The Crouch Formula
- Quick Speed Estimates

Knowing how fast!

- We are always needing to estimate boat speed.
- New boat proposals, or existing craft with different power, or changed displacement.
- The main factors are weight and power, but hull size (length) is important, also – crudely, larger boats are more efficient than smaller ones!

Basis of Crouch Formula ('C'):

- For a particular hull, the assumption is that the resistance per tonne of displacement is proportional to the speed.
- Since resistance is, broadly, made up of frictional resistance and wave/spray making resistance, which vary differently with speed, it is odd that this is the case, but tank tests have shown it to be approximately so, for a reasonable speed range.
- (Ref: Barnaby – 'Basic Naval Architecture').

Power Estimation:

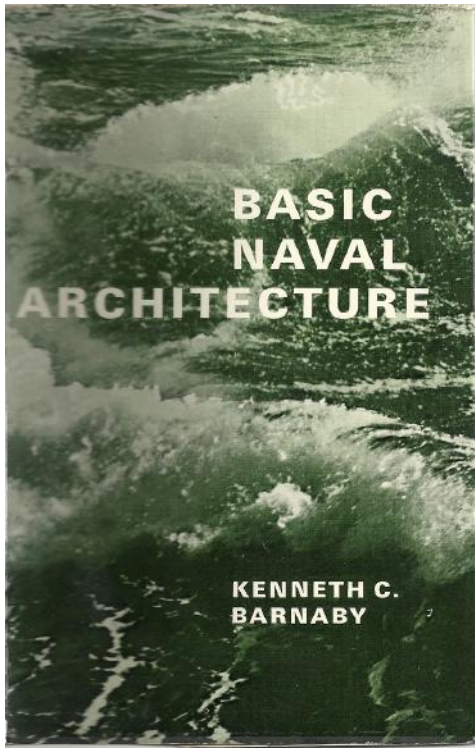
- Daniel Savitsky is the modern Guru for planing craft performance estimation – read his papers.
- However - simple but very useful formula was invented by George Crouch – a Webb Institute (USA) Mathematics Professor, and a very successful fast boat designer between the wars...

There are other formulae...

- Keith, Hacker, Burgess, Reyes, Wyman (more recent). Useful but we are concerned with Crouch.
- UK Naval Architect, K.C.Barnaby

– basically same as Crouch but Barnaby uses 'K' instead of 'C'.

- Crouch used mph, feet, pounds.
- Barnaby used knots, feet, tons.



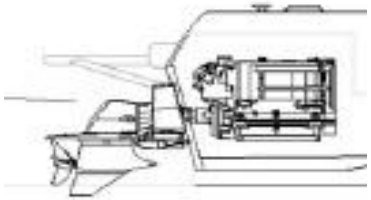
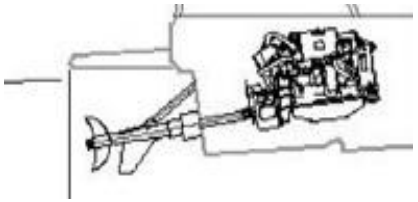
Crouch Formulae:

- Original Formula: $C = V(W/P)^{0.5}$
  - 'C' is the Crouch constant
  - V is Speed
  - W is total craft Weight
  - P is Power

  Units are free but -
  - YOU MUST BE CONSISTENT !!!!
  - 'C' is a constant – not a dimensionless coefficient!

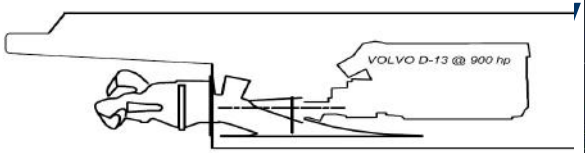
Crouch Formula – remember:

- Very useful for comparing like sized (same length) boats of similar type.
- Collect known figures from known craft (particularly your own)!
- Use consistent units !
- Input correct parameters !
- Note! Actual number calculated for 'C' depends on the units used – of course !

Crouch – Power ('P')...

- Use either shaft power (SHP) or installed brake power (BHP) (or equivalent kW) all time – don't mix them!
- Don't mix BHP and MHP...
- Quoted outboard motor power is usually measured at the prop (i.e. SHP).
- Inboards normally measured a (BHP) – so drive train l



~ 3% for jets; ~ 5% for surface d

Crouch – Speed ('V')...

- Use Knots, mph, kph, metres/second, or whatever you prefer – but be consistent !

Crouch – Weight ('W')...

- Again – use whichever units you prefer: Tonnes; Long Tons; kg; pounds...
- Again – Be consistent !
- Note! This weight is actual displacement of the craft on the water – it must include everything:

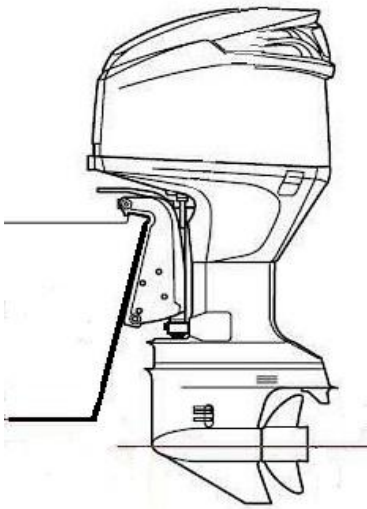
Basic craft weight + crew (clothing), fuel, water, equipment, cargo, beer, etc...

Compare similar craft types...

- One mistake is to expect the same constant for widely differing boats and speed ranges – 'C' will be much lower for a non-stepped hull with submerged shafts, than for a stepped hull with surface drives!

Compare like with like...

- Remember - Formula only based on speed ('V'), weight ('W') and power ('P')!
- Even with same hull, 'C' will vary depending on whether surface drive or stern drive – or, for example - with mounting height of outboard motors.



Variation in Hull Length...

- We saw with graph that 'C' (or 'K') increased with hull length:

- We can modify the formula to compare

Crouch modification ('Cc'):

- Frequent mistake is to use the previous basic formula to compare boats of different lengths (i.e. size)...
- For same type of craft but different length, use modified formula (Lh is the hull length):

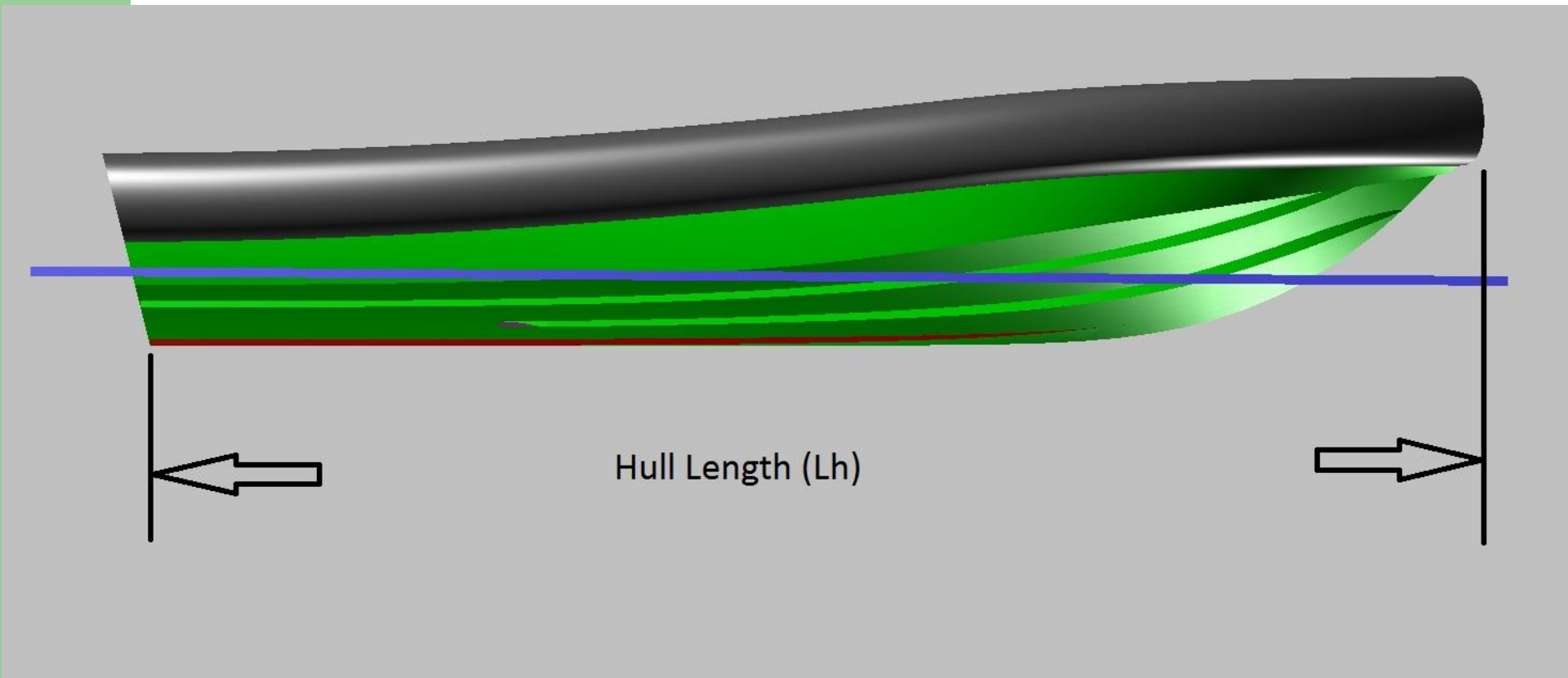
$$Cc = \left(V\left(W/P\right)^{0.5}\right) * 1/Lh^{0.25}$$

or

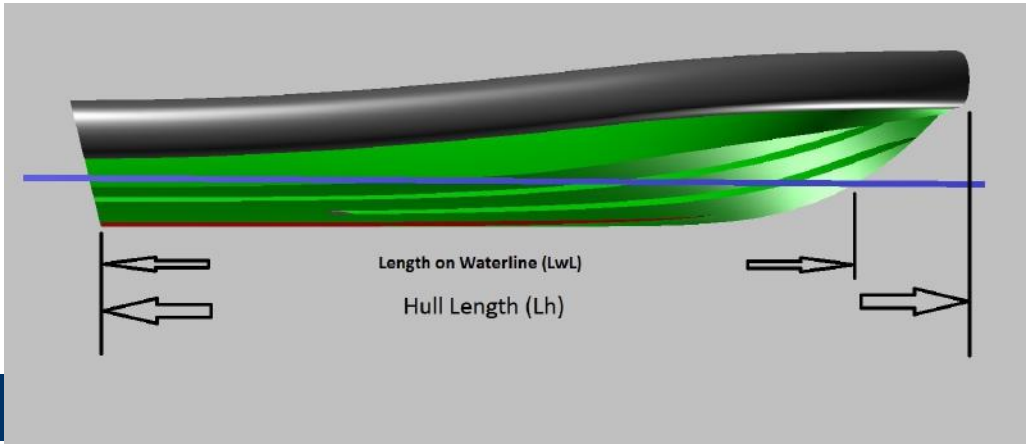
$$Cc = C/Lh^{0.25}$$

Consistent Length Definition:

- This is my version:



Why this mod?



- Comes from Froude relationship (works for planing craft, too): Fn = V/(g x LwL)^0.5 (g is gravitational acceleration)
- Simple version: V/LwL^0.5 (speed divided by sq.root of waterline length – traditionally uses knots and feet)
- For equivalent speed in different length craft, this should stay constant – i.e. if V/LwL^0.5 = 6 then V is 26.8 knots for 20' LwL and 37.9 knots for 40' LwL!

So – Notes on usage:

- Since 'C' only works for same length hulls, it is suggested that 'Cc' is used all the time
- 'C' and 'Cc' are really a measure of efficiency!
- Collect reliable weight, power and speed information on as many craft as possible and calculate their 'Cc'.
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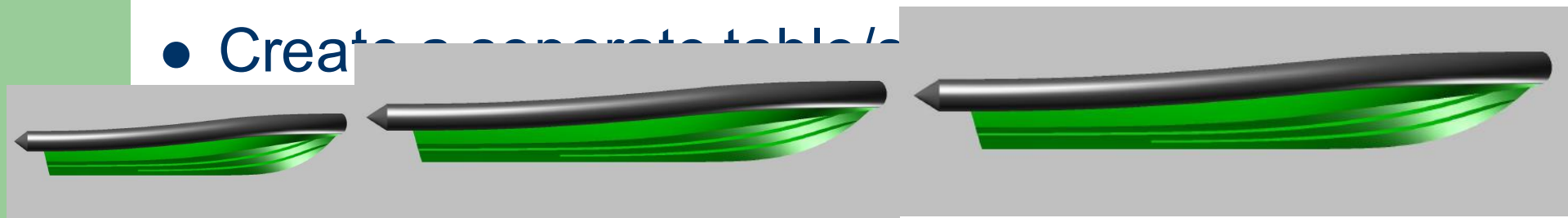


NOTE!

- Must emphasise again:
- Even if craft are different sizes they must be of same type!!!

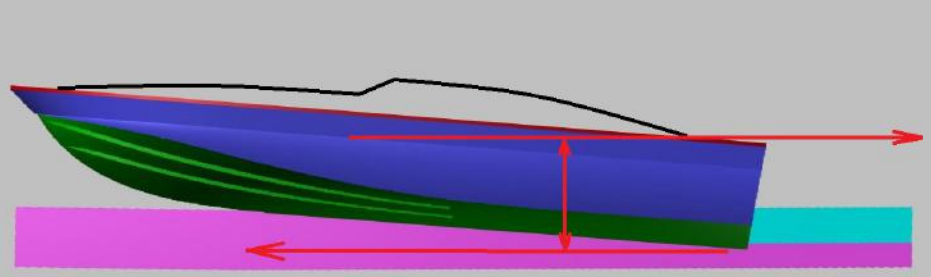
More Notes – Remember 'Like for Like'!

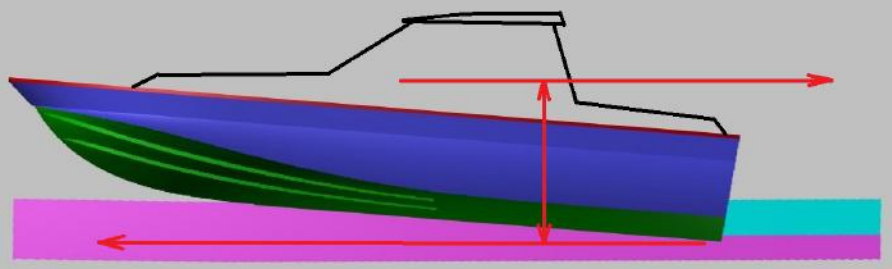
- Formula doesn't include terms for differing appendages – rudders, struts, thickness of drive legs, etc. So these must be similar between compared boats.

More Notes – Remember 'Like for Like'...

- Aerodynamics - If comparing two similar hulls where one is flush decked and other has high wheelhouse, 'Cc' will probably be higher for the low one – less aerodynamic drag!

(But maybe a change of trim...)





Aero Lift effect...

At very high speeds, with craft that show significant aero lift, 'C' and 'Cc' increase rapidly due to the increasing amount of craft weight carried by aero lift !

More...

- Centre of Gravity (CG) position...
- Craft weight

More...

- Props – type (and condition!)

Repeat...

- The Crouch Formula ('C') in standard form (for same length) and modified form ('Cc') (for differing lengths) can be very useful if used carefully – and it is also quick once you have established a database
- For preliminary estimates
- Not a substitute for proper calculations when designing a new craft