Is There a Step?

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In the early days of aviation there was considerable discussion about 'getting the aircraft on the step'. The standard technique was to climb slightly above the desired cruise altitude and then gently dive the aircraft to 'get on the step'. This resulted in a higher cruise velocity. Recently many aviation writers have denigrate the idea, claiming that a 'step' does not exist. But, it does exist — you just have to go hunting for it!

To explain the 'step' and how you might find it again requires looking at the power available and power required curves. Figure 1 shows the power required as well as power available curves for 45%, 50% and 55% for a Model E33A at 15,000 feet on a standard day. At 15,000 feet, the 45%, 50% and 55% power available curves roughly correspond to full throttle and 2100, 2300, and 2500 rpm respectively. On each of the curves two points, the minimum velocity and the maximum velocity, are labelled. For a constant power setting, in level cruise flight, the aircraft will fly at either of these two velocities and only at these two velocities (see also the article on Speed Stability). At any other velocity the aircraft will either climb or descend.

First notice that at 45% power/2100 rpm 15,000 feet is approximately the absolute ceiling of the aircraft. Furthermore, note that at 45% power the spread between maximum and minimum velocities is quite small and that the minimum velocity is greater than the

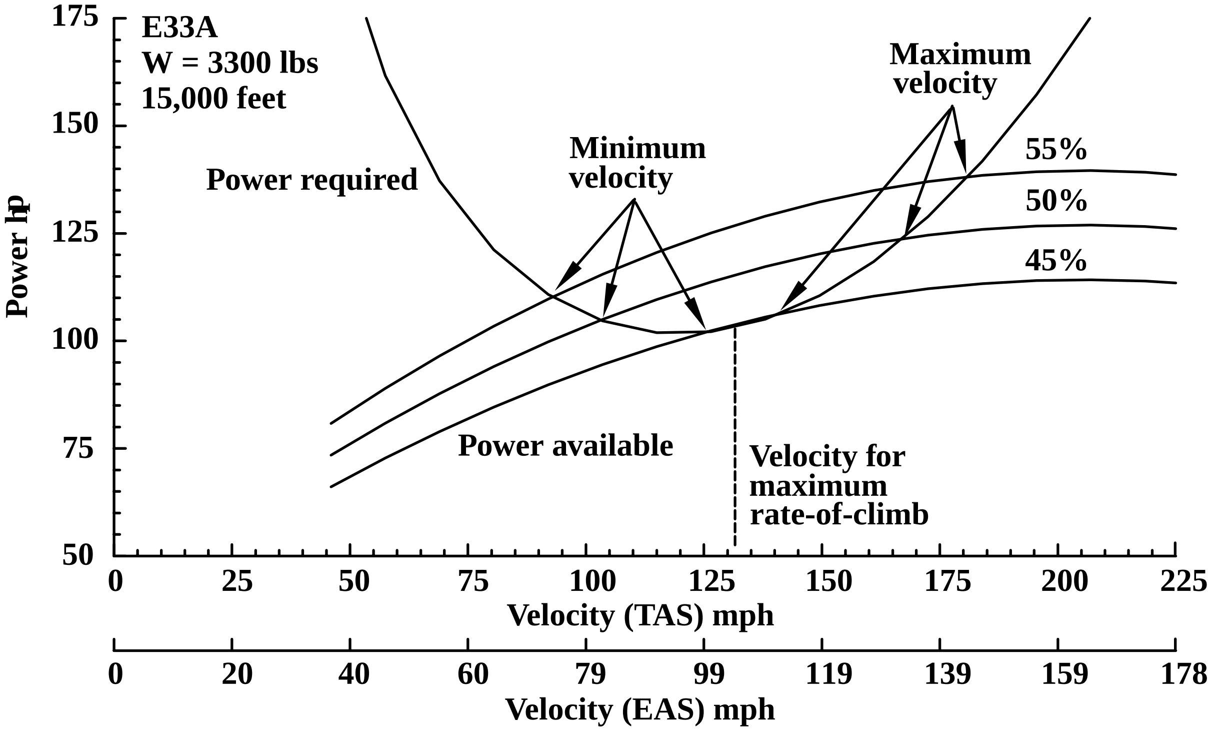

Figure 1. Power required and available in steady level flight.

the stall velocity of the aircraft. For higher power settings the spread is larger. The velocity for maximum rate-of-climb is indicated by the dotted line. Getting on the 'step' occurs when the aircraft is at the maximum velocity for the particular altitude and power available.

Operationally suppose that you are climbing to 15,000 feet at maximum throttle and 2500 rpm at a velocity less than the velocity for maximum rate-of-climb indicated in Figure 1 by the dotted line. If, as you reach 15,000 feet, you roll the prop back to 2300 or 2100 rpm without allowing the aircraft to accelerate, then the aircraft may settle at a cruise velocity represented by the minimum velocity, i.e., the aircraft is not 'on the step'. However, if you climb slightly above 15,000 feet and then 'dive' down to 15,000 without rolling the prop back then the aircraft will accelerate through the velocity for maximum rate-of-climb. Once above the velocity for maximum rate-of-climb, if you now roll the prop back to 2300 or 2100 rpm the aircraft will settle at a cruise velocity represented by the maximum velocity, i.e., it is 'on the step'.

Why then do many aviation writers claim that there is no step? At lower altitudes where the power required to maintain steady level flight is lower and where power available is higher, the minimum velocity for steady level flight is *less* than the stall velocity. Consequently, the aircraft will stall before it reaches the minimum velocity. Furthermore, we normally cruise climb at velocities above the velocity for maximum rate-of-climb. Thus, in practice, only at the higher altitudes does the 'step' exist.

What about the ancient aviators? Well in the early days of aviation, aircraft had much higher drag which translates into much higher power required to maintain steady level flight. They also had significantly lower power available. Consequently, the 'step' occurred at much lower and more common altitudes. Today operating at 15,000 feet is equivalent to operating at eight of ten thousand feet in those days.

Operationally, is this important? How about that west to east flight over the Rocky Mountains when the predicted tailwinds are 40–50 knots and we decide to break out the oxygen bottle, climb up to 15,000 or even 17,000 feet to avoid the mountain wave and it's associated turbulence, pull the power back to 55% burning 10–10.5 gph and fly all the way across the mountains. If the winds are not as predicted or quit on us and we plan it right, we can always drop into somewhere along the way. The extra 10–15 kts that represents being 'on the step' can make the difference. However, because of the narrow spread of permissible velocities careful speed control is necessary. Keep your eye on both the airspeed indicator and the rate-of-climb indicator.

How about when we are forced to climb up into the teens to avoid ice? Again getting 'on the step' going either east or west may make the difference. Even going south it can make the difference. On a flight from Ketchican to Whidby Island down the Inland Passage one July the choice was to go back and it was as far back as to continue and into a headwind to boot, to go down to near sea level and scud run and pay the penalty of increased fuel consumption and an extra stop with an instrument approach to near minimum or to go up and fly to better weather. We broke out the oxygen and climbed well into the teens to avoid the ice, got 'on the step' to get that extra few knots, pulled the power back so we were burning about 10 gph and trucked on in. We landed with plenty of fuel reserve and could have diverted to Vancouver if necessary.

Lest you think that getting 'on the step' applies to only general aviation the story is that at it's operational altitude of about 80,000 feet the velocity spread for the U2 was only about 10 knots. Over several hours that 10 knots made a considerable difference.