

# Climb Time for



**Costs and performance are improving, but 2014 will be a critical year.**

Lockheed Martin photo by Matthew Short

**T**he F-35 joint strike fighter program is on a roll. Production prices and operating cost estimates are coming down, flight test is accelerating, development issues are being cleared, pilot training is underway, and target dates for operational service have been announced.

There are still risks in the program, but the services and Pentagon leaders insist the F-35 is their top priority and have pledged to protect its funding no matter what happens with the rest of the defense budget.

In a September interview, Air Force Lt. Gen. Christopher C. Bogdan, the F-35 program executive officer, said, “We are really, really close to turning the corner” on the fighter. “I am confident,” he said, that the Marine Corps, Air Force, and Navy will have everything they need to achieve their target initial operational capability dates in the second half of 2015, second half of 2016, and late 2018, respectively. Those dates were announced by the services in June.

After a program review summit last summer of Pentagon, contractor, and international F-35 partners, Undersecretary of Defense for Acquisition, Technology, and Logistics Frank Kendall declared the strike fighter was no longer “one of my problem programs.” Kendall also forecast that he’d green-

light a significant hike in F-35 production rates following a program review this fall.

Production has been held to about 30 airplanes a year for the last three years, but Kendall said he saw no reason not to start ramping up to 44 airplanes in 2015 and 66 in 2016.

Following this fall’s Oct. 21 review, Kendall said production rates could increase—“consistent with budget priorities”—so long as progress continues, particularly in software, reliability and sustainability, and test.

“This is not the program of 2010,” Kendall told reporters at a press conference after the June summit. While he said it was too soon to “declare success,” he was impressed by the program’s progress and forecast significantly lower cost reports in the months to come.

The coming year will be telling, however. Bogdan said his optimism is tempered by the prospect of “hard stuff” the program will have to achieve in the next 12 months.

“The two things we need to ... really turn the corner, is to watch the production ramp rate go up because we really haven’t seen that yet,” he said. The second accomplishment needs to be demonstrating success with major software milestones.

One aspect of that software verification work is live, guided weapon launches. These began in October. While many types

# the F-35

By John A. Tirpak, Executive Editor



*Left: AF-01, piloted by Maj. Matthew Phillips, completes the first aerial weapons release of an AIM-120 AMRAAM over a test range in China Lake, Calif. Below: Maj. Jay Spohn, the first Air National Guard pilot to be qualified in the F-35 and an instructor pilot at Eglin AFB, Fla., runs a preflight check on an F-35 in 2012.*



Photo by Jim Haseltine





*Lt. Col. Matt Kelly pilots an F-35 during aerial refueling testing June 19. It was the first time an F-35B tanked from a KC-10.*

of munitions have been released from the fighter to demonstrate they can come away from the airplane safely, “in the next year, we’re actually going to try to ... hit something,” Bogdan said. The first tests included laser guided bombs and air-to-air missiles.

The ramp rate is a big challenge because it “stresses the supply chain pretty good when you’re doubling your production over the next three years,” he noted. For now, though, “engine and aircraft [production] are stable.”

However, once it’s clear the production increase and the software and weapon tests are going well, then “I would tell you ... the program’s turned the corner,” he said.

Two key developments over the summer highlighted the program’s progress. The government and Lockheed Martin struck a deal on production Lots 6 and 7 dropping the price four percent with each lot. Also, Bogdan sent a revised life cycle cost estimate to the Senate forecasting the US military fleet of 2,443 F-35s will cost \$857 billion to buy, own, and operate for the next 53 years. That projection was 22 percent lower than the previous estimate, created by the Pentagon’s Cost Assessment and Program Evaluation shop, which famously pegged it at \$1.1 trillion.

While skeptics may be suspicious that these positive developments are coming at a time when defense programs are getting intense scrutiny, all this good news out of the project “is not spin. It’s just fact,” Bogdan said.

Now in its 12th year, the F-35 program has had a turbulent development. Three years ago, the project had to be restructured as deadlines slipped, flight testing lagged, technical problems abounded, and costs rose.

Vice Adm. David J. Venlet, then the F-35’s PEO, asked for—and got—extensions of time and money to get the program back on track. About \$6 billion was added to the program, along with 30 more months of development time, to resolve problems of concurrency. Concurrency is performing

development, flight testing, production, training of operational pilots and maintainers, establishment of depots, and stand-up of operational bases all at the same time.

“I’m not sure that both the good and the bad got equal time” in public discussions about the F-35 until recently, Bogdan said. “Sometimes, not enough of the bad” was publicized, he said. Then, “people got surprised when things went off the rails”—and the bad news became a major story.

Since taking over the program in the summer of 2012, Bogdan’s mantra has been “no more time and no more money.” He won’t request any more of either from Congress and said if any of the three services, eight international partners, or two foreign military sales customers involved in the program want to make changes to it, those changes must be thoroughly justified and paid for by deleting something else. He’s established a team within the project whose sole job is to minimize changes, which drive costs up.

### **An Imbalance of Risk**

The program left to him by Venlet is “pretty credible and pretty realistic,” Bogdan said in a speech at the Air Force Association’s Air & Space Conference in September.

He admitted throwing “a hand grenade into the crowd” in his speech the year before, by declaring the relationship between the government and its contractors on the F-35 was the worst he’d seen in his years as an acquisition officer.

“That was intentional,” Bogdan said of those harsh comments, and they had the desired effect of getting the attention of contractors, the press, and Capitol Hill alike—making clear the urgency of changing the program’s culture.

The old, dysfunctional relationship was not based on transparency and good communications, and it was also not fair, he said. There was an imbalance of risk, wherein the government was bearing too much and the contractors not enough.



Now, though, “the balance of risk has changed,” he said. While the relationship is not yet perfect, the Lots 6 and 7 results—achieved in only several months, after it took nearly 14 months to negotiate Lot 5 alone—demonstrate improved communication, he said. Bogdan pointed out that the government has “zero” liability if costs on Lots 6 and 7 are higher than those quoted by Lockheed Martin and engine-maker Pratt & Whitney; the companies will have to eat any overages. However, if costs are lower than expected, the government and the contractors share in the savings. Lot 8 comes up for negotiation next month.

Bogdan’s speech at the 2012 AFA conference was “an impactful day,” said Lorraine M. Martin, Lockheed Martin’s F-35 vice president and general manager, in an interview. She and Bogdan resolved to make Lots 6 and 7 the “test case [for] how we can do business better together—communicating,

coordinating, being responsive, ... which is what a good partnership is all about.”

“[Through Lot 7], we’ve brought the price down 55 percent since the first time we negotiated for a production aircraft,” Martin said. The price decrease was made possible by negotiating two lots at once, an improved learning curve, higher volume, and because of lessons learned on Lot 5, she said.

“We spent a lot of time in [Lot] 5 really understanding costs,” she observed, chalking up most of the delay to the process of reaching agreement with the government on what those costs actually were.

“The next round of efficiencies,” however, will depend on increasing the volume produced, to obtain the economies of scale, she said. The US military services expect to buy more than 2,400 F-35s; export orders will involve at least 600 more.

The program office’s new lower cost estimate is informed by thousands of hours of real-world experience in test and training flights and maintenance, while the previous CAPE estimate—now three years old—did not have those numbers to work with and is “stale,” Bogdan said.

In his 2013 Air Force Association Air & Space Conference speech, Bogdan forecast that “by 2019, you’re going to see an airplane, in my opinion, that is comparable in cost” to fourth generation fighters. It will be somewhat more expensive “because you would expect that a fifth generation aircraft would cost somewhat more,” but he said he’s got contractor commitment to aim for price equivalency with fourth gen fighters. For the Air Force, the price is ultimately expected to come in at about \$85 million a copy, flyaway cost.

Because affordability is the top management priority, Bogdan said he’s copied a tactic used by the Navy on its Virginia-class submarine program and by European governments and contractors for the Typhoon fighter. He’s established a “cost war room,” populated by government and contractor experts whose sole job is to scrutinize operating costs and look for more efficient ways to do things. The contractors have provided office space and efficiency experts “with their own nickel,” Bogdan said.

The war room was a good idea in any case, but it was mostly in response to the reliability and maintainability experience so far on the F-35, which “is one of my biggest worries, long term,” he said.

The R&M cost curves “we’re seeing right now are not where we need them to be, not where the services need them to be,” Bogdan said. One headache is parts shortages: It’s taking too long to fix parts and some were not designed properly in the first place.

Tires on the F-35B short takeoff and vertical landing model, for example, are being changed out too often. As it turns out, he said, the qualities that make a tire work well for a vertical landing on the F-35B are “on the opposite end of the spectrum” from the qualities that make a tire last a long time in conventional use. Lockheed Martin and tire manufacturer Dunlop have gone back to the drawing board, but the tire redesign “isn’t costing me one penny,” Bogdan said.

This is just one sign the program now demands accountability from contractors and customers alike to live up to their promises. When the tire is redesigned, Bogdan said he will expect the companies to “stand behind” their product with a warranty.

The spares situation, Martin said, came about for several reasons.

“The spares inventory wasn’t funded the way the program office would have hoped at the beginning,” she said. “It’s being fixed, going forward, ... but in some cases, we don’t have the spares we’d be looking for.” Complicating the problem is the rapid stand-up of multiple F-35 operating locations; something not “originally planned for” in the spares plan. “We ... have six operational bases right now,” she said, and there have to be spares available in all locations.

The stand-up of the USAF and USMC depots should help the spares shortfall by creating more places where parts can be fixed, freeing the parts manufacturers to concentrate on production rather than rework of parts.

Bogdan said he’s taken a “whack-a-mole” approach to reliability issues. “We have a good list of all those bad actors,” he said. “So we are systematically going through and applying engineering discipline, money, and work to ... bring that list down”—20 items at a time—“until we get the reliability and maintainability on this airplane to what the users need.”



USAF photo by Andy Morataya

**Lt. Gen. Christopher Bogdan leads a discussion about F-35 requirements at the Air Force Association’s Air & Space Conference and Technology Exposition Sept. 17, 2013.**





Lockheed Martin photo by Andy Wolfe

**A Marine Corps short takeoff and vertical landing version of the F-35 takes off from USS Wasp during developmental testing on Aug. 12, 2013. Tire fatigue is an issue for the STOVL version of the Lightning II, but the fix isn't costing DOD.**

### Testing Takes Off

By the end of this calendar year, the F-35 program will be “50 percent done” with the test flight program, versus one-third done at the end of last year, Bogdan reported. Test flying is accelerating because more test aircraft were added, and the flights themselves are being run “more efficiently.” Departure testing and engine airborne restart testing are finished, and “we’re very happy to have come through that cleanly,” said Bogdan, himself a former test pilot.

All versions of the F-35 have performed aerial refueling with all US tanker types, and the short takeoff and vertical landing F-35B has made runs on the small carrier *Wasp* for vertical landing tests. Testing of the Multifunction Advanced Data Link, or MADL, system also is underway.

“That’s a big deal for us,” Bogdan said, “because this airplane is so darn smart, if you can’t talk to other people, we will lose huge capability in the future.”

He said the Air Force and Marine Corps versions have completed one “lifetime” of durability testing and have started a second lifetime; the Navy model has nearly finished its first durability lifetime.

The program will deliver 36 aircraft this calendar year, Bogdan said. He said “the biggest thing” that has changed on the program since last year is the number of sites where F-35s are flying. Each service has several operating locations now; Air Force and Marine Corps depots have been stood up; and the Navy has started flying its new F-35Cs at Eglin AFB, Fla. Italy’s Final Assembly and Check-Out (FACO) facility recently began assembling its first fuselage.

“So in just one year, we’ve added five or six different sites, ... and over the next four years, we’ll add another 11 sites,” Bogdan said. From 2011 through 2017, “we’ll have 17 more places where we’ll be operating the F-35. That is a big, big increase.”

Eglin, the all-service F-35 schoolhouse, has trained some 67 operational pilots, and there are more than 100 F-35 pilots in all. More than 100 F-35s are flying.

Most long-term issues with the F-35 are also largely resolved, to varying degrees, Bogdan reported.

The F-35 helmet—on which pilots depend for 360-degree situational awareness, night vision, targeting, and aircraft status data—had a number of problems with nighttime acuity, latency of the image as pilots moved their heads, and a jittery presentation.

Martin said the helmet concerns have been generally corrected after “a good six months” of testing fixes. Some were with software, and the night vision problem

is being remedied by substituting a new, more advanced camera than the existing 2005-vintage model. It will be cut into production starting with Lot 7.

“But we can go to war with the helmet we have,” she said, and in fact, the existing helmet “has been deemed suitable for Marine Corps IOC.” The helmet has “9,000 flying hours on it,” and pilots “love it,” she said. Bogdan agreed that the helmet matter seems to be resolved. He canceled an alternative helmet development; its existence had offered contractors a stiff incentive to fix the original equipment. Progress in resolving the helmet issues made the alternative unnecessary, he announced in October.

The original F-35C arrestor hook has been redesigned and tested, and the new hook will soon be integrated into production.

Regarding issues with fuel dumps, “we’re stuck with the design,” Bogdan said in the AFA speech. Underwing pressure was keeping dumped fuel against the airframe, getting into areas where it shouldn’t go. Tweaks of affected areas on the wing will mitigate the problem and render the situation acceptable to the Navy and Marine Corps. USAF tends not to dump fuel, he said.

Critics joked that the F-35 Lightning II can’t survive an encounter with lightning, since it doesn’t fly in thunderstorms.

“The truth of it is, you usually don’t get clearance to fly an airplane in lightning until near the end of the development program,” Bogdan said, and the F-35 is only halfway through flight test. Still, the program will accelerate lightning qualification to satisfy critics; it should be in place by 2015.

The Marine Corps will declare the F-35 operational with what is called the 2B software. It will have all the basic weapons, sensors, software, electronic warfare, and other capabilities expected for initial operations and, at that minimum level, will still be better than those on any current Marine Corps fighter.

The 3I software, considered interim software as is the 2B, is the same suite of programs but on a more powerful processor, Martin explained. The 3F software—which will

equip the Air Force's first war-ready aircraft—"is the final ... development capability as committed to on the F-35," she said.

The 3F software "has some more data fusion in it [and] has about 300,000 extra lines of code to be coded that we haven't finished yet, out of 8.6 million [lines in the fighter]," Martin explained. That's "nontrivial, but we do have the time, and we have a plan that we feel comfortable can be executed," she said.

The 2B software has had "three main drops, and they have all been on time, with the capability we had promised." There's also clear agreement with the program office about just what has to be in each software drop, she said, so "there's no question between us and [Bogdan] at any time where we are."

### Breaking the Code

Martin asserted that, as of September, 95 percent of the F-35 software has been coded and "86 percent is flying."

Bogdan agreed that "the interim capabilities" of the software as it stands now "are pretty secure." However, "I am less confident on the back end ... [in] the 2016 to 2017 time frame, with our final capability."

The F-35 has "10 million lines of code on the airplane [and] 10 million lines of code on offboard systems. That is just an awful lot of software." The pacing is critical, he said in the AFA speech.

"The labs, the airplanes, the software engineers" now working on the 2B and 3I will have to shift to the 3F at some point. If that shift happens in "a timely way," he will be confident in the software effort going forward, he said. But "if I have to leave people and resources on 2B and 3I longer, you can bet that affects our final capability."

Stakeholders should keep an eye on the 2B and 3I software progress; "that will give you a very good indication of what's going to happen in 2017," Bogdan suggested.

Air Force Chief of Staff Gen. Mark A. Welsh III rarely misses a chance to advocate for the F-35 as crucial to the service's future combat ability. Last spring, he also said the F-35 will have to bear a much greater part of the air superiority mission than it was ever intended to, because of the small number of F-22s.

"I believe the Chief is probably right," Bogdan said in the interview. As a replacement for the F-16, the F-35 will inherit the Viper's air-to-air role.

To give it more dogfighting capability, Bogdan said the F-35 program has a science and technology funding line that looks at future capabilities and growth potential for the fighter. "We are specifically targeting sensors and weapons that enhance our ability in the air-to-air realm," he reported. "We ... will make this airplane even better than it is today in an air-to-air role."

There are block upgrade plans "already in place for the aircraft," Martin said. There are "significant roadmaps" for electronic warfare, communications, weapons, and sensors, "not only to support the US but our partners as well." The summit-level steering committee is "now in the process of looking at Block 4A and 4B for added capabilities," she said.

The power plant is a likely improvement area. Bogdan said there could be modular enhancements to the F135 engine, or "a whole new engine 20 years from now." The entire S&T community, he said, "continues to advance engine technology, and ... the F-35 is going to use some of that someday. We have to."

Moreover, the F-35's stealth can be improved, he said.

"It's not just coatings, ... shape, [or] ... countermeasures kind of stuff. There's a whole host of things you can do" without affecting the aircraft's shape or "mold line." The program "would like to tap into that," he said.

Bogdan acknowledged that Lockheed Martin offered stealthy external weapons or fuel pods on the stillborn FB-22 proposal, and something similar could extend the F-35's range, even as the services are putting a premium on longer-range systems to defeat anti-access, area-denial threats.

However, combat commanders "have to decide in some form of trade if they're willing to pay the penalty of maybe a little less stealth, a little less payload for increased range," Bogdan said. "I've not heard that demand signal yet."

The recent news of positive developments coming from the program office shouldn't be construed as advocacy, Bogdan maintained.

"I have to run the program to the best of my ability and let the chips fall where they may," he insisted. Program advocacy is best left to Lockheed Martin, the services, and the international partners. To be an F-35 advocate would mean "I lose my credibility," he said.

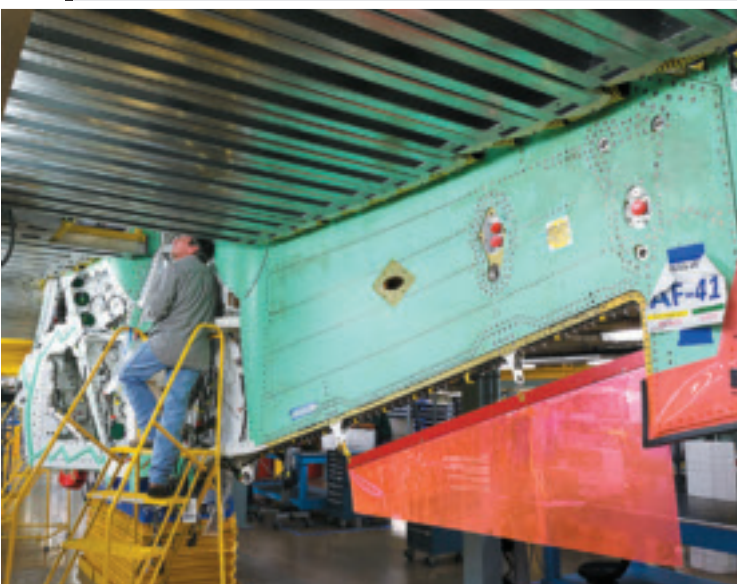
Even so, Bogdan is confident "it's going to come out good."

Having made countless visits to Capitol Hill since taking over the F-35, Bogdan said he believes there is a "sea change" in the way the fighter is perceived there.

"I think the Hill appreciates our candor and the transparency we're providing them on the program," he asserted, hastening to add that he's only one of many messengers from the Defense Department explaining how things are going on the F-35. Service Chiefs and the "whole senior leadership" of the Defense Department are telling Congress "what is and what isn't." It's appreciated, he said. Members of Congress "don't like to make decisions in a vacuum; they want information to make good decisions," and a diet of news skewed good or bad doesn't help.

Ten years from now, Bogdan concluded, "people will look back and they'll go, 'What was all the fuss about? This is a darn good airplane.'"

Lockheed Martin photo by Neal Chapman



Lockheed Martin employees work on assembling the 100th F-35 in January at the company's facility in Fort Worth, Tex. The aircraft will be known as AF-41.