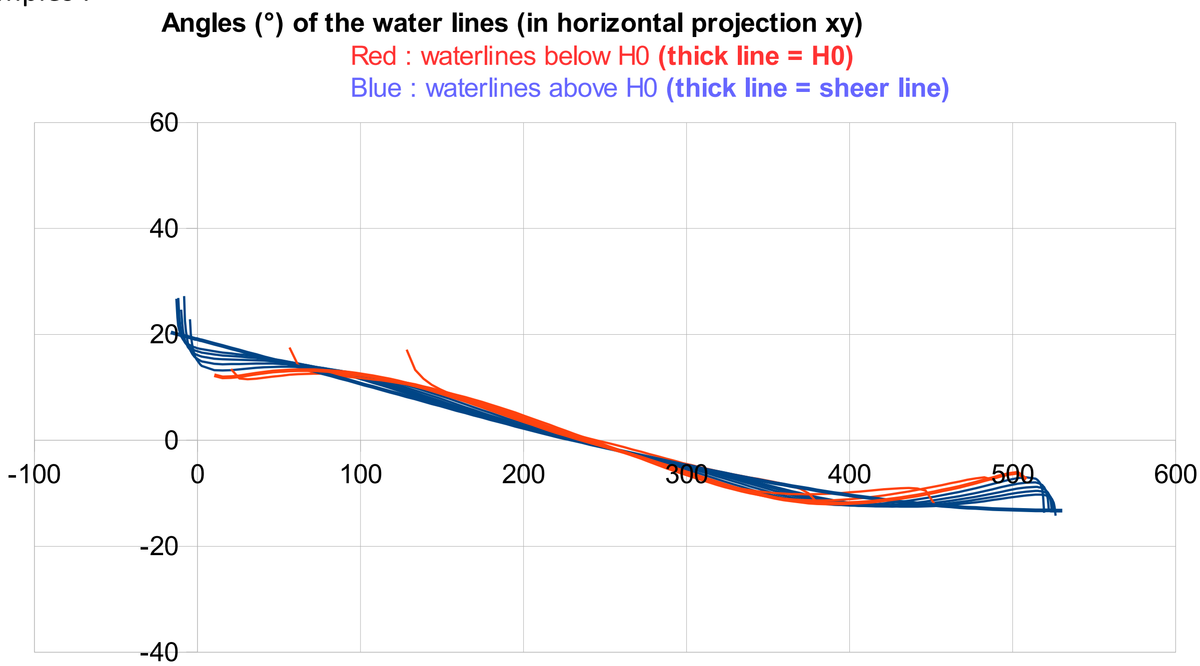
4. Curves of control

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 evolution xith x (for the definition of the V shape of the sections) and the combination law of V and E sections.
-

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

Examples :

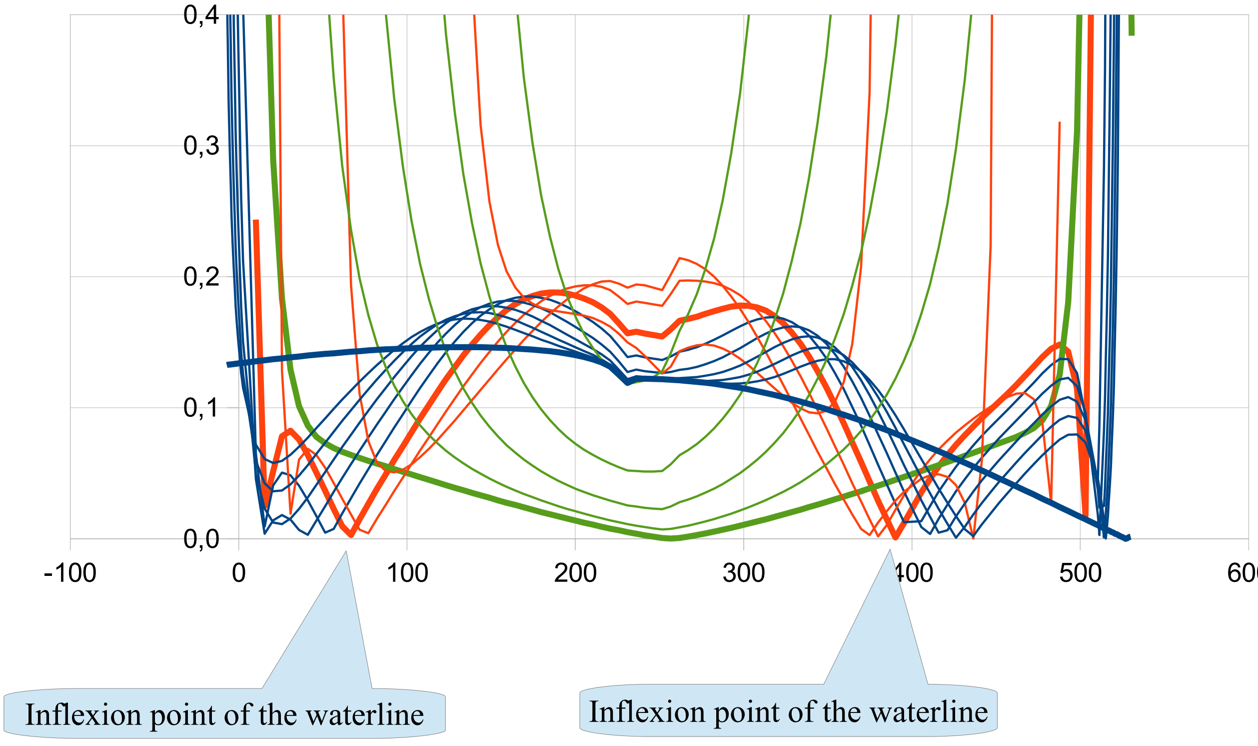


Curvatures 1/R :

Red : waterlines below H0 **(thick line = H0)**

Blue : waterlines above H0 **(thick line = sheer line)**

Green : keel and buttock lines **(Thick line = keel line)**



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 : Car2, 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,

Example of offsets data (units : cm) :

Car2 x >>	**-11,75**	**Car1 x >>**	**-5,87**	**C0 x >>**	**0,00**	**C1 x >>**	**51,34**
y	**z**	**y**	**z**	**y**	**z**	**y**	**z**
2,17	**33,79**	4,28	**33,59**	6,33	**33,39**	21,99	**31,91**
2,02	28,82	4,04	27,11	6,02	26,30	21,42	23,83
1,81	24,14	3,67	21,01	5,51	19,62	20,17	16,22
1,67	21,80	3,41	17,96	5,14	16,28	19,14	12,42
1,50	19,46	3,09	14,90	4,67	12,94	17,72	8,61
1,28	17,12	2,67	11,85	4,06	9,60	15,74	4,81
1,02	14,78	2,13	8,80	3,26	6,26	12,90	1,01
0,65	12,44	1,38	5,75	2,11	2,92	8,57	-2,80
0,39	11,27	0,82	4,23	1,26	1,25	5,20	-4,70
0,19	10,68	0,41	3,47	0,64	0,42	2,64	-5,65
0,13	10,53	0,27	3,27	0,41	0,21	1,70	-5,89
0,08	10,46	0,17	3,18	0,27	0,10	1,10	-6,01
0,00	**10,39**	0,00	**3,08**	0,00	**0**	0,00	**-6,13**

C2	x >>	102,68	C3	x >>	154,02	C4	x >>	205,36	C5	x >>	256,70
	y	z		y	z		y	z		y	z
	33,54	**30,85**		41,05	**30,21**		44,67	**30,00**		44,68	**30,25**
	33,16	22,47		40,80	21,72		44,41	21,48		44,42	21,66
	31,99	14,58		39,93	13,73		43,62	13,45		43,64	13,58
	30,88	10,64		39,06	9,74		42,91	9,44		42,98	9,54
	29,17	6,70		37,62	5,74		41,79	5,43		41,96	5,50
	26,53	2,75		35,12	1,75		39,80	1,42		40,20	1,46
	22,35	-1,19		30,60	-2,25		35,77	-2,59		36,56	-2,58
	15,31	-5,13		21,83	-6,24		26,64	-6,61		27,74	-6,62
	9,44	-7,10		13,77	-8,24		17,25	-8,61		18,16	-8,64
	4,83	-8,09		7,13	-9,24		9,05	-9,61		9,59	-9,65
	3,13	-8,34		4,63	-9,49		5,91	-9,87		6,27	-9,91
	2,02	-8,46		3,00	-9,62		3,83	-9,99		4,07	-10,03
	0,00	**-8,58**		0,00	**-9,74**		0,00	**-10,12**		0,00	**-10,16**

C6	x >>	308,04	C7	x >>	359,38	C8	x >>	410,72	C9	x >>	462,06
	y	z		y	z		y	z		y	z
	41,49	**30,99**		35,32	**32,24**		26,58	**33,98**		15,92	**36,21**
	41,25	22,26		35,05	23,32		25,98	24,96		15,11	27,30
	40,50	14,04		34,11	14,94		24,57	16,48		13,78	18,90
	39,82	9,93		33,17	10,74		23,38	12,24		12,83	14,71
	38,70	5,82		31,63	6,55		21,70	7,99		11,63	10,51
	36,68	1,71		29,11	2,35		19,31	3,75		10,09	6,31
	32,69	-2,41		24,88	-1,84		15,87	-0,49		8,06	2,12
	24,04	-6,52		17,31	-6,04		10,57	-4,73		5,21	-2,08
	15,43	-8,57		10,76	-8,13		6,41	-6,85		3,12	-4,18
	8,06	-9,60		5,53	-9,18		3,25	-7,92		1,57	-5,23
	5,25	-9,86		3,59	-9,44		2,11	-8,18		1,01	-5,49
	3,40	-9,98		2,32	-9,58		1,36	-8,31		0,65	-5,62
	0,00	**-10,11**		0,00	**-9,71**		0,00	**-8,45**		0,00	**-5,75**

C10	x >>	513,40	Cav1	x >>	519,27	Cav2	x >>	525,13
	y	z		y	z		y	z
	4,14	**38,95**		2,76	**39,29**		1,38	**39,64**
	3,90	32,70		2,53	31,49		1,25	33,26
	3,36	22,88		2,22	24,15		1,09	27,25
	3,08	18,99		2,03	20,48		0,99	24,25
	2,74	15,09		1,80	16,81		0,88	21,24
	2,33	11,20		1,53	13,14		0,74	18,24
	1,83	7,30		1,20	9,47		0,58	15,23
	1,16	3,41		0,76	5,80		0,37	12,23
	0,69	1,46		0,45	3,96		0,22	10,73
	0,34	0,49		0,22	3,05		0,11	9,98
	0,22	0,24		0,14	2,82		0,07	9,79
	0,14	0,12		0,09	2,70		0,04	9,70
	0,00	**0,00**		0,00	**2,59**		0,00	**9,60**

6. Hull stability at total displacement

At first, you have to complete the data for a simplified mass spreadsheet.

Simplified Mass spreadsheet				
	Hull weight unit (kg/m2)	Mass (kg)	Zg (/H0) (m)	Zg (m)
Canoe (kg)	**4,18**	26,16	0,06	0,049
Load (kg)		**170,15**	**0,27**	0,255
M tot (kg)		**196,3**		
Zg tot (m)				**0,227**

4 Cells are to fulfill (here above in light yellow) :

Canoe hull weight unit, in kg per square meter of hull surface **(Cell K229)**
>>> 4,18 in the example above, i.e. 0,856 lbs/sq.ft. The mass spreadsheet use this data and the hull surface is given the hydrostatics data output (6,26 m2 for the hull of reference) to compute the canoe weight estimation, here 26,16 kg, i.e. 57,7 lbs.

Load (kg) (Cell L230) : 170,15 kg in the example above, i.e. 375 lbs

Load Zg (m) position / waterline H0 (the one defined above by the Tc value) **(Cell M230)** : 0,27 m in the example above.

Then you can study the Hull stability at total displacement :

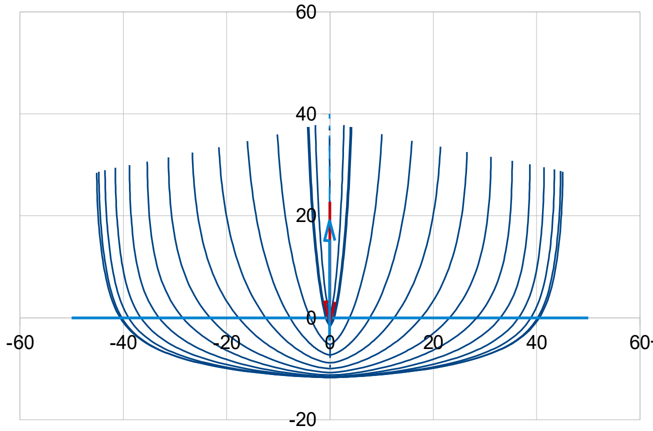
Data to enter		Results					
Heel (°)	**0,1**	Disp. Heel 0°	**0,15851**	**Disp tot(m3)**	**0,19631**		
Height (cm)	**-1,5277**	**> Disp. (m3)**	**0,19631**	>> Lwl (m)	5,225	>> Bwl (m)	0,808
		Xc (m)	2,44	/ Xc Heel 0°	2,45	>> Draft (m)	0,117
		Yc (m)	0,00	/ Yc Heel 0°	0,00	Ym (m)	0,00
		Zc (m)	-0,04	/ Zc Heel 0°	-0,04	>> GZ (m)	0,0004
		>> Sw (m2)	2,83	/ Sw Heel 0°	2,61	**GM (cm)**	**20,3**
						(inch)	*8,01*

Data to enter are :
Heel angle (°) : for the initial stability study, you can choose 0,1° (and check with heel 0,2° that the GM is numerically stable) . For the stability when cambrered waves come from beam (for example, a motor boat passes near you, you can test also heel 20° **(Cell B227)**
Height (cm), hull rising (positive value) or depression (negative value) : once the heel angle is set, you have to iterate on the height value up to have exactly the same displacement than the one coming from the mass spreadsheet, i.e. Disp. = Disp tot. **(Cell B228)**

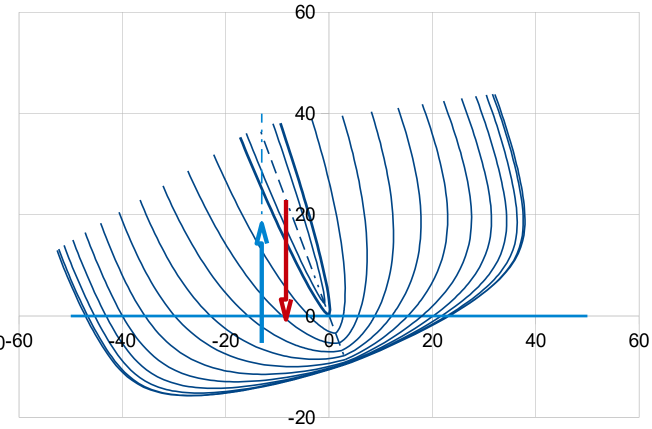
Important : when using the VPP application, you have at first to set the equilibrium ***with heel at 0,1°***, because the resulting data LwL, Bwl, Draft and Sw are used as input by the VPP.

Drawing of the hull with heel is also proposed, with a visualization of the vectors buoyancy and weight. Example :

Heel = 0,1° ; Height = -1,5277 cm



Heel = 20° ; Height = 0,1005



Data to enter		Results					
Heel (°)	**0,1**	Disp. Heel 0°	**0,15851**	**Disp tot(m3)**	**0,19631**		
Height (cm)	**-1,5277**	**> Disp. (m3)**	**0,19631**	>> Lwl (m)	5,225	>> Bwl (m)	0,808
		Xc (m)	2,44	/ Xc Heel 0°	2,45	>> Draft (m)	0,117
		Yc (m)	0,00	/ Yc Heel 0°	0,00	Ym (m)	0,00
		Zc (m)	-0,04	/ Zc Heel 0°	-0,04	>> GZ (m)	0,0004
		>> Sw (m2)	2,83	/ Sw Heel 0°	2,61	**GM (cm)**	**20,3**
						(inch)	*8,01*

Data to enter		Results					
Heel (°)	**20,0**	Disp. Heel 0°	**0,15851**	**Disp tot(m3)**	**0,19631**		
Height (cm)	**0,1005**	**> Disp. (m3)**	**0,19631**	>> Lwl (m)	5,127	>> Bwl (m)	0,785
		Xc (m)	2,43	/ Xc Heel 0°	2,45	>> Draft (m)	0,101
		Yc (m)	-0,13	/ Yc Heel 0°	0,00	Ym (m)	-0,08
		Zc (m)	-0,05	/ Zc Heel 0°	-0,04	>> GZ (m)	0,0468
		>> Sw (m2)	2,63	/ Sw Heel 0°	2,61	**GM (cm)**	**13,7**
						(inch)	*5,39*

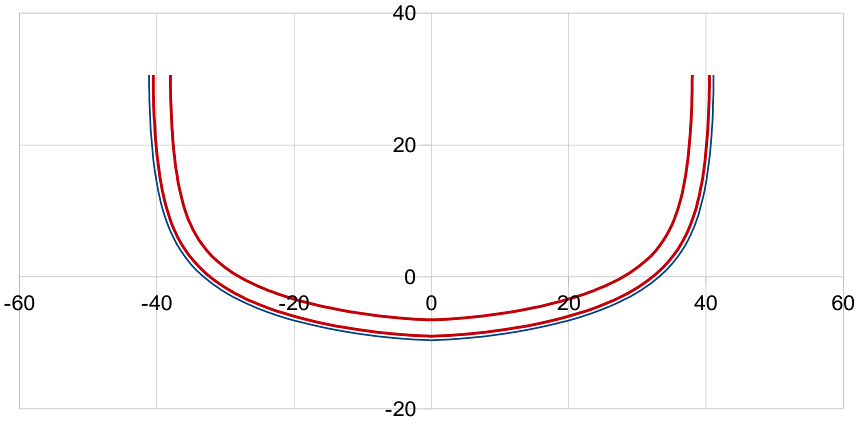
7. Data for hull sections drawing at scale one, inc. hull frames

This section, in complement of 5. proposing data for a transfer to a 3D modeller, provides the data which can be used for a scale one drawing of any section at a given X position, inc. a hull frame when necessary. This section is divided in 2 sub-sections 7.1 and 7.2 for respectively sections behind or in front of midship (station C5).

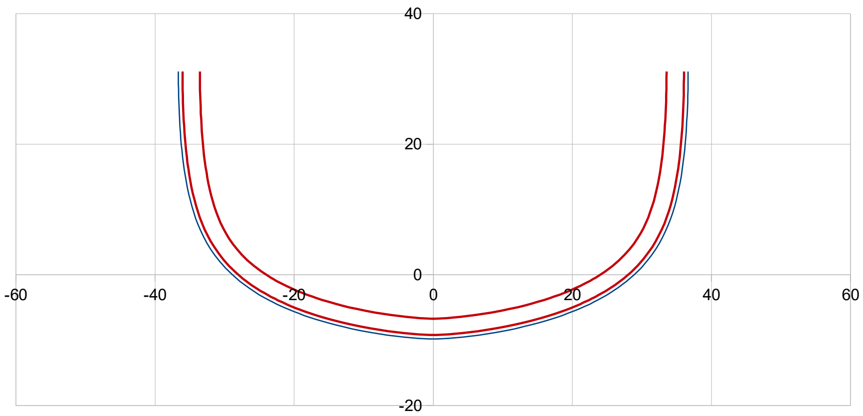
The User should enter the X value of the section, the current thickness of the hull, the height of the hull frame, the current thickness of the deck, the height of the deck bar. **Unities : cm** .

Example :

7.1	**0 < Section X ≤ C5 (midship)**			
Data to enter	**X (cm)**			
>	**150,0**			
Hull thickness (cm) >	**0,6**	**Frame H >**	**2,5**	



7.2	C5 ≤ Section X < C10		
Data to enter	x (cm)		
>	350,0		
Hull thickness (cm) >	0,6	Frame H >	2,5



VPP spreasheet application

A VPP application is proposed on a specific spreadsheet. Most of the necessary data is retrieved from the output of the Gene-Hull spreadsheet. Only 4 additional data are necessary to input, here below in yellow light cells :

Data from Gene-Hull										
Sa hull	S person(s)	Cd aero	Dép. (kg)	Lwl (m)	v (m2/s)	Lwl/Bwl	Bwl/Tc	Lwl/D^1/3	Cp	LCB
0,36	0,74	0,5	196,31	5,225	1,00E-006	6,47	6,91	8,99	0,520	-2,35
	Water mass / vol. (kg/m3)		1000	Vol hull (m3)	Sw Hull 0°	Bwl (m)	Tc (m)			
				0,19631	2,826	0,808	0,1169			
Flat sea – No wind							Residuary drag assumption			
Boat speed							for canoe >>	0,70		

At constant power on flat sea with Head wind :	Power (W)	75,0

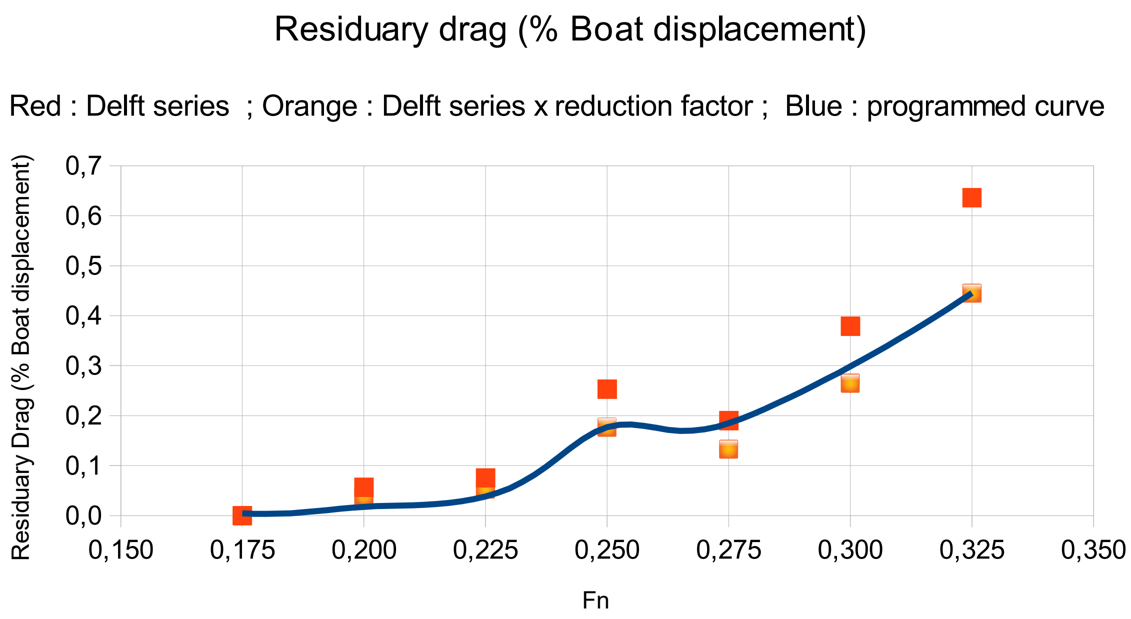
S Person(s) is the frontal surface of the 2 paddlers, used for the computation of the aero drag, in the example this surface is estimated to 0,37 x2 = 0,74 m2   **(Cell B5)**

Cx is the aero drag coefficient for both the canoe (S = Beam x Fore free board) and the paddlers, here taken to 0,5 **(Cell B6)**

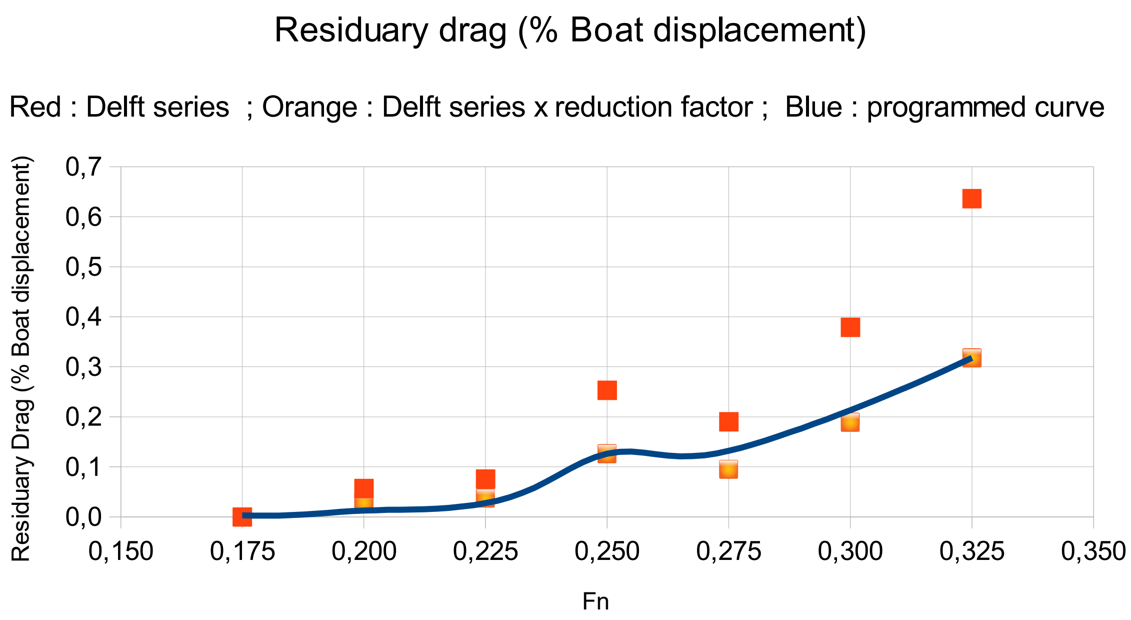
Residuary drag reduction factor for Canoe hull : the residuary drag is based on the Delft series and its parametric approach as described in « Principles of Yacht Design » L. Larsson and R.E. Eliasson Second Edition 2000. But, as the Lwl/Bwl of the usual Canoe hulls is a bit greater than 5, a reduction factor is proposed , at 0,7 or another value that the user can set, on **Cell I9 .**

Examples with 0,7 and 0,5 :

Factor = 0,7



Factor = 0,5 :

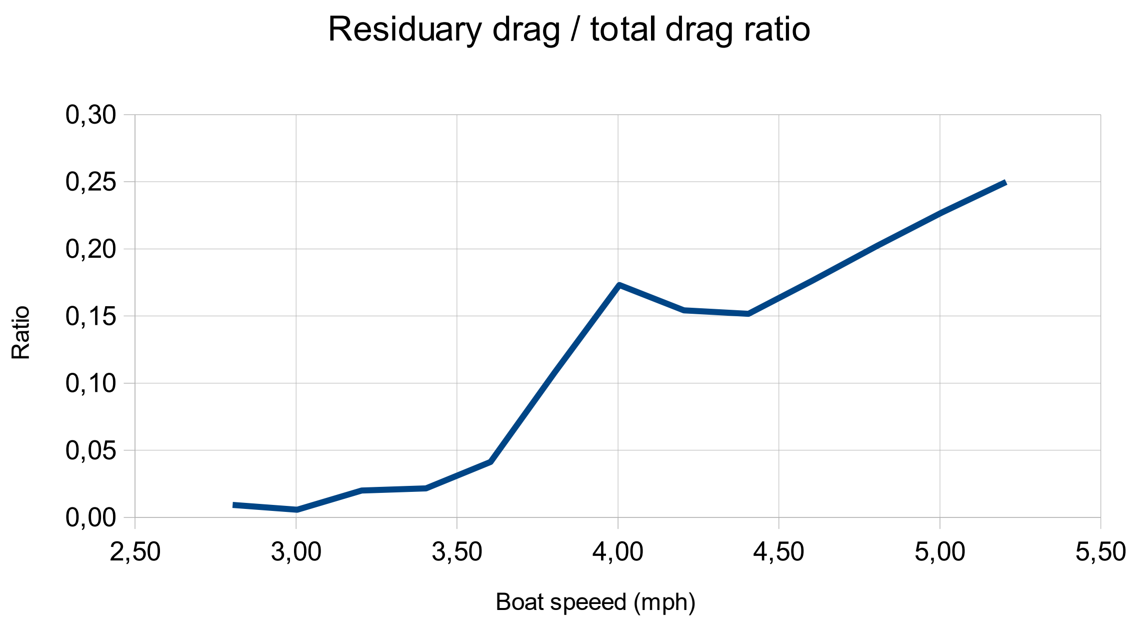


The constant power to set for computation of the speed on calm water with head wind (Cell F26)

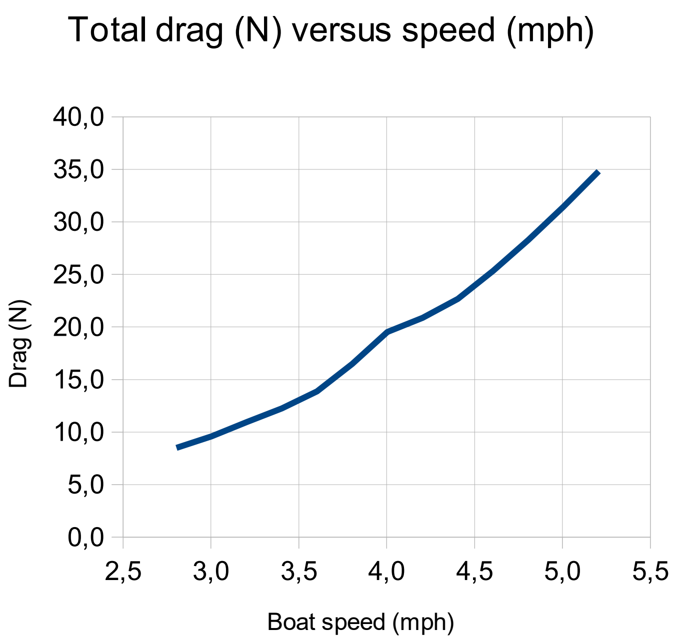
What is the influence of such assumption on the results ? Example with Power 75 W :

Reduction factor 1,0 >>> Speed = 4,97 mph
Reduction factor 0,7 >>> Speed = 5,10 mph
Reduction factor 0,5 >>> Speed = 5,20 mph

The influence on speed is quite moderate as the drag main component is from friction. Example with reduction factor = 0,7 :

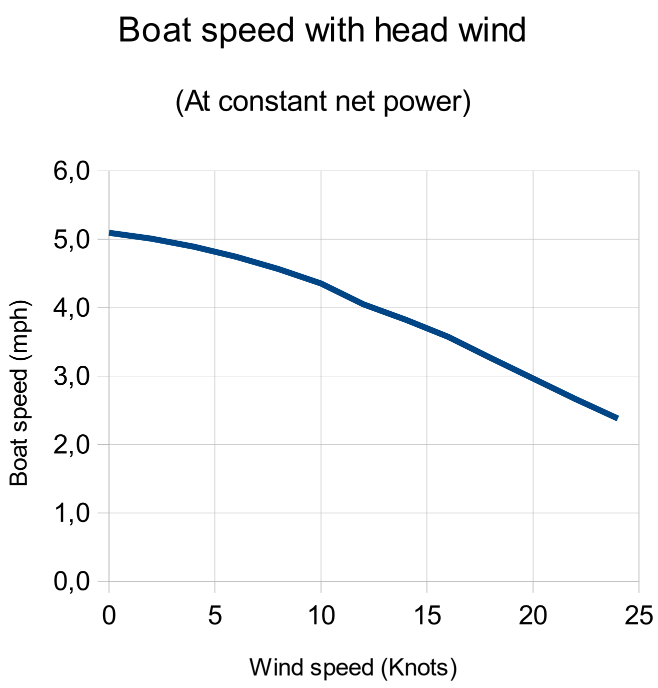


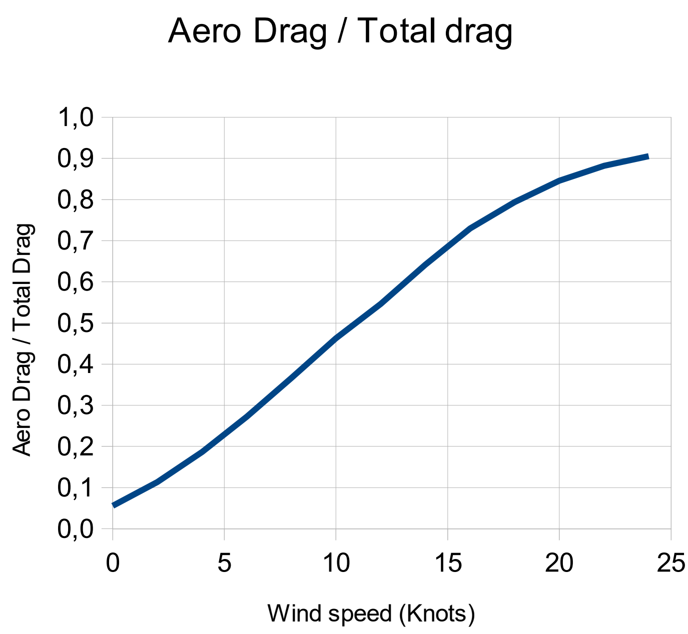
VPP outputs :
On calm water without wind, the drag curve and the propulsion net power are proposed.



Examples :

When fixing a propulsion net power (in Watt) in cell F26 , the boat speed and the aero drag ratio are computed versus head wind. Example with 75 W





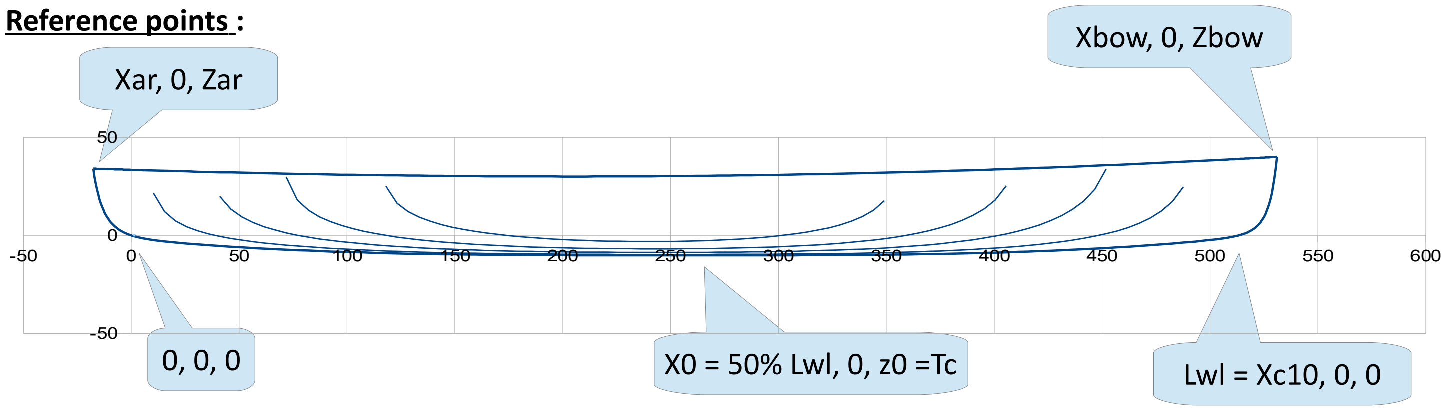
Annex : main formulations involved in Gene Hull

As a complement to the User Guide, this annex proposes the main formulations involved in Gene-Hull. for the geometrical definition of the keel line, of the sheer line and of the sections.

Coordinates system :
x = 0 at section C0 (= rear point of the waterline), x positive towards front
y = 0 in the symmétrical longitudinal plan, y positive towards starboard,
z = 0 waterline surface, z positive towards up

1. The keel line in the vertical plan of symmetry xz

<u>Reference points</u> :



The keel line is defined by 2 polynomes for respectively the fore part (when x > x0 = 50% Lwl) and the rear part (when x < x0). Both polynomes are of the type :

$$z = z_0 + a\,(x - x_0)^{[b + c\,(X-X0)^n]}$$

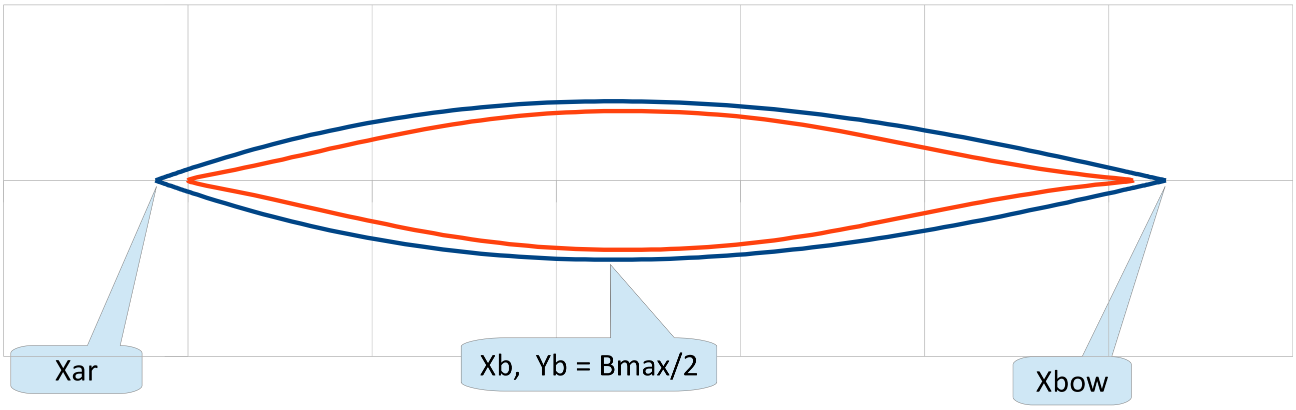
, where a, b, c are defined to comply with the reference points showed here above and n is an adimensional parameter :

- n = Cet, an additional input for the fore polynome, contibuting to shape the bow, Cet can vary from 0,1 to 100
- n = 1, for the rear polynome.

2. The sheer line, in its horizontal projection xy

The sheer line is defined by 2 polynomes for respectively the fore part (when x > x0 = 50% Lwl) and the rear part (when x < x0).

<u>Reference points for the sheer line</u> :



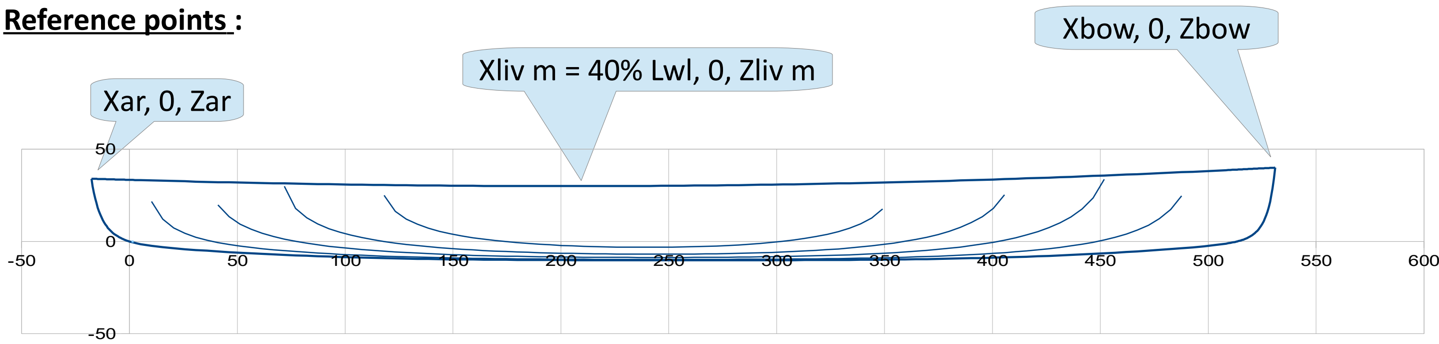
The sheer line is defined by a polynome of this type :

$$Y_g = B_g/2 - a\ |X_b - X|^{(b + c\,|X_{bg} - X|^n)}$$

, where a, b, c are computed to comply with the reference points showed here above and n is an adimensional parameter.

3. Sheer line / in its vertical projection xz

Reference points :



The keel line is defined by 2 polynomes for respectively the fore part (when x > 40% Lwl) and the rear part (when x < 40% Lwl). Both polynomes are of the type :

Fore : $Z = Z_{liv\,m} + (Z_{bow} - Z_{liv\,m}) / (X_{bow} - X_{liv\,m})^n * (X - X_{liv\,m})^n$

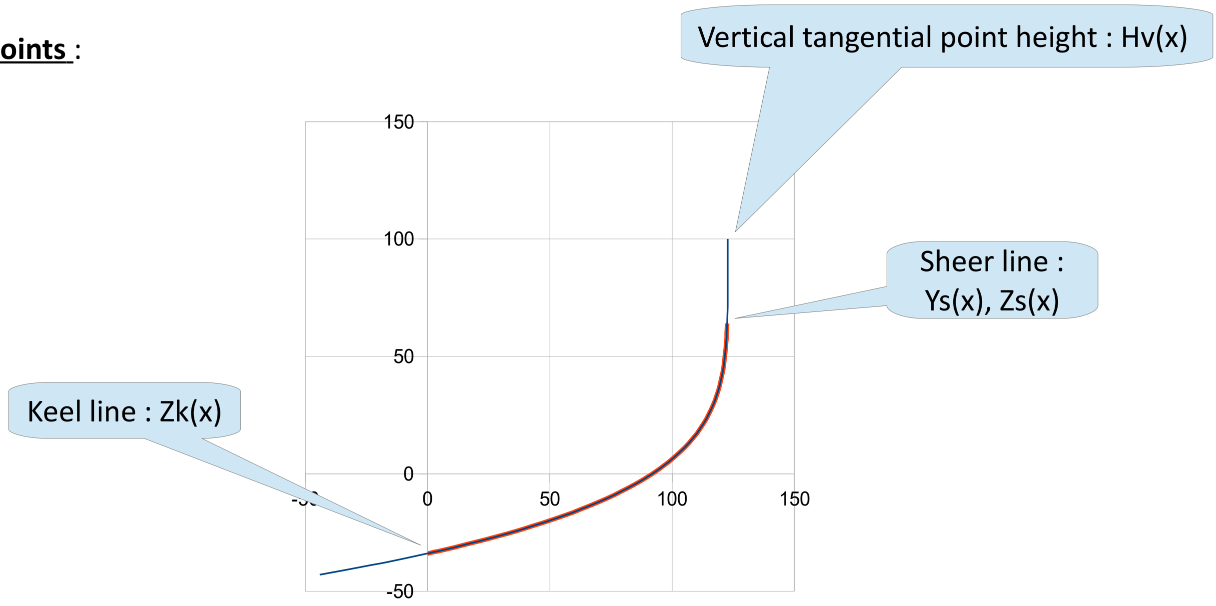
Aft : $Z = Z_{liv\,m} + (Z_{ar} - Z_{liv\,m}) / (X_{liv\,m} - X_{ar})^n * (X_{liv\,m} - X)^n$

4. Sections

2 types of elementary sections are defined, « V » shape and « E » shape, and then a combination of V and E shapes is operated to define the real sections.

4.1 **<u>« V » shape sections</u>**

Reference points :



The formulation is of the type :

$$Y_v(x,z) = A(x) - (\ H_v(x) - z\ )^{\wedge Puiv(x)} / B(x)$$

, with :

$$H_v(x) = H_{v\ m} + (H_{v\ ar} - H_{v\ m})*[|X - X_5| / |X_{ar} - X_5|]^{\wedge PuiHv} \quad \text{for } x < x_5$$

$$H_v(x) = H_{v\ m} + (H_{v\ av} - H_{v\ m})*[|X - X_5| / |X_{bow} - X_5|]^{\wedge PuiHv} \quad \text{for } x > x_5$$

$$P_{uiv}(x) = P_{uiv\ ar} + (P_{uiv\ av} - P_{uiv\ ar})*[(X - X_{ar})/(X_{bow} - X_{ar})]^{\wedge PuiPuiv}$$

$$B(x) = [(H_v(x) - Z_k(x))^{\wedge Puiv(x)} - (H_v(x) - Z_s(x))^{\wedge Puiv(x)}]/Y_s(x)$$

$$A(x) = [(H_v(x) - Z_k(x))^{\wedge Puiv(x)}]/B(x)$$

, where the input data are the adimensional parameters :

C Hv av
C Hv m
C Hv ar
Pui Hv
Pui V av
Pui V ar
Pui Pui V

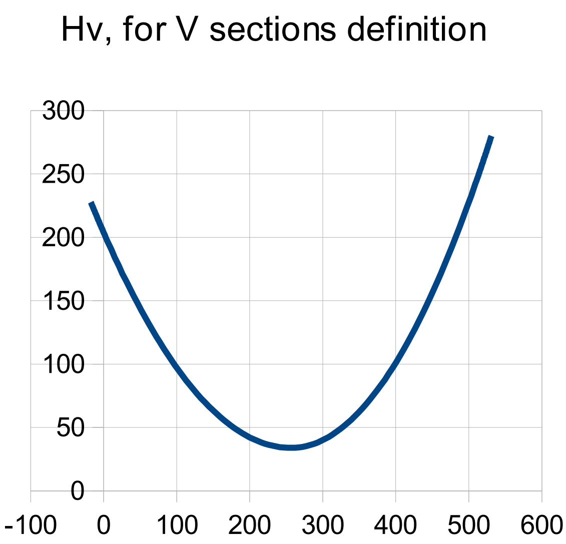
, and :

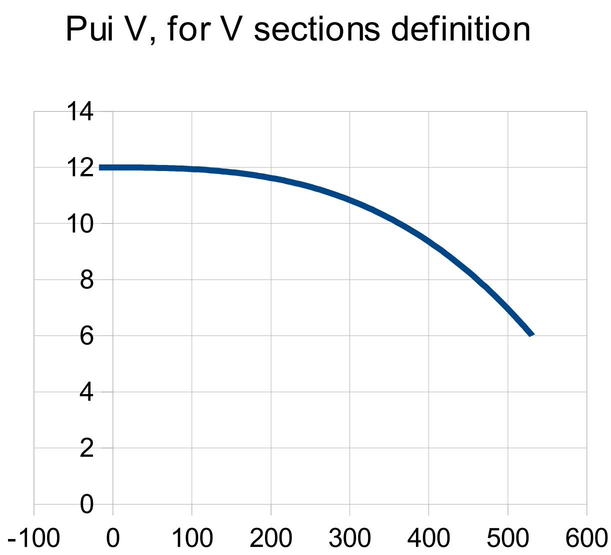
X_5 = 50% Lwl

Hv ar = C Hv ar * Zar ; Hv m = C Hv m * Z liv m ; Hv av = C Hv av * Zbow

Zk(x) is the keel line height ; Zs(x) is the sheer line height ; Ys(x) is the sheer line half beam

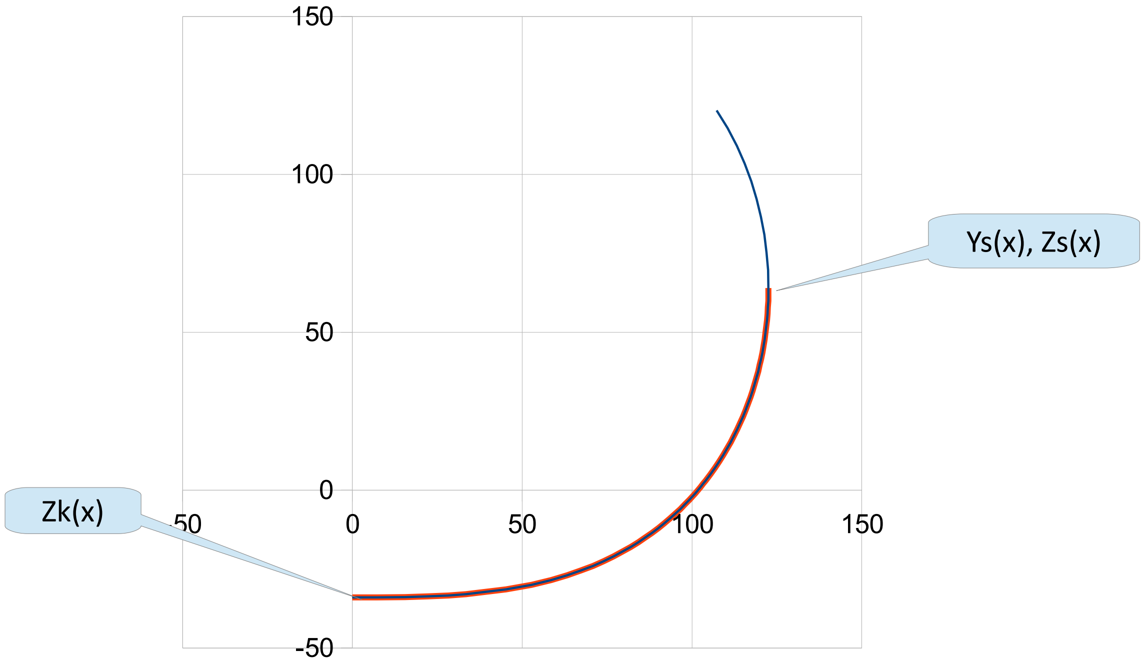
Examples of Hv(x) and Puiv(x) functions :





4.2 « E » shape sections

Reference points :



The formulation is of the type :

$$Y_E(x,z) = Y_S(x) - [1-((Z_S(x) - z)/(Z_S(x) - Z_K(s))^{\wedge}2]^{\wedge(1/PuiE)}$$

, where the input adimensional parameter is $\mathbf{P_{uiE}}$

4.3 Combination of V and E shapes

The combination law is :

VE sections : $Y_{VE}(x,z) = Y_V(x,z)^{mix(x)} * Y_E(x,z)^{(1-mix(x))}$

UE sections : $Y_{UE}(x,z) = Y_U(x,z)^{mix(x)} * Y_E(x,z)^{(1-mix(x))}$

, with :

$$mix(x) = mix_{av} + (mix_{ar} - mix_{av}) * [(X_{bow} - X)/(X_{bow} - X_{ar})]^{P_{uimix}}$$

, where the input data are the adimensional parameters :

mix VE av
mix VE ar
Pui mix VE

Examples of mix(x) :

VE law of combination