

« C1 » : 16m Catamaran example, with Gene-Hull Catamaran 3.0 and SA-VPP Catamaran 1.0

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An example of the use of both applications is here given for « C1 » a Catamaran of 16 m, through the following steps :

Step 1 : Hull generation

Step 2 : Sailplan preliminary definition

Step 3 : Mass preliminary estimation and distribution

Step 4 : Introduction of a loading >> hydrostatics and initial stability

Step 5 : Catamaran heeled >> righting moment at various heel angles

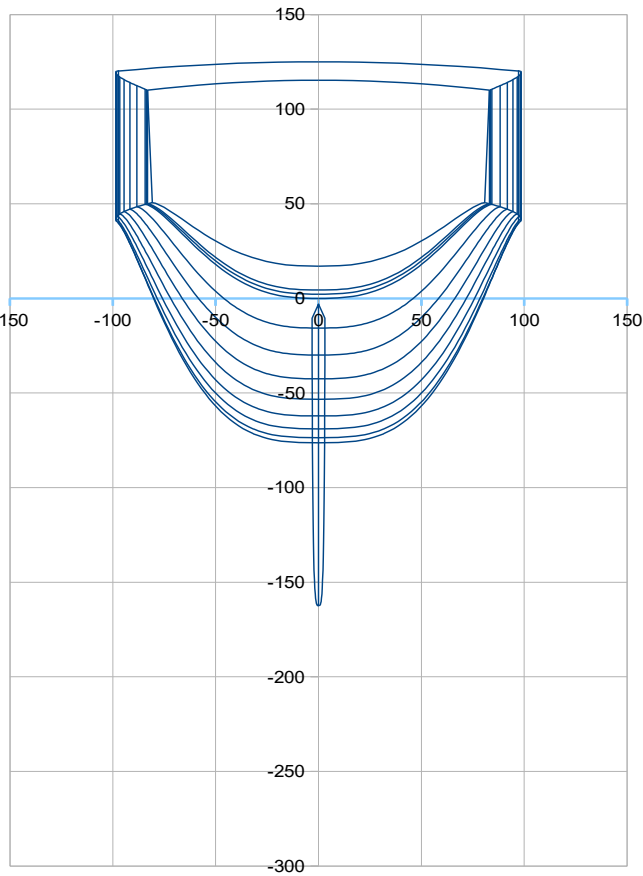
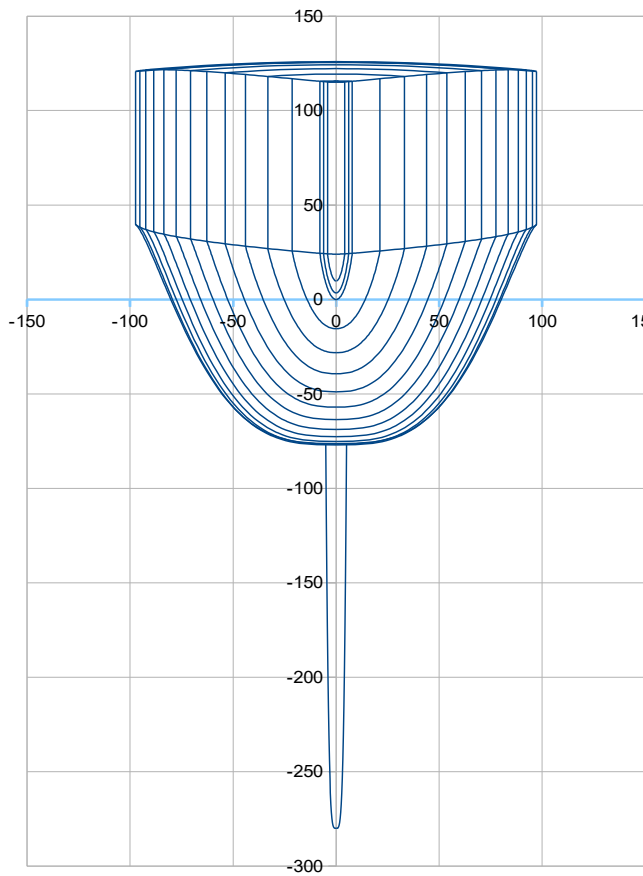
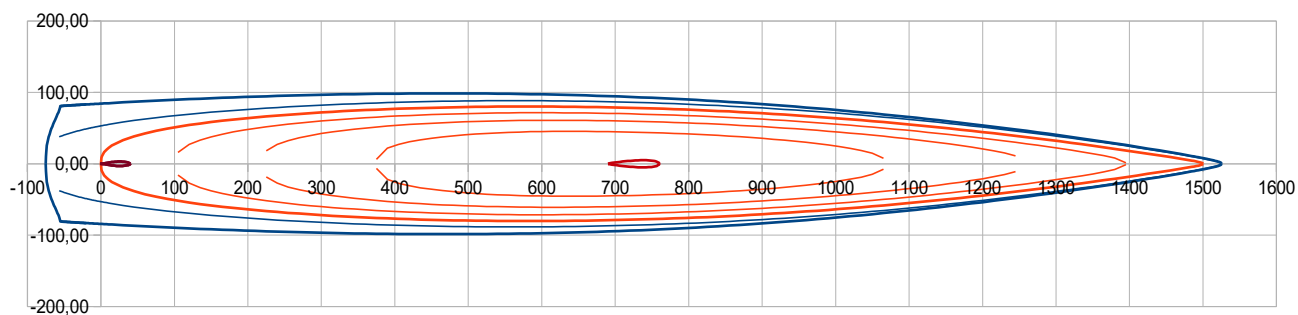
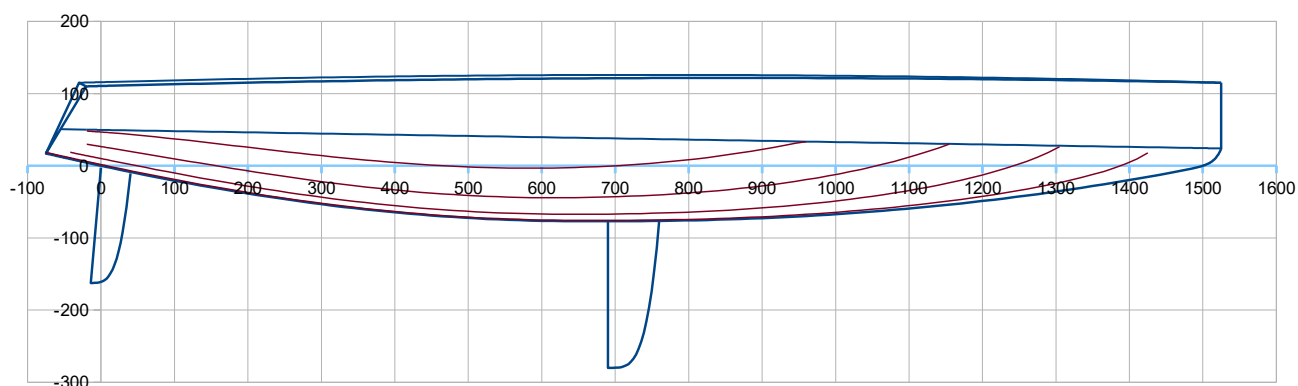
Step 6 : Performance estimation with « SA-VPP Catamaran 1.0 »

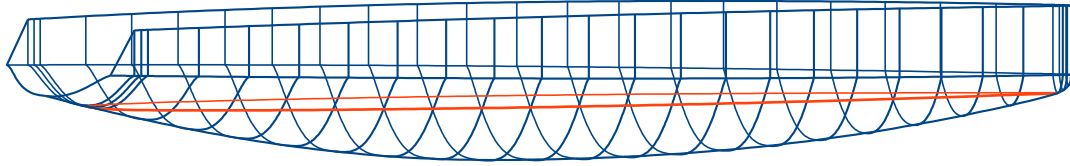
C1 input data are the ones in place in both Gene-Hull and SA-VPP applications, from which you can at first test various values of the parameters and of the geometrical data. And after this learning by testing stage, you can start your own project.

Step 1 : Hull Generation

Loa : 16 m ; Lwl : 15 m ; Boa : 8,07 m ; Bwl hull : 1,60 m >> Lwl / Bwl : 9,35

Displacement : 15,96 t ; $X_c (=LCB)$: 45,9 % Lwl ; C_p : 0,565 ; Wetted surface (total) : 57,8 m²





Hydrostatics data :

2.1 Hull

Loa (m)	16,00	Lwl (m)	15,00					
>> ft	52,49		49,21					
Bhull (m)	1,97	at X (% Lwl)	31,0	Boa (m)	8,07	Space hulls axis (m)	6,10	
>> ft	6,47			>> ft	26,48	> S/Lw	0,41	
Bwl (m)	1,60	at X (% Lwl)	39,0	> Lwl / Bwl	9,35			
>> ft	5,26							
Tc (m)	0,77	at X (%Lwl)	45,0	Freeboards (m) >		Aft	Midship	Fore
>> ft	2,53			> Bwl / Tc	2,08	1,1	1,20	1,15
				>> ft		3,61	3,94	3,77
Displacement at H0 (m3)	7,70072	at LCB (m)	6,893	LCB (%Lwl)	45,95	Zc (m)	-0,280	
>> lbs	17401	w. seawater	1025	kg/m3		>> ft	-0,92	
Cp	0,565			> Lwl/D^(1/3)	7,60			
Sf (m2)	17,56	at Xf (m)	6,674	Xf (%Lwl)	44,49	>>> Xc - Xf (%Lwl)	1,46	
>> ft2	188,99	>> ft	21,90					
Sw (m2)	25,40	>Sm/D^(2/3)	6,51					
>> ft2	273,36							
Shull (m2)	64,52	at X (m)	7,102	Z (m)	0,185			
>> ft2	694,51	>> ft	23,30	>> ft	0,61			
Sdeck (m2)	23,38	at X (m)	6,224					
>> ft2	251,64	>> ft	20,42					

2.2 Daggerboard

Vol. (m3)	0,06612	at X (m)	7,243	X (%Lwl)	48,29	Z (m)	-1,550
Mass (kg)	36,36	>> ft	23,76			>> ft	-5,09
>> lbs	80						
Draft oa (m)	2,80		Sw (m2)	2,37		Sxz (m2)	1,14
>> ft	9,19		>> ft2	25,49		>> ft2	12,25
CLR (m)	7,37	CLR (%Lwl)	49,10	CLR = Center of Lateral Resistance			
>> ft2	79,28	method : daggerboard profile extended to the waterline, LCR at 25% chord and 45% draft oa					

2.3 Rudder

Volume (m3)	0,01904	at X (m)	0,154	X (%Lwl)	1,03	Z (m)	-0,732	
Sw (m2)	1,15	>> ft	0,51			Sxz (m2)	0,55	per rudder
>> ft2	12,33					>> ft2	5,93	

2.4 Catamaran : 2 Hulls + 2 Daggerboards + 2 Rudders

Loa (m)	16,00	Boa (m)	8,07					
>> ft	52,49	>> ft	26,48					
Displacement at H0 (m3)	15,57176	at LCB (m)	6,879	LCB (%Lwl)	45,86	Zc (m)	-0,291	
(kg)	15961	>> ft	22,57			>> ft	-0,96	
>> lbs	35188							
Sw (m2)	57,82	>Sw/D^(2/3)	9,27	Lwl/D^(1/3)	6,01			
>> ft2	622,36			DLR	132	$M(lbs/2240)/(Lwl(ft)/100)^3$		

2.5 Data from the mass spreadsheet

Light boat:	M (kg)	15961	at Xg (m)	6,900	Xc (%Lwl)	46,00	at Zg (m)	2,137
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The last line is the recopy of the main results of the mass estimation sheet, see here after.

Step 2 : Sailplan preliminary definition

Data to enter (Yellow cells) >> in feet

Xmast (m)	7,50	24,61
Zboom(m)	2,62	8,60
I (m)	20,20	66,27
J (m)	6,50	21,33
P (m)	20,00	65,62
E (m)	6,50	21,33

Results considering St = fore + main triangles and its geometrical center CE for the Lead estimation

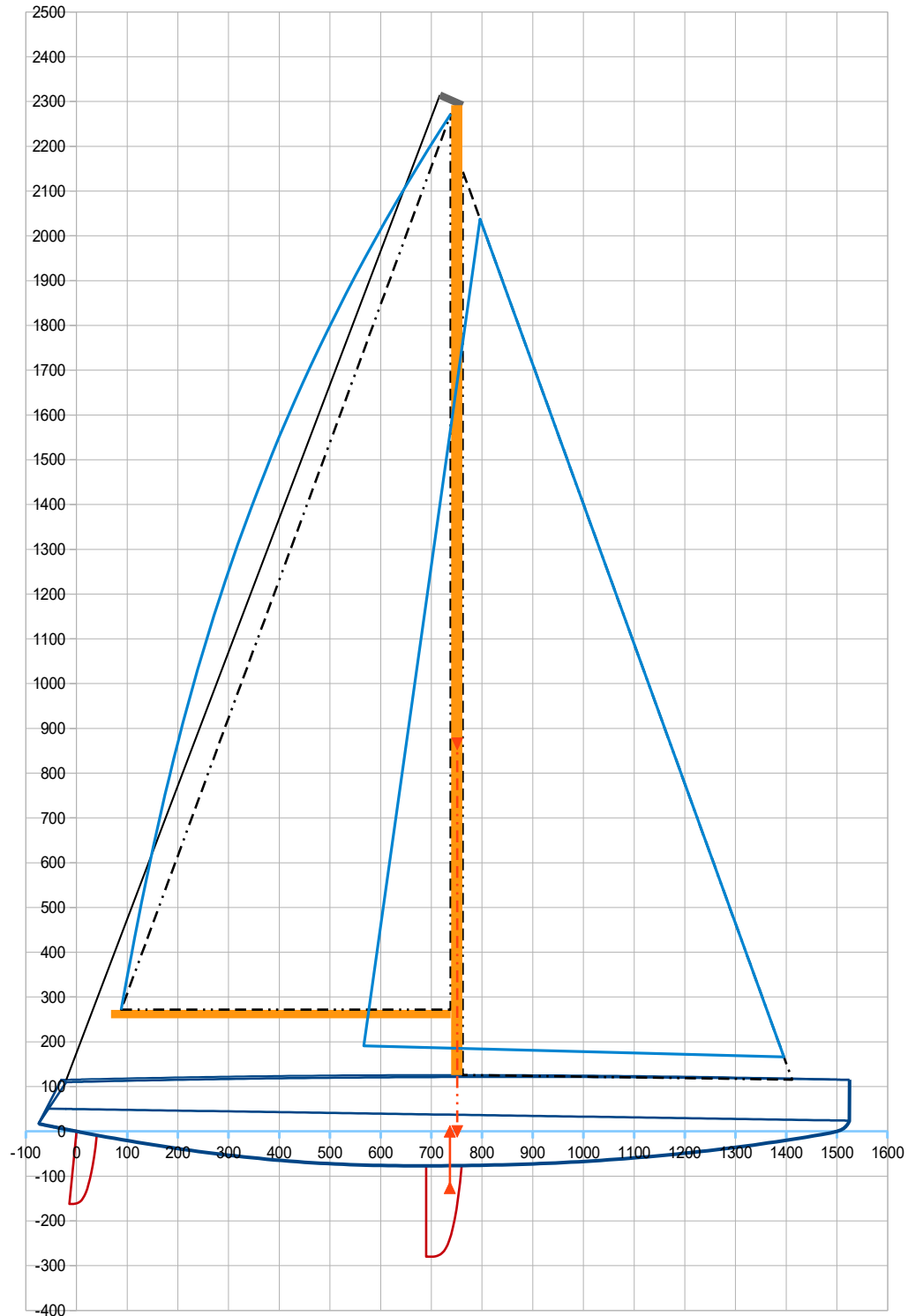
Surface triangles St (m2)	130,7	1406,30	sqft	Main (%)	49,75
XCE (m)	751,14	ZCE (m)	8,66	Fore (%)	50,25
Lead (CE - CLR) (% Lwl)	1,0	CE geometrical center of the 2 triangles, CLR see Gene-Hull sheet			
Sdaggerboard / St (%)	1,74	ratio daggerboards area / triangles area		St/Sw	2,26
Srudder / St (%)	0,84	ratio rudders area / triangles area		St/D^(2/3)	20,95

Results considering SA = jib + mainsail for an upwind sailing

SA (m2)	162,0	1743,99	sqft		
Xsa (m)	7,07	Zsa (m)	9,02	Geometrical center of the real sails	
>> SA/Sw	2,80	ratio sails surface / wetted surface			
>> SA/D^(2/3)	25,98	ratio sails surface / displacement^(2/3)			

For the VPP : SA (m2) ZCE (m) Zdeck (m) Zmast (m) Main (m2) Spi (m2) ZCE spi (m)

(Mainsail + Fore triangle) 147,15 9,11 1,15 22,72 81,50 229,78 10,54



Step 3 : Mass preliminary estimation and distribution

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)	129,04	30,00		3871,31	7,10	27495,17	0,19
, with S, Xs and Zs from Gene-Hull sheet		(kg/m2)					
Deck – roof – cockpit (structure)	114,88	40,00		4595,11	6,22	28600,55	1,25
, with S, Xs and Zs from Gene-Hull sheet		(kg/m2)					
Rig, sails and deck fittings		20,00		3192,21	8,00	25537,69	7,50
		(% Disp.)					
Cabin accomodation and motor		25,00		3990,26	7,00	27931,85	1,00
		(% Disp.)					
2 Daggerboards				72,73	7,24	526,78	-1,55
2 Rudders – Helms		1,50		239,42	0,15	36,87	-0,73
		(% Disp.)					
Results : Light weight boat >>>				15961,04	6,90	110128,91	2,14
							34105,75

Step 4 : introduction of a loading >> hydrostatics and initial stability

>>> introduction of a load of 600 kg :

5.1 Mass spreadsheet with input of a load

Data to enter : yellow cells	Mass (kg)	Xg (m)	Zg (m)	Yg (m)	(in the coordinates of the 2D)
Boat light weight (kg)	15961,04	6,900	2,137	0	from the mass spreadsheet
Load (kg)	600,00	4,00	2,00	0,00	Crew at center
			2,00	3,00	Crew sit windward
Total >>> Mass (kg)	16561,04	6,795	2,132	0,000	Crew at center
Disp. (m3)	16,15711		2,132	0,109	Crew sit windward

>>> Equilibrium computation at heel 0° (upright) :

5.2 Computation : input of an Heel angle and iteration on Height and Trim up to Displacement equality and Xc (LCB) = Xg

Data to enter	Results for leeward hull	Results for windward hull	Results for the 2 hulls	and to to compare with :
Heel (°) 0,0	%Disp 0,50	%Disp 0,50	Disp. (m3) 15,80291	/ Disp. (m3) 16,15711
Height (cm) -0,5933	Disp. (m3) 7,90145	Disp. (m3) 7,90145	Xc heel (m) 6,800	/ Xg (m) 6,795
Trim (°) 0,155	Xc heel (m) 6,800	Xc heel (m) 6,800		
	Other results	Other results		
	Yc heel (m) -3,050	Yc heel (m) 3,050		
	Zc heel (m) -0,293	Zc heel (m) -0,293		
	Sw (m2) 29,32	Sw (m2) 29,32		
	Sf (m2) 17,65	Sf (m2) 17,65		
	Lwl (m) 15,18	Lwl (m) 15,18		
	Bwl (m) 1,61	Bwl (m) 1,61		
	Tc (m) 0,78	Tc (m) 0,78		
	Cp 0,565	Cp 0,565		
	LCB (%Lw) 46,0	LCB (%Lw) 46,0		
	Lwl/Bwl 9,42	Lwl/Bwl 9,42		
	Bwl/Tc 2,07	Bwl/Tc 2,07		
	Lwl/D^1/3 7,62	Lwl/D^1/3 7,62		

The results are given for each hull and for the 2 hulls where the equilibrium could be checked :

In the example above, for the loading 600 kg and at heel 0°, the sinkage is 1,6 cm together with a slight nose-up trim of 0,16° (Trim > 0 = nose-up) . Each hull has a Lwl of 15,32 m.

>>> equilibrium at heel 1° , to evaluate the $GM_{1^\circ} = 18,41 \text{ m}$

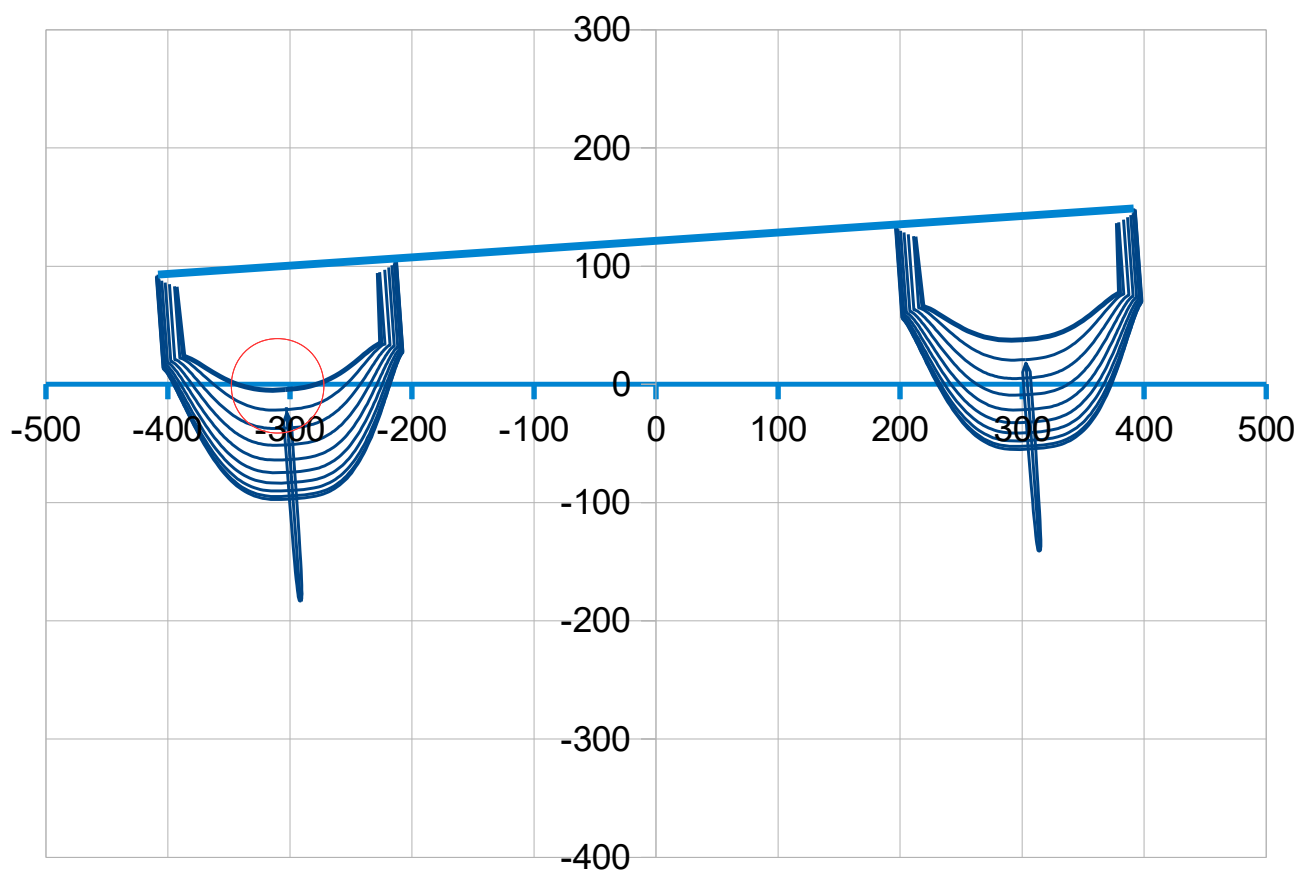
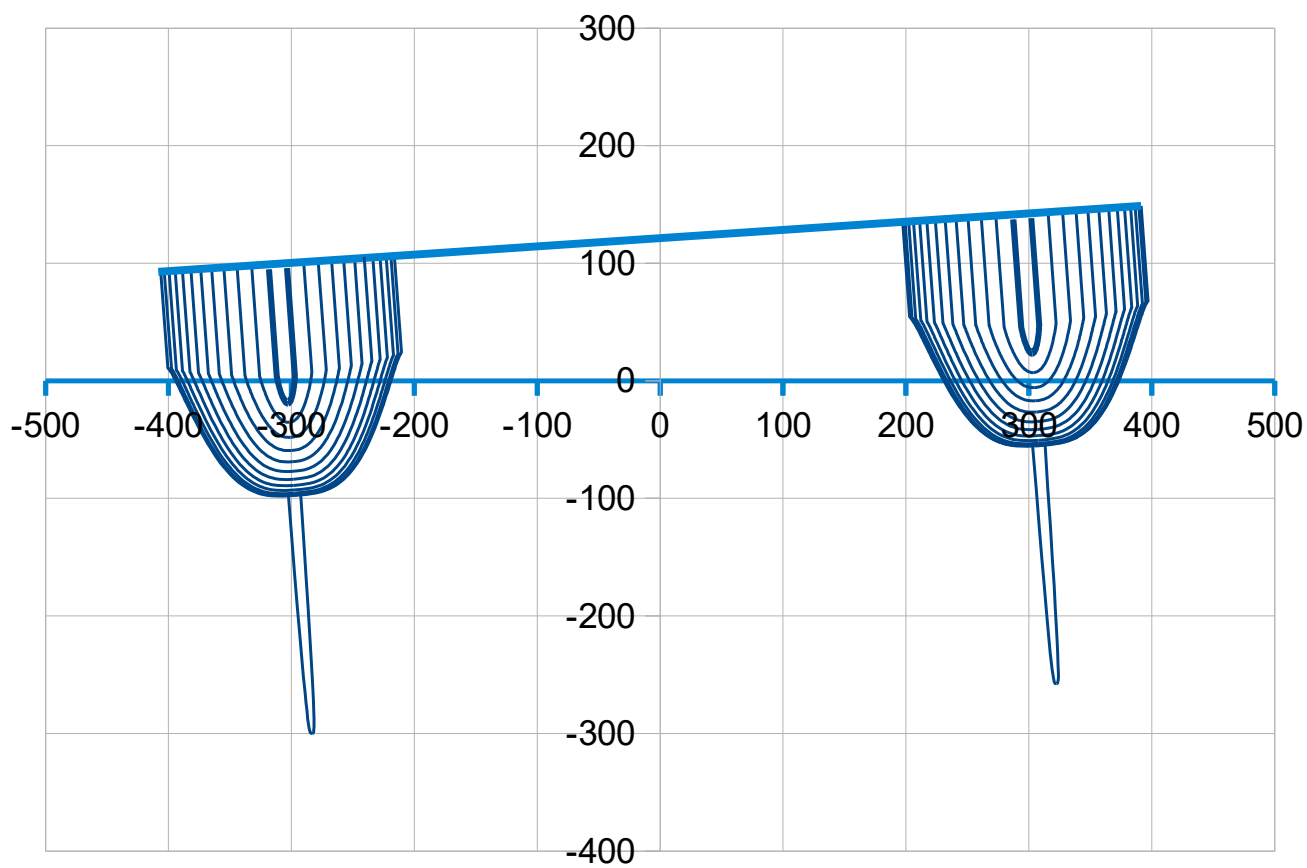
Data to enter		Results for leeward hull		Results for windward hull		Results for the 2 hulls		and to to compare with :	
Heel (°)	1,0	%Disp	0,56	%Disp	0,44	Disp. (m3)	16,15711	/ Disp. (m3)	16,15711
Height (cm)	-1,4481	Disp. (m3)	9,02428	Disp. (m3)	7,13283	Xc heel (m)	6,795	/ Xg (m)	6,795
Trim (°)	0,145	Xc heel (m)	6,776	Xc heel (m)	6,820	Other results		GZ & RM (Crew sit windward)	
		Other results		Other results		Yc heel (m)	-0,358	Hull Mom(m4)	5,791
		Yc heel (m)	-3,051	Yc heel (m)	3,048	Zc heel (m)	-0,298	Mom(kN.m)	58,23
		Zc heel (m)	-0,314	Zc heel (m)	-0,278	Sw (m2)	59,17	Yg heel (m)	0,071
		Sw (m2)	31,54	Sw (m2)	27,63			GZ (m)	0,430
		Sf (m2)	18,61	Sf (m2)	16,84			RM (kN.m)	69,84
		Lwl (m)	15,90	Lwl (m)	14,62	Relevant only at Heel = 1° equilibrium			
		Bwl (m)	1,66	Bwl (m)	1,57	Yg heel (m)	-0,037	with crew at center	
		Tc (m)	0,84	Tc (m)	0,73	Gz (m)	0,321		
		Cp	0,555	Cp	0,574	>> GM1° (m)	18,41		
		LCB (%Lw)	47,3	LCB (%Lw)	44,1				
		Lwl/Bwl	9,58	Lwl/Bwl	9,28				
		Bwl/Tc	1,98	Bwl/Tc	2,15				
		Lwl/D^1/3	7,64	Lwl/D^1/3	7,59				

Step 5 Catamaran heeled : righting moment at various heel angles up to the emergence of the windward hull

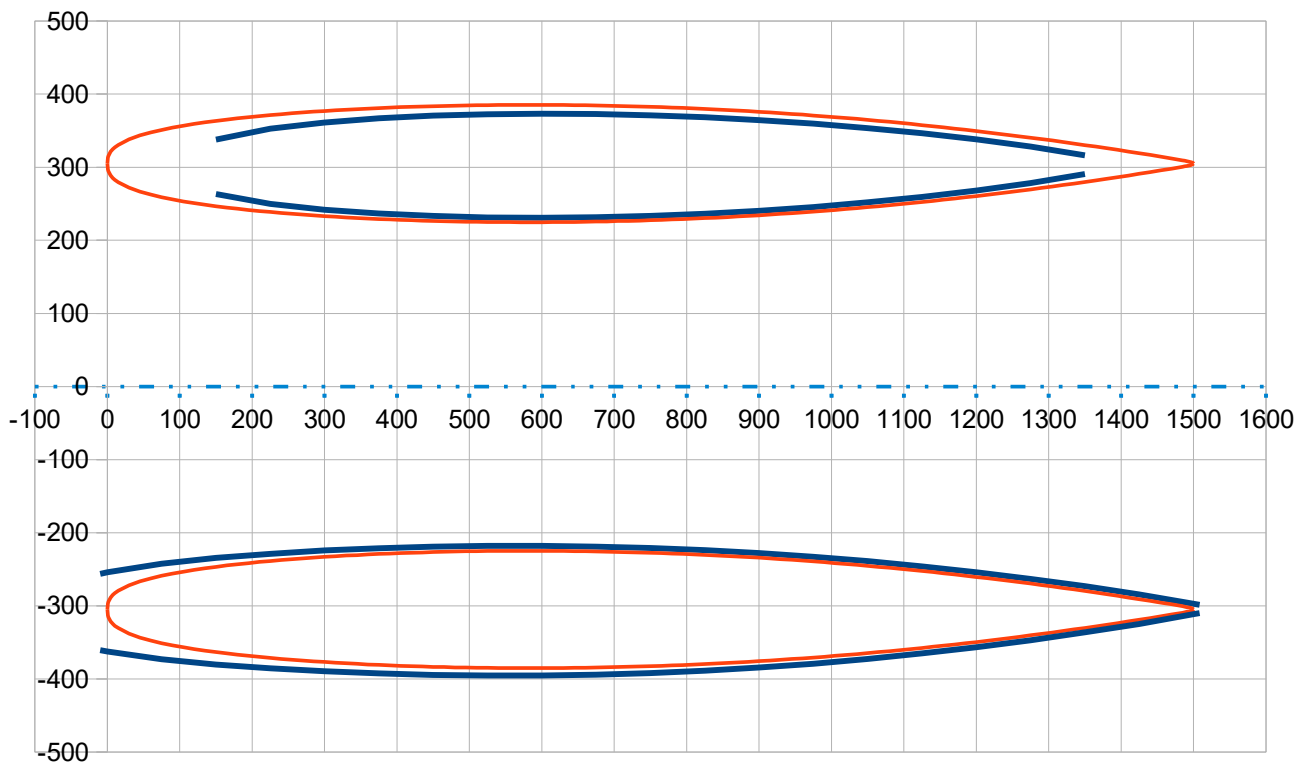
>>> at heel 4° :

Data to enter		Results for leeward hull		Results for windward hull		Results for the 2 hulls and to to compare with :			
Heel (°)	4,0	%Disp	0,73	%Disp	0,27	Disp. (m3)	16,15710	/ Disp. (m3)	16,15711
Height (cm)	0,5457	Disp. (m3)	11,75836	Disp. (m3)	4,39874	Xc heel (m)	6,795	/ Xg (m)	6,795
Trim (°)	0,062	Xc heel (m)	6,751	Xc heel (m)	6,913	Other results GZ & RM (Crew sit windward)			
		Other results		Other results		Yc heel (m)	-1,388	Hull Mom(m4)	22,432
		Yc heel (m)	-3,041	Yc heel (m)	3,030	Zc heel (m)	-0,324	Mom(kN.m)	225,56
		Zc heel (m)	-0,362	Zc heel (m)	-0,222	Sw (m2)	57,85	Yg heel (m)	-0,040
		Sw (m2)	36,26	Sw (m2)	21,60			GZ (m)	1,348
		Sf (m2)	20,50	Sf (m2)	13,73			RM (kN.m)	219,02
		Lwl (m)	16,00	Lwl (m)	13,13	Relevant only at Heel = 1° equilibrium			
		Bwl (m)	1,77	Bwl (m)	1,42	Yg heel (m)	-0,149	with crew at center	
		Tc (m)	0,98	Tc (m)	0,56	Gz (m)	1,240		
		Cp	0,583	Cp	0,576	>> GM1° (m)	'Put Heel 1°		
		LCB (%Lw)	46,9	LCB (%Lw)	44,1				
		Lwl/Bwl	9,02	Lwl/Bwl	9,21				
		Bwl/Tc	1,81	Bwl/Tc	2,56				
		Lwl/D^1/3	7,04	Lwl/D^1/3	8,01				

The displacement repartition is 0,73 D for the leeward hull and 0,27 D for the windward hull. In blue are all the other output data for each hull. The overall righting moment RM is 219 kN.m and the overall wetted surface Sw is 57,85 m2. The trim is 0,06°.



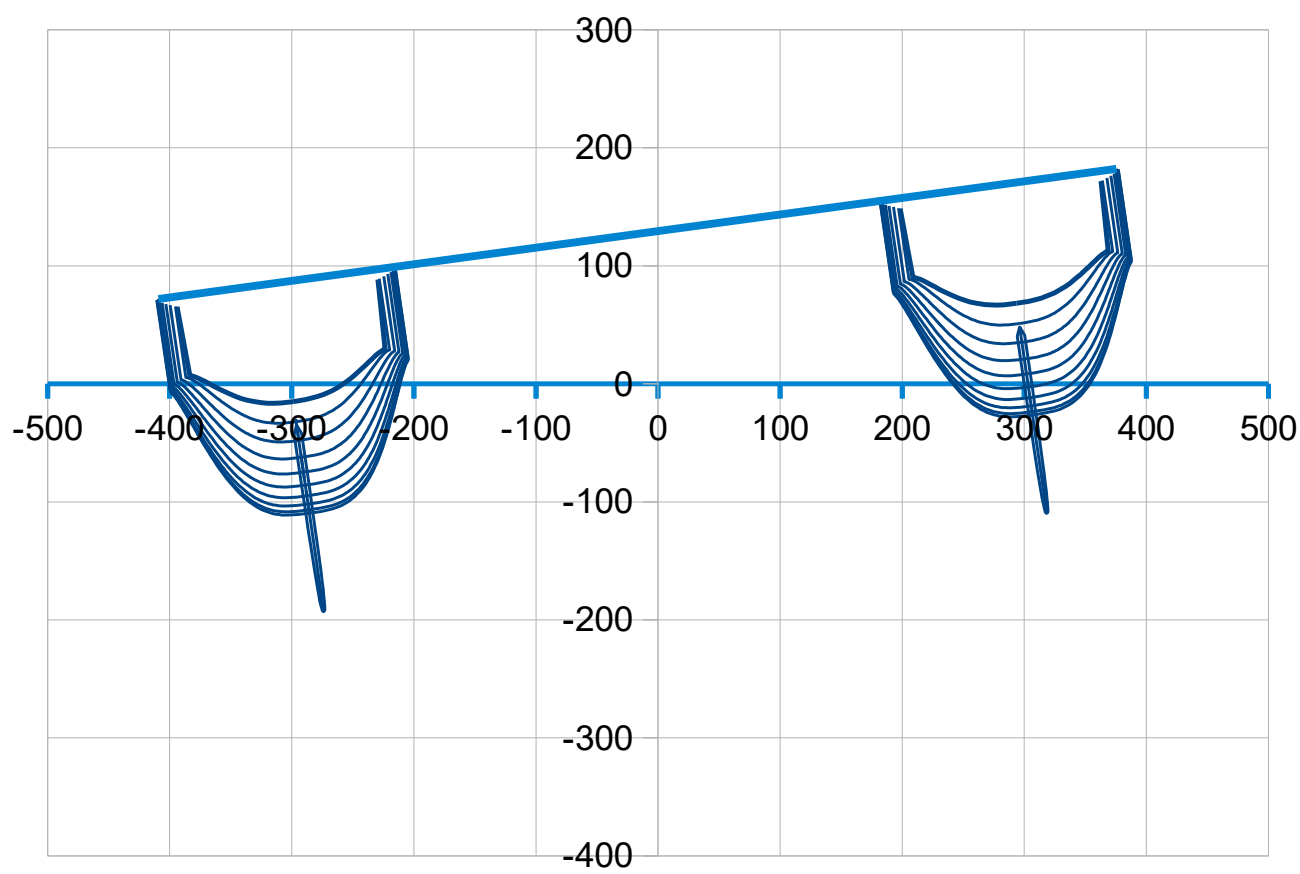
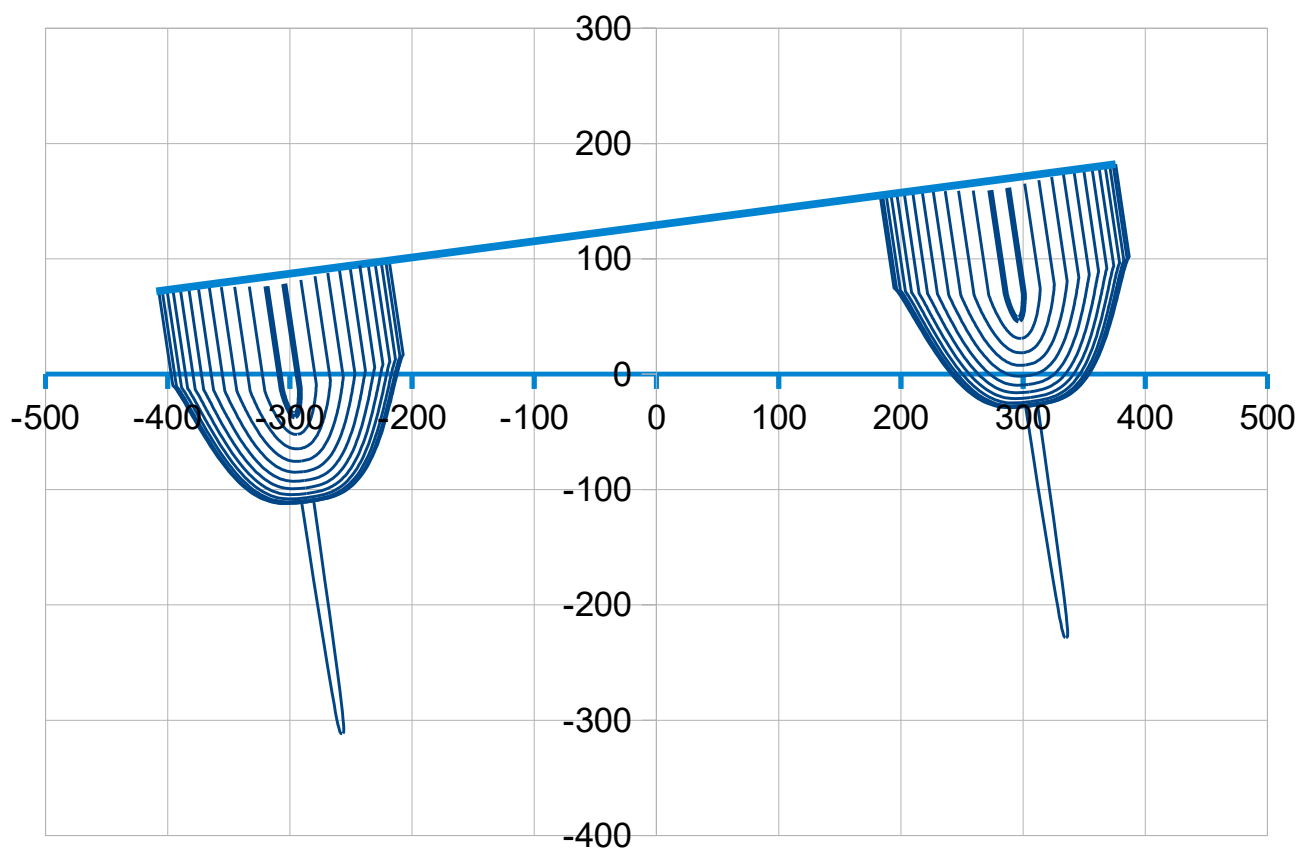
>>> for this heel angle, the rear transom bottom end is just at the level of the water.

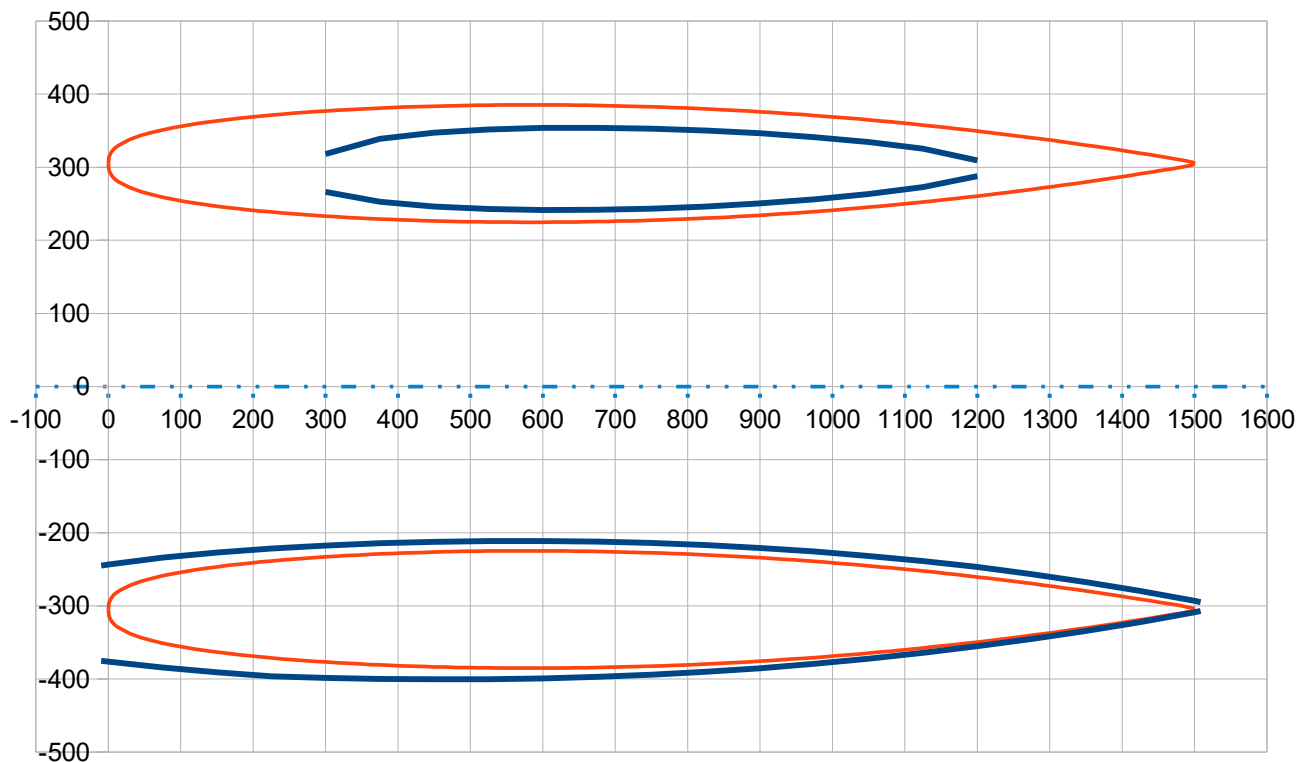


>>> at heel 8° :

Data to enter	Results for leeward hull	Results for windward hull	Results for the 2 hulls	and to to compare with :
Heel (°) 8,0	%Disp 0,91	%Disp 0,09	Disp. (m3) 16,15710	/ Disp. (m3) 16,15711
Height (cm) 7,3092	Disp. (m3) 14,76020	Disp. (m3) 1,39690	Xc heel (m) 6,795	/ Xg (m) 6,795
Trim (°) -0,190	Xc heel (m) 6,773	Xc heel (m) 7,028	Other results	GZ & RM (Crew sit windward)
	Other results	Other results	Yc heel (m) -2,484	Hull Mom(m4) 40,131
	Yc heel (m) -3,001	Yc heel (m) 2,976	Zc heel (m) -0,391	Mom(kN.m) 403,53
	Zc heel (m) -0,412	Zc heel (m) -0,174	Sw (m2) 52,59	Yg heel (m) -0,189
	Sw (m2) 39,58	Sw (m2) 13,01		GZ (m) 2,295
	Sf (m2) 22,08	Sf (m2) 8,34		RM (kN.m) 372,83
	Lwl (m) 16,00	Lwl (m) 9,90	Relevant only at Heel = 1° equilibrium	
	Bwl (m) 1,89	Bwl (m) 1,12	Yg heel (m) -0,297	with crew at center
	Tc (m) 1,12	Tc (m) 0,29	Gz (m) 2,187	
	Cp 0,609	Cp 0,602	>> GM1° (m) 'Put Heel 1°	
	LCB (%Lw) 47,0	LCB (%Lw) 44,5		
	Lwl/Bwl 8,47	Lwl/Bwl 8,81		
	Bwl/Tc 1,68	Bwl/Tc 3,88		
	Lw/D^1/3 6,52	Lw/D^1/3 8,86		

The displacement repartition is 0,09 D for the leeward hull and 0,91 D for the windward hull. In blue are all the other output data for each hull. The overall righting moment RM is 373 kN.m and the overall wetted surface Sw is 52,59 m2. The trim is -0,19°.

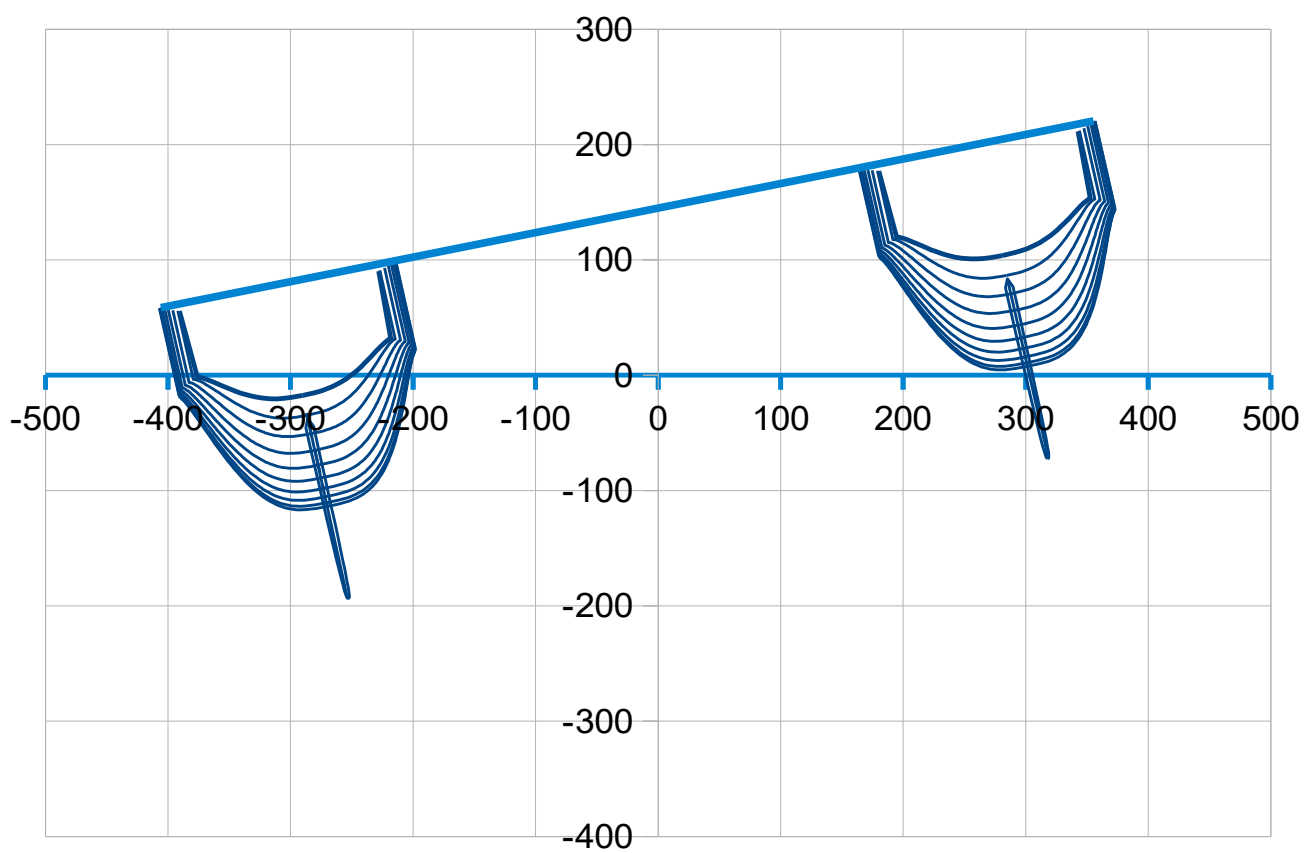
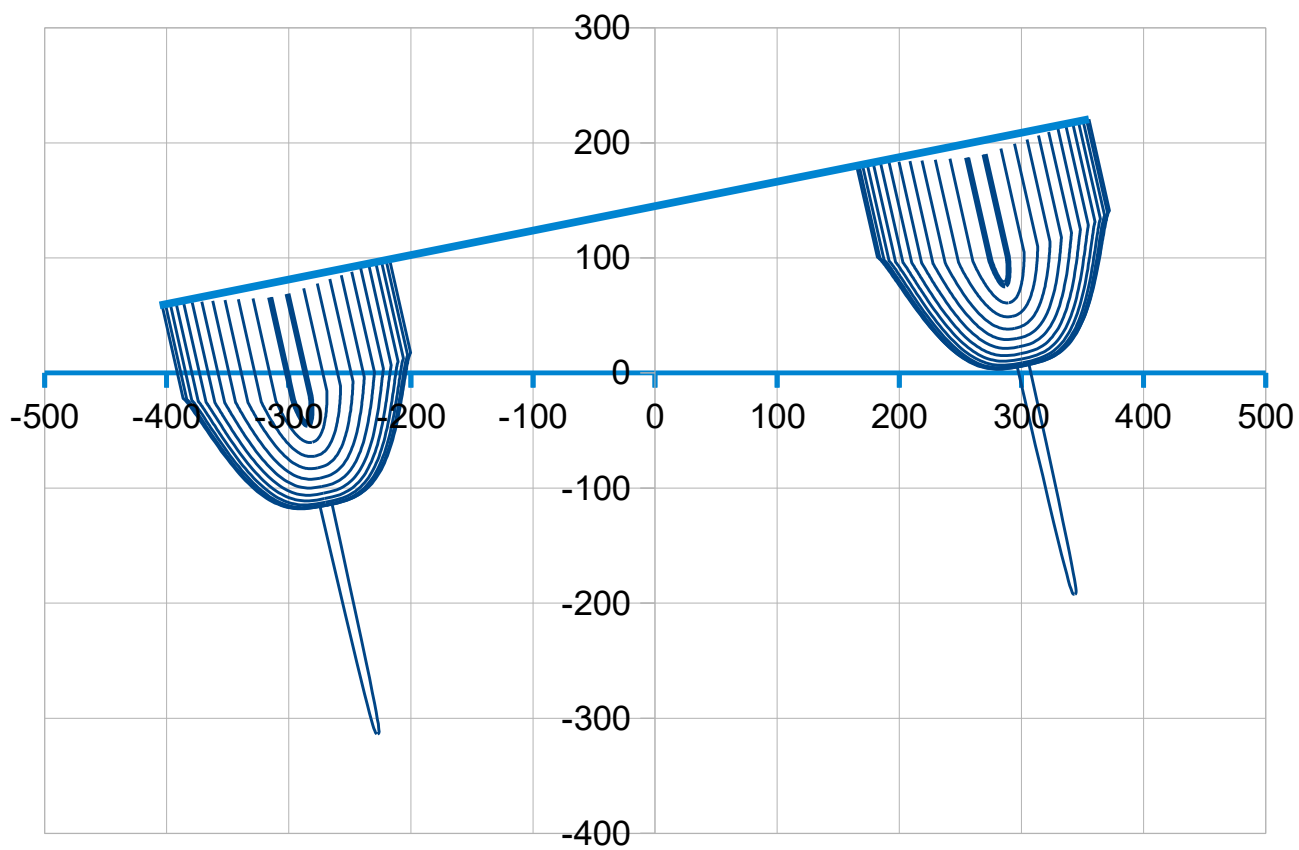


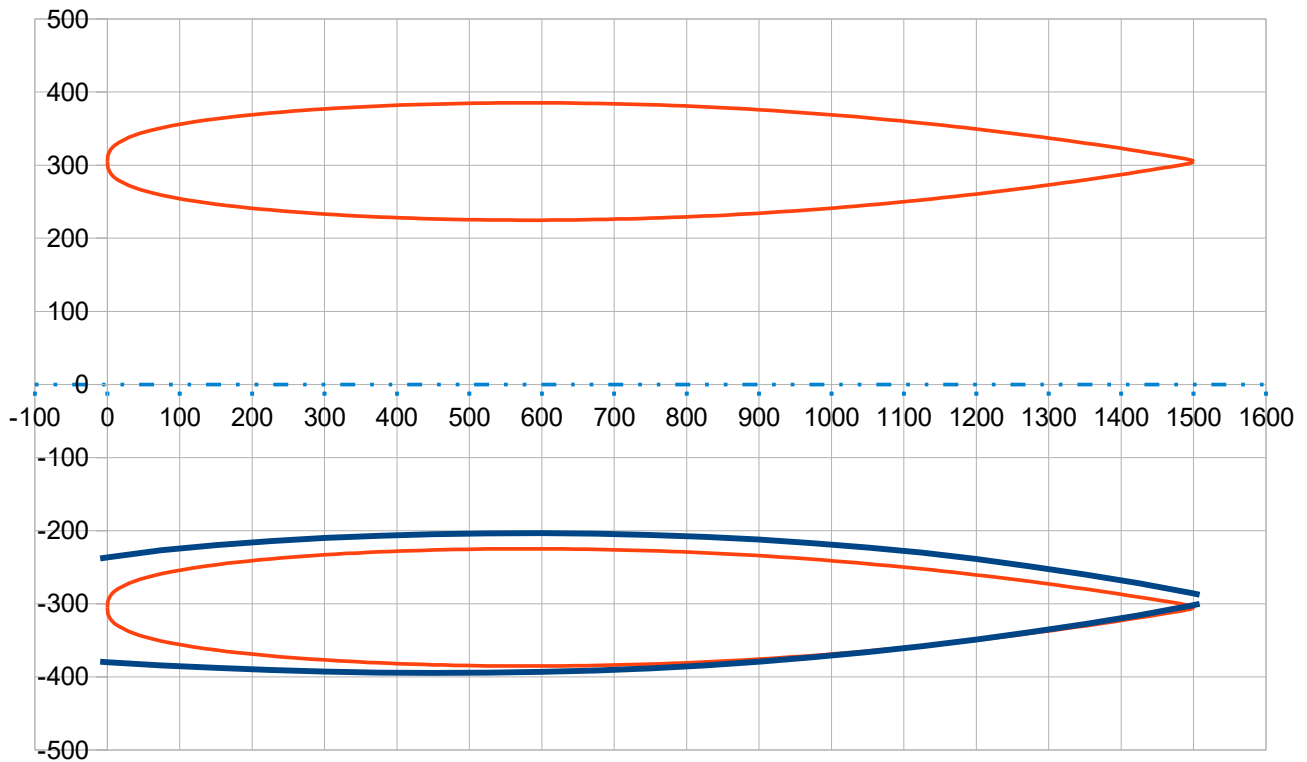


>>> at heel 12° :

Data to enter	Results for leeward hull	Results for windward hull	Results for the 2 hulls	and to to compare with :
Heel (°) 12,0	%Disp 0,99	%Disp 0,01	Disp. (m3) 16,15712	/ Disp. (m3) 16,15711
Height (cm) 21,3907	Disp. (m3) 16,07197	Disp. (m3) 0,08516	Xc heel (m) 6,795	/ Xg (m) 6,795
Trim (°) -0,425	Xc heel (m) 6,801	Xc heel (m) 5,648	Other results	GZ & RM (Crew sit windward)
	Other results	Other results	Yc heel (m) -2,903	Hull Mom(m4) 46,654
	Yc heel (m) -2,918	Yc heel (m) 0,000	Zc heel (m) -0,435	Mom(kN.m) 469,12
	Zc heel (m) -0,432	Zc heel (m) -1,124	Sw (m2) 43,25	Yg heel (m) -0,337
	Sw (m2) 39,73	Sw (m2) 3,51		GZ (m) 2,566
	Sf (m2) 22,45	Sf (m2) 0,00		RM (kN.m) 416,88
	Lwl (m) 16,00	Lwl (m) 0,00	Relevant only at Heel = 1° equilibrium	
	Bwl (m) 1,91	Bwl (m) 0,00	Yg heel (m) -0,443	with crew at center
	Tc (m) 1,18	Tc (m) 0,00	Gz (m) 2,460	
	Cp 0,619	Cp #DIV/0 !	>> GM1° (m) 'Put Heel 1°	
	LCB (%Lw) 47,2	LCB (%Lw) #DIV/0 !		
	Lwl/Bwl 8,39	Lwl/Bwl #DIV/0 !		
	Bwl/Tc 1,62	Bwl/Tc #DIV/0 !		
	Lw/D^1/3 6,34	Lw/D^1/3 0,00		

The displacement repartition is 0,01 D for the leeward hull (actually the volume of the windward daggerboard, as the hull is fully emerged) and 0,99 D for the windward hull. In blue are all the other output data for each hull. The overall righting moment RM is 417 kN.m (it is the maximum value) and the overall wetted surface Sw is 43,25 m2. The trim is -0,425°.

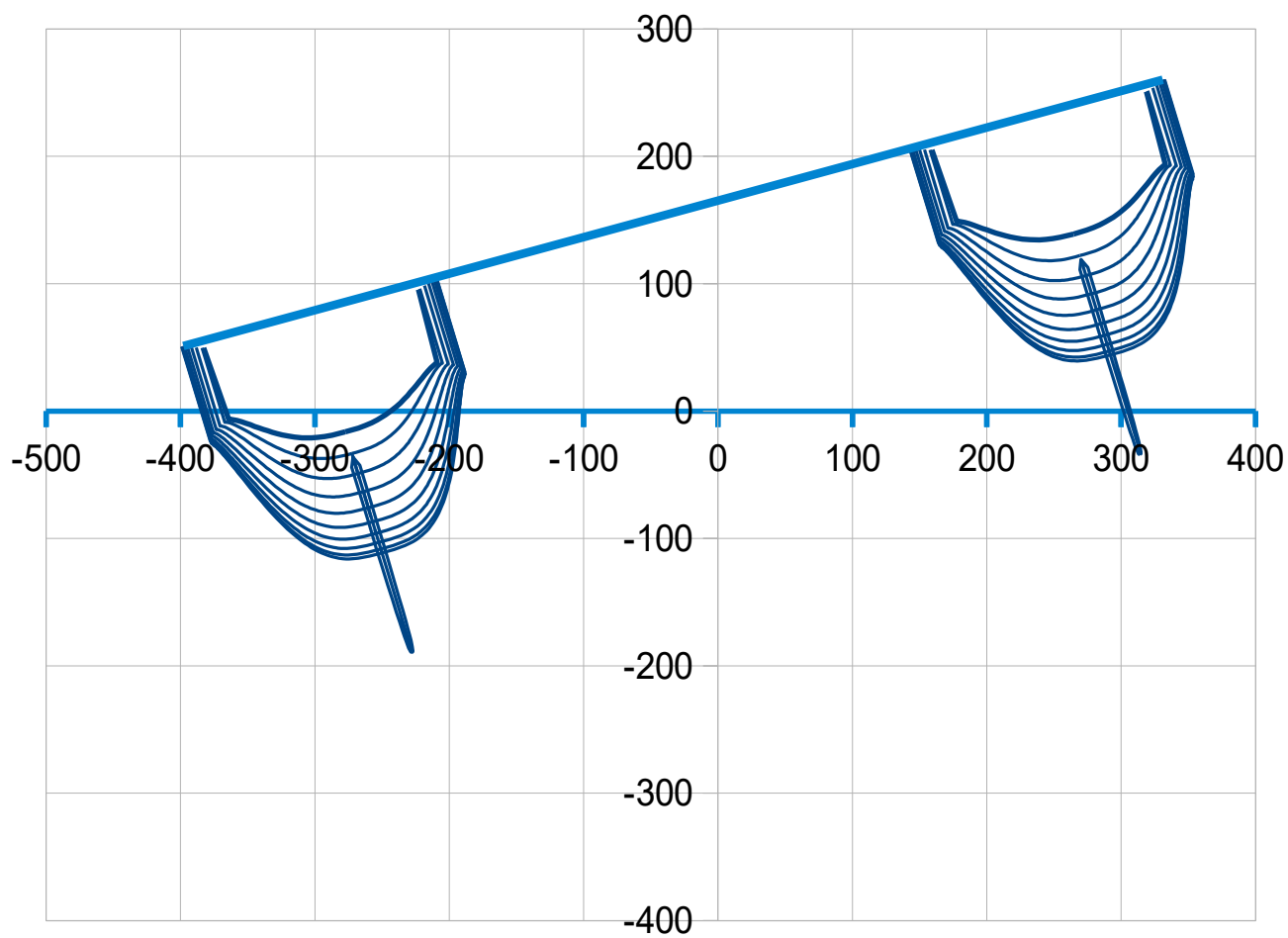
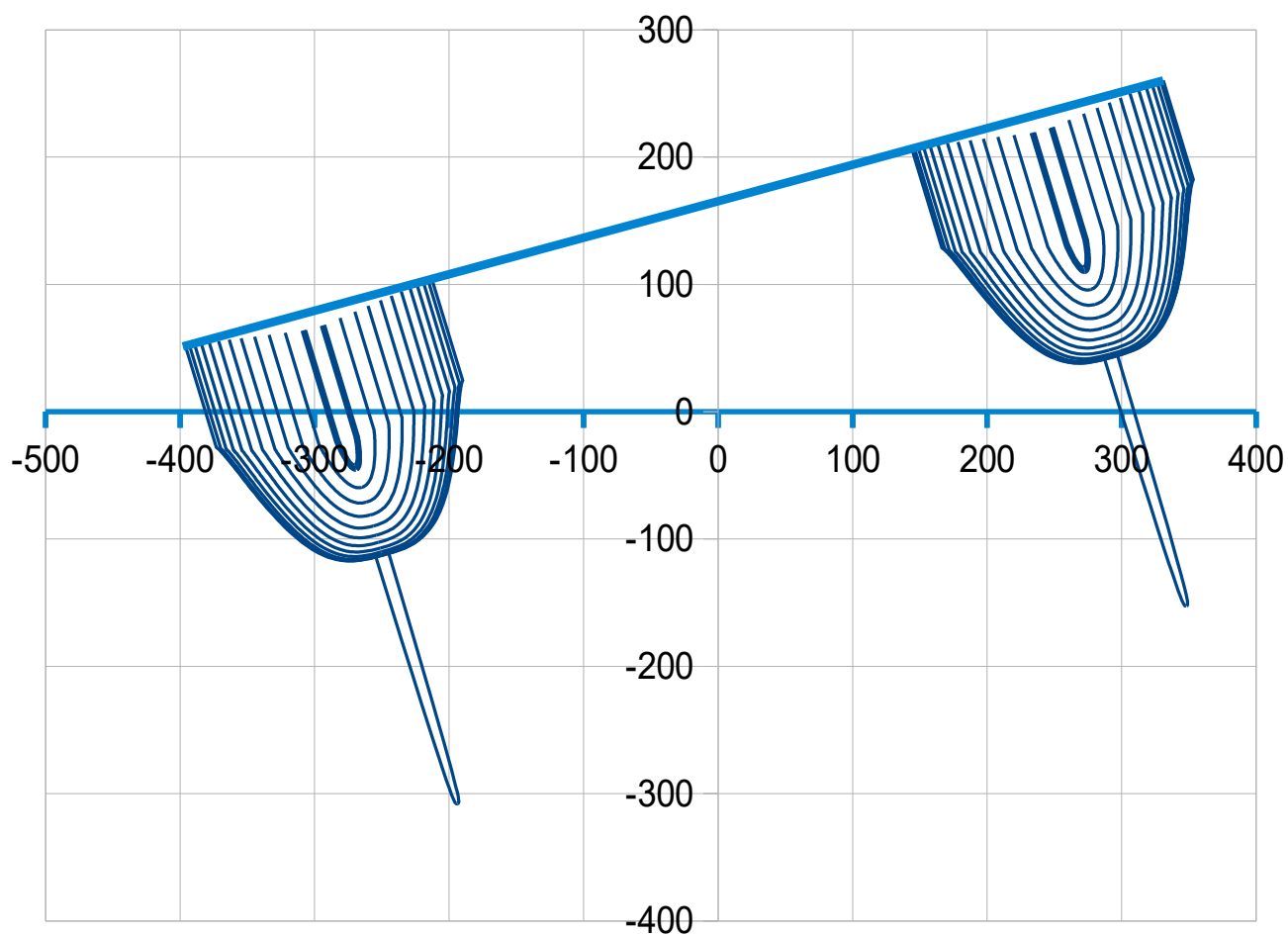


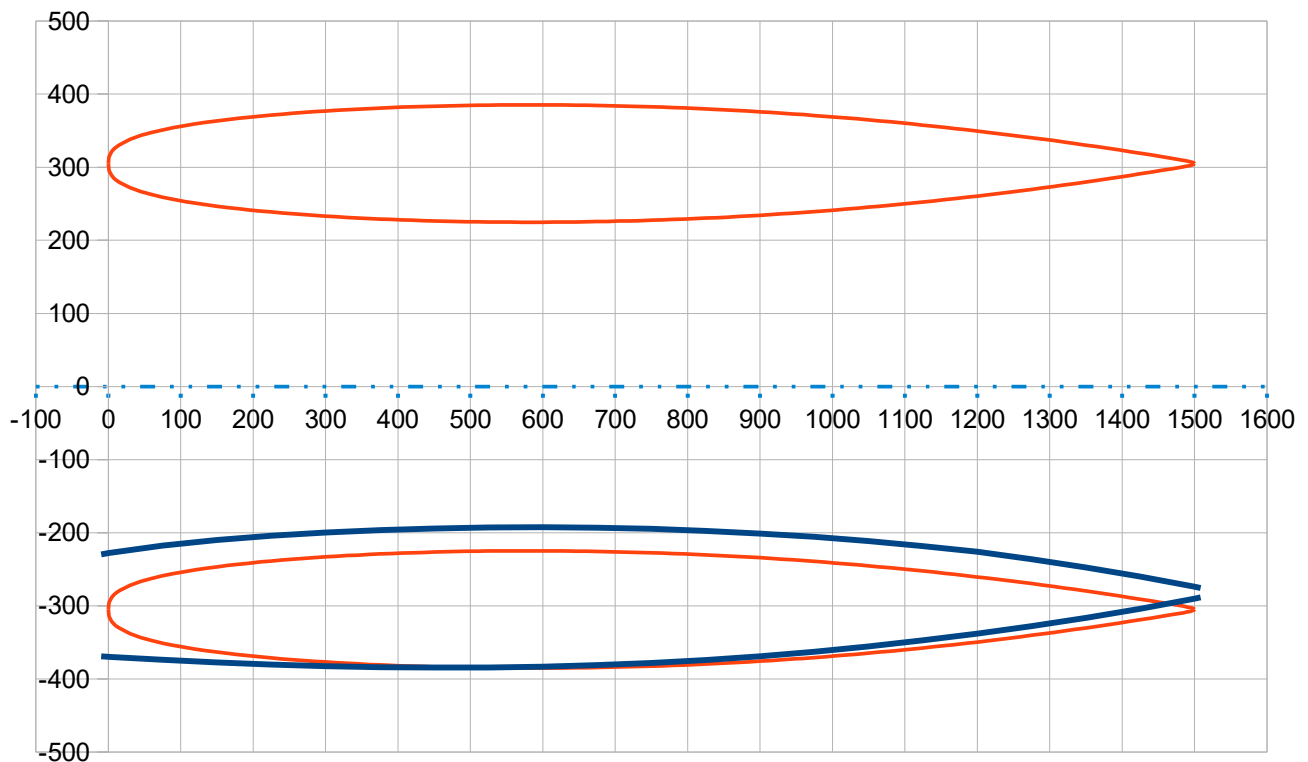


>>> at heel 16° :

Data to enter	Results for leeward hull	Results for windward hull	Results for the 2 hulls	and to to compare with :
Heel (°) 16,0	%Disp 0,99	%Disp 0,01	Disp. (m3) 16,15712	/ Disp. (m3) 16,15711
Height (cm) 40,5246	Disp. (m3) 16,07197	Disp. (m3) 0,08516	Xc heel (m) 6,795	/ Xg (m) 6,795
Trim (°) -0,470	Xc heel (m) 6,801	Xc heel (m) 5,647	Other results	GZ & RM (Crew sit windward)
	Other results	Other results	Yc heel (m) -2,779	Hull Mom(m4) 44,659
	Yc heel (m) -2,793	Yc heel (m) 0,000	Zc heel (m) -0,428	Mom(kN.m) 449,06
	Zc heel (m) -0,426	Zc heel (m) -0,909	Sw (m2) 42,52	Yg heel (m) -0,483
	Sw (m2) 39,01	Sw (m2) 3,51		GZ (m) 2,296
	Sf (m2) 22,53	Sf (m2) 0,00		RM (kN.m) 372,96
	Lwl (m) 16,00	Lwl (m) 0,00	Relevant only at Heel = 1° equilibrium	
	Bwl (m) 1,91	Bwl (m) 0,00	Yg heel (m) -0,588	with crew at center
	Tc (m) 1,17	Tc (m) 0,00	Gz (m) 2,191	
	Cp 0,619	Cp #DIV/0 !	>> GM1° (m) 'Put Heel 1°	
	LCB (%Lw) 47,2	LCB (%Lw) #DIV/0 !		
	Lwl/Bwl 8,36	Lwl/Bwl #DIV/0 !		
	Bwl/Tc 1,63	Bwl/Tc #DIV/0 !		
	Lwl/D^1/3 6,34	Lwl/D^1/3 0,00		

The displacement repartition is 0,01 D for the leeward hull and 0,99 D for the windward hull. The overall righting moment RM is 373 kN.m (the windward hull is clearly off the water and the RM is already less than for heel 12°) and the overall wetted surface Sw is 42,52 m2. The trim is -0,47°.





Step 6 : Performance estimation with « SA-VPP Catamaran 1.0 »

The input data (prepared within Gene-Hull Catamaran 3.0)

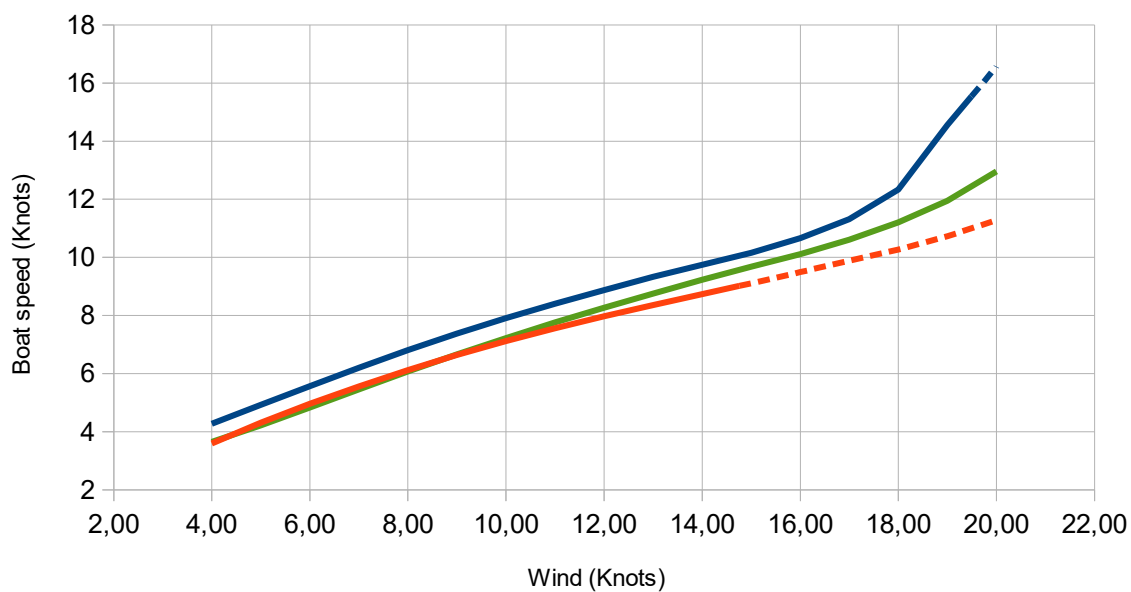
For SA-VPP	Heel (°)	Lwl (m)	Bwl (m)	Tc (m)	Cp	LCB (%Lwl)	Sf (m2)	Sw tot (m2)	Disp. (m3)	RM (kN.m)
Lee Hull	0,0	15,32	1,62	0,79	0,563	46,4	17,82	29,67	8,079	17,658
Wind Hull	0,0	15,32	1,62	0,79	0,563	46,4	17,82	29,67	8,079	
Lee Hull	4,0	16,00	1,77	0,98	0,583	46,9	20,50	36,26	11,758	219,024
Wind Hull	4,0	13,13	1,42	0,56	0,576	44,1	13,73	21,60	4,399	
Lee Hull	8,0	16,00	1,89	1,12	0,609	47,0	22,08	39,58	14,760	372,834
Wind Hull	8,0	9,90	1,12	0,29	0,602	44,5	8,34	13,01	1,397	
Each daggerboard				Each rudder			Hull beam	Hulls axis space		
Vol. (m3)	Sw (m2)	Chord (m)	Draft (m)	Vol. (m3)	Sw (m2)	Chord (m)	Boa (m)	Space (m)		
0,06612	2,37	0,70	2,80	0,01904	1,15	0,40	1,97	6,10		
From the Sailplan sheet :							Adjustments			
SA (m2)	ZCE (m)	Zdeck (m)	Zmast (m)	Main (m2)	Spi (m2)	ZCE spi (m)	Reefing	Flat mini	Windward daggerboard	
147,15	9,11	1,15	22,72	81,50	229,78	10,54	1,00	0,5	1,0	

Output figures :

The figures are provided automatically, here below presented with the boat C1 as example. The dashed lines are used when the windward hull displacement is less than 30% of the total, indicating that it is a more tricky sailing which requires either more attention from the crew or a sail area reduction.

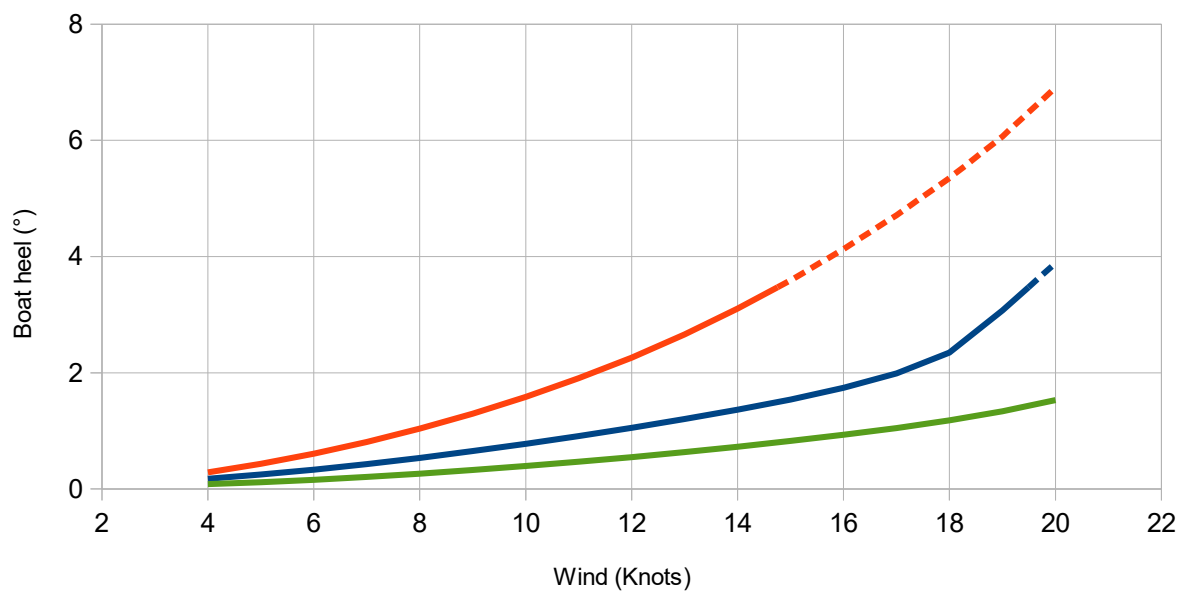
SA-VPP Cata : Speed results

Red : upwind ; Blue : reaching twa 90° ; Green : downwind with spi twa 135°
Continue lines : %D windward hull > 30% ; Dashed lines : %D windward hull < 30%



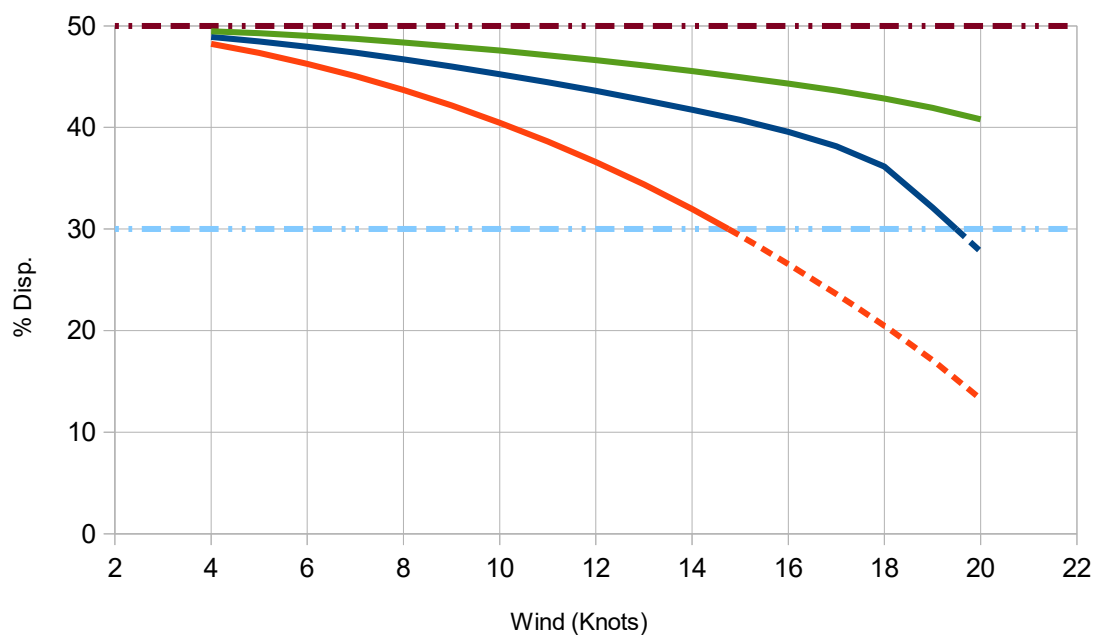
SA-VPP Cata : Heel results

Red : upwind ; Blue : reaching twa 90° ; Green : downwind with spi twa 135°
Continue lines : %D windward hull > 30% ; Dashed lines : %D windward hull < 30%

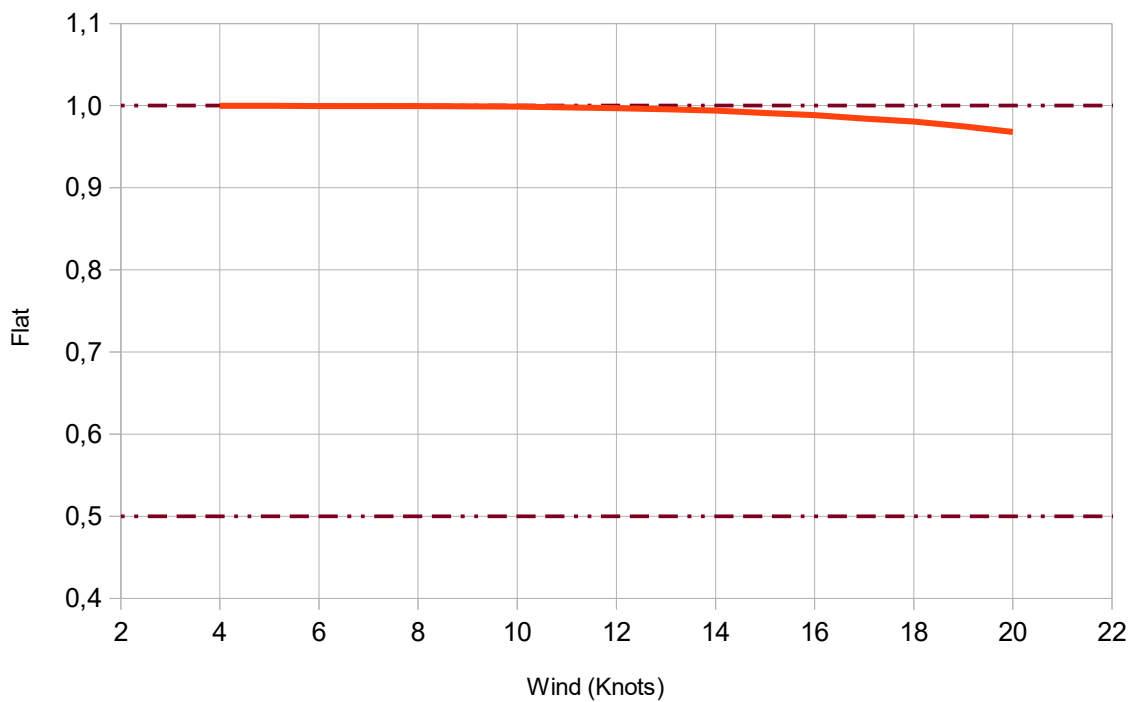


SA-VPP Cata : % of Displacement supported by the windward hull

Red : upwind ; Blue : reaching twa 90° ; Green : downwind with spi twa 135°

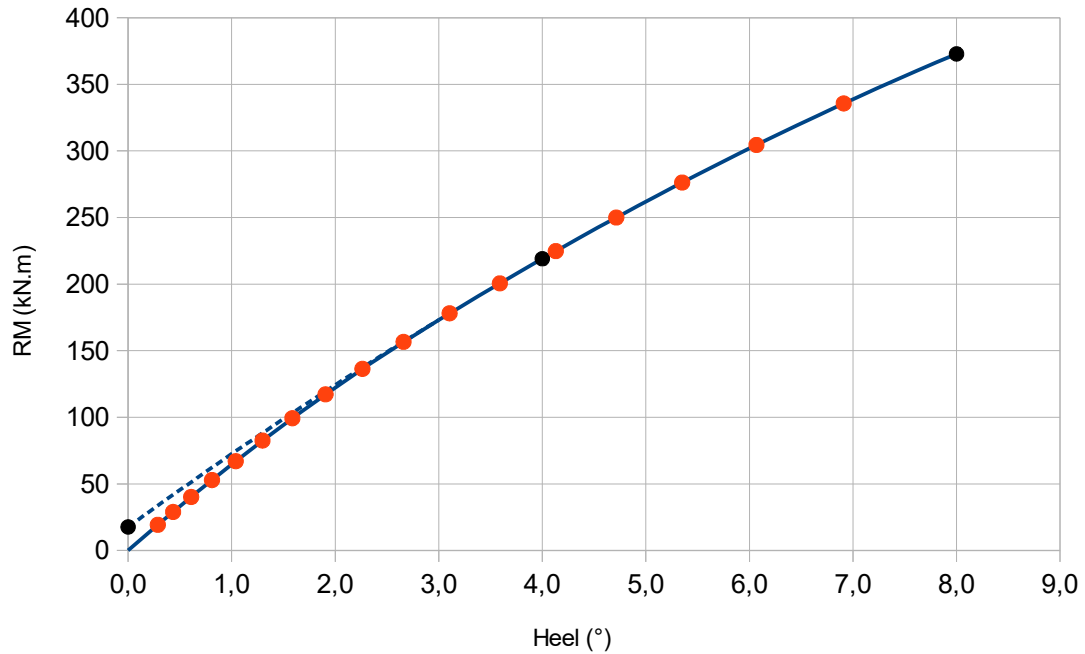


SA-VPP cata : Optimal Flat when upwind



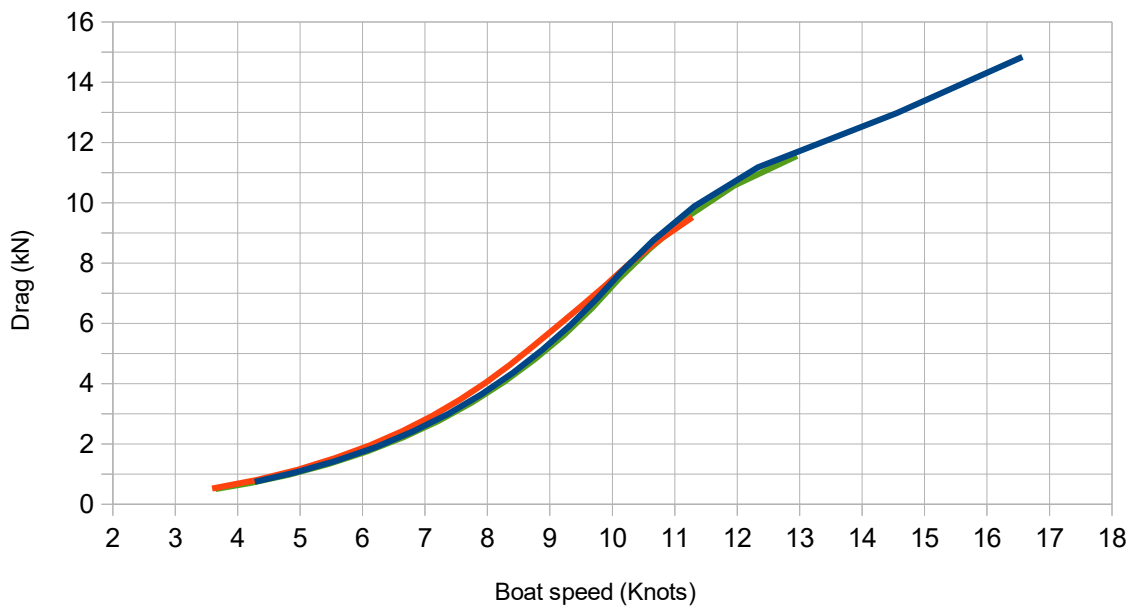
SA-VPP : Righting Moment RM versus heel angle

Black points : RM input values ; Blue : RM programmed function
Red points : SA-VPP output when upwind



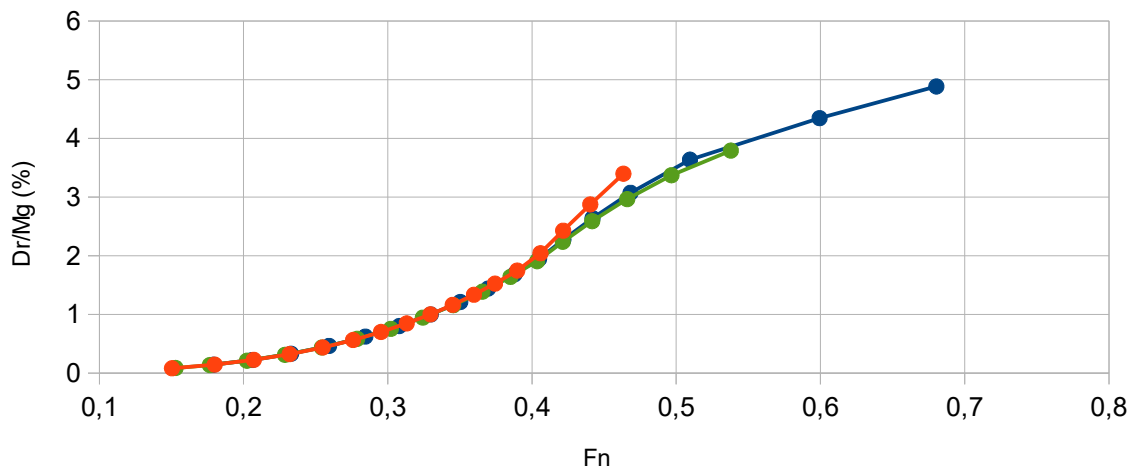
SA-VPP : Drag versus boat speed

Red : Upwind ; Blue : reaching twa 90° ; Green : downwind with spi twa 135°



Residuary drag Dr/Mg (%) of the leeward hull

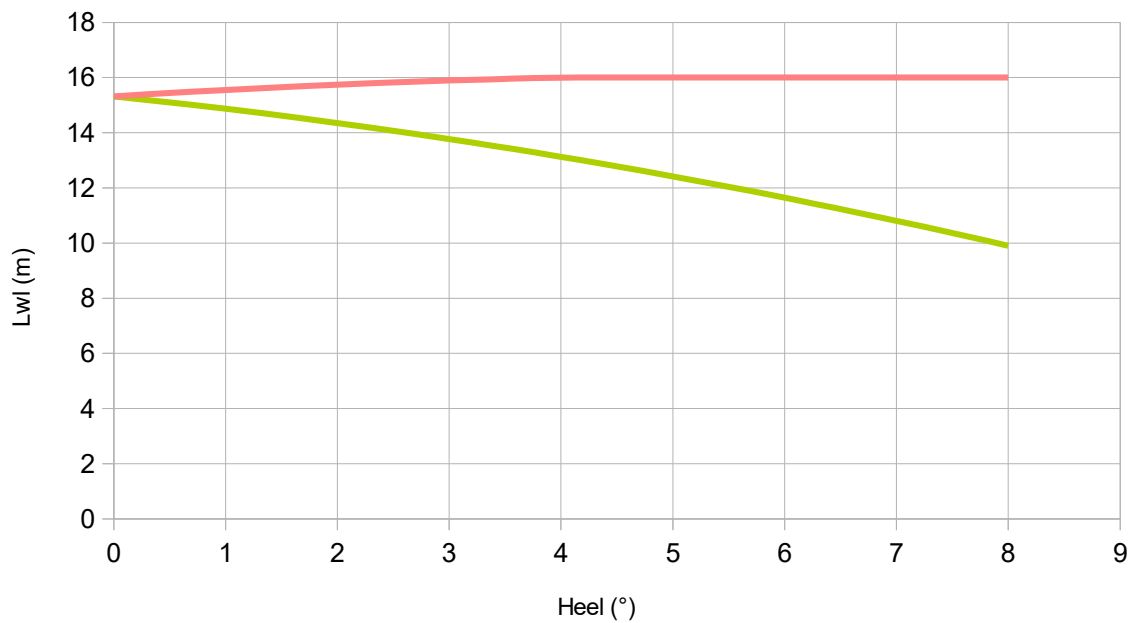
Red : upwind ; Blue : reaching twa 90° ; Green : downwind with spi twa 135°



Other figures about parameters of each hull for the heeled catamaran :

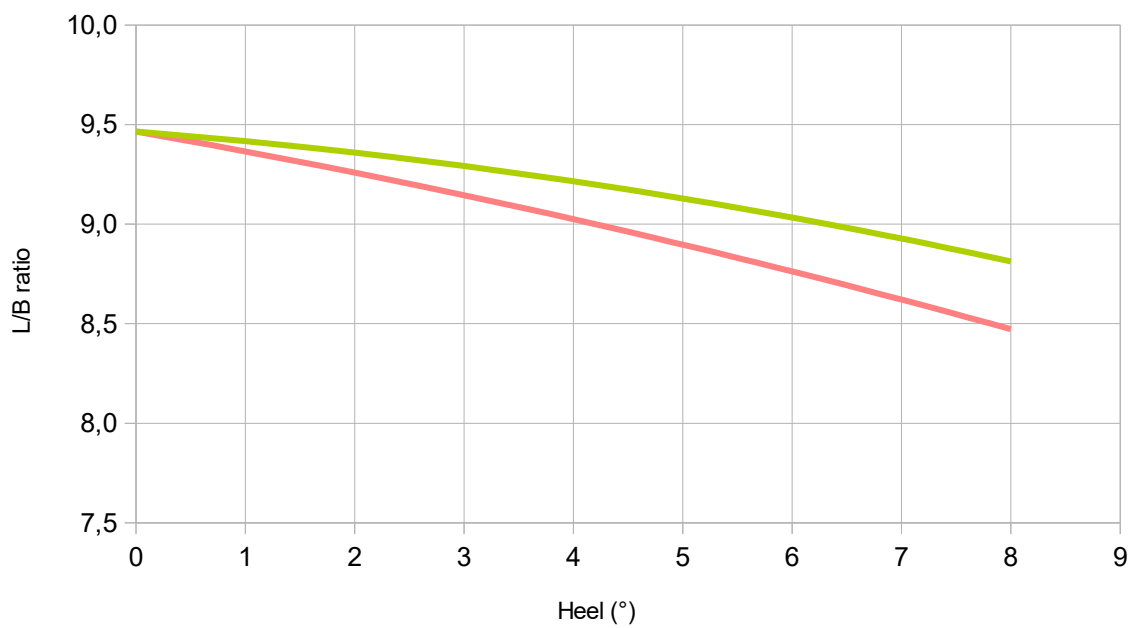
Hull Lwl (m)

Pink : leeward hull ; Green : windward hull



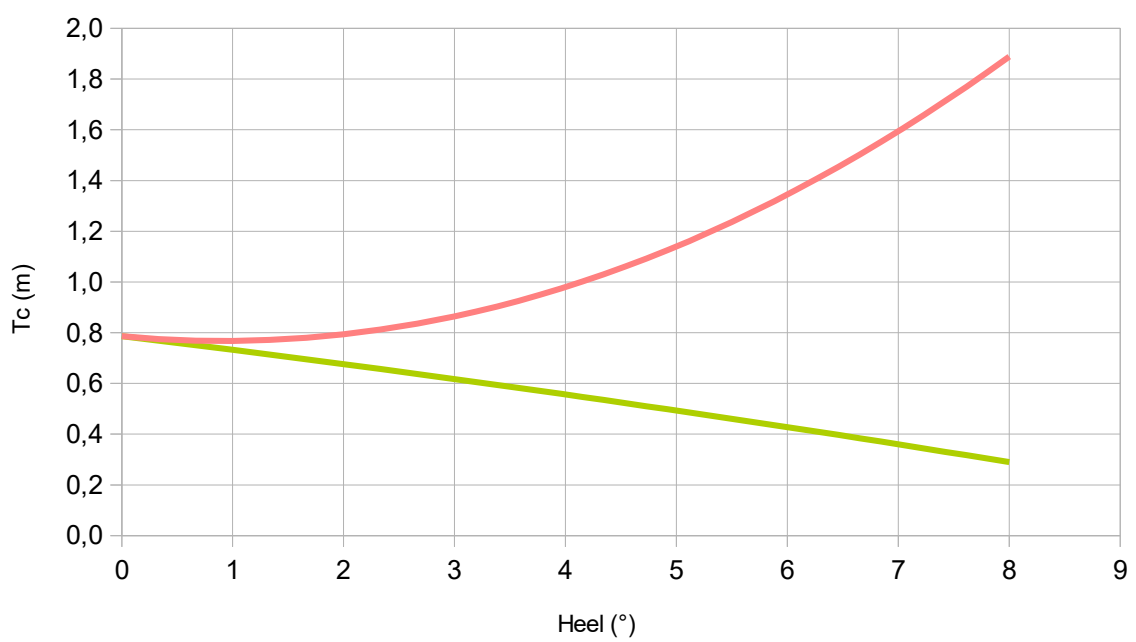
Hull Lwl/Bwl

Pink : leeward hull ; Green : windward hull



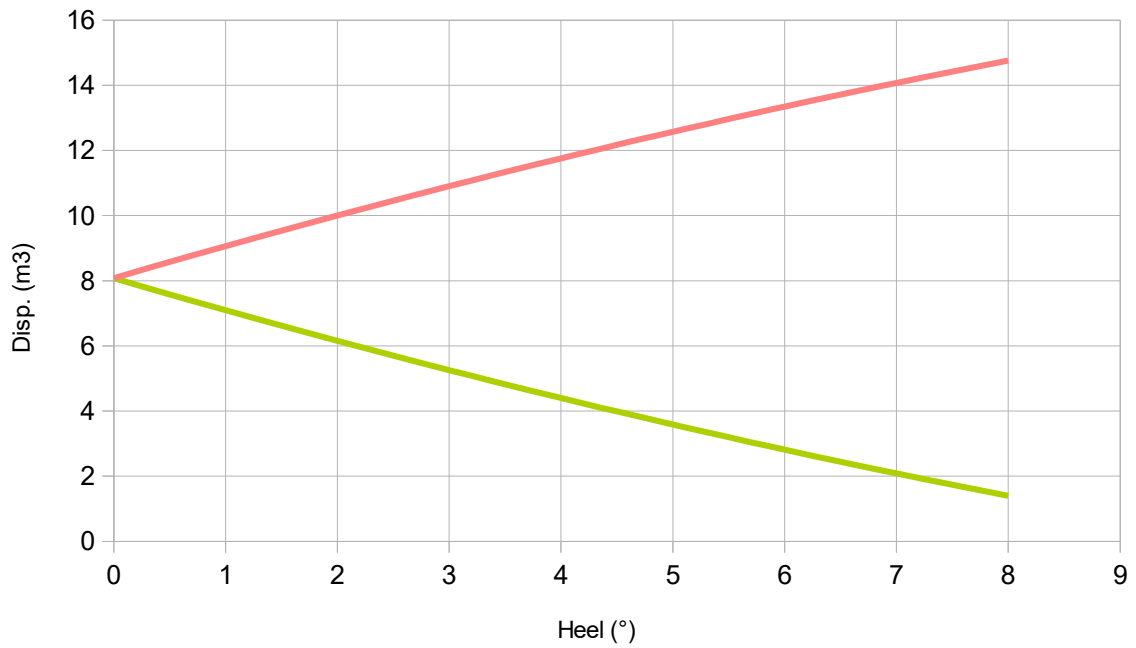
Hull bodies draft Tc (m)

Pink : leeward hull ; Green : windward hull



Hull displacements (m3)

Pink : leeward hull ; Green : windward hull



Sw hull bodies

Pink : leeward hull ; Green : windward hull

