Monday, September 28, 2026

Educational Summary of the Adaptive Propeller Principle

It is known propellers haven't seen substantial innovation for many decades now. It is a long time these days! Less known they (propellers) have the potential to become the only propulsors of choice below axial speeds of Mach 0.8.

Jet lovers will hate me for this, but below that speed limit (Mach 0.8) all what remains of jet technology will be – potentially, of course! - the turboshaft engines. Turbofans and turbojets will be effectively pushed back into the transonic and supersonic speed ranges. (They will be used only by aircraft flying transonic and supersonic speeds.)

Today number of "prop believers" is very few. But - is definitely more than zero! I am one of them. Basis of my conviction is a kind of Blade Angle Formula. A mathematical formula from propeller theory, slightly rearranged to describe the 3D nature of speed vectors of the airflow around a propeller blade. Typically, vectors of the resulting speed are arranged along a continuous 3D surface. This surface is well-known - even very famous – because it is nothing but the surface of the blades of an ideal propeller.

Bad news – this 3D surface will change whenever a speed component (RPM and/or axial speed) changes. Also (this makes it really bad), the surface will change in 3D, meaning that today's 2D pitch control of the blades is quite insufficient to reach optimal regime of propeller operation. (BTW this is the reason why jets keep happily trespassing in the "propeller-country" of the full range of possible flight speeds.) The vector-GIF attached shows how the surface is changing in 3D. In fact it is simple: the surface is twisting.

Good news – that 3D diagram of the speed vectors around a propeller blade can be mechanically modelled by an assembly of rods and shafts hinged together. The mechanical model – however easy it may seem – produces the geometry of the optimal propeller blade with 100% precision!

I am enclosing a second GIF to show (and explain) how the mechanical vector-imitation works. This particular model is made for the case of a blade of a proprotor used by tiltrotors. This application is important, because tiltrotors have to use the same "propeller" for both vertical lift and hover, and for cruising flight in airplane mode. That is for the two extremes of the speed range these aircraft (the tiltrotors) fly.

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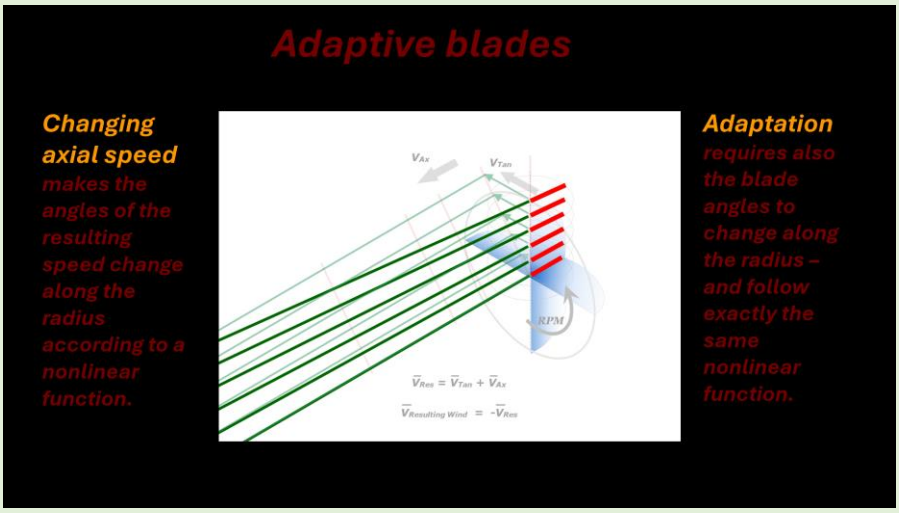

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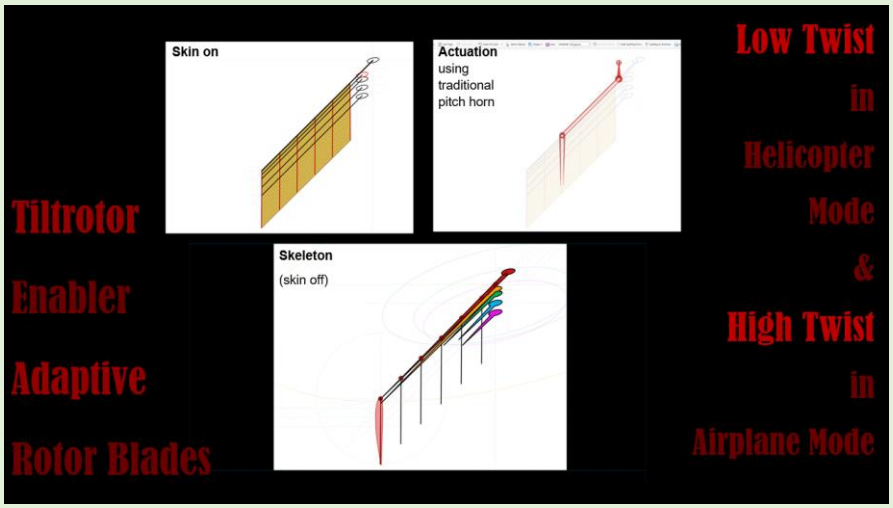

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