

Gene-Hull 2.2_User Guide_English version

Introduction

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

Two similar files « VE » and « UE » are proposed, one **VE** involve sections defined by combination of « V » and « E » shapes (E for Elliptic), the other one **UE** involve sections defined by combination of « U » and « E » shapes. A specific « VE double ended » file and its user guide are also available on request for that kind of hull with a double ended configuration.

In the present state of this development, some limitations exist which could be overtaken within further versions already in preparation. Main are :

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

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>

On request, a technical appendix can give you all the formulations involved and if necessary you can improve the tool yourself and share it with the community of amateurs of naval architecture. Or you can contact me with your remarks and improvement requests.

Jean-François Masset - January 2018

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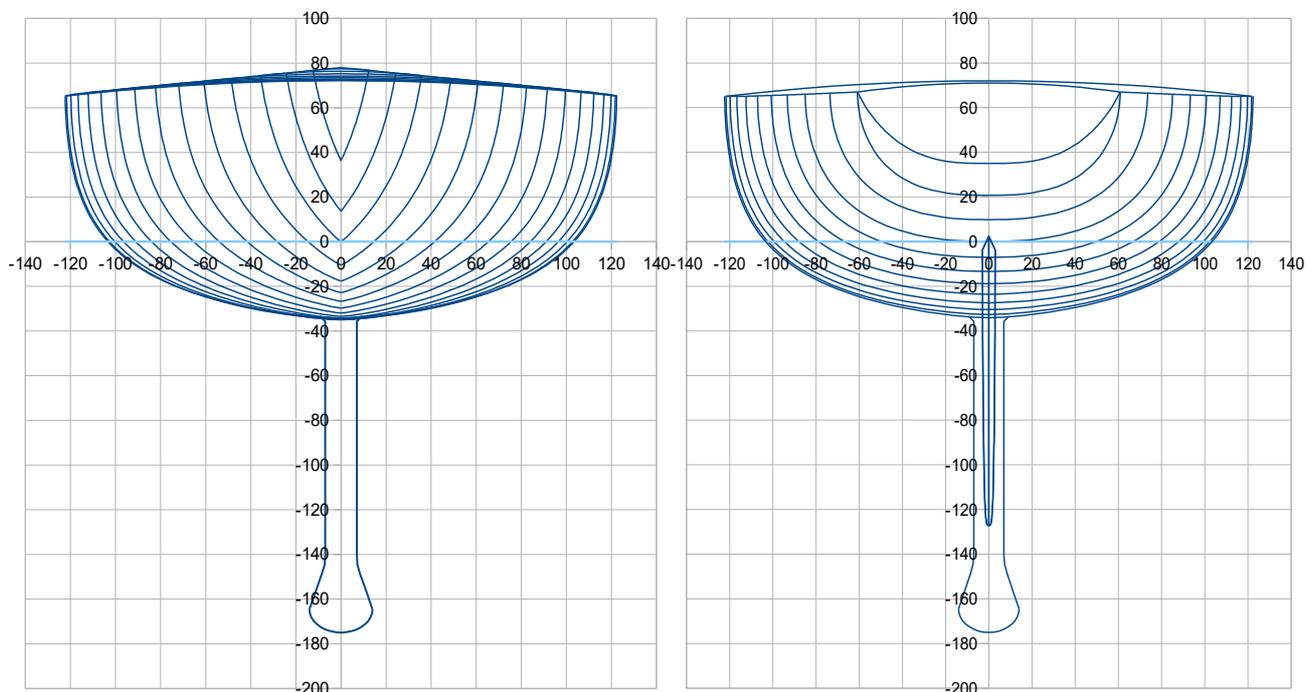
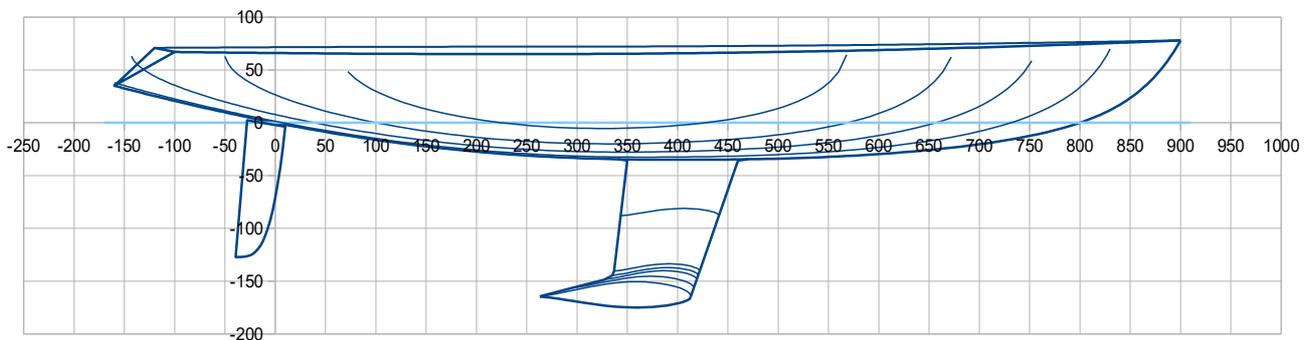
Summary presentation

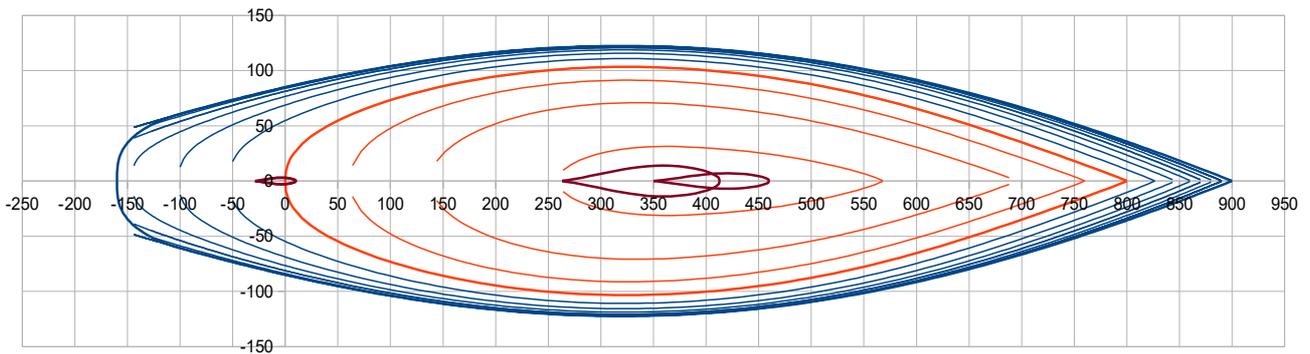
The spreadsheet application includes on the first sheet an User space (input & outputs) followed by an Administrator space where the computations are carried out. The User space includes 7 successive sections :

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

The coordinates x,y,z used for 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.

Input

1. Data to enter

Data to enter are in column B (cases B12 to B84), the ones of the hull of reference are in column D. Simplified views of the hull are showed opposite to the data so that one can see 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*).

Length of waterline

Lwl (m) : length of waterline at H0

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

Draft

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

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

Bow end

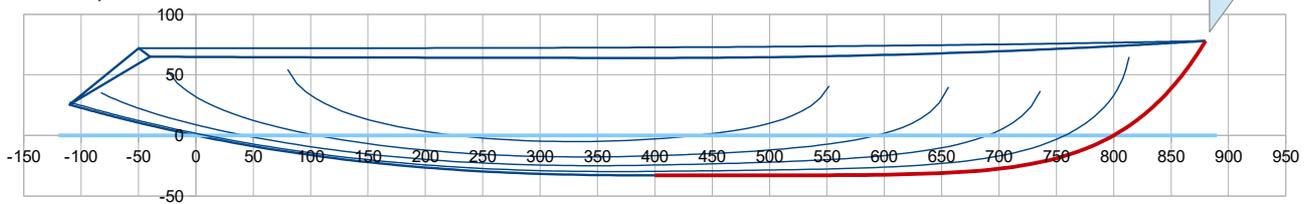
Xbow (m) : should be > Lwl ; **Z bow (m)** : it is the front freeboard

Coefficient form for the bow line

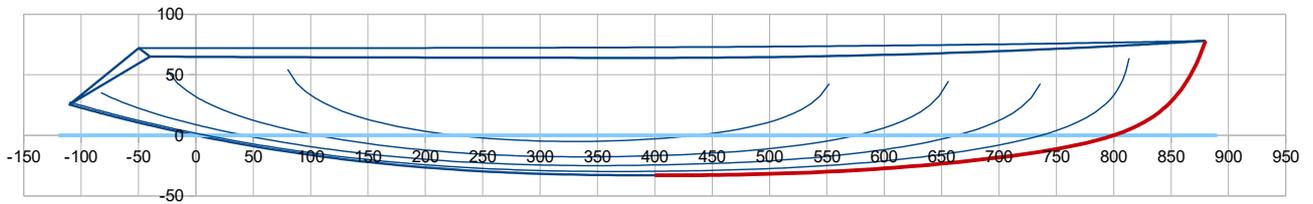
Cet : adimensional coefficient > 0, from 0,1 to 100 typically. This coefficient is involved in the polynomial formulation of the front part of the keel line and mostly influence the bow shape. Examples :

Xbow , Zbow

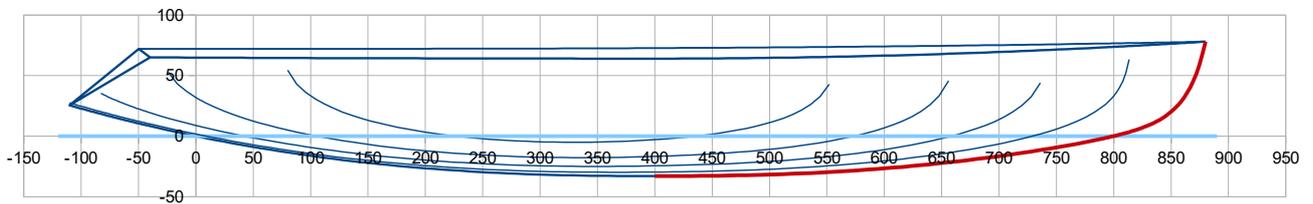
Cet = 0,1 :



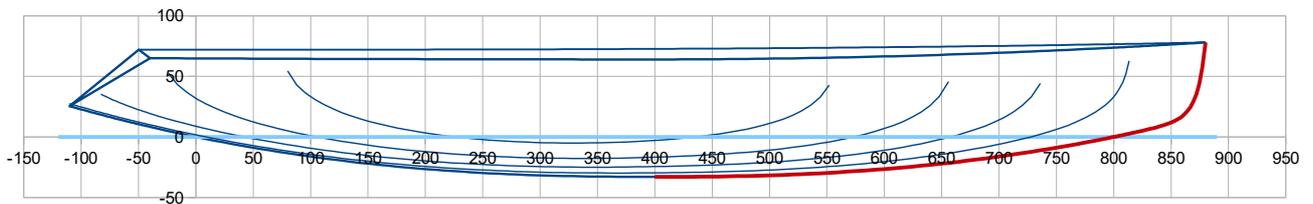
Cet =10 :



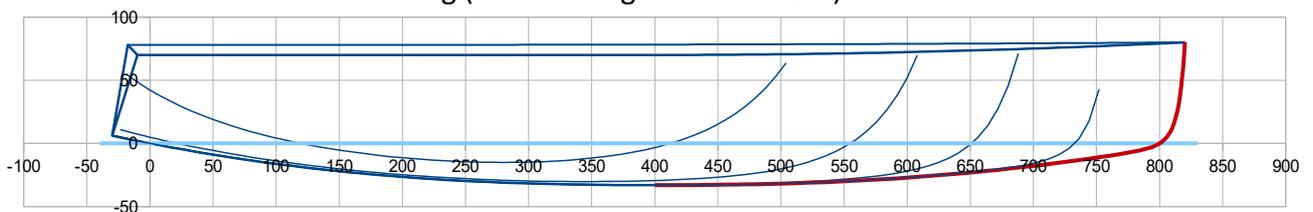
Cet 20 :



Cet 50 :



Cet 50 with a short front overhang (Xbow little greater than Lwl) :

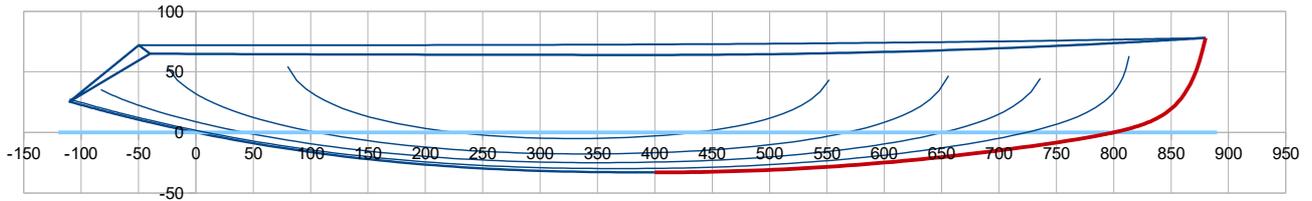


Important : Cet being a sensible parameter for the system, it is recommended to put at first Cet = 1 when beginning a new hull having new geometrical data. Once all geometrical data are firstly input, then one can vary Cet av.

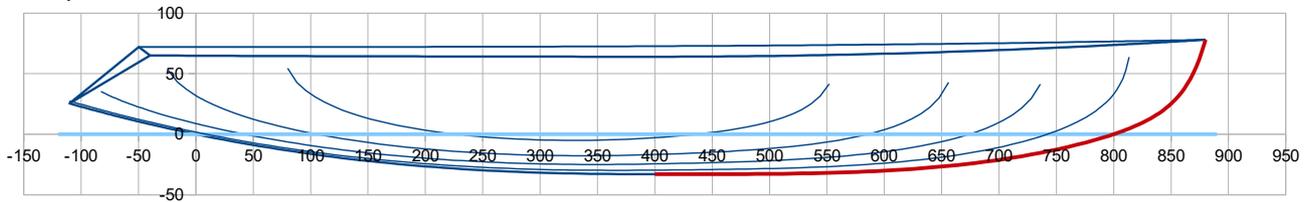
Keel line polynomial / front part ($x > 50\% Lwl$)

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

Pui q av = 2 :



Pui q av = 3,5 :

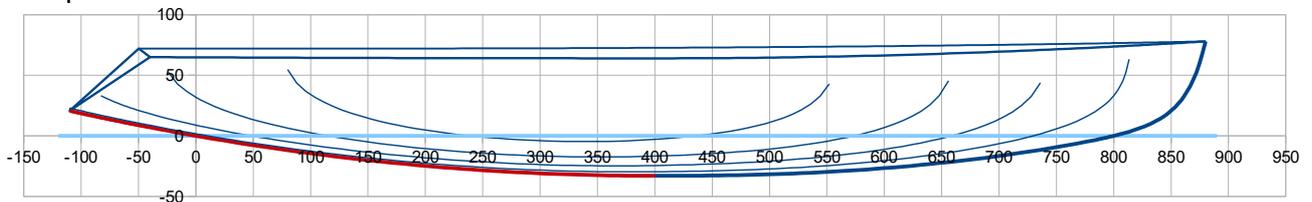


Nota : for the bow shape, eventually these 3 data are influent and in interaction : Xbow (acting on the front overhang), Cet (acting on the bow line) and Pui q av (acting on the overall shape of the front keel line).

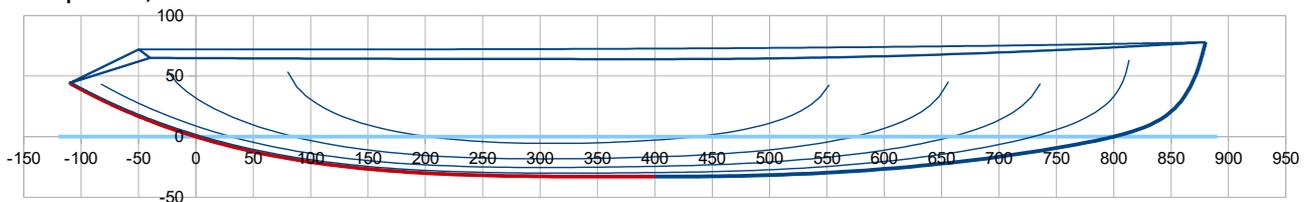
Keel line polynomial / rear part ($x < 50\% Lwl$)

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

Pui q ar : 2



Pui q ar : 3,5



Rear transom end point

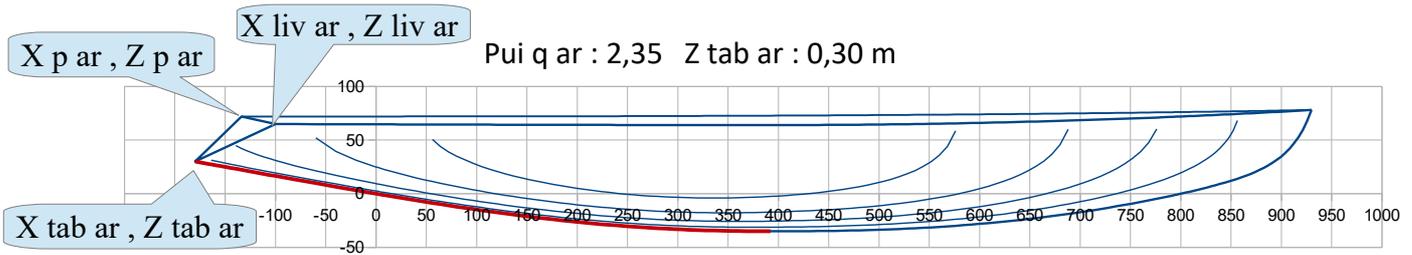
X tab ar (m) : X of the rear point overall, should be less than all other X.

Nota : condition to comply with an inverted rear transom as modelled :

Condition : $X\ tab\ ar < X\ p\ ar < X\ liv\ ar < 0$

Z tab ar (m) : Z of the rear point. This data influence the shape of rear end of the the keel line.

Example :



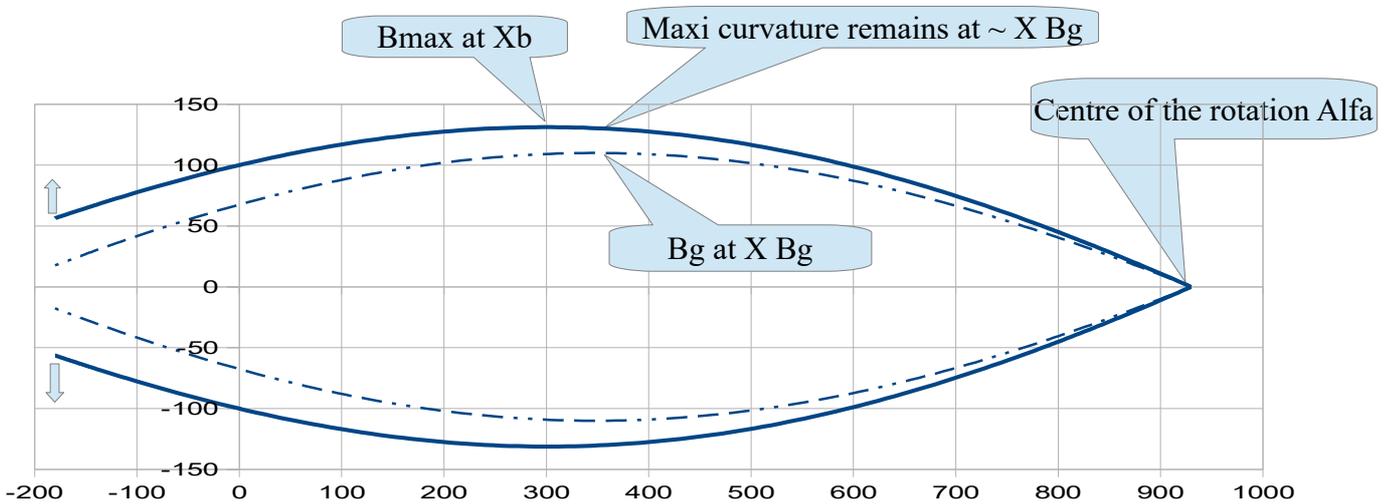
Nota : for the rear keel line shape, eventually these 3 data are influent and in interaction : $X\ tab\ ar$, $Z\ tab\ ar$ (= the rear point location) and $Pui\ q\ ar$ (acting on the overall shape of the rear keel line).

Sheer line in horizontal plan (plan xy)

Bg (m) , X Bg (%Lwl) and Alfa (°) :

An indirect approach is proposed to define the sheer line, in order to position the maximum Beam independently of the sheer line maximum curvature :

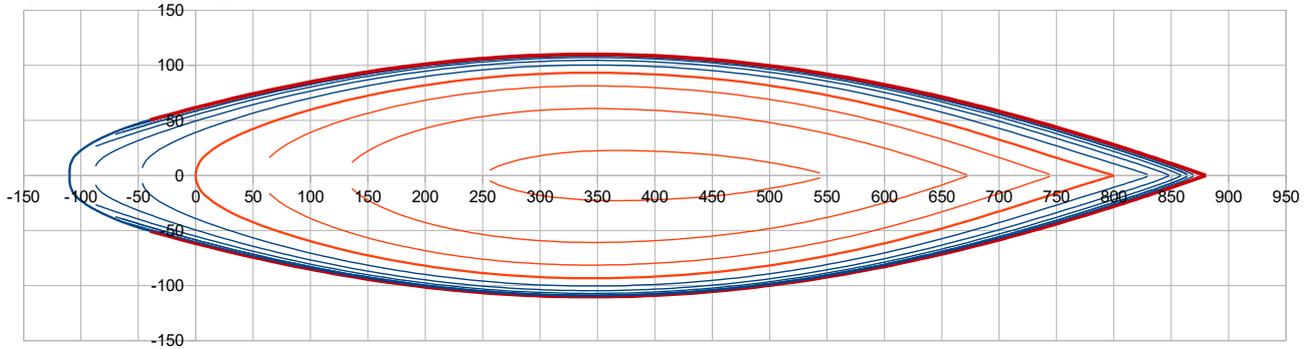
At first a virtual sheer line is defined with as input the maximum beam **Bg** positioned in **X Bg** (dashed line here below). Then, this line is « open » by rotation of a half-angle **Alfa** with the bow end as center for this rotation (as showed here below), to obtain the real sheer line with a new 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 B_g , $X\ B_g$ and $Alfa$ leads to a the real sheer line with maximum beam B_{max} at a real position X_b . By doing so, the sheer line maximum curvature remains close to $X\ B_g$.



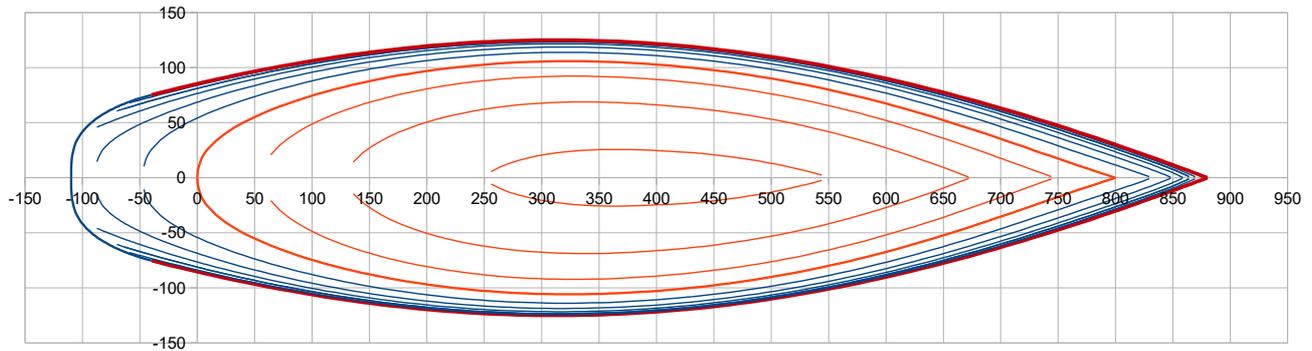
Nota : this « Alfa » reshaping of the hull is powerful, it can be done at any moment of the hull definition, all the stations and waterlines are automatically updated.

Example 1 :

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



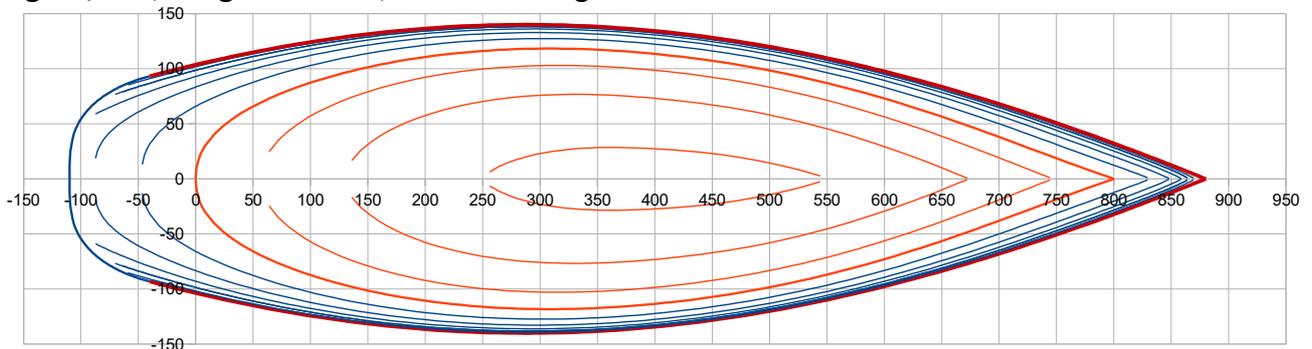
... + rotation Alfa = 1,55° >>> real hull with Bmax = 2,5 m at Xb = 39 %Lwl



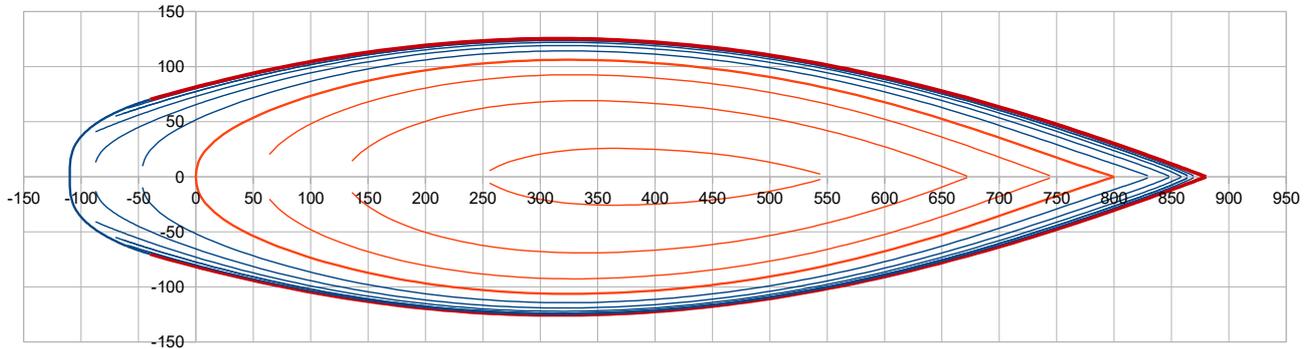
One can just use Alfa = 0°, or even adopt an inverted approach with a negative value of Alfa >>>

Exemple 2:

Bg = 2,8 m ; X Bg = 36 %Lwl ; Alfa = 0° >>> generic hull

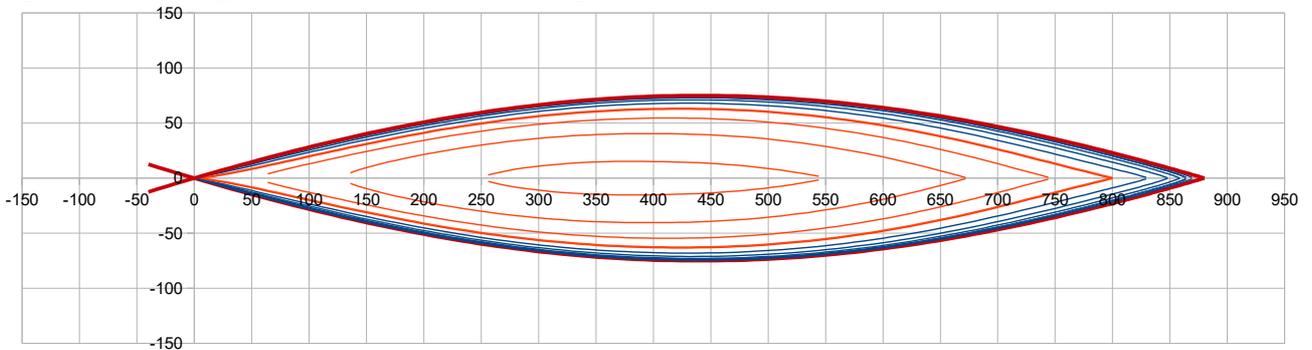


... + rotation $\text{Alfa} = -1,45^\circ \gg \gg$ Real hull $\text{Bmax} = 2,5 \text{ m}$ at $\text{Xb } 39 \% \text{ Lwl}$

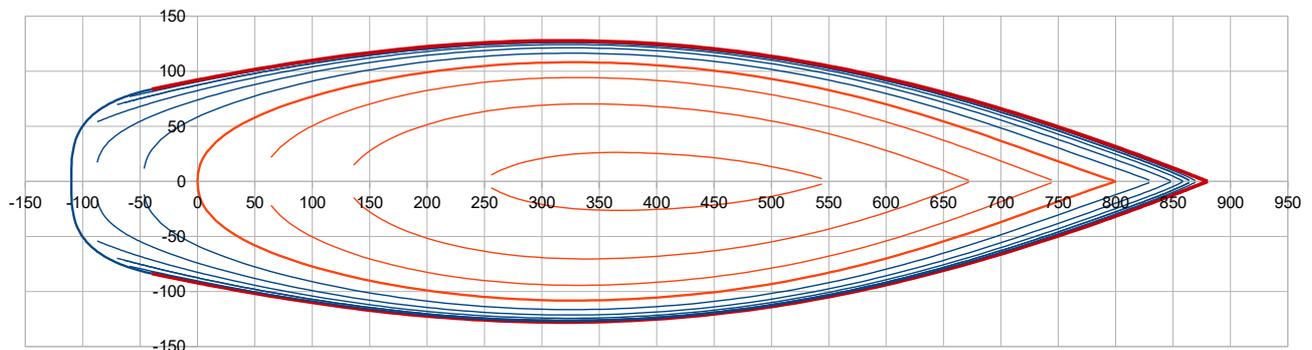


The generic hull could even be virtual and yet be transformed into a real one by application of a great enough Alfa $\gg \gg$ **Example 3 :**

$\text{Bg} = 1,5 \text{ m}$; $\text{X Bg} = 55 \% \text{ Lwl}$; Alfa = $0^\circ \gg \gg$ generic hull



... + rotation $\text{Alfa} = 6^\circ \gg \gg$ Real hull $\text{Bmax} = 2,55 \text{ m}$ at $\text{Xb } 40 \% \text{ Lwl}$



In each case the maximum curvature of the sheer line remains close to X Bg of the generic hull :
 $\gg \gg$ Exemple 1 : 43% Lwl ; Exemple 2 : 36 % Lwl ; Exemple 3 : 55 % Lwl

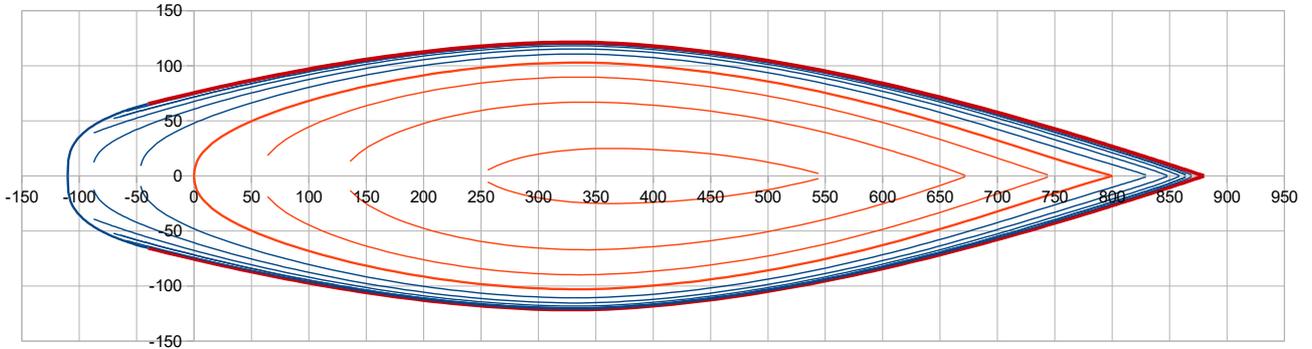
Nota : the « rotation » is explained in the technical appendix, actually concerning only the y values of the sheer line, the x values being unchanged (the rotation matrix is used only for the y values).

Pui liv, Cor Pui liv and Pui Cor Pui : there 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).

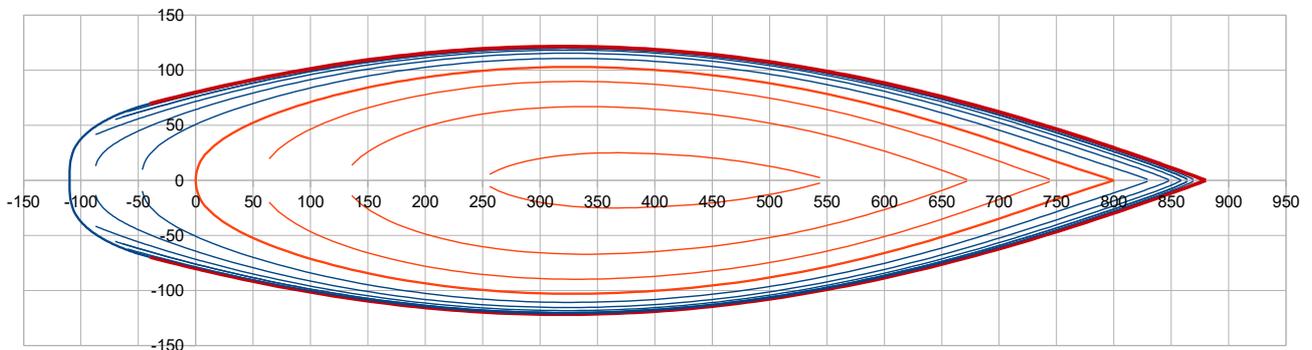
Pui liv = 2 gives the better curvature regularity in the midship zone, it is the recommended value.

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. Exemples :

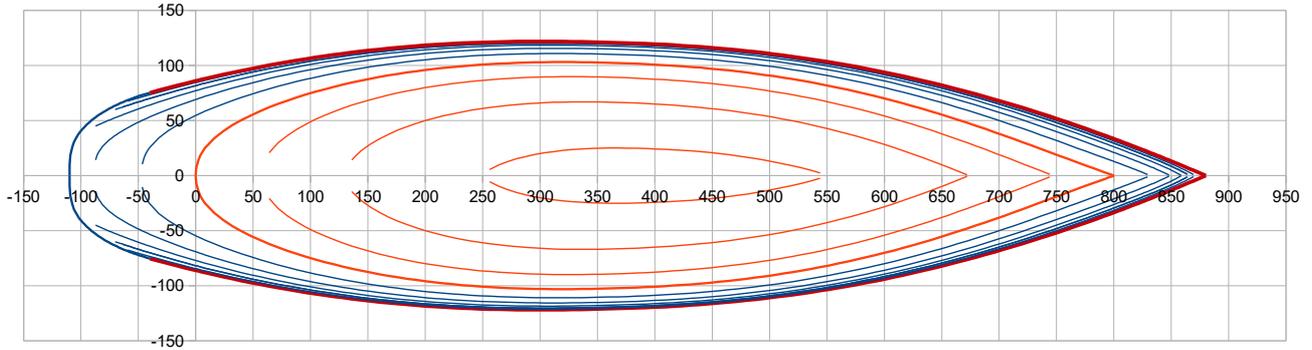
Pui liv = 1,8 :



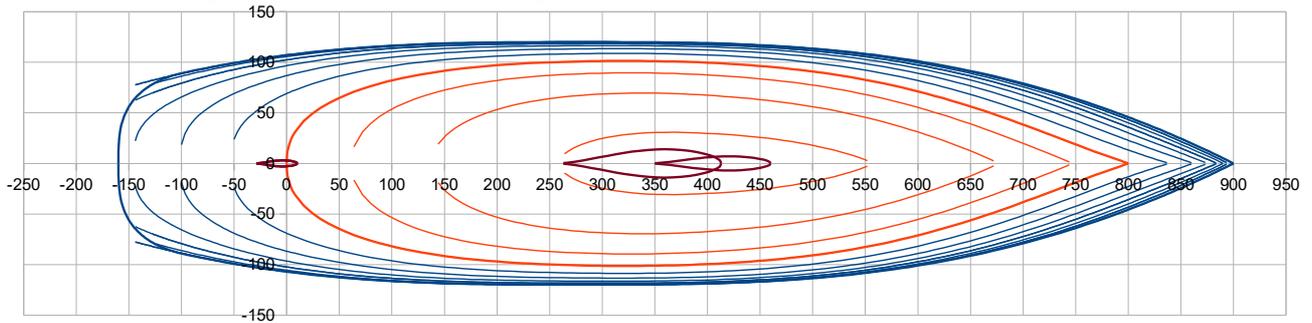
Pui liv = 2 :



Pui liv = 2,3 :

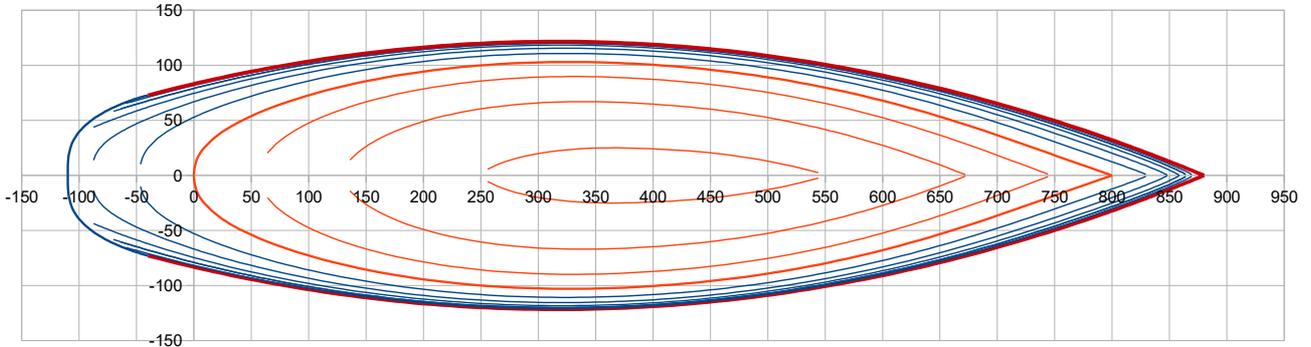


... up to a « barge » like shape when using Pui liv = 3 :

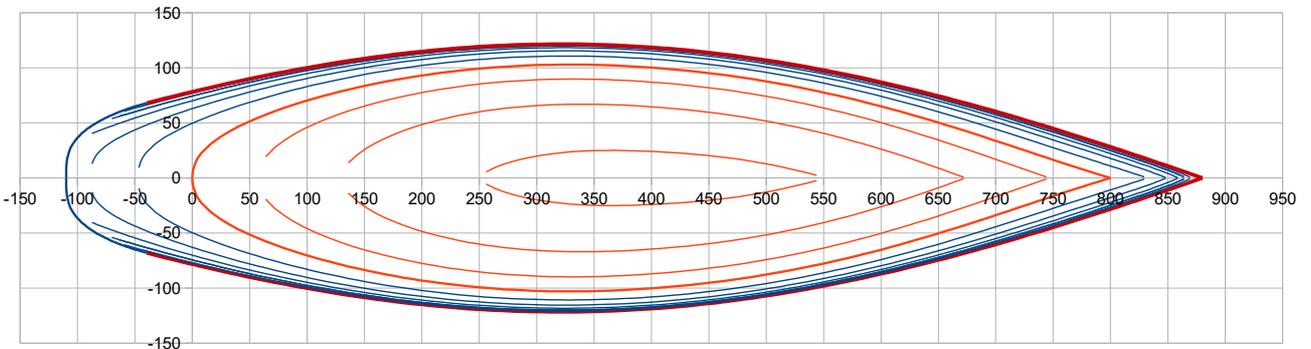


Cor Pui liv can add more or less tension towards the front and aft ends of the sheer line, meaning ends with less curvature. Examples :

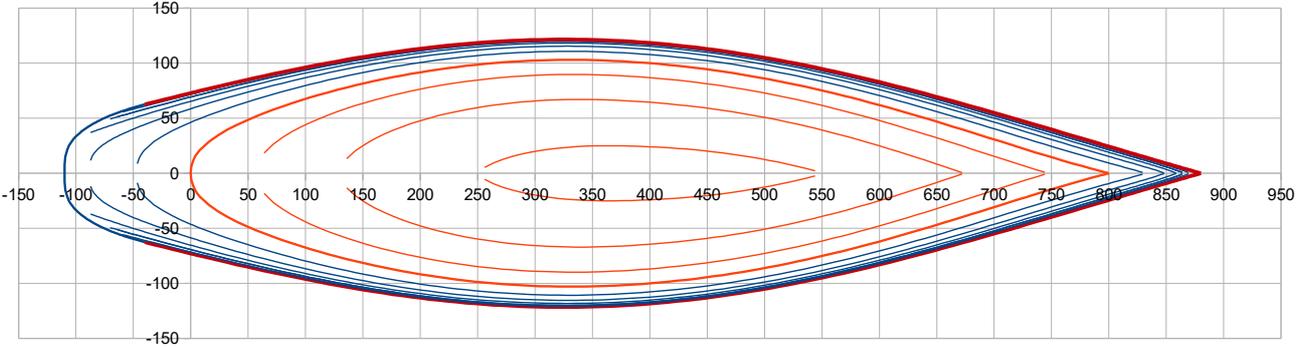
Cor Pui liv = 0



Cor Pui liv = 0,03



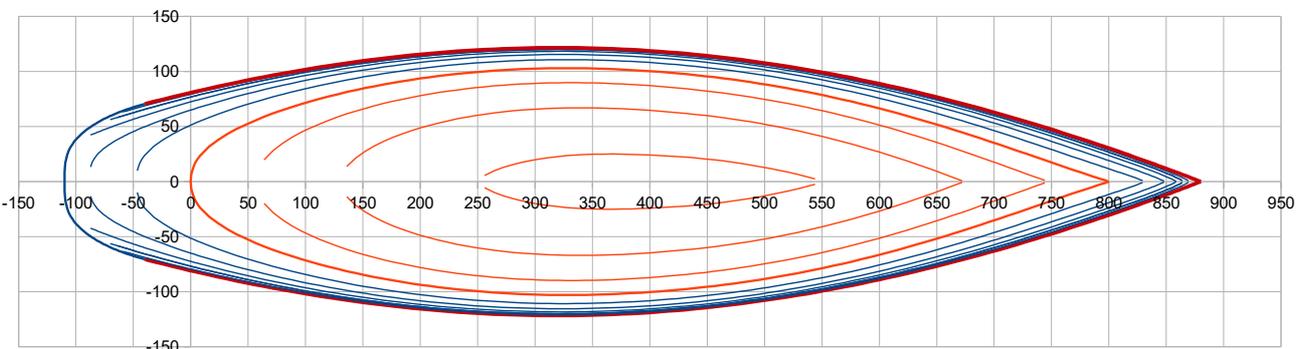
Cor Pui Liv = 0,06 :



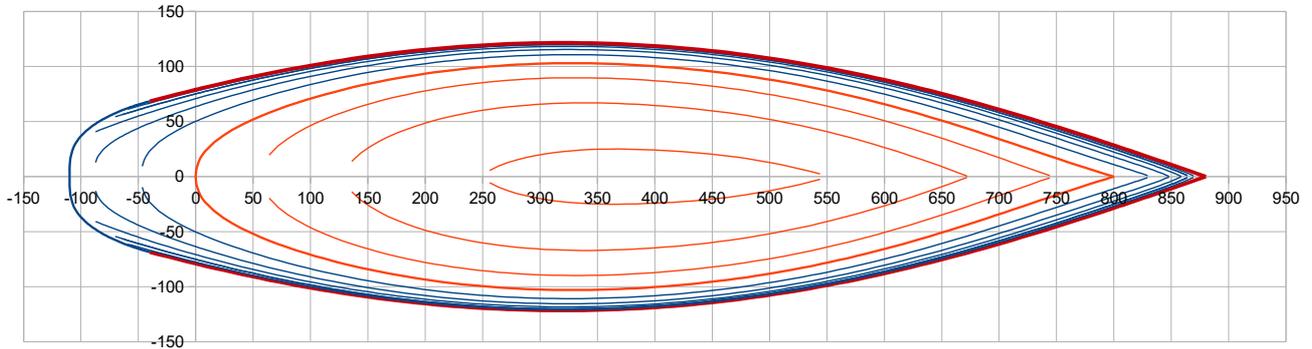
Negative values of Cor Pui Liv can be tested too, with the inverted effect.

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

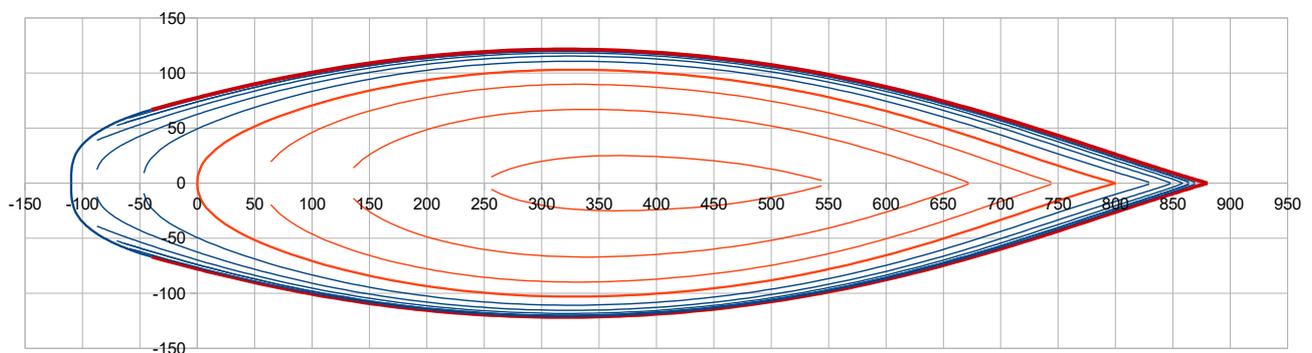
Pui Cor Pui = 1



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 shear line triggered by Cor Pui.

X liv ar (m) : it is the X position X of the rear point of the shear line (see picture page 7). 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 .

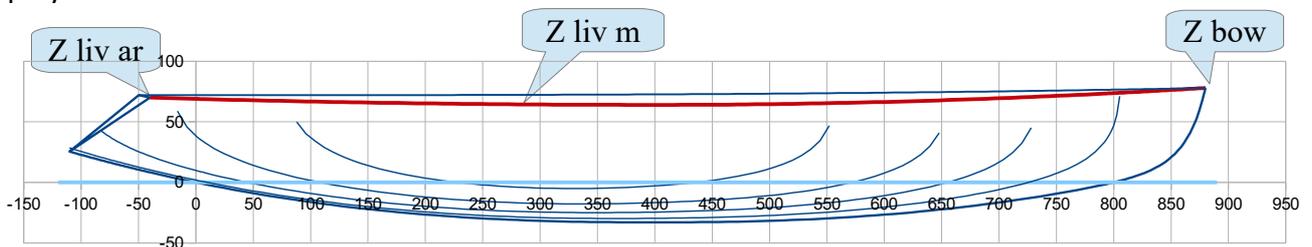
Nota : Y value of the shear line aft point is not specified, as it results from the 6 previous parameters here above detailed.

Sheer line in vertical projection (plan xz)

Z liv m (m) : it is the freeboard at 30% Lwl

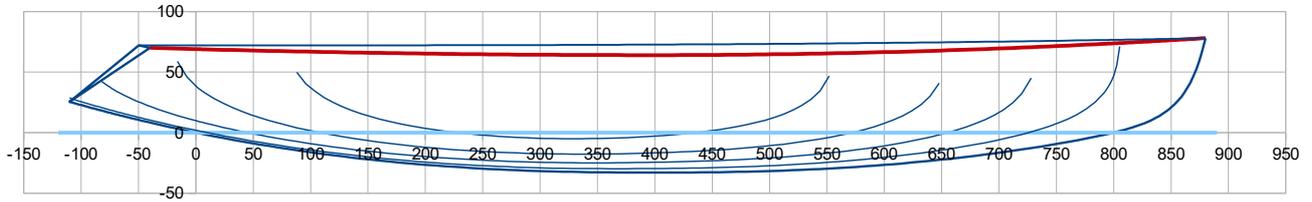
Z liv ar (m) : it is the aft freeboard, specified at the shear line aft point.

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

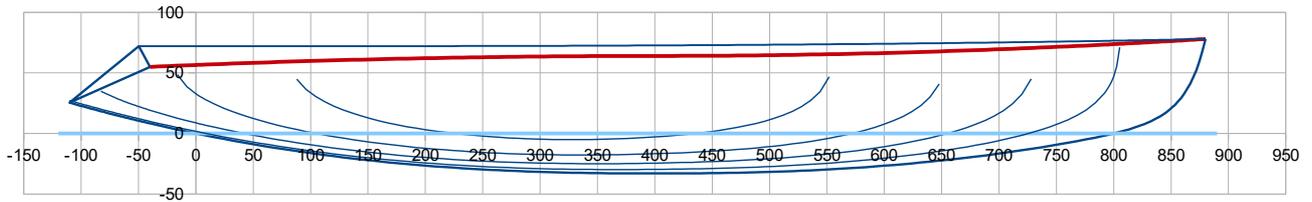


Pui liv z : it is the power of this polynomial. Recommended values 2 to 3 . Some examples with two different values of Z liv ar :

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 :

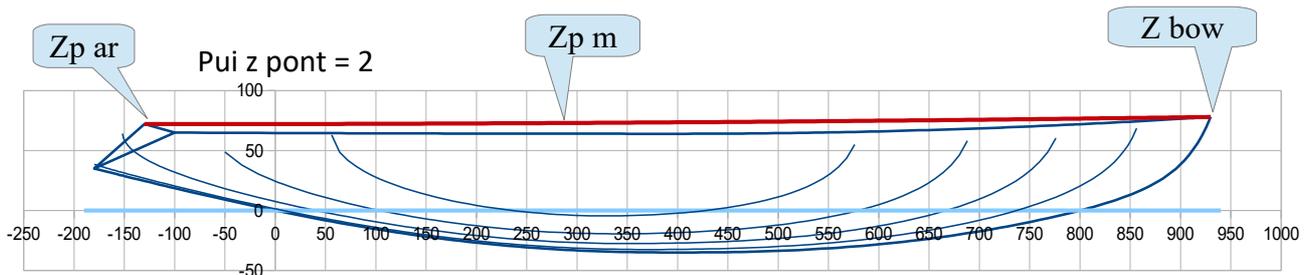


Deck / central line of symmetry

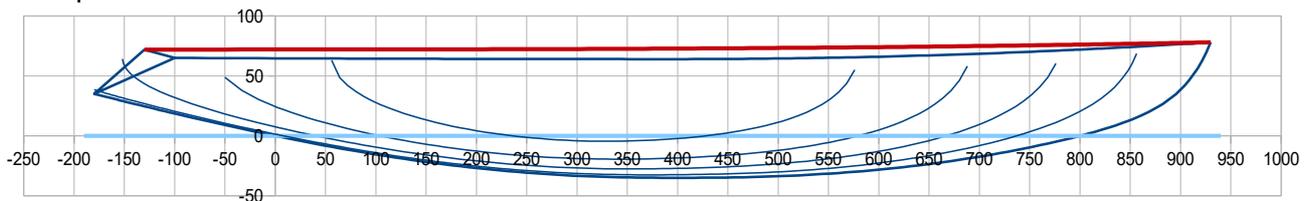
A deck surface with a circular curvature is defined from both the sheer line definition and the central line one (at $y = 0$) going from the front end of the hull (X bow, Z bow) and defined by :

- a point at midship : **Zp m (m)** at $X = 50\% \text{ Lwl}$
- a point at the rear end of the deck : **Xp ar (m) , Zp ar (m)** .

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



Pui z pont = 3

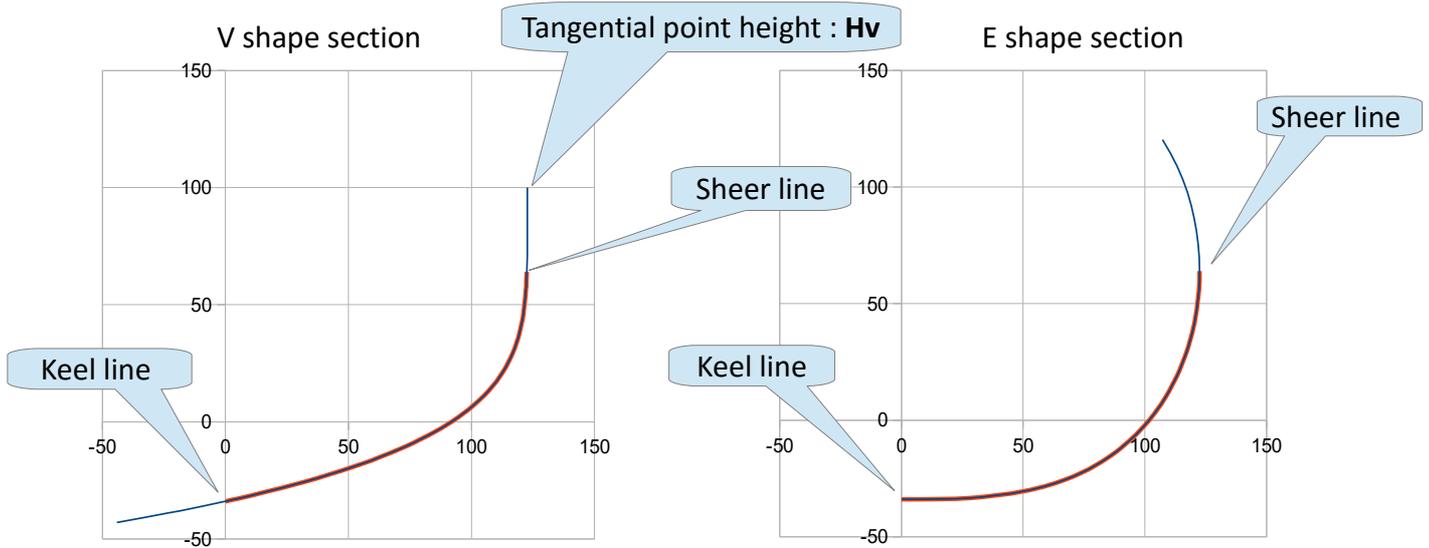


VE Sections (combination of « V » and « E » sections (E for Elliptic))

In the VE version of the spreadsheet application, sections are defined as a combination of 2

polynomials, one representative of a V shape section and the other one representative of a E shape section. In the UE one, 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 useful.

For the VE file, sections are combination of these two shapes sketched here below. Adimensional parameters to enter concern the height of the tangential point H_v , the degree and the coefficients of the polynomials V and E, their variation with x.



Parameters for V sections :

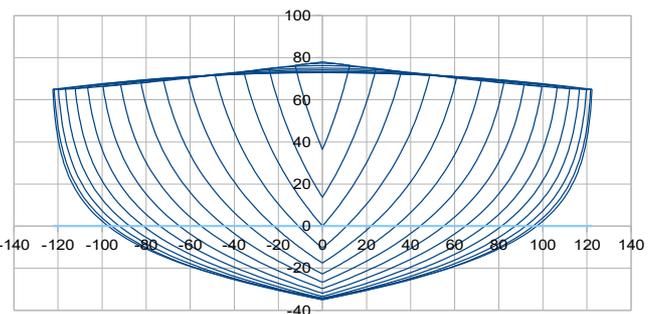
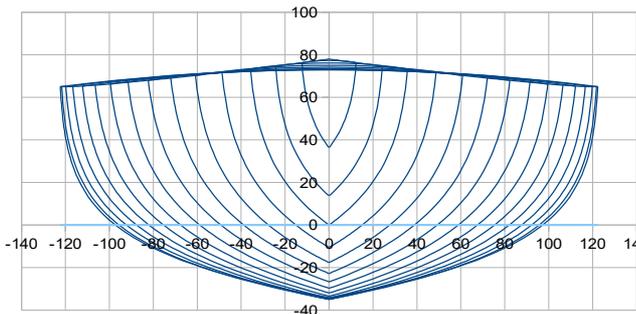
$C_{Hv\ av}$; $C_{Hv\ ar}$; $C_{Hv\ m}$; $P_{ui\ Hv}$

These parameters deal with the height H of the polynomial tangential vertical point as a function of the x position of the section (formulation details in the technical appendix). **$C_{Hv\ av}$** at bow end , **$C_{Hv\ m}$** at midship and **$C_{Hv\ ar}$** at rear end, are the relative heights H_v to respectively Z bow, Z liv m and Z liv ar and **should be > 1,1** . The larger C_{Hv} , the more the V shape is sharp ; the smaller C_{Hv} , the more the V shape is rounded. **$P_{ui\ Hv}$** 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 combination with E sections) :

$C_{Hv\ av} = 1,5$; $C_{Hv\ m} = 6$; $C_{Hv\ ar} = 6$

>>>

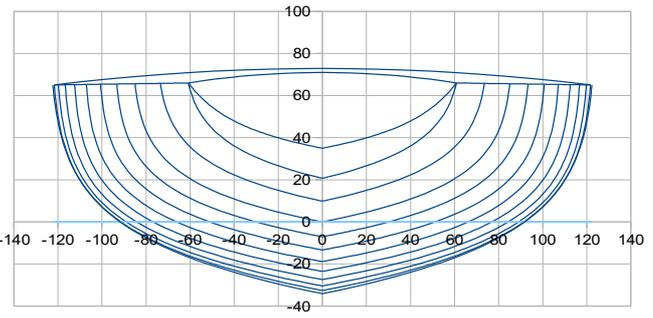
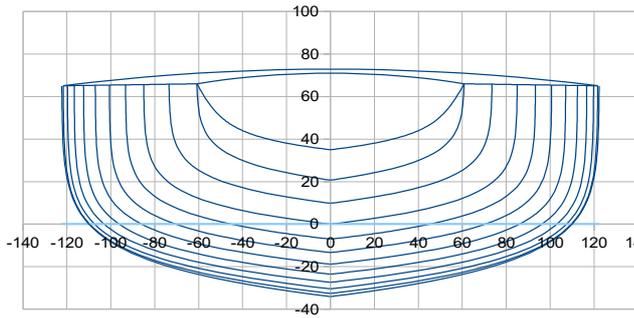
$C_{Hv\ av} = 6$; $C_{Hv\ m} = 6$; $C_{Hv\ ar} = 6$



C Hv av = 6 ; C Hv m= 4 ; C Hv ar = 4

>>>>

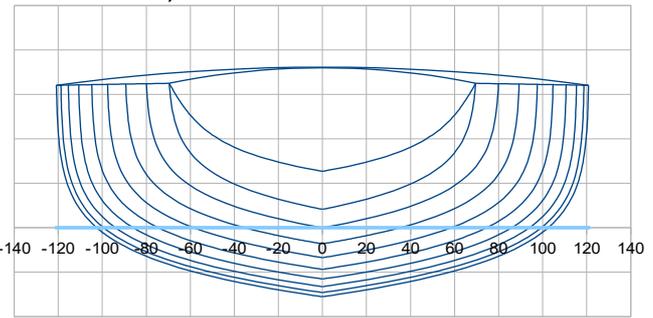
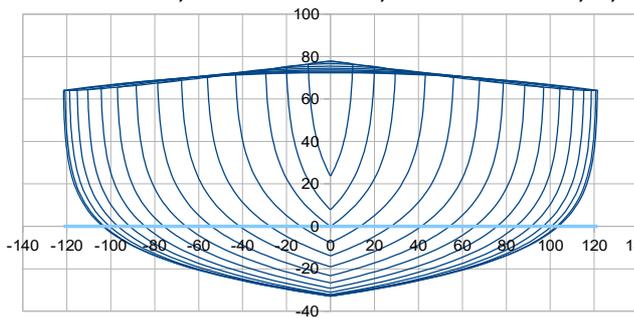
C Hv av = 6 ; C Hv m= 7 ; C Hv ar = 7



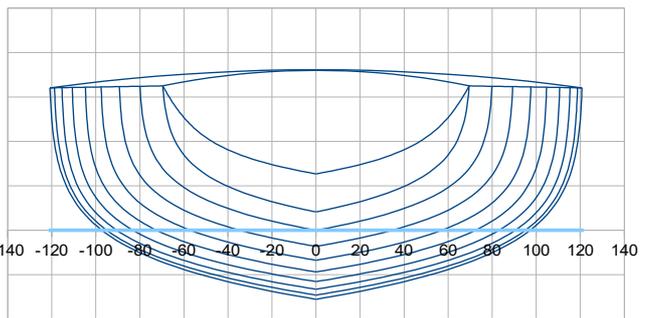
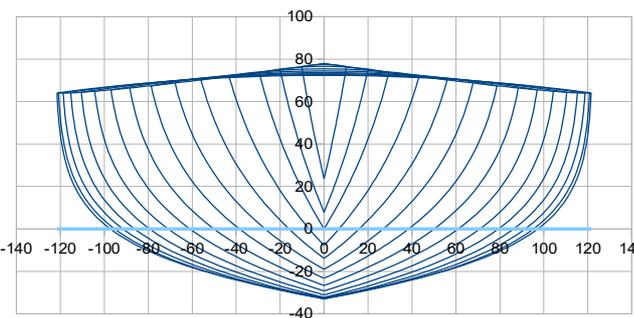
Pui V av ; Pui V ar ; Pui Pui V ; Cor Pui Pui

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

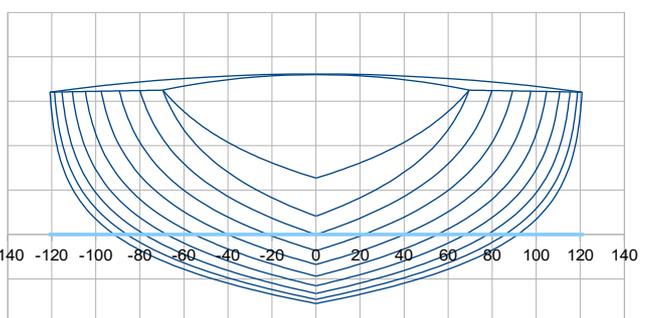
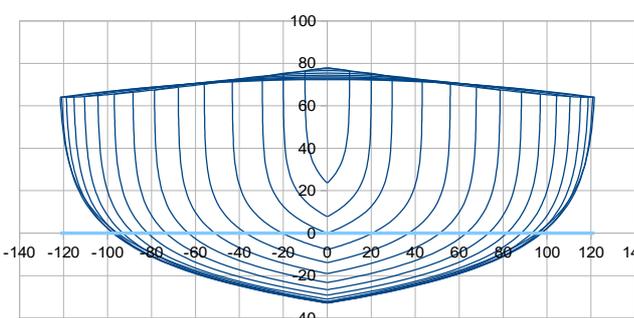
Pui V av = 13 ; Pui V ar = 28 ; Pui Pui V = 1,5 ; Cor Pui Pui = 0,5



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



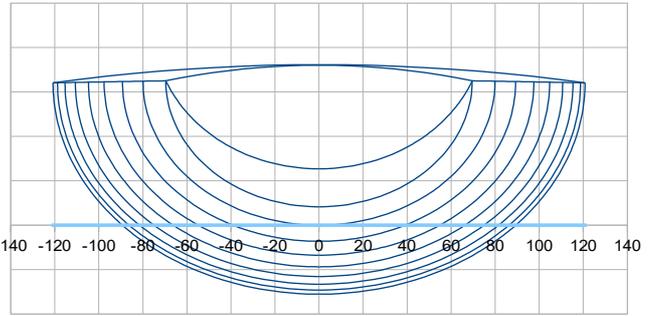
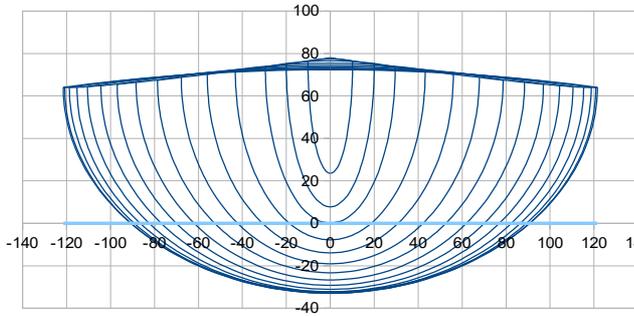
Pui V av = 28 ; Pui V ar = 13 ; Pui Pui V = 1,5 ; Cor Pui Pui = 0,5



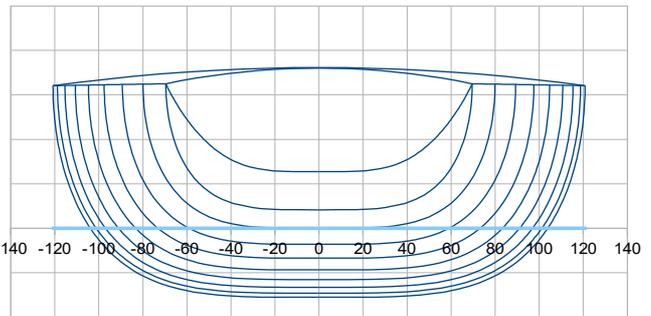
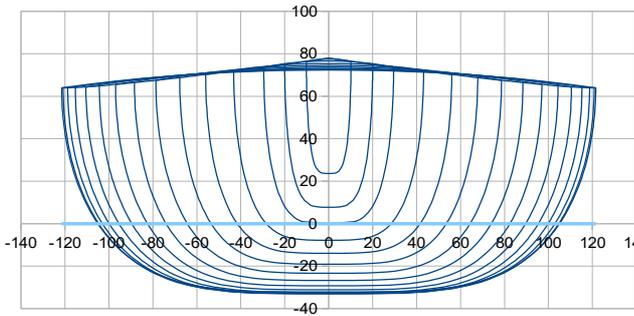
E sections parameter :

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

Pui E = 2

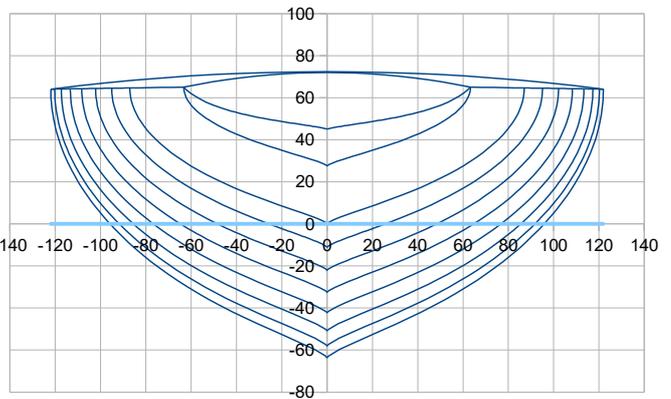
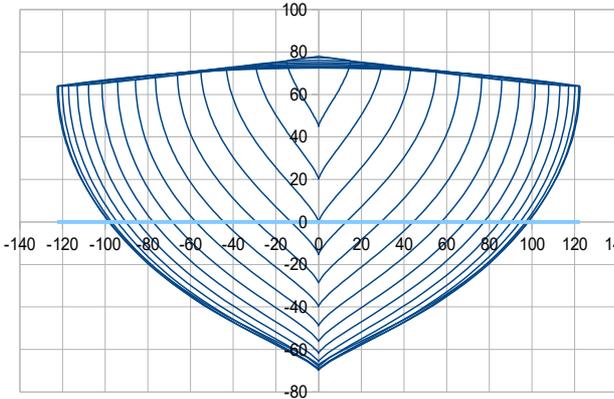
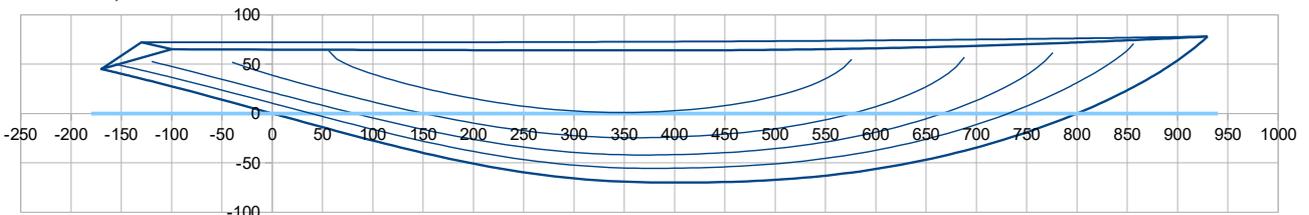


Pui E = 4



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

Pui E = 0,5



V and E sections combination :

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

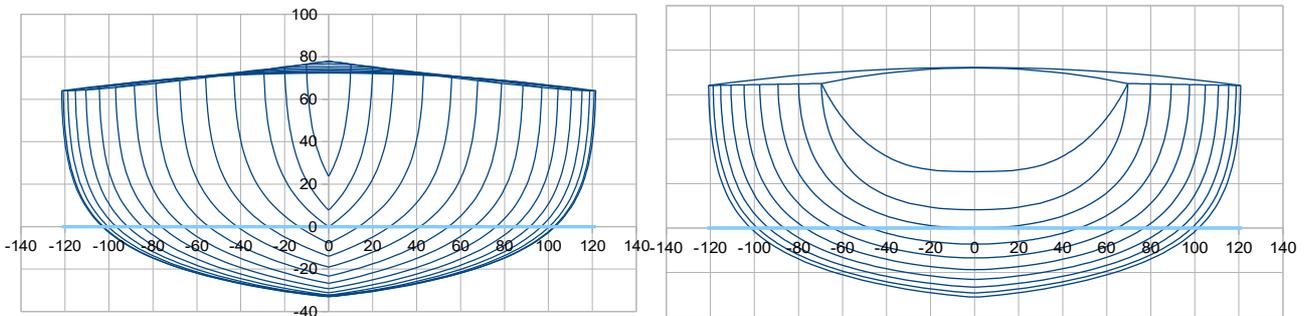
mix VE av ; mix VE ar : adimensionals between 0 to 1. 1 means 100% V shape and 0 means 100% E shape.

mix VE av = 1 and mix VE ar = 0 >>> Evolution from V sections at the front to E sections at the rear of the hull , it is the usual case.

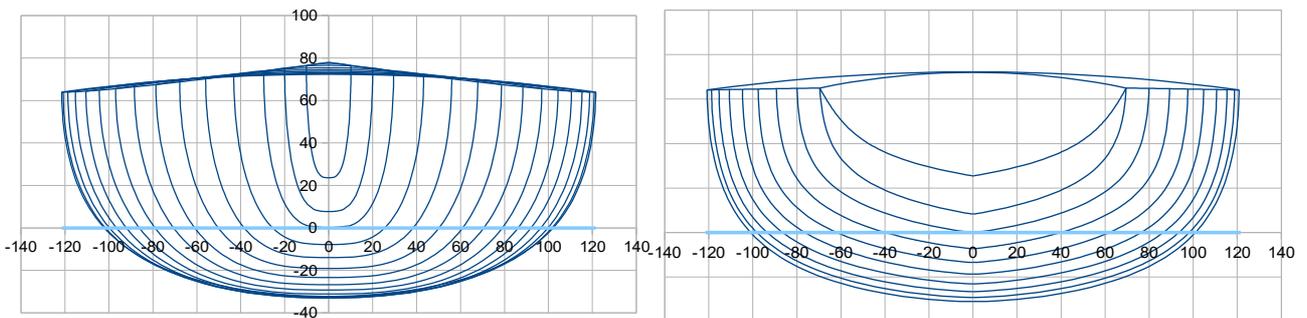
mix VE av = 0 et mix VE ar = 1 >>> It is the exact contrary, evolution from E sections at the front to V sections at the aft of the hull.

Examples :

mix VE av = 1 and mix VE ar = 0 (it is the usual case : V shape in the fore body evolving to E shape in the rear body)



mix VE av = 0 and mix VE ar = 1 (reverse case)



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

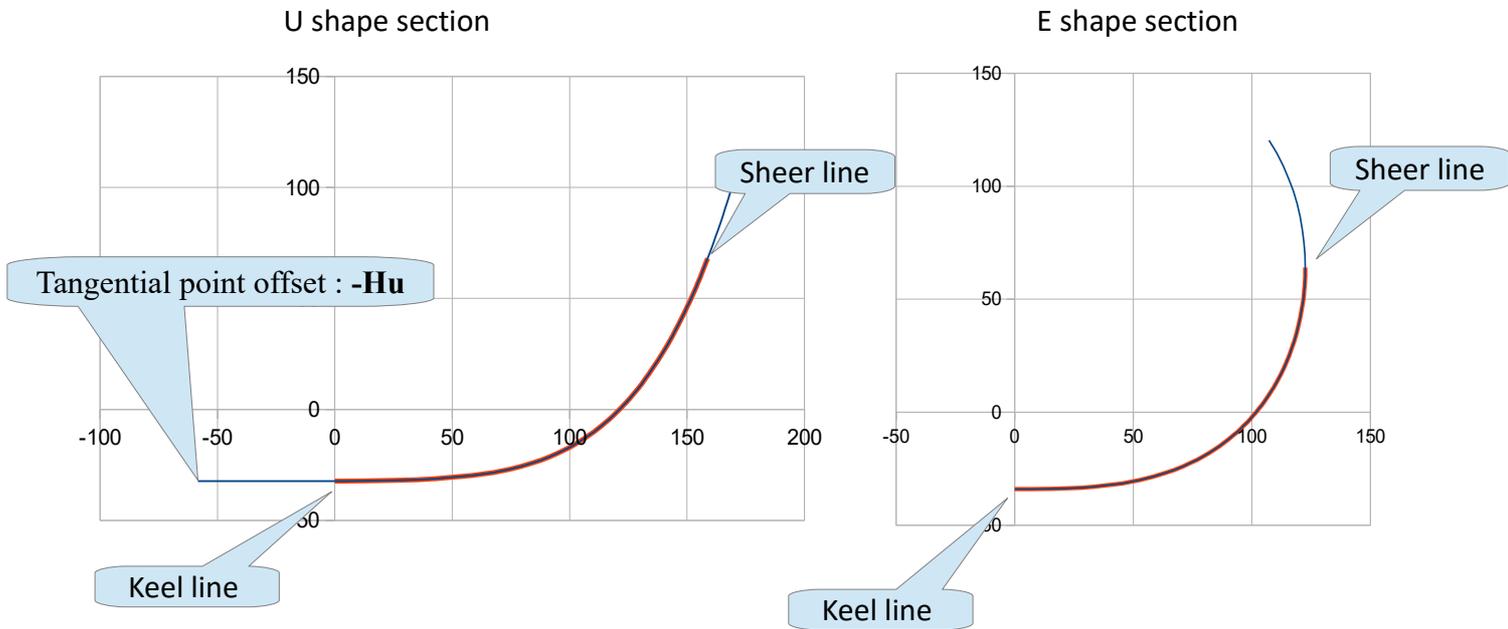
Pui mix VE : adimensional, it is the power of the polynomial function with x from **mix VE av** at front end to **mix VE ar** at rear end of the hull.

UE sections (combination of U and E sections)

For the UE file :

As for VE sections, 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.

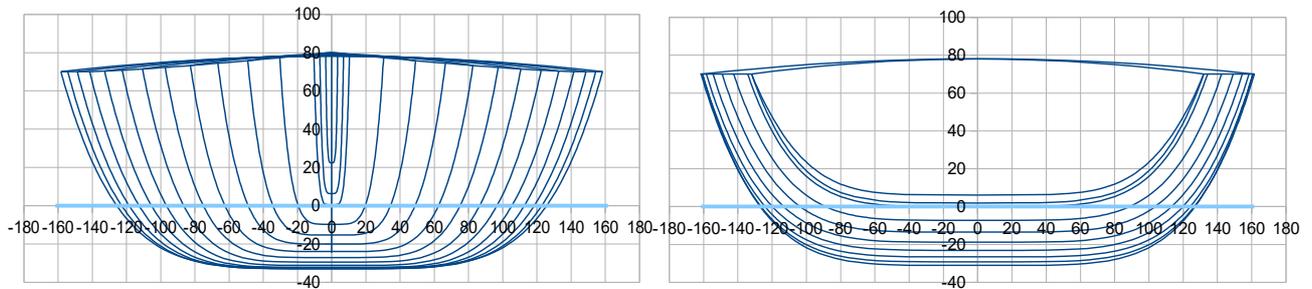


Parameters for U sections :

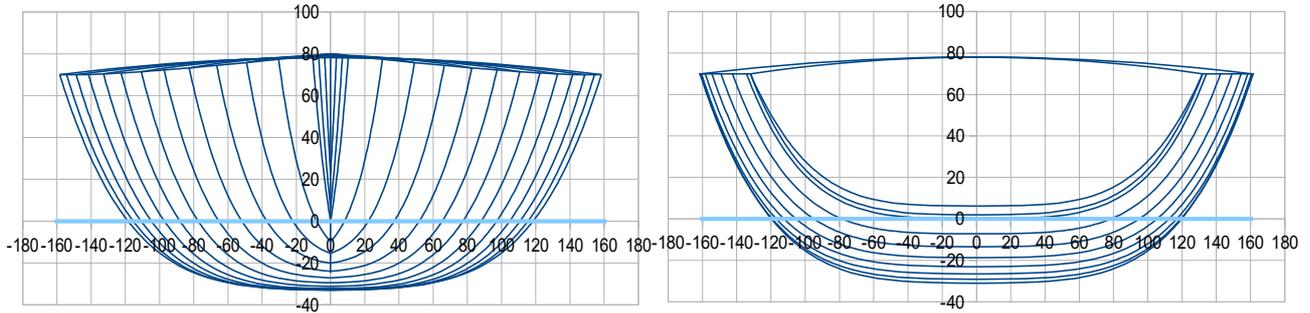
$C_{Hu\ av}$; $C_{Hu\ ar}$; $P_{ui\ Hu}$

These parameters deal with the offset H_u / 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 ≥ 0** . The closer to 0, the more the U flatness is extended. **$P_{ui\ Hu}$** 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) :

$C_{Hu\ av} = 0$; $C_{Hu\ ar} = 0$; $P_{ui\ Hu} = 1$



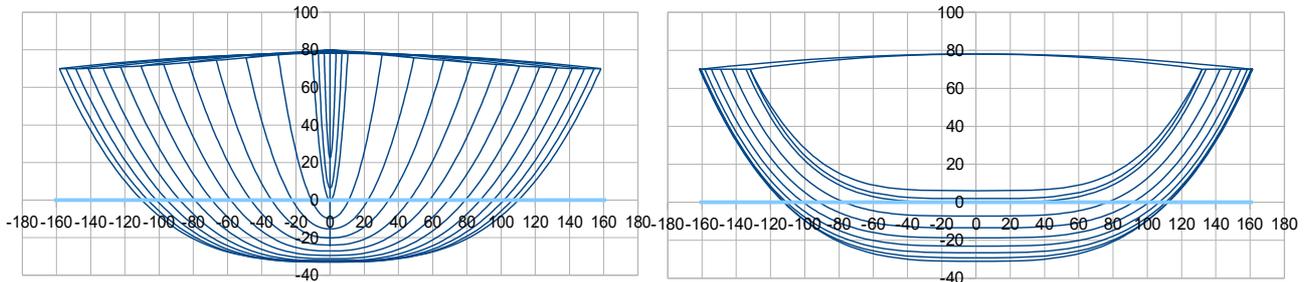
C Hu av = 0,4 ; C Hu ar = 0,16 ; Pui Hu = 1



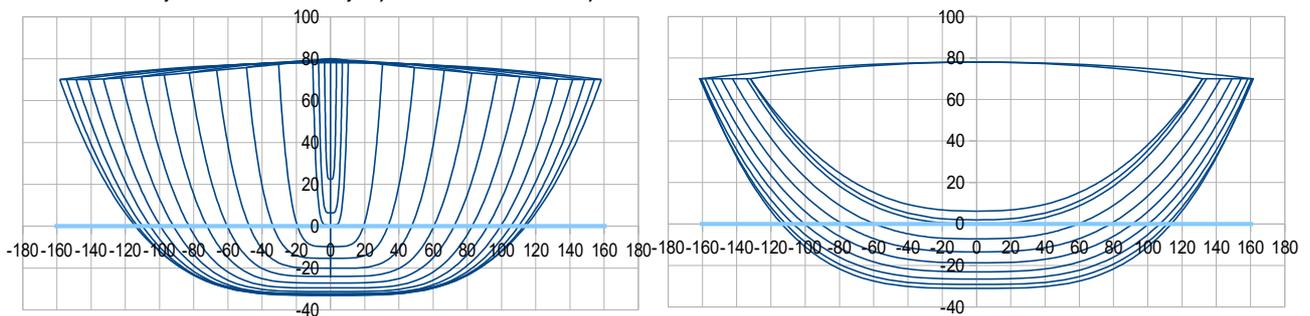
Pui U av ; Pui U ar ; Pui Pui U ; Cor Pui Pui

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) :

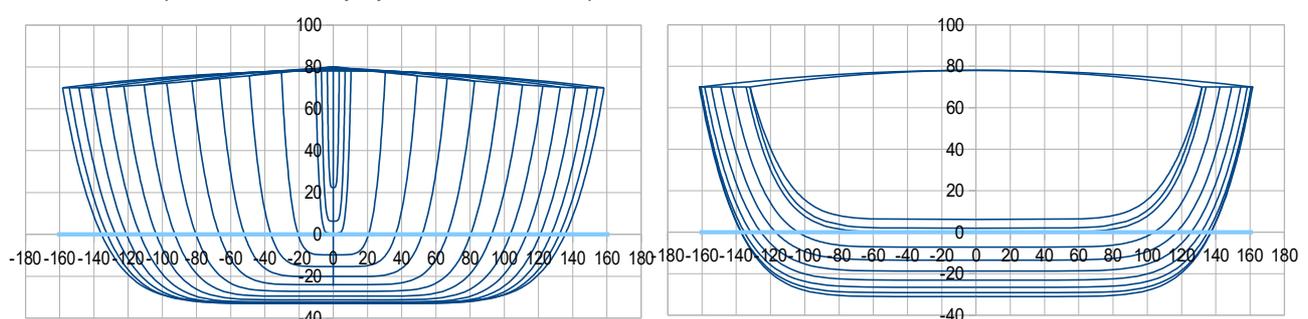
Pui U av = 2 ; Pui U ar = 4 ; Pui Pui U = 1 ; Cor Pui Pui = 0



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



Pui V av = 5 ; Pui V ar = 7,5 ; Pui Pui V = 4 ; Cor Pui Pui = 0



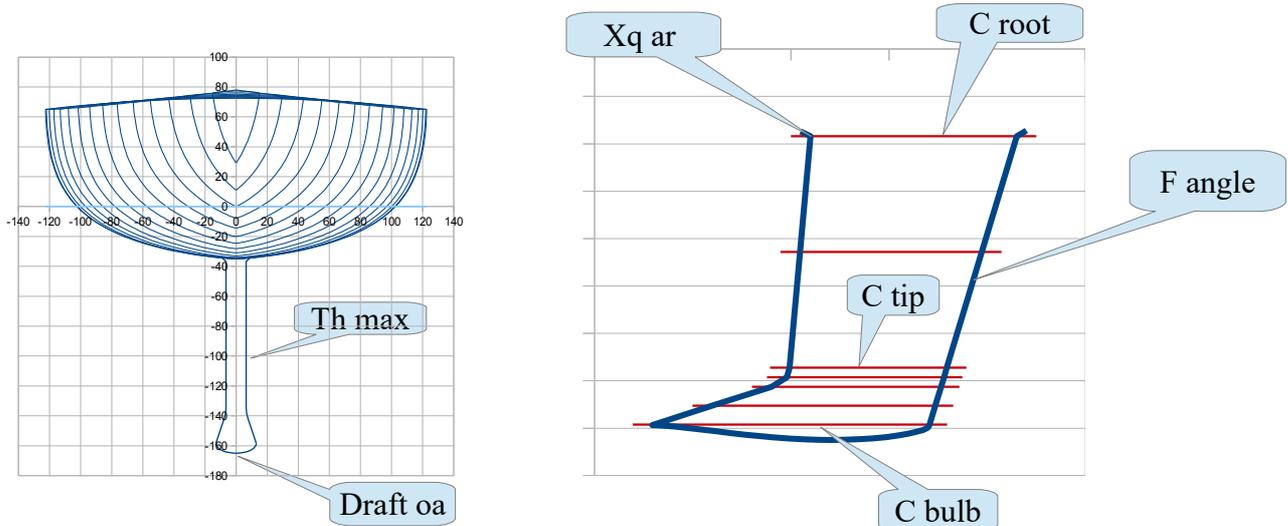
A last recommendation on input data for the hull :

Probably that the use of the polynomial parameters are not 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 very low or high values so to better see the effects, and this « learning by testing » process will help you to progress rapidly.

1.2 Keel data

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



Xq ar (m) : X of the rear upper point

C root (m) : length of the root profile (see Nota herebelow)

C tip (m) : length of the tip profile before enlargement for the bulb

Th max (cm) : Maximum thickness of the profile, constant between C root and C tip.

F angle (°) : leading edge angle / horizontal, usually between 45° and 90°

C bulb (m) : length of the bulb profile

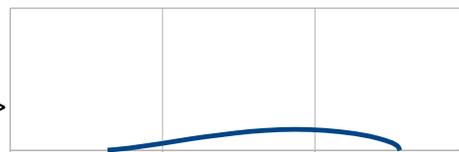
Th bulb (cm) : Maximum thickness of the bulb

Draft oa (m) : draft overall

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

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

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



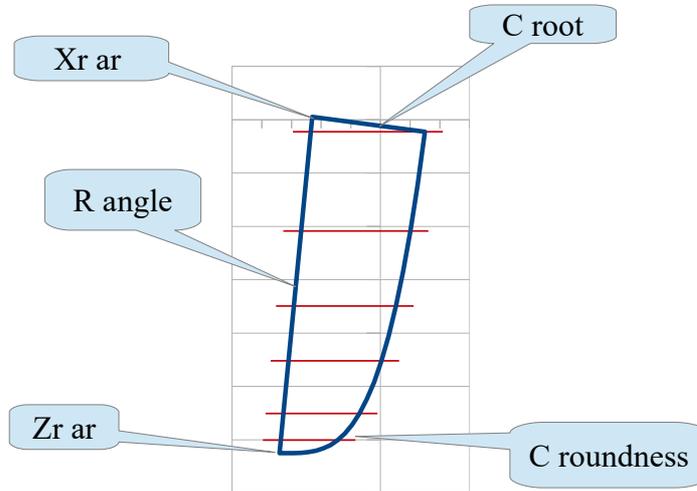
Nota : Profiles are calculated and drawn with a cut-off at 97,5% c so to avoid trailing edges too tapered and unfeasible. Chords Croot, Ctip and C bulb here above are the real lengths taking into account the cut-off, computed chord c being C/0,975.

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

Density bulb : Bulb part, below C tip level.

1.3 Rudder data

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



Xr ar (m) : X of the rear upper point

C root (m) : X length of the upper profile

t/c (%) : relative thickness of the horizontal Naca profiles, constant for the rudder.

R angle (°) : trailing edge / horizontal, usually between 75° to 85°

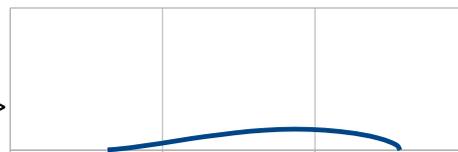
Zr ar (m) : Z of the rear lower point

C roundness : roundness coefficient of the mlower part of the rudder, usually 2,5 to 5,5

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

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

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



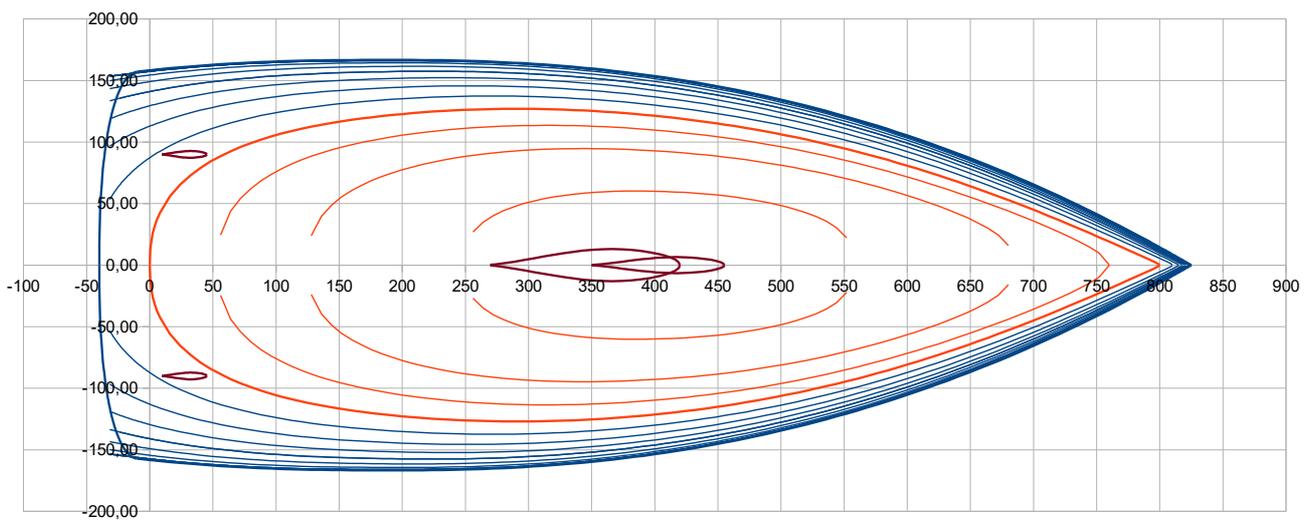
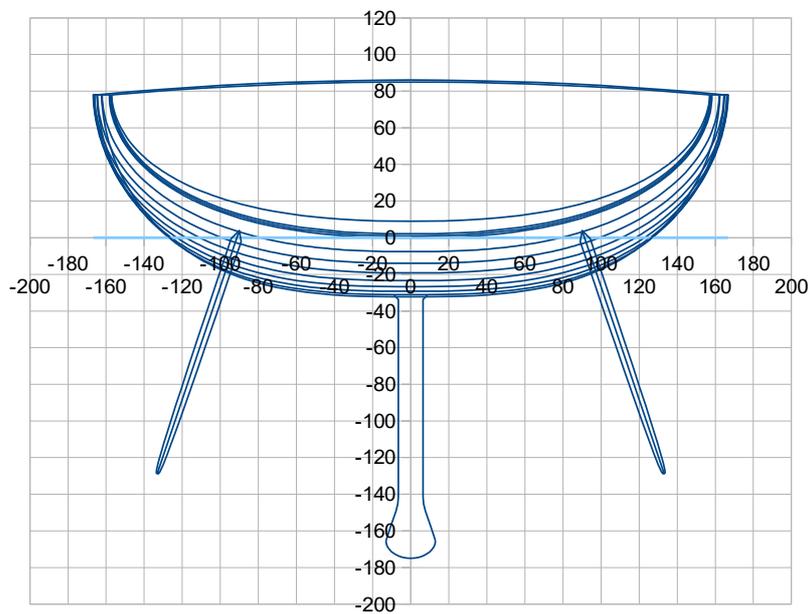
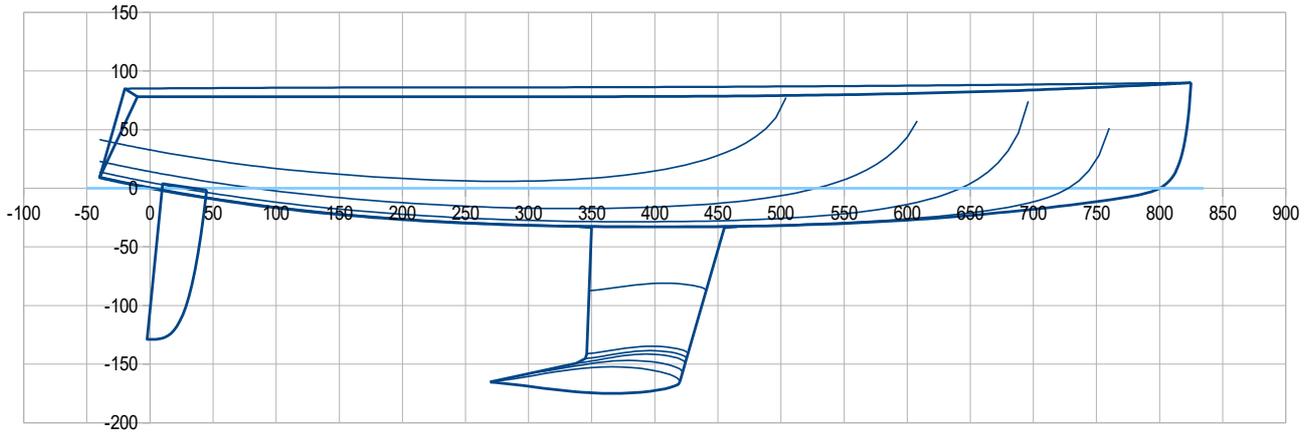
Nota : Profiles are calculated and drawn with a cut-off at 97,5% c so to avoid trailing edges too tapered and unfeasible. Computed chord c are equal to $C/0,975$, C being the geometrical chords.

Nb of rudders : Number of rudders, 1 ou 2

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

Angle (°) : when Nb = 2, angle / vertical of each rudder (put 0 when Nb = 1) .

Example with Nb =2 rudders, Offset y = 0,9 m and angle = 18°



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

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 :

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

... + the curve of the sections areas, for 3 waterlines : $H0$, $H0+3cm$, $H0-3cm$

... + to contribute to the mass balance data :

- S_{hull} (surface of the hull) , its center of gravity position X,Z
- S_{deck} (surface of the deck), its center of gravity position X
- Keel weight and position of the center of gravity X,Z

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

3. The 3 views 2D

The views are automatically redrawn after every input data modification.

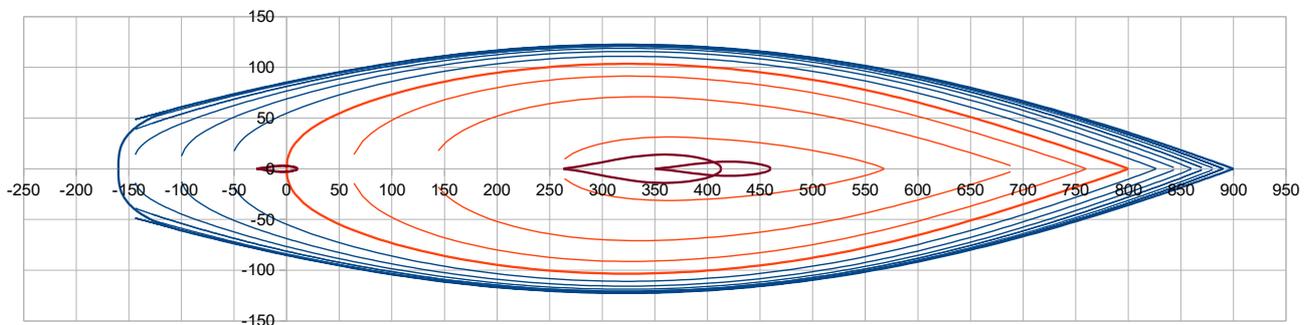
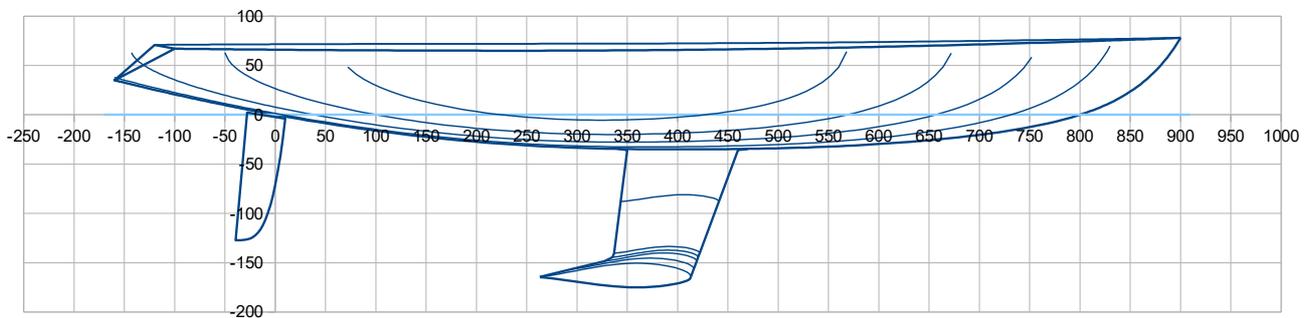
View of the front sections include sections $\geq C4$ (= 40% Lf), with a half section pitch : C4, C4,5, C5, In front of C10 (Front perpendicular), 2 complementary sections Cav1 and Cav2 are drawn, at 1/3 and 2/3 of the bow overlenght.

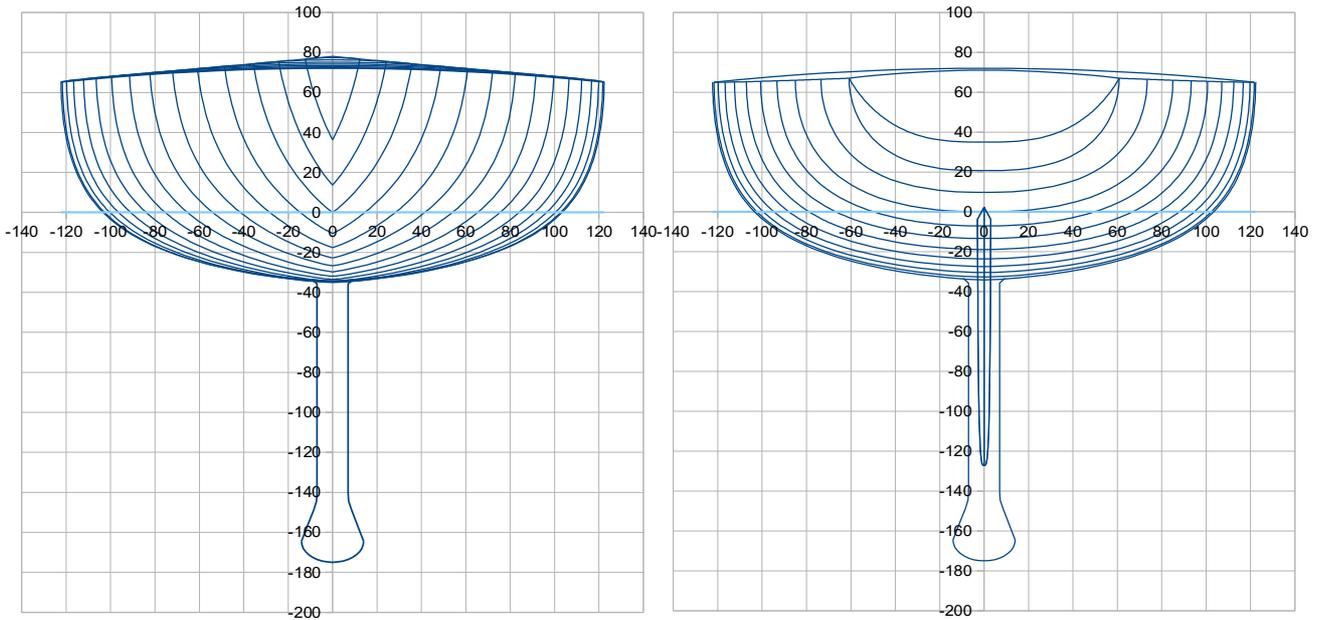
View of the rear sections includes sections $\leq C4$, with a half section pitch : C4, C3,5, C3, C2,5, ... Behind C0, 2 complementary sections Car1 and Car2 are drawn, Car2 at the rear end point of the sheer line and Car1 at the middle point between this rear point and C0. And the rear transom is also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

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 :

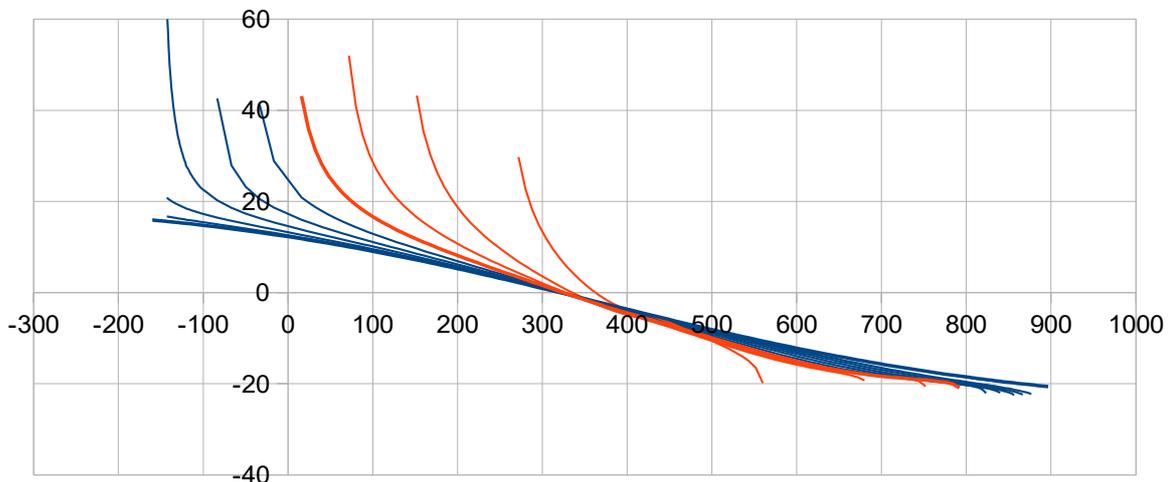
- Waterlines angles in the horizontal plan xy, with the same color code blue/red as for the bottom view.
- Curvature 1/R of :
 - Waterlines and sheer line (in the horizontal plan xy) with idem color code blue/red,
 - Keel line and Buttocks lines (vertical longitudinal cuts) in green, keel line being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

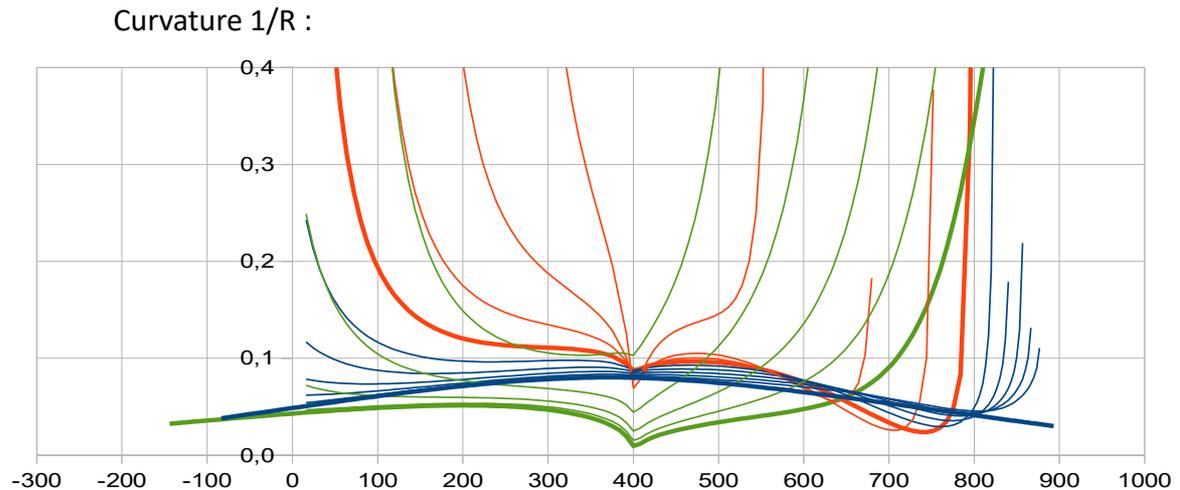
User intervention : As long as the project length is fixed, it is recommended to fix the scale of the X coordinates in the views.

Examples :

Waterlines angles in the horizontal plan xy

- Red : waterlines below H0 (**thick line = H0**)
- Blue : waterlines above H0 (**thick line = 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 and 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 keel, data of the naca profiles in various horizontal sections
- x,z data of the longitudinal profile of the rudder, data of the naca profiles in various horizontal sections

6. Hull with heel

This section is for the computation and drawing of the hull with heel, in hydrostatic condition at constant displacement. The User should introduce 3 data :

- Heel angle ($^{\circ}$) (typically 0 to 30°)
- Height (cm) : the small elevation (few cm) which help maintain constant the hull displacement ;
- Trim ($^{\circ}$) : usually within 0° to -2° , negative value = nose down

>>> the user should iterate on the values of Height and Trim up to :

- obtain the exact equality of the displacement (*Displacement with heel = Displacement with zero Heel at H_0*) and ,
- obtain a given LCB position (*could be to maintain the zero heel LCB if we consider negligible the LCG displacement with small trim*)

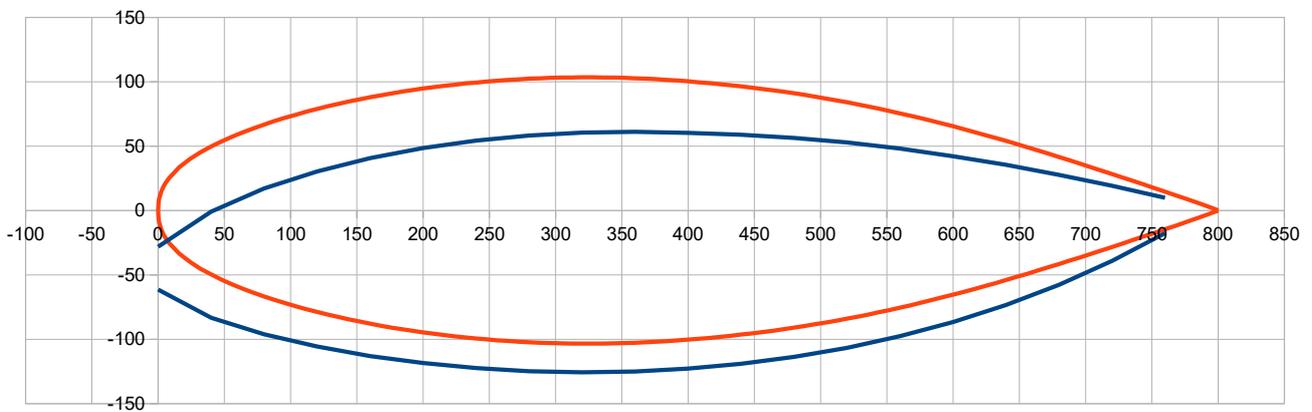
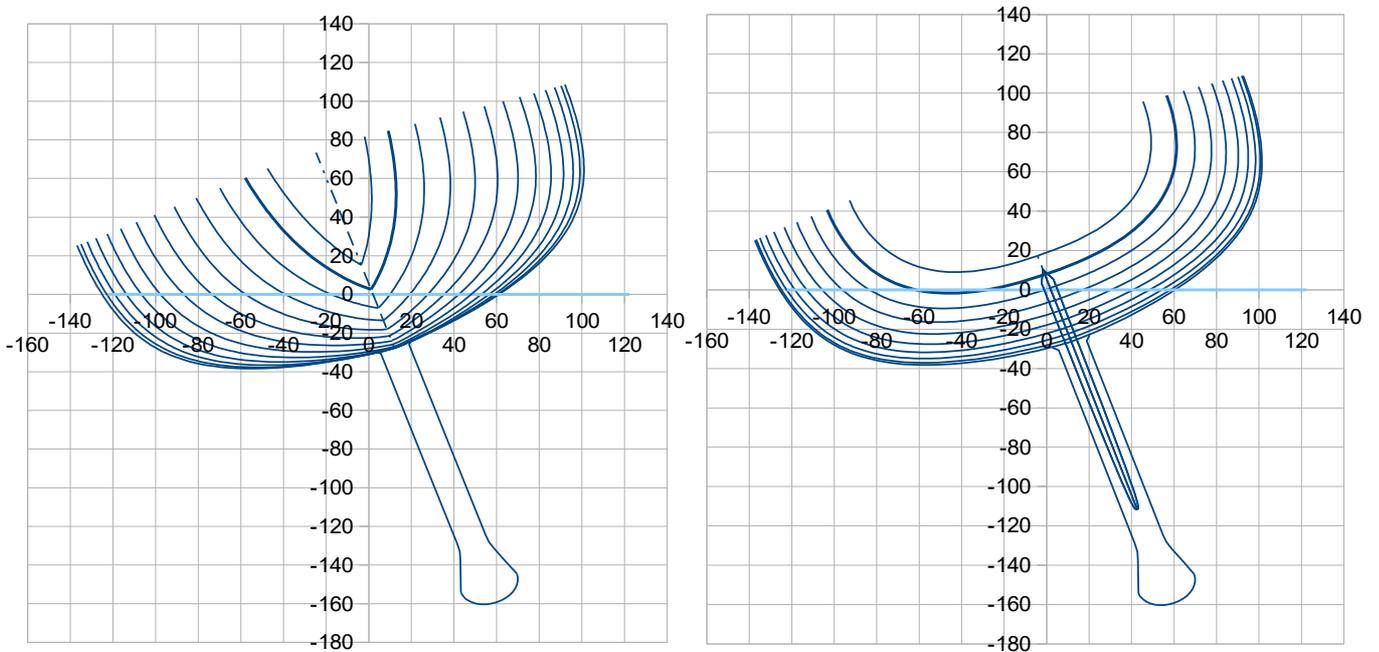
Drawings and results are then automatically produced, including :

- center of buoyancy position and comparison with its initial position,
- righting moment due to the transversal offset of the buoyancy (m4),
- wetted surface and comparison with the one at zero heel,

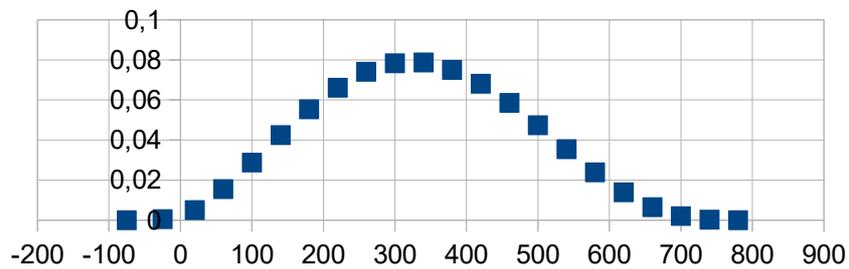
A plot shows the righting moment per volumes inter sections, so that to assess the hull balance with heel.

Example with heel angle = 20° :

Data to enter		Results					
Heel (°)	20,0	Disp. Heel 0°	2,39635	Mom (m4)	0,717	Mom (kN.m)	7,21
Height (cm)	5,8493	> Disp. (m3)	2,39635	/ Xc 0°	3,71	>> Xc 0° - Xc heel° (% Lwl)	0,00
Trim (°)	-0,393	Xc heel (m)	3,71	/ Yc 0°	0,00		
		Yc heel (m)	-0,30	/ Zc 0°	-0,18		
		Zc heel (m)	-0,19	/ Sw 0°	16,85		
		Sw heel (m2)	16,25				



Hull Righting Moment (m4) per volumes inter sections



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

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

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

Example :

Data to enter	x (cm)
>	600,0

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

