Defiant Vs. Valor: Inside the Head-to-Head Helo Battle To Replace the Black Hawk

The UH-60 Black Hawk is a helicopter legend, and the battle to replace it is heating up.

// BY ERIC TEGLER MAY 8, 2020

In 2022 the Army will choose a new aircraft to replace its Reagan-era UH-60 Black Hawk helicopter. Two contenders from Sikorsky-Boeing and Bell will battle it out to become the winner of the Service's Future Long-Range Assault Aircraft (FLRAA) program and the Army's next combat helo when it deploys in 2030.

But "helicopter" isn't even the right word to describe these two aerial beasts.

The Black Hawk helicopter.
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Bell's V-280 is actually a tilt-rotor, similar to the V-22 Osprey currently flown by the Marine Corps, Air Force, and Navy but smaller and with a V-tail. Rather than relying on a single large main rotor for lift in forward flight and vertical takeoff and landing (VTOL) like a helicopter, it tilts two large rotors (called prop-rotors) at each of its wingtips 90 degrees from horizontal to vertical and back. It's essentially an airplane in forward flight and twin-rotor helicopter in VTOL flight.

"THE BLACK HAWK IS A TALL BAR...IN MY VIEW IT'S THE GREATEST HELICOPTER THE WORLD HAS EVER KNOWN."

Meanwhile, Sikorsky-Boeing's SB-1 might look like a normal helicopter, but it's actually a "compound helicopter," including stacked, counter-rotating main rotors, a pusher propeller, and aircraft-like rudders. The pusher-propeller can provide significant forward thrust, relieving the need to tilt its main rotor for forward flight. Counter-rotating main rotors give extra lift, stability and smoothness. This gives the SB-1 speed, climb, and VTOL advantages over normal helicopters.

Their designs stem from the Army's desire for a multi-mission VTOL aircraft that flies much faster and farther than the workhorse Black Hawk. In fact, the Army wants its UH-60 replacement to be capable of a top speed of 230 knots (265 mph) or more, one-third faster than the 159-knot (183 mph) twin-engine Black Hawk.

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Despite being more than 40 years old, bettering the Black Hawk won't be easy. The helicopter has been built in two dozen variants for the Army alone and operated by 30 global militaries.

"The Black Hawk is a tall bar," says Army veteran helicopter pilot and Sikorsky test pilot Bill Fell. "We've been building them for over 40 years. In my view it's the greatest helicopter the world has ever known."

NEW DESIGNS, DIFFERENT CONTROLS

Both prototypes have already logged real-world flight hours. Bell's V-280 has accumulated 170 hours of flight test time and even performed a flight demonstration at the 2019 Fort Worth (TX) Alliance Air Show. As for the SB-1, it has over 13 flight hours under its belt and made its first public flight in late February.

But the way they fly is different. Their respective tilt rotor and compound pusher-helicopter designs allow their pilots to manipulate thrust in multiple axes at once, giving them agility a UH-60 can't match.

In a traditional helicopter like the Black Hawk, the pilot has three primary flight controls. There's the cyclic, a stick between the pilot's legs. Move it left or right and the helicopter rolls left or right. Move it forward or backward and it pitches the nose up or down. The collective is a lever by the pilot's left thigh. Pulling it up increases lift from the main rotor and increases engine power, making the helicopter climb. Lowering it decreases lift/thrust and the aircraft descends. Anti-torque pedals control the tail rotor. Step on the left pedal and the nose rotates to the left, press the right pedal and the nose rotates right.

Defiant and Valor employ programmable fly-by-wire digital flight controls, allowing engineers to tune pilot inputs and feedback.

V-280 Valor

The V-280 gets lift from its wings as well as its proprotors, adding another dimension Bell test pilot, Ernie McGuinness says. "Below 120 knots (138 mph) it flies like a helicopter. Beyond 120 it flies like an airplane."

The traditional cyclic is moved to the pilot's right hand in sidestick fashion in the V-280. Since the Valor is a tilt-rotor, it acts a bit more like an airplane control yoke in cruise and a cyclic in vertical flight. Bell replaces the collective with what it calls a "power lever." It controls the thrust of Valor's twin proprotors and the power of the twin engines but has shorter travel than a collective.

The V-280 has a thumb-wheel located on the power lever. Roll the wheel (like the one on your computer mouse) forward and the 35-foot-diameter proprotors tilt forward and down, accelerating the aircraft. Roll it backward and they tilt back and up, decelerating the V-280 hard. In hover or at slow speed the foot pedals rotate the nose left or right by commanding differential pitch between the proprotors. At speed, the pedals actuate rudders on the V-tail.

SB-1 Defiant

"In a helicopter when you want to turn really hard, you slow down," says Sikorsky-Boeing test pilot, Ed Henderscheid. "In the SB-1 you can turn as hard as a fixed wing airplane and the prop will maintain your speed. It allows the pilot to manipulate the flight path in ways we've never been able to before."

The SB-1 is more traditional with a cyclic and collective similar to the Black Hawk but moves the cyclic to the pilot's right hand in sidestick fashion. It also adds a thumb-wheel and two buttons on the collective to control its pusher-propeller. Rolling the wheel forward with your thumb increases propeller pitch, speeding the aircraft up. Rolling it backward decreases pitch/thrust, slowing things down.

A "zero thrust" button automatically puts the prop in negative pitch, dramatically slowing the Defiant. A clutch button engages or disengages the propeller. Rather than a tail rotor, the foot pedals command opposite pitch on each stacked main rotor, making Defiant rotate left or right at slow speed or in hover. At higher speeds the pedals actuate Defiant's rudders like an airplane.

LIFTING OFF AND CLIMBING OUT

BELL / SIKORSKY-BOEING

Flying the Valor or Defiant is a new experience for any pilot, including veteran Bell and Sikorsky-Boeing test pilots, but there are two common themes—power and speed.

Lifting off vertically and flying away in either machine is an eye-opener test pilots say. Despite both aircraft weighing around 30,000 pounds, they leap into the air far more aggressively than a 12,000-pound Black Hawk.

The competing Defiant and Valor teams won't offer VTOL rate-of-climb/acceleration numbers but they easily surpass the UH-60 and are expected to do so with a dozen soldiers inside.

V-280 Valor

"When flying with our chase jet [an L-39 trainer], it's very easy to run away from him while we climb out," McGuinness affirms.

McGuinness and fellow Bell test pilot, Paul Ryan, are Navy and Marine Corps veteran helicopter pilots respectively. They're also Navy TPS graduates, widely experienced in rotary wing machines including the Black Hawk. Paul Ryan helped develop Bell's V-22.

Lifting off vertically in the Valor is much like in a helicopter with similar cyclic and pedal inputs."The biggest difference that you feel from an UH-60 is the kick in the seat as you [tilt] the pylons forward and fly away," McGuinness says. "It put a huge smile on my face the first time I did it."

Ryan adds that as the pilot rolls the tilt control wheel forward on the power lever, the big proprotors come into his peripheral view.

"It's neat to see those big ole' blades spinning by you."

SB-1 Defiant

"The SB-1 is so much more powerful than a legacy Black Hawk," says Sikorsky-Boeing test pilot, Bill Fell.

Like Henderscheid, Fell is a veteran Army helicopter pilot and Navy Test Pilot School (TPS) graduate with rotary wing experience in the Black Hawk and many other helicopters. He says that while the pilot raises the collective to lift the Defiant off the ground in the same way as in a Black Hawk, the SB-1 responds quicker thanks to its rigid coaxial rotors and greater twin engine power, climbing much more dramatically. With its counter-rotating main rotors and digital flight control, it also requires less input from the pilot.

"If it's not really windy, you don't need to work the cyclic left-right or forward-aft to keep the aircraft straight and relatively level," Fell says. "You can pull up on the collective, never touch the cyclic, and fly away."

When ready, the Defiant pilot can engage its pusher prop, feeding in thrust to accelerate. Fell compares the sensation to an airplane takeoff, quickly gathering speed: "At some point you feel thrust from the pusher prop kick in. It's like a turbo in a car. That's a cue to the pilot to pull the nose up and fly it like an airplane using thrust from the prop to accelerate or climb."

TRANSITING TO TARGET

As a medium-lift helicopter replacement, a Valor or Defiant would have to haul soldiers, weapons, or gear to battle just like the UH-60. Both teams affirm they can do so faster and more comfortably.

So far, the SB-1 has achieved around 140 knots (161 mph) top speed in flight testing. Bell says it has exceeded 300 knots (345 mph) with the V-280.

V-280 Valor

"Pilots with pure rotary wing experience will love it," McGuinness says of the Valor's swiftness. "They'll get addicted to the speed."

Bell's pilots relay anecdotes from the field where the V-280's operational big brother, the V-22, is the preferred choice for troops because it gets them where needed so much faster than a helicopter. "When you go back to another aircraft that peaks out at only half the speed [of V-280], it feels like it takes forever to do anything with," Ryan says.

The comfort of winged-flight during transit is one of the advantages of a tilt-rotor. Valor's pilots compare it to a turboprop airplane."The ride is far smoother than any helicopter I've flown," McGuinness says. "It's going to be a good, smooth ride for the guys in the back and it's only going to take half the time to get there."

In cruise or high-speed flight, the V-280's pilots use the sidestick, power lever, and pedals as one would in an airplane.

SB-1 Defiant

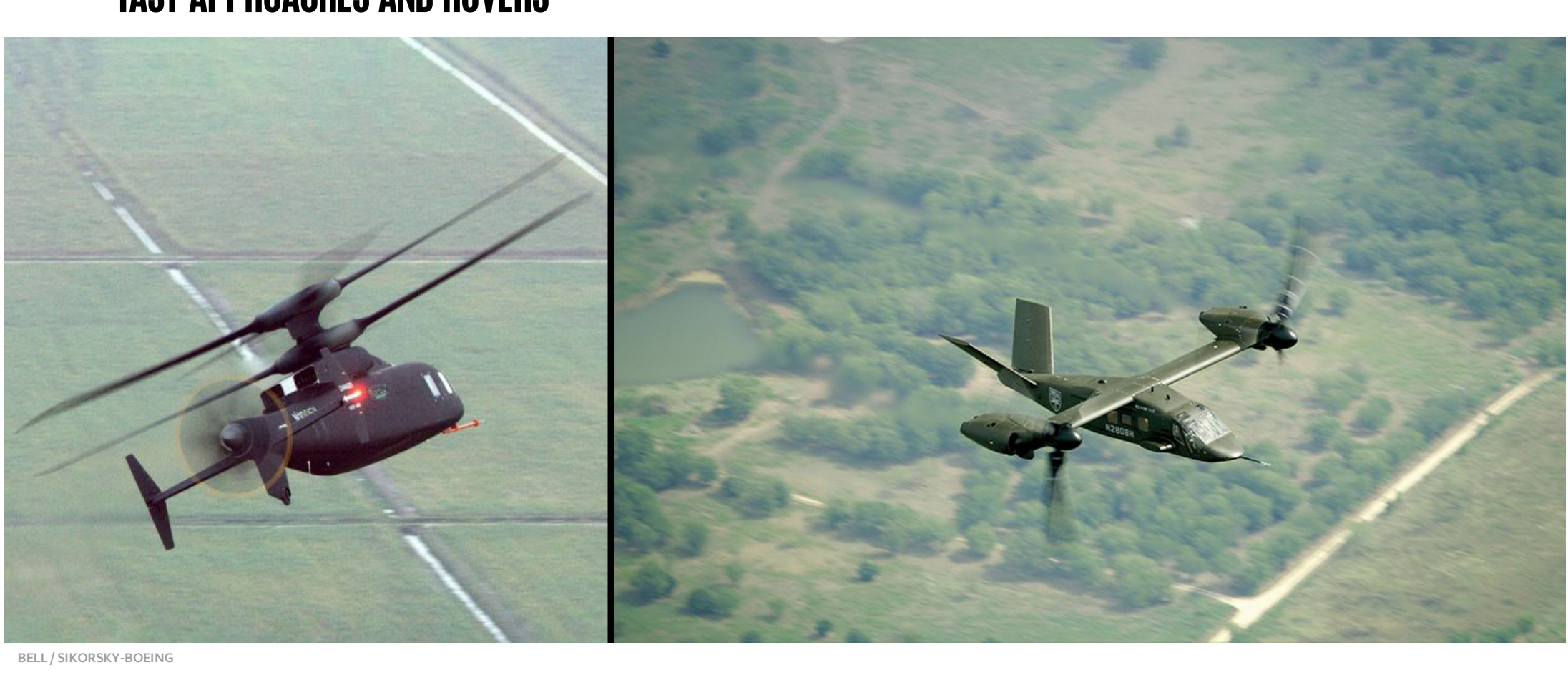
Defiant's pilots say their compound helicopter flies like an airplane in high-speed flight too, but without losing helicopter tools like the collective."If you're in a steep turn, instead of raising the nose and adding more prop to hold speed, you can add collective. It's always there," Fell says.

With its pusher prop—about the same size as a P-51 Mustang propeller—engaged, the SB-1's main rotors don't need to pitch to generate thrust. As a result the collective is automated at speeds above 80 knots (92 mph).

"Unlike a normal helicopter where your collective continues to come up as you push the nose down to go fast, in this aircraft the faster you go, the lower the collective goes," Fell says. "The pilot feels a little tug on the collective. It's the flight control system saying 'I got this.'"

Despite its rigid coaxial rotor setup, Henderscheid assures that Defiant is much smoother and less noisy than conventional helicopters thanks to an active anti-vibration system. Consisting of four force generators that vibrate at a sine-wave opposite the rotor frequency, it's analogous to a noise-canceling headset.

FAST APPROACHES AND HOVERS



BELL / SIKORSKY-BOEING

Given sophisticated anti-aircraft threats, the Army reckons its FLRAA aircraft will need to fly fast and low, figuratively slamming on the brakes as late as possible to slow to a hover or touch down in a hot landing zone (LZ).

Though they do this differently, Defiant and Valor improve markedly on the UH-60.

V-280 Valor

Ryan says the V-280's deceleration is almost more impressive than its acceleration."This thing will slow down like crazy from above 200 knots."

In flight testing, Bell has decelerated the Valor to a hover from 220 knots (253 mph) in 45 seconds. The aircraft can slow so rapidly that Bell actually limits its rotor-tilt rate to prevent structural damage. McGuinness adds that you can think of V-280 tilting its proprotors or tilting its fuselage. Coming into an LZ with its proprotors tilted up 95 degrees from horizontal, Valor's nose is 4 to 5 degrees below the horizon, giving pilots a great view of the hover or landing spot.

The V-280 is much smoother than a helicopter in a hover, says McGuinness, and it can rotate and yaw with the best of them. "There were a lot of naysayers for the V-22, saying that tilt-rotors couldn't handle in low speed regimes...it handles great."

SB-1 Defiant

According to Sikorsky-Boeing, simulations have shown that the SB-1 can slow from 200 knots (230 mph) to a hover in a half-mile while remaining largely nose-level. "The deceleration capability you get from the pusher prop is uncanny," Fell says. "When you decrease pitch or even dial in negative pitch on that prop you really feel your shoulder straps grab you as you lunge forward from slowing down.

"If I'm in a Black Hawk and I want to do a similar deceleration, I'm going to raise the nose about 30 degrees up. At 30 degrees nose-up, you don't see much but the sky. Always being able to see the landing zone and the exact spot you want to land this machine on is a huge safety benefit with Defiant."

Hovering is also a piece of cake in the Defiant, Henderscheid says, "because the SB-1 had to have the power to go fast, it doesn't even break a sweat to hover." It can also rotate at up to 30 degrees per second.

"If you've ever been in a helicopter, that's an eye-watering yaw rate."

SURVIVING

Survivability was a concern when the UH-60 was designed in the early 1970s, and it's a challenge that's only gotten tougher. Whichever FLRRA contender is selected, it will have to survive at the "X"—defined by the Army as the terminal area where it actually has to go deliver troops, conduct reconnaissance, or pull off the attack mission.

V-280 Valor

The Valor is designed to sustain battle damage with structures that break away without threatening its passenger/crew. If one engine fails, the remaining functional engine can still send power to both proprotors. According to Bell, it cannot hold a hover with one engine out, but it could do a short rolling takeoff in an emergency. Bell's emphasis is arguably more on speed with the V-280.

"I think the hot LZ scenario is more survivable in a tilt-rotor than in typical helicopters. You're really minimizing that time of vulnerability," McGuinness says. "There's nothing that I'd do in [Black Hawk] that I wouldn't do in this aircraft. I have no trouble taking this plane to the X."

SB-1 Defiant

Conversely, Sikorsky-Boeing has emphasized rotary-wing capabilities. With its pusher propeller disengaged, the SB-1 is essentially a conventional twin-engine helicopter, its coaxial main rotors notwithstanding. Like Bell, Sikorsky-Boeing considers the last 5 kilometers traveled to the LZ the most vulnerable for an assault aircraft.

Randy Rotte, Boeing's sales director for Future Vertical Lift, explains that the Sikorsky-Boeing team didn't want to sacrifice helicopter qualities to get speed and endurance. If Defiant loses an engine, for example, it can still hover reliably and fly at up to 150 knots.

"If we lose one engine or the [pusher prop], we are still able to complete the mission," Rotte says.

THE NEW BLACK HAWK: A DIFFICULT CHOICE

The tradeoffs between the two FLRAA aircraft will make the Army's decision a tough one. Speed, agility, survivability, maintainability, cost, and manufacturing capability among others will tip the balance. Bell already has a tilt-rotor in service with the other Armed Forces. Sikorsky already supplies the Army with the Black Hawk.

Whatever selection the Army makes, it won't fly like any helicopter before it.

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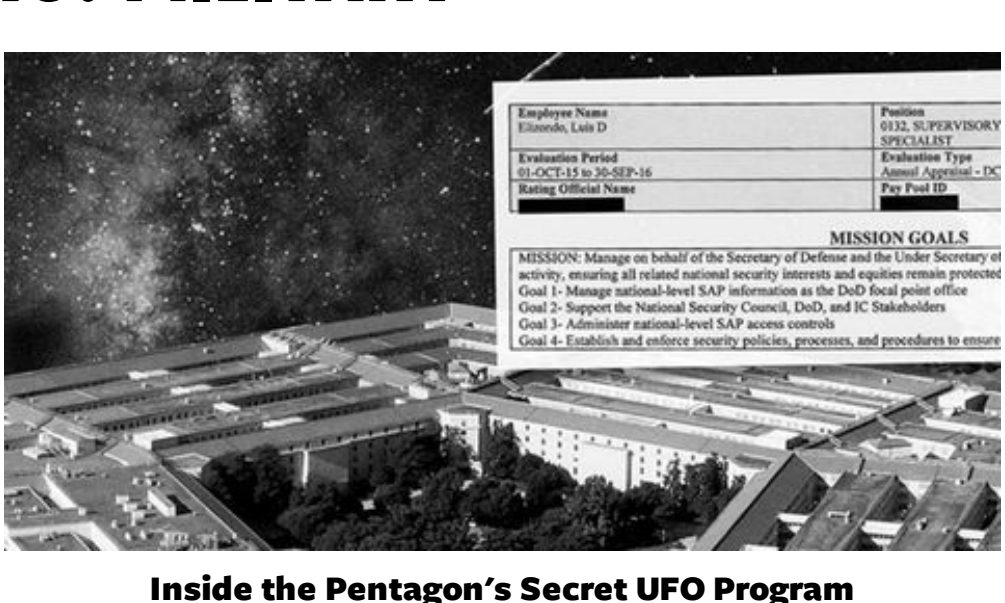
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