TOP: DARIN RUSSELL/LOCKHEED MARTIN

THE F-35 FACES ITS MOST CRITICAL TEST

WHAT PILOTS SAY ABOUT THE WORLD'S MOST ADVANCED FIGHTER.

INTERVIEWS BY LINDA SHINER

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In my interviews with F-35 pilots, one word repeatedly came up: "survivability." Surviving the Lockheed Martin F-35's primary mission—to penetrate sophisticated enemy air defenses and find and disable threats—requires what the fifth-generation jet offers: stealth and a stunning array of passive and active sensors bringing information to the pilot. The F-35 can see trouble coming—ahead, behind, or below the aircraft—far enough in advance to avoid a threat or kill it. Faced with multiple threats, the sensor suite recommends the order in which they should be dispatched.

U.S. forces first took these capabilities into combat last September, when Marine F-35Bs struck the Taliban in Afghanistan (five months after its combat debut with the Israeli air force). More than 360 of the multi-service aircraft—Air Force F-35As, Marine short-takeoff-and-vertical-landing Bs, and carrier-capable Cs—have been delivered to 16 U.S. airbases and to seven other countries. Reaching these milestones has not been easy. The program's difficulties and its cost—$406 billion for development and acquisition—have been widely reported. But now the F-35 is in the hands of the best judges of its performance, its pilots. I asked eight of them—test pilots who contributed to the jet's development as well as active-duty pilots—about their experiences. Here, in their own words, are their answers.

BILLIE FLYNN | EXPERIMENTAL TEST PILOT, LOCKHEED MARTIN

A test pilot with the company for more than 15 years, Flynn flew the first F-35 airshow demonstration, at the Paris Air Show in 2017.

For four years, all people could talk about was how we'd lost a dogfight against a 40-year-old F-16. Paris was the first time we showed what the airplane could do. The F-35 engine is the most powerful fighter engine in the world, so on takeoff, I pulled straight up. The F-22 Raptor is an airshow favorite because it is super maneuverable. It has thrust vectoring; it controls the engine exhaust with paddles that move. The F-22 can do a downward spiral, and I did the same thing in the F-35—without thrust vectoring. I pull up to vertical, skid the airplane over the top, and spiral down like a helicopter hovers. That pedal turn [executed with rudder inputs] ended the discussion of how an F-35 would perform in a dogfight.

LIEUTENANT COLONEL DAVID "CHIP" BERKE | USMC (RET.)

The first non-test pilot to fly the F-35, Berke commanded Marine Fighter Attack Training Squadron 502 at Marine Corps Air Station Beaufort, South Carolina. He is the only Marine ever to have qualified to fly the F-22 Raptor and served as the F-22 division commander at the Air Force's 422nd Test and Evaluation Squadron.

David Berke flew the Lockheed Martin F-22 before the F-35. Fifth-generation aircraft, says the pilot, offer a different set of capabilities from fourth-generation aircraft, and pilots must fly them differently as well.

Fighter aircraft all have to have a level of performance and maneuverability: speed, Gs, turn rate, turn radius, acceleration, climb—all of those things. In the F-35, there's not a massive change in those performance metrics. The F-35 is better [than legacy aircraft], but not a lot better. But those ways to measure an airplane are not nearly as relevant now as they used to be. They're not irrelevant, but they are not as important as all the other qualities that you should be measuring an airplane by.

If you were to write down all the ways in which you could measure an airplane—payload, fuel, ordnance, handling—and ask 100 pilots to rank which is the most important, I guarantee you that 100 out of 100 pilots would say "situational awareness." By far. Not a single pilot in the world would say "turn radius." Not one. Because the more you know, the more accurately you know it, the better able you are to make a decision.

In situational awareness, the F-35 is superior to all platforms, including the Raptor. I'd never been in an airplane that so effectively and seamlessly integrates information to tell me what's going on around me—and not just from the radio frequency spectrum, but laser, infrared, electro-optical. That's usually the first thing people notice when they get in the airplane. They know so much more than they ever knew before.

After situational awareness, you want to be able to dictate access regardless of the capability of the threat. A highly robust air-defense network can deny access. The biggest problem that legacy aircraft have right now is that the threat gets to dictate when and where we fly.

NO AIRPLANE HAS EVER COME OFF THE ASSEMBLY LINE AS A PERFECT MACHINE. THEY EVOLVE ALL THE TIME. IF YOU LOOK AT THE F-18 OPERATIONALLY FROM THE FIRST FLIGHT IN 1983 TO WHERE IT IS NOW, IT'S AMAZING HOW MUCH THAT AIRPLANE HAS EVOLVED. THE SAME THING IS TRUE OF THE F-35.

—DAVID "CHIP" BERKE

Air-defense networks can also be limiting for stealth aircraft. The first thing you have to think about in the F-35 is managing your signature. In an F-18, you don't even think about it because everybody sees you the minute you take off, so you don't spend a lot of time trying to hide. Managing all the components of low observability is very challenging, and pilots have to think about it all the time. And they don't do it well the first time. We all struggle with that initially. But you de-brief and analyze and start to build a database of the methods being used to detect you. You start to build a strategy that will keep others from finding you. Where do you want to put other people in the formation so you can maximize information sharing and sensor coverage and sensor footprints? It's really no different, from a philosophical viewpoint, from what we've always done. We spend a lot of time trying to figure out what our weaknesses are: What do I need to fix as a pilot?

In an F-22 and F-35, one of the most enjoyable things is being virtually undetectable until it's way, way, way too late for the threat. If you manage the signature really well, and you do it in a way that is integrated with the other platforms, most of the time the threat doesn't know you're there. And that's why I have extreme faith that the machine is going to be the most dominant aircraft ever built.

LIEUTENANT JG THORYS STENSRUD | U.S. NAVY
STRIKE FIGHTER SQUADRON 125

Stensrud graduated from the U.S. Naval Academy in 2015, and trained in T-6s and T-45s. Last year he joined VF-125, NAS Lemoore, California.

My first flight was July 2018. It was surreal. I don't think it really hit me until after we landed—just how impressive the jet is and how big a step it is from a T-45 to the first gray, Navy jet.

It definitely was a challenge to learn, and I don't think anyone's going to be crushing it right off the bat. The basic skills come pretty quickly, in two or three flights. The most challenging part is how much information the jet presents to you and focusing on the right things at the right time. Over time, you kind of find the best way to process the information. I can't think of another experience I've had that's quite like that.

I'm sure some people brought some skills from video games that might have helped them out, but probably not too much. I played some video games growing up, and I don't find comparability between playing video games and flying the F-35.

My training class was the first to have the opportunity to go straight to the F-35. I hope that we can live up to the expectation and add to the corporate knowledge around the jet.

The F-35C Navy variant has a larger wing than the Air Force and Marine models, folding wingtips, and more robust landing gear—all required for carrier operations. These two C models fly with Strike Fighter Squadron 147 at Naval Air Station Lemoore in California.

Former test pilot Art Tomassetti estimates that he spent as many as 200 hours in the simulator to prepare for some of his one-hour test flights.

COLONEL ARTHUR "TURBO" TOMASSETTI | USMC (RET.)

The only government test pilot to fly all three variants of the X-35 aircraft, Tomassetti is the F-35 Marine Corps program manager at Lockheed Martin. He was the first pilot to fly the X-35 in three regimes on a single sortie: short takeoff, supersonic dash, and vertical landing.

All three variants have the same specified top speed—Mach 1.6. Because they're slightly different airplanes, some may get to it a little faster than others. Obviously, with the big wing on the F-35C, you've got to drive that a little bit harder to get to 1.6.

[When you cross the Mach threshold], you can notice it only if you're paying attention to it. There is a little bit of a shudder, or vibration. If you were distracted or busy with something else, you might miss it. [On the mission that first combined short takeoff, supersonic dash, and vertical landing in a single flight], I think I noticed the transition just because of the magnitude of the event. You know, "Here's young Major Tomassetti, first job out of test pilot school, flying over the dry lakebed in Edwards getting ready to take this X-airplane supersonic" and you start to think, "Hey, Chuck Yeager did this. What did I do right in my life to deserve being in this particular position?"

I STARTED MY MARINE CORPS FLYING LIFE AS A HARRIER PILOT, AND I WENT TO FOUR MEMORIAL SERVICES IN THE FIRST YEAR I FLEW THE AIRPLANE. WITH THE F-35, I WANTED TO GET US TO THE POINT WHERE SOME YOUNG F-35 PILOT DOESN'T GO TO FOUR MEMORIAL SERVICES.

—ART "TURBO" TOMASSETTI

One of the marvels of this airplane is the digital flight control technology. You are telling the airplane to go up or down, speed up or slow down, go left or right. And the computers figure out what's the best way to do that, and they're going to move the flight controls to do it. And the interesting thing is, they may not do it the same way twice. So let's say the airplane gets damaged, and one of the flight controls is no longer available. A legacy airplane would still try to use that surface because it doesn't know any better. The F-35 digital flight control systems will say, "That surface isn't doing much for me anymore, so I'm going to have to compensate by using some other things. Maybe I'll have to move them a little bit more to get the same effect because the pilot still wants to turn left."

And every time I took somebody out for a first flight, when we came back—I was usually at plane side when they were coming down the ladder—I was waiting for the minute when they lifted their visor to see the expression on their face. And in every case, that expression was a smile. And when you ask people, "Do you feel like you need to practice landings?" they say, "No, not really." And that's something that you did in all of your legacy airplanes. It's not great empirical data, but it was enough to convince me that we had gotten to where I had hoped we would get to.

In the Harrier, I needed to practice hover because hovering was hard, especially if it was windy out. In this airplane, hovering is so easy that there have been pictures of pilots with their hands above the canopy rails showing, "Look, no hands" because once you put it where you want, it's going to stay there until you tell it to move or it runs out of gas.

An F-35C kicks into afterburner over Eglin Air Force Base, Fort Walton Beach, Florida. To maintain a small radar signature, the jet carries weapons in internal bays and has antennas embedded in its skin.

MAJOR VALERIE "TWITCH" WETZBARGER | F-35 INSTRUCTOR PILOT, USAF 56TH FIGHTER WING, LUKE AIR FORCE BASE

Wetzbarger flew the F-15E Strike Eagle for six years before transitioning to the F-35A. Before joining the 56th Fighter Wing, Wetzbarger flew F-15Es with the 492nd Fighter Squadron, RAF Lakenheath, U.K., and the 391st Fighter Squadron, Mountain Home Air Force Base, Idaho. She deployed twice to the Middle East from 2014 to 2015.

The transition from a 4th-gen fighter to a 5th-gen fighter was like learning how to drive an automatic car from a manual. My dad was an F-4 pilot, and he always told me, "A jet's a jet's a jet, so don't be intimidated by switching from one jet to another." The F-35 actually handles a lot like the F-15E, with the difference being, the F-35 is a high angle-of-attack fighter with advanced control logic. [Angle of attack is the angle between the wing and the oncoming air.] Those of us not used to low speed, high-AOA performance from our previous aircraft must practice and adapt to those flight regimes.

The primary mission of the F-35 is suppression of enemy air defenses. The training missions that maximize our learning are when we can locate surface-to-air missiles, protect the other strikers in the formation, bomb or suppress the targets we've been assigned, and then fight our way out. That mission is very similar to the F-15E, but the information fusion, pilot interface, and physical capabilities in the F-35 take our efficiency across the formation and among partner nations to a whole new level.

I'm constantly learning as new capabilities present themselves and the tactics are upgraded, adapted, and changed every six months or so. Every time I teach a new mission set, I have to refresh my knowledge with the latest tactics and guidance. Keeping current and absorbing each other's lessons is what it takes to be proficient as a fighter pilot in any community.

At Luke Air Force Base, we fly fairly complex missions while developing the mindset, "every wingman is a flight lead." To execute effectively, we break down those missions into phases. Some of my favorite advice is, "Slow is smooth, smooth is fast." This means slow down, do your part right the first time, and that will be quicker in the end. In the cockpit, it's important to prioritize, execute efficiently, and move on to the next priority. That is your contribution to the overall team effort.

My husband and I both learned the F-35 at the same time, and with great experiences behind us we were ready to learn a new jet and discover how we could contribute to this new melting-pot community of fighter experience. I appreciate the Air Force leaders supporting us living together as a family and the squadron treating us as individual pilots. I have also enjoyed seeing more females in fighter cockpits as they realize that the fighter community supports them and their families.

The F-35 enables the U.S. Air Force to be a more integrated force. For example, in my squadron, Americans, Italians, and Norwegians work together and teach each other. Flying the same jet builds a stronger joint and coalition team and makes us more capable as a NATO unit.

I THINK F-35 PILOTS REALIZE, ESPECIALLY WITH SUCH A MIX OF BACKGROUNDS, THAT IT TAKES THE ENTIRE TEAM TO WIN A WAR. WE'RE NOT GOING AROUND BEATING OUR CHESTS LIKE "F-35s ARE THE BEST."

—VALERIE "TWITCH" WETZBARGER

After a February 2019 flight at Luke Air Force Base, Arizona, F-35 instructor pilot Valerie Wetzbarger stands next to the F-35A. Luke received its first F-35 in 2014.

JON BEESLEY | LOCKHEED F-35 CHIEF TEST PILOT, 2002–2011

With more than 23 years as a Lockheed Martin test pilot, Beesley worked on the development of the F-117 Nighthawk and F-22 Raptor, as well as the F-35 Joint Strike Fighter. On December 15, 2006, Beesley took the first F-35 prototype, designated AA-1, on its first flight.

⬆ At Luke Air Force Base, a Royal Australian Air Force maintainer walks on an F-35 wing, its skin made of composites. Thirteen countries have ordered the jet.

For four years leading up to first flight, I spent a lot of time working on the STOVL Weight Attack Team, or SWAT. [Formed in April 2004, SWAT cut 2,700 pounds from the F-35B in six months.] That effort let us go in and fix quite a few things. There was at first a zealousness about commonality [among variants], and that's very important to the airplane, but you don't have to make bulkheads common to all variants. Nobody's gonna pull into an Air Force or Marine Corps base and say, "I need a new bulkhead." They're gonna come in and say, "I got this bad mission system box."

Ordinarily, if you're getting a bunch of weight out, you'd really cripple the airplane, but in fact, all the variants became better. It was really kind of a magical moment.

But AA-1, the very first airplane, was built prior to SWAT to the original specifications. To decide how the airplane ought to fly, we did hundreds of simulations before the first flight. When we flew the first flight, we were flying an engine that had never flown before, and we were doing it in a single-engine airplane. We were also flying electrohydrostatic actuators. Lightning is a beautiful name for the airplane, because everything is electric, including the actuators. The fact that all of that stuff worked so well on the first flight was just thrilling to me because we didn't anticipate it.

Long ago Jack Krings [test pilot and First Undersecretary of Defense under President Ronald Reagan], made a statement that always stuck with me. He said, "Air combat has always been about stealth." If you look back even into World War I, pilots attacked out of the sun. Why? Well, they didn't want to be seen.

Why does the F-117 look the way it does? Flat plates and simple shapes. Why do the F-22 and the F-35 look the way they do? You can almost see the evolution of computers. With the computers available in the late 1970s, the prediction of radar cross-section—how an airplane would reflect radar—was obviously a challenge. With 1970s computers, you design very simple surfaces, which tend to be flat. Just think how your personal computer improved between the 1970s and the 1990s and 2000s. By that time, we were able to predict the radar effects from curved surfaces and much more complex shapes. When you can allow the airplanes to look more like airplanes, you gain performance.

On the F-35, they used the Navy approach [to test maneuvers at high angle of attack]. That was to go up, disable all the limitations in the flight control system for an instant, get the airplane wrapped up, and then re-engage the whole flight control system to show that it would recover itself.

It's the part of the airplane that people don't understand. The F-35 is as maneuverable as any other airplane, except perhaps the F-22. Russian airplanes are also very maneuverable, but if you dig into [the Russian demonstrations of maneuverability], what you're seeing is the capabilities of airplanes flown by exceptional pilots. What we were building with the F-35 is an airplane that everybody can fly. That's the critical part of it.

SQUADRON LEADER ANDY EDGELL | ROYAL AIR FORCE, F-35 PATUXENT RIVER INTEGRATED TEST FORCE

Last year, Edgell flew as lead test pilot for the first F-35 flight trials on the aircraft carrier HMS *Queen Elizabeth*, including executing an unprecedented aft-facing landing. Previously a Harrier pilot, Edgell embarked in HMS *Ark Royal* and HMS *Illustrious* and led over 70 combat operations in support of British operations in Afghanistan.

Lots of people want me to make the comparison between the Harrier and the F-35, but it is chalk and cheese. Whereas I don't want fleet pilots to be thinking about how the F-35 is flying or responding, I'll tell you that was pretty much all I was doing in the Harrier. I equate it to a unicycle. You have to continuously pedal; keep moving something, whether it's your left hand, your right hand, your feet. F-35, you just sit there and go hands free and it will stay exactly where you've put it. Flying an F-35 to an aircraft carrier is an absolute pleasure, as opposed to a Harrier, which frankly can be borderline terrifying.

For tests in departure resistance, we truly had to trick the system. We would disengage all the self-protect mechanisms to put it into an out-of-control regime. And then we would allow the controller to wake up. It would recognize the situation it was in, and then it would get itself out of the situation. Absolutely fascinating. It will null all of the pitch rates, yaw rates, and roll rates to the extent that you can get it out the attitude that you've got it into.

When it comes to true departure resistance, we allowed the system to be 100 percent engaged, and we would [fly like] a very badly trained pilot. So everything that I have been taught not to do as a pilot since the age of—crikey, when did I first start flying? Maybe 13—I was being asked to do.

At Mach 1.2, I was asked to put in full left rudder, yank the stick into the back left corner, a couple of seconds later, reverse it over to the right-hand side, switch rudder pedals, and then push the stick all the way forward into the front left. No pilot in his right mind should ever be doing this. But it is the way we needed to get the data to ensure that this is a 100 percent robust aircraft. I distinctly remember one occurrence. I was full backstick [very nose high], and probably with a full left rudder-pedal input. And I was at about 5 1/2 or 6 G, at which point I needed to switch rudder pedals, but due to the G, I couldn't lift my right leg up to reverse the rudder pedal! So I aborted the maneuver. The control room said, "Yeah, Test, you didn't put the right rudder in." I said, "Yeah, I know. I couldn't lift my leg up."

I can understand why people think that because it is so heavily computerized, flying the F-35 can't be fun. The F-35 absolutely is fun to fly! It's exhilarating because there is so much power. I vividly remember a pull-out of a dive. It was about a 70-degree dive to get to the actual test point, at 5,000 feet. I recovered full backstick, a pull-out to 50-degree angle of attack, and I could not believe how quickly the aircraft turned the corner. I had probably been flying the aircraft for about three years at that point, but at that moment, it absolutely took my breath away. Legalized hooliganism! All in the pursuit of data and good test points, of course.

YOU BECOME HIGHLY DEMANDING AS A TEST PILOT. EVERY SYSTEM GETS TWEAKED. IT WOULD UPSET ME IF A FLEET PILOT SPENT EVEN A NANOSECOND THINKING ABOUT THE HANDLING OF THE AIRCRAFT.

—ANDY EDGELL

During flight trials last fall on the HMS *Queen Elizabeth,* Royal Air Force pilot Andy Edgell is greeted by a sailor on the 65,000-ton vessel.

An aft-facing landing on an aircraft carrier is an example [of a situation] where things are not going to plan. The ship may be dead in the water and the wind down the deck exceeds the limits for a tailwind landing, and you need to reverse the direction of your approach. It seems like a stunt—some might say a little unnecessary. But if that is what you need to do to recover your multi-million-dollar aircraft, then that is what you need to do. So we were really evaluating the handling of the aircraft—the propulsion, performance—when the wind is coming off the stern of the aircraft carrier. And it is disappointingly very, very benign. You just modify your pattern. There is nothing cosmic about it. The aircraft doesn't really care what direction the ship is pointing in. It just seems a little bit bizarre. I did, for a moment, stare through the windows of the bridge. And you think to yourself, "This is a view that no one really gets." You are flying nearly 200 miles an hour at about 105 feet, just pointing directly at the bridge. It certainly got some attention.

LIEUTENANT COLONEL YOSEF MORRIS | USAF 4TH SQUADRON COMMANDER, 388TH FIGHTER WING, HILL AIR FORCE BASE

In 2012, Morris transitioned to the F-35 from the F-16. He was part of the initial cadre that stood up the first F-35 squadron at Edwards Air Force Base, and he led the 4th Fighter Squadron in 2017 and 2019 Red Flag exercises.

In the two years since [the 388th's] last Red Flag exercise, the airplane itself has had some pretty significant advancements. A couple of months before the 2017 Red Flag, the Air Force declared that the squadron was what we call "initial operational capable." So the jet still had some operating limitations—altitude, airspeed, Gs, things like that. The software on the aircraft, though very capable, still had some limitations in terms of some of the systems and some of the weapons it could control.

Fast forward two years, and we're operating with what's referred to as full warfighting capability software. It's a more advanced F-35 than it was two years ago.

[In the mission to suppress enemy air defenses,] we're trying to prevent surface-to-air missiles from targeting other aircraft that are trying to get to different objectives. The F-35 has some really good sensors that can help us locate those threats. That's a very satisfying mission to be able to target something that's trying to shoot at you, especially when [you're] helping out some other assets to get to a target and keeping them safe.

The jet is sort of like a big antenna. It is receiving emissions from things that are radiating. And sometimes the [F-35's] radar is actively trying to get information on, for example, an adversary aircraft. We can mission-plan the sensors, depending on the type of mission.

And in a large-force environment like Red Flag, where there might be as many as 60 or 70 aircraft on the Blue side and 10 or 20 adversary aircraft, lots of things on the ground—that's a lot of information to interpret. Reading the first sortie on the first day, I certainly felt overwhelmed with the amount of information. And the next sortie I flew, I could manage some of my sensors differently to give me just the information I needed for that particular mission. Figuring out how to declutter your display to match the scenario is one of the main skills we learn here that we can't simulate in day-to-day training, because you don't get to train with the rest of the Department of Defense on a daily basis. ◻

What's wrong with this picture? The aircraft is facing aft, as Edgell executes the first aft-facing landing on a carrier.