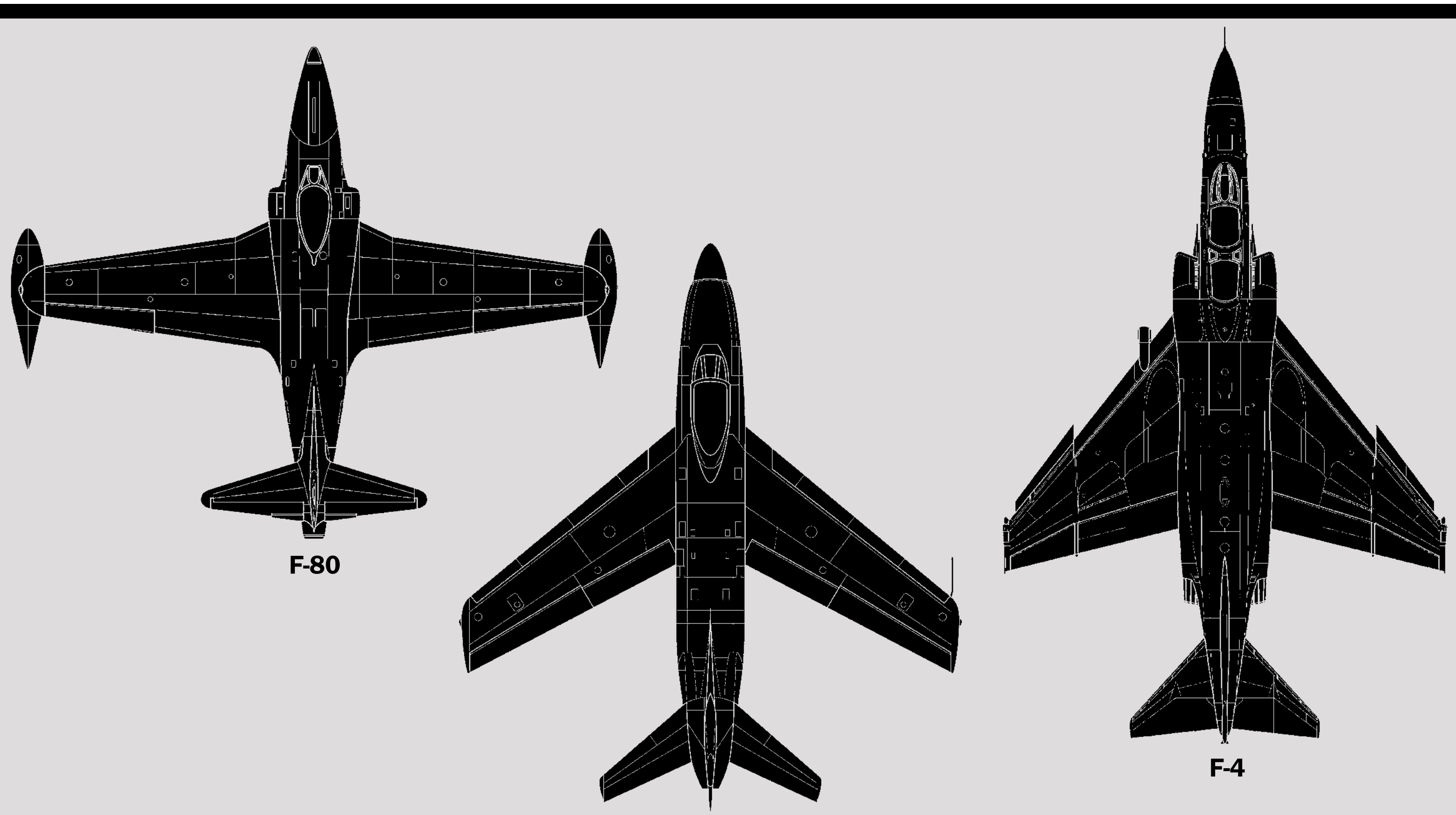
The Sixth Generation Fighter

By John A. Tirpak, Executive Editor



Illustrations not to scale

"**Within** the next few years, we will begin work on the sixth generation [fighter] capabilities necessary for future air dominance." The Secretary of the Air Force, Michael B. Donley, and the USAF Chief of Staff, Gen. Norton A. Schwartz, issued that statement in an April 13 *Washington Post* article.

The Air Force may have to move a little faster to develop that next generation fighter. While anticipated F-22 and F-35 inventories seem settled, there won't be enough to fix shortfalls in the fighter fleet over the next 20 years, as legacy fighters retire faster than fifth generation replacements appear.

The Air Force will have to answer a host of tough questions about the nature of the next fighter.

Should it provide a true "quantum leap" in capability, from fifth to sixth generation, or will some interim level of technology suffice? When will it have to appear? What kinds of fighters will potential adversaries be fielding in the next 20 years? And, if the program is delayed, will a defense industry with nothing to work on in the meantime lose its know-how to deliver the needed system?

What seems certain is that more is riding on the Air Force's answers than just replacing worn-out combat aircraft.

Initial concept studies for what would become the F-22 began in the early 1980s, when production of the F-15 was just hitting its stride. It took 20 years to go from those concepts to initial operational capability. Industry leaders believe that it will probably take another 20 years to field a next generation fighter.

That may be late to need. By 2030, according to internal USAF analyses, the service could be as many as 971 aircraft short of its minimum required inventory of 2,250 fighters. That assumes that all planned F-35s are built and delivered on time and at a rate of at least 48 per year. The shortfall is due to the mandatory retirement of F-15s and F-16s that will have exceeded their service lives and may no longer be safe to fly.

Defense Secretary Robert M. Gates has set the tone for the tactical aviation debate. He opposed the F-22 as being an expensive, "exquisite" solution to air combat requirements, and has put emphasis on the less costly F-35 Lightning II instead. He considers it exemplary of the kind of multirole platforms, applicable to a wide variety of uses, that he believes the US military should be buying in coming years. He and his technology managers have described this approach as the "75 percent" solution.

Gates has also forecast that a Russian fifth generation fighter will be operational in 2016—Russia says it will fly the fighter this year—and a Chinese version just four years later. Given that US legacy fighters are already matched or outclassed by "generation four-plus-plus" fighters, if Russia and China build their fifth generation fighters in large numbers, the US would be at a clear airpower disadvantage in the middle of the 2020s. That's a distinct possibility, as both countries have openly stated their intentions to build world-class air fleets. If they do, the 75 percent solution fails.

What You See Is What You Get

The Air Force declined to offer official comment on the status of its sixth generation fighter efforts. Privately, senior leaders have said they have been waiting to see how the F-22 and F-35 issues sorted out before establishing a structured program for a next generation fighter.

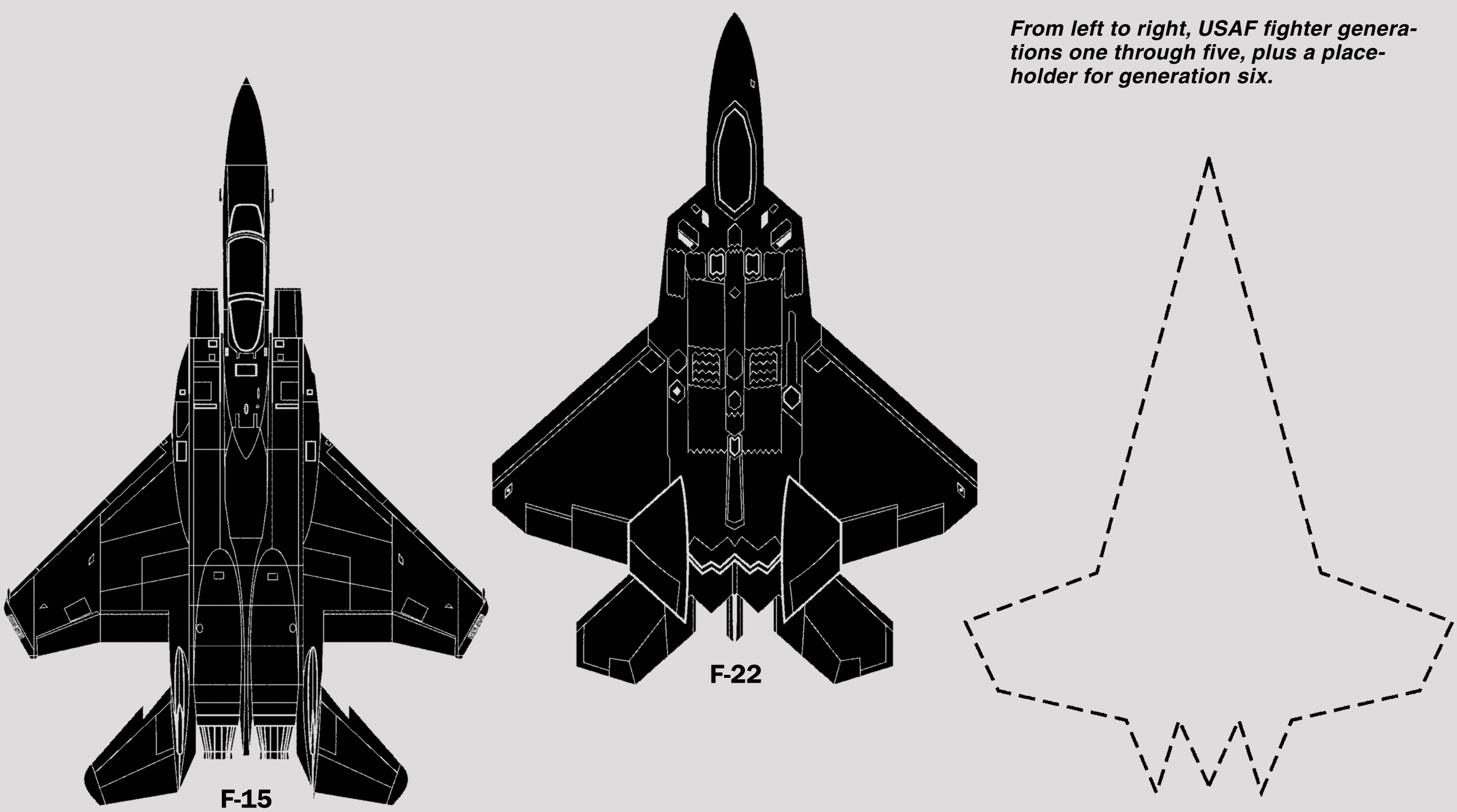
The Air Force has a large classified budget, but it seems there is no "black" sixth generation fighter program waiting in the wings. A senior industry official, with long-term, intimate knowledge of classified efforts, said the F-22 wasn't stopped at 187 aircraft because a secret, better fighter is nearly ready to be deployed. He said, "What you see is what you get."

That opinion was borne out in interviews with the top aeronautic technologists of Boeing, Lockheed Martin, and Northrop Grumman, the three largest remaining US airframers. They said they were unaware of an official, dedicated Air Force sixth generation fighter program and are anxiously waiting to see what capabilities the service wants in such a fighter.

The possibilities for a sixth generation fighter seem almost the stuff of science fiction.

It would likely be far stealthier than even the fifth generation aircraft. It may be able to change its shape in flight, "morphing" to optimize for either speed or persistence, and its engines will likely be retunable in-flight for efficient supersonic cruise or subsonic loitering.

The sixth generation fighter will likely have directed energy weapons—



From left to right, USAF fighter generations one through five, plus a placeholder for generation six.

Illustrations by Zaur Eylanbekov

The technologies are emerging, but what's needed is a program to pull them together.

Fighter Generations

The definition of fighter generations has long been subject to debate. However, most agree that the generations break down along these broad lines:

Generation 1: Jet propulsion (F-80, German Me 262).
Generation 2: Swept wings; range-only radar; infrared missiles (F-86, MiG-15).
Generation 3: Supersonic speed; pulse radar; able to shoot at targets beyond visual range ("Century Series" fighters such as F-105; F-4; MiG-17; MiG-21).
Generation 4: Pulse-doppler radar; high maneuverability; look-down, shoot-down missiles (F-15, F-16, Mirage 2000, MiG-29).
Generation 4+: High agility; sensor fusion; reduced signatures (Eurofighter Typhoon, Su-30, advanced versions of F-16 and F/A-18, Rafale).
Generation 4++: Active electronically scanned arrays; continued reduced signatures or some "active" (waveform canceling) stealth; some supercruise (Su-35, F-15SE).
Generation 5: All-aspect stealth with internal weapons, extreme agility, full-sensor fusion, integrated avionics, some or full supercruise (F-22, F-35).
Potential Generation 6: extreme stealth; efficient in all flight regimes (subsonic to multi-Mach); possible "morphing" capability; smart skins; highly networked; extremely sensitive sensors; optionally manned; directed energy weapons.

high-powered microwaves and lasers for defense against incoming missiles or as offensive weapons themselves. Munitions would likely be of the "dial an effect" type, able to cause anything from impairment to destruction of an air or ground target.

Materials and microelectronics technologies would combine to make the aircraft a large integrated sensor, possibly eliminating the need for a nose radar as it is known today. It would be equipped for making cyber attacks as well as achieving kinetic effects, but would still have to be cost-effective to make, service, and modify.

Moreover, the rapid advancement of unmanned aircraft technologies could, in 20 years or so, make feasible production of an autonomous robotic fighter. However, that is considered less likely than the emergence of an uninhabited but remotely piloted aircraft with an off-board "crew," possibly comprising many operators.

Not clear, yet, is whether the mission should be fulfilled by a single, multirole platform or a series of smaller, specialized aircraft, working in concert.

"I think this next round [of fighter development] is probably going to be dominated by ever-increasing amounts of command and control information," said Paul K. Meyer, vice president and general manager of Northrop Grumman's Advanced Programs and Technology Division.

Meyer forecast that vast amounts of data will be available to the pilot, who may or may not be on board the aircraft. The pilot will see wide-ranging, intuitive views of "the extended world" around the aircraft, he noted. The aircraft will collect its own data and seamlessly fuse it with off-board sensors, including those on other aircraft. The difference from fifth generation will be the level of detail and certainty—the long-sought automatic target recognition.

Northrop Grumman illustration

A Northrop Grumman artist's conception of a sixth generation fighter employing directed energy weapons and stealthy data networking.

Directed Energy Weapons

Embedded sensors and microelectronics will also make possible sensor arrays in "locations that previously weren't available because of either heat or the curvature of the surface," providing more powerful and comprehensive views of the battlefield, Meyer noted. Although the aircraft probably won't be autonomous, he said, it will be able to "learn" and advise the pilot as to what actions to take—specifically, whether a target should be incapacitated temporarily, damaged, or destroyed.

Traditional electronics will probably give way to photonics, said Darryl W. Davis, president of Boeing's advanced systems division.

"You could have fewer wires," said Davis. "You're on a multiplexed, fiber-optic bus ... that connects all the systems, and because you can do things at different wavelengths of light, you can move lots of data around airplanes much faster, with much less weight in terms of ... wire bundles."

Fiber optics would also be resistant to jamming or spoofing of data and less prone to cyber attack.

A "digital wingman" could accompany the main fighter as an extra sensor-shooter smart enough to take verbal instructions, Meyer forecasted.

Directed energy weapons could play a big role in deciding how agile

Technology Readiness Levels

Pentagon leaders now seek to reduce weapon risks and costs by deferring production until technologies are mature. Pentagon technology readiness levels—TRLs—are defined as follows:

TRL 1: Basic principles observed and reported. Earliest transition from basic scientific research to applied research and development. Paper studies of a technology's basic properties.

TRL 2: Invention begins; practical applications developed. No proof or detailed analysis yet.

TRL 3: Active R&D begins. Analytical and lab studies to validate predictions. Components not yet integrated.

TRL 4: Basic elements are shown to work together in a "breadboard," or lab setting.

TRL 5: Fidelity of demonstrations rises. Basic pieces are integrated in a somewhat realistic way. Can be tested in a simulated environment.

TRL 6: Representative model or prototype. A major step up in readiness for use. Possible field tests.

TRL 7: Prototype of system in operational environment is demonstrated—test bed aircraft, for example.

TRL 8: Final form of the technology is proved to work. Usually the end of system development. Weapon is tested in its final form.

TRL 9: Field use of the technology in its final form, under realistic conditions.

a sixth generation fighter would have to be, Meyer noted. "Speed of light" weapons, he added, could "negate" the importance of "the maneuverability we see in today's fashionable fighters." There won't be time to maneuver away from a directed energy attack.

Pulse weapons could also fry an enemy aircraft's systems—or those of a ground target. Based on what "we have seen and we make at Northrop Grumman," Meyer said, "in the next 20 years ... that type of technology is going to be available."

With an appropriate engine—possibly an auxiliary engine—on board to provide power for directed energy weapons, there could be an "unlimited magazine" of shots, Meyer said.

Hypersonics—that is, the ability of an air vehicle to travel at five times the speed of sound, or faster—has routinely been suggested as an attribute of sixth generation fighters, but the industry leaders are skeptical the capability will be ready in time.

While there have been some successes with experimental hypersonic propulsion, the total amount of true hypersonic flying time is less than 15 minutes, and the leap to an operational fighter in 20 years might be a leap too far.

"It entails a whole new range of materials development, due to ... sensors, fuzes, apertures, etc.," Meyer noted, "all of which must operate in that intense heat environment at ... Mach 5-plus."

Still, "it is indeed an option that we would consider" because targets will be fleeting and require quick, surgical strikes at great distances. However, such an approach would probably be incompatible with a loitering capability.

Davis said he thinks hypersonics "will start to show up in sixth generation," but not initially as the platform's power plant, but rather in the aircraft's kinetic munitions.

"I think it will start with applications to weapons," Davis said. And they may not necessarily be just weapons but "high-speed reconnaissance platforms for short missions on the way to the target."

Because of the extreme speed of hypersonic platforms and especially directed energy weapons, Davis thinks it will be critical to have "persistent eyes on target" because speed-of-light weapons can't be recalled "once you've pulled the trigger," and even at hypersonic speed, a target may move before the weapon arrives. That would suggest a flotilla of stealthy drones or sensors positioned around the battlefield.

Not only will hypersonics require years more work, Davis said it must be combined with other, variable-cycle engines that will allow an aircraft to take off from sea level, climb to high altitude, and then engage a hypersonic engine. Those enabling propulsion elements are not necessarily near at hand in a single package.

The sixth generation fighter, whatever it turns out to be, will still be a machine and will need to be serviced, repaired, and modified, according to Neil Kacena, deputy director of Lockheed Martin's Skunk Works advanced projects division. He is less confident that major systems such as radar will be embedded in the aircraft skin.

"If the radar doesn't work, and now you have to take the wing off, ... then that may not be the technology that will find its way onto a sixth gen aircraft," he said. In designing the next fighter, life cycle costs will be crucial, and so practical considerations will have to be accommodated.

Toward that end, he said, Lockheed Martin is working on new composite manufacturing techniques that use far fewer fasteners, less costly tooling, and therefore lower start-up and sustainment

USAF photo

F-22 Raptors on a training mission soar over the mountains near Elmendorf AFB, Alaska. The fifth generation fighter features all-aspect stealth and full-sensor fusion.

Boeing illustration

In Boeing's conception, traditional electronics give way to photonics, reducing weight and increasing processing speed.

costs. It demonstrated those technologies recently on the Advanced Composite Cargo Aircraft program.

Given the anticipated capabilities of the Russian and Chinese fifth generation fighters, when will a sixth generation aircraft have to be available?

Davis said the Air Force and Navy, not industry, will have to decide how soon they need a new generation of fighters. However, "if the services are thinking they need something in 2020" when foreign fifth generation fighters could be proliferating in large numbers, "we're going to have to do some things to our existing generation of platforms," such as add the directed energy weapons or other enhancements.

Kacena agreed, saying that Lockheed Martin has "engaged with both services and supplied them data and our perspectives" about the next round of fighter development. If the need exists to make a true quantum leap, then sixth generation is the way to go, but, "if it's driven by the reduction in force structure [and] ... the equipment is just getting old and worn out in that time frame, then [we] may very well be on a path of continuous improvement of fifth generation capabilities." Lockheed Martin makes both the F-22 and F-35.

He said the company's goal is to find the knee in the curve where "you get them the most bang for the buck without an 80 to 90 percent solution. Something that doesn't take them beyond the nonlinear increase in cost."

Lt. Gen. David A. Deptula, the Air Force deputy chief of staff for intelligence-surveillance-reconnaissance and a fighter pilot, said the next fighter generation may well have characteristics fundamentally different from any seen today, but he urged defense decision-makers to keep an open mind and not ignore hard-learned lessons from history.

Although great strides have been made in unmanned aircraft, said Deptula, "we have a long way to go to achieve the degree of 360-degree spherical situation awareness, rapid assimilation of information, and translation of that information into action that the human brain, linked with its on-site sensors, can accomplish."

Numbers Count, Too

Despite rapid increases in computer processing power, it will be difficult for a machine to cope with "an infinite number of potential situations that are occurring in split seconds," Deptula added, noting that, until such a capability is proved, "we will still require manned aircraft."

It's important to note that America's potential adversaries will have access to nearly all the technologies now only resident with US forces, Deptula said. Thinking 20 to 30 years out, it will be necessary to invest properly to retain things US forces depend on, such as air superiority.

However, he warned not to put too much emphasis on technology, per se. "Just as precision air weapons and, to a certain degree, cyberspace are redefining our definition of mass in today's fight, we have to be very wary of how quickly 'mass' in its classic sense can return in an era of mass-precision and mass-cyber capabilities for all."

In other words, numbers count, and too few fighters, even if they are extremely advanced, are still too few.

Hanging over the sixth generation fighter debate is this stark fact: The relevant program should now be well under way, but it has not even been defined. If the Pentagon wants a sixth generation capability, it will have to demonstrate that intent, and soon. Industry needs that clear signal if it is to invest its own money in developing the technologies needed to make the sixth generation fighter come about.

Moreover, the sixth generation program is necessary to keep the US aerospace industry on the cutting edge. Unless it is challenged, if the "90 percent" solution is needed in the future, industry may not be able to answer the call.

Under Gates, Pentagon technology leaders have said they want to avoid cost and schedule problems by deferring development until technologies are more mature. Unfortunately, this safe and steady approach does not stimulate leap-ahead technologies.

Meyer said, "We need to have challenges to our innovative thoughts, our engineering talents, our technology integration and development that would ... push us ... to the point where industry has to perform beyond expectations."

He noted that today's F-35 is predicated on largely proven technologies and "affordability," but it was the B-2 and F-22 programs that really paved the way for the systems that underpin modern air combat.

The B-2 bomber, he noted, "was a program of significant discovery," because it involved a great deal of invention to meet required performance. The B-2 demanded "taking ... basic research and developing it in the early ... phases" of the program, which yielded nonfaceted stealth, enhanced range and payload, nuclear hardening, new antennas, radars, and flight controls.

Today, Meyer said, most programs are entering full-scale development only when they've reached a technology readiness level of six or higher (see chart).

"We probably had elements on the B-2 ... that were at four, and a lot at five," Meyer said.

Programs such as the sixth generation fighter "are the ones we relish because they make us think, they make us take risks that we wouldn't normally take, and in taking on those risks we've discovered the new technologies that have made our industry great," he asserted.

Davis said that other countries are going to school on the US fighter industry and taking its lessons to heart.

"We still think you have to build things—fly them and test them—in order to know what works and what doesn't," said Davis. "And, at some point, if you don't do that, just do it theoretically, it doesn't get you where you need to be."

He added, "If we don't continue to move forward, they will catch us." ■