2018-11-05

Canoes F17 and C18 V3 comparison

Canoe F17 is a free interpretation inspired by Freedom 17, according to data as given at @4,25" waterline from :

https://www.bearmountainboats.com/products/freedom-17

Canoe C18 V3 is a free interpretation inspired by Cirrus 18, according to data (given at @4" waterline ?), from :

http://www.greenval.com/cirrus.html

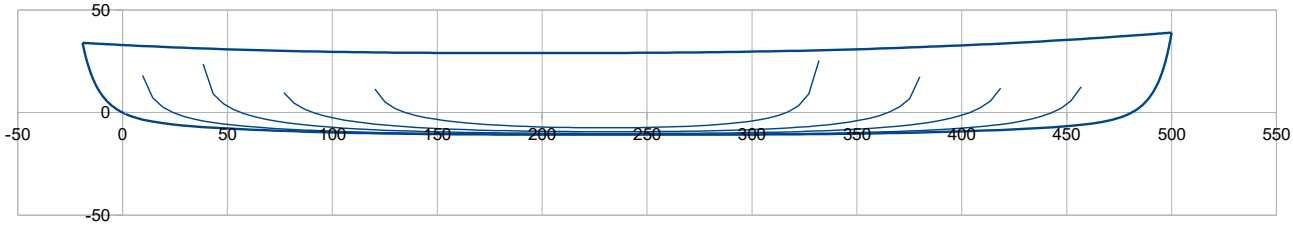
Canoe F17 :

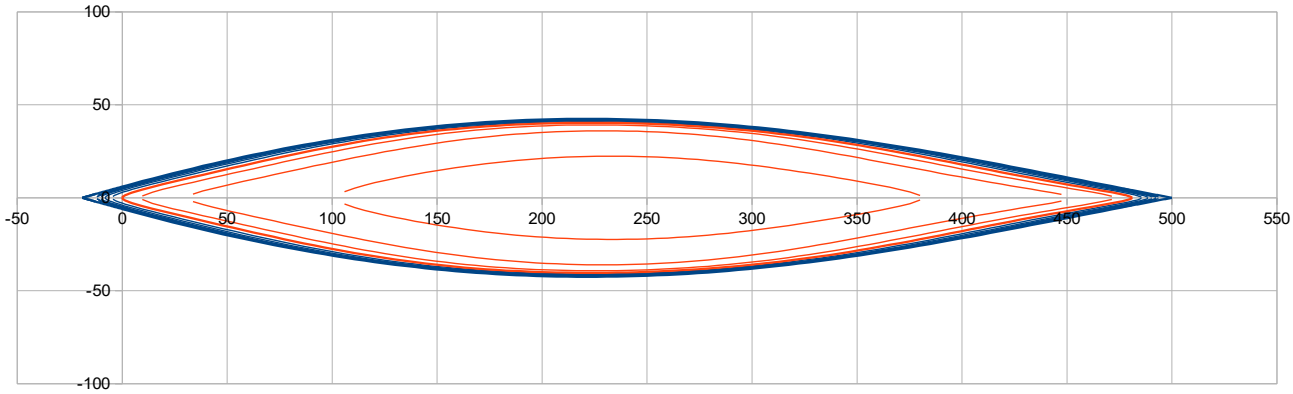
Loa : 5,19 m (17') ; Boa : 0,849 m (33,43")

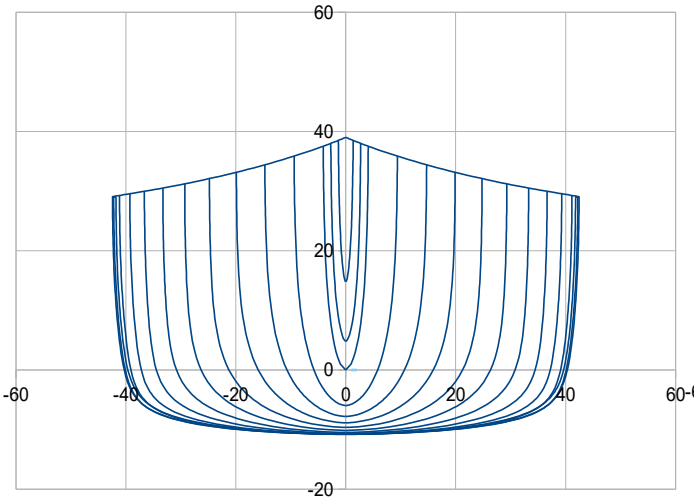
At 4,25" waterline (as drawn here below) :

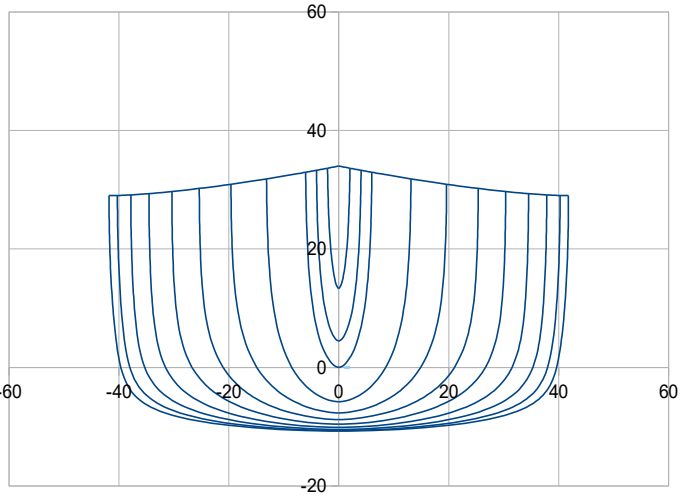
Lwl : 4,81 m (15,78') ; Bwl : 0,8065 m (31,75") ; Cp : 0,567 ; LCB : 48,5 %Lwl

Sw : 2,79 m2 (30,04 sq.ft.) ; Displacement : 200,1 kg (441 lbs)









Hydrostatics data at waterline H0 = 4,25" :

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

Hull

Loa (m)	**5,190**	**Lwl (m)**	**4,81**	> Lwl/D^(1/3)	8,22	Fn at 5 mph	0,325		
>> ft	***17,03***	***>> ft***	***15,78***	*DLR*	*50*	*M(lbs/2240)/(Lwl(ft)/100)^3*			
B (m)	**0,849**	**at X (% Lwl)**	**46,2**						
>> inch	***33,43***								
Bwl (m)	**0,8065**	**at X (% Lwl)**	**46,0**	> Bwl / B	0,950				
>> inch	***31,75***					**Freeboards (m) >**	**Aft**	**Midship**	**Fore**
Tc (m)	**0,108**	**at X (%Lwl)**	**50**				**0,34**	**0,29**	**0,39**
>> inch	***4,25***					***>> inch***	***13,39***	***11,42***	***15,35***
Displacement at H0 (m3)		**0,20009**	**at Xc (m)**	**2,332**	**Xc (%Lwl)**	**48,48**	**Zc (m)**	**-0,044**	
(kg)		**200,09**	*>> ft*	*7,65*			*>> inch*	*-1,75*	
>> lbs		***441,0***	*with water mass / vol. of*		*1000*	*kg/m3*			
Cp (%)	**56,71**								
Sf (m2)	**2,50**	**at Xf (m)**	**2,316**	**Xf (%Lwl)**	**48,15**	>>> Xc – Xf (%Lwl)	0,32		
>> ft2	*26,89*	*>> ft*	*7,60*						
Angle immersed sheer li (°)		**34,8**	at section C4 (40% Lwl)						
Sw (m2)	**2,79**	>Sw/D^(2/3)	8,16						
>> ft2	*30,06*								
Shull (m2)	**5,97**	**at X (m)**	**239,49**	**Z (m)**	**0,05**				
>> ft2	*64,31*	*>> ft*	*785,71*	*>> ft*	*0,15*				

Simplified mass spreadsheet with the payload 170,15 kg (375 lbs) :

Assuming an average weight unit of 4,18 kg/m2 of hull surface (0,856 lbs/sq.ft.)

Simplified Mass spreadsheet

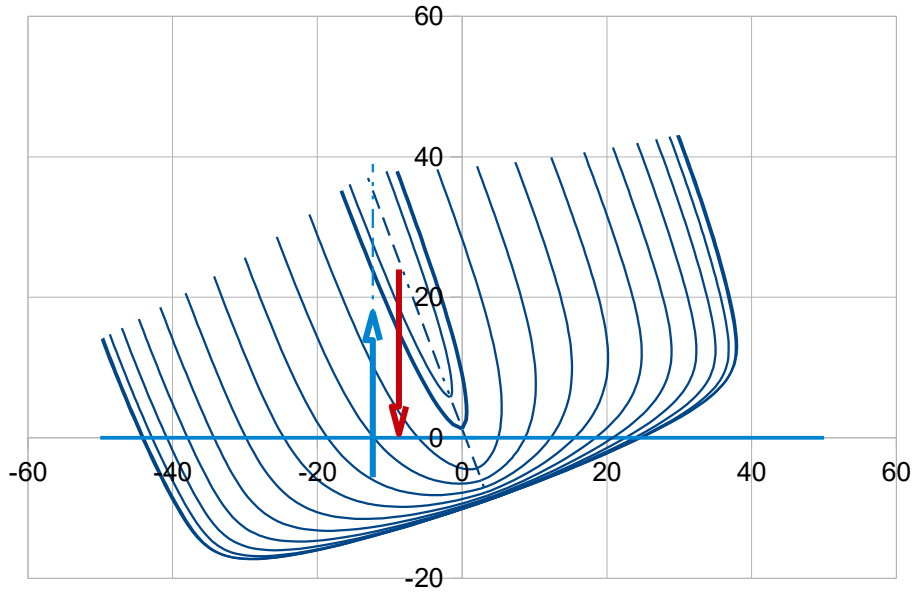
	Hull weight unit (kg/m2)	Mass (kg)	Zg (/H0) (m)	Zg (m)
Canoe (kg)	**4,18**	24,97	**0,05**	0,048
Load (kg)		**170,15**	**0,27**	0,272
M tot (kg)		**195,1**		
Zg tot (m)				**0,243**

>>> canoe weight : 24,97 kg (55 lbs) and total displacement with load : 195,1 kg (430 lbs)

GM at total displacement, at Heel 0,1° (initial stability) et 20° :

Data to enter		**Results**					
Heel (°)	**0,1**	Disp. Heel 0°	**0,20009**	**Disp tot(m3)**	**0,19512**		
Height (cm)	**0,2013**	**> Disp. (m3)**	**0,19512**	>> Lwl (m)	4,802	>> Bwl (m)	0,802
		Xc (m)	2,33	/ Xc Heel 0°	2,33	>> Draft (m)	0,106
		Yc (m)	0,00	/ Yc Heel 0°	0,00	Ym (m)	0,00
		Zc (m)	-0,04	/ Zc Heel 0°	-0,04	>> GZ (m)	0,0003
		>> Sw (m2)	2,79	/ Sw Heel 0°	2,79	**GM (cm)**	**16,6**
						(inch)	*6,54*

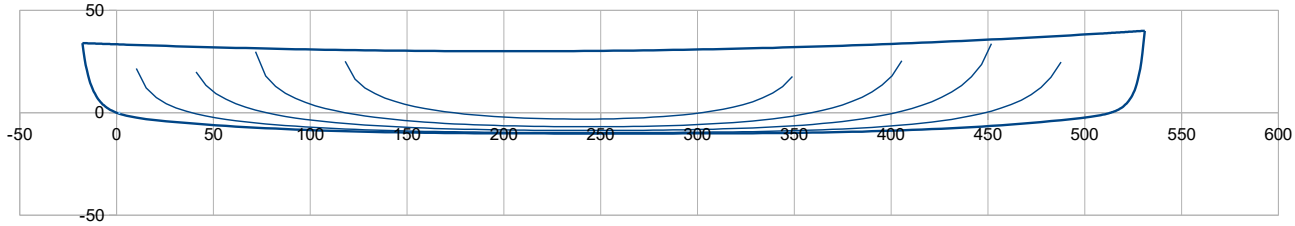
Data to enter		**Results**					
Heel (°)	**20,0**	Disp. Heel 0°	**0,20009**	**Disp tot(m3)**	**0,19512**		
Height (cm)	**1,3635**	**> Disp. (m3)**	**0,19512**	>> Lwl (m)	4,759	>> Bwl (m)	0,796
		Xc (m)	2,32	/ Xc Heel 0°	2,33	>> Draft (m)	0,094
		Yc (m)	-0,12	/ Yc Heel 0°	0,00	Ym (m)	-0,09
		Zc (m)	-0,06	/ Zc Heel 0°	-0,04	>> GZ (m)	0,0364
		>> Sw (m2)	2,58	/ Sw Heel 0°	2,79	**GM (cm)**	**10,6**
						(inch)	*4,19*

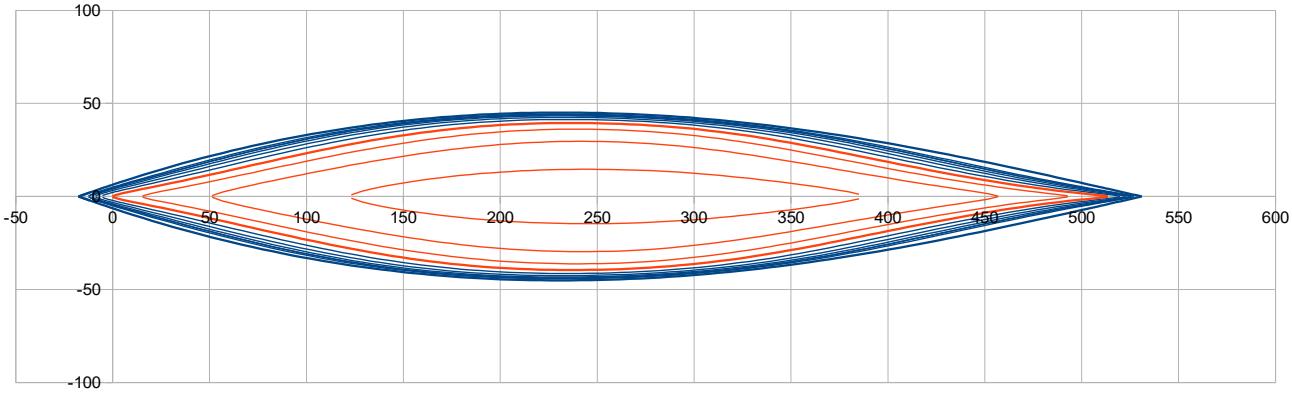


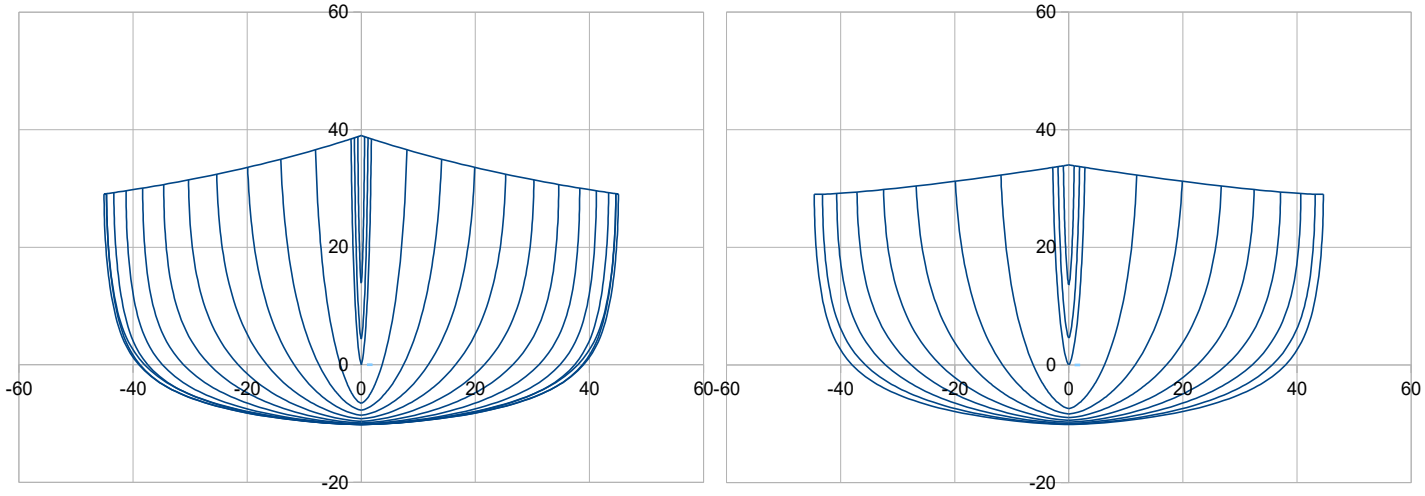
Canoe C18 V3 :

As there was no indication on the Cp, I take the opportunity to investigate on this value, and the lowest drag at around 5 mph is obtained with a Cp of 0,52 (below this value, we are outside the limit of validity of the residuary drag computation from Delft series). A slight reduction of the Lwl (at @ 4" waterline) also contributes to a drag reduction of the loaded canoe. I also pay attention to put the free boards and the Bwl/Lwl ratio in agreement with the Yukon 1000 rules. This version is named **C18 V3** :

Loa : 5,486 m (18') ; Boa : 0,902 m (35,50")
At 4" waterline (as drawn here below) :
Lwl : 5,13 m (16,84') ; Bwl : 0,7903 m (30,75") >>> Bwl/Lwl = 0,14406
Cp : 0,52 ; LCB : 47,65 %Lwl
Sw : 2,61 m2 (28,07 sq.ft.) ; Displacement : 158,51 kg (349,5 lbs)







Hydrostatics data at waterline H0 = 4" :

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

Hull

Loa (m)	**5,486**	**Lwl (m)**	**5,33**	> Lwl/D^(1/3)	9,70	Fn at 5 mph	0,309		
>> ft	***18,00***	***>> ft***	***17,50***	*DLR*	*31*	*M(lbs/2240)/(Lwl(ft)/100)^3*			
B (m)	**0,902**	**at X (% Lwl)**	**45,0**						
>> inch	***35,50***								
Bwl (m)	**0,7811**	**at X (% Lwl)**	**47,0**	> Bwl / B	0,866				
>> inch	***30,75***			**Freeboards (m) >**		**Aft**	**Midship**	**Fore**	
Tc (m)	**0,1016**	**at X (%Lwl)**	**50**			**0,34**	**0,29**	**0,39**	
>> inch	***4,00***				***>> inch***	***13,39***	***11,42***	***15,35***	
Displacement at H0 (m3)		**0,16634**	**at Xc (m)**	**2,550**	**Xc (%Lwl)**	**47,80**	**Zc (m)**	**-0,040**	
(kg)		**166,34**	*>> ft*	*8,37*			*>> inch*	*-1,56*	
>> lbs		***366,7***	*with water mass / vol. of*		*1000*	*kg/m3*			
Cp (%)	**54,04**								
Sf (m2)	**2,46**	**at Xf (m)**	**2,547**	**Xf (%Lwl)**	**47,75**	>>> Xc – Xf (%Lwl)		0,05	
>> ft2	*26,46*	*>> ft*	*8,36*						
Angle immersed sheer li (°)		**33,0**	at section C4 (40% Lwl)						
Sw (m2)	**2,72**	>Sw/D^(2/3)	8,99						
>> ft2	*29,26*								
Shull (m2)	**6,27**	**at X (m)**	**265,31**	**Z (m)**	**0,06**				
>> ft2	*67,46*	*>> ft*	*870,44*	*>> ft*	*0,19*				

Simplified mass spreadsheet with the payload 170,15 kg (375 lbs) :

Assuming an average weight unit of 4,18 kg/m2 of hull surface (0,856 lbs/sq.ft.)

Simplified Mass spreadsheet

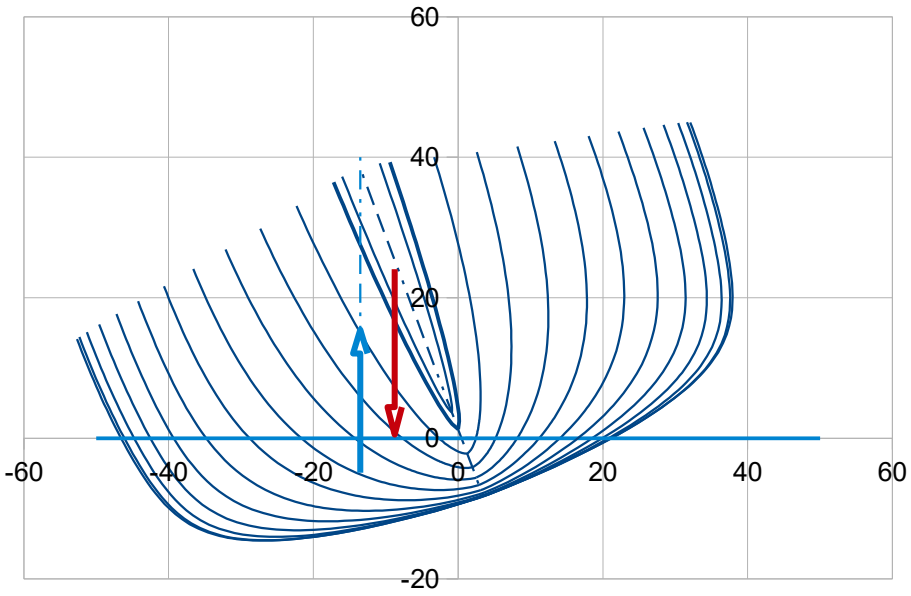
	Hull weight unit (kg/m2)	Mass (kg)	Zg (/H0) (m)	Zg (m)
Canoe (kg)	**4,18**	26,16	0,06	0,078
Load (kg)		**170,15**	**0,27**	0,284
M tot (kg)		**196,3**		
Zg tot (m)				**0,256**

>>> Canoe weight is 26,16 kg (57,7 lbs) and total displacement with load : 196,3 kg (432,6 lbs)

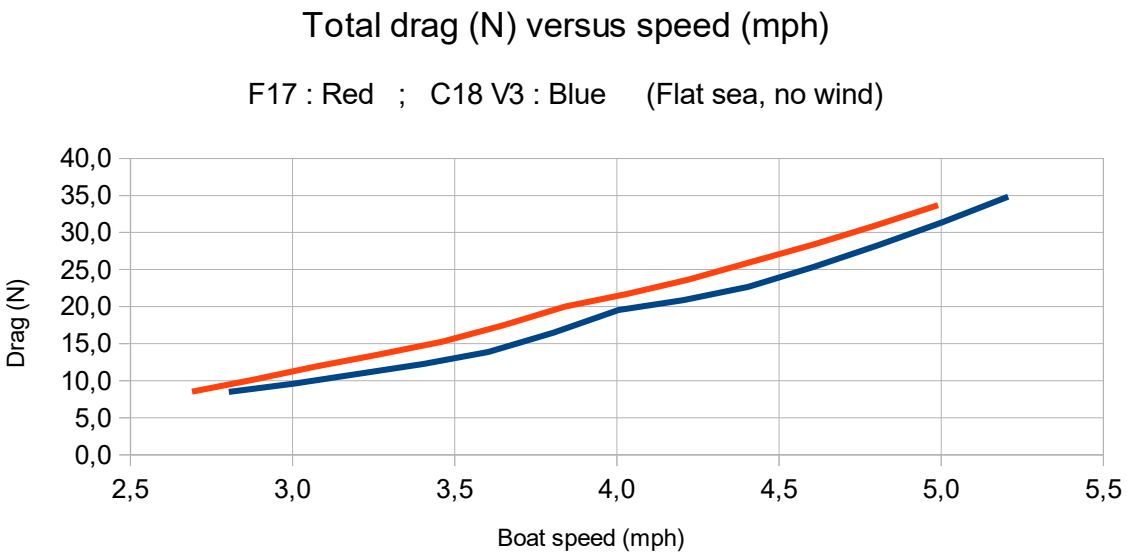
GM at total displacement, at Heel 0,1° et 20° :

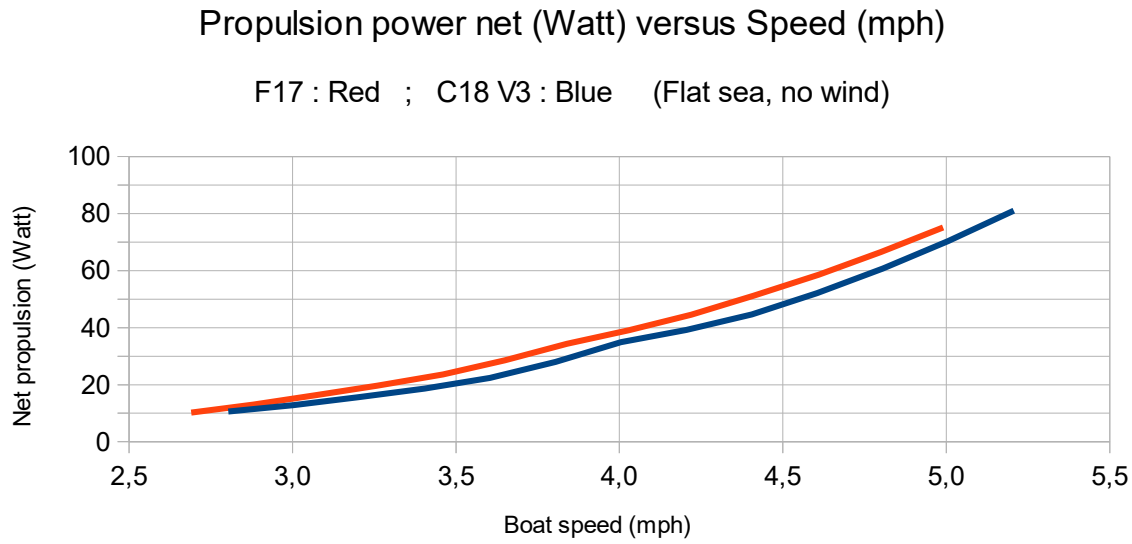
Data to enter		Results					
Heel (°)	**0,1**	Disp. Heel 0°	**0,15851**	**Disp tot(m3)**	**0,19631**		
Height (cm)	**-1,5277**	**> Disp. (m3)**	**0,19631**	>> Lwl (m)	5,225	>> Bwl (m)	0,808
		Xc (m)	2,44	/ Xc Heel 0°	2,45	>> Draft (m)	0,117
		Yc (m)	0,00	/ Yc Heel 0°	0,00	Ym (m)	0,00
		Zc (m)	-0,04	/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

Data to enter		Results					
Heel (°)	**20,0**	Disp. Heel 0°	**0,15851**	**Disp tot(m3)**	**0,19631**		
Height (cm)	**1,3635**	**> Disp. (m3)**	**0,16971**	>> Lwl (m)	5,051	>> Bwl (m)	0,762
		Xc (m)	2,43	/ Xc Heel 0°	2,45	>> Draft (m)	0,088
		Yc (m)	-0,14	/ Yc Heel 0°	0,00	Ym (m)	-0,09
		Zc (m)	-0,05	/ Zc Heel 0°	-0,04	>> GZ (m)	0,0477
		>> Sw (m2)	2,46	/ Sw Heel 0°	2,61	**GM (cm)**	**13,9**
						(inch)	*5,49*

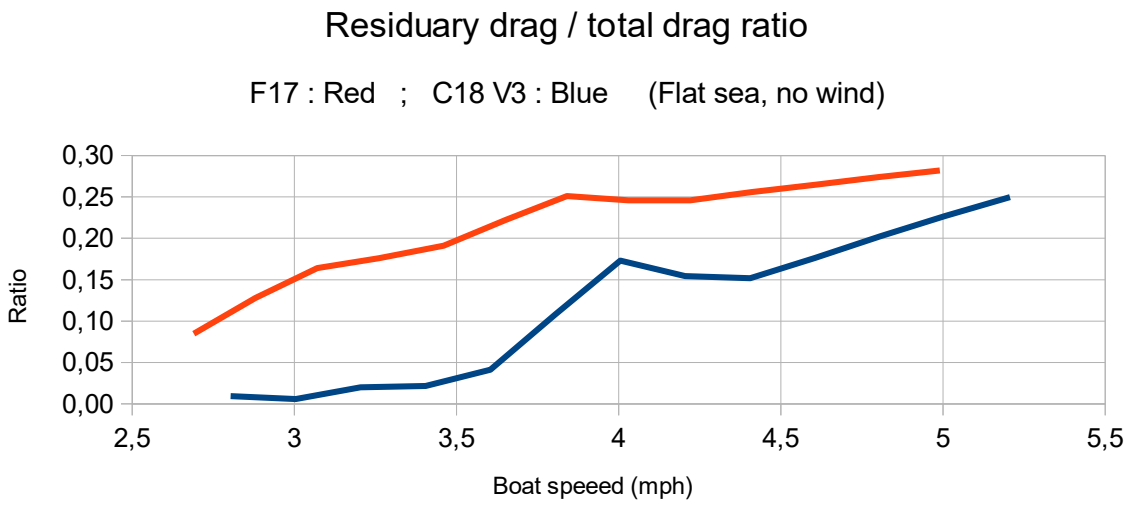


Drag and propulsion net power comparison :



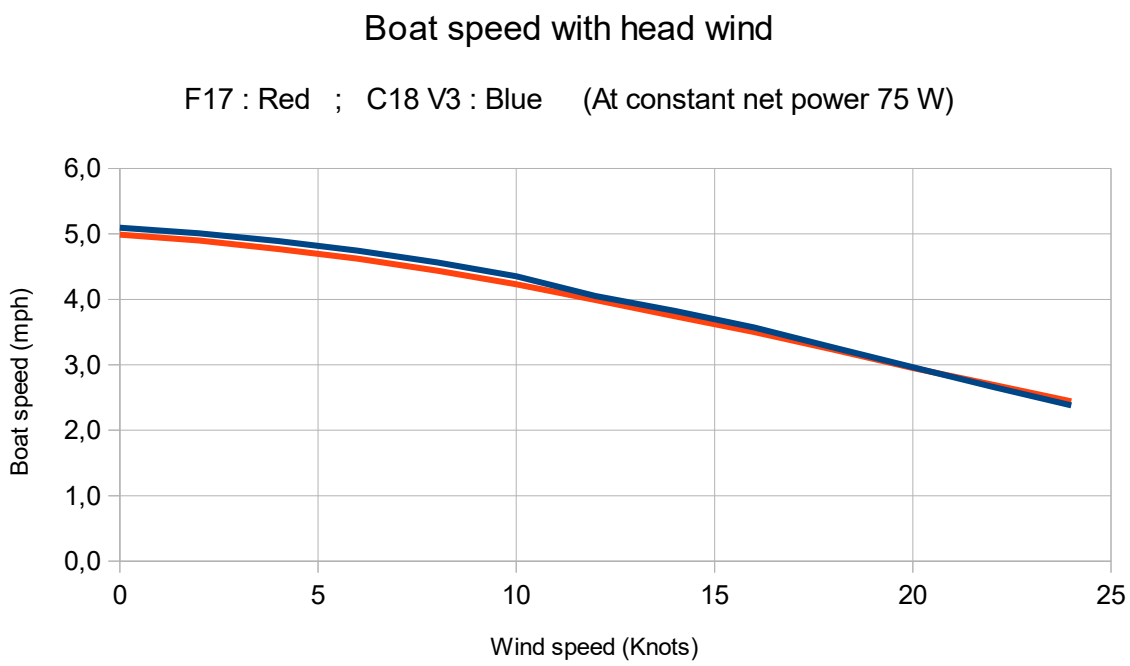


Residuary drag / Total drag ratio :



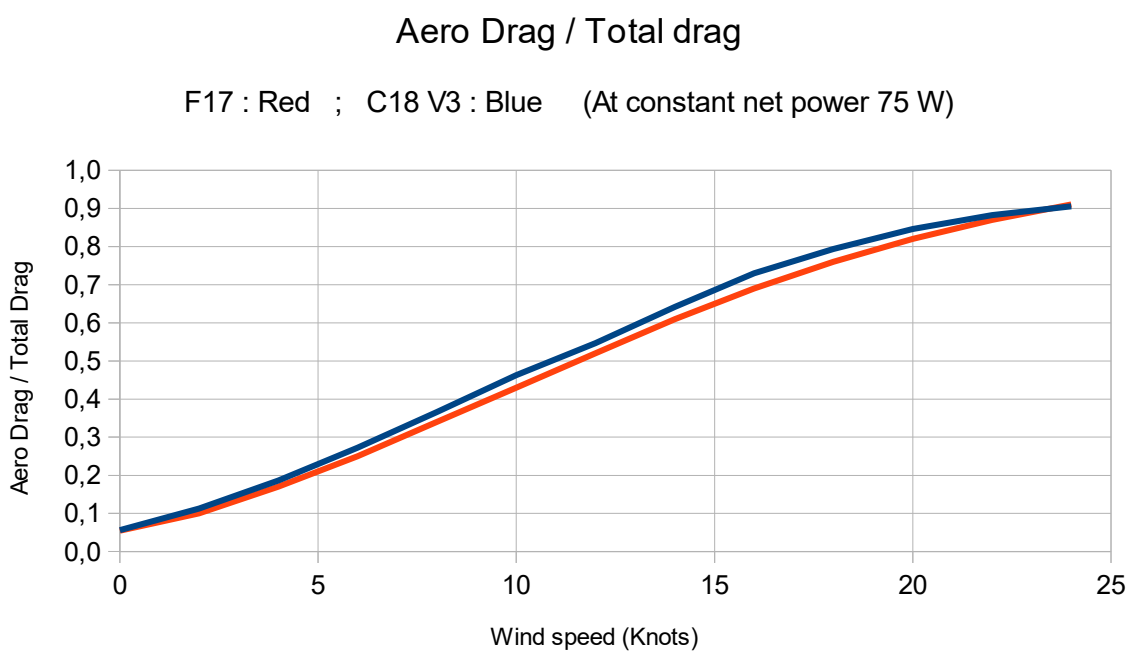
Boat speed comparison at constant propulsion net power and with head wind

For constant net power 75 W :



>>> with 12 knots of wind, the speed falls to 4 mph
>>> with 20 knots of wind, the speed falls to 3 mph

Aero drag / Total drag ratio at constant propulsion net power and with head wind :



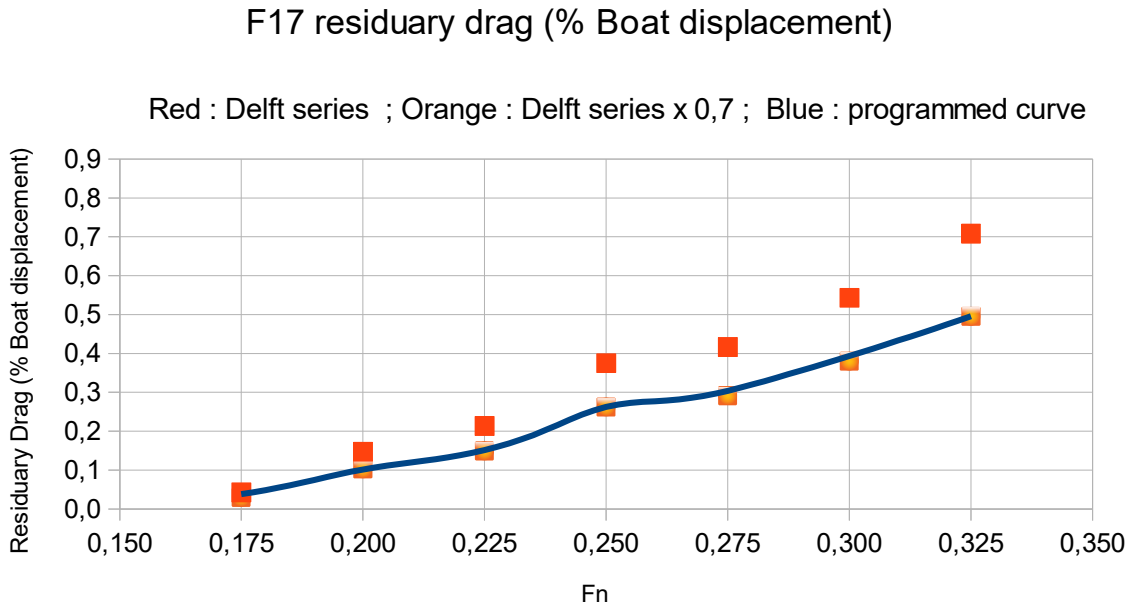
>>> with head wind 24 knots, the aero drag is 90% of the total drag.

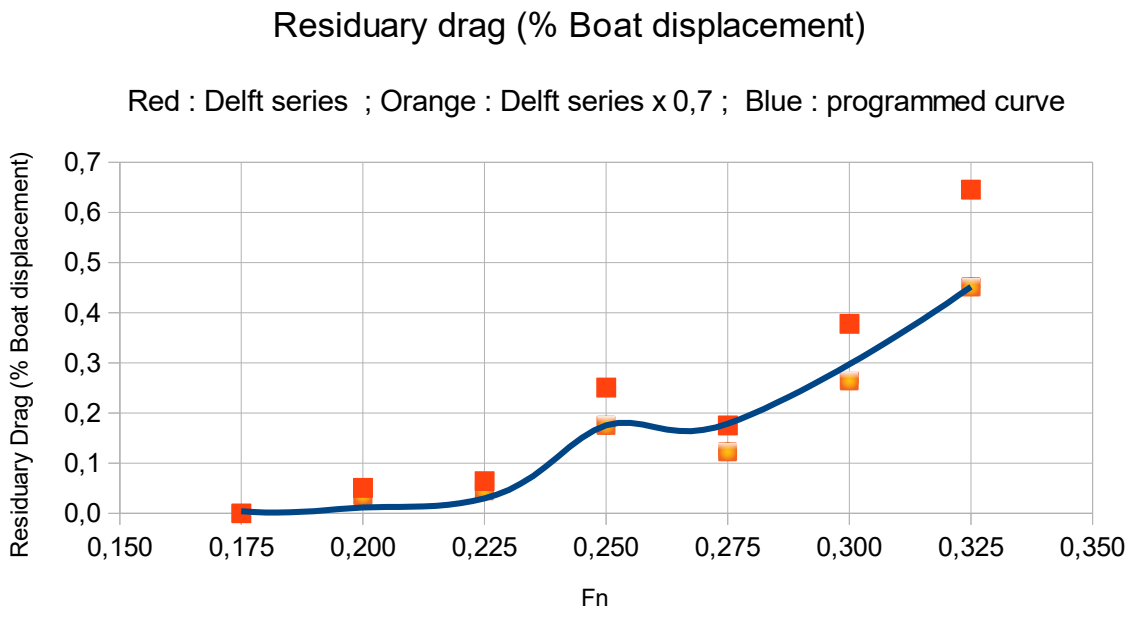
Annex : Drag components computation

For the Residuary drag adimensional curve :

With reference to the Delft series (as given in book « Principle of Yachts Design » L. Larsson and R. Eliasson, 2nd edition 2000), we consider :

- the range of Froude Fn 0,175 to 0,325
- a mitigation factor of 0,7 : to take into account the higher Lwl/Bwl ratio of the canoes (usually > 6) compared to the limit of use of these Delft curves (Lwl/Bwl limited to 5), The user can choose another factor.
- and a smooth formulation.





Other drag components are :

- frictional drag, based on the wetted surface of the canoe at their total displacement :
  Canoe 18'6" : 2,88 m2 ; Canoe 17' : 2,68 m2
  Friction coefficient : ITTC 57 formula with Re based on 0,7 Lwl

- aerodynamic drag, based on :
  - canoe : surface = Beam oa x Bow height and Cx = 0,5
  - 2 persons in paddling mode : surface = 2 x 0,37 m2 and Cx = 0,5