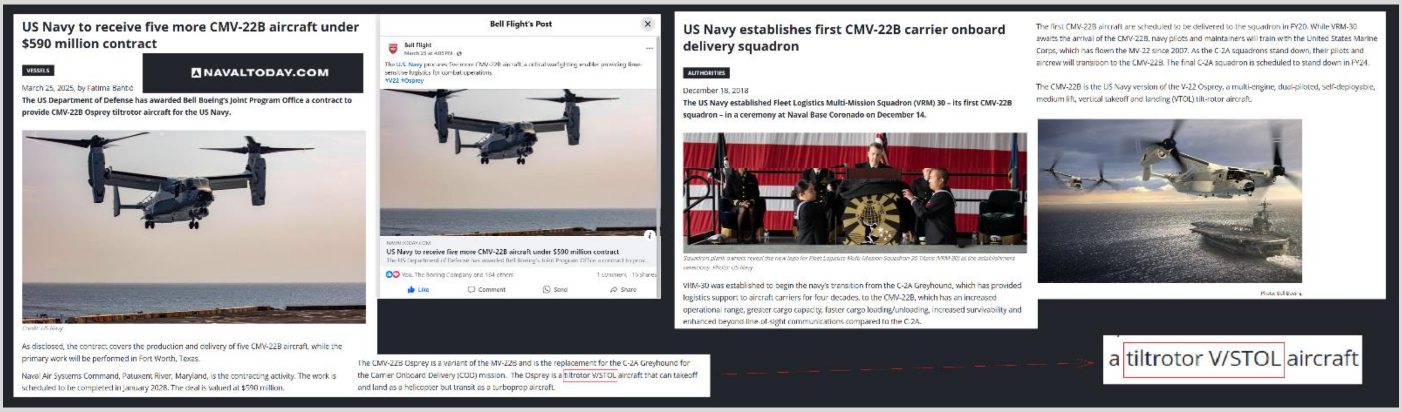
# *(Transcript)*

# Tiltrotor Business - A Comment.

Couple of days ago, following a link in a Facebook post I found this report. (See link and image below.) Love tiltrotors therefore seeing their business grow is good news.

https://www.navaltoday.com/2025/03/25/us-navy-to-receive-five-more-cmv-22b-aircraft-under-590-million-contract/




https://1drv.ms/i/c/c06dc4a61754f5c0/ESDeJOcpNuVJjai6lGtJJ8UBdUdPjXUZyOH2PZEaM5cAqQ?e=dLO7AW

Then I found the paragraph with the aircraft definition quite interesting, and decided to comment on it. The paragraph says: "The Osprey is a tiltrotor V/STOL aircraft that can take off and land as a helicopter but transit as a turboprop aircraft."

I think, for the outsiders the inserted code "STOL" may seem even flashy. Kind of a hint to the presence of some extra capabilities of the aircraft. Of course, insiders know that the opposite is true. STOL (short takeoff and landing) rather means a limitation. The real purpose of having it in the definition part of the aircraft, most probably is to prevent future complaints, litigation and penalties from the customers.

VTOLs are superior to STOLs. Therefore, if the word STOL could be omitted, then it would make the V-22 more valuable – both as just a product for sale, and also as a real-life aircraft with better capabilities.

Referring to my earlier posts (with special regard to the **one** posted 24th December 2024), it seems the situation could use some improvement. Or, even more directly:

- I wonder if Bell and Boeing are aware of the fact that they are just a rotor blade modification away from making the V-22 a 100% VTOL aircraft?

The issue becomes even hotter when we look at a greater picture of the tiltrotor landscape. The prestige and money(!) involved are enormous. Because, presently, there is a huge risk of the future V-280 Valor inheriting all the problems of the V-22 - not just the aerodynamic ones, but including also the undesirable "STOL" prefix in the name - unless those blades finally get their proper upgrade.

Laszlo

# Dialog

*<u>VFSmember_01:</u>*

I have often wondered whether the tilt rotor is in reality tilt propeller.

Rotor blades are unique to helicopters and in over 85 years since Mr Sikorsky flew the first helicopter, the helicopter manufacturers has perfected the design of the rotor blade and the controls of the rotor hub.

Many of these are not part of the Tilt Rotor blades or propellers.

Am I missing something here?

*<u>Laszlo:</u>*

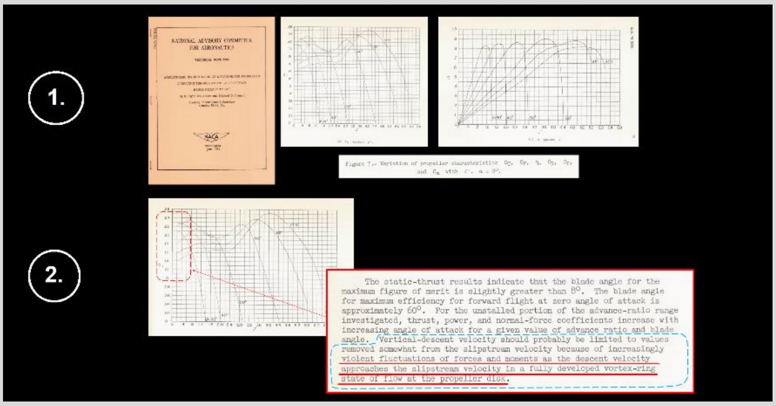
Thank you for the question!

I think, you are in a sense right: the V-22 proprotors – although they have a sophisticated hub with cyclic control – have blades with a very high, 47,5 degrees root-to tip twist. Very much unlike a helicopter blade. Much closer to the blade of a traditional high speed propeller. And that exactly is what, in my opinion, causes all present day trouble of the tiltrotors.

The many decades of rotor system development you write about, have taken place with main focus on the basic regimes of the helicopter operation: vertical takeoff and landing, rotor-edgewise flight, and hover. It is known edgewise flight has its own physical speed limit, which cannot be exceeded using this technology. (Textbooks have great descriptions of the why.) Still, a couple of decades ago some players of the VTOL business decided to circumvent this limit. They wanted to fly even faster with their VTOLs, therefore started experimenting with a different concept - the tiltrotors.

Because the new concept was successful, manufacturers started testing, even pressing their limits. This is normal nature of every business. Top product, the V-22 has been built – making miracles on the one hand, and trouble on the other. For many years gains seemed to outweigh the losses. But records and lessons have been gathered too, and today the root cause of the problems - and a solution too! - look clearer.

The basic problem is that traditional, high speed propeller blades are not suitable to handle normal tasks of the helicopter operation: vertical takeoff and landing, and hover. Not even with the complex hubs. Old NACA documents have charts with test-evidence proving this fact. (See insert.)




https://1drv.ms/i/c/c06dc4a61754f5c0/EQ4Rl0Ry2e5AgkYmT7Bsco0Bznbr62u4dHtqJ3Um0uQO6Q?e=WsBkXV

Here is what NACA engineers have written about a case when they tested a high speed propeller for hover, in 1954:

„… Vertical-descent velocity should probably be limited to values removed somewhat from the slipstream velocity because of increasingly violent fluctuations of forces and moments as the descent velocity approaches the slipstream velocity (i.e. state of hover (Kruppa)) in a fully developed vortex-ring state of flow at the propeller disk."

This terrible work regime also has a trap: although efficiency drops low, the propeller still develops thrust. A nonzero static thrust. And that is why present day V-22s are forcing their high speed proprotor blades operate just in this particular regime. To make a bad situation even worse, against the 24 degrees of the NACA propeller blade twist, Ospreys have a whopping 47,5 degrees root-to tip blade twist. The "violent fluctuations" these blades generate keep killing also internal parts of the aircraft – including the famous gearboxes, pinion gears and others. (See **post of December** last year.)

Summing up the above, the requirement for a decent operation is loud and clear: cruising flight regime requires high speed blades - while the helicopter regime requires helicopter blades. It boils down to a requirement of introducing the variable blade twist capability. New adaptive blades can supply that feature. That is why an upgrade may be so important.

This is about all - sorry for the long story!

*VFSmember_02:*

With all due respect to you, this position is flawed. Increased rotor thrust is always good. But STOL is separate, entirely.

The capability for STOL operation is not a comment on some reduced capability due to lack of rotor thrust, but the opportunity to takeoff at higher weights than VTOL by using ground speed and the resulting wing lift. It requires wheeled gear upsized to be capable of the takeoff roll, a structural design capable of the increased weight, and sometimes wing provisions/high-lift devices for low speed (flaps, maybe slats). This increased empty weight is warranted as can takeoff at higher weights, and still VTOL at midpoint or destination after burning off fuel).

STOL is a capability. Increased rotor thrust is independent of the decision to enable STOL operation. If I can get greater rotor thrust for higher VTOL weight, I'd get a yet higher STOL weight.

*Laszlo:*

… I still have the impression that in some way you may support the idea of adaptive blades. Hope it remains that way!

*VFSmember_02:*

Yes, I do support the idea of adaptive blades. In fact, I am of a fan of adaptation in general, As it allows solving constraints or requirements at different times in different ways, instead of a compromise solution. I ran a program at a government Agency specifically focused on rotor adaptation.

But the addition of adaptive capability must not come at the expense of safety, robustness, and all other requirements solved by the fixed solution being replaced. Rotor blades are a very special product, as there are so many constraints to be solved. Successfully developing and fielding a new, FIXED rotor blade is hard enough even for experts in the industry. To date, no one has adequately developed a robust solution that has made its way to the field. For rotor blades, one of the most stringent requirements is to retain aerodynamic, weight/balance, and dynamic similarity among all of the blades at ALL times as an asymmetry can have dire consequences.

So while I support your quest, you have to be credible as a rotor blade designer before you will be trusted to develop an adaptive solution on your own. Safety is on the line.

*Laszlo:*

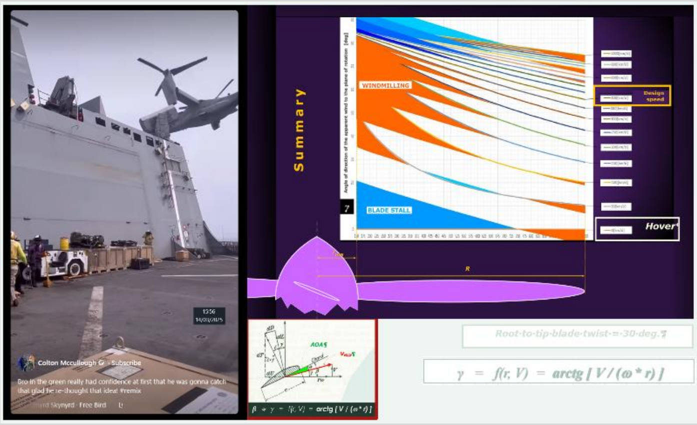
Thank you, VFSmember_02! Of course, I agree with your statements. It is beyond question that developing new rotor blades can be done only by highly specialized teams of experts. My present hope is those teams do exist and, also, are active. They are the ones who can design, prototype and field authentic products. For sure they (if exist and active) also are capable of recognizing new concepts, and know whether those concepts have the potential of rewards big enough for them to start an effort.

Your last sentence is about safety. As we know safety has many faces. One of those faces may be related to the video on this link:

https://www.facebook.com/reel/1118847913069452

This video was brought up by the Facebook the other day, without additional information. Discussion and commenting there has been extremely intensive.

A V-22 carries out a hover mission. The operation goes on without any apparatus-malfunctioning, in a more or less standard way. Unfortunately you still can't call it "normal". Pilots and experts can tell more about the horrors that are happening. I have a chart to illustrate the aerodynamic conditions over a similar rotor/propeller blade in hover.




Hover_03.png

The propeller analyzed in the chart has a 2 m diameter, and has blades with a 30 degrees root-to tip twist. This is a little less than that of the proprotor blades of the V-22 with their 47,5 degrees. The 30 degrees ensures a 400 km/h design speed (axial) at a 2598 RPM. Rotational speed was chosen to produce a 0,8 Mach tip speed, in order to achieve some optimal propeller loss-ratio. (At 0,8 Mach classic equations of aerodynamics are considered to remain true yet.)

On the chart zero axial speed may correspond also to the regime of hover. We see the blades are at least 90% stalled, with the part near the tip windmilling. That is - developing negative thrust. Those parts being "simply" stalled are still developing positive thrust, but experience a growing drag force resulting a great torque trying to slow the engines.

All this together is providing a sufficiently varied basis to generate a most complex airflow around the rotors. At the same time the low level of efficiency (a value well below 10% ! ) supplying the energy-feed to create a really huge bubble of everything bad an airflow can do for a helicopter. Including the VRS. The video is just an illustration of how all this is working out in real life.

My claim is, using the adaptive blades the hover efficiency of the V-22 can reach that of a Boeing CH-47 Chinook. The downwash damage can be reduced accordingly.

Laszlo