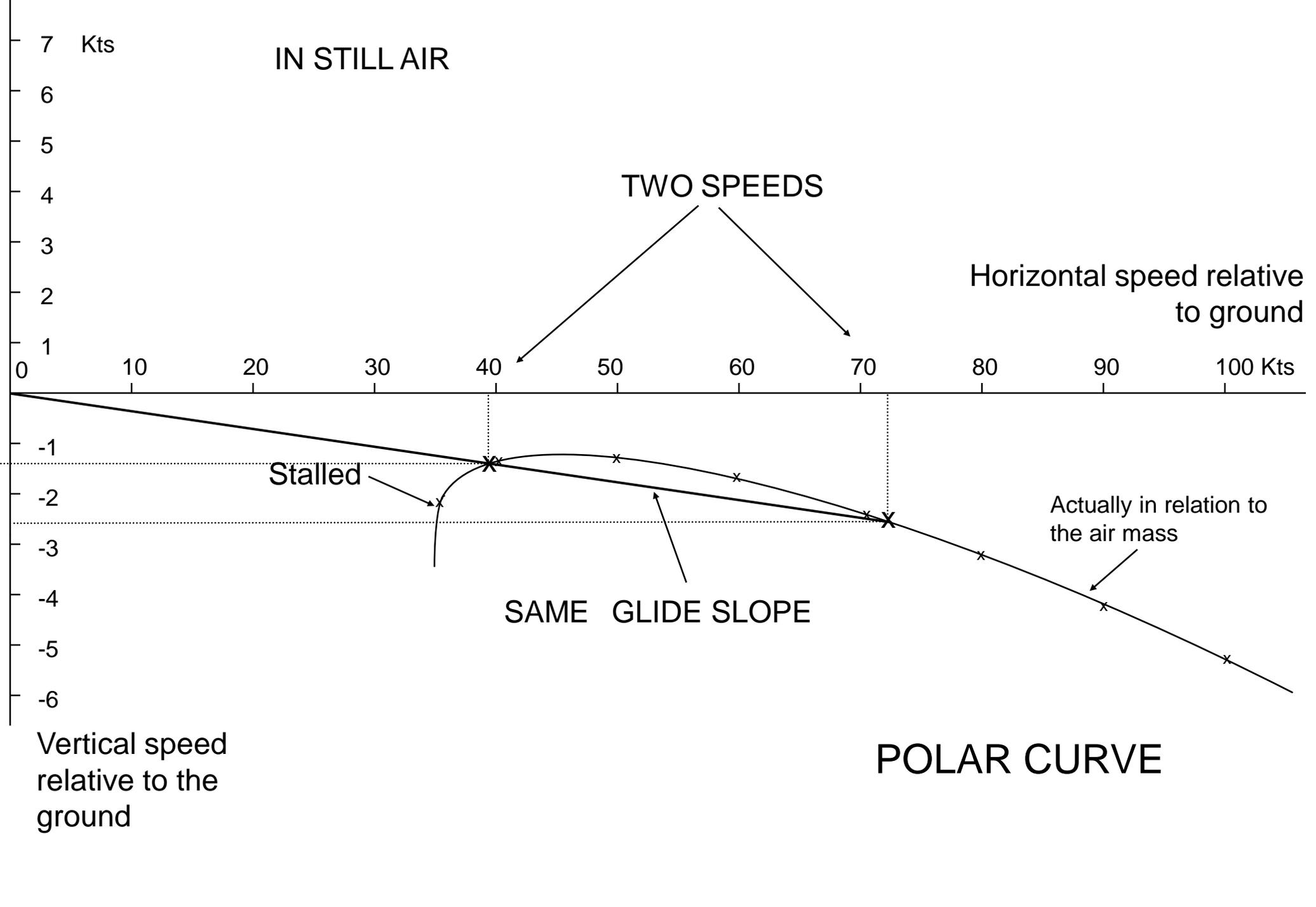
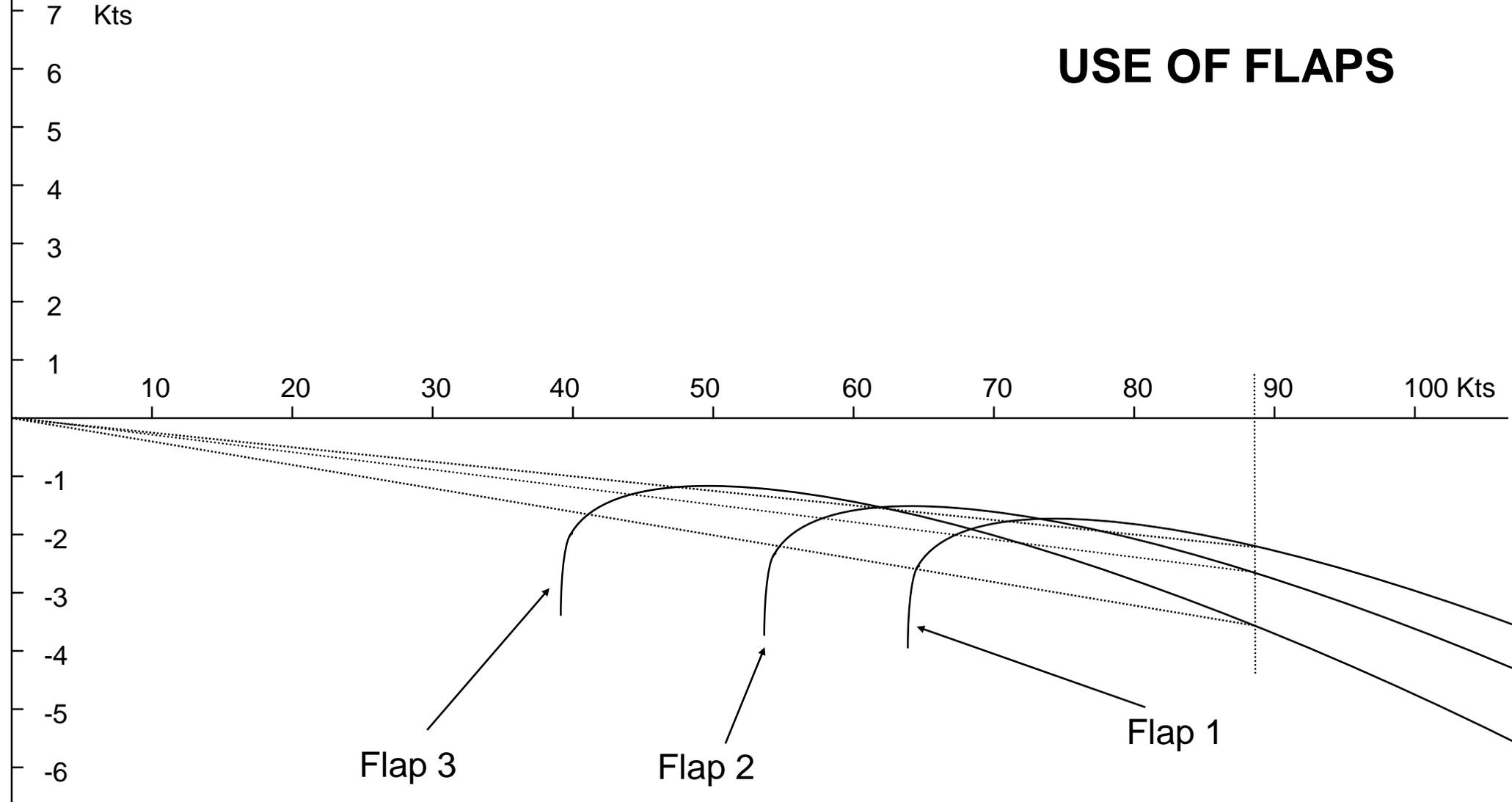


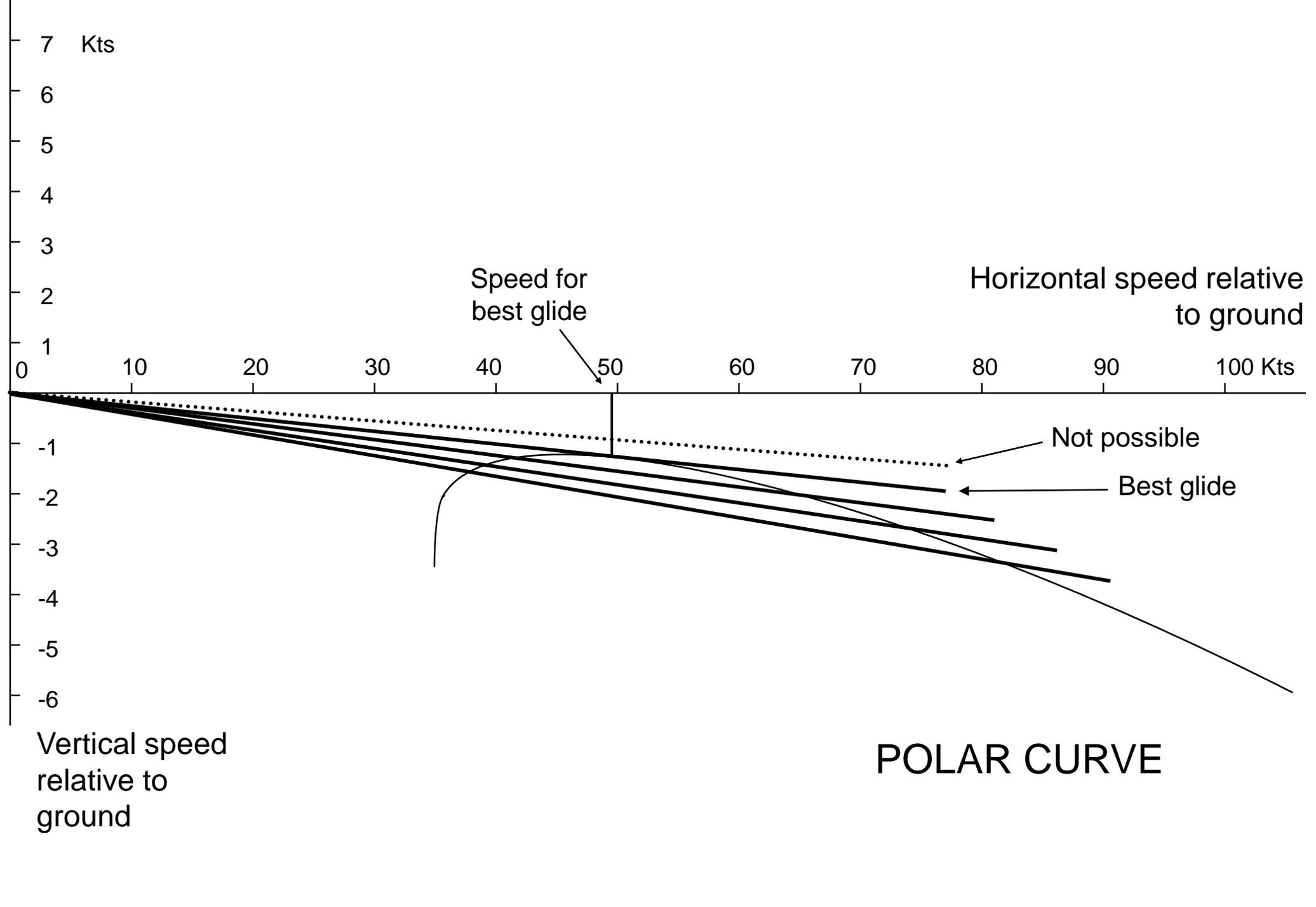
THE POLAR CURVE

Diagrams (speeds) not necessarily to scale

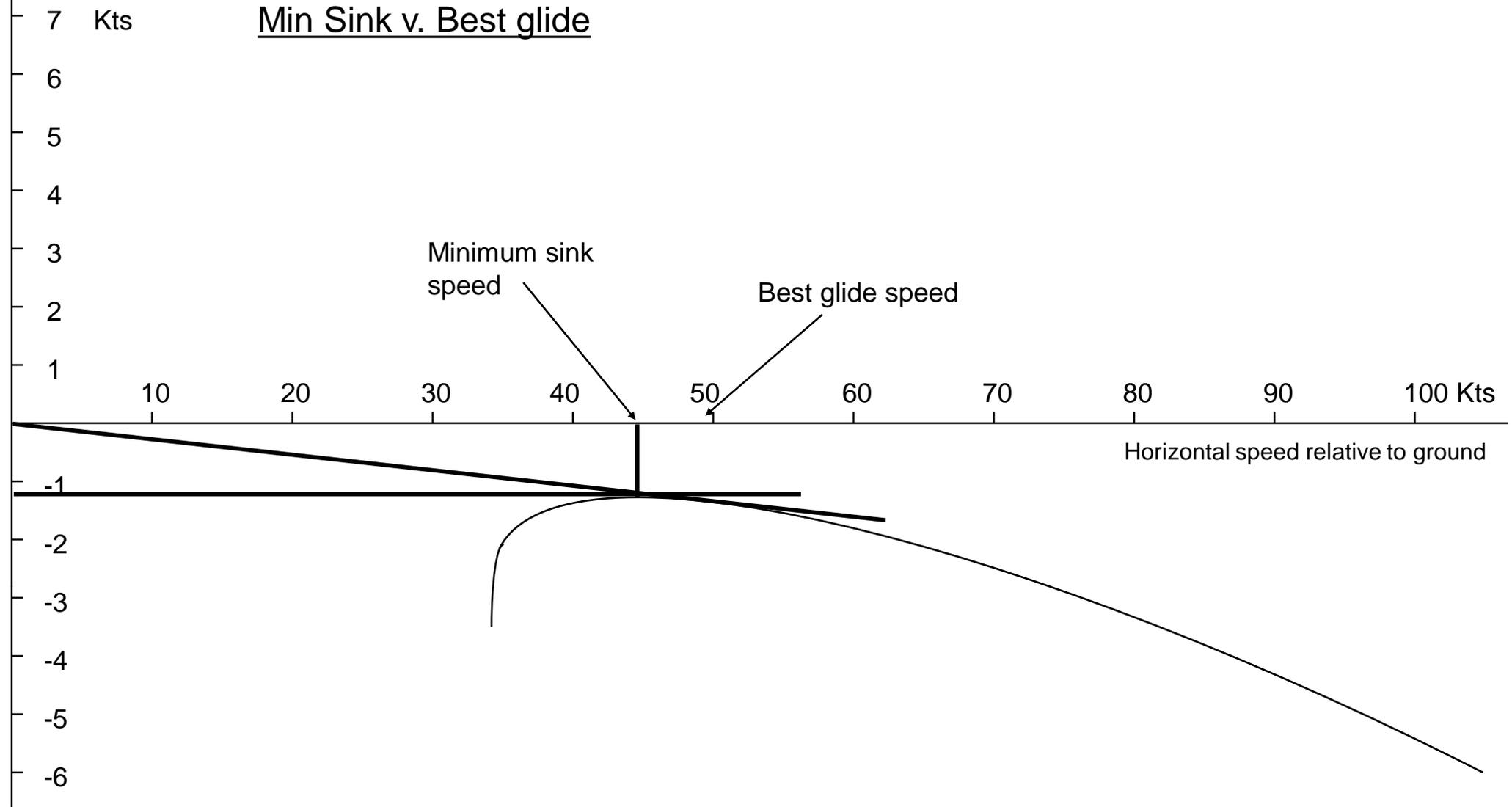


USE OF FLAPS





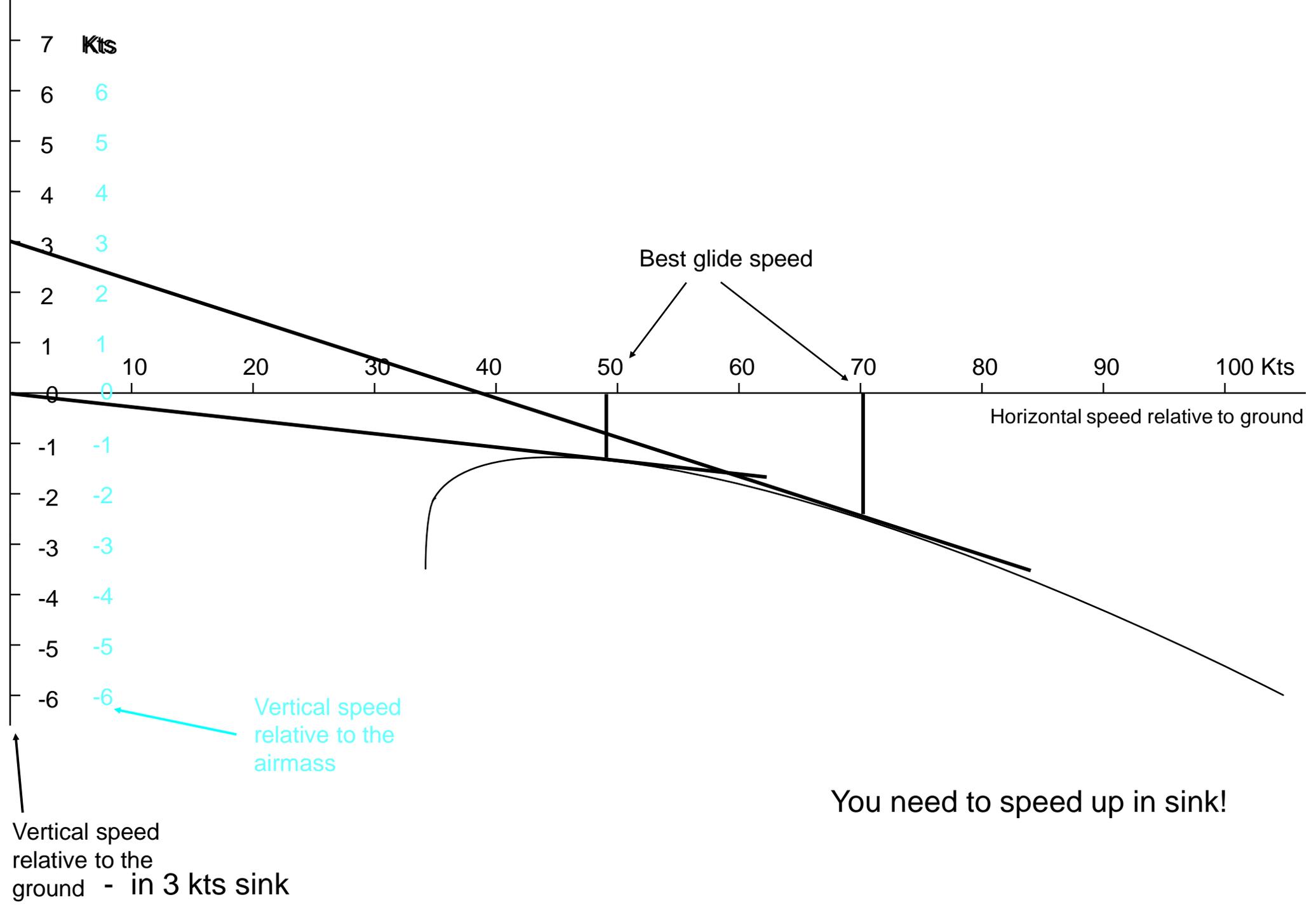
Min Sink v. Best glide

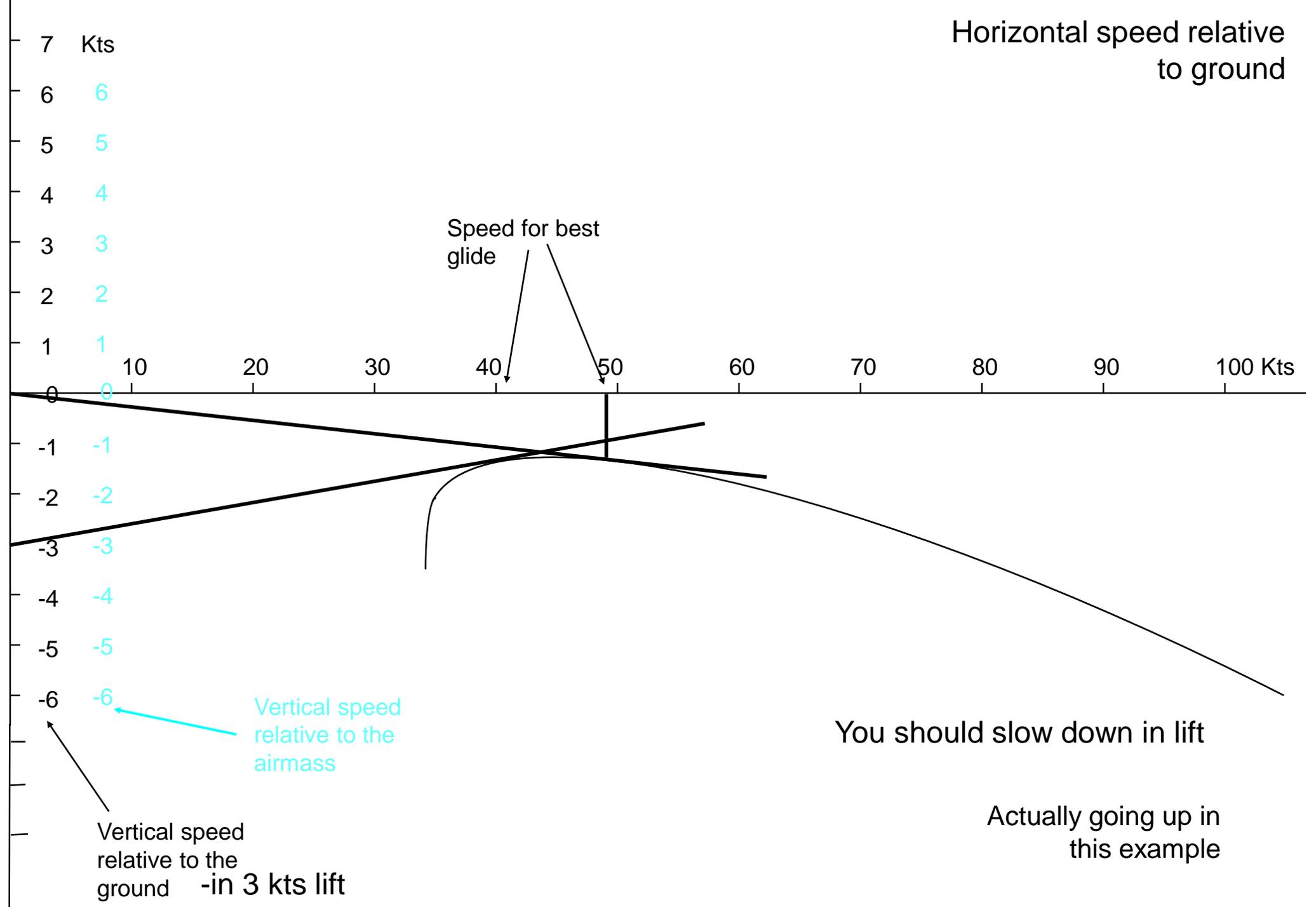


Vertical speed
relative to ground

Least possible sink rate: max time in the air

Best possible glide angle: max distance through the air.





Horizontal speed relative to ground

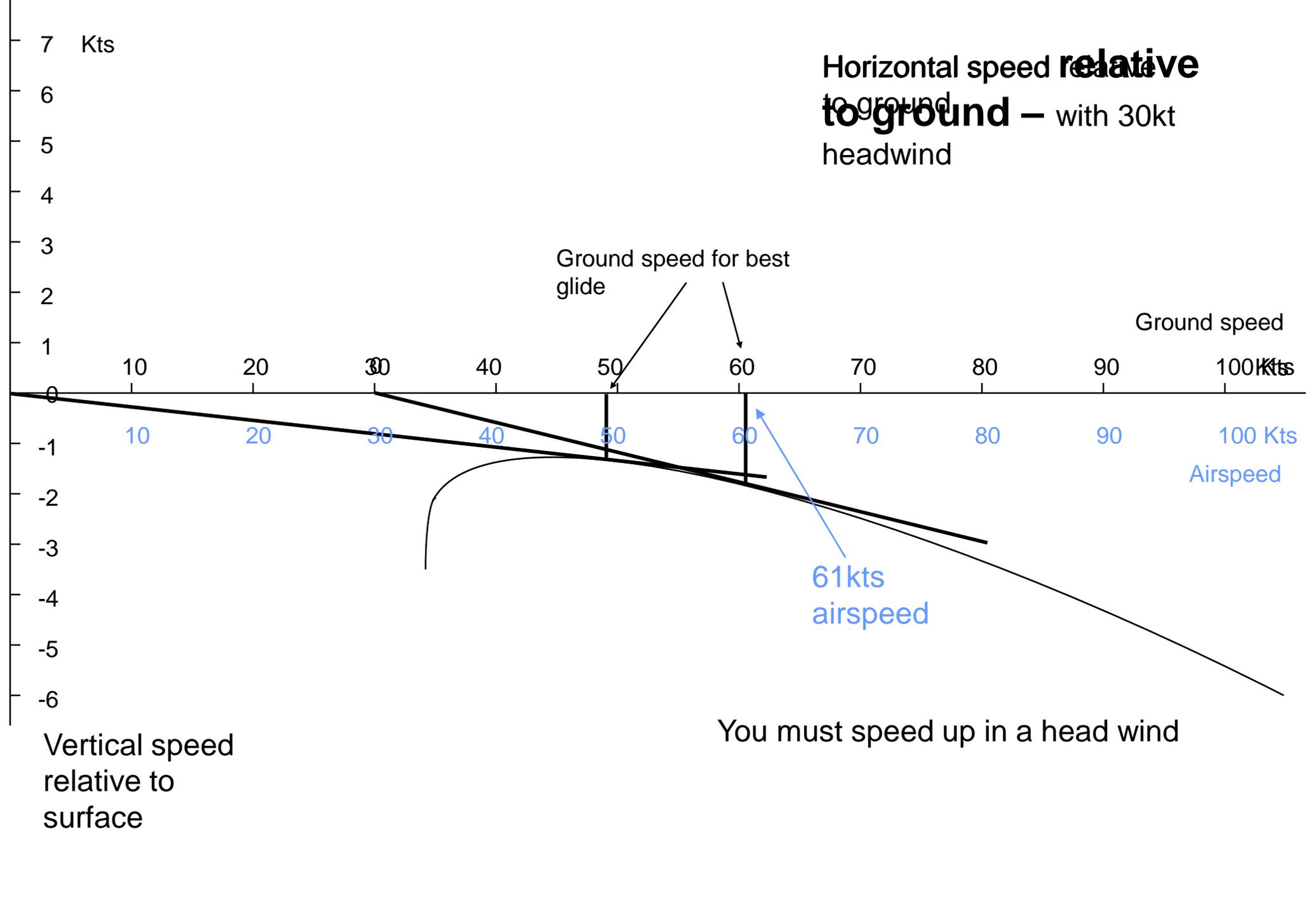
Speed for best glide

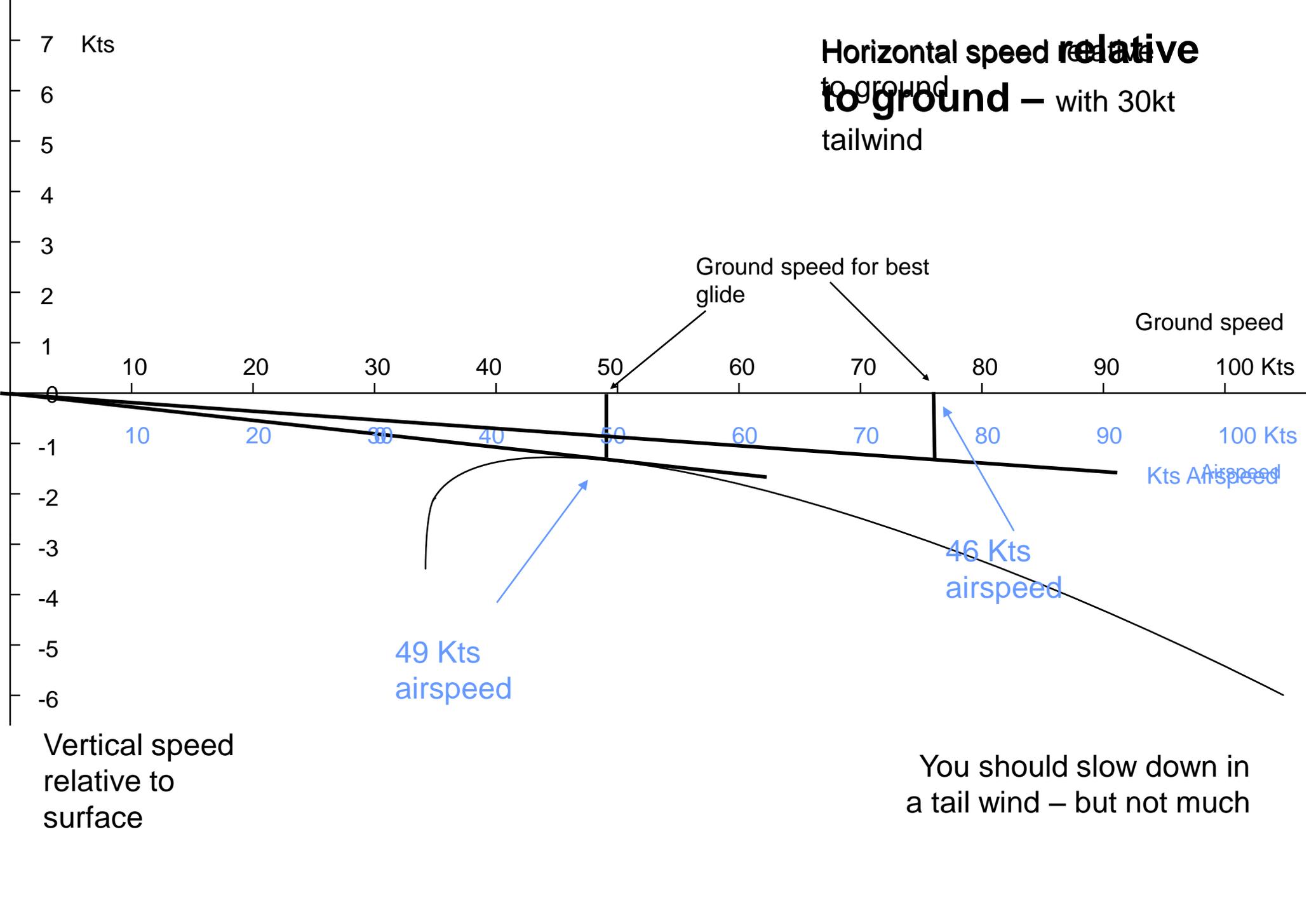
Vertical speed relative to the air mass

Vertical speed relative to the ground -in 3 kts lift

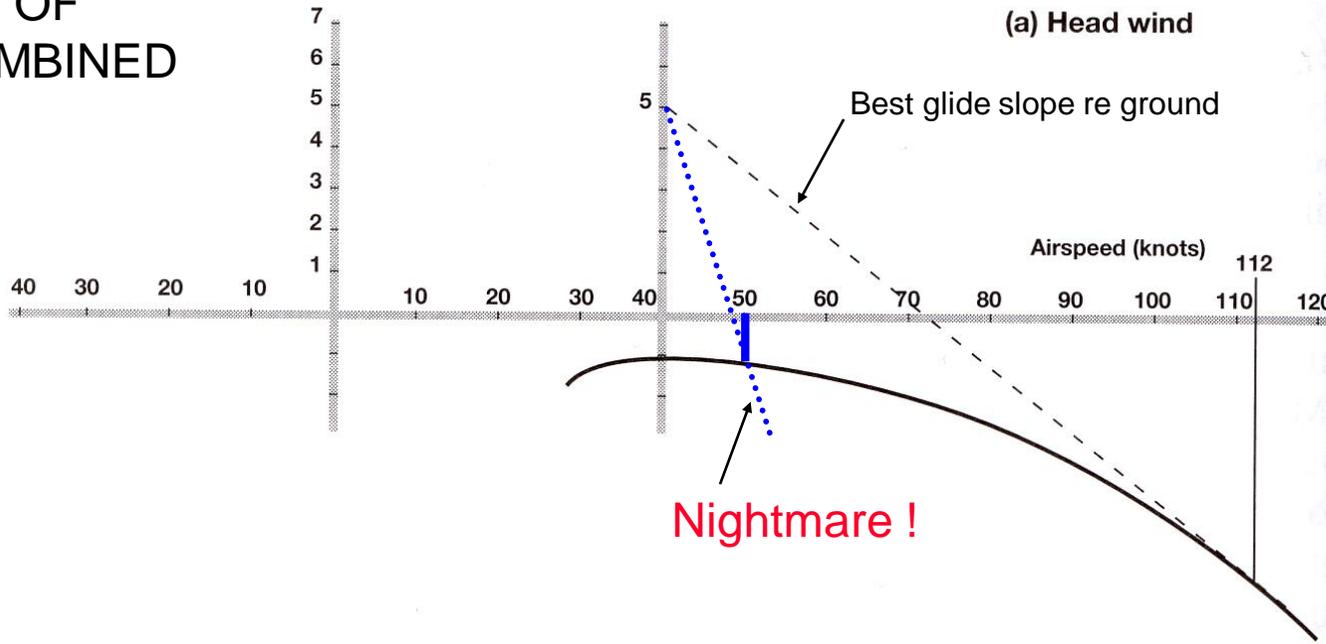
You should slow down in lift

Actually going up in this example

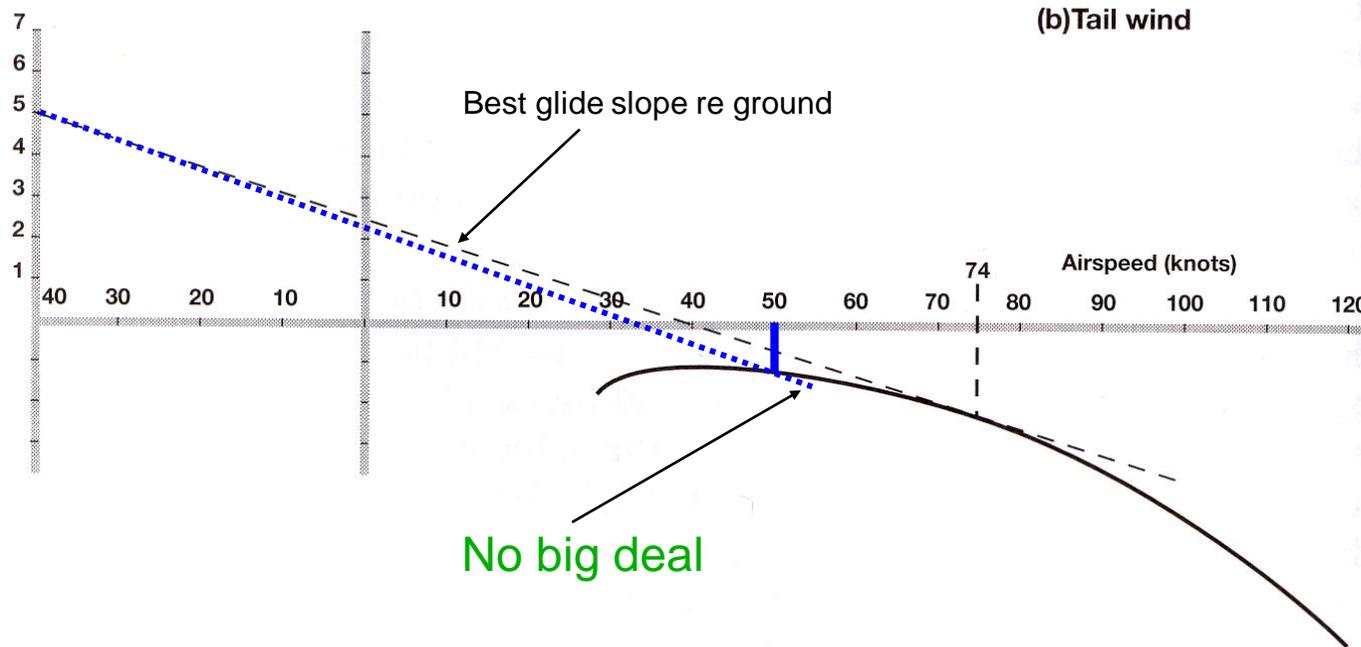




EXAMPLE OF BOTH COMBINED



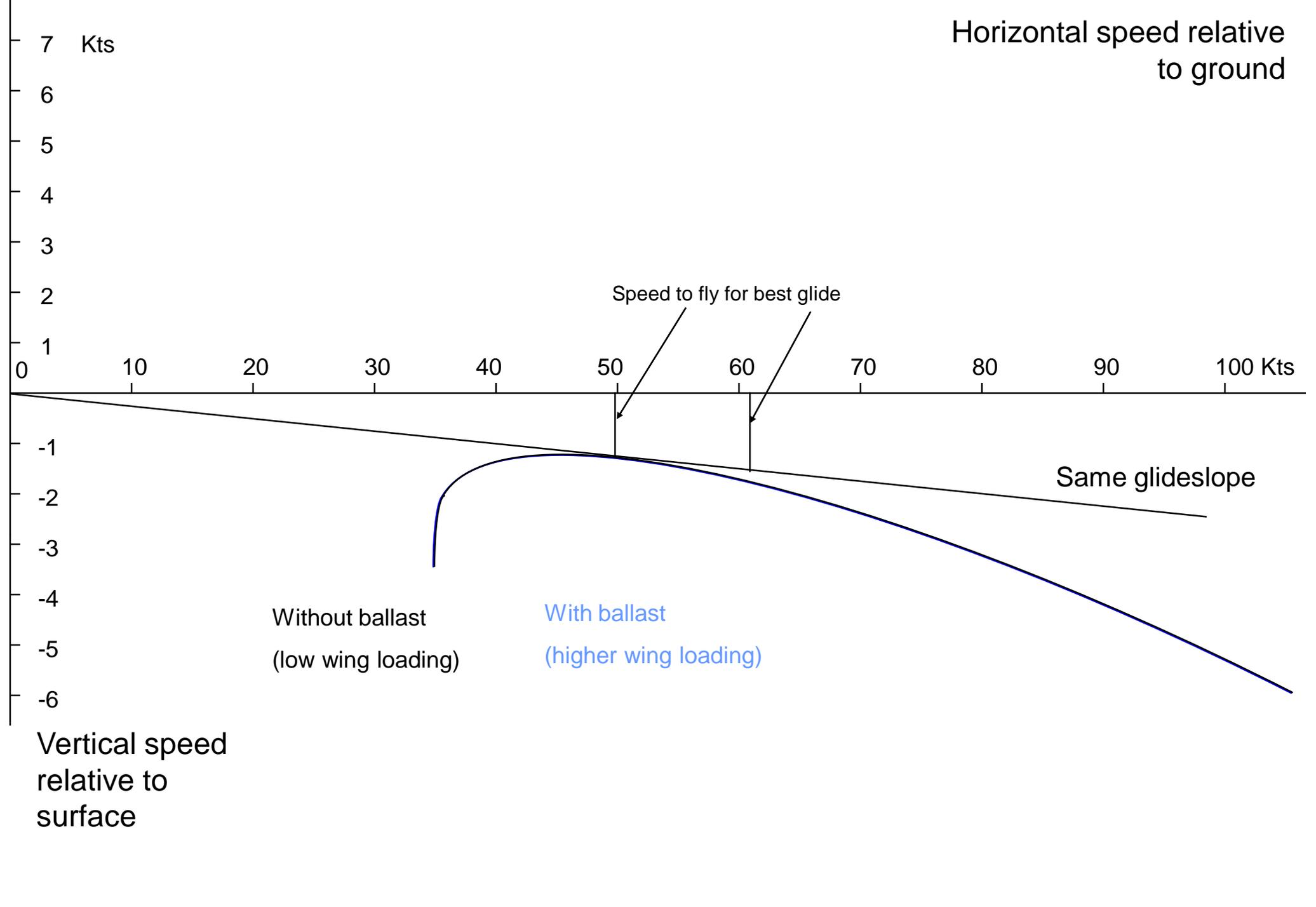
Speed to fly when crossing wave gaps (assume 5kts sink).



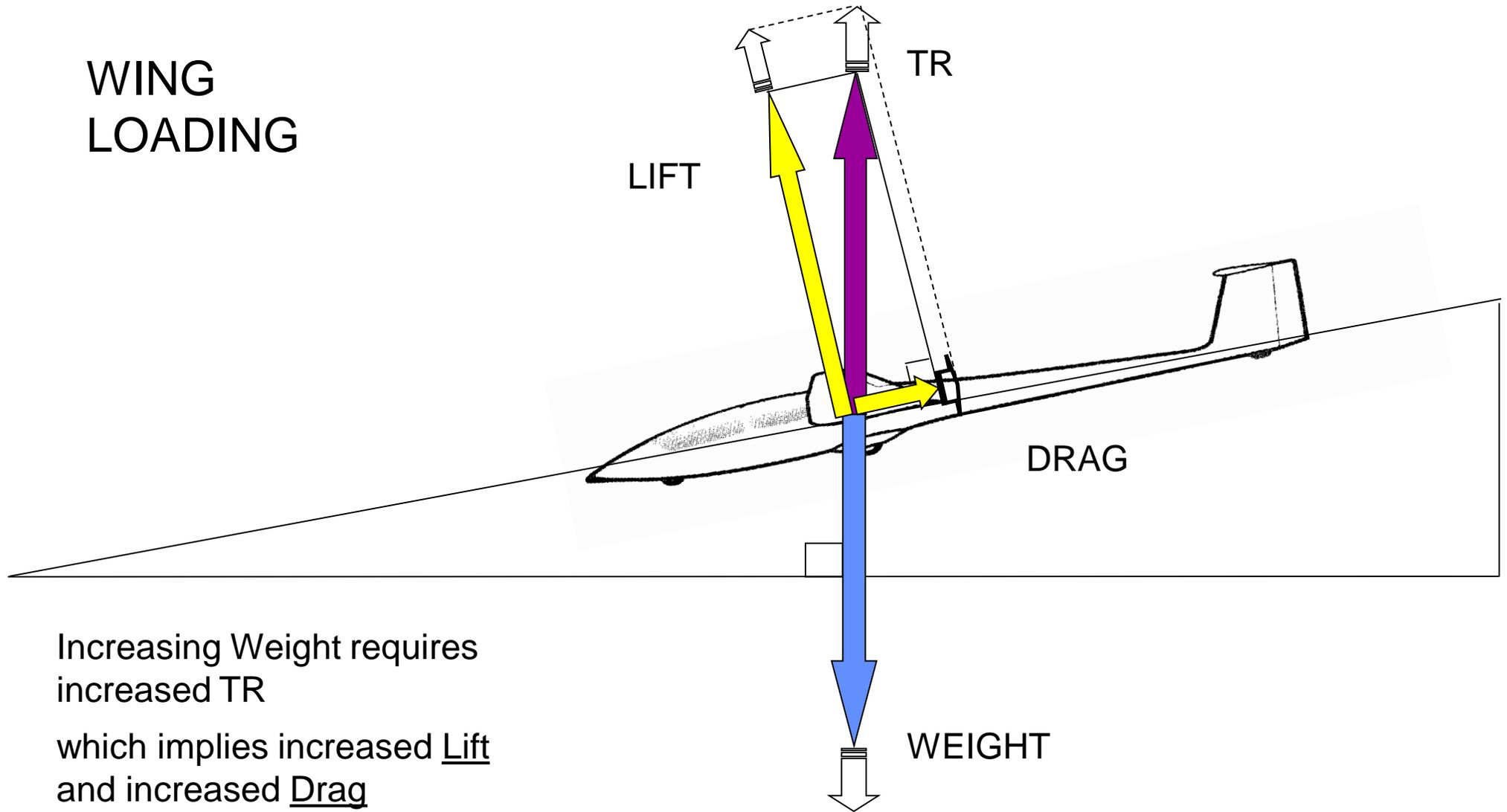
(SPM –Stewart)

EFFECT OF BALLAST

- If we carry ballast the polar curve is moved to the right and downwards
 - Slightly more accurately it is 'expanded from the origin' as the square root of the wing loading
- This enables flight down the same glide slope but faster
- However climbing will be slower
 - Therefore ballast is only used in conditions of good lift
 - And you must be able to dump it if conditions are deteriorating
 - And usually before you can land



WING LOADING

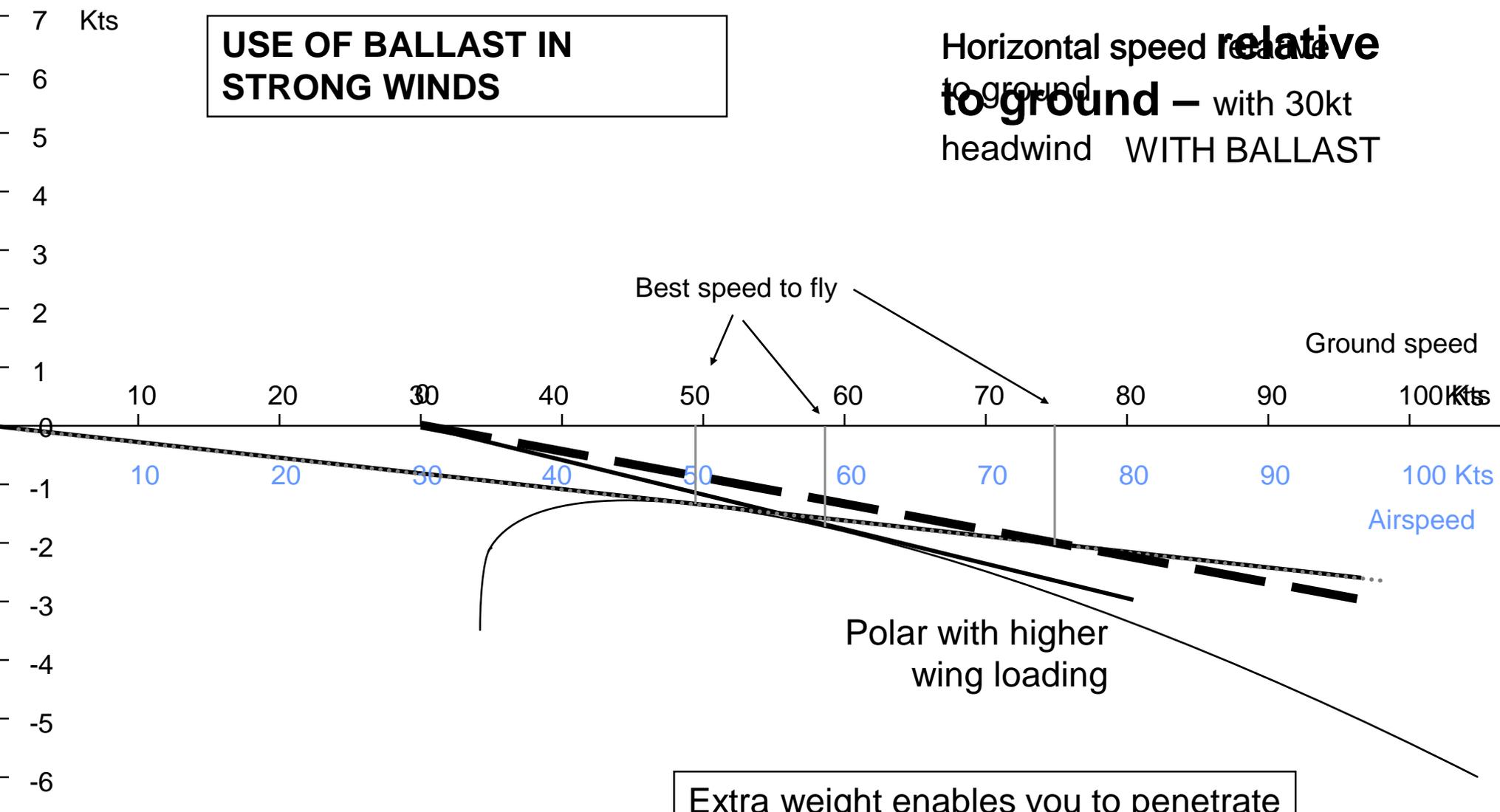


Increasing Weight requires
increased TR
which implies increased Lift
and increased Drag

But we come down the
same glideslope

USE OF BALLAST IN STRONG WINDS

Horizontal speed **relative to ground** – with 30kt headwind **WITH BALLAST**



Best speed to fly

Ground speed

Airspeed

Polar with higher wing loading

Extra weight enables you to penetrate into a headwind better

Vertical speed relative to surface

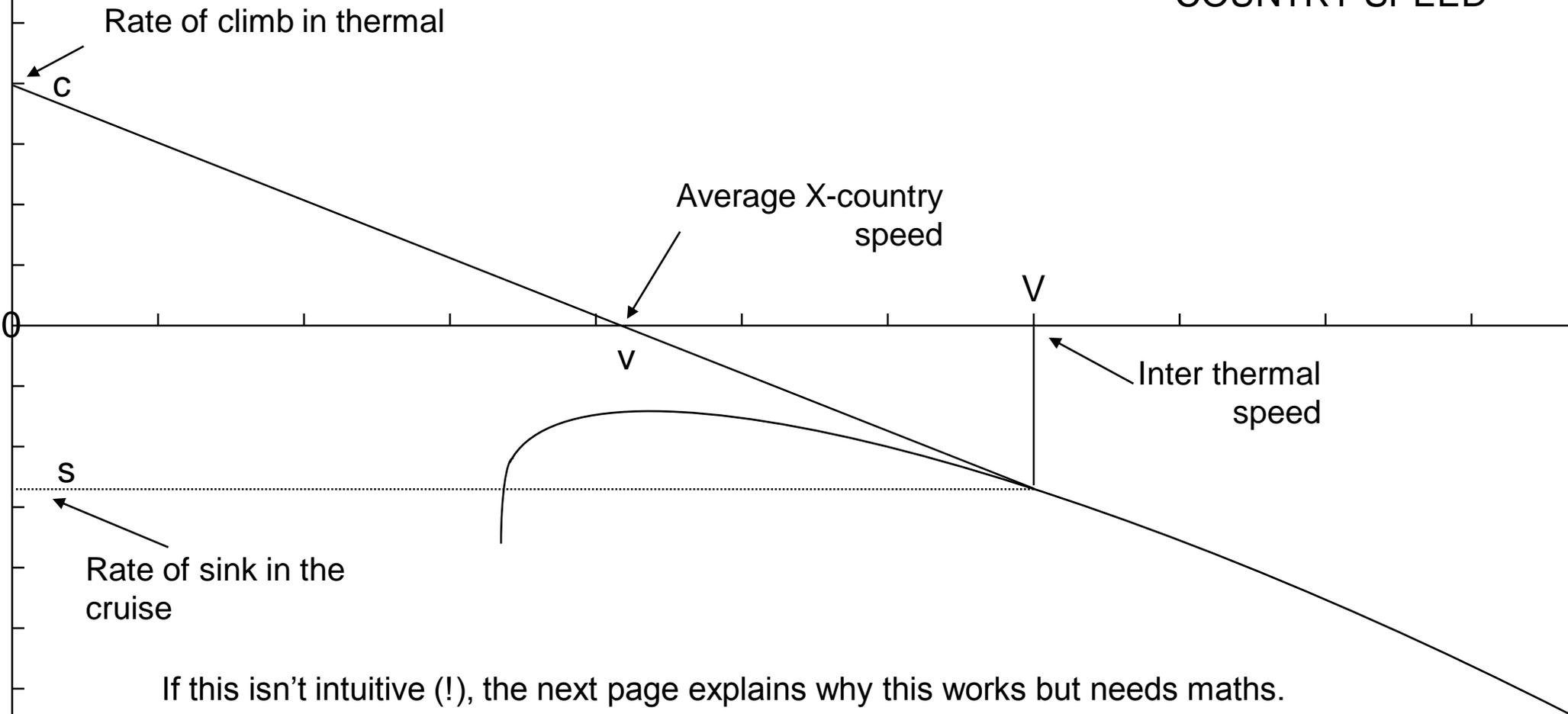
MacCREADY

- The foregoing explains in terms of the polar curve what speed should be flown for particular circumstances
- The theory was encapsulated by Dr Paul MacCready (around the late 1940's) although it had a long history before that (See Reichmann's book)
- MacCready is credited with the invention of the 'Speed to Fly Ring' (or the 'MacCready Ring'), still found on some gliders, which indicates what speed to fly in lift or sink taking into account the polar and the predicted* thermal strength. Some versions also took account of variable wing loading.
- The MacCready ring has essentially been superseded by the advent of the microprocessor enabling 'glide computers' (or so called 'flight directors') to be produced which indicate speed to fly for lift/sink and head/tailwind components (obtained by interfacing with GPS and poss vario) and based on stored polar curve data for the type of glider in question
- Glide computers can also provide additional functions such as glide statistics and navigation including terrain avoidance.
- * The theory of 'best speed to fly between thermals' requires knowledge of the strength of the next thermal (!). See Reichman's book for a full explanation of this.

GLIDE CALCULATIONS

- Note 1 nautical mile = 6076 feet.
 - The BGA apparently expect you to know this !

AVERAGE X-COUNTRY SPEED



If this isn't intuitive (!), the next page explains why this works but needs maths.
Don't worry about it !

Note that, by similar triangles

$$v/c = V/(c+s) \quad \text{i.e. } v = Vc/(c+s)$$

t = time in the climb
T = time in the cruise
V = cruise speed

c = achieved rate of climb
s = rate of sink in the cruise
v = average X-ctry speed

**AVERAGE X-
COUNTRY
SPEED**

∴ height gained in the climb = ct
and height lost in the cruise = sT

Put these equal $ct = sT$ i.e. $t/T = s/c$

Average X-ctry speed, $v = VT/(t+T)$

$$\begin{aligned} &= \cancel{V} \left[1 + \frac{t}{T} \right] = \cancel{V} \left[1 + \frac{s}{c} \right] \\ &= \frac{Vc}{[c+s]} \end{aligned}$$

By similar Δ 's this is v, as shown on the previous page.

BRONZE LECTURES

PRINCIPLES OF FLIGHT

END

QUESTIONS ?