PITCH FOR POWER - OR HOW DO WE FLY AIRPLANES 1993, 1995

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If you don't believe that religion exists in aviation, then there are two situations you have never witnessed. One is the verbiage following a gear up landing, the other is a discussion on what controls airspeed.

On one side of the story lies the statement that "pitch controls airspeed." Wolfgang back in the 1940's was one of the earlier pioneers with this concept. On the other side is the "power controls airspeed." The obvious question is why do otherwise rational souls seem ready to go to war over the difference, and why in fact is there a difference.

The objective of this small literary work is to explain why the FAA has the statement "when power is variable, power controls airspeed" and why it does not, in and of itself, disagree with "pitch equals airspeed", to look at why some persons fly angle of attack and pitch for airspeed and why that does not violate the power principle, to look at several viewpoints about aircraft control, and some special flight characteristics.

We will also look at the Flat Earth Society, and three different aircraft types, their special characteristics, and then some actual scenarios. Another topic we will look at is predictability of the results of a control change. I merely ask you to be open minded.

First let us define some terms used. (1) Steady state means the stabilized condition, one where performance is constant. (2) Transient state, where a change is in progress, this is the result of a control input change, it is dynamic. (3) The word "controls" means the FIRST manipulation made by a pilot to effect a change, and does not refer to the subsequent interactive changes, nor to the aircraft's inherent aerodynamic features.

The concept of a CONTROL (transient) change being made resulting in future intended performance (steady state) is vital in any reactive system. For example, when you turn your air conditioner on, or any other electrical motor, do you notice it runs differently while it is getting up to speed compared with when it is running in a stabilized fashion? Do you notice the refrigerator in your kitchen sounds differently when it kicks on compared to its running mode? The answer is yes! The reason is that there is the transient state (a control change), and the steady state (performance), fluorescent lights being turned on is another example.

Well the same thing happens when an airplane flies. An airplane has a transient condition or change state, this is the CONTROL phase of the maneuver. An airplane also has a steady state, or normal condition, this is the PERFORMANCE phase of an operation.

A very obvious example is "why does an airplane turn." Is it the ailerons which make the airplane roll, or is it the fact there is a coordinated bank, or is it the back pressure on the yoke? The ailerons are a control to initiate a turn (transient) and the bank causes the horizontal component of lift (steady state turn), and back pressure is needed to maintain altitude. Some people might even take things further and say that the rudder can be used to cause a skid which then results in a bank and hence in a turn, at least while eating sandwiches on a long cross country!

Understanding the control phase (or change or transient), and that it results in (but is different to) the performance phase (or steady state) is crucial in avoiding over simplification.

Thus, to climb an aircraft you first point the nose up (CONTROL INPUT) then after the engine loads up you add power to maintain the speed you would otherwise lose, (PERFORMANCE). If you only add power to induce a climb, then you are relying on specific flight characteristics. Adding power in some aircraft may actually cause the aircraft to descend, in this case, relying on specific flight characteristics fails to work!

To increase speed, you add power first (CONTROL) and the aircraft responding to the drag equations will then accelerate. That increased speed would interact with the aircraft stability forces, and may cause a climb (PERFORMANCE), so the nose may be lowered to prohibit the climb, and the lowered nose allows the stability forces to stabilize at a new airspeed (PERFORMANCE).

The same rules apply for descents and for speed reductions. The following table shows what is happening.

	CONTROL	PERFORMANCE
SPEED UP	add power	lower nose
SLOW DOWN	reduce power	raise nose
CLIMB	raise nose	add power
DESCEND	lower nose	reduce power

The concept of control and of performance being separate is essential to understand. A byproduct of the above concept is that the performance issues can be used in limited cases as control inputs, but this increases student confusion. Just like our sandwich eating friend using the rudder to make small turns while on a cross country. That does not mean it can't be done, but one must understand what is happening.

If the power is reduced, many airplanes will slow down, and in so doing the aircraft stability will lower the nose to get an angle of attack that in the steady state will retain the trimmed steady state airspeed (performance). Thus if the power is reduced the airplane will descend. This is a byproduct of very specific flight characteristics. But in some aircraft reducing the power may cause the nose to rise, and vice versa. If a student is taught specific flight characteristics, then what he is being taught may not be valid for other aircraft, or for aircraft in general.

At this point we need to look at the flat earth society. If you believe in a flat earth, one that is not a spheroid, you will have no problems at all navigating with symbolic road maps. This is analogous to using specific flight characteristics to control the airplane, or using the steady state conditions as the control inputs. Unfortunately, the flat earth believers have a tougher time when they navigate around the globe, or in deep space! They might as well be piloting the Titanic.

The control (change) versus performance (steady state) features will by definition be at odds, and by definition they also interact. So let us look at what and why some people are polarized and adamant in their belief.

A well known author says "pitch is airspeed and the Navy says so thus the FAA must be wrong". On the same pages as those fighting words there are graphs, one axis is airspeed and the other is power! He explains this anomaly by saying that the power is not really for the airspeed, (i.e. all you learned in math class was wrong), the power is to hold the altitude for the given airspeed. This mixes control and performance. The Navy flies angle of attack, it is true, but they also fly at critical angles of attack, and with specific flight characteristics and flight regimes not found in general or air carrier aircraft or operations.

Another way of looking at this issue is to consider the automobile. It reacts exactly as would an airplane, except its only stability equation is force::drag, whereas lift vectors of an airplane are probably more significant than the power::drag equation.

When a car goes up hill it slows down, and to regain that speed, power is needed. This throws another issue into the arena, kinetic (speed of an object) versus potential energy (height of an object), and that one energy form can be translated into another. Potential energy (altitude) can be traded for kinetic (speed) and vice versa.

If you are a dogmatic pitch for airspeed person, or a dogmatic power for airspeed person, you are missing the point, there is a short term control input, then the need for a long term performance input. The pitch for airspeed folks must study control versus performance, and the power for airspeed folks must study steady state issues. Both need to look at kinetic versus potential energy, both need to look at specific flight characteristics, both need to look at ease of learning, and both need to look at autopilots!

One recent commercial series of books tells you that for an ILS you pitch for the glideslope. The aircraft is a guided missile (mostly) and goes where it is pointed, that is CONTROL. But the same series says when you are not in the clouds you use power to control the glide angle? My question is simply, how does the airplane know when it is in the clouds, and why do clouds change the way it flies, I of course am removing the pilot from this rhetorical question! Both are wrong and both are right.

Let us look at some real live scenarios.

1. If you are at cruise altitude and are asked to speed up, what do YOU do first? Do you add power first or do you lower the nose first. Don't cheat and say you will do both together!
2. Do crop dusters 3 feet above the ground lower the nose to speed up or do they add power first?
3. If you add power first in the above scenarios, then at what magical altitude do you change to pitch! and why?
4. On the ground, does pitch control airspeed?
5. Why do AFMs give power settings for airspeed and not pitch settings?
6. If pitch for airspeed is the only way to go, then why don't all aircraft have AOA indicators, and why don't ADI's (artificial horizons) have much better resolutions?
7. If you are low and slow on an approach, then do you lower the nose for speed and add power for the glide slope?
8. Why do GPWS systems say WHOOP WHOOP PULL UP, and not WHOOP WHOOP ADD POWER, when they want you to climb?
9. Why do autopilots pitch for altitude and for glide slope, and why do autothrottles have a SPEED or an EPR/N1 setting?
10. Why do flight directors pitch for altitude and for glide slope?
11. Why do you rotate on takeoff, why not add more power? (In some aircraft climb power is more than takeoff power)
12. Adding power in some aircraft lowers the nose causing a descent, and vice versa.
13. You are in a dive approaching the ground rapidly. Will you pull out of the dive, or will you add power to gain the altitude?
14. Why does the same author have pitch for glide slopes in clouds but power for glide slopes in clear weather?
15. In steep turns when losing altitude, do you pull back or do you add power?
16. Airplanes use less power for the same airspeed at higher altitudes, and more at lower altitudes, so why not add power to descend?
17. Try doing a loop with power for altitude!
18. A one engine inoperative ILS, are you seriously going to use power to get back up to glide slope?
19. If pitch is used for big altitude changes (loops, immelmans), and for small changes (ILS approaches) then when do you change from pitch to power?

Because the transient state by definition transitions into the steady state, the two obviously interact. When you change one, by definition a change in the other is required.

Predictability is essential for autopilots, everyone knows autopilots fly better than real pilots, so how do they do it? Whether you are in a J3 Cub or a Boeing 747, vertical speed in feet per minute is:

fpm change = TAS * 103 * tan(pitch change)

and this is predictable, and it is about the only thing that is. Airspeed is much less predictable since it requires more inputs such as current speed, desired speed, acceleration rate assumed, vertical path, current weight, vertical path (if any), and whether you are climbing or descending.

A historical review might help. Air Piloting, 1938, page 17 says "all airplane parts aim for simplicity, in moving the flippers, when a pilot wants to go down he pushes forward, when he wants to climb he pulls back". What Wolfgang Langewiesche actually said in 1944 is something very few people know about, "in instrument flight airspeed is regulated by the elevator, if the airspeed reads too low you work the stick, you are THEREBY BOUND TO LOSE SOME ALTITUDE BUT THAT IS NOT YOUR IMMEDIATE CONCERN". Try that low to the ground, or when ATC detects a traffic conflict and the cost is death, injury or a violation. But what does he later say? "the cheapest way of getting back to your altitude is to use the stick". For a dive, even close to the ground, he says "the trouble is perhaps not even that close to the ground the pilot does not have the courage to do the right thing, to let the stick go forward". Wolfgang was very confused, he had brilliant ideas, but he was still confused.

In reality people put the nose where they want it and set power for a desired speed. This is attitude instrument flight.

If you use power to control altitude, you are using specific flight characteristics, and are using either (1) a steady state equation for a change (which is wrong), or (2) using the effect of air on the elevator (in which case why not use the elevator itself?). There is nothing wrong in using specific flight characteristics of an airplane, as long as you know WHAT and WHY you are doing it.

Some people teach pitch for airspeed so a student will always recover from stalls. This is mixing apples and oranges. Don't we want to teach what works ALL the time, and teach correctly, as opposed to teaching a restricted view of the world, why not teach what works and what is natural.

Aeronautical engineers are emphatic on pitch for airspeed, and (in the steady state) they are correct. They object to teaching anything other than pitch for airspeed. The problem is they don't fly for a living, nor do they teach. Just because I understand golf, I can’t play it, just because I know exactly how heart surgery works does not mean you want me to do your bypass!

What else in the FAA opposes pure pitch for airspeed teaching?

- AC 61-21A: p60 ml (middle left), 65 tr (top right), 97 br, 111 mr, 119 tr, 125 tr, 126 tl, 150br.
- AC 61-27C: p19 mr, 20 tr, 56 tr, 57 tl, 63 br, 75 tl, 75 ml, 76 tl, 76 bl, 76 mr, 78 mr, 79 br, 81 bl, tr, 85 tl, 87 bl, mr, 88 tr, br, 89 tl, 90 mr, 141 ml, 251 2a 2b 3a 4a, 253 9b, 1a2, 260 1d 1e, 262 1f, 1g, 265 2h1
- AC 61-23B: p29 bl, p93 ml
- FAA Academy Jet Eval p55, p56
- FAA B727 Jet Eval 26.01.18 turns 26.01.30 ils glide slope
- UAL B737 profiles entire book
- Boeing issue of B727 page 07.10.05 on the pitch channel.
- Army aviators FM 1-5 page 3-4 para 3-7 page 3-6 para 3-9
- Air force AFM 51-37 page 2-6 para 2.5

Many people say to the argument that pitch controls glide slope or altitude, "well alright you are correct that pitch controls altitude or glide slope, but only for the first second or two". Eureka! Exactly what I am saying! The first few seconds are the CONTROL phase, the remaining hours are the PERFORMANCE result, no argument! They are beginning to see the light.

Don't oversimplify and teach one concept or the other concept, but study the whole picture, and if you are still confused then please teach COORDINATED power and a pitch change simultaneously, but preferably understand the role that BOTH power and PITCH play in airspeed, and in altitude, and teach what can be easily learned, and thus help the pilot when he transitions to aircraft where student pilot thinking may hinder his future progress in flying.

Don't oversimplify by confusing steady and changing state, potential and kinetic energy, special aircraft design, remember this humble pitch, both play a powerful part.

The above views are personal and based on experience as a pilot under 91, 135 and 121, instructor and check airman of small and large aircraft, as well as being a mathematics major, Member British Computer Society, Member Royal Institute of Navigation, Member Royal Institution of GB.

If you don't like this, then read it again!

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