

## **How Much Will Each F-35 Cost?**

**by Winslow T. Wheeler**

In two hearings in the Senate and House Armed Services Committees, Under Secretary for Acquisition, Technology and Logistics Ashton Carter and his Director for Cost Assessment and Program Evaluation Christine Fox presented new unit cost estimates for the F-35. Those estimates are extremely optimistic (and very incomplete).

Incomplete because the \$114 million to \$135 million “Average Procurement Unit Cost” (APUC) Carter and Fox announced, in “then year” dollars,<sup>1</sup> to buy 2,443 aircraft does not include the research, development, test and evaluation for the F-35. Their current estimate of the additional development costs is about \$60 billion (to add to the current estimate of \$278 to \$329 billion to produce 2,443 F-35s).<sup>2</sup> Including development would add about \$25 million to the cost of each aircraft, making the Carter-Fox total program unit cost vary from \$139 million to \$160 million.

It may be that Carter and Fox are unwilling to testify to a total program unit cost because they are unwilling to inflict further “sticker shock.” Presumably, the official, more complete numbers will be made available later in April when the Defense Department releases its new Selected Acquisition Report (SAR), now about 18 months over due. What Carter and Fox thought they had to gain by delaying the more complete revelation does not merit speculation; their existing (and truncated) production unit cost estimates have little to do with unfolding realities.

The 2011 budget request for the F-35 plans to buy 43 aircraft for \$8.654 billion in procurement funding. That makes for a production unit cost for the 2011 buy of \$201 million per F-35.<sup>3</sup> In his March 24 testimony to the House Armed Services Committee, Carter stated that the unit cost “will decrease significantly” from this level as purchases increase and production processes “optimize.”<sup>4</sup> This is consistent with conventional wisdom that there exists a “learning curve” for aircraft production that progressively shrinks unit cost steadily as production proceeds. Thus, Carter and Fox argue, F-35 unit production costs will come down from the currently unsettlingly high number of \$201 million each down to the \$114 to \$135 million band.

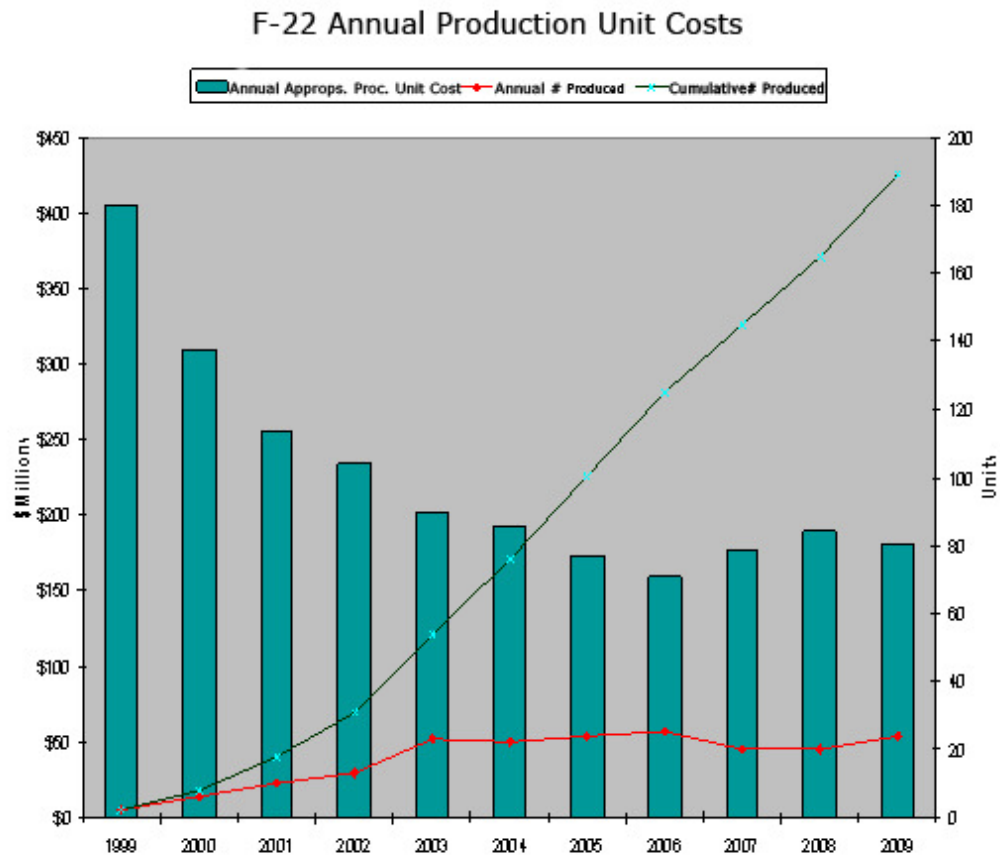
The last 50 years of actual DOD aircraft cost history, especially of “stealth” aircraft, do not treat the Carter-Fox estimates, and the prevailing conventional wisdom, very politely, however. The absence of any such progressive “learning curve” in unit cost has been thoroughly demonstrated by the analysis of Chuck Spinney, using actual procurement data.<sup>5</sup> In the case of the F-35, we can test the likelihood and amount of “learning curve” reduction in the unit cost by comparing the F-35 at this point in its program history to its closest aircraft relative, the F-22.

Indeed, the F-22 program is an excellent precursor for the F-35. Both aircraft are “fifth generation” aircraft that combine “stealth” with complex long range, radar systems (the F-35 adds an extra emphasis on air-to-ground functions). Both rely heavily on extensive computerization (the F-35 encompasses significantly more software). Both programs

employ concurrent development and production (the F-35 schedule incorporates even more production before the end of development). Both are from the same prime contractor and to a large extent the same aviation bureaucracy in the Pentagon (the F-35 adds two bureaucratically required complications: STOVL and carrier operations). There are no other contemporary U.S. aircraft with a more closely related design, production, and bureaucratic heritage. Due to its more complex nature, the schedule and cost of the F-35 can be expected to experience more delays and increases in the future than the F-22 did. In other words, using the F-22 “learning curve” should underestimate future F-35 developments.

Based on annual reports from the office of the DOD Comptroller, “Program Acquisition Costs by Weapon System,” showing annual appropriations for F-22 production,<sup>6</sup> we can track the annual amounts paid for F-22 production. See these data in Figure 1 below.

Figure 1: F-22 Annual Production Unit Costs (All costs are then-year dollars.)

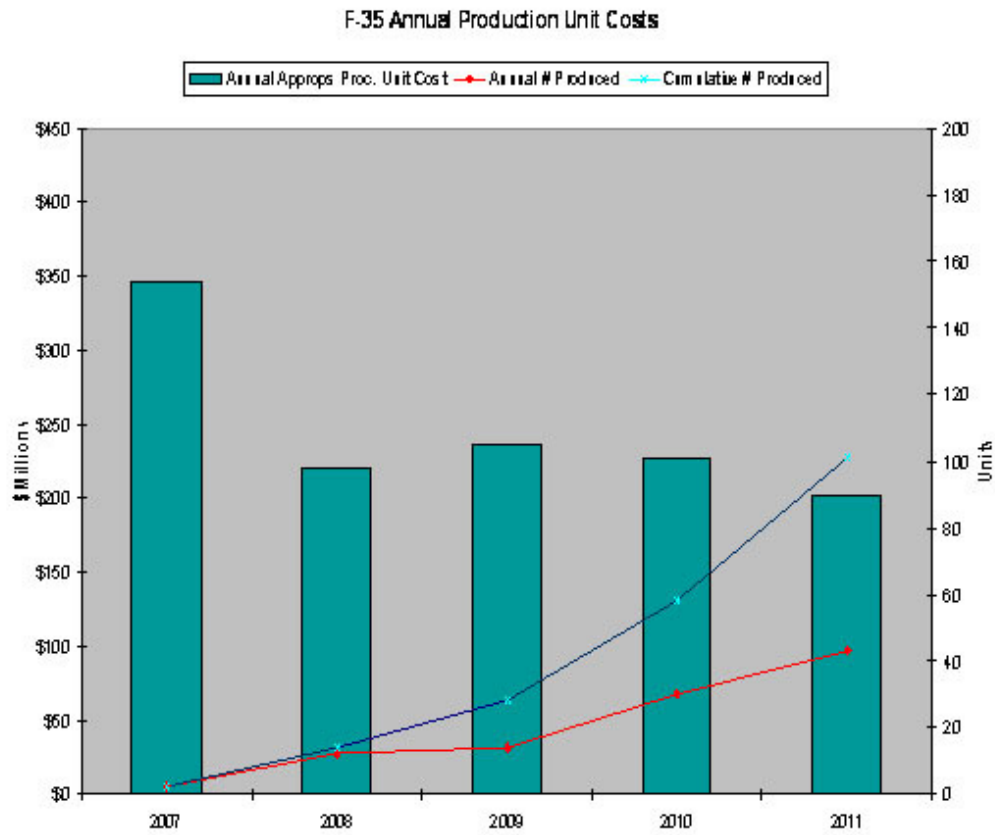


Some interesting points are apparent:

- Unit procurement cost for the F-22 roughly leveled out, with little cost reduction (learning) thereafter, by the fifth production year of the program. Across all F-22 procurement, the average unit cost based on actual appropriations calculates to \$197 million per copy. At year five, the unit procurement cost was essentially the same: \$201 million per unit. (Note also, at that point in the program, year five, a total of 54 F-22's had been acquired.)
- Toward the end of the program, the learning curve went backwards as unit procurement costs went back up. When the learning curve did so, it was during the three year period of the F-22's "Multiyear Procurement Buy," which is thought by conventional wisdom to reduce costs, not increase them.

Using the same data from the same sources, the chart for the F-35 looks like Figure 2.

Figure 2: F-35 Annual Unit Costs (All costs are then-year dollars.)



Note the following:

- Since the second year, F-35 unit procurement costs have roughly leveled off at the same levels as for 2010 and 2011, \$227 and \$201 million per copy, respectively.
- By production year four (2010), 58 units have been produced, which compares to the 54 F-22 units that had been produced when that program achieved relative production cost stability. If you argue the more complex F-35 requires more production experience to effect “learning,” the 101 units produced by the end of 2011 should easily suffice; thereby making the unit production cost \$201 million per copy.

Carter, Fox, and other advocates of the F-35 will contend the F-22 cost experience is irrelevant for two reasons. First, the F-35 will see a much longer production run than the F-22, affording time and opportunity for learning and optimization of production – the old learning curve argument. Second, they will lean on how well they are solving the currently horrendous F-35 production problems: that is, all the out of station work; missing, late, and non-fitting components; redesign, etc., etc., etc. pointed out by the Government Accountability Office, the Defense Contract Management Agency, and the Independent Manufacturing Review Team: A litany of problems just like those of the F-22 production line. Surely, they will say, once this legion of problems is addressed, we will see more efficient, cheaper production.

Not so fast. Addressing many of the current assembly line problems assumes a stable design for the F-35. We are a long way off from that; we may never get there. (Indeed, we never got there with the F-22 and are still modifying produced units.) Not only have recently uncovered design fixes not yet been incorporated into production (such as the new airframe strengthening needed for the carrier variant and so far unfunded nuclear wiring to be added to the Air Force variant) but also there are certain to be many modifications imposed on the aircraft design as the F-35 contorts through its initial flight testing, now only 3 percent done and currently scheduled to finish in April 2016. In other words, a stable enough design to produce “optimally” is years off.

Moreover, once the current production “glitches” and fixes based on test flights are resolved, the production turbulence is not over. As Spinney has pointed out for the F-18, F-16 and other aircraft, the changes never stop. Engineering change proposals, upgrades in the form of new production blocks, product improvements, and new requirements from the user never end. The F-16 is now in a “Block 50” modification, which about doubles the cost of the early block F-16s. Modern tactical aircraft procurement programs never really allow a design to stabilize, a primary reason why Spinney found the “learning curve” to be illusory.

A downward learning curve for the F-35 is likely to be an even greater illusion; it will have no assembly line in the paradigm of World War II production. The fabrication of stealth aircraft is inherently unsuited to real assembly-line production – something I learned when I visited the Lockheed Fort Worth plant to observe the infinitesimally

precise, hand-labor intensive riveting for the F-22 mid-fuselage section (essential to meet the stealth requirement). Just riveting a single F-22 mid-fuselage costs 30,000 man-hours of hand labor. An additional stealth cost burden is getting the stealth skin coatings right. From the moribund Advanced Cruise Missile to the F-117 to the B-2 to the F-22, each and every stealth creation has had serious problems meeting its radar cross-section thresholds. The most recently reported F-22 foible appears in a lawsuit that reveals Lockheed's misapplication of the stealth coatings, high repair costs, and the need for design and production fixes.

Overall, completed F-22s required almost \$200 million in modifications in the 2010 Air Force budget alone, an expense that will continue and very probably grow. It is this kind of ongoing turbulence that ensures the likely growing nature of future F-35 production unit costs; just for it to remain at \$201 million per copy would be extraordinary.

What of the 2,443 F-35s for the U.S. and the 730 for allies now scheduled, a production volume that is central to the Carter-Fox hypothesis of a learning curve and essential for justifying their much lower (but not actually affordable) unit cost estimates? The simple answer is that such a long production run will not occur. First of all, the DOD budget has no room for the significant increase in annual production spending that the F-35 plan requires, even if the unit cost does not increase. Inevitably, the annual production quantities will have to be squashed to a level the budget can accommodate; one expert predicted to me the annual buy will have to come down from 80 or more to 50 or less.

Indeed, for the last half century, higher than anticipated unit costs have led to production stretch outs which inevitably lead to further cost growth. That is the inexorable "death spiral" that underlies progressively smaller production runs, higher costs, and shrinking, aging forces. Nothing the Carter-Fox team has done is changing that.

In fact, the process has already begun. Just this week, based in large part on the currently admitted \$114 to \$135 million unit cost, Denmark announced its deferral for two years of a decision on how to replace its F-16s. The F-35 once had a lock on that sale, but no more. In addition, the United Kingdom, the Netherlands, Norway and Australia are all witnessing controversies that are likely to delay and/or truncate their F-35 purchases. But most importantly, at home in the United States factions in the U.S. Navy are openly horrified at the budget crushing costs of the F-35. That, together with traditional Navy distaste for U.S. Air Force dominated aircraft programs, may well lead the Navy to back out of the program, just as it did in past decades with naval variants of the F-111 and the F-16.

In short, the question is not whether F-35 production will shrink, but by how much. Publicly admitted unit costs will go up; purchases by allies and us will go down. The costs will increase further, and so on.

F-35 unit cost, just for the procurement side of the ledger, is far more likely to stay around \$200 million per copy, or go up, than it is to reduce to the not particularly affordable costs Carter and Fox now predict.

It also worth remembering that the \$200-plus million unit cost anticipated here is incomplete. An accurate sticker price includes the total cost of development, testing, facilities and other factors amortized across the ultimate size of the fleet. With the fleet size shrinking by some currently unknown, but very substantial, factor, the unit cost for the total program is sure to grow to even more horrifying levels.

Whatever that final unit cost may ultimately be, to predict it now will surely be met with gales of derisive laughter from the advocates of this ongoing disaster -- gales that will last only until the actual bill arrives on their doorstep.

Something between \$250 and \$300 million? Start laughing.

#### Endnotes:

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<sup>1</sup> Unless stated otherwise, all dollars cited in this piece are “then year” dollars, i.e. dollars stated in the amounts actually, or to be, appropriated. The author believes this gives a fuller appreciation for costs actually incurred.

<sup>2</sup> None of these numbers include other real F-35 costs, such as military construction unique to the F-35 and the amounts spent in DOD to administer and supervise the program, which one corporate expert estimated to be to be on the order of magnitude of 3 percent of total program costs. Also, none of these cost estimates include the expense of supporting and maintaining the F-35 with crew training, maintenance, spare parts, and much else. Even the lowest – extremely optimistic - of the estimates for support and maintenance of the F-35 triple the cost of the program to over \$700 billion. One less unrealistic Navy estimate puts that number at approximately \$1 trillion.

<sup>3</sup> If the F-35 R&D request were included, total F-35 funding for 2011 would be \$11.449 billion, which would calculate to a \$266 million unit costs for all 2011 spending.

<sup>4</sup> See p. 8 of Carter’s testimony at [http://armedservices.house.gov/pdfs/JointALSFCarter\\_Testimony032410.pdf](http://armedservices.house.gov/pdfs/JointALSFCarter_Testimony032410.pdf).

<sup>5</sup> See Spinney’s analysis of aircraft purchases at [http://www.chaliventures.com/Links\\_to\\_Reports/Links\\_to\\_Idisk.html](http://www.chaliventures.com/Links_to_Reports/Links_to_Idisk.html); scroll down to “Specific Reports on Tactical Fighters.” For disclosure purposes, I should add that Spinney is a friend and colleague; however, it is notable that his various analyses have been constantly validated by ongoing analysis by GAO, among others.

<sup>6</sup> Find these reports for each budget year at <http://comptroller.defense.gov/Budget2011.html>.