

## Gene-Hull Catamaran 2.4\_User Guide\_English version

This **Catamaran version** of the application includes :

- the Hull generation (using the UE shape version more adapted for multihull),
- Daggerboards and rudders generation,
- the Catamaran configuration with heel angle (inc. 2 hulls + 2 daggerboards + 2 rudders) can be studied within its hydrostatic equilibrium, from which wetted surface and righting moment RM can be computed for each heel angle, floatation surfaces of the leeward and the windward hull are drawn,
- one can introduce a hard chine associated with a spray rail,
- an early stage Sailplan can be defined (input : mast position , I J P E values), from which the « lead » is computed (>>> the optimal relative position of the mast and the daggerboards) and also the ratios involving the sail surface.
- an early stage Mass spreadsheet can be defined, from which the light boat weight and CdG coordinates are computed

Gene-Hull Catamaran makes possible the generation of hulls with their 2D views and their hydrostatic characteristics as output, daggerboard 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 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 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-keel-rudder with heel angle is also proposed, in hydrostatic condition, at iso displacement and with control of the longitudinal center of buoyancy thanks to iteration on height and trim parameters. It provides the transversal offset of the center of buoyancy and so the corresponding contribution to the righting moment, and 2D drawings (sections and floatation waterline) which can help assess the relevance of the hull with heel.

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, some limitations exist which could be overtaken within further versions. Main is :

- necessarily inverted (or quasi vertical) rear transom (but hull with classic transom can be generated, it is just that the transom itself is not drawn)
- no inverted bow possible

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 unpredictable (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 spreadsheet 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>

In the annex, the main formulations involved are detailed, 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 4 sheets :

- Gene-Hull
- Hulls storage
- Sailplan
- Mass spreadsheet

**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 with heel
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

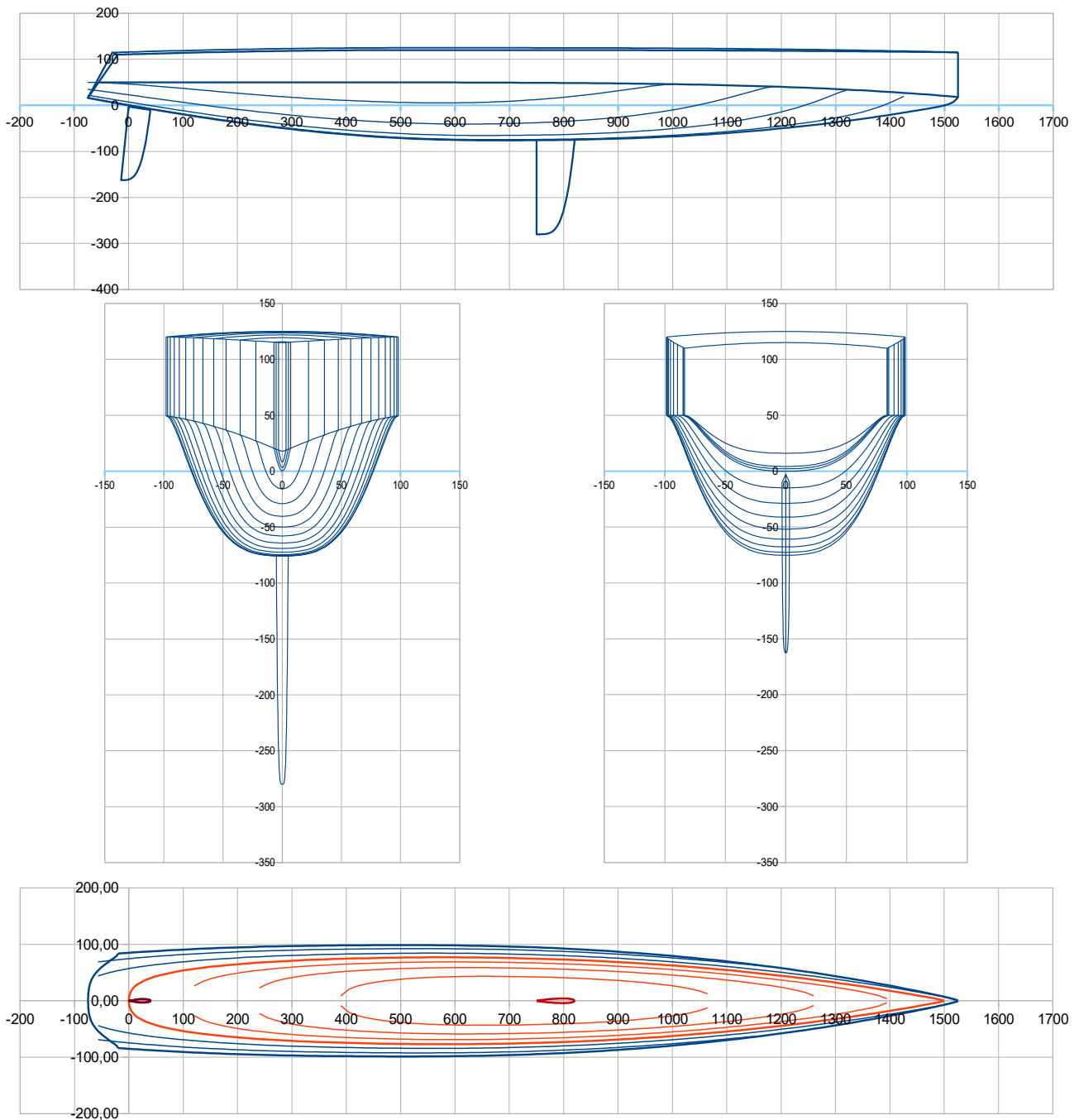
**Sailplan input and output** : includes an User space (input and outputs) followed by an Administrator space where the computations are carried out

**Mass spreadsheet input and output** : includes an User space (input and outputs)

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

The coordinates  $x, y, z$  used for the « one hull » 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),
- Showned 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. For the catamaran views with its 2 hulls, the longitudinal axis is the catamaran axis of symmetry.

## Gene-Hull sheet / Input

### 1. Data to enter for the hull body

Data to enter are in column B (cells B12 to B68), the ones of the 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 Imperial units in column C (*in italic blue in the file*).

1.1 Hull data	metric	>> feet	Hull of ref.
Lenght of waterline :			
Lwl (m)	15,00	49,21	15,00
Beam between hulls axis			
Bhu (m)	6,10		6,10
Maximum draft of the hull body :			
Tc (m)	0,76	2,49	0,76
X Tc (%Lwl)	45,00		45,00
Hull bow :			
Xbow (m)	15,25	50,03	15,25
Zbow (m)	1,15	3,77	1,15
Shape coefficient of the bow :			
Cet	90		90
Polynomials of the keel line, front part and rear part :			
Pui q av	2,35		2,35
Pui q ar	2,2		2,2
Rear end of the transom :			
X tab ar (m)	-0,75	-2,46	-0,75
Z tab ar (m)	0,160	0,52	0,160
Sheer line, in horizontal projection xy :			
Bg (m)	2,12	6,96	2,12
X Bg (% Lwl)	28,0		28,0
Alfa (°)	-0,40		-0,40
Pui liv y	2,50		2,50
Cor Pui liv	0,055		0,055
Pui Cor Pui	0,40		0,40
X liv ar (m)	-0,20	-0,66	-0,20
Scow	0,05		0,05
Option Hard Chine line, in vertical projection xz :			
Type	1		1
1,2 Zhc av (m)	0,18	0,59	0,18
2 Zhc m (m)	0,45	1,48	0,45
1,2 Zhc ar (m)	0,5	1,64	0,5
Pui hc z	5		5
Sheer line, in vertical projection xz :			
Z liv m (m)	1,2	3,94	1,2
Z liv ar (m)	1,10	3,61	1,10
Pui liv z	3		3
Deck / central line rear end			
Z p m (m)	1,25	4,10	1,25
X p ar (m)	-0,30	-0,98	-0,30
Z p ar (m)	1,15	3,77	1,15
Pui deck z	3,0		3,0
Sections : as a combination of « U » shape and « E » sl			
Sections U :			
C Hu av	0,25		0,25
C Hu ar	0,60		0,60
Pui Hu	1,00		1,00
Pui U av	5,00		5,00
Pui U ar	5,00		5,00
Pui Pui U	4,00		4,00
Cor Pui Pui U	0,00		0,00
Sections E and combination UE :			
Pui E1	0,50		0,50
Pui E2	3,31		3,31
mix UE av	0,50		0,50
mix UE ar	0,30		0,30
Pui mix UE	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.

### Beam between hulls axis

**Bhu (m)** : transversal distance between the 2 hulls axis (cell B14)

### Hull body draft

**Tc (m)** : maximum draft of the hull body (cell B16)

**X Tc (%Lwl)** : longitudinal position of the maximum draft (in % of Lwl) (cell B17)

### Hull bow end

**Xbow (m)** : should be > Lwl (inverted bow is not possible) (cell B18)

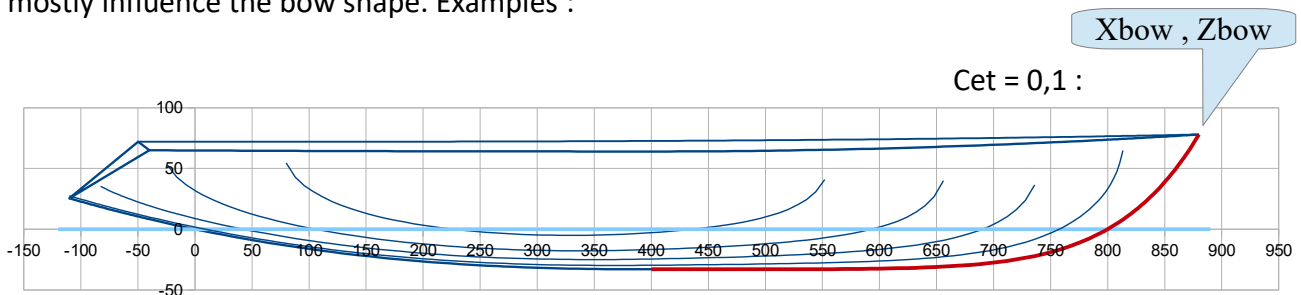
**Zbow (m)** : it is the front freeboard (cell B19)

### Bow coefficient

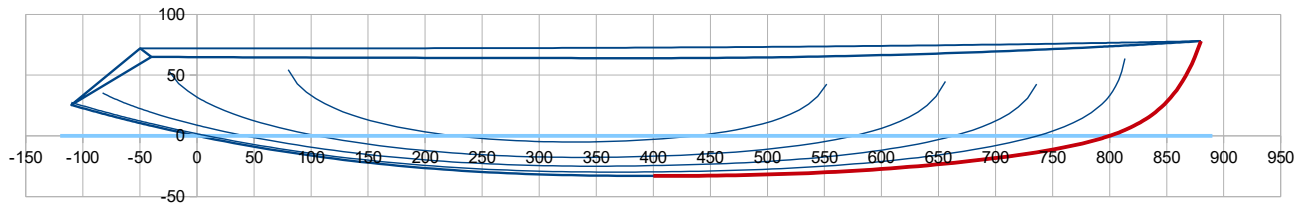
For the bow shape, 3 data are influent and in interaction : **Xbow** (acting on the front overhang), **Cet** (acting on the bow line) and **Pui q av** (acting on the overall shape of the front keel line).

**Cet** : adimensional coefficient > 0, from 0,1 to 100 typically. (cell B 22)

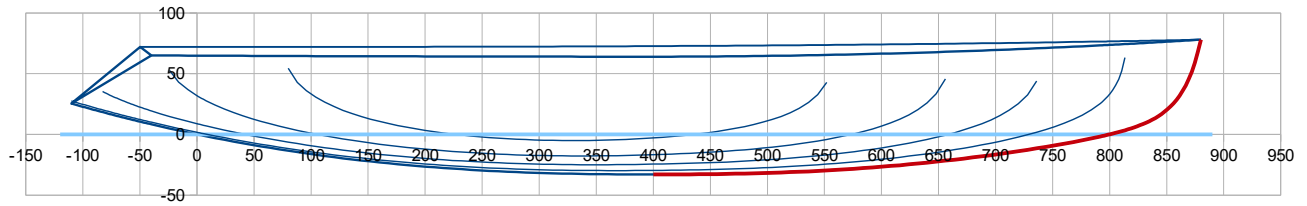
This coefficient is involved in the polynomial formulation of the front part of the keel line and mostly influence the bow shape. Examples :



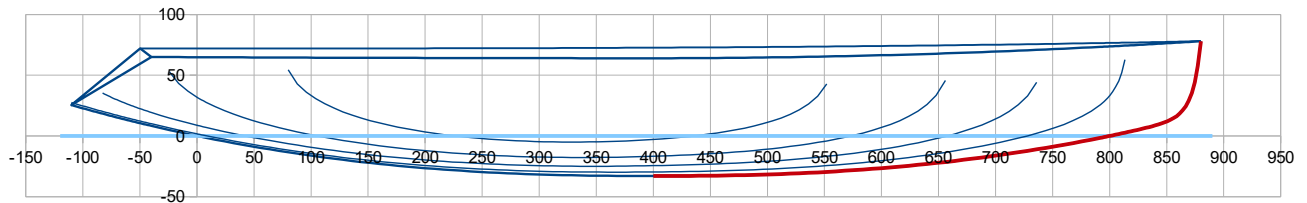
Cet =10 :



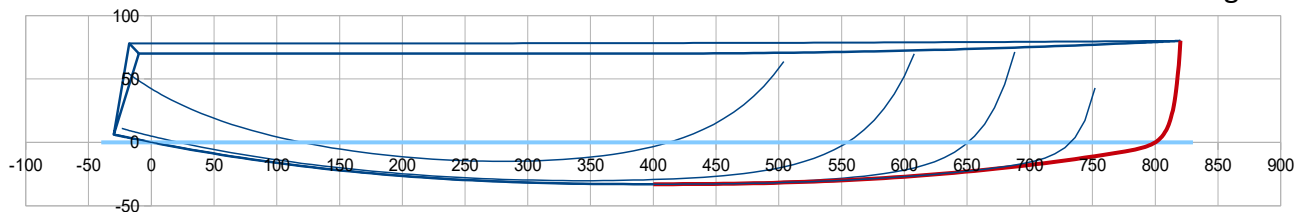
Cet 20 :



Cet 50 :



Cet 50 with a shorter front overhang :

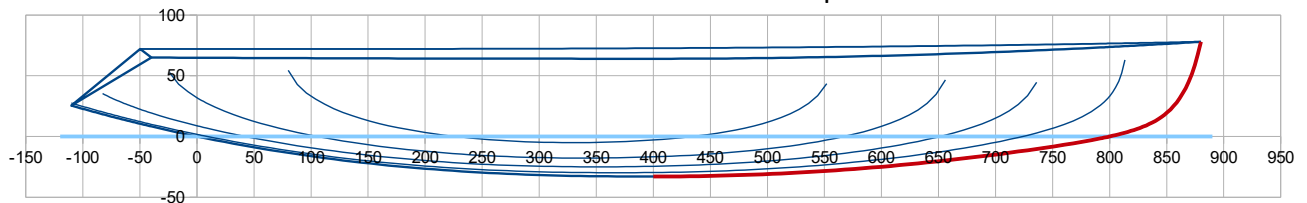


### Keel line polynomial / front part ( $x > X_{Tc}$ )

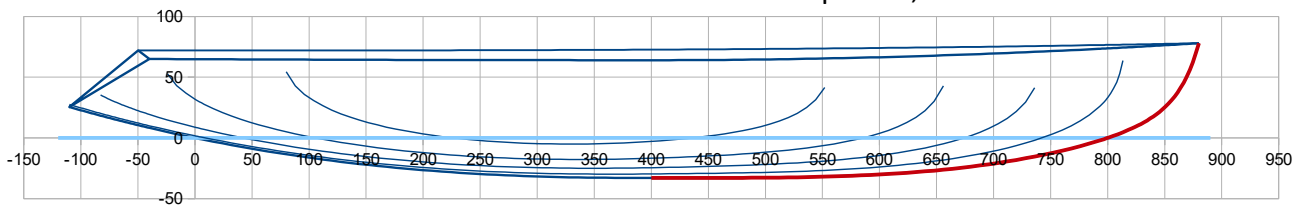
**Pui q av** : adimensional coefficient which figures the power factor of the front polynomial (details of the formulation in the technical appendix on request). (Cell B24)

Should preferably be  $\geq 2$  , some examples :

Pui q av = 2 :



Pui q av = 3,5 :



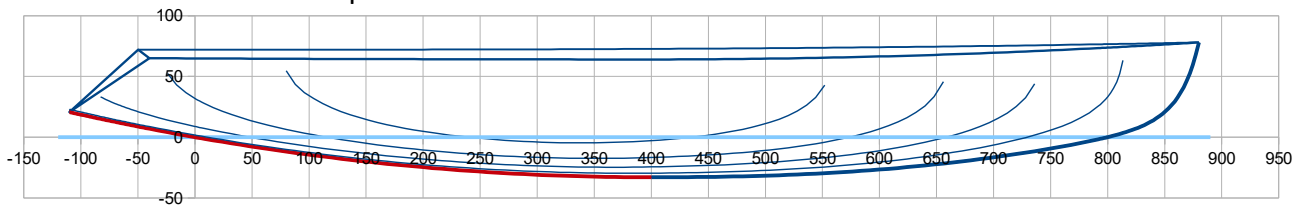
### Keel line polynomial / rear part ( $x < X_{Tc}$ )

For the rear keel line shape, 3 data are influent and in interaction : **X tab ar**, **Z tab ar** (= the rear point location) and **Pui q ar** (acting on the overall shape of the rear keel line).

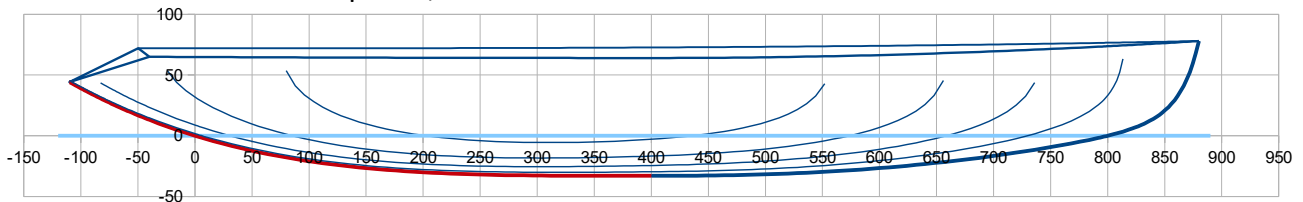
**Pui q ar** : adimensional coefficient which figures the power factor of the rear polynomial (details of the formulation in the technical appendix on request). **(cell B25)**

Should preferably be  $\geq 2$  , some examples :

Pui q ar : 2



Pui q ar : 3,5



### Rear transom end point

**X tab ar (m)** : X of the rear point overall, should be less than all other X. **(cell B27)**

Nota : an inverted rear transom is modelled, implying the respect of this condition :

$$X_{tab\ ar} < X_{p\ ar} < X_{liv\ ar} < 0$$

**Z tab ar (m)** : Z of the rear point. **(cell B28)**

This data influence the shape of rear end of the the keel line.

Example :

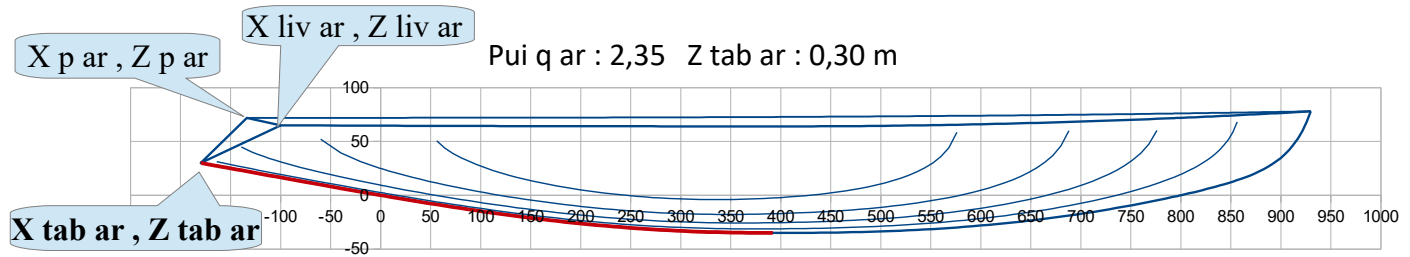
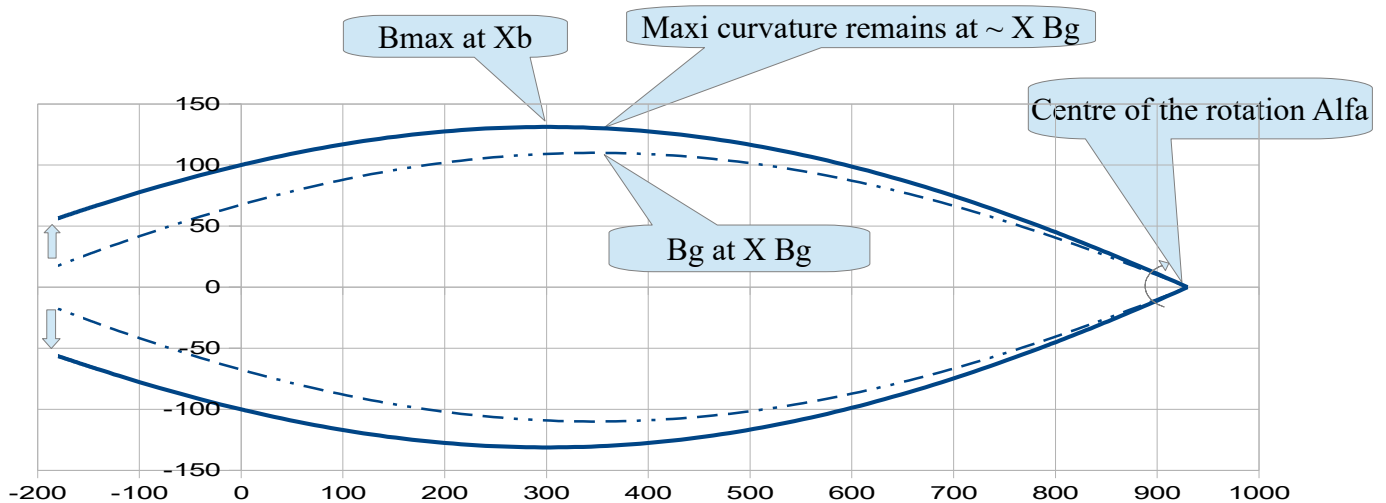


Fig. 1

### Sheer line in horizontal plan (plan xy)

An indirect approach is proposed to define the sheer line projection in the horizontal plan, using 3 data : **Bg (m)** , **X Bg (%Lwl)** and **Alfa (°)**. This approach allows both to adjust the rear transom width and to position the maximum beam **Bmax** independently of the sheer line maximum curvature.

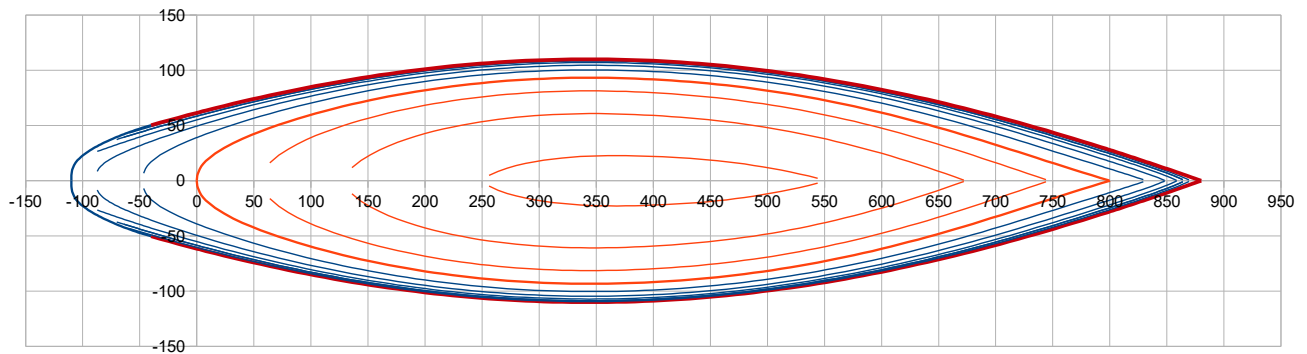
At first a virtual sheer line (dashed line here below) is defined with as input the maximum beam **Bg (m)** (cell B30) positioned in **X Bg (%Lwl)** (cell B31). Then, this line is « open » by rotation of a half-angle **Alfa (°)** (cell B30) with the bow end as center for this rotation (as showed here below), to obtain the real sheer line with a new maximum beam **Bmax** at a new location **Xb** (**Bmax** and **Xb** being computed by the system and showed in blue opposite to the input data). So a set of values for **Bg**, **X Bg** and **Alfa** leads to the real sheer line with maximum beam **Bmax** at a real position **Xb**. By doing so, the sheer line maximum curvature remains close to **X Bg** and is disconnected to



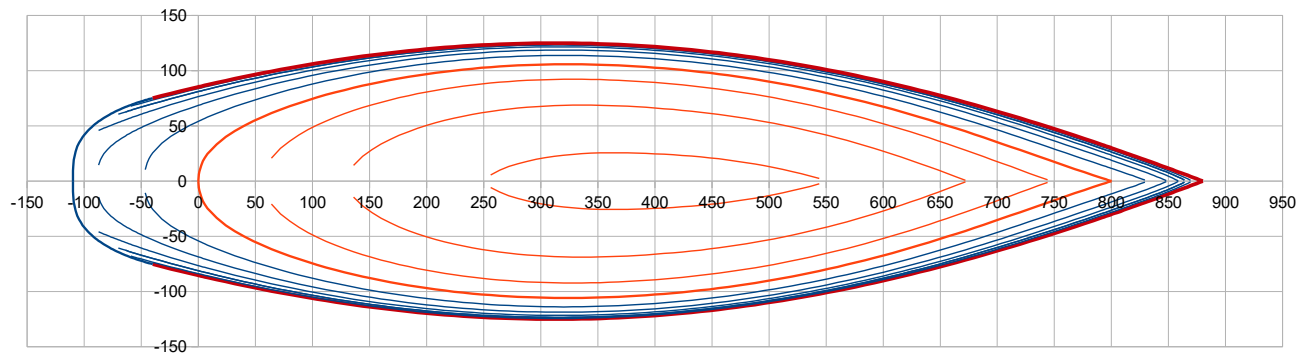
*Nota : this « Alfa » reshaping of the hull is powerful, it can be done at any moment of the hull definition, all the stations and waterlines are automatically updated.*

Example 1 :

**Bg = 2,2 m ; X Bg = 43 % Lwl ; Alfa = 0° >>> generic hull**



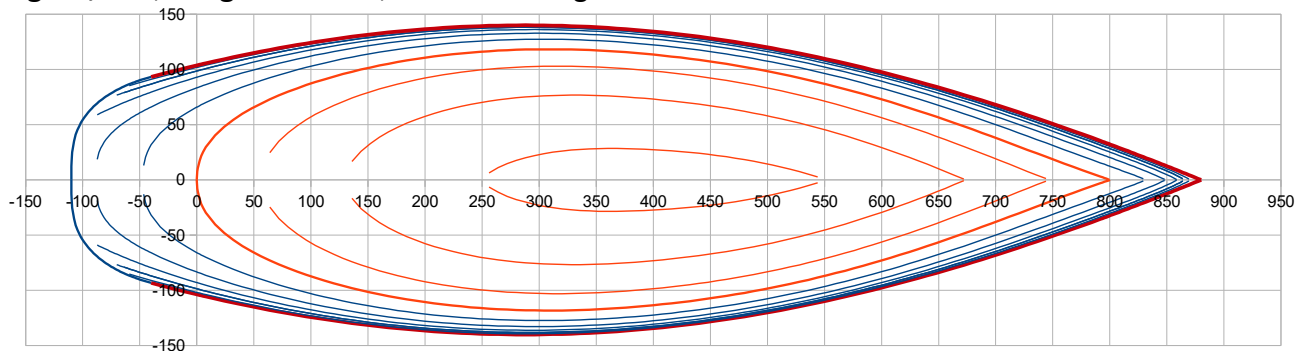
... + rotation  $\text{Alfa} = 1,55^\circ$  >>> real hull with  $B_{\text{max}} = 2,5 \text{ m}$  at  $X_b = 39 \% \text{Lwl}$



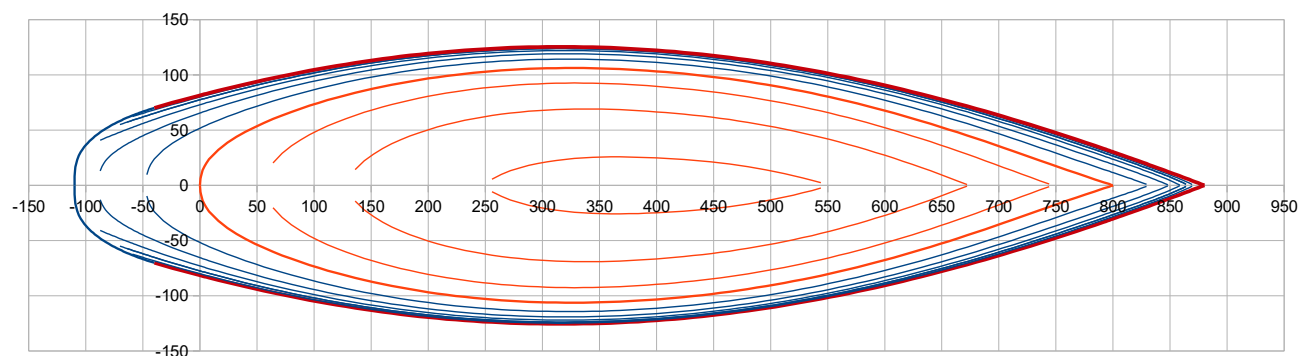
One can just use  $\text{Alfa} = 0^\circ$ , or even adopt an inverted approach with a negative value of  $\text{Alfa}$  >>>

**Example 2:**

$B_g = 2,8 \text{ m}$  ;  $X_{B_g} = 36 \% \text{Lwl}$  ;  $\text{Alfa} = 0^\circ$  >>> generic hull



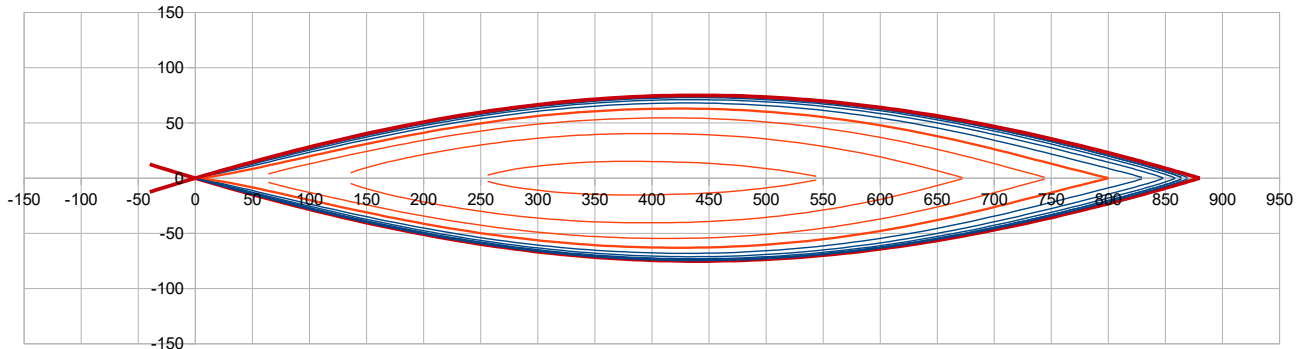
... + rotation  $\text{Alfa} = -1,45^\circ$  >>> Real hull  $B_{\text{max}} = 2,5 \text{ m}$  at  $X_b 39 \% \text{Lwl}$



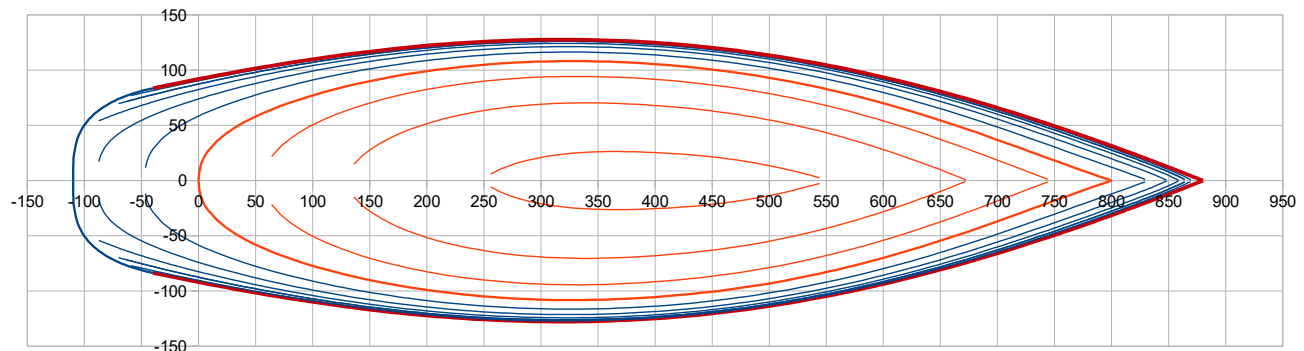
The generic hull could even be virtual but yet be transformed into a real one by application of a

great enough Alfa >>> **Example 3 :**

**Bg = 1,5 m ; X Bg = 55 %Lwl ; Alfa = 0° >>> generic hull**



... + rotation Alfa = 6° >>> Real hull **Bmax = 2,55 m at Xb 40 % Lwl**



In each case the maximum curvature of the sheer line remains close to X Bg of the generic hull :

>>> Exemple 1 : 43% Lwl ; Exemple 2 : 36 % Lwl ; Exemple 3 : 55 % Lwl

Nota : the « rotation » is explained in the technical appendix, actually concerning only the y values of the sheer line, the x values being unchanged (the rotation matrix is used only for the y values).

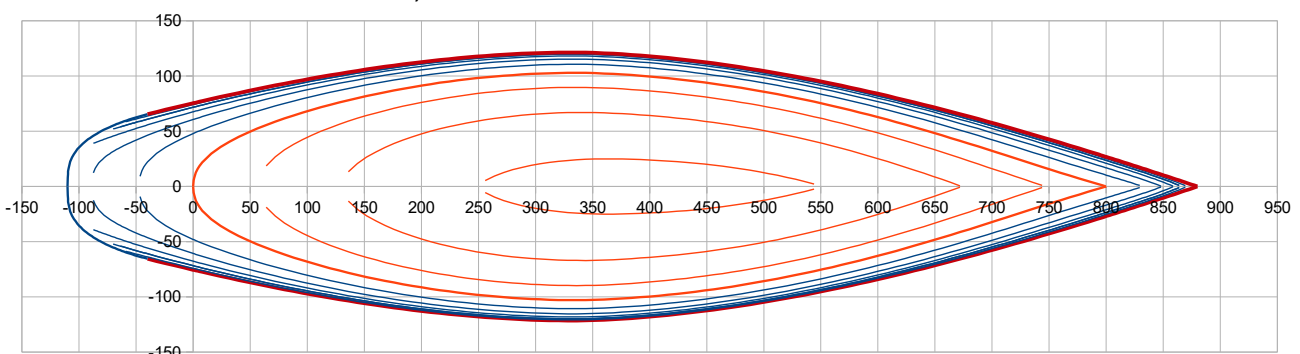
**Pui liv, Cor Pui liv and Pui Cor Pui** are 3 adimensional coefficients for respectively the power of the sheer line polynomial, its correction along with x and the power of the correction polynomial itself (formulation details in the technical appendix).

**Pui liv (cell B33) :**

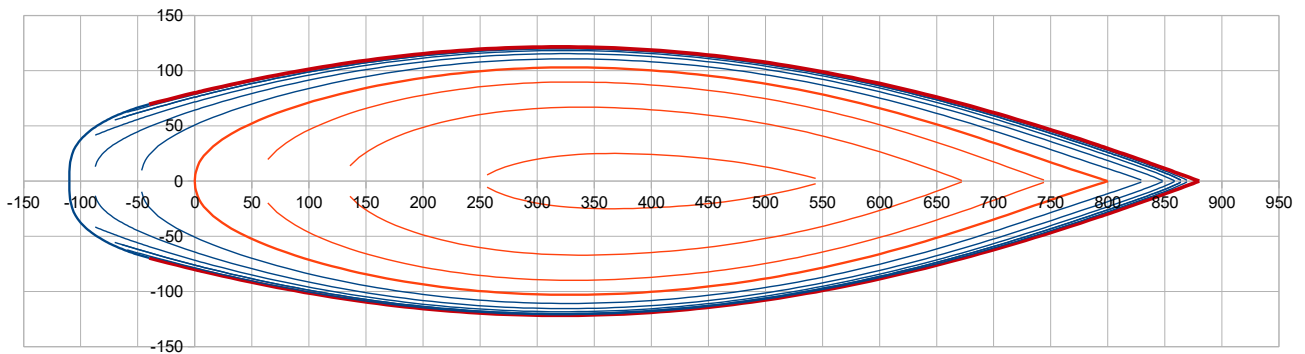
***Pui liv = 2 gives the better curvature regularity in the midship zone, it is the recommended value.***

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 :

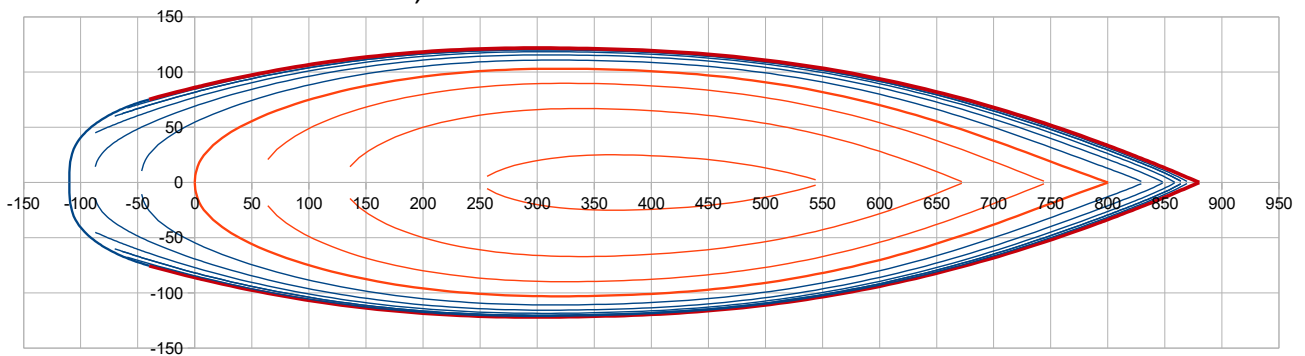
**Pui liv = 1,8 :**



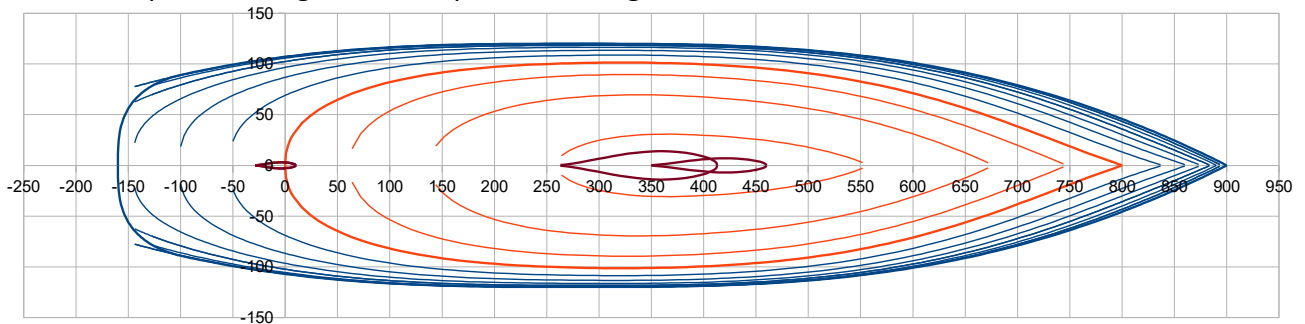
Pui liv = 2 :



Pui liv = 2,3 :

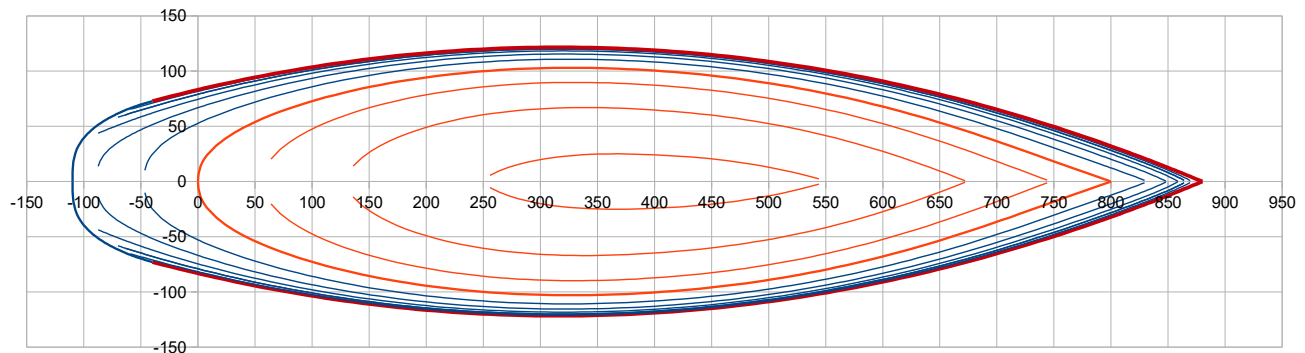


... up to a « barge » like shape when using Pui liv = 3 :

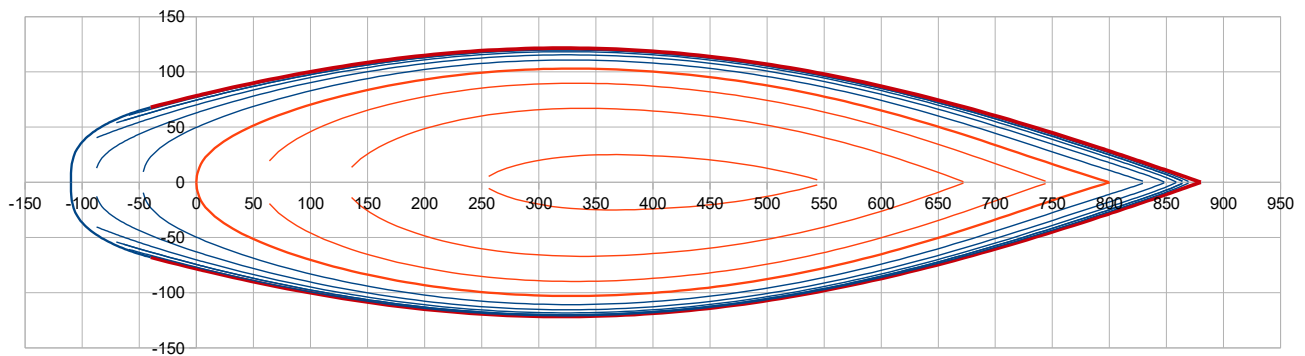


**Cor Pui liv (cell B34)** can add more or less tension towards the front and aft ends of the sheer line, meaning ends with less curvature. Examples :

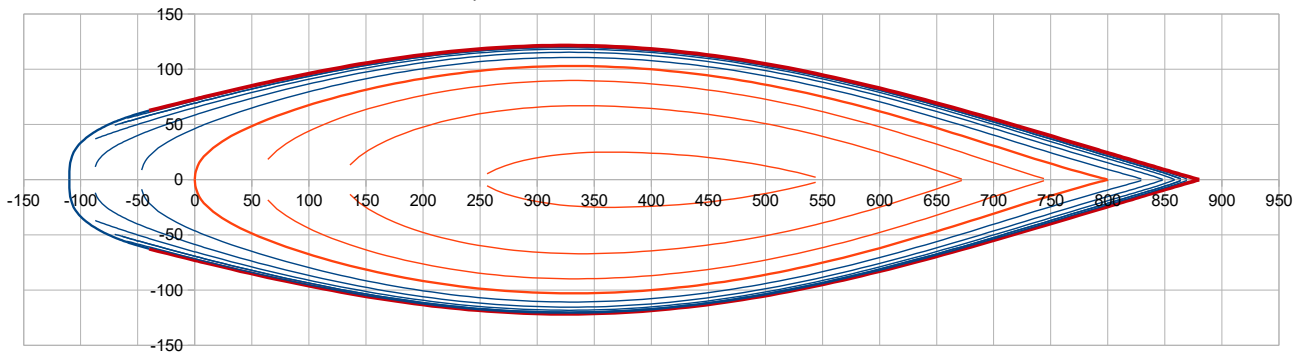
Cor Pui liv = 0



Cor Pui liv = 0,03



Cor Pui Liv = 0,06 :



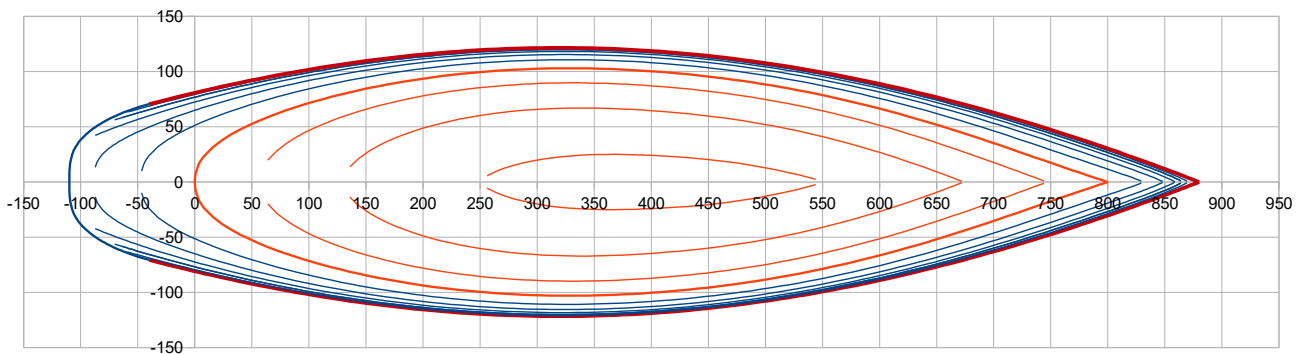
Negative values of Cor Pui Liv can be tested too, with the inverted effect.

**Pui Cor Pui (cell B35)** acts on the application with x of the correction Cor Pui liv.

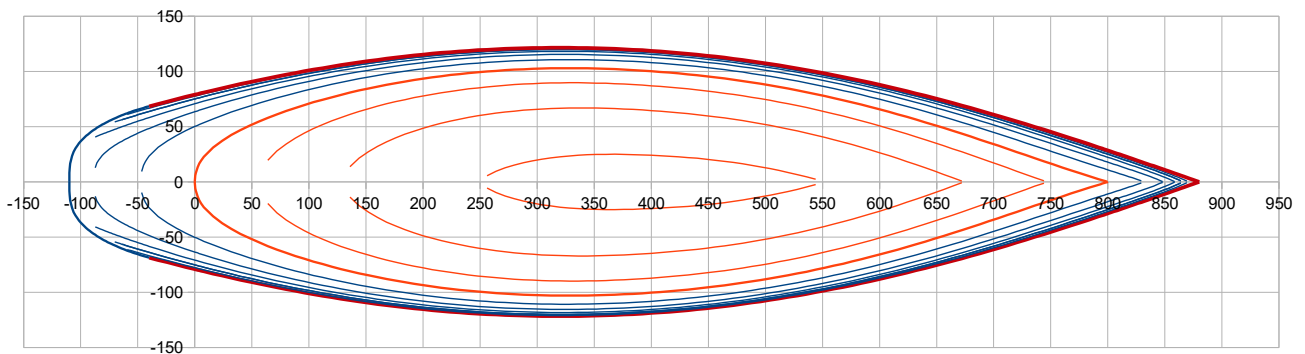
Pui Cor Pui =1 >>> correction application is linear.

Pui Cor Pui > 1 >>> amplifies the correction application towards the ends. Some examples :

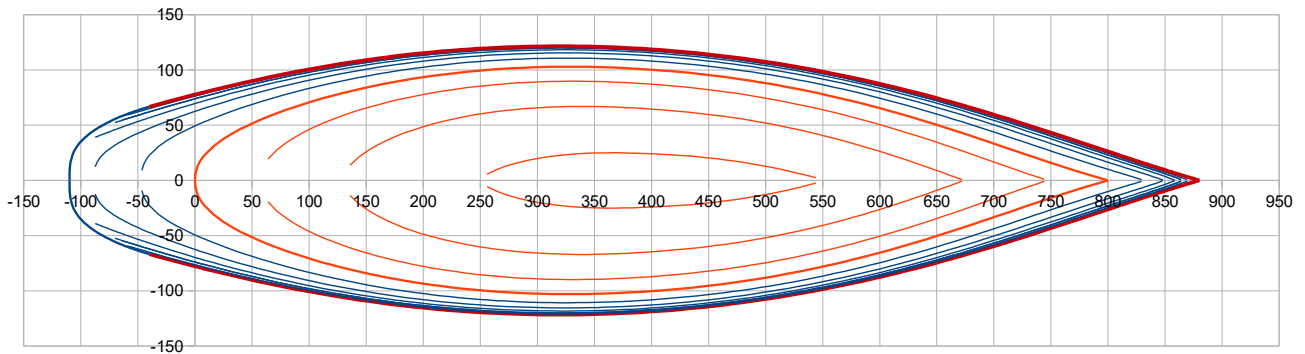
Pui Cor Pui = 1



Pui Cor Pui = 2,5



Pui Cor Pui = 5



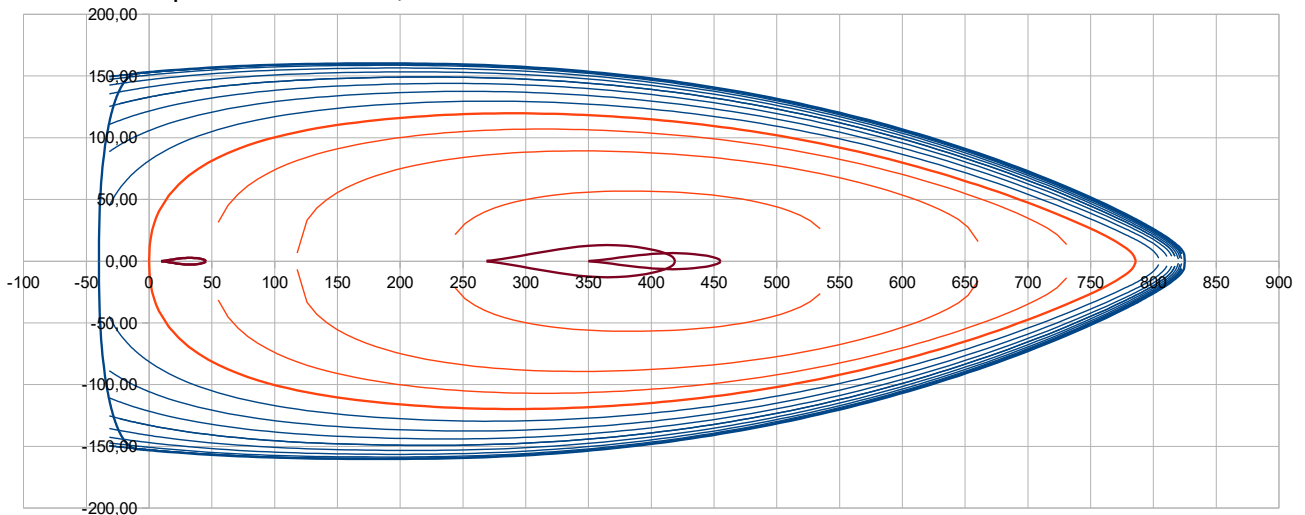
**Nota :** with recommended values of 0,5 to 2, Pui Cor Pui acts as a fine tuning of the tensioning of the ends of the sheer line triggered by Cor Pui liv.

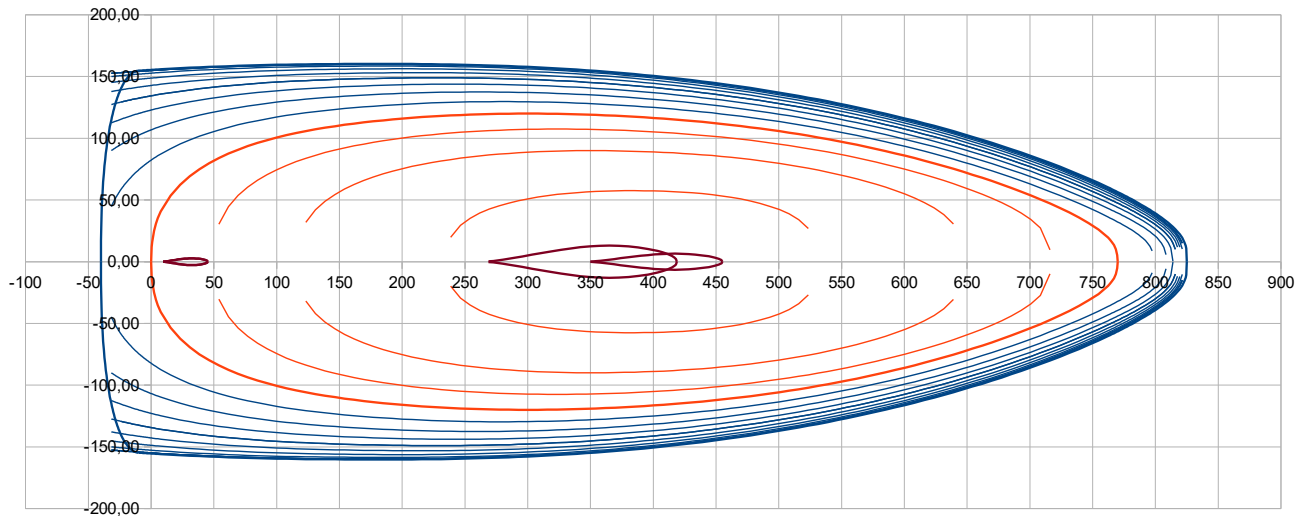
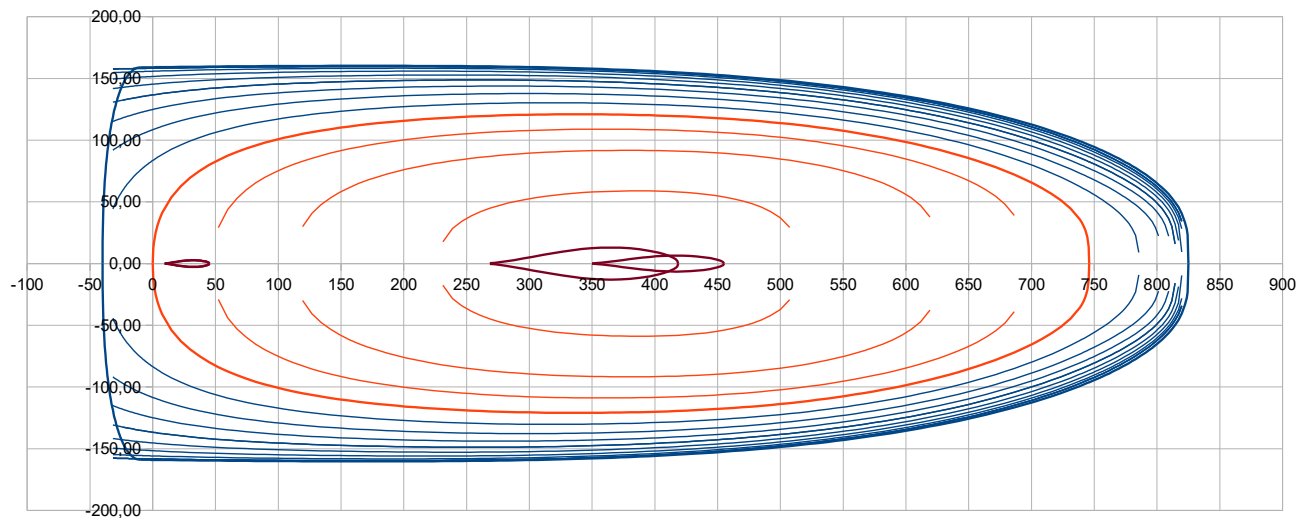
**X liv ar (m) (Cell B36) :** it is the X position of the rear point of the sheer line (see Fig. 1 page 8). Condition to fullfil :  $X_{liv ar} < 0$  and  $> X_{p ar}$ .  $X_{liv ar}$  is the position taken for the draw of the station named Car 1 .

**Nota :** Y value of the sheer line aft point is not specified, as it results from the 6 previous parameters here above detailed.

**Scow (Cell B37) :** it is a coefficient introducing a scow influence on the bow shape of the sheer line.  
Scow = 0 to 1 ; **0 = no scow bow ; 1 = full « rectangular » size scow bow**

Example with Scow = 0,2



Example with  $Scow = 0,4$ Example with  $Scow = 0,8$ 

### Option Hard chine line, its definition in the vertical projection (xz plan)

**Type :** 0 = no hard chine ;  
 1 = hard chine defined by 2 heights ;  
 2 = hard chine defined by 3 heights ;

When Type = 1 , two data to input :

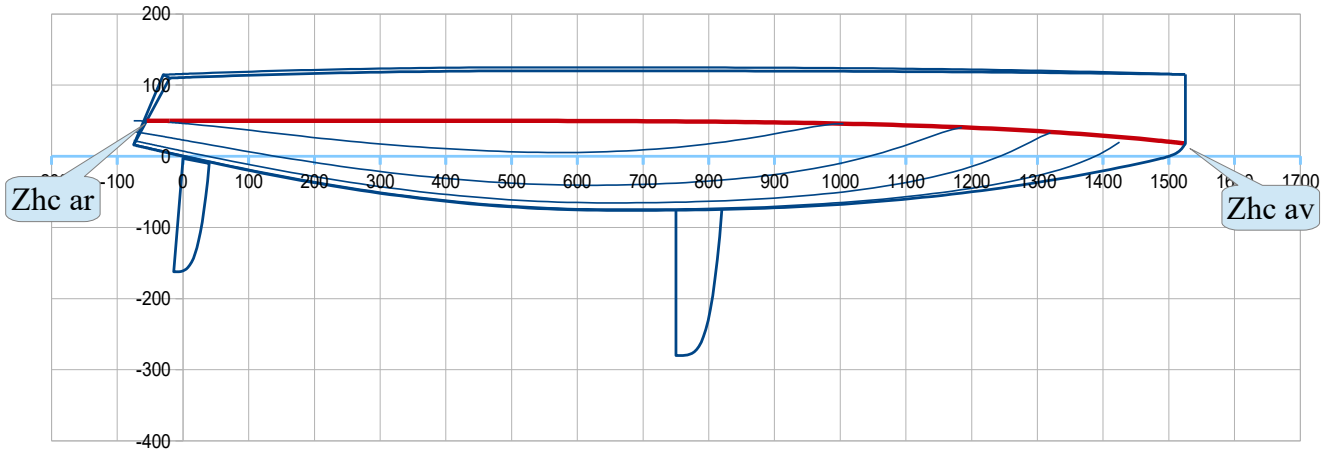
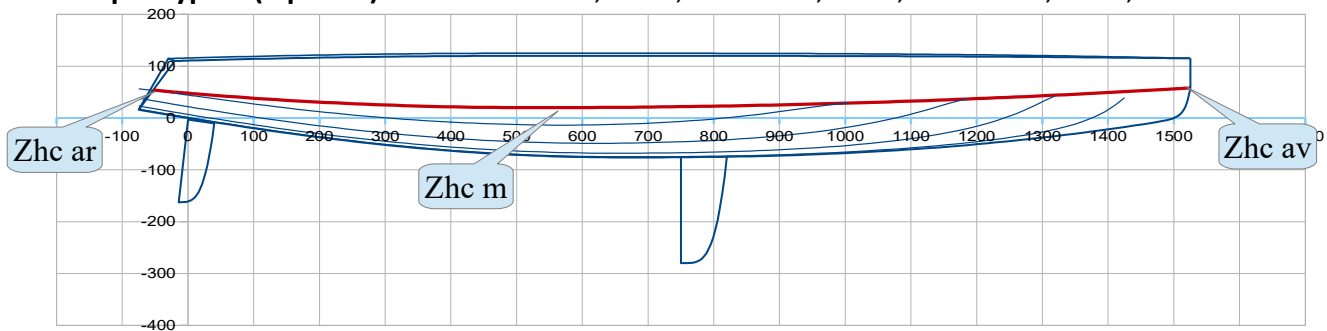
1,2 **Zhc av (m)**: height of the hard chine line at the bow (cell B40)

1,2 **Zhc ar (m)** : height of the hard chine line at the aft (cell B42)

When Type = 2, a third height is to input :

2 **Zhc m (m)** : height of the hard chine line at 35% Lwl (cell B41)

**Pui hc z** : power of the polynomial defining the hard chine line, should be >1 (cell B43)

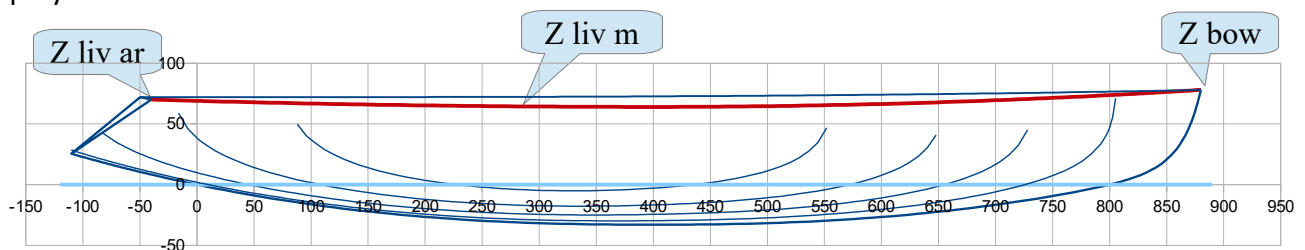
**Example Type 1 (2 points)** with  $Z_{hc\ av} = 0,18\ m$  ;  $Z_{hc\ ar} = 0,38\ m$  ;  $P_{ui\ hc\ z} = 5$ **Example Type 2 (3 points)** with  $Z_{hc\ av} = 0,42\ m$  ;  $Z_{hc\ m} = 0,20\ m$  ;  $Z_{hc\ ar} = 0,75\ m$  ;  $P_{ui\ hc\ z} = 2$ 

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

**$Z_{liv\ m}$  (m)** : it is the freeboard at 35%  $L_{wl}$  (cell B45)

**$Z_{liv\ ar}$  (m)** : it is the aft freeboard, specified at the sheer line aft point. (cell B46)

Together with  **$Z_{bow}$**  defined here before, these are the 3 freeboards on which leans the xz polynomial for the sheer line definition.

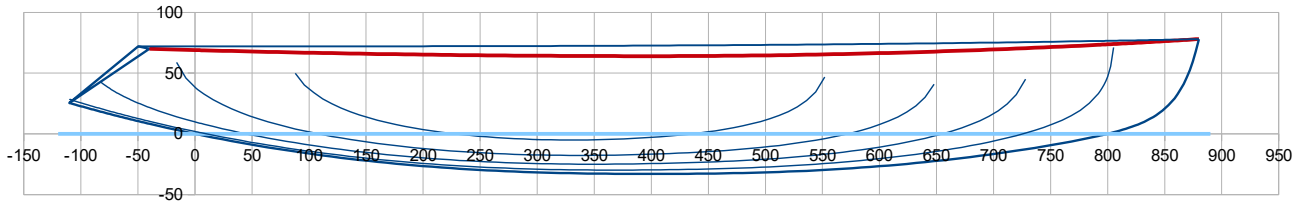


**$P_{ui\ liv\ z}$**  : it is the power of this polynomial for the fore part of the line. (cell B47)

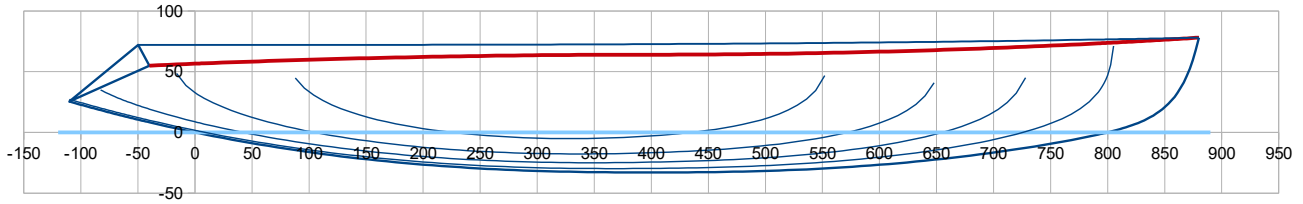
Usual values : 2 to 3.

Examples with two different values of  $Z_{liv\ ar}$  :

Z bow : 0,78 ; Z liv m = 0,64 ; **Z liv ar = 0,70** ; Pui liv z = 2 :



Z bow : 0,78 ; Z liv m = 0,64 ; **Z liv ar = 0,55** ; Pui liv z = 2 :

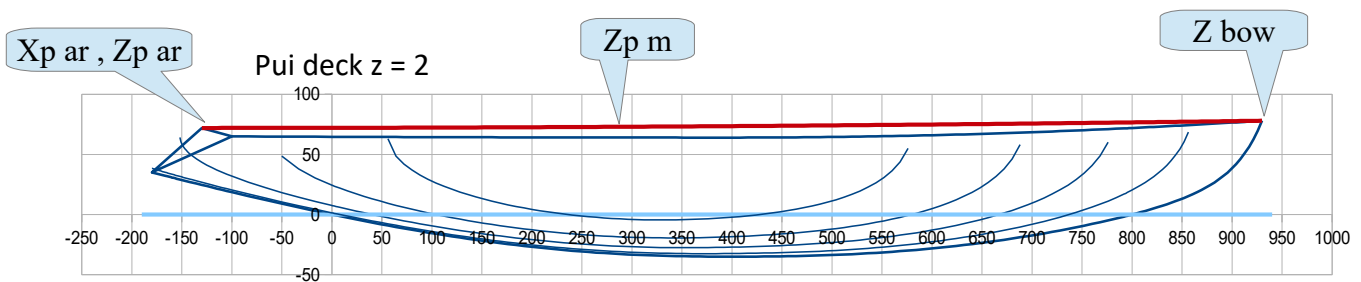


### Hull deck / central line of symmetry

A deck surface is made of transversal circular arcs based on both the sheer line definition and the central line of symmetry (at  $y = 0$ ) going from the front end of the hull (X bow, Z bow) and defined by :

- a point at midship : **Zp m (m)** at  $X = 35\% \text{ Lwl}$  (cell B49)
- a point at the rear end of the deck : **Xp ar (m) , Zp ar (m)** (cells B50 & B51)

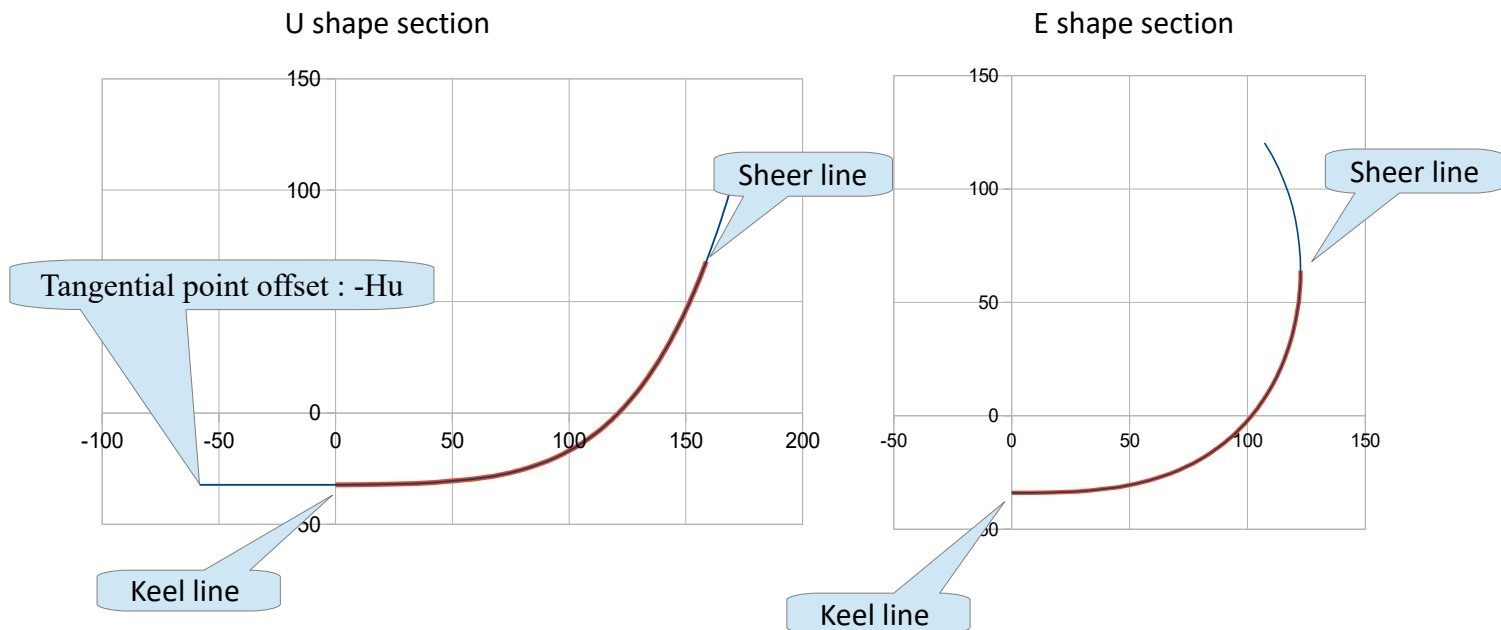
**Pui deck z (Case B52)** : it is the power of the polynomial defining the fore part of this deck central line. Recommended value : 2 à 3. Example :



## UE sections (combination of U and E sections)

For the UE file :

UE sections are defined as a combination of 2 polynomials, one representative of a U shape section and the other one representative of a E shape section. Data to enter concern respectively the U parameters, the E ones and their combination all along X, from front to aft end of the hull. These two last points being identical as for VE, they are not described again in this chapter.



### Adimensional parameters for U sections :

**C Hu av ; C Hu ar ; Pui Hu** (cells B55, B56, B57)

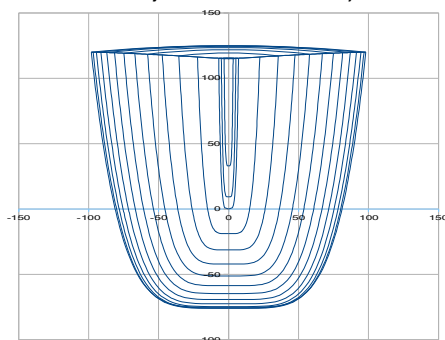
These parameters deal with the offset  $Hu$  / symmetry axis of the polynomial tangential horizontal point as a function of the x position of the section (formulation details in the technical appendix).

**C Hu av** is for the front offset and **C Hu ar** is for the rear offset, both **should be  $\geq 0$** . The closer to 0, the more the U flatness is extended.

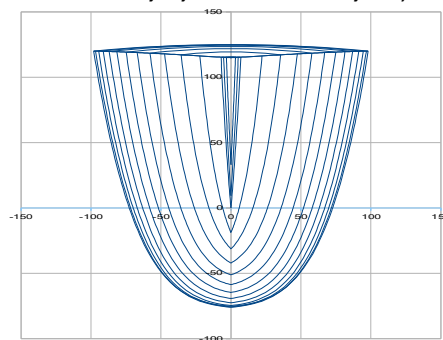
**Pui Hu** is the power of the polynomial computing the evolution from C Hu ar to C Hu av.

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

**CHu av = 0 ; C Hu ar = 0 ; Pui Hu = 1 >>>>>**



**CHu av = 0,5 ; C Hu ar = 0,5 ; Pui Hu = 1**

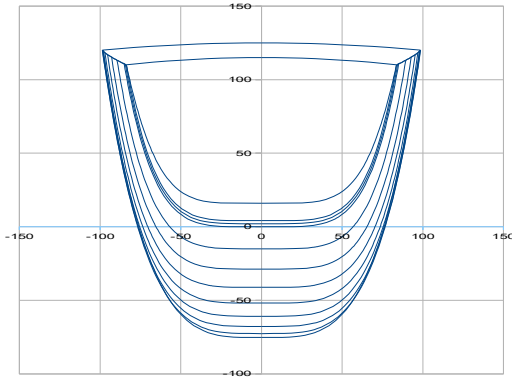
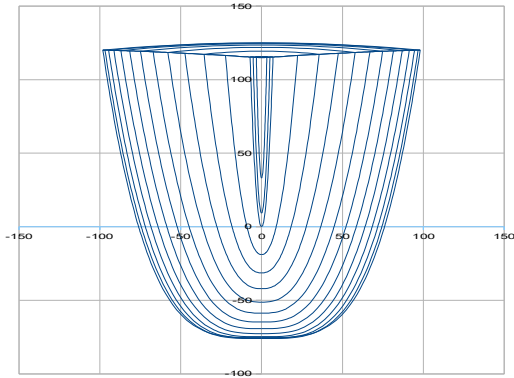


**Pui U av ; Pui U ar ; Pui Pui U ; Cor Pui Pui (cells B59, B60, B61, B62)**

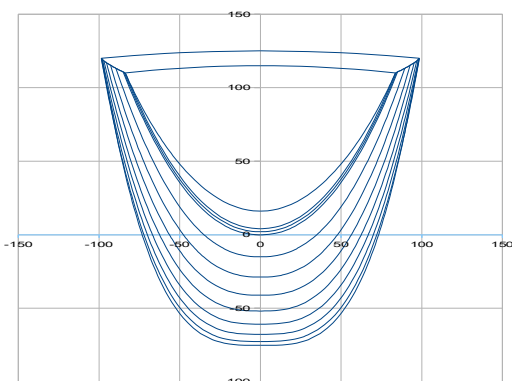
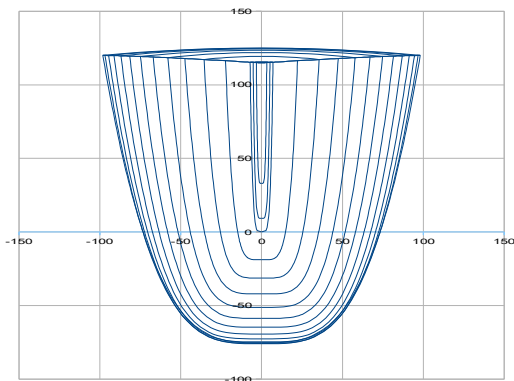
These parameters are dealing with the power of the polynomial with position x of the section (formulation details in technical appendix). **Pui U av** for the front power; **Pui U ar** for the rear power. The larger Pui U, the more the U is square shape. **Pui Pui U** is the power of the polynomial computing the evolution from Pui U ar to Pui U 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 (U sections only, without the combination with E sections) :

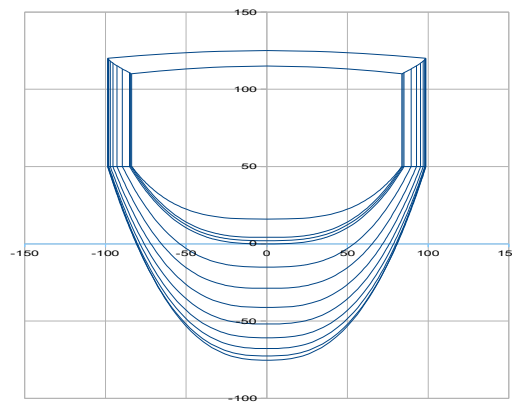
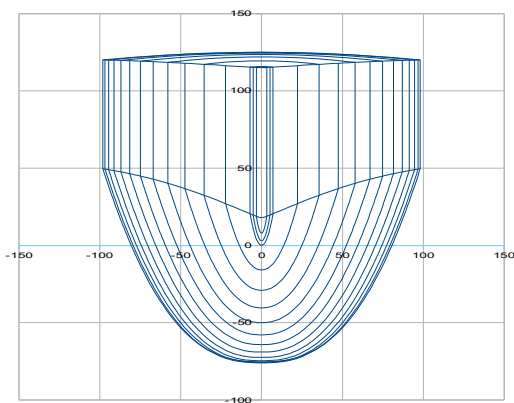
**Pui U av = 2 ; Pui U ar = 5 Pui Pui U = 1 ; Cor Pui Pui = 0**



**Pui U av = 5 ; Pui U ar = 2 ; Pui Pui U = 1 ; Cor Pui Pui = 0**



**Pui U av = 2 ; Pui U ar = 3 Pui Pui U = 1 ; Cor Pui Pui = 0 , with a hard chine :**



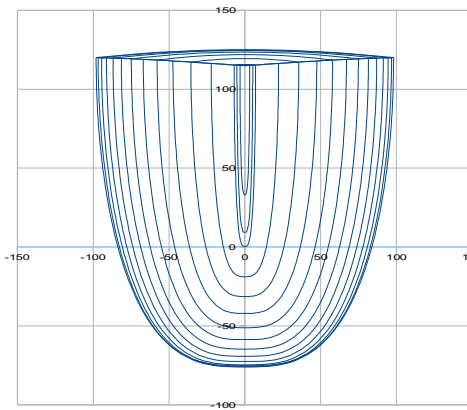
**E shapes adimensional parameters :**

**Pui E1 , Pui E2 :** powers of the E generalised function. **(cells B64 , B65)**

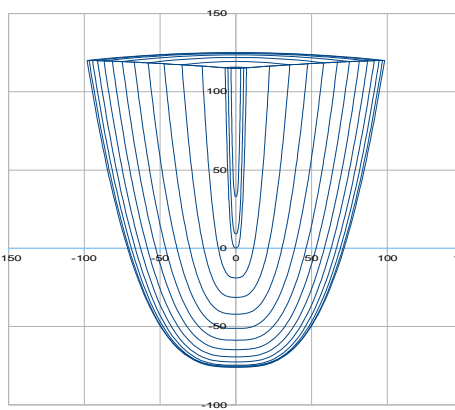
Some examples (E sections only, without combination with U sections). Examples :

**Pui E1 influence :**

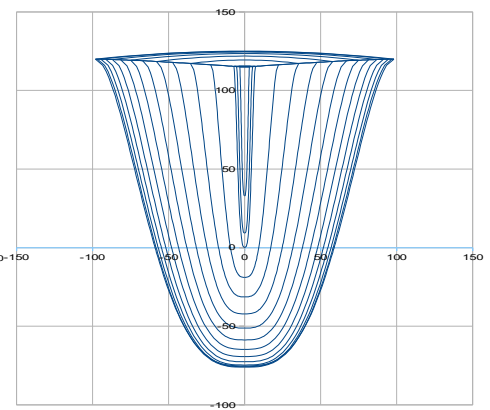
**Pui E1 = 2 ; Pui E2 = 3**



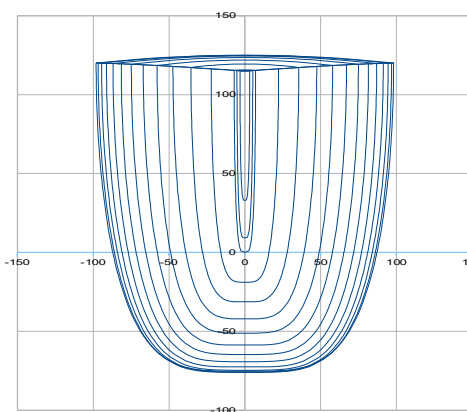
**Pui E1 = 1 ; Pui E2 = 3**



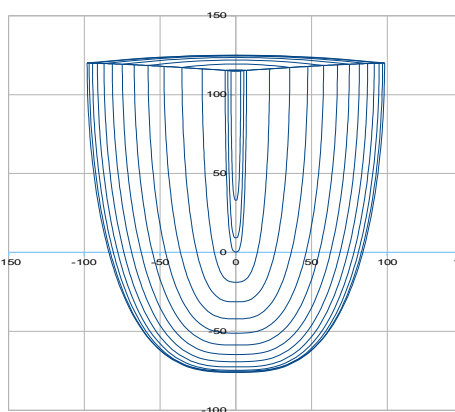
**Pui E1 = 0,5 ; Pui E2 = 3**

**Pui E2 influence :**

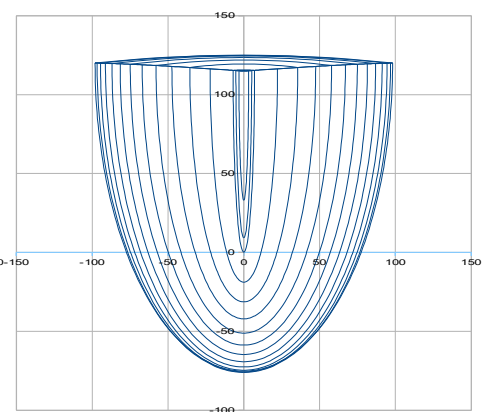
**Pui E1 = 2 ; Pui E2 = 4**



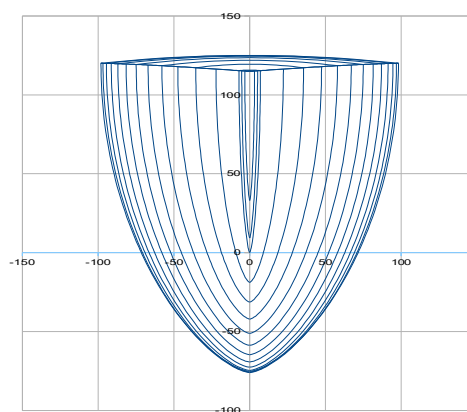
**Pui E1 = 2 ; Pui E2 = 3**



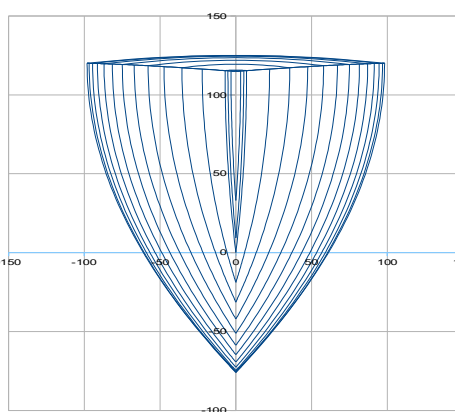
**Pui E1 = 2 ; Pui E2 = 2**



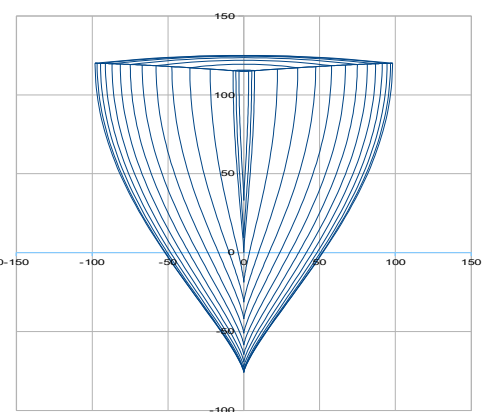
**Pui E1 = 2 ; Pui E2 = 1,5**



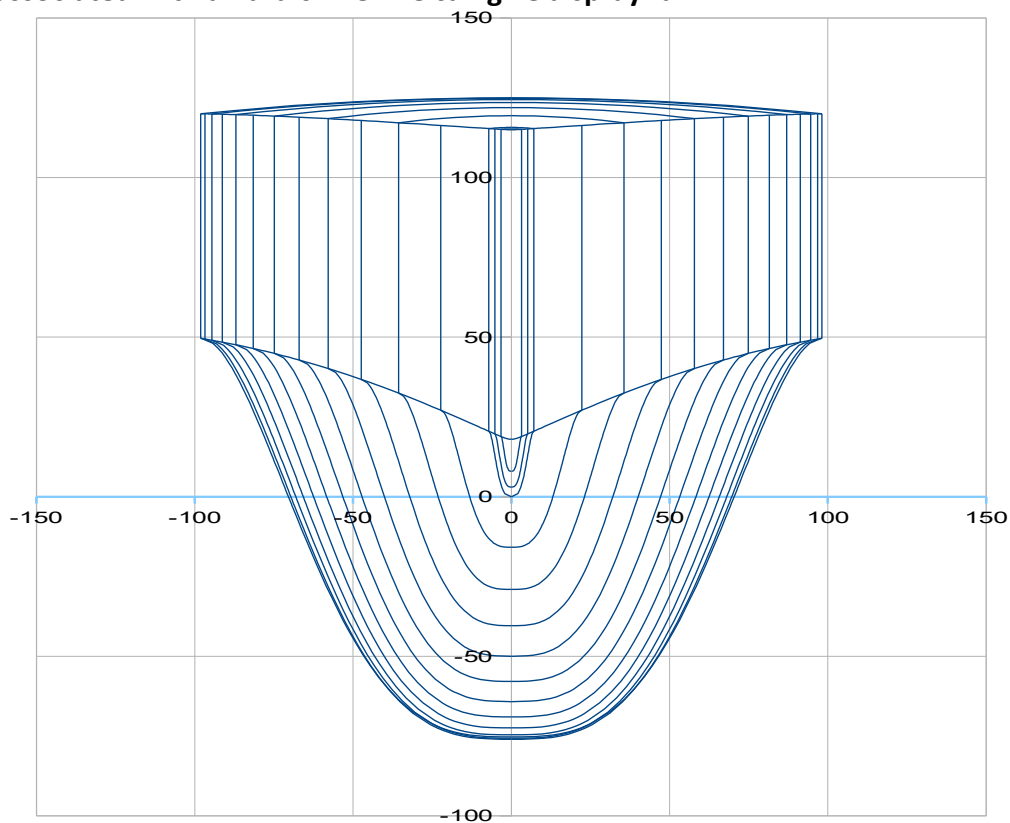
**Pui E1 = 2 ; Pui E2 = 1**



**Pui E1 = 2 ; Pui E2 = 0,75**



**PE1 = 0,5 associated with a hard chine line can give a spray rail :**



### U and E sections combination :

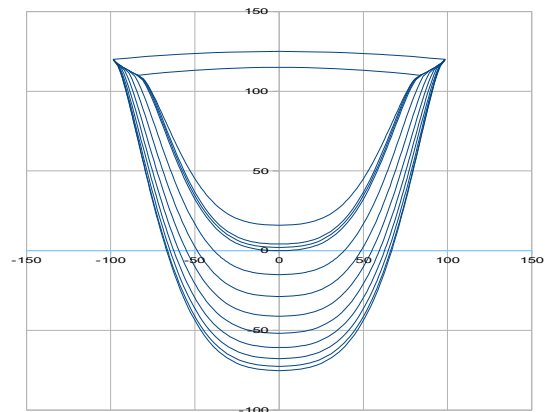
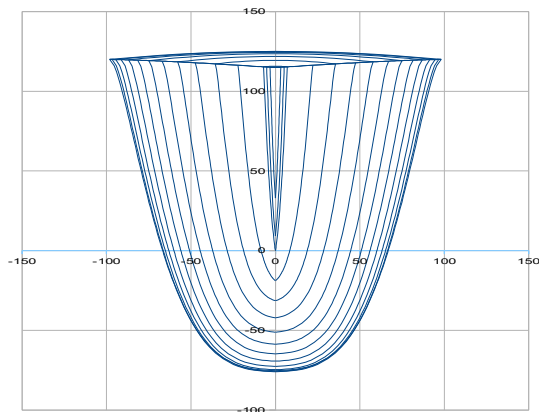
V et E sections are combined in function of x, with :

**mix VE av ; mix VE ar** : adimensionals between 0 to 1. **(cells B66 and B67)**

1 means 100% V shape and 0 means 100% E shape.

**Pui mix VE (cell B68)** : 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.

Example with : **mix VE av = 0,8 ; mix VE ar = 0,2 ; Pui mix VE = 1**



### A last recommendation on input data for the hull :

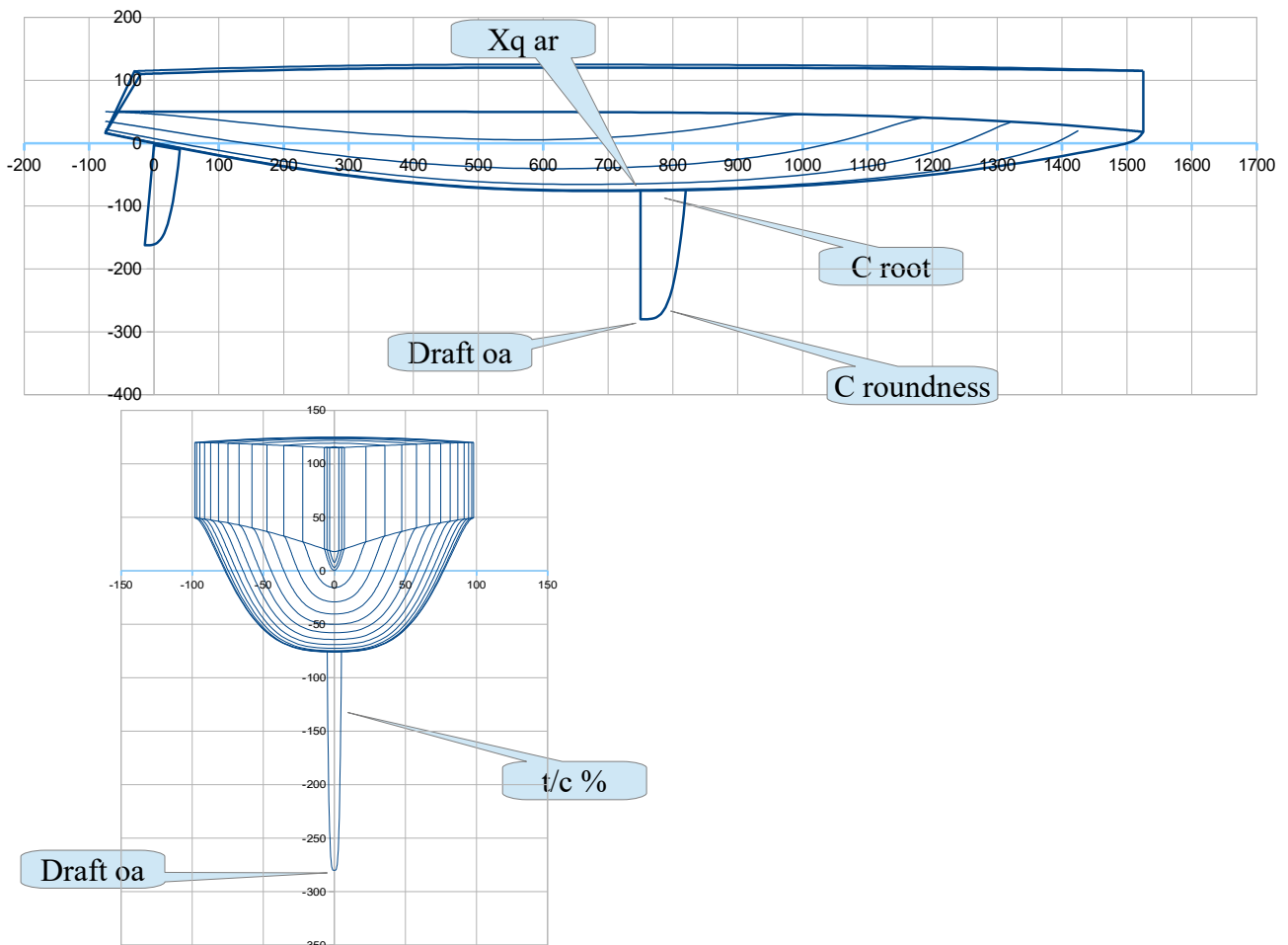
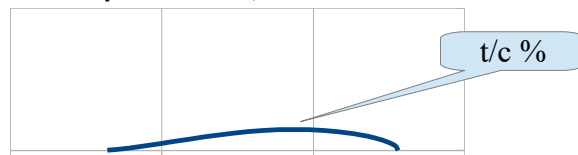
Probably that the use of the adimensional parameters are not always very intuitive at the beginning :

- the ones of hull of reference data are there to guide in your first steps,
- you can test the effect of each parameter, including by testing a priori very low or very high values so that to better see the effects, and this « learning by testing » process will help you to progress rapidly.

## 1.2 Daggerboard data

Data to enter are in column B , cells B70 to B78 :

<b>Xq ar (m)</b>	<b>7,50</b>	Rear point of the root chord
<b>C root (m)</b>	<b>0,70</b>	Root chord length
<b>C roundness</b>	<b>4,00</b>	Roudness of the profile lower part ; should be usually 2,5 to 5,5
<b>t/c (%)</b>	<b>14,00</b>	Relative thickness of the profile
<b>Draft oa (m)</b>	<b>2,80</b>	should be > hull draft Tc
<b>naca 00xx</b>	<b>0</b>	Type of profile (in the horizontal plans)
<b>naca 63-0xx</b>	<b>1</b>	Put 1 for the profile used, 0 for the others
<b>naca 65-0xx</b>	<b>0</b>	
<b>Density</b>	<b>0,55</b>	

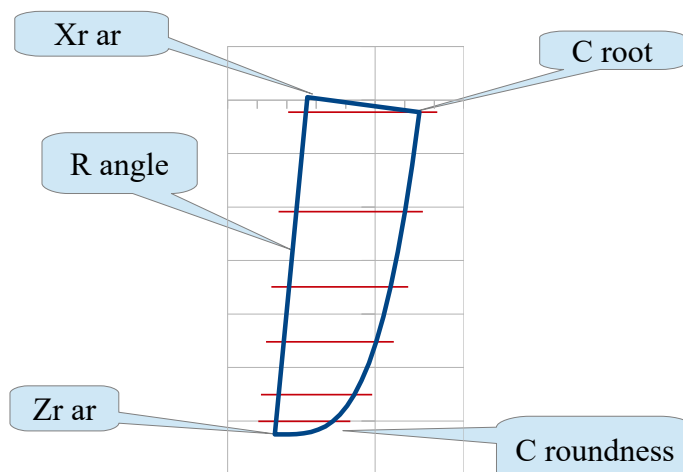


### 1.3 Rudder data

Data to enter are in column B , cells B80 to B88 :

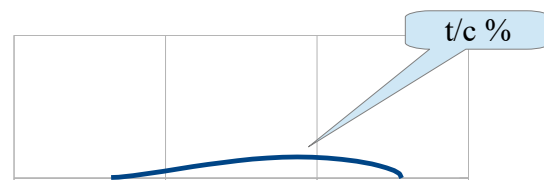
<b>Xr ar (m)</b>	<b>0,00</b>	Rear point of the root chord
<b>C root (m)</b>	<b>0,40</b>	Root chord length
<b>t/c (%)</b>	<b>15,00</b>	Relative thickness of the profile
<b>R angle (°)</b>	<b>85,00</b>	Rudder rear angle, should be around 80°-85°
<b>L ar (m)</b>	<b>1,60</b>	Rudder rear span
<b>C roundness</b>	<b>3,50</b>	Roudness of the profile lower part ; should be usually 2,5 to 5,5
<b>naca 00xx</b>	<b>0</b>	Type of profile (in the horizontal plans)
<b>naca 63-0xx</b>	<b>1</b>	<b>Put 1 for the profile used, 0 for the others</b>
<b>naca 65-0xx</b>	<b>0</b>	

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.



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

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



Nota : daggerboard and rudder 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.

**Storage of Gene-Hull input data** : the spreadsheet includes a second sheet called « **Hulls storage** » where you can store by copy/paste the input data in column B, for your various projects or variants of a hull during the iteration process. The hulls given as examples are stored here too.

### 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 output computations).

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 automatically 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 metric units), its translation in DLR (in lbs,feet units)
- $Lwl/Bwl$
- Displacements for 3 waterlines :  $H0$ ,  $H0-3cm$ ,  $H0+3cm$ ,
- $Xc$  (LCB) and  $Zc$  positions of the center of buoyancy
- $Cp$  (Prismatic coefficient) of the hull
- $Sf$  (floatation area) and its longitudinal center
- $Sw$  (hull wetted surface)
- Daggerboard and rudder volume, lateral surface and wetted surface
- .....

... + the curve of the sections areas, 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 for each hull), its center of gravity position  $X$

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

...+ the recopy of the data coming from the mass spreadsheet : boat light weight and CoG location.

Example :

**2. Data sum-up and results of hydrostatic and surfaces calculations****2.1 Hull**

Loa (m)	16,00	Lwl (m)	15,00					
>> ft	52,49		49,21					
Bhull (m)	1,97	at X (% Lwl)	34,0	Boa (m)	8,07			
>> ft	6,47			>> ft	26,49			
Bwl (m)	1,54	at X (% Lwl)	39,0	> Lwl / Bwl	9,742			
>> ft	5,05							
Tc (m)	0,76	at X (%Lwl)	45,0	Freeboards (m) >		Aft	Midship	Fore
>> ft	2,49					1,1	1,20	1,15
Displacement at H0 (m3)	7,53709	at Xc (m)	6,954	Xc (%Lwl)	46,36	>> ft 3,61	>> ft 3,94	>> ft 3,77
>> lbs	17032	w. seawater	1025	kg/m3				
Disp at H(cm)	-3,00	at Xc (m)	6,972	Xc (%Lwl)	46,48		Zc (m)	-0,266
Disp at H(cm)	3,00	at Xc (m)	6,934	Xc (%Lwl)	46,22		Zc (m)	-0,288
Cp (%)	58,08							
Sf (m2)	17,26	at Xf (m)	6,636	Xf (%Lwl)	44,24	>>> Xc - Xf (%Lwl)		
>> ft2	185,84	>> ft	21,77					2,12
Angle immersed sheer li (°)	50,7	at section C4 (40% Lwl)						
Sw (m2)	25,24	>Sm/D^(2/3)	6,57					
>> ft2	271,65							
Shull (m2)	64,45	at X (m)	7,099	Z (m)	0,187			
>> ft2	693,69	>> ft	23,29	>> ft	0,61			
Sdeck (m2)	23,95	at X (m)	6,301					
>> ft2	257,84	>> ft	20,67					

**2.2 Daggerboard**

Vol. (m3)	0,05431	at X (m)	7,843	X (%Lwl)	52,29	Z (m)	-1,540
Mass (kg)	29,87	>> ft	25,73			>> ft	-5,05
>> lbs	66						
Draft oa (m)	2,80		Sw (m2)	2,39		Sxz (m2)	1,15
>> ft	9,19		>> ft2	25,71		>> ft2	12,36
CLR (m)	8,03	CLR (%Lwl)	53,50	CLR = Center of Lateral Resistance			
>> ft2	86,38	method : daggerboard profile extended to the waterline, LCR at 25% chord and 45% draft oa					

**2.3 Rudder**

Volume (m3)	0,01907	at X (m)	0,154	X (%Lwl)	1,03	Z (m)	-0,730
Sw (m2)	1,15	>> ft	0,51			Sxz (m2)	0,55
>> ft2	12,34					>> ft2	5,93

per rudder

**2.4 Catamaran : 2 Hulls + 2 Daggerboards + 2 Rudders**

Loa (m)	16,00	Boa (m)	8,07				
>> ft	52,49	>> ft	26,49				
Displacement at H0 (m3)	15,22093	at Xc (m)	6,943	Xc (%Lwl)	46,29	Zc (m)	-0,287
(kg)	15601	>> ft	22,78			>> ft	-0,94
>> lbs	34395						
Sw (m2)	57,54	>Sw/D^(2/3)	9,37	Lwl/D^(1/3)	6,05		
>> ft2	619,40			DLR	129	$M(lbs/2240)/(Lwl(ft)/100)^3$	

**2.5 Data from the mass spreadsheet**

Light boat:	M (kg)	15601	at Xg (m)	6,952	Xc (%Lwl)	46,34	at Zg (m)	1,922
-------------	--------	-------	-----------	-------	-----------	-------	-----------	-------

Hull design and mass should be adjusted so that Displacement (kg) = M (kg), and Xc (m) equal or close to Xg (m) .

### 3. The 3 views 2D

The views are automatically redrawn after every input data modification.

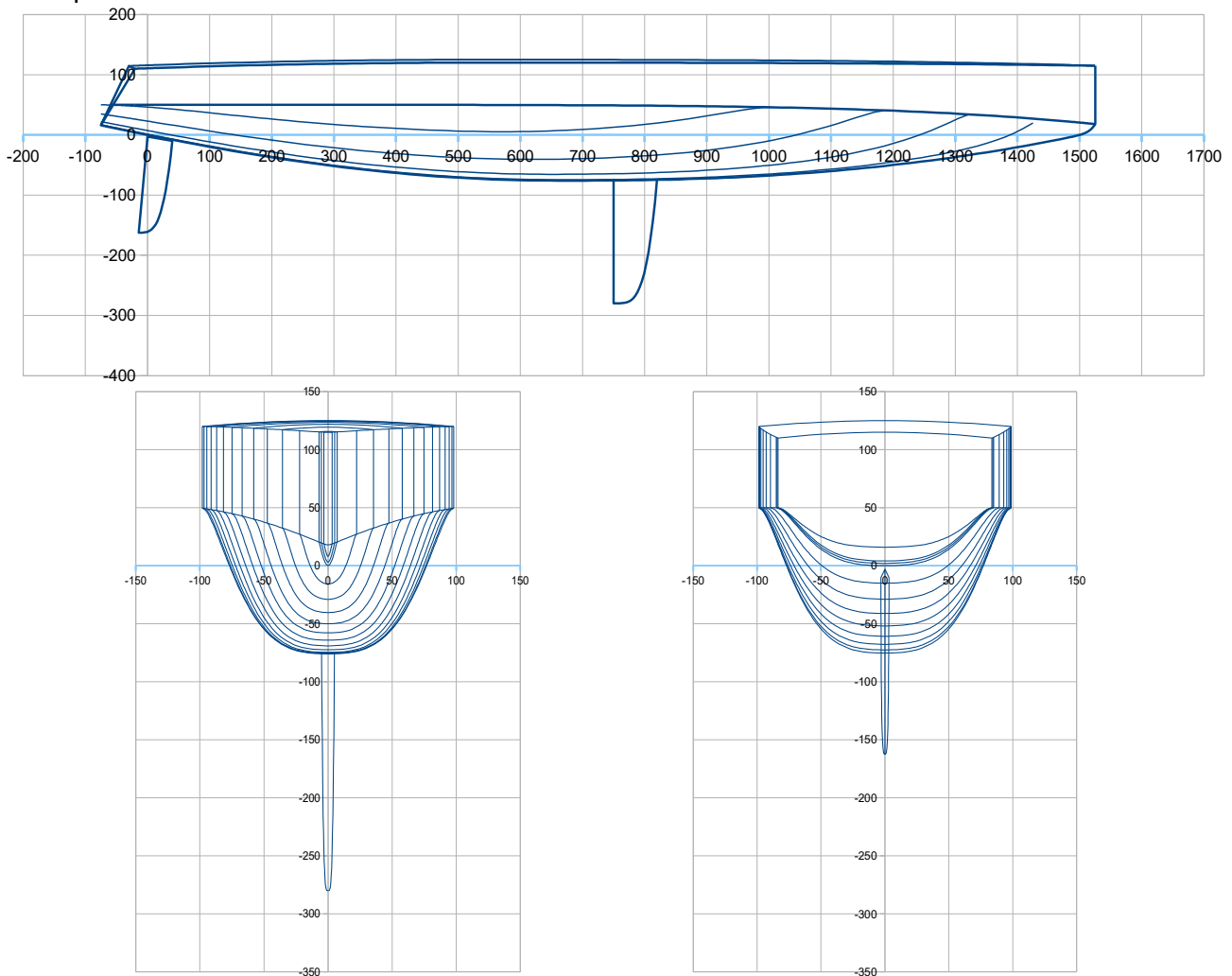
View of the front sections include sections  $\geq C4$  ( $= 40\% Lwl$ ), with a half section pitch :  $C4, C4,5, C5, \dots$ . In front of  $C10$  (Front perpendicular), 2 complementary sections  $Cav1$  and  $Cav2$  are drawn, at  $1/3$  and  $2/3$  of the bow overlenght.

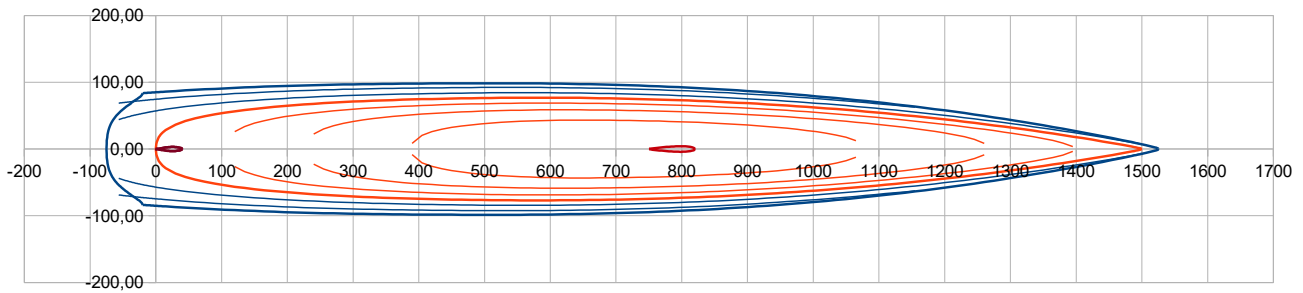
View of the rear sections includes sections  $\leq C4$ , with a half section pitch :  $C4, C3,5, C3, C2,5, \dots$ . Behind  $C0$ , 2 complementary sections  $Car1$  and  $Car2$  are drawn,  $Car2$  at the rear end point of the sheer line and  $Car1$  at the middle point between this rear point and  $C0$ . And the rear transom is also computed and drawn in this view (as long as it is an inverted one within the condition :  $X_{tab} < X_{pont} < X_{liv} < 0$ ).

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

**User intervention** : 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 :

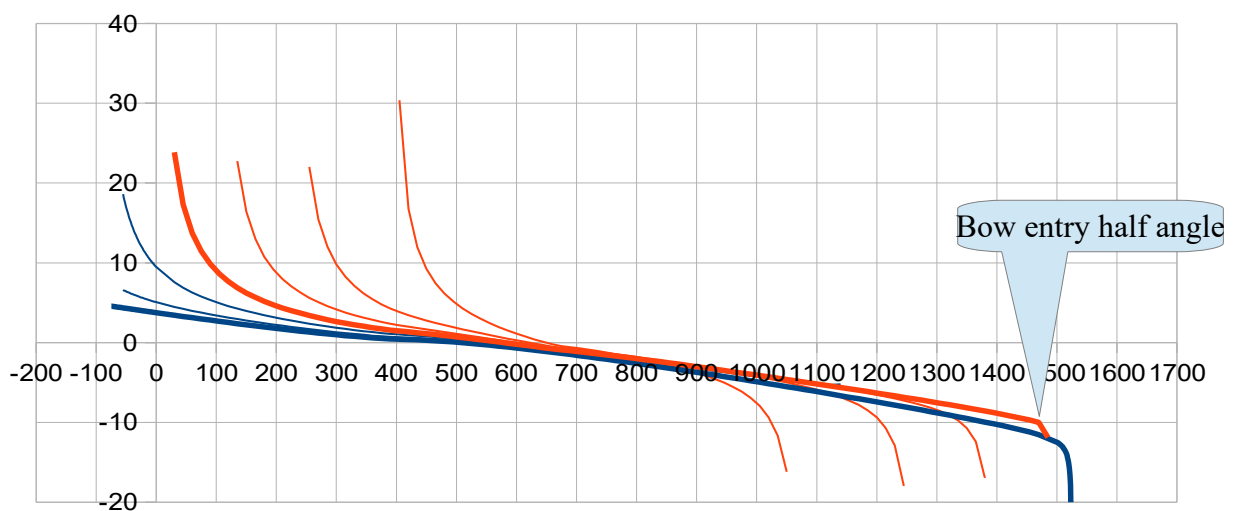
- Waterlines angles in the horizontal plan xy, with the same color code blue/red as for the bottom view.
- Curvature  $1/R$  of :
  - Waterlines and shear line (in the horizontal plan xy) with idem color code blue/red,
  - Keel line and Buttocks lines (vertical longitudinal cuts) in green, keel line 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 length is fixed, it is recommended to fix the scale of the X coordinates in the views.

Examples :

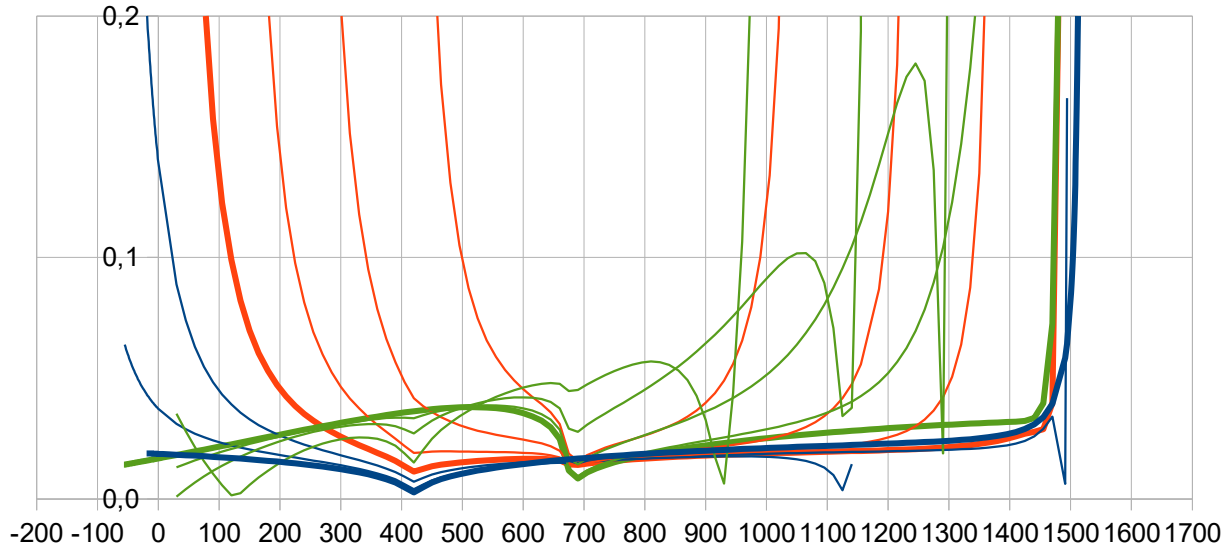
Waterlines angles in the horizontal plan xy

Red : waterlines below H0 (**thick line = H0**)  
 Blue : waterlines above H0 (**thick line = shear line**)



Curvature  $1/R$  :

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, they are provided to facilitate a transfer towards a 3D modeller like Multisurf or equivalent. It includes :

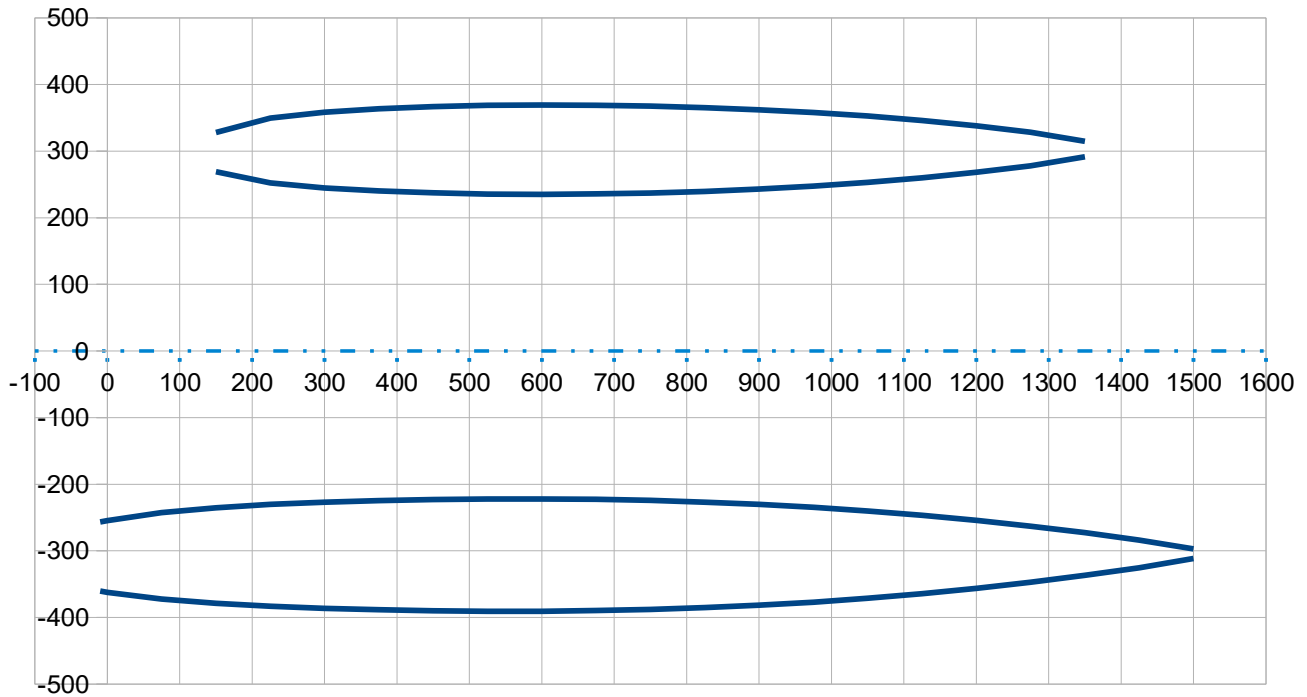
- x,y,z data for each section : Car1, C0, C0,5, ...etc ..., C9,5, C10, Cav1, Cav2.
- x,y,z data of the intersection curve between the rear transom and the hull,
- x,y,z data of the intersection curve between the rear transom and the deck,
- x,z data of the keel line including the bow,
- x,y,z data of the sheer line,
- x,z data of the deck central line of symmetry,
- x,z data of the longitudinal profile of the daggerboard, 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. Hydrostatics of the heeled catamaran (i.e. with 2 hulls, 2 daggerboards and 2 rudders)

This section is for the computation and drawing of the inclined catamaran (with a given heel angle), in hydrostatic conditions at constant displacement and  $X_c$  (LCB) =  $X_g$  conditions. The User should introduce 3 data + one :

- Heel angle (°) (typically 0 to 30°) (**cell B402**)
- Height (cm) : the small elevation (few cm) which help maintain constant the hull displacement ; (**cell B403**)
- Trim (°) : which help maintain  $X_c = X_g$ , negative value = nose down (**cell B404**)





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

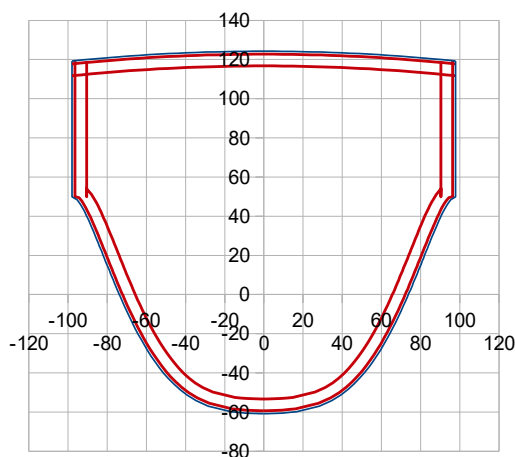
This section provides the data which can be used for a scale one drawing of any section at a given X position, inc. a hull frame or a deck bar when necessary. This section is divided in 2 sub-sections 7.1 and 7.2 for respectively sections behind or in front of C3,5.

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)
>	375,0

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



### Sailplan input and output

This sheet can provide an early stage definition of the sailplan, with 2 main results about the sail surface  $St$  (Main + Fore triangles) and the so-called « Lead ». Also computed are ratios usually considered by naval architects.

Data to enter			>> in feet				Results for the Sailplan (i.e. Fore + Main triangles)			
<b>Xmast (m)</b>	<b>8,05</b>				<b>26,41</b>		<b>Geometrical center</b>			
<b>Zboom(m)</b>	<b>2,62</b>				<b>8,60</b>		Xv (m)	8,032	Zv (m)	8,082
<b>I (m)</b>	<b>18,20</b>				<b>59,71</b>		<b>Surface triangles St (m2)</b>	<b>113,77</b>	<b>1224,61</b>	<b>sqft</b>
<b>J (m)</b>	<b>6,20</b>				<b>20,34</b>		>> St / Sw	1,98		
<b>P (m)</b>	<b>18,50</b>				<b>60,70</b>		>> St / D <sup>(2/3)</sup>	18,52		
<b>E (m)</b>	<b>6,20</b>				<b>20,34</b>		>> Sdaggerboards / St (%)	2,02		
							>> Sruders / St (%)	0,97		
							<b>Lead (Xv – CLR) (% Lwl)</b>	<b>0,5</b>		

The 6 input data in column B, cells B3 to B8. The other needed data come from the Gene-Hull sheet.

**Xmast (m)** : is the X position of the mast (cell B3)

**Zboom (m)** : is the Z position of the boom (cell B4)

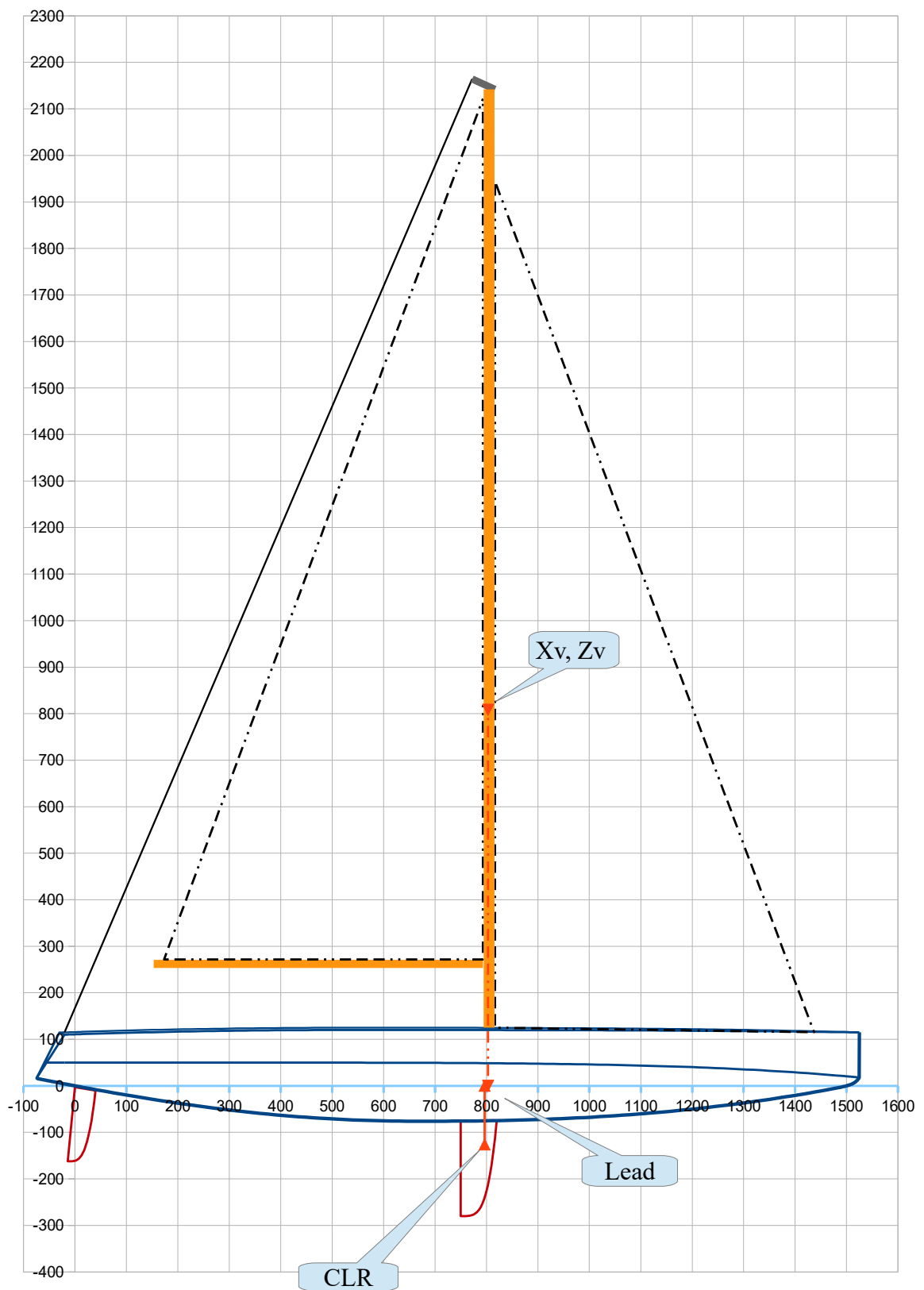
**I (m) , J (m)** : are the fore triangle height and base (cells B5, B6)

**P (m), E (m)** : are the main triangle height and base (cells B7, B8)

The output includes data and ratios in relation with the sailplan triangles surface and position, and a 2D drawing :

- The geometrical center of the sailplan triangles : Xv, Zv
- The surface of the triangles St
- ratio St / Sw , Sw being the wetted surface
- ratio St / D<sup>(2/3)</sup>, D being the displacement
- ratio Sdaggerboards / St , Sdaggerboards being the xz surface of the 2 daggerboards
- ratio Sruders / St, Sruders being the xz surface of the 2 rudders
- Lead Xv – CLR, CLR being the Center of Lateral Resistance estimated by this method : daggerboard profile extended to the waterline, CLR at 25% chord and 45% draft oa

, all the needed data for these ratios automatically coming from the Gene-Hull sheet.



### Mass spreadsheet input and output

This mass spreadsheet can provide the frame for an early stage estimation of the light weight mass and CoG position, in order to help adjust accordingly the hull design concerning its displacement and CoD position.

Mass and Xg, Zg position – early stage estimation		Input data		Results			
Data from Gene-Hull sheet are in blue		L or S or V	mass unit	Mass	Xg	M Xg	Zg
Data to enter are in bold black (inc. default value to initiate)		m or m2 or m3	or % Disp.	(kg)	(m)		(m)
2 Hulls (structure)		128,89	30,00	3866,75	7,10	27449,95	0,19
	, with S, Xs and Zs from Gene-Hull sheet		(kg/m2)				
Deck – roof – cockpit (structure)		115,45	38,82	4481,94	6,30	28241,78	1,25
	, with S, Xs and Zs from Gene-Hull sheet		(kg/m2)				
Rig, sails and deck fittings			20,00	3120,29	8,00	24962,32	7,50
			(% Disp.)				
Cabin accomodation and motor			25,00	3900,36	7,00	27302,54	0,12
			(% Disp.)				
2 Daggerboards				59,74	7,84	468,52	-1,54
2 Rudders – Helms			1,10	171,62	0,15	26,44	-0,73
			(% Disp.)				
Results : Light weight boat >>>				15600,70	6,95	108451,55	1,92
							29979,70

The input data to enter by the user and based on his experience, are in black bold police, including :

- **(cell C5)** average mass / m2 for Hull (skin, structure, reinforcements)  
, based on the hull surface data in cell B5 and coming from the Gene-Hull sheet
- **(cell C7)** average mass / m2 for Deck (deck, roof cockpit, reinforcements)  
, based on the hull surface data in cell B5 and coming from the Gene-Hull sheet
- **(cell C9)** average mass / % Disp. for Rig, sails and deck fittings, **(cell E9)** and **(cell G9)** for the X and Z position of this mass
- **(cell C11)** average mass / % Disp. for cabin accomodation and motor, **(cell E11)** and **(cell G11)** for the X and Z position of this mass
- **(cell C15)** average mass / % Disp. for the rudder system

The output data, light weight boat mass and position Xg, Zg are reported in the Gene-Hull sheet, and also used in the Catamaran with heel study.

### Annex : main formulations involved in Gene Hull (common for VE and UE versions)

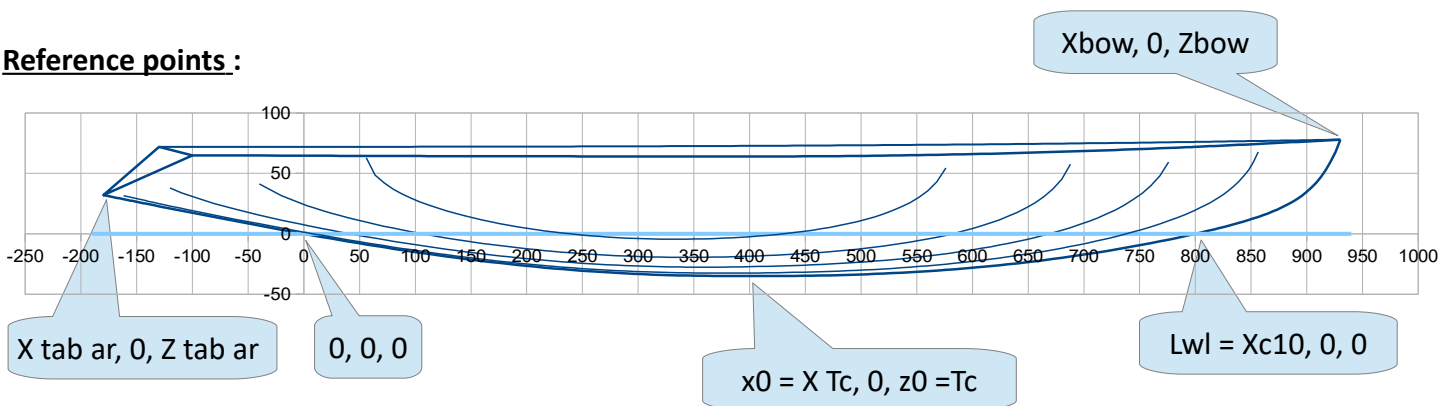
As a complement to the User Guide, this annex proposes the main formulations involved in Gene-Hull. for the geometrical definition of the keel line, of the sheer line and of the sections.

#### Coordinates system :

$x = 0$  at section C0 (= rear point of the waterline),  $x$  positive towards front  
 $y = 0$  in the symmetrical 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

##### Reference points :



The keel line is defined by 2 polynomes for respectively the fore part (when  $x > x_0$ ) and the rear part (when  $x < x_0$ ). Both polynomes are of the type :

$$z = z_0 + a (x - x_0)^{[b + c (X-X_0)^n]}$$

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

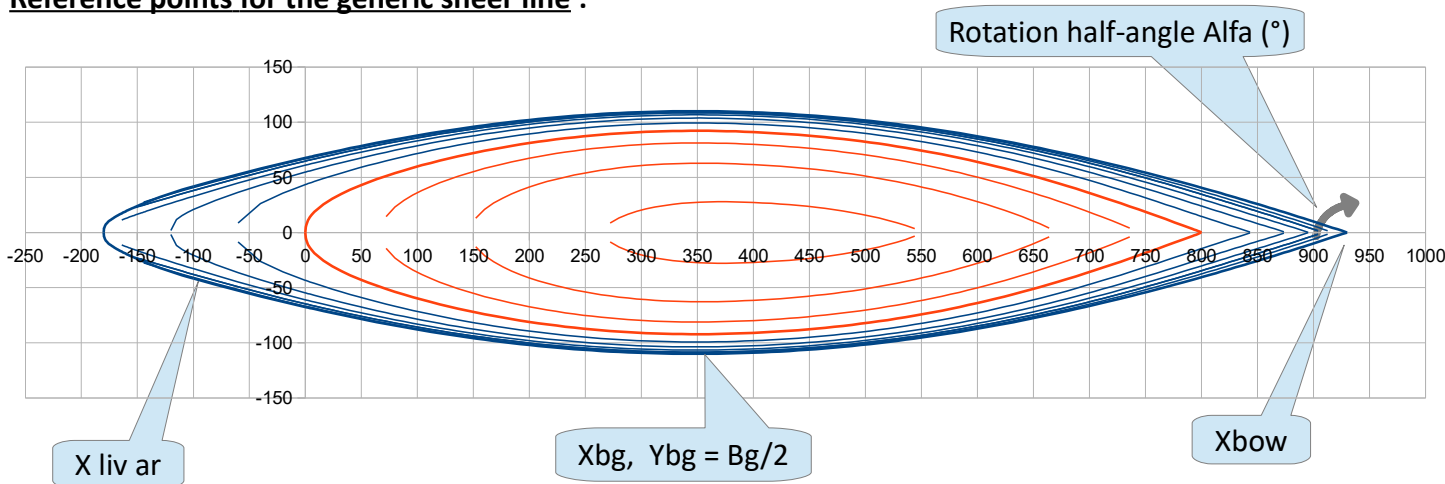
$n = \text{Cet}$ , an additional input for the fore polynome, contributing to shape the bow, Cet can vary from 0,1 to 100

$n = 1$ , for the rear polynome.

## 2. The sheer line, in its horizontal projection xy

The sheer line is computed through a 2 steps method : at first the sheer line of a generic hull, then the real sheer line by « opening » the previous one of an half angle alfa with the bow end as the center of rotation. Exactly, only the y values issued from the rotation are taken into account, the x values are kept unchanged.

### Reference points for the generic sheer line :



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

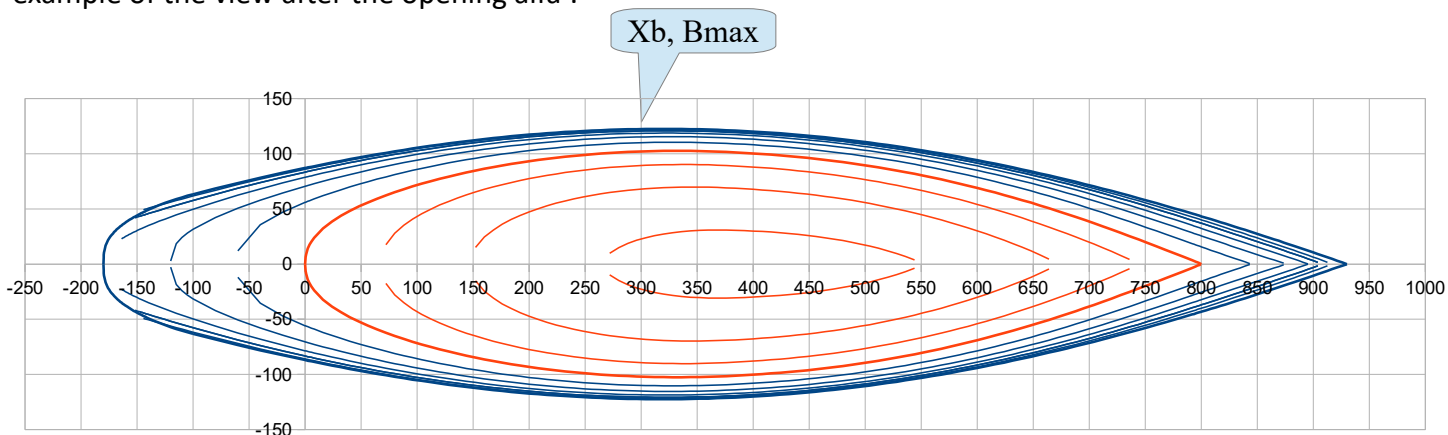
$$Y_g = B_g/2 - a |X_{bg} - X|^b + c |X_{bg} - X|^n$$

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

Then the real sheer line is computed through :

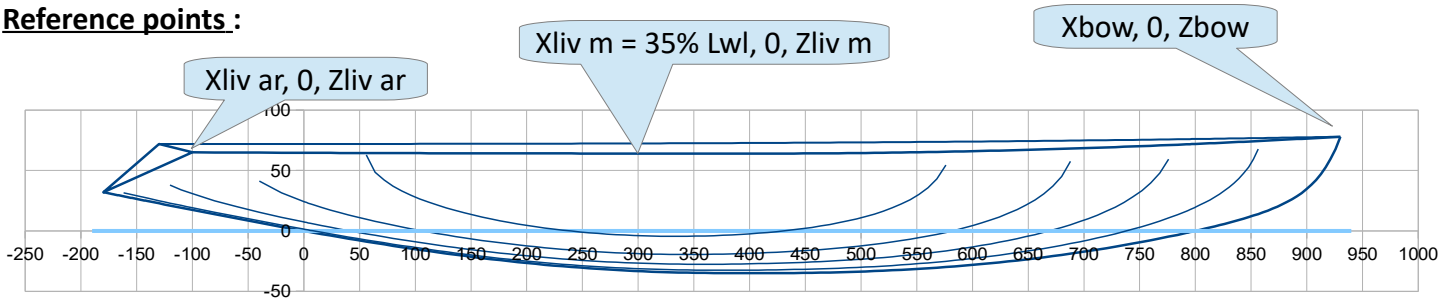
$$Y = Y_g + (X_{bow} - X) \sin(\alpha) + Y_g (1 - \cos(\alpha))$$

After this reformulation of Y, the maximum beam Bmax and its position Xb can be computed. An example of the view after the opening alfa :



### 3. Sheer line / in its vertical projection xz

**Reference points :**



The keel line is defined by 2 polynomes for respectively the fore part (when  $x > 35\% Lwl$ ) and the rear part (when  $x < 35\% Lwl$ ). Both polynomes are of the type :

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

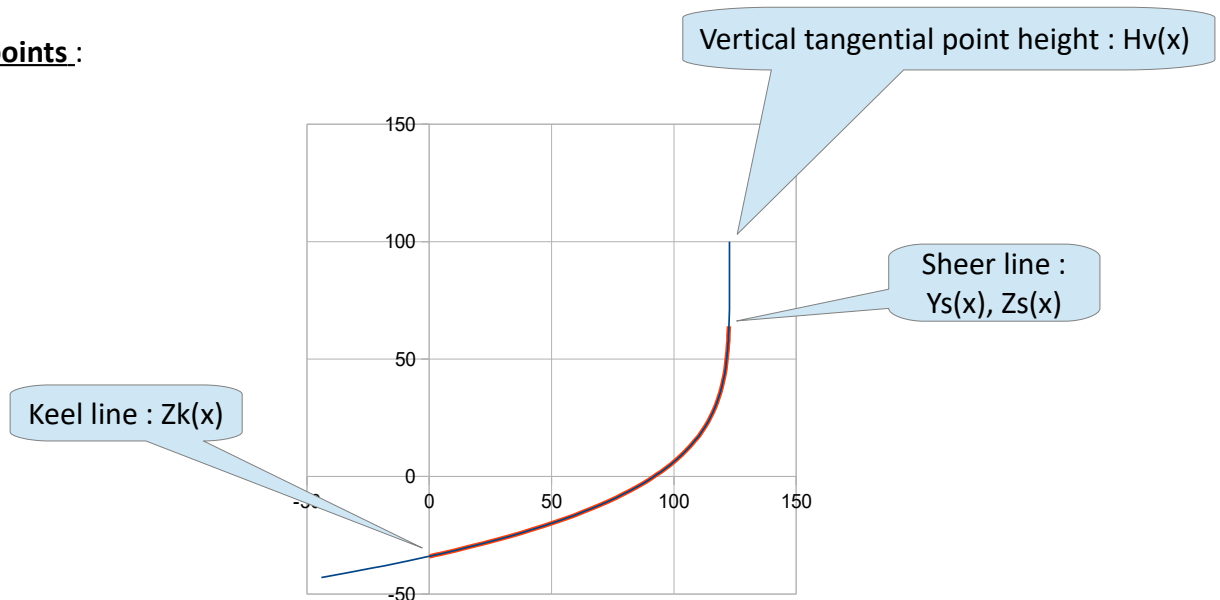
$$\text{Aft : } Z = Z_{liv\ m} + (Z_{liv\ ar} - Z_{liv\ m}) / (X_{liv\ m} - X_{liv\ ar})^n * (X_{liv\ m} - X)^n$$

### 4. Sections

3 types of elementary sections are defined, « V » shape, « U » shape and « E » shape, and then combination of either V and E shapes, or U and E shapes, is operated to define the real sections.

#### 4.1 « V » shape sections

**Reference points :**



The formulation is of the type :

$$Y_v(x, z) = A(x) - (H_v(x) - z)^{P_{uiv}(x)} / B(x)$$

, with :

$$H_v(x) = H_{v\ m} + (H_{v\ ar} - H_{v\ m}) * [IX - X_5] / [IX_{tab\ ar} - X_5]^{P_{uiHv}} \quad \text{for } x < x_5$$

$$H_v(x) = H_{v\ m} + (H_{v\ av} - H_{v\ m}) * [IX - X_5] / [IX_{tab\ av} - X_5]^{P_{uiHv}} \quad \text{for } x > x_5$$

$$P_{uiv}(x) = P_{uiv\ ar} + (P_{uiv\ av} - P_{uiv\ ar}) * [(X - X_{tab\ ar}) / (X_{bow} - X_{tab\ ar})]^{P_{uiPuiV}} - Cor_{PuiPuiV} * (X - X_{tab\ ar}) / (X_{bow} - X_{tab\ ar})]$$

$$B(x) = [(H_v(x) - Z_k(x))^{P_{uiv}(x)} - (H_v(x) - Z_s(x))^{P_{uiv}(x)}] / Y_s(x)$$

$$A(x) = [(H_v(x) - Z_k(x))^{P_{uiv}(x)}] / B(x)$$

, 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
Cor Pui Pui V

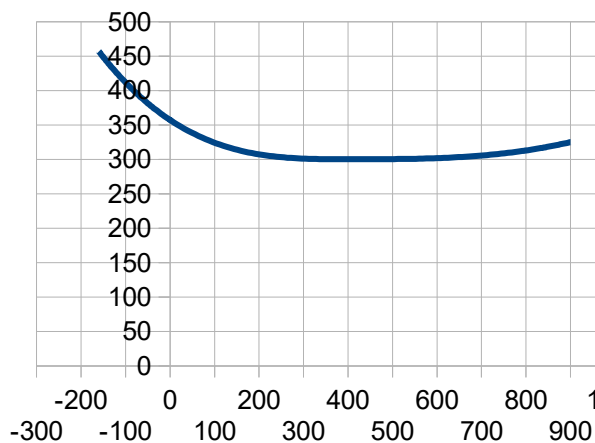
, and :

$$X_5 = 50\% \text{ Lwl}$$

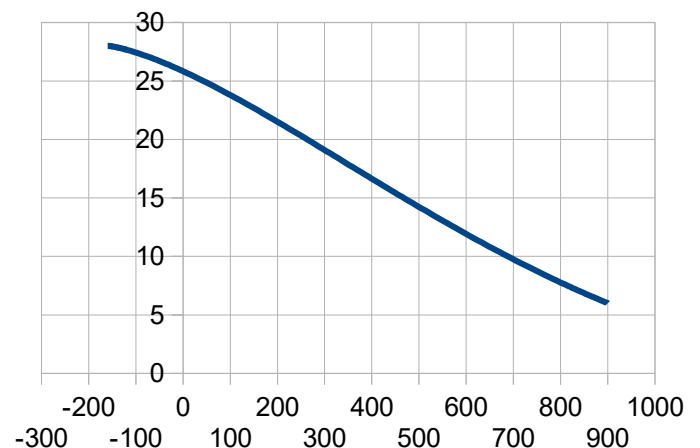
$$H_{v\ ar} = C_{Hv\ ar} * Z_{liv\ ar} ; H_{v\ m} = C_{Hv\ m} * Z_{liv\ m} ; H_{v\ av} = C_{Hv\ av} * Z_{bow}$$

Examples of  $H_v(x)$  and  $P_{uiv}(x)$  functions :

$H_v(x)$  for "V" sections

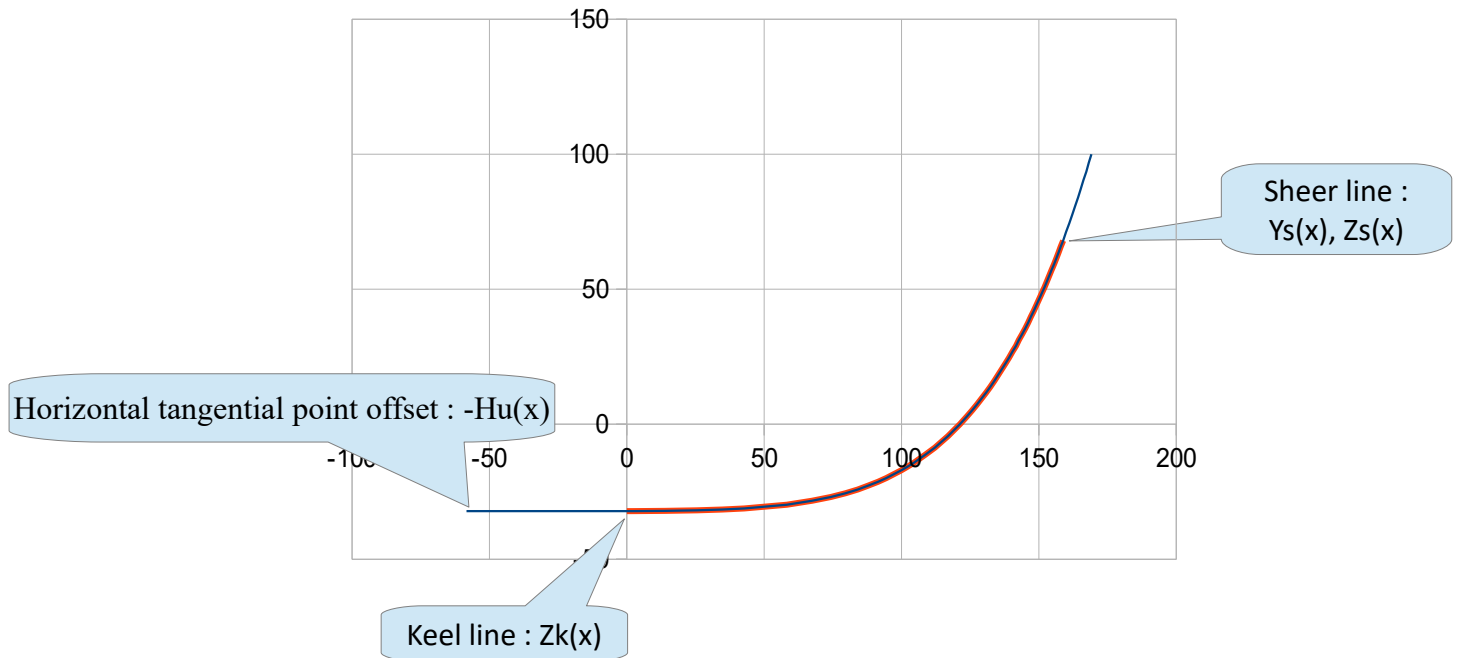


$P_{uiv}(x)$  for "V" sections



## 4.2 « U » shape sections

Reference points :



The formulation is of the type :

$$Y_u(x, z) = -H_u(x) + [(z - T(x))/U(x)]^{(1/P_{uiu}(x))}$$

, with :

$$H_u(x) = H_{u\ ar} + (H_{u\ av} - H_{u\ ar}) * [(X - X_{tab\ ar}) / (X_{bow} - X_{tab\ ar})]^{P_{uiHu}}$$

$$P_{uiu}(x) = P_{uiu\ ar} + (P_{uiu\ av} - P_{uiu\ ar}) * ((X - X_{tab\ ar}) / (X_{bow} - X_{tab\ ar}))^{[P_{uiPuiu} - Cor_{PuiPuiu} * (x - X_{tab\ ar}) / (X_{bow} - X_{tab\ ar})]}$$

$$U(x) = (Z_s(x) - Z_k(x)) / ((Y_s(x) + H_u(x))^{P_{uiu}(x)} - H_u(x)^{P_{uiu}(x)})$$

$$T(x) = Z_k(x) - U(x) * H_u(x)^{P_{uiu}(x)}$$

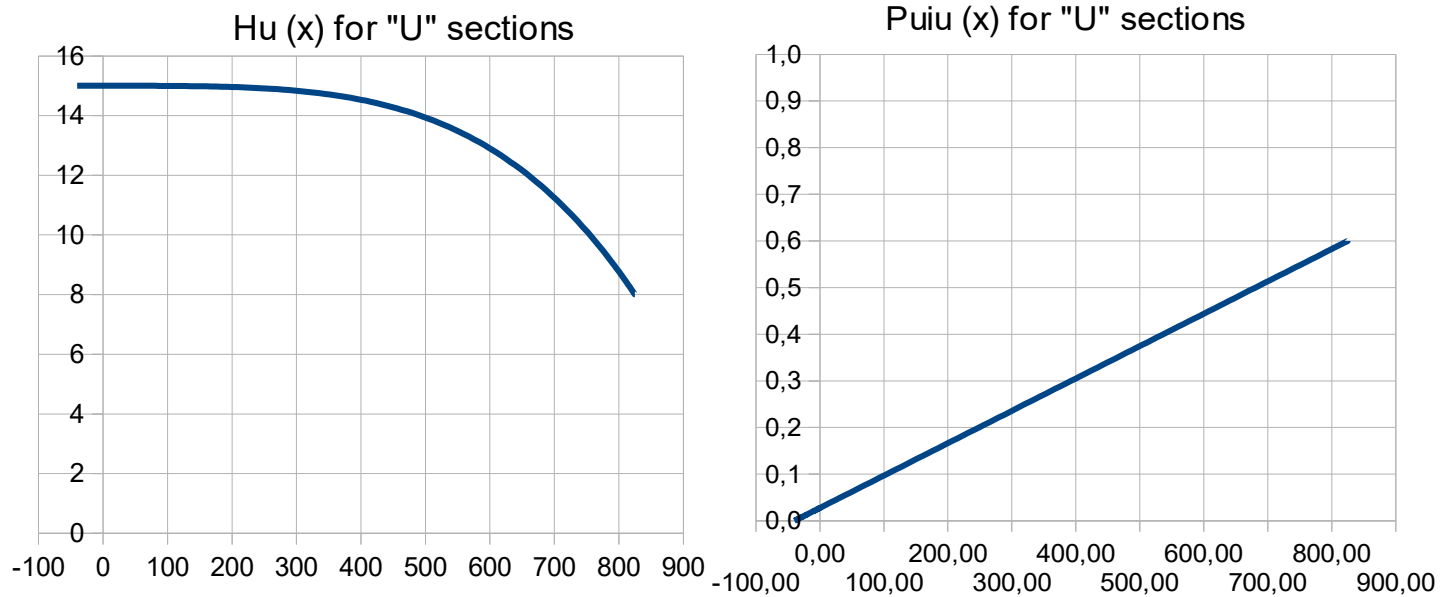
, where the input data are the adimensional parameters :

**C Hu av**  
**C Hu ar**  
**Pui Hu**

**Pui U av**  
**Pui U ar**  
**Pui Pui U**  
**Cor Pui Pui U**

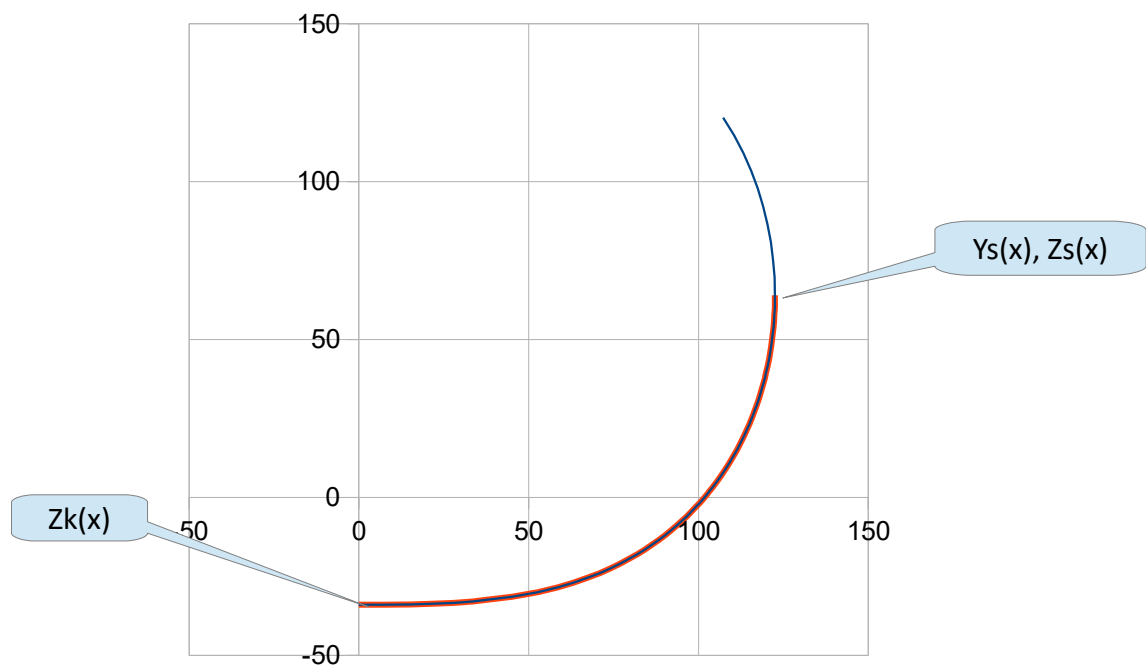
, and  $H_{u\ av} = C_{Hu\ av} * (B_{max} / 2)$  ;  $H_{u\ ar} = C_{Hu\ ar} * (B_{max} / 2)$

Examples of  $H_u(x)$  and  $P_{ui}(x)$  functions :



#### 4.3 « E » shape sections

Reference points :



The formulation is of the type :

$$Y_E(x, z) = Y_s(x) - [1 - ((Z_s(x) - z) / (Z_s(x) - Z_k(s)))^{P_{uiE1}}]^{1/P_{uiE2}}$$

, where the input adimensional parameters are  $P_{uiE1}$  and  $P_{uiE2}$

#### 4.4 Combination of shapes

Two combinations are proposed :

- VE sections
- UE sections

The combination law is the same in both cases :

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

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

, with :

$$\text{mix}(x) = \text{mix}_{av} + (\text{mix}_{ar} - \text{mix}_{av}) * [(X_{bow} - X)/(X_{bow} - X_{tab ar})]^{\text{Pui mix VE}}$$

, where the input data are the adimensional parameters :

**mix VE av**  
**mix VE ar**  
**Pui mix VE**

Examples of  $\text{mix}(x)$  :

mix (x) law combination for the sections

