Gene-Stab Sailboat 3.5_User Guide

This 3.5 version of Gene-Stab is just the necessary update to take into account the data and the sections formulation of the version 3.5 of Gene-Hull Sailboat, there si no specific change in itself.

Gene-Stab Sailboat 3.5 is a specific file dedicated to the stability issue of a sailboat project generated with « Gene-Hull Sailboat 3.5». It makes possible the computation of the GZ curve up to 180° of heel angle and the information which are deduced, mostly :

- the angle of vanishing stability AVS,
- the stability index STIX,
- the righting energy,
- the positive / negative area ratio under the GZ curve,
- the influence of another Zg (the height of the center of gravity) on these results.

Why a specific module on stability ?

« Gene-Hull Sailboat 3.5 » already provides a stability subroutine which allows the computation of the GZ curve but through manual iterations up to an equilibrium for each heel angle, which makes the construction of the GZ curve very long and laborious to do. In «Gene-Stab », the computation of each equilibrium for each heel angle is done automatically, so that the construction of the GZ curve, from 0° to 180° with a step of 5°, takes only about 10 minutes. The file is not attached as an extra sheet to the Gene-Hull Sailboat file because it would be a too big and complex spreadsheet application to deal with. So it is proposed as a specific file but with using the data coming from Gene-Hull Sailboat through an easy copy/paste process explained in the present User guide. Moreover, it provides a sheet dedicated to the computation of the STIX index.

Together with « Gene-VPP », another detached application using « Gene-Hull Sailboat » data, «Gene-Stab » is an extra tool which completes the toolbox of spreadsheet applications to design and optimise a sailboat project at its early stage.

It is a free and open source speadsheet application, developed on a support itself free and widespread (Open Office Calc, version ≥ 4.0.1) : to open and use an ods file, you have to download Open Office or Libre office according to : http://www.openthefile.net/extension/ods

In the present User Guide, I hope you will find all information necessary to take advantage of the application, as usual an « Examples » document is also proposed to highlight on typical output, and for any questions or improvement requests, you can contact me.

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Summary presentation

The spreasheet application includes 3 sheets :

- Stab
- Hulls storage
- STIX

Stab : includes an User space (input & outputs) followed by an Administrator space (from line 217) where all the computations are carried out. The User space includes the following sections :

Hull data (To **copy/paste** from Gene-Hull file)

Hydrostatics data (To **copy/special paste** from Gene-Hull file)

Stability and Righting Moment with a loading

- Mass spreadsheet with input of a load
- Computation with input of an heel angle

Hulls storage :

Storage of input data

- Hull data
- Hydrostatics data
- Loading

Storage of some output data

STIX : includes an User space (input & outputs) followed by an Administrator space (from line 44) where the computations are carried out. The User space includes the following sections :

Input data

Computation of STIX parameters

Annex 1 : The STIX formulation according to ISO 12217-2 2013

Annex 2 : The areas ratio criteria according to Imoca class rule

Stab sheet / Hull data

To do : a copy/paste, as a whole in one click, of the Hull input data generating a hull within « Gene-Hull Sailboat 3,3 ». Example (with reference boat V1) :

Hull data		feet conversion			
Lenght of waterline :			Type of geometrical data		
Lwl (m)	8,00	26,25	<<< Length		
Maximum draft of the hull body :					
Tc (m)	0,3700	1,21	<<< Height		
X Tc (%Lwl)	50,0				
Hull bow :					
Xbow (m)	9,00	29,53	<<< Length		
Zbow (m)	0,85	2,79	<<< Height		
Shape coefficient of the bow :					
Cet	3,00				
Kbrion	0,00				
Polynomials of the keel line, front part and rear part :					
Pui q av	2,45				
Pui q ar	2,35				
Rear end of the transom :					
X tab ar (m)	-1,30	-4,27	<<< Length		
Z tab ar (m)	0,24	0,79	<<< Height		
Sheer line, in horizontal projection xy :					
Bg (m)	2,199	7,21	<<< width		
X Bg (% Lwl)	43,0				
Alfa (°)	2,00				
Pui liv y	2,00				
Cor Pui liv	0,025				
Pui Cor Pui	2,00				
X liv ar (m)	-0,60	-1,97	<<< Length		
Scow	0,03				
Pui Scow	0,25				
Option Hard Chine line, in vertical projection xz :					
Type	0	Bratio fore			
1,2 Zhc av (m)	0,75	1,00			
2 Zhc m (m)	0,20	Bratio aft			
1,2 Zhc ar (m)	0,42	1,00			
Pui hc z	2				
Sheer line, in vertical projection xz :					
Z liv m (m)	0,72	2,36	<<< Height		
Z liv ar (m)	0,74	2,43	<<< Height		
Deck / central line rear end					
Z p m (m)	0,83	2,72	<<< Height		
X p ar (m)	-0,70	-2,30	<<< Length		
Z p ar (m)	0,78	2,56	<<< Height		
Kroof (%B)	0,0				
Sections :					
	PE1	C PE1	PE2		
Fore	2,000	1,630	1,000		
Mid	3,310	1,000	1,700		
Aft	2,000	1,490	2,800		
Keel data	Inverted L		Inverted T		Without bulb
Type	1	Type	0	Type	0
Xq ar (m)	3,60	Xq ar (m)	3,55	Xq ar (m)	3,45
C root (m)	1,15	C root (m)	1,00	C root (m)	1,20
C tip (m)	0,90	C tip (m)	0,70	C tip (m)	0,90
Th keel (%)	13,50	Th keel (%)	14,64	Th keel (%)	14,68
F angle (°)	70,00	F angle (°)	75,00	F angle (°)	75,00
C bulb (m)	1,55	C bulb (m)	1,815	H ballast (m)	0,3680
Th bulb (cm)	27,60	Th bulb(cm)	26,00		
		Lf bulb(m)	0,47		
Draft oa (m)	1,75	Draft oa (m)	2,00	Draft oa (m)	1,75
naca 00xx	0	naca 00xx	0	naca 00xx	0
naca 63-0xx	1	naca 63-0xx	1	naca 63-0xx	1
naca 65-0xx	0	naca 65-0xx	0	naca 65-0xx	0
Density Wing	7,30	DensityWing	7,30		
Density Bulb	7,30	Density Bulb	7,30	D Ballast	7,30
Rudder data	Suspended		With skeg		
Type	1		0		
Xr ar (m)	-0,28	Xr ar (m)	-0,20		
C root (m)	0,40	C root (m)	0,60		
t/c (%)	15,00	t/c (%)	12,00		
R angle (°)	85,00	R angle (°)	85,00		
L ar (m)	1,30	L ar (m)	1,30		
C roundness	3,50	F angle (°)	75,00		
naca 00xx	0	naca 00xx	1		
naca 63-0xx	1	naca 63-0xx	0		
naca 65-0xx	0	naca 65-0xx	0		
Nb of rudders	1				
Offset y (m)	0,00				
Angle (°)	0,0				

Stab sheet / Hydrostatics data

To do : a copy/special paste (text, number, format), as a whole in one click, of the Hydrostatics data output within « Gene-Hull Sailboat 3,3 ». Example (with reference boat V1) :

2. Data sum-up and results of hydrostatic and surfaces calculations								
2.1 Hull								
Loa (m)	**10,30**	**Lwl (m)**	**8,00**		> Hull speed (Knots)	6,89	at Froude 0,4	
>> ft	*33,79*		*26,25*					
Boa (m)	**2,60**	**at X (% Lwl)**	**38,0**	Bsheer (m)	2,60	at X (% Lwl)	38,0	
>> ft	*8,53*							
Bwl (m)	**2,19**	**at X (% Lwl)**	**40,0**	> Bwl / Boa	0,844			
>> ft	*7,20*				**Freeboards (m) >**	**Aft**	**Midship**	**Fore**
Tc (m)	**0,370**	**at X (%Lwl)**	**50**			**0,74**	**0,72**	**0,85**
>> ft	*1,21*				*>> ft*	*2,43*	*2,36*	*2,79*
Displacement at H0 (m3)		**2,44334**	**at LCB (m)**	**3,765**	**LCB (%Lwl)**	**47,06**	**ZCB (m)**	**-0,130**
	>> lbs	*5521*	*w. seawater*	*1025*	*kg/m3*		*>> ft*	*-0,43*
Cp	**0,545**							
Sf (m2)	**11,85**	**at LCF (m)**	**3,586**	**LCF (%Lwl)**	**44,83**	>>> LCB – LCF (%Lwl)		2,23
>> ft2	*127,51*	*>> ft*	*11,77*					
Angle Freeboard/Half beam		29,1	(°), at section C4 (40% Lwl)			**Half entry angle (°)**	**18,6**	**at 95% Lwl**
Sw (m2)	**12,80**	>Sw/D^(2/3)	7,06					
>> ft2	*137,82*							
Shull (m2)	**29,47**	**at X (m)**	**3,636**	**Z (m)**	**0,093**			
>> ft2	*317,20*	*>> ft*	*11,93*	*>> ft*	*0,30*			
Sdeck (m2)	**20,09**	**at X (m)**	**3,511**	**Z (m)**	**0,79**			
>> ft2	*216,21*	*>> ft*	*11,52*	*>> ft*	*2,59*			
2.2 Keel								
Vol. keel(m3)	**0,14938**	**at X (m)**	**4,019**	**X (%Lwl)**	**50,23**	**Z (m)**	**-1,098**	
		>> ft	*13,18*			*>> ft*	*-3,60*	
Ballast (kg)	**1090,5**	**at X (m)**	**4,019**	**X (%Lwl)**	**50,23**	**Z (m)**	**-1,098**	
>> lbs	*2404*	*>> ft*	*13,18*			*>> ft*	*-3,60*	
Draft oa (m)	**1,75**		**Sw (m2)**	**3,66**		**Sxz (m2)**	**1,36**	
>> ft	*5,74*		*>> ft2*	*39,45*		*>> ft2*	*14,61*	
CLR (m)	**4,34**	**CLR (%Lwl)**	**54,23**	*CLR = Center of Lateral Resistance*				
>> ft	*14,23*	method: keel profile extended to the waterline, CLR at Z 45% draft and					25,00	% chord
2.3 Rudder(s)								
Number	**1**							
Volume (m3)	**0,01486**	**at X (m)**	**-0,12**	**X (%Lwl)**	**-1,47**	**Z (m)**	**-0,54**	
Sw (m2)	**0,91**	*>> ft*	*-0,39*			**Sxz (m2)**	**0,44**	per rudder
>> ft2	*9,80*					*>> ft2*	*4,71*	
2.4 Hull + Keel + Rudder(s)								
Displacement at H0 (m3)		**2,60757**	**at LCB (m)**	**3,757**	**LCB (%Lwl)**	**46,96**	**at ZCB (m)**	**-0,188**
	(kg)	**2673**	*>> ft*	*12,33*			*>> ft*	*-0,62*
	>> lbs	*5892*						
, of wich Ballast (kg)		**1090**	**at Xg (m)**	**4,019**	**Xg (%Lwl)**	**50,23**	**at Zg (m)**	**-1,098**
	>> lbs	*2404*	*>> ft*	*13,18*			*>> ft*	*-3,60*
	>> % Ballast	40,8						
	Sw (m2)	**17,38**	>Sw/D^(2/3)	9,17	Lwl/D^(1/3)	5,81		
	>> ft2	*187,07*			***DLR***	***145***	*M(lbs/2240)/(Lwl(ft)/100)^3*	
2.5 Data from the mass spreadsheet								
Light boat:	**M (kg)**	**2673**	**at Xg (m)**	**3,782**	**Xg (%Lwl)**	**47,28**	**at Zg (m)**	**-0,078**

This copy/special paste hould include the **2.5 Data from the mass spreadsheet** , which are exactly the Mass, Xg and Zg of the light weight boat, being of course also involved in the following.

These two blocks of input data for « Stab » can also be stored at such in « Hulls storage ».

Stab sheet / Stability and Righting Moment with a loading

Mass spreadsheet with input of a load

The format of this sub-section is exactly the same as the one in « Gene-Hull Sailboat 3.5 ». The data of the light weight boat (Mass and X,Y,Z) are there automatically recopied from the line 2.5 mentioned here before. **The user has just to input the mass and X,Y,Z of the loading :**

- **For the stability issue, we recommend to put Y = 0 even for the so-called « Crew sit windward » case**, meaning that you investigate the GZ value up to 180° with all masses centred.
- If your goal is the knowledge of the righting moment RM for the usual sailing condition, meaning heel angles in the 0°- 30° range, then you can input an Y representative of the Crew position when sit windward.

Example (for reference boat V1), the data to input are in the yellow cells :

Mass spreadsheet with input of a load					
	Mass	Xg	Zg	Yg	(in the coordinates of the 2D
Data to enter : yellow cells	(kg)	(m)	(m)	(m)	
Boat light weight (kg)	*2672,61*	*3,782*	*-0,078*	*0*	*from the mass spreadsheet*
Load (kg)	300,00	2,00	0,85	0,00	Crew at center
			0,85	0,00	Crew sit windward
Total >>> Mass (kg)	2972,61	3,602	0,015	0,000	Crew at center
Disp. (m3)	2,90011		0,015	0,000	Crew sit windward

Computation with the input of an heel angle

The format of this sub-section is also exactly the same as the one in « Gene-Hull Sailboat 3,3 », but now **the User has to input only an heel angle and the equilibrium is automatically computed**, i.e. the height and and the trim are output.

Example with the input of heel = 20° (for reference boat V1) :

Data to enter : yellow cell		Results			
Heel (°)	20	Disp. (m3)	2,90012	/ Disp. (m3)	2,90011
> Height (cm)	3,2962	Xc heel (m)	3,602	/ Xg (m)	3,602
> Trim (°)	0,166	Yc heel (m)	-0,328	Yg heel (m)	-0,005
		Zc heel (m)	-0,195	> GZ (m)	0,323
		Sw heel(m2)	17,53	RM (kN.m)	9,414
		Bwl heel (m)	2,04	FB mini (cm)	26,2
		LCB – LCF (%Lwl)	0,80	Obliquity (°)	2,7
Check % convergence					
0,00	*: Disp*				
0,00	*: X*	*Kvol. :*	*1,000*		

Specific results			
Relevant only when heel = 0°		DLR	179
Lwl (m)	7,73	Z fore (cm)	4,5
Bwl (m)	2,04	Z aft (cm)	2,2
Tc (m)	0,34	Trim (°)	0,17
Cp Hull	0,568	LCB Hull (%)	44,91
Relevant only when heel = 1°			
Yg heel (m)	-0,005	with crew at center	
Gz (m)	0,323		
> GM1° (m)	0,94		

The results includes the GZ value which is here the core output data for the stability issue, when the heel angle is investigated up to 180°. The other output values (Righting Moment RM, Wetted surface Sw, …) are helpful and relevant only for the usual sailing condition (up to 30° , when the sheer line is not yet in the water) .

The convergence accuracy of the automatical computation is checked through the comparison of the reference values :

Displacement computed / Displacement from the loading case
Xc / Xg

, and evaluated through % of the deviations, here in the example the convergence is very high :

Check % convergence	
0,00	*: Disp*
0,00	*: X*

Kvol. is the fraction of keel volume still in the water :

1 = all the keel is still immerged in the water
0 = all the keel is out of the water
a figure between 1 and 0 indicates the fraction of keel volume still in the water

The process to build the GZ curve up to 180° of heel

After the copy/paste of the 2 blocks of data and the input of the loading, you are ready to start this process. But before, just a last point : the complete building of the GZ curve means that beyond a certain heel angle, the deck and its various protuberances or recesses are in the water and so involved in the computation. Protuberances are typically the ones bring by a roof, recesses the ones bring by a cockpit. Here, for a first approach consistent with an early stage project, one can assume that these volumes in plus or in less roughly compensate, and that the computation with a flush deck is an average significant enough. **To put the hull with a flush deck** means that you neutralize the roof volume in the input data, through **input Kroof (%B) = 0 (in Cell B53).**

Kroof (%B)	**0,0**

(That said, if you estimate that assumption too conservative, you can do another process with a dose of extra volume in the form of a roof (e.g. Kroof = 29 in the example with boat V1) and see the difference, we will highlight on that alternative here after).

The process is to compute the GZ from heel = 0° to 180° with a step of 5° , and fulfill a pre set table with the results for each heel, as detailed here below with an example :

** Start : to input heel = 0 in yellow cell B153 :

Data to enter : yellow cell		Results			
Heel (°)	**0**	**Disp. (m3)**	**2,90011**	**/ Disp. (m3)**	**2,90011**
> Height (cm)	-2,1573	**Xc heel (m)**	**3,602**	**/ Xg (m)**	**3,602**
> Trim (°)	0,520	Yc heel (m)	0,000	Yg heel (m)	0,000
		Zc heel (m)	-0,190	**> GZ (m)**	**0,000**
		Sw heel(m2)	**18,25**	**RM (kN.m)**	**0,000**
		Bwl heel (m)	**2,25**	**FB mini (cm)**	**67,5**
		LCB – LCF (%Lwl)	**2,06**	**Obliquity (°)**	**0,0**

** On the right side (cells L149 to N149), the heel, trim and GZ data are automatically recopied :

Heel (°)	Trim (°)	GZ (m)	Recopy of the equilibrium data
0,00	0,520	0,000	<<< to copy-special paste (Number, Format) in GZ table

** You copy/special paste (numbers,formats) the 3 data in order to fulfill the table below :

GZ data storage (by copy/special paste)

Heel (°)	**Trim (°)**	**GZ (m)**
0,00	0,520	0,000

** Next step, to input heel =5 in yellow cell B153 :

Data to enter : yellow cell		**Results**			
Heel (°)	**5**	**Disp. (m3)**	**2,90011**	**/ Disp. (m3)**	**2,90011**
> Height (cm)	-1,8072	**Xc heel (m)**	**3,602**	**/ Xg (m)**	**3,602**
> Trim (°)	0,497	Yc heel (m)	-0,092	Yg heel (m)	-0,001
		Zc heel (m)	-0,191	**> GZ (m)**	**0,090**
		Sw heel(m2)	**18,18**	**RM (kN.m)**	**2,632**
		Bwl heel (m)	**2,23**	**FB mini (cm)**	**57,3**
		LCB – LCF (%Lwl)	**1,96**	**Obliquity (°)**	**0,7**

** On the right side, the heel, trim and GZ data are automatically recopied :

Heel (°)	Trim (°)	GZ (m)	Recopy of the equilibrium data
5,00	0,497	0,090	<<< to copy-special paste (Number, Format) in GZ table

** You copy/special paste (numbers,formats) the 3 data in order to fulfill the table below :

GZ data storage (by copy/special paste)

Heel (°)	**Trim (°)**	**GZ (m)**
0,00	0,520	0,000
5,00	0,497	0,090

** Next steps, ... same with heel = 10 , 15, ... up to 180 by step of 5, at the end of this process you have completed the Trim & GZ table :

...... / ......

GZ data storage (by copy/special paste)

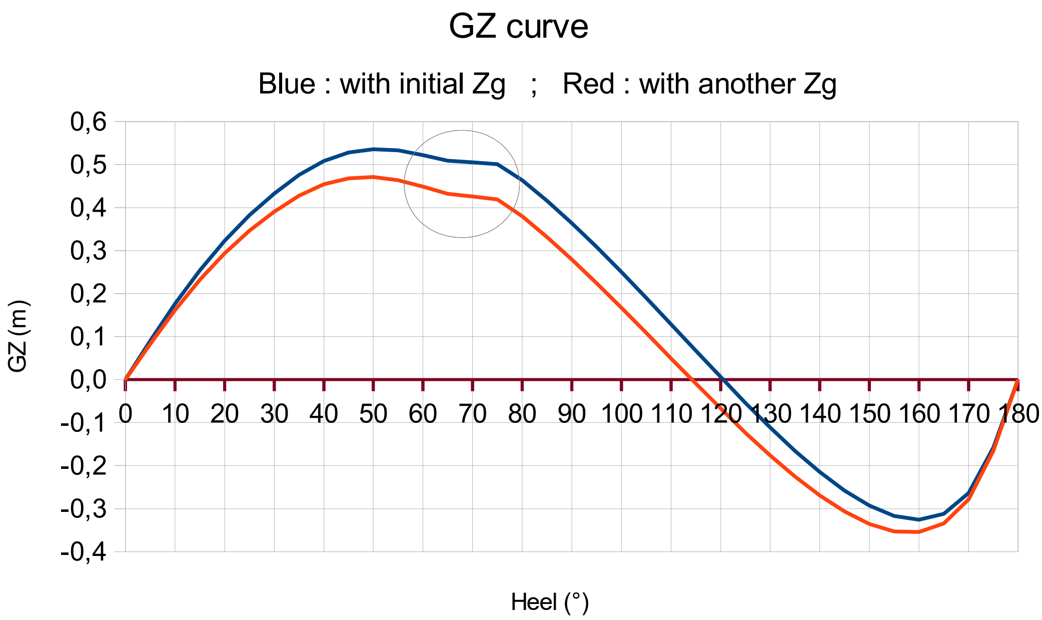
Heel (°)	Trim (°)	GZ (m)
0,00	0,520	0,000
5,00	0,497	0,090
10,00	0,430	0,176
15,00	0,320	0,254
20,00	0,166	0,323
25,00	-0,029	0,382
30,00	-0,261	0,433
35,00	-0,521	0,476
40,00	-0,789	0,509
45,00	-1,052	0,528
50,00	-1,301	0,536
55,00	-1,516	0,533
60,00	-1,692	0,522
65,00	-1,833	0,509
70,00	-1,928	0,505
75,00	-2,006	0,501
80,00	-2,071	0,463
85,00	-2,100	0,416
90,00	-2,101	0,364
95,00	-2,080	0,308
100,00	-2,031	0,250
105,00	-1,958	0,190
110,00	-1,860	0,129
115,00	-1,739	0,067
120,00	-1,596	0,006
125,00	-1,436	-0,054
130,00	-1,255	-0,111
135,00	-1,064	-0,166
140,00	-0,863	-0,215
145,00	-0,656	-0,258
150,00	-0,448	-0,293
155,00	-0,244	-0,317
160,00	-0,058	-0,326
165,00	0,103	-0,312
170,00	0,218	-0,264
175,00	0,258	-0,158
180,00	0,255	0,000
		AVS (°)
		120,51
		Areas ratio
		3,43

At the lower end of the table, the angle of vanishing stability AVS is automatically computed as well as the positive/negative areas ratio under the GZ curve. Here, in this example :

AVS = 120,51°

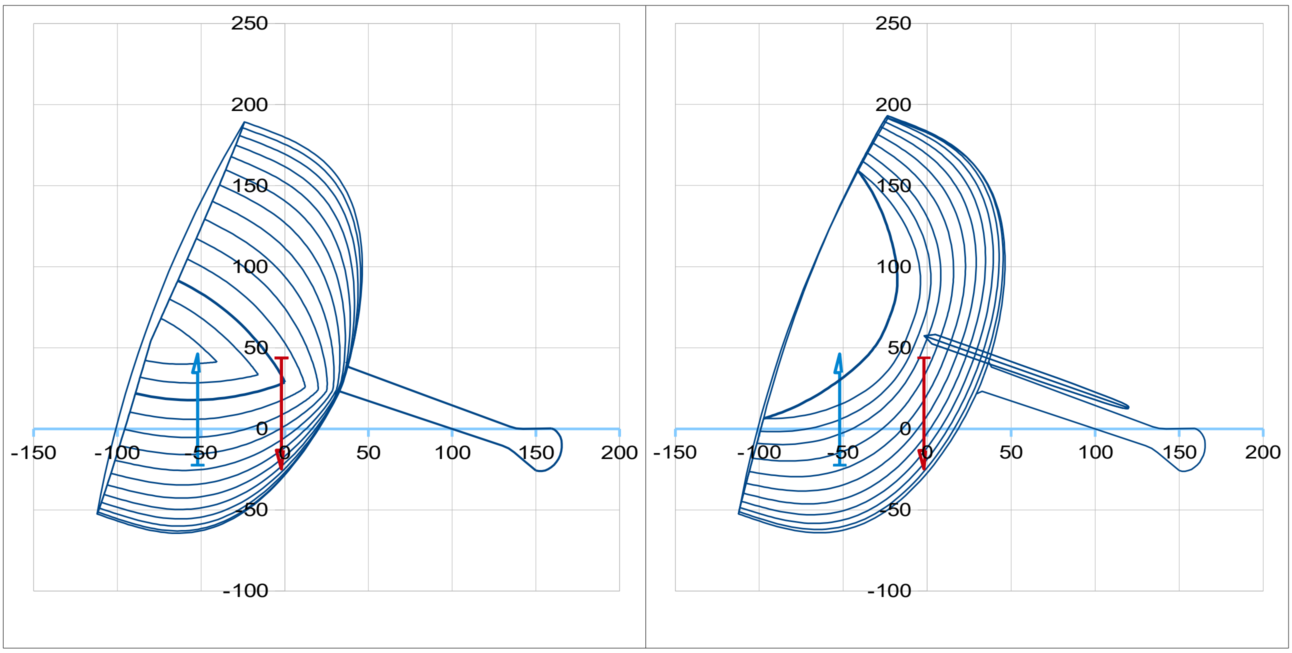
Areas ratio = 3,43

>>> The GZ curve is output (on the right side of the sheet) **:**



The blue curve is the GZ curve corresponding to the table here above.

The irregularity one can observed for heel angle ~ 60° to 80° is not a numerical problem, it is due to the progessive emergence of the keel volume which gives a slight rebound to the GZ curve. For example, the configuration at 70° where the keel is partly out the water (Kvol. = 0,351) :



The red curve is a variant of the GZ curve automatically produced with **another vertical position Zg of the total mass Zg, that you can input in cell P 152**. Example, here Zg = 0,100 m is tested, to compare with the value Zg = 0,015 m which results from the mass spreadsheet with load :

With another Zg
0,100

This option is proposed because 1) at the early stage, you can be uncertain on the exact value of Zg resulting from the preliminary mass spreadsheet with loading, and 2) it is easy to do because there is no need to re build the GZ curve step by step, as the new curve can be automatically deduced from the previous one through :

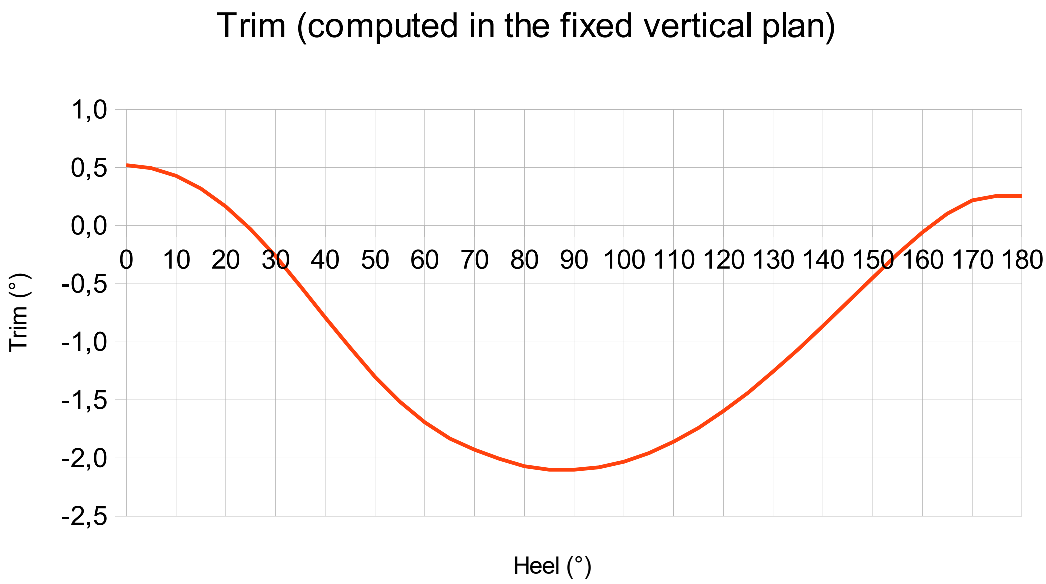
$$GZ (Zg, heel) = Gz (Zgo, heel) – (Zg – Zgo) * \sin (heel)$$

So by introducing another Zg , a new table of values for GZ is automatically output, inc. a new AVS and a new areas ratio, and showed as the red curve in the above GZ curve :

With another Zg	
0,100	< to input
GZ (m)	
0,000	
0,083	
0,161	
0,232	
0,294	
0,346	
0,390	
0,427	
0,454	
0,468	
0,471	
0,464	
0,449	
0,432	
0,426	
0,419	
0,380	
0,332	
0,279	
0,224	
0,167	
0,109	
0,049	
-0,009	
-0,067	
-0,123	
-0,176	
-0,225	
-0,269	
-0,307	
-0,335	
-0,353	
-0,355	
-0,334	
-0,278	
-0,165	
0,000	
AVS (°)	
114,20	
Areas ratio	
2,37	

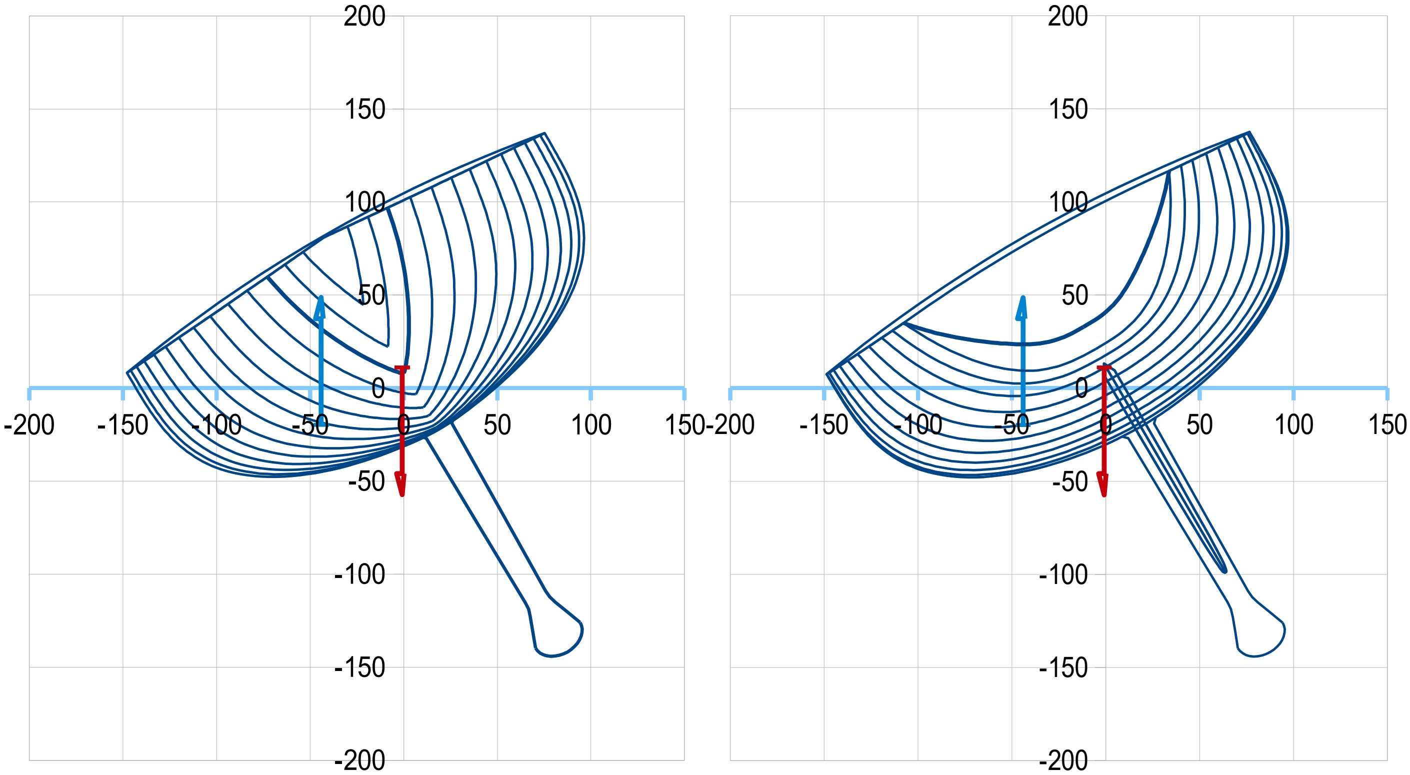
A higher Zg (0,100 istead of 0,015 m) logically gives a lower AVS (here 114,20° instead of 120,51°) and a lower areas ratio (2,37 instead of 3,43), highlighting the importance of this data for the stability issues.

>>> The Trim curve is also output :



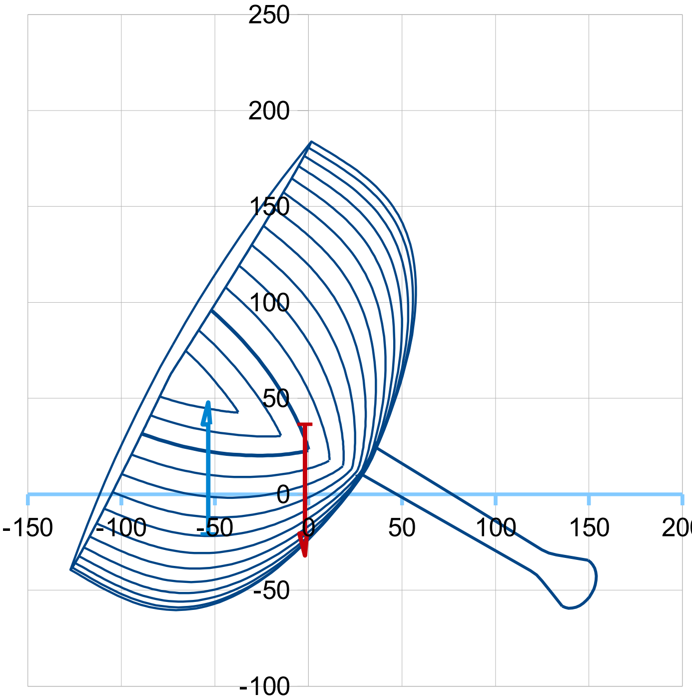
The hull fore and aft stations are shown for each heel angle. Some examples :

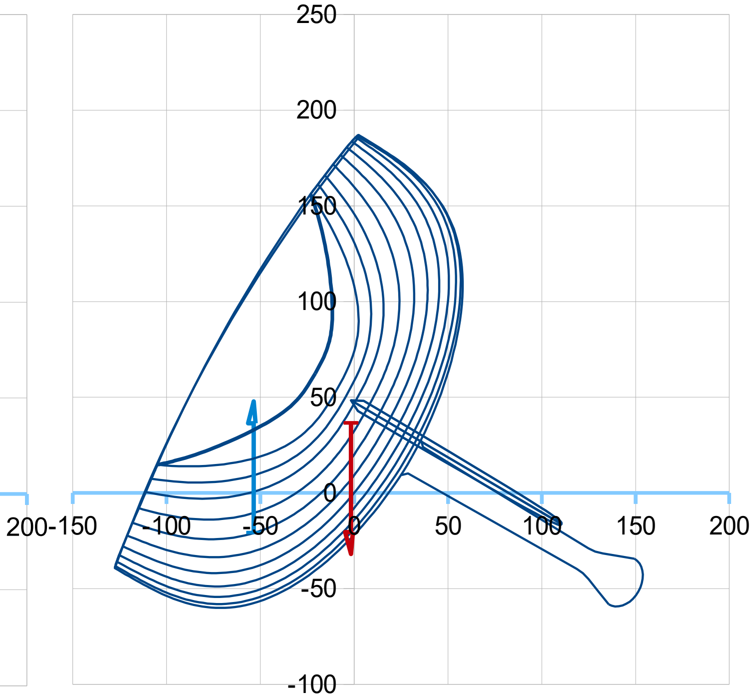
At heel 30° >>> GZ = 0,433 m The usual limit of normal sailing condition



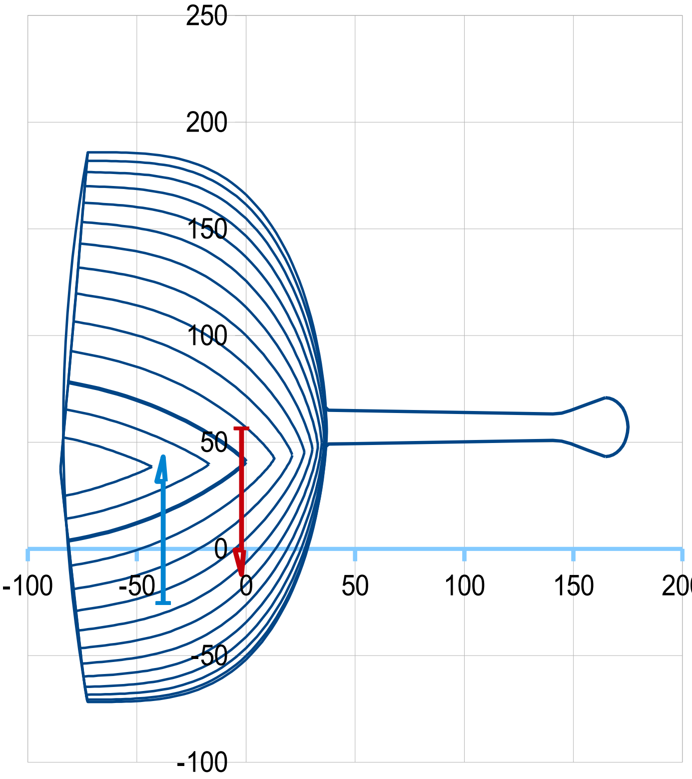
At heel 60° >>> GZ = 0,522 m

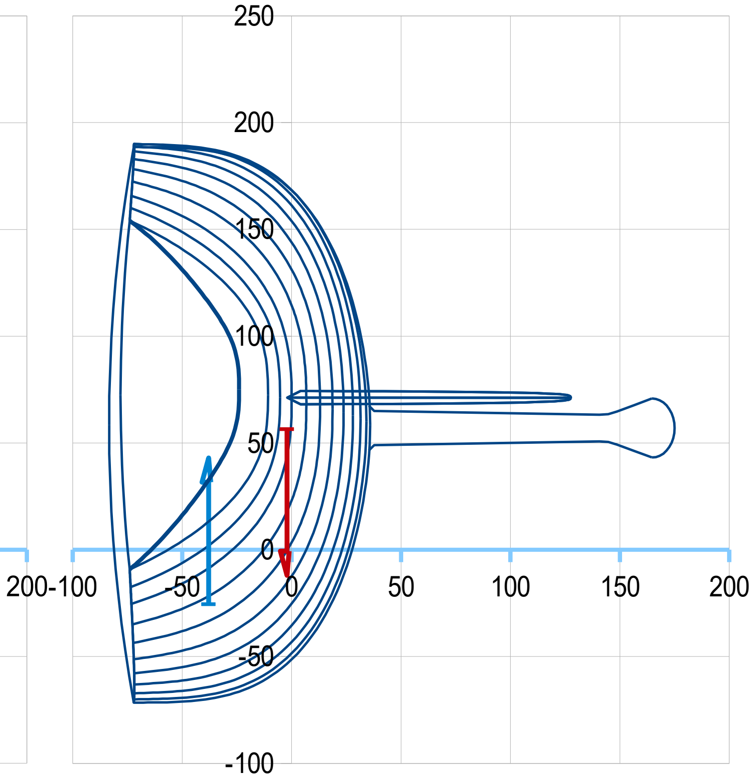
At this angle, a cabin roof and/or a cockpit recess are not yet involved usually. On the other hand, the keel usually begins to emerge.



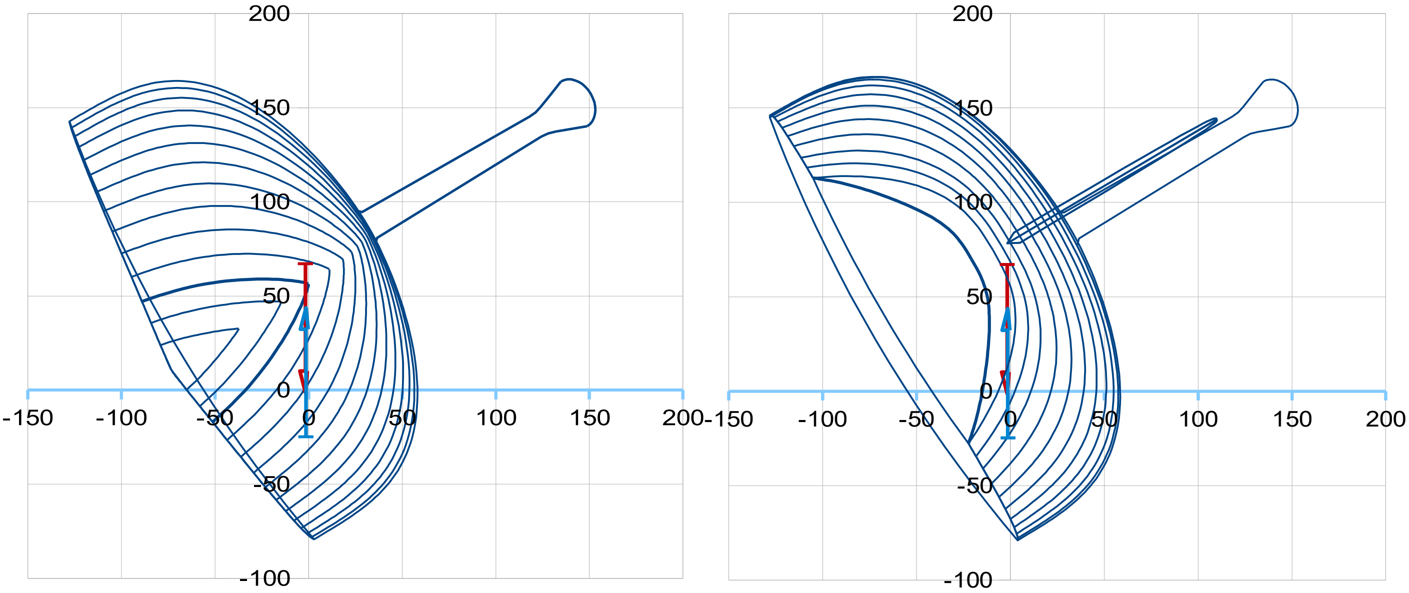


At heel 90° >>> GZ = 0,364 m

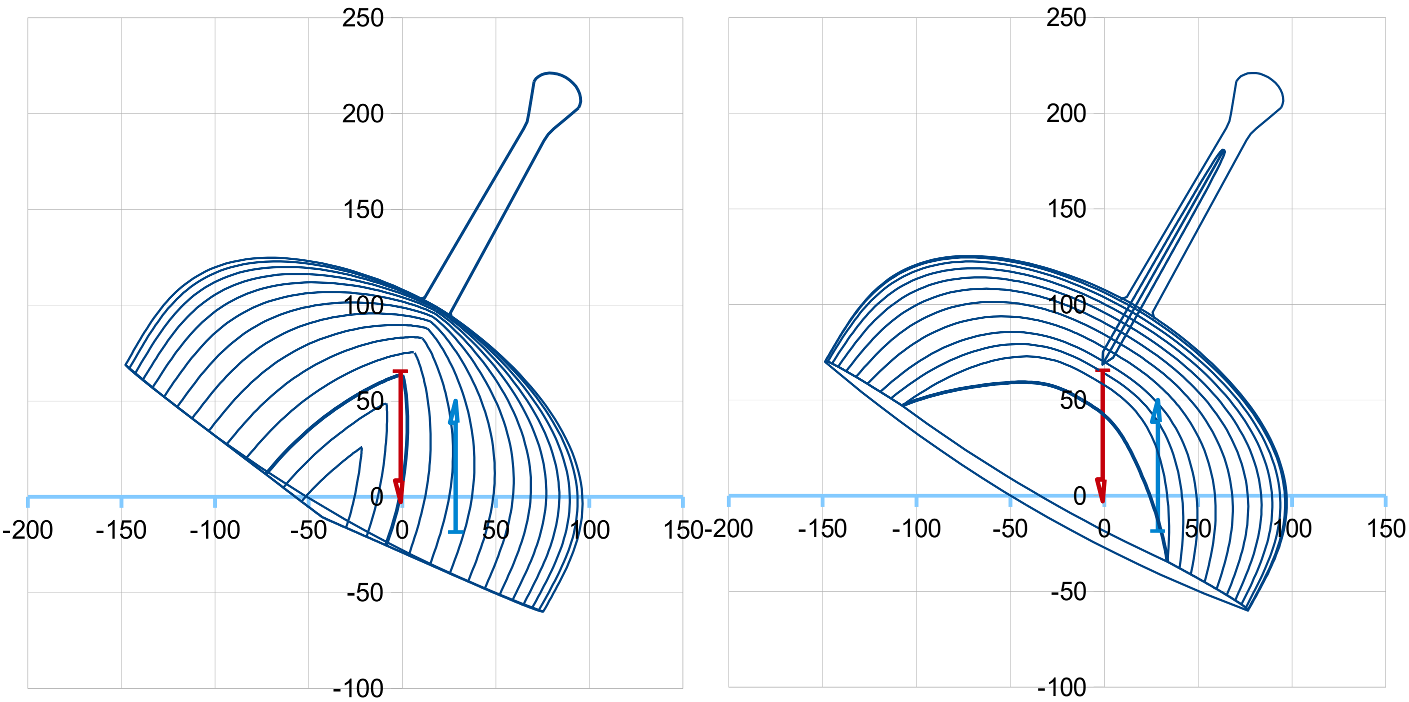




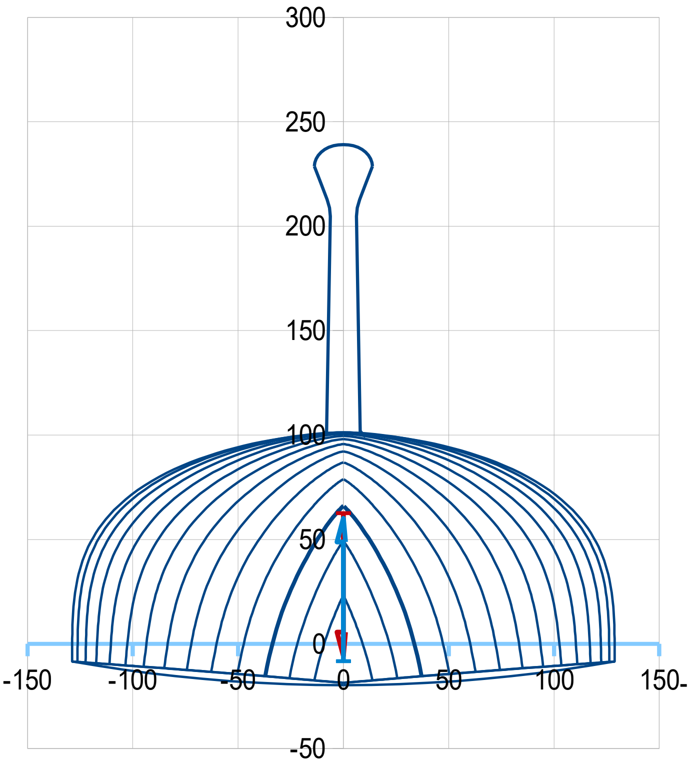
At heel 120,51° >>> GZ = 0,000 m   Angle of Vanishing Stability

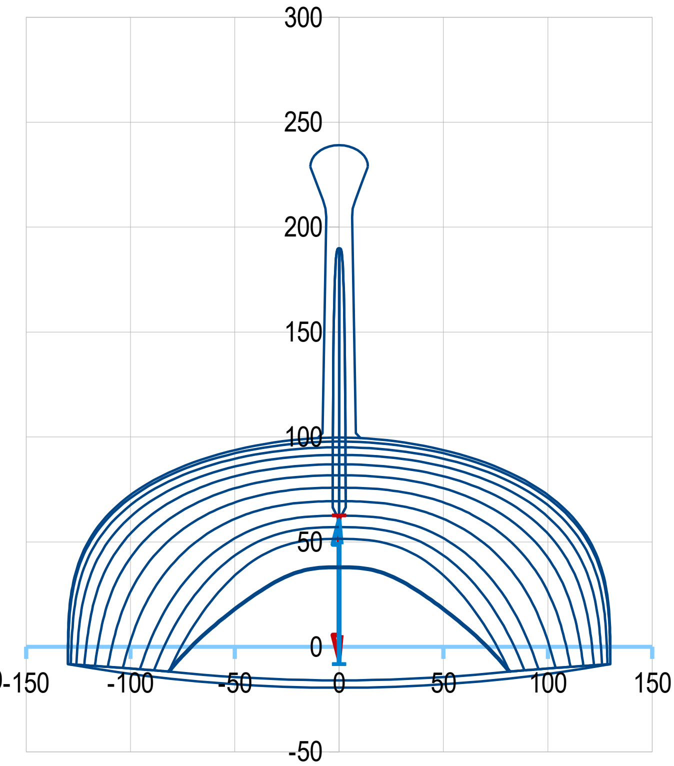


At heel 150° >>> GZ = - 0,293 m



At heel 180° >>> GZ = 0,000 m



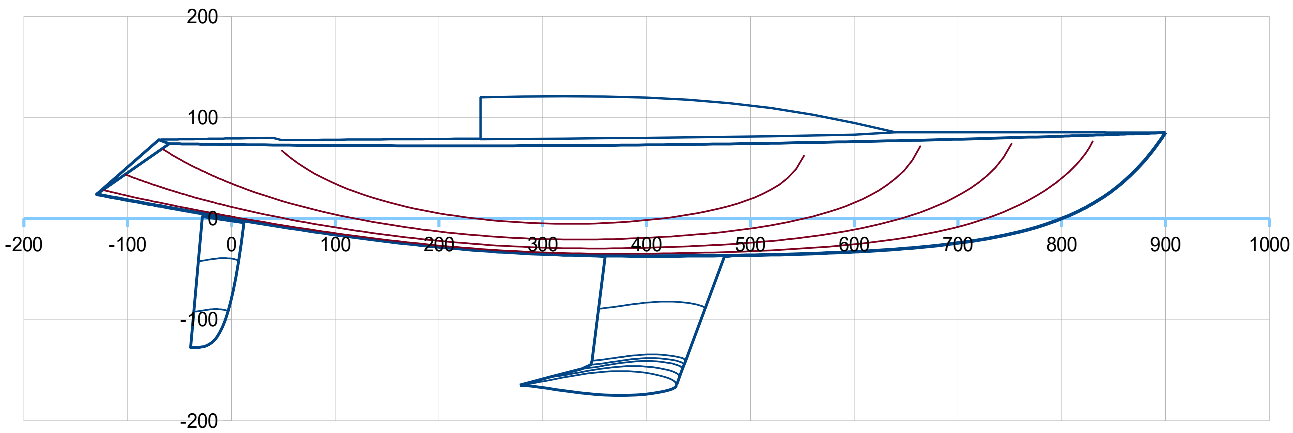


The influence of the cabin roof on the Gz curve

You may estimate that a flush deck assumption for the GZ curve is too disadvantageous, in particular for the AVS estimation, that the extra volume above the deck do more than compensate the recesses bring by the cockpit. In that case, you can repeat the process with a value Kroof > 0 in oder to involved such extra volume in the heeled configurations. To remind that this parameter Kroof is the ratio roof height / deck beam (in %), for the proposed « standard » roof extended from C3 to C8.

Example in the V1 case :
With Kroof (%) = 29 >>>

Kroof (%B)	29,0

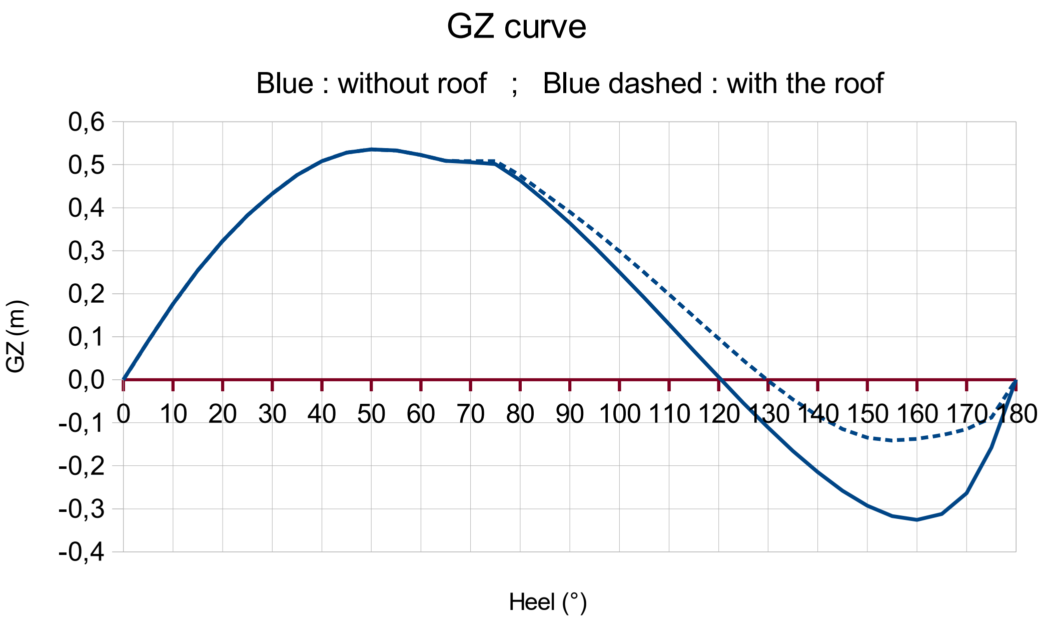


Example of results, with Kroof (%) = 29 :

GZ data storage (by copy/special paste)		
Heel (°)	**Trim (°)**	**GZ (m)**
0,00	0,520	0,000
5,00	0,497	0,090
10,00	0,430	0,176
15,00	0,320	0,254
20,00	0,166	0,323
25,00	-0,029	0,382
30,00	-0,261	0,433
35,00	-0,521	0,476
40,00	-0,789	0,509
45,00	-1,052	0,528
50,00	-1,301	0,536
55,00	-1,516	0,533
60,00	-1,692	0,522
65,00	-1,833	0,509
70,00	-1,932	0,508
75,00	-2,017	0,509
80,00	-2,082	0,475
85,00	-2,113	0,432
90,00	-2,117	0,391
95,00	-2,093	0,346
100,00	-2,039	0,300
105,00	-1,960	0,250
110,00	-1,854	0,199
115,00	-1,727	0,147
120,00	-1,581	0,096
125,00	-1,417	0,046
130,00	-1,235	-0,002
135,00	-1,040	-0,046
140,00	-0,834	-0,084
145,00	-0,619	-0,114
150,00	-0,398	-0,135
155,00	-0,176	-0,141
160,00	0,046	-0,137
165,00	0,258	-0,129
170,00	0,432	-0,115
175,00	0,536	-0,088
180,00	0,557	0,000
		AVS (°)
		129,76
		Areas ratio
		9,24

>>> The AVS increases from 120,51° to 129,76°, the areas ratio from 3,43 to 9,24, demonstrating the importance of any roof (waterproof) volume above the deck for the GZ curve, the AVS and the areas ratio.

Here is the comparison of the two GZ curves to show the typical difference (*this figure was done for the show, it is not an automatical drawing of Gene-Stab*).



The influence of the roof volume usually starts at about 75° of heel angle. The two curves perfectly illustrates how the AVS and the Areas positive/negative ratio can be different.

STIX sheet

The STIX formulation proposed is the one according to the norm ISO 12217-2 2013 for Sailboat of length > 6 m (see Annex 1). Most of the data necessary for this computation comes from the Stab sheet. Just to note that **in Stab, 1) the GZ table should be fulfilled up to 180° and 2) the heel cell (B153) should be put at 0** in order that the Lwl and the Bwl taken into account in STIX are those which correspond to the loading condition when upright. Anyway, if heel is not at zero, a message remind you this need :

Example : heel not at 0 in Stab :

Length waterplane (to put heel = 0 in Stab)	Lwl (m)	« put Heel 0 »
Beam waterplane (to put heel = 0 in Stab)	Bwl (m)	« put Heel 0 »

>>> put heel = 0 in Stab :

Length waterplane (to put heel = 0 in Stab)	Lwl (m)	8,260
Beam waterplane (to put heel = 0 in Stab)	Bwl (m)	2,244

The whole input data are (with boat V1 example and Kroof = 0) :

STIX according to ISO 12217-2 2013 for Sailboat of Length > 6 m

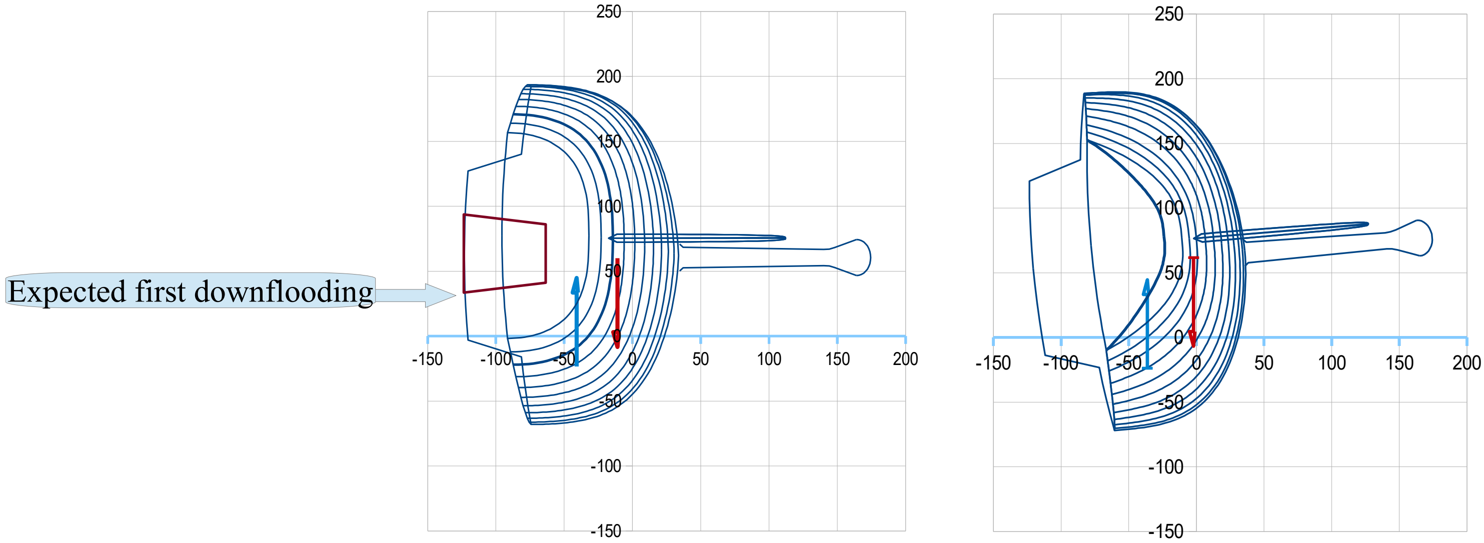
Input data (in yellow cells the necessary input, in blue the data coming from Stab**)**				
Hull length excluded bolted on extensions (bowsprit, stem roller, etc...)	LH (m)	10,300		
Hull width excluded bolted on extensions (cab rails, rub rails, etc …)	BH (m)	2,600		
Displacement (ISO consider either mMO Minimum Operating condition or mLA Loaded Arrival condition)	m (kg)	2973		
Length waterplane (to put heel = 0 in Stab)	Lwl (m)	8,258		
Beam waterplane (to put heel = 0 in Stab)	Bwl (m)	2,246		
Sail area (Mainsail + fore triangle)	As (m2)	**47,1**	**<<< to input**	
Height of sail area centroid (/H0)	hCE (m)	**5,26**	**<<< to input**	
Height of center (m) of lateral area below the waterline when the boat is upright (/H0)	hLP (m)	0,587		
Height of waterline in loading condition (to put heel = 0 in Stab)	(m)	0,022		
Data coming from the GZ Curve :		**With Zg (m)**	**With Zg (m)**	
		0,015	**0,100**	
Righting arm at 90°	GZ90° (m)	0,364	0,279	
First occuring downflooding angle	PhiD (deg)	**95**	**95**	**<<< to input**
>> Righting arm at downflooding angle (Computed in Stab)	GZD (m)	0,308	0,224	
Angle of vanishing stability	AVS (deg)	120,5	114,2	
Area under the GZ curve up to AVS	AGZ (m.deg)	42,338	35,167	

In blue are the input data that come automatically from Stab. **The User should input only 3 new data :**

As (m2) : the sail area (Mainsail + fore triangle), which can be recovered from the sheet « Sailplan » , cell E14, of « Gene-Hull Sailboat 3,2 » . It is the same As area as also used in Gene-VPP dedicated to the speed prediction. Here for boat V1 : 47,1 m2

hCE (m) : height of sail area centroid . Idem, can be recovered from the sheet « Sailplan » , cell F14, of « Gene-Hull Sailboat 3,2 » . It is the ZCE also used in SA-VPP. Here for boat V1 : 5,26 m

phiD (°) : the angle of first downflooding : the norm ISO considers various downflooding angles in the formulations leading to the STIX (see Annex 1). Here to simplify and to be conservative within an early stage approach, we consider only one angle PhiD assumed to correspond to the very first downflooding, typically that could be the first flooding of companionway top corner. When looking at the typical configuration with heel 90° here below , one can guess that this angle PhiD is usually few degrees over 90, so here let's take 95° to be a priori conservative : At 90° : >>> At 95° :



The output is given both for the initial Zg (here 0,015 m) and for the « another » Zg (here 0,100 m) from the input in the Stab sheet.

STIX according to ISO 12217-2 2013 for Sailboat of Length > 6 m

Input data (in yellow cells the necessary input, in blue the data coming from Stab)				
Hull length excluded bolted on extensions (bowsprit, stem roller, etc...)	LH (m)	10,300		
Hull width excluded bolted on extensions (cab rails, rub rails, etc …)	BH (m)	2,600		
Displacement (ISO consider either mMO Minimum Operating condition or mLA Loaded Arrival condition)	m (kg)	2973		
Length waterplane (to put heel = 0 in Stab)	Lwl (m)	8,258		
Beam waterplane (to put heel = 0 in Stab)	Bwl (m)	2,246		
Sail area (Mainsail + fore triangle)	As (m2)	**47,1**	**<<< to input**	
Height of sail area centroid (/H0)	hCE (m)	**5,26**	**<<< to input**	
Height of center (m) of lateral area below the waterline when the boat is upright (/H0)	hLP (m)	0,587		
Height of waterline in loading condition (to put heel = 0 in Stab)	(m)	0,022		
Data coming from the GZ Curve :		**With Zg (m) 0,015**	**With Zg (m) 0,100**	
Righting arm at 90°	GZ90° (m)	0,364	0,279	
First occuring downflooding angle	PhiD (deg)	**95**	**95**	**<<< to input**
>> Righting arm at downflooding angle (Computed in Stab)	GZD (m)	0,308	0,224	
Angle of vanishing stability	AVS (deg)	120,5	114,2	
Area under the GZ curve up to AVS	AGZ (m.deg)	42,338	35,167	
Computation of the STIX parameters				
	LBS (m)	8,939	8,939	
	FL	0,959	0,959	
(0,75 – 1,25)	FDL	0,911	0,911	
	FB	1,921	1,921	
(0,75 – 1,25)	FBD	1,039	1,039	
	FR	2,192	1,683	
(0,5 – 1,5)	FKR	1,058	1,015	
(0,4 – 1,5)	FIR	0,979	0,927	
(0,5 – 1,0)	FWM	1,000	1,000	
(0,5 – 1,5)	FDS	0,947	0,896	
(0,5 – 1,25)	FDF	1,056	1,056	
	>> STIX	**26,8**	**24,9**	
	>> AVS (°)	**120,5**	**114,2**	
>>Righting Energy (m.deg.kg)		**125 855**	**104 537**	
	Areas ratio	**3,4**	**2,4**	

To compare with :

Design category	**Cat. A**	**Cat. B**	**Cat. C**	**Cat. D**
STIX Lower limit	**32**	**23,0**	**14,0**	**5**
AVS (°) mini required	**124,1**	**115,1**	**90,0**	**75**
Righting energy (m.deg.kg) mini required	**172 000**	**57 000**		

The results in this example shows that with Zg = 0,015 m, the classification in Cat. B is possible :

- the STIX = 26,8 / 23 minimum for cat. B
- The AVS = 120,5° / 115,1° minimum for cat. B
- The Righting energy = 125 855 m.deg.kg / 57 000 minimum for cat. B

One can not that with the higher Zg 0,100 m , the AVS drops to 114,2° < 115,1° , the classification in Cat. B is no longer possible. This highlights on the necessity to not put the weights too high.

One can also highlight on the influence of PhiD , e.g. ± 5° / 95° :
with 90° >>> STIX = 26,1
with 95° >>> STIX = 26,8
with 100° >>> STIX = 27,5
>>> always > 23 , so this does not change for the classification in Cat. B.

The Areas ratio, already computed in the Stab sheet, is here just recopied.

Annex 1 – the STIX formulation according to ISO 12217-2 2013

For Sailboat of length > 6 m :

STIX = (7 + 2,25 LBS) . (FDL.FBD.FKR.FIR.FDS.FWM.FDF)^0,5

, where :

Loadings :

Two loadings should be considered for the computation of this stability index, in order to detect its lower value which should remains over the minimum required for the category A, i.e. STIX > 32.

subscript MO = Minimum Operating condition

subscript LA = Loaded Arrival condition

Downflooding angles (in deg) :

The following can be specifically considered:

- **ϕd** is the downflooding angle to any downflooding opening
- **ϕda** is the angle of heel at which openings which are not marked “KEEP SHUT WHEN UNDER WAY” having a combined total area, expressed in square centimetres (cm2), greater than the number represented by 1,2.LH.BH.FM first become immersed;
- **ϕdc** is the downflooding angle at which recesses which are not quick-draining begin to fill with water;
- **ϕdh** is the downflooding angle at which any main access hatch (i.e. having an opening area greater than 0,18 m2 each) giving direct access to the main open air helm position first begins to become immersed.

Base length factor :

LBS = (LH + 2.LWL) / 3

LH = Hull length (m) excluding bolted on extensions (bowsprit, stem roller, etc ...)
LWL = Waterline length (m) at the given displacement m

Displacement length factor :

FDL = [0,6 + (15.m.FL) / LBS^3 / (333 – 8.LBS)]^0,5 *(0,75 < FDL < 1,25)*

m = displacement (kg)

FL = (LBS / 11)^0,2

Beam displacement factor :

FB = (3,3 . BH) / (0,03 . m)^(1/3)

If FB > 2,2 **FBD** = [(13,31 . BWL) / (BH . FB^3)]^0,5 *(0,75 < FBD < 1,25)*

If FB < 1,45 **FBD** = [(BWL . FB^2) / (1,682 . BH)]^0,5

If 1,45 ≤ FB ≤ 2,2 **FBD** = 1,118 . (BWL / BH)^0,5

BH = Hull width (m) excluding bolted on extensions (cap rails, rub rails, etc …)

BWL = Waterline beam (m) at the given displacement m

Knockdown recovery factor

FR = GZ90 . m / (2 . As . hCE)

If FR ≥ 1,5 **FKR** = 0,875 + 0,0833 FR *(0,5 < FKR < 1,5)*

If FR < 1,5 **FKR** = 0,5 + 0,333 FR

if ϕv < 90° **FKR** = 0,5

GZ90 = righting arm (m) at 90° heel

As = sail area (m2) (Mainsail + Fore triangle + Mizzen sail if any (ketch option))

hCE = height of center of sail area when the boat is upright

ϕv = angle of vanishing stability AVS (°)

Inversion recovery factor

If m < 40000 kg **FIR** = ϕv / (125 – m/1600) *(0,4 < FIR < 1,5)*

If m > 40000 kg **FIR** = ϕv / 100

Dynamic stability factor

FDS = [AGZ / (15,81 . LH^0,5)]^0,3 *(0,5 < FIR < 1,5)*

AGZ = the positive area under the GZ curve (m.deg), from 0 to ϕv

Wind moment factor

If ϕd > 90° **FWM** = 1,0 *(0,5 < FWM < 1,0)*

If ϕd < 90° **FWM** = VAW / 17

VAW : the steady apparent windspeed to heel the vessel to ϕd when carrying full sail

VAW = [13 . m . GZD / (As . (hCE + hLP) . Icos(ϕdw)I^1,3)]^0,5

GZD = righting arm at ϕd heel (m)

hLP = height of center (m) of lateral area below the waterline when the boat is upright (/H0)

ϕdw = is ϕdc or ϕdh, whichever is less

Downflooding factor

FDF = ϕdf / 90 *(0,5 < FDF < 1,25)*

ϕdf = the least of the following : ϕdc, ϕdh, ϕda and ϕv

Design category	A	B	C	D
STIX lower limit	32	23	14	5

Annex 2 – The areas ratio criteria according to Imoca class rule