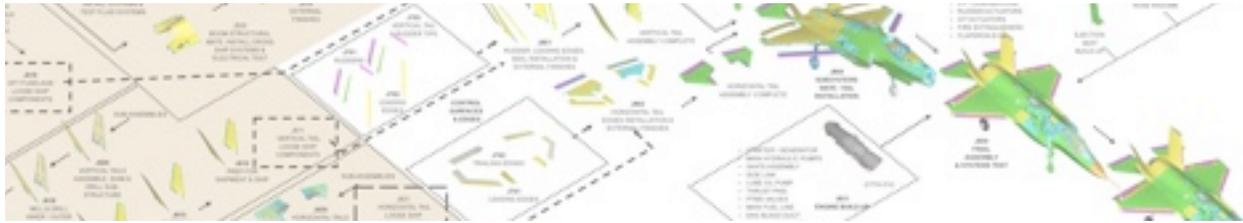


# Hasik Analytic LLC



## Exquisite Capabilities, Part II

### Why the F-35 is looking a lot like the F-22 these days

*The F-35 Lightning II Joint Strike Fighter (JSF) program was doubtfully affordable before the bottom fell out of the United States' finances. With little reason to hope for a big price reduction from Lockheed Martin, the Pentagon cannot plan—as it has been planning—to replace nearly its entire fighter-bomber fleet with JSFs. As budget reductions may be coming quite quickly, the Defense Department will need to offer some large programs for cancellation or severe truncation. As the F-35 is increasingly occupying a cost-for-strategic-value position akin to that of the F-22, its long-term fate may soon be similar: that of a silver bullet airplane, procured in small numbers, in anticipation of more affordable follow-ons. And if that comes to pass, almost every big business in the industry beyond Lockheed Martin will rejoice.*

**Defense-Industrial Research Memorandum #2011-04, 12 August 2011**

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#### THE BACKGROUND

*Given the abruptness of the cuts imposed under the trigger and the real possibility that Congress may not be able to reach a deficit reduction compromise in time to avoid the trigger, DoD should immediately begin contingency planning for how to handle such a reduction.*

— Todd Harrison, Center for Strategic and Budgetary Assessments<sup>1</sup>

I do agree—the Pentagon should be planning, as its real budget could fall over the next few years between 20 and 40 percent. As I noted last week, given the deadlines in the BCA, it is

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<sup>1</sup> "Defense Funding in the Budget Control Act of 2011," CSBA Online, 4 August 2011

likely that what must be done in the long run will at least partly be done in the short run. As the next several months will thus see some frantic changes in plans at the Pentagon, I will be devoting considerable time to analyzing the range of possibilities for military suppliers. And as the largest single acquisition program at the Pentagon today is that of the F-35 Joint Strike Fighter (JSF), I will start there. For if the Pentagon is about to actually start planning, investors and industry managers might start too, particularly if they are involved with or competing against that program.

The Joint Special Committee has just been appointed, and we have repeatedly heard over the past few days that it contains few legislators highly sympathetic to Defense. Moreover, if they are unable to agree by November on cuts—cuts that Standard & Poor's doesn't even consider adequate—then sequestration will mandate an immediate cut of nearly \$100 billion in the Defense Department's budget for FY2013.<sup>2</sup> It's hard to make people redundant that fast, and some operations and maintenance efforts will still need to be funded. But development and procurement programs can be killed quickly and with extreme prejudice.

*Proposed F-35 spending, all US military services, procurement and RDT&E*

| 2012          | 2013           | 2014           | 2015           | 2016           |
|---------------|----------------|----------------|----------------|----------------|
| \$9.4 billion | \$10.2 billion | \$11.4 billion | \$14.9 billion | \$14.5 billion |

As noted in the table above, the current proposal for the JSF shows it consuming a lot of money. Zeroing the program won't solve the federal government's budget problem on its own, but such an action could account for most of the needed reduction in RDT&E and procurement spending over the next few years. A clean kill probably won't come to pass, but something close to it could. That is, I am about to lay out a contrarian view of the future of the program, but one which planners in this business really should consider.

## THE COSTS

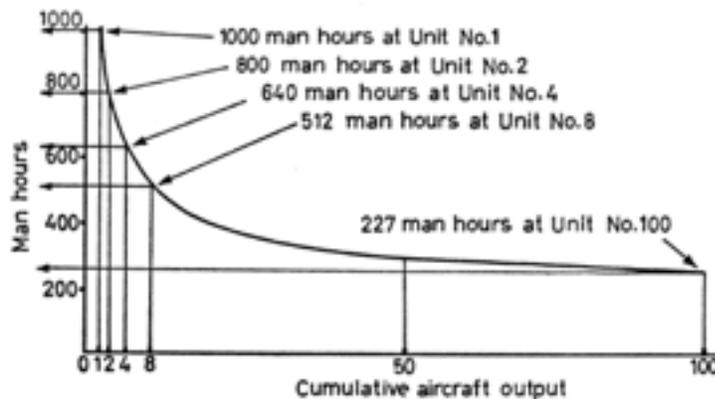
*[The Super Hornet is] still the only modern fighter program which has had a negative cost curve combined with increased capability.*

— Chris Chadwick, president of Boeing Military Aircraft<sup>3</sup>

That the F-35 was loudly advertised as affordable is today just adding to the disgust at its price. At its expected procurement cost, as forecast by the Defense Department, it will cost roughly twice as much as the the F-16C/Ds and F-18C/Ds that it is meant to replace. The airplane certainly isn't affordable now, but Lockheed Martin assures its customers that it will be later. With a production run exceeding 3,000 units, unit costs are to drop to a level not seen since the 1980s. The trouble with this promise is that the industrial progress required would be far in advance of recent experience.

<sup>2</sup> Harrison, *op. cit.*

<sup>3</sup> Bill Sweetman, "Boeing Calls Lockheed Martin on Cost Claims," *Ares* (the defense technology blog of Aviation Week & Space Technology), 31 May 2011.



*T.P. Wright's original (1936) chart on the aircraft production learning curve*

In the classic figuring, with each doubling of cumulative output in aircraft manufacturing, costs would drop by approximately 20 percent. In his seminal study of aircraft production, T.P. Wright described that as an 80 percent "learning curve" (see the chart at left).<sup>4</sup> Subsequent studies placed the effect anywhere between 78 and 90 percent for aircraft,<sup>5</sup> with 85 percent the parameter most often cited.<sup>6</sup>

The trouble is that past history hasn't been recent history, and history is no guide anyway. A wide

range of experience rates have been observed across industries, and even with similar products.<sup>7</sup> The magnitude of the effect of learning seems to have a lot to do with the share of labor costs in total production costs. For jet aircraft, that generally lies between 30–50 percent, which limits the overall contribution that a prime contractor can have on costs within his four factory walls.<sup>8</sup>

The *experience curve* is a broader concept, encompassing total cost progress from all factors of production. Some really impressive experience curves have been seen in aerospace, such as the 76 percent parameter in early production of the Sidewinder missile, but that was famously an effect of competition.<sup>9</sup> This outcome was systematically noted over 30 years ago: in the 1970s, cost increases over the lives of military acquisitions in the US averaged 1.53 times in non-competitive programs, but just 1.16 in competition ones.<sup>10</sup> And of course, there has been no

<sup>4</sup> T.P. Wright, "Factors Affecting the Cost of Airplanes," *Journal of Aeronautical Sciences*, 3 #4 (1936), pp. 122-128.

<sup>5</sup> Todd Sandler and Keith Hartley, *The Economics of Defense*, Cambridge Surveys of Economic Literature (Cambridge University Press, 1995), p. 125.

<sup>6</sup> Rodney D. Stewart, Richard M. Wyskida, and James D. Johannes (eds.), *Cost Estimator's Reference Manual*, 2nd ed. (Wiley, 1995).

<sup>7</sup> Armen Alchian, "Costs and Output," in M. Abramowitz (ed.), *The Allocation of Economic Resources: Essays in Honor of B. F. Halley* (Stanford University Press, 1959).

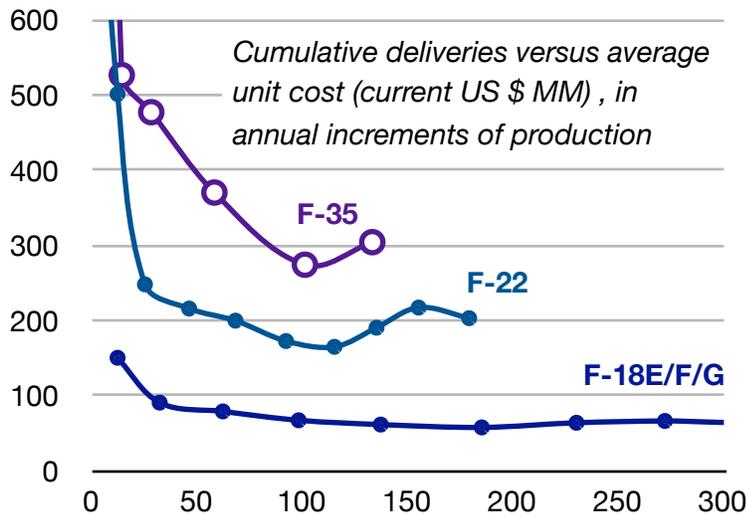
<sup>8</sup> Sandler & Hartley, 1995, p. 125.

<sup>9</sup> See Frederic M. Scherer, *The Weapons Acquisition Process: Economic Incentives* (Harvard Business School Press, 1964), pp. 118–119. The basic mathematical theory of how competition contributes to learning was laid out in A. M. Spence, "The Learning Curve and Competition," *Bell Journal of Economics* 12 #1 (Spring 1981), pp. 49–70. For a recent indictment of ignoring the value of competition, see Jacques Gansler's newly-released *Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry* (MIT Press, 2011). What might happen, in the case of the JSF, in the absence of competition was rather ominously noted in John Birkler, et al., *Assessing Competitive Strategies for the Joint Strike Fighter* (RAND, 2001).

<sup>10</sup> E. Dews, et al., *Acquisition Policy Effectiveness: Department of Defense Experience in the 1970s* (RAND, 1979), p. 28.

effective competition in the JSF program since Lockheed Martin was awarded the development contract in October 2001. By continually insisting that the military has no alternative to the JSF, Pentagon officials have been clearly, if unintentionally, signaling Lockheed that its inability to control costs will not jeopardize its business.

Regarding competitors, Chadwick’s comment about the Super Hornet/Growler series is almost true. It holds in regard to production costs alone; with RDT&E included, the curve is closer to flat. But that’s the problem, when



related to the F-35. Most modern jet fighter cost curves have tended to bottom out somewhere between the first 100 and 200 units. The only two US-built fighters programs with long production runs in the past 20 years, those of the F-18E/F/G-series and the F-22, bear out this experience. As shown in the chart below, the F-35 is actually well into this region of the curve, but with unit costs that are alarmingly high.

Lockheed Martin can’t exactly explain how it will reduce costs over the long haul to something approaching its advertised \$65

million per plane. That’s not by itself alarming, for even if the specific mechanics of experience curve cost reduction are readily imagined, they are not easily modeled and measured. What’s alarming in this case, though, is how production today—fifteen years after development began—was recently described by the government’s deputy program director as *artisanal*.<sup>11</sup> Don’t presume, though, that things will naturally get better from here: manual processes in manufacturing generally don’t tend to show more catch-up than automated ones.<sup>12</sup> Worse, the engineering changes that have been rife in the program—as in perhaps any modern jet fighter program—may very well continue to disrupt the cost reduction effort for the next several years.<sup>13</sup>

Were that not enough, we might note how alarming it was that Lot IV of low-rate initial production (LRIP)—the fourth year of that effort—was undertaken through a cost-plus contract, and that the Lot V contract still isn’t really a fixed-price deal. Lot V, though, gets the customers to 101 units at \$274 million each in total (RDT&E included) in-year costs. That’s just a lot of money. In short, this could be a \$200 million fighter plane. It’s looking to be at least a \$150 million fighter plane. Lockheed’s assertion that it’s a \$65 million fighter plane isn’t so much laughable at this point as contemptuous. At the probable price, and the financial resources likely

<sup>11</sup> Dave Majumdar, “DoD Strives To Curb Rework From F-35 Production,” *Defense News*, 27 July 2011.

<sup>12</sup> See Paul S. Adler and Kim B. Clark, “Behind the Learning Curve: A Sketch of the Learning Process,” *Management Science* 37 #3 (March 1991), pp. 267–281, who cite a little-noticed study by the Defense Contract Audit Agency, “Report on Improvement Curve Experience,” DCAAP 7641-14, April 1970.

<sup>13</sup> Adler and Clark, p. 278

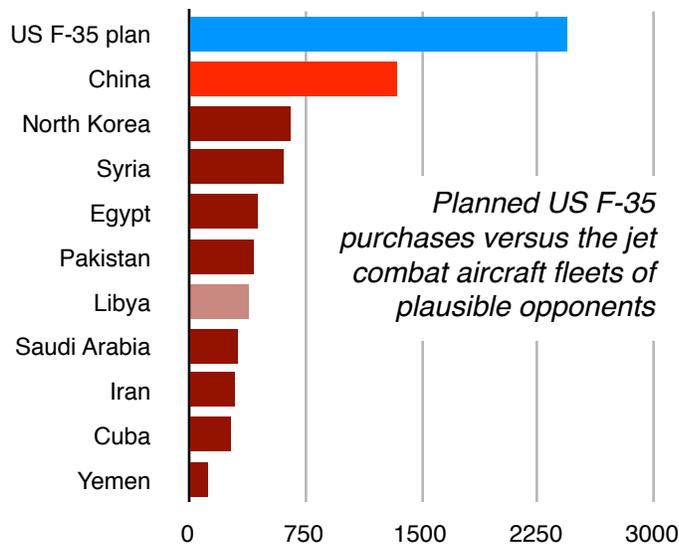
to be available, the US can't buy 2,443 of them. It can probably buy fewer than 1,000—if a thousand would be an intelligent buy. And that is another matter.

THE REAL REQUIREMENTS

*Strategy is what you need when you don't have any more money.*  
 — Andrew Krepinevitch<sup>14</sup>

Expensive is bad, but expensive and superfluous are together worse. The second trouble with the F-35 program is that even if affordability could actually be predicated upon massive numbers, massive numbers just aren't needed.

In the first place, as shown in the chart below, this is because there are only two categories of plausible opponents of the US armed forces: China, and anyone else. The Chinese "People's Liberation" Air Force and (soon) Navy have an impressive inventory of jet fighters, but they are mostly of considerable vintage, and considerably outnumbered by the three fighter forces of the US. Anyone else's air forces hardly count these days, if they ever did. It's not that fighting them is bloodless; it's that the budgeting for air forces in the US seemingly makes no reference to their actual strength. The recent crushing of the Libyan Air Force has laid bare how



unprofessional most of these Third World outfits really are—Colonel Qaddafi had one of the largest air forces in the world, but it was of absolutely no use against European air forces routinely maligned in America as underfunded.

The denigrations of possible opponents, of course, needn't stop there: note how the Pakistanis couldn't find noisy helicopters—much less stealth drones—penetrating their airspace the other week. None of these folks—other than perhaps a future, hostile Other-Than-Saudi Arabia—have the money to reconstitute the air fleets leftover from the largesse of the Cold War. And even if the Iranians have oil money, sanctions have worked

wonders against their armament ambitions. Autarky doesn't work any better for a profoundly restrictive society that systematically abuses half its population.

There will of course come the usual angst about ground-based air defenses—stealth fighters are needed to penetrate those, no? Well, Libya's resistance amounted to nothing. If Serbia back in the day (on NATO's side now, remember?) had a highly professional and dense network, it did only manage to shoot down two fighters (if including that F-117) and a few dozen drones.

<sup>14</sup> Krepinevitch was speaking of how the United Kingdom had long managed a global position on Italian resources, but British will and strategy. "Defense Spending in a Time of Austerity: the chronic problem of exorbitantly expensive weapons is becoming acute," *The Economist*, 26 August 2010. Note how the magazine ran this article literally a year ago; finances in the US have exactly improved since then.

Russia, Serbia's long-time supplier, is further the only country outside NATO that appears have impressive technology in this arena. So far, Iran is the only *verboden* country to which PVO Almaz-Antey has sought to sell; that deal came to nought after extreme US displeasure. This suggests a solution rather like that proposed in the 1990s for those supposedly under-employed Russian nuclear scientists. In the long run, defeating air defenses might be most cost-effectively accomplished by just restricting rogues' access to anti-aircraft missiles, and that might be best handled with a few large envelopes of cash mailed to Moscow.

And yet, one could say, the US Air Force still seems to be aiming for an old school Royal Navy two-power standard with just its JSF fleet. That is, its plan for 1,763 F-35As would provide more aircraft of that one type than there are jet fighters, bombers, and attack aircraft in both the Chinese and North Korean air forces together, and more jet fighters than in the Russian and Chinese air forces combined. That's not counting the USAF's 187 F-22s, or the Navy and USMC's planned fleet of 680 F-35Bs and -Cs. Seen this way, it's just incomprehensible what all these aircraft are *for*.

There is, of course, China—if an unlikely adversary, it will remain unlikely if the US prepares comprehensively to fight against it. The problem there is that not so many -A model F-35s would be useful in a fight over Taiwan, at least if the Japanese aren't on board. Taipei is only 350 nautical miles from Kadena Airbase on Okinawa, but even with full access for the war, only so many squadrons can cluster around that strip.<sup>15</sup> It's numerically notable how the Army's 1st Battalion of the 1st Air Defense Artillery protects the island with its Patriot missiles; it's well within range of ballistic weapons on the mainland. After that, the next nearest US or Japanese base is 700 nautical miles away, at Tsuiki Field on Kyushu; that distance requires a tanker connection for real combat sorties, and access again requires Japanese permission. From there, it's next to Anderson Field on Guam—over 1400 nautical miles, which is pointedly not a distance from which to run combat air patrols. Thus, the plan for any fight for Taiwan must presume that the flying will be done from fields actually on Formosa, and from aircraft carriers.

Seriously sizing up the possible opposition thus leads us to a big and important point about future force structure. To reprise what I wrote last week, senior officers in at least one military service may not like this, but here it is, for eventually they will salute and carry on:

*The Navy needs fighters. The Air Force needs tankers and bombers.*

That is, if the F-35 is to be bought at all—and with fifty or so already in the works, at least some small number will be bought—then the strategically sensible emphasis should be on the F-35C. General Phillip Breedlove, the USAF vice chief of staff, noted late last month that a sufficiently large budget cut would force a “fundamental rethinking” of what his service does.<sup>16</sup> So be it. The Air Force already has a grail, though one which has been irrelevant to the fighting in Iraq and Afghanistan, and that would be only partly relevant to any fighting over Taiwan. The Navy, however, could seriously benefit from even small numbers of F-35Cs on its carrier decks. The F-35B constitutes a closely related but separate matter; if it can indeed clear its current

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<sup>15</sup> Zalmay Khalilzad *et al.*, *The United States and Asia: Toward a New U.S. Strategy and Force Posture* (RAND, 2001), pp. 70–71.

<sup>16</sup> Hearing before the US Senate Armed Services Committee, 28 July 2011.

probation and graduate on time, it could (as the Commandant has cogently noted) double the number of stealth fighter-equipped carriers in the fleet. This ought to be the *noyau dur* of demand for the JSF: the potentially high marginal value of even a squadron per ship.

I should also emphasize that when I write *bombers*, I do not mean that they must be manned, or that they must have four engines, or that they must have a 'B' in the designator. By the end of this decade, the Air Force and the Army will have over 500 MQ-1C and MQ-9 attack drones, and the Air Force will probably be well on its way to procuring the planned MQ-X jet drone. Fully 223 re-winged A-10s are also supposed to soldier on as long as 2025, and the A-10 is an airplane that the Army and Marines just love to see flying towards the front.<sup>17</sup> None of these can quite hit the Chinese mainland from Guam, but they would do awesome work on enemy ground forces elsewhere. And as for China, aircraft like Northrop Grumman's X-47 could have the range and stealth required to go feet-dry.

This is not to say that the USAF needs no land-based, manned fighters or fighter-bombers at all. It's just that the numbers on hand today are grossly excessive to real requirements. The F-16s and F-15s are more than a match to their opposition, and if they're wearing out, more than the several hundred already in the desert might be stored as attrition reserves. This is important because the USAF has planned to withdraw all its F-16s by 2025—at that point even the first batch of Block 52s will have reached even their extended life of 8,000 hours.<sup>18</sup> Another 178 very old F-15s (the so-called Golden Eagles) are supposed to be flying alongside the F-22 at that point, though well on their way out. But 2025 is a fully fourteen years away, and that leaves plenty of time to figure out how to procure a smaller and more affordable fighter fleet.

## THE ALTERNATIVE

So what might they do? The budget problem is now actually acute, and I thus foresee the F-35 sensibly winding up like the F-22, as a sort of silver bullet aircraft, though largely for the Navy. With less intensity, perhaps, the Simpson-Bowles Commission last year recommended something broadly similar: dropping the F-35B, and buying far fewer F-35As and -Cs. As a partial substitute, the commission recommended buying the latest Block 60 F-16E/Fs (so far sold only to the UAE) for the USAF and F-18E/Fs for the Navy and the USMC. Lockheed Martin CFO Bruce Tanner called that split between Falcons and Lightnings "not viable," as his factory in Fort Worth was now optimized for producing the latter, and could only build about four of the former per month.<sup>19</sup>

OK—fine. Bruce should watch what he wishes for. If the new defense secretary really takes charge, he might tell Lockheed and the USAF that the zoomies can forgo those F-16Es, and instead buy F-18Es—and Fs and Gs—whether or not any of the services get their F-35s at all. There's absolutely nothing wrong with the USAF flying Super Hornets; the RAAF does so quite happily. The US Navy would probably be very happy to have that budgetary millstone lifted from its corporate neck, and even thrilled to see the Air Force getting back on the Saint Louis

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<sup>17</sup> John A. Tirpak, "Making the Best of the Fighter Force," *Air Force Magazine*, March 2007

<sup>18</sup> Tirpak, *op. cit.*, and the excellent database maintained by Lieven Dewitte and Stefaan Vanhastel at [www.f-16.net](http://www.f-16.net).

<sup>19</sup> Marina Malenic, "Lockheed Martin Officials Defend F-35 As 'Affordable,'" *Defense Daily*, 3 December 2010.

bandwagon. Besides, if necking down to a common primary fighter type is such a good-and-ballyhooed idea, then all the better to do so with a fighter whose costs are stable and known.

I must own up to having proposed roughly this idea for the USAF over seven years ago, and as the alternative to another stealth fighter program then getting under way.<sup>20</sup> I wrote [something](#) similar on my blog in March 2010; Stephen Trimble [covered](#) those views on his DEW Line blog at Flight Global; a French commentator reviewed it as *l'Option Nucléaire*. Others have recommended this as well.<sup>21</sup> Even the Defense Department admits that it is now considering at least the consequences of terminating the F-35 program.<sup>22</sup> It's not that I'm bearish on stealth fighters; I'm just bearish on any fighter that costs that much when the government is borrowing a trillion dollars per year.

So there's the austerity alternative: just equip all three fighter-flying services with Super Hornets. Buy a small run of F-35Cs for the Navy; perhaps buy some F-35Bs for the USMC, and buy a lot of MQ-9s for ground support. Someday, perhaps, buy something like the X-47C (the really big one that Northrop has in mind) as a bomber. In the short run, save that excess of early-production F-35As for accelerated export deliveries: not every partner government will dump the -35; some will be happy to take theirs, and more so for the caché of operating an aircraft now possessed of the scarcity of the F-22. The United States and the rest might then, as a Republican presidential candidate suggested some twelve years ago, skip a generation of weapons, take a building holiday, and spend the next decade investing in the next crop of ideas. After all, the US Navy and the USMC did very well with that strategy in another financially challenging decade, the 1930s.

## THE BUSINESS IMPLICATIONS

The F-35 might still not then be the last manned fighter, but it's already today an awfully expensive way to do most of the things it's supposed to do. In that context, winding up the F-35 program early is not a crazy idea, any more than winding up the F-22 program was. The difference now is that the financial calamity is more apparent. Thus, this nuclear option is more like a serious possibility that ought to make one wonder about the possible outcomes in industry.

For **Lockheed Martin**, and particularly in Fort Worth, it would be the *Götterdämmerung*. That's about all that needs to be said, except that anyone who supplies equipment for manned fighters specifically would also rue the general reduction in manned numbers. **Martin Baker** rather immediately comes to mind, but there are doubtless more.

At **Boeing**, I'd say that they'd be popping champagne corks, but I suspect that they prefer American sparkling wine. If the folks from Missouri aren't already showing models of Super

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<sup>20</sup> See James Hasik, "Buy Super Hornets instead of Raptors," *Proceedings of the US Naval Institute* 129 #1 (January 2003).

<sup>21</sup> See, for example, Robert Dorr, "To solve Air Force's 'fighter gap,' buy Navy Super Hornets," *Air Force Magazine*, 19 May 2008.

<sup>22</sup> Megan Scully, "Pentagon: Cutting F-35 Would Be Complicated, Costly," *National Journal*, 8 August 2011.

Hornets in USAF livery, they ought to be; the F-15 is a fine airplane, but their newer model is, well, a newer model.

Perhaps those observations are obvious. What's more interesting is who else would benefit. In three categories, most of the combat aircraft industry would relish the relative *dénouement* of the JSF, or at best prove dispassionate:

*The fighter-makers.* As I wrote last year, **Saab**, **Dassault**, and **EADS** (the one shareholder in Eurofighter GmbH with little interest in the JSF program) would get quite enthused about this possibility. Each of these three European companies has an interest in killing specifically the F-35A, as Norway, Denmark, the Netherlands, Italy, Canada, and Turkey would all open up as marketing targets for their aircraft. Last year, I suggested that Belgium and even Portugal might eventually make that list, but their finances now strongly suggest that they will be flying F-16s until cloaking devices prove popular. I had also suggested Australia, but any demise of the F-35A would almost certainly just turn the RAAF's into an all-Hornet fighter fleet.

*The also-airframers.* **BAE Systems** and **Alenia** could be of split opinions, in that both are major subcontractors to Lockheed Martin for the F-35, but each also has big interests in the Typhoon program, and would thus stand to gain from Lockheed's loss.

*The drone-builders.* Perhaps most notably in the long run, **Northrop Grumman** and **General Atomics** would start making even more serious plans for the MQ-X program. That glimmer is naturally in eyes across those companies, but any big reduction in the planned procurement of JSFs would open the door sooner to more, and to more sophisticated, drones. Saab, Dassault, Alenia and others would get enthused about the future potential for the Neuron as well. But Northrop and GA would be particularly happy to skip this generation of weapons, for the generation had been conceived as a single program, which the former missed with the down-select in 1996, and the latter has just bypassed from the git-go.

Indeed, there are so many who stand to gain at the expense of Lockheed—the company that had once dreamed of dividing the manned fighter market with, maybe, Sukhoi—that a grand anti-Lockheed coalition ought to be forming. It's a shame that the *Conquistadores del Cielo* no longer gather (or so they say), for that “Leave Your Swords at the Door” rule might not have been honored next year.

If nothing else, this is going to be an interesting autumn.

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