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HOW TO AVOID ACQUISITION DISASTERS AND CREATE AFFORDABLE SOLUTIONS FOR AMERICA'S AIR WARRIORS BY APPLYING LESSONS FROM THE PAST

by

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Biography

CDR Daniel S. Vogel was born and raised in Pittsburgh, Pennsylvania. Upon graduation from high school, he joined the Navy's NROTC program and enrolled at Virginia Polytechnic Institute and State University. After graduating Magna Cum Laude with a B.S. in Mechanical Engineering in December 1994 he reported for Undergraduate Naval Flight Officer training in March of 1995.

Receiving his "Wings of Gold" in June of 1996, CDR Vogel reported for duty at the S-3B Viking Fleet Replacement Squadron, VS-41. In August of 1997, he joined VS-33, making two deployments to the Western Pacific and Arabian Gulf in support of Operation Southern Watch.

In 2000, CDR Vogel joined the VT-4 Warbucks as an instructor training Naval Flight Officers and Navigators from the USAF, USMC, USN and international militaries in the T-1 and T-39 aircraft. He was selected as Naval Flight Officer Instructor of the Year for 2002.

After transition to the E-2C Hawkeye, CDR Vogel reported in 2003 to VAW-120, the E-2C Fleet Replacement Squadron. Joining the VAW-124 Bear Aces, CDR Vogel deployed in support of Operations Enduring and Iraqi Freedom from 2005-2006.

CDR Vogel's previous duty station was as USN liaison officer at the US Department of Homeland Security Domestic Nuclear Detection Office where he worked with numerous federal, state and local agencies. While at DHS, he received his Defense Acquisition Program Manager Level II qualification.

CDR Vogel has over 2,500 flight hours and 300 carrier arrested landings in numerous US military aircraft.

Introduction

The US military procurement system in general, and military aviation procurement in particular, is in a financial death spiral. Conventional wisdom from many in the Department of Defense (DOD) and the military aviation industry has been that the best method of achieving efficiency and economy in the procurement cycle and delivering flexible capability for deployed forces is to develop qualitatively superior multi-mission aircraft. The need to justify every new platform as being "superior" to aircraft currently fielded has consistently caused the military-industrial acquisition complex to push the edge of technology too far. This mindset has led to steadily lengthening procurement times and steadily decreasing force levels made up of highly expensive aircraft with debatable net gains for the war fighter. As a 2007 draft US Air Force Central Command white paper stated, "Very often, the US is paying premium execution costs for a capability that is far and above what is required."[1] The continued pursuit of the "best of the best" over "good enough" does not serve the national interest if the cost and delays in delivering the best prevents enough assets from being delivered, and results in the ones that are delivered being used at extremely high rates and in sub-optimal modes with premium operating costs.

This paper will examine if there are lessons from the past that should be applied to better make use of limited funds available during a period of shrinking defense budgets. It will focus on finding common links related to increases in budgeted costs among tactical military aviation programs. This is not a new area of concern. In general, past reform efforts have been unsuccessful. Norman Augustine, a former Lockheed-Martin CEO and longtime government insider, published his somewhat cynical, but nevertheless prescient 52 business "laws" for the first time in 1983. Just under 30 years later, the military finds itself fast approaching Augustine's Law Number XVI.

> In the year 2054, the entire defense budget will purchase just one aircraft. This aircraft will have to be shared by the Air Force and the Navy 3 ½ days each per week except for leap year, when it will be made available to the Marines for the extra day.[2]

The 50-year pursuit of a multi-service platform that is multi-role from inception has not provided the cost savings that many in the military procurement system predicted. Therefore, the final portion of this paper will recommend changes for the US military to create a credible force at an affordable price. Merely reforming the process of military procurement within the authority of the Office of the Secretary Defense (OSD) and the subordinate services will not fix this problem. There must be philosophical change as well. Leaders must learn from past aircraft programs gone wrong the correct ways to develop and field cost-effective and sufficiently capable military aircraft.

World War II Lessons

Military aircraft procurement underwent a dramatic change during and after World War II. Prior to that time, there was little money available for large-scale procurement of weapons systems with the exception of rare fits of shipbuilding. Rather the Air Force and Navy procured small numbers of incrementally improved aircraft.[3] This changed dramatically during the war, as dozens of manufacturers produced different models of tactical aircraft in quantity.

The P-47 Thunderbolt

One aircraft that proved particularly versatile in roles beyond its designers' original intentions was the P-47 Thunderbolt. The prototype Thunderbolt was originally flown in 1941 with a proven and in-production Pratt and Whitney (P&W) R-2800 engine[4] and was designed for the high-altitude fighter mission. However, with the appearance of the P-51 in the European Theater of Operations, the Thunderbolt was relegated increasingly to low altitude tactical support.[5] Due to the ruggedness of the R-2800 and its stout airframe, the P-47 excelled with this

new focus on close air support and interdiction. The ability of the P-47 to absorb damage from antiaircraft fire provided a clear advantage over less robust, lighter weight, more complex water-cooled fighters.[6] While designed as a high-level interceptor, the P-47's performance allowed it to be adapted to a multi-role capability *after* it had been fielded operationally, becoming an effective asset for the duration of the war. A total of 15,630 P-47s were built, the highest number of any US fighter model.[7] The P-47 showed that designing an airframe for a single purpose and coupling it with proven engine technology is the most efficient path to procure a combat aircraft. Increased capabilities and missions can be incrementally added as use and operational needs dictate.

The Me-262 Schwalbe

The P-47 experience can be contrasted with another airframe that had its first flight in 1941, the world's first operational jet "fighter", the Me-262. American bombers and their fighter escorts would have had a much harder time over Nazi Germany had higher numbers of Me-262s appeared earlier. Germany's design was far ahead of any fighter that the allies had fielded operationally at the time. According to Generalleutnant Adolf Galland of the Luftwaffe, the delivery date of the Me-262 was delayed when Adolf Hitler ordered that the plane be redesigned into a 'blitz-bomber' in 1943. From Galland's viewpoint, the Me-262 could have been in operation one year earlier and therefore drastically altered the operation of US daylight bombers over Germany.[8] Other historians point to different factors, stating that, "The key element in the late deployment of the Me-262 was the protracted development period of the jet engines."[9] The fact that the Jumo-004B-1 powerplant configuration was not frozen for production until June of 1944 severely impacted Me-262 development.[10] Its airframe was mostly complete in 1941, just like the P-47, but the Me-262's engine was not in production like the R-2800. Initial testing of

the airframe with prototype engines was not done until 1942 and the airframe still retained a piston engine and propeller mounted in the nose for safety concerns.[11] The protracted development and cost of the Me-262 was a major reason that only 1,100 were produced – less than 10 percent of the P-47 total.[12] In these limited numbers, it was never able to make a decisive contribution to the German war effort. Compared to the fielding of the P-47, the major problems for producing operational Me-262's were two-fold. First, concurrent engine development delayed adequate flight testing of the airframe and the start of production. Second, shifting requirements directed by non-technical persons in higher command forced a fighter to be modified into a multi-role fighter-bomber.[13]

Cold War Efforts

Since World War II, the development time for airplanes has become longer while the cost to produce them has continued to rise.[14] Many in government viewed this trend as an indication of a decaying procurement system. Numerous studies have been funded over the years to examine how the services generate requirements and then acquire hardware solutions. One decade after the conclusion of World War II, a Commission on the Organization of the Executive Branch of the Government released five staff papers that discussed different areas of the military procurement system. A section labeled, "The Problem" discussed the need "to find a way to convert the Joint Chiefs of Staff organization from a trading post to an objective group in which the national interest is paramount and which will facilitate the reaching of decisions."[15] The report goes on to state that,

> There are three essential stages to the development of military requirements. First, there must be a statement by the military services of their needs, based on national policy and objectives. This should be realistic, but not necessarily limited to any arbitrary fiscal ceiling. Second, feasibility should be tested both industrially and economically. Third, the political and social acceptability of the program must be ascertained.[16]

DOD has repeatedly failed to follow these recommendations in establishing new aircraft requirements.

The TFX Program

Certainly one of the best historical examples of US government missteps in aircraft procurement is the initiation and execution of the Tactical Fighter Experimental (TFX) program that ultimately produced the F-111 during the 1960s. The greatest obstacle that this program faced was trying to climb two mountains at once: attempting to achieve commonality in one airframe for both the Air Force and Navy, while also creating a "generalist" airframe capable of multiple disparate missions. These overlaid requirements could not be met by pushing technology well past the current state of the art. The resultant risks inherent in TFX development were seen early on in the program and many aviation technical experts doubted its overall feasibility.[17] In examining the TFX program it becomes clear that none of the three recommendations for requirements in the 1955 report on reform were followed. While the TFX was troubled by issues of political and social acceptance,[18] only matters dealing with the first two recommendations of the 1955 report will be expanded upon below.

First, TFX requirements were not based solely on objective threats, but also on a perceived USAF mandate that every new aircraft fly higher, faster, or farther than those already in use. The original intent of the TFX was to replace the F-105 Thunderchief in the tactical nuclear delivery mission. Some of the specified improvements made tactical sense, such as the requirement for a reduced runway length for takeoff and landing. However, the new speed requirement for a low-altitude supersonic dash capability was more than just an incremental improvement. Both NASA and USAF technical reports advised that this change from subsonic to supersonic requirements would cause the aircraft to grow in both size and weight.[19] Issues for

the TFX were compounded when Secretary of Defense McNamara instituted a new national objective for the program – the TFX was now to be a joint aircraft and fulfill both USAF tactical nuclear strike (air-to-ground) and USN fleet air defense (air-to-air) requirements. In September 1961 McNamara informed the Secretaries of the Navy and Air Force that he desired the Navy and Air Force versions of the TFX to be as close to the same airframe as possible.[20] His intent was noble – to achieve cost savings by getting the services to cooperate on fulfilling disparate requirements with a single platform.[21] The idea of a multi-mission platform for multiple services *from the drawing board* appealed greatly to McNamara because he believed it supported his philosophical desire to shift the US military to a flexible response strategy. In his estimation, if the TFX was able to do the many missions that were being incorporated into its requirements well, it would give the President numerous options for the employment of force regardless of where it was stationed, how it was deployed, and what munitions were required.[22] He wanted this vast capability packaged into the aircraft's design upfront, and not just left as an outgrowth after it was built. This was different than prior programs like the P-47 that became multi-mission after they were already in service. The misguided pursuit of cost savings in commonality and multi-role objectives was intended to reduce inefficiency in the procurement program. Instead, in the words of one USAF General, it resulted in the TFX being "too complicated, too big, too expensive, too many things."[23]

The TFX program, after years of contentious development, eventually unraveled. Designing the F-111 with both variable-sweep-wings and new afterburning turbo-fan technology in its TF-30 engines was determined to be the only way one airframe could possibly meet the wide range of requirements. Neither technology had been used in a production aircraft before.[24] There was very little hard test data on either technology. Due to schedule pressures, the F-111

started full scale production prior to adequate flight testing. A total of 331 F-111's were built before expensive design changes to the airframe and its TF-30 engines necessary to achieve adequate performance were incorporated into the production line.[25]

The TFX reinforced two major pitfalls of designing an airframe around engines that are not yet in production. First, the ability to meet requirements for the design with respect to range, loiter time, and speed within schedule was hampered by airframe-to-engine integration problems. Actual installed engine performance throughout the maneuvering envelope was a critical unknown. The F-111 design was finalized well before this information was learned through flight testing.[26] Second, it should be expected that engine thrust will be increased during the life of a military airplane and it should be designed with a performance margin to take advantage of these future incremental gains.[27] Overall, the TFX failed to achieve McNamara's hoped for economic efficiencies as much as it failed to meets its multi-role requirements.

The F-14 Tomcat

The difficulties of a poor engine-airframe match would not only plague the F-111's performance, it would also go on to haunt the Navy's substitute for the F-111B, the F-14 Tomcat. To save on development costs, the Navy planned to take the TF-30 from the F-111 program, but only for prototype and the earliest models of Tomcats. A better engine being jointly developed by the USAF and USN for both the F-14 (USN) and F-15 (USAF) would be used starting with the 7th production Tomcat. However, due to cost overruns with that engine's development as well as with the other system carried over from the F-111B – the AWG-9 fire control system – the Navy's version of the new engine was cancelled. As of 1983, the total USN bill for "Band-Aid" fixes to the TF-30 was roughly a quarter of a billion dollars.[28] It wasn't until a decade later that the F-14 received suitable engines borrowed from a USAF engine upgrade[29]

that resulted in 80 percent engine commonality with USAF aircraft.[30] The F-14D with new engines finally was performing to design specifications with a flyaway cost of about $65 million per airframe in 2003 dollars, when it was cancelled in favor of the F/A-18E/F.[31] This new aircraft promised cost savings over continued production of the F-14D to be achieved by 60 to 70 percent in airframe and engine commonalities with earlier versions of the Hornet. It proved a vain hope. The F/A-18E/F failed to deliver even close to the promised commonality with earlier F/A-18 models[32] and had a unit cost of $87 million in 2003 dollars.[33] The TFX and F-14 show that commonality in new aircraft production almost never lives up to its promised return. However, commonality and associated logistic efficiencies in modular components like engines can be achieved by incremental upgrades capitalizing on mature technology borrowed from sister services. This is the most cost-effective approach.

The YF-16 and YF-17 Fighters

The advantages in developing a platform around mature engine technology can also be seen in the 1974 Lightweight Fighter Competition between the YF-16 and YF-17. When the USAF chose the General Dynamics YF-16, Northrop disputed the award on the basis that the competition was not fair since the YF-16 was designed around a mature engine. In contrast, Northrop's YF-17 used a prototype engine that was delivered with insufficient time for proper airframe integration.[34] The Navy chose to develop the YF-17 from a single purpose dogfighter into the multi-role F-18 "strike fighter", and simultaneously completed its engine development. This program predictably came in over budget. While the single role USAF F-16 program with its mature engine came in under budget. A 1987 RAND Corporation report on cost estimating identified sufficient engine maturity such that no major design changes were made prior to the 612th production aircraft as a principal reason the F-16 came in under budget. The same study

cited one of the reasons for the F-18 cost to be underestimated as the adaptation of a land-based airplane to a carrier-capable one.[35] In recent times, the only other major tactical aircraft acquisition program to come in on budget was the A-10, and it used an in-production engine from the Navy's S-3.[36] The lesson of history is clear. Developing an engine and an airframe at the same time carries a substantial risk of cost growth.

Even though the TFX and F-18 programs did not deliver on cost schedule and performance, many of McNamara's ideas relating to enforced multi-role and multi-service aircraft development "took hold and survived in spite of logic."[37] Showing how the wrong lessons from the past were learned, a 1980 author commented that:

> Through the 1970's interest burgeoned in making aircraft more thoroughly 'multi-role'. This meant, most particularly, well suited to various modes of both bombing and air combat. It is redolent of how in World War II, certain light bombers were adapted as long range fighters.[38]

What is not mentioned is that this WWII conversion of bombers to "long range fighters" was done after the models were already flying operationally and were found to possess characteristics that met narrow requirements for *night combat missions* with non-maneuvering bomber targets.[39] With DOD and industry having learned only the wrong lessons from history, the stage was set for the third attempt in 25 years to create a cost-saving, joint service, multi-role tactical jet aircraft.

The Joint Strike Fighter

The origins of the current Joint Strike Fighter (JSF) program have some striking similarities to those of the TFX. While there can be many points that could be used as a "JSF started here" date, the origin of the push to have one aircraft fill many roles clearly benefited from Dr. William J. Perry's elevation to Secretary of Defense in 1994. Like McNamara, Perry came to the conclusion that the United States could not afford separate weapons for the services.

Perry then promoted a leading edge program promising commonality and multi-role capability as being the solution without a thorough study of requirements first. Perry also believed that the United States could not financially sustain the number of contractors that were currently producing weapons systems.[40] However, four years later the Defense Science Board seemed to say the opposite! It advocated a change in DOD acquisition to guard against DOD depending on an isolated industrial base with little competition. Many of the process recommendations from the board's report were used in formulating the JSF schedule, yet the goal of a six to seven-year duration from Systems Demonstration to IOC[41] was never reached.[42] The issues of cost growth and schedule slip are not just with the process, but also with the government's contravention of the process for its own convenience. A real problem was DOD adding capabilities to a program that increased costs disproportionately to the benefit. As total JSF procurement numbers of F-35s continue to fall due to rising cost and delays, the program runs the risk of bringing about the diminished defense industrial base and reduced war-fighting capabilities that the reforms were supposed to prevent.

JSF Requirement Issues

Just like the TFX, the JSF became a sponge for a breathtaking set of "needs" for each of the services. The CBO stated in a January 1997 study:

> Concerns about the Joint Strike Fighter may be the most troubling, since it makes up about two-thirds of total planned procurement. Critics have doubts about the ability of the JSF program to deliver a family of aircraft that can meet the distinctly different requirements for each of the services – namely, an inexpensive, multirole fighter for the Air Force; a very stealthy, longer-range, carrier-based, ground attack plane for the Navy; and a multipurpose fighter for the Marine Corps that will be able to take off from the short deck of an amphibious ship and land vertically.[43]

The USN's requirement for all-aspect stealth resulted in internal weapons bays, much like the USAF's requirement for supersonic dash required internal weapons bays for the TFX. Admiral Dennis McGinn, the Director of Air Warfare for the Navy in 1996, called the JSF "the

core system for opening a wedge into any sophisticated enemy air defense system."[44] Requirement for stealth, when combined with a goal for 80 percent commonality among the design variants meant that all JSF versions were required to have all-aspect stealth. The CBO correctly identified that the overall cost of incorporating stealth into a design would "reduce other elements of capability and increase costs."[45] As with the TFX, this poor requirements discipline, misapplied commonality, and mandated multi-role capability contributed to ripple effects throughout the program.

JSF Engine Issues

Not surprisingly, the JSF's concurrent engine development also greatly affected costs. One of the original selling points for the JSF was that it would use the F-22's mature engine technology to reduce costs. A novice might have thought that when all JSF competitors chose P&W's F119 engine, programmatic efficiency and economy would follow. Sadly, this has not been the case. The JSF requirement for power delivery by a single engine at its design weight required a thrust increase of at least 20 percent for the F119 since that engine was designed for the dual-engine F-22.[46] The JSF simply weighs too much for one F119 to power. In comparison, the light-weight, single-role F-16 called for no major thrust increase when it used just one of the F-15's engines.[47] Also, just like the USN's stealth requirement, the single service short takeoff vertical landing (STOVL) requirement the USMC carried over from its AV-8B Harrier created problems. Since each competitor for the prototype phase used a different vertical lift system, P&W was left with much development work to do. With JSF costs continuing to rise, a Presidential Panel has already advocated canceling the F-35B.[48] This would take away the STVOL capability the USMC said it so badly needed but now seems unable to justify. The JSF engine development program has now increased 50 percent over the original contract award.

With congress continuing to add funding for an alternate engine back into the budget to "reduce development risk" the average unit procurement costs for multiple JSF engine variants are now 45 to 55 percent higher than in 2006.[49] As of 22 November 2010, 31 Low-Rate Initial Production JSF airframes are already in production.[50] Like TFX, solving any problems discovered during flight test is sure to be costly, and any gains of using the F-22 engine have been squandered.

DOD Handling of Outside Criticism

DOD has repeatedly ignored outside criticism of commonality and multi-role requirements. Chuck Spinney, a longtime defense acquisition official and observer, commented in 2000 that the JSF program would "sink into the familiar swamp of cost growth and schedule slippage that usually precedes a performance shortfall."[51] Nine years later, Winslow Wheeler and Pierre Sprey, long time champions of defense acquisition reform, cynically suggested renaming the F-35 Lightning II as the "Aardvark II" in an unflattering allusion to the F-111. They cited numerous issues that caused the JSF commonality between derivatives to approach 30 percent instead of the promised 70 percent.[52] This issue was foreshadowed in the 1997 CBO report which showed that in four "commonality driven" development programs, the highest achieved estimate of commonality was 10 percent, notwithstanding all programs having early estimates of between 50 to 70 percent.[53] As Mr. Sprey was one of the key participants in conceiving the F-16 and A-10 programs – the only recent tactical aircraft efforts that have come in on schedule and under budget – his opinion should carry considerable weight. Unfortunately, the military-industrial establishment responds by saying that the analysis is a distortion of facts and all is well with JSF.[54] If all is well, why do costs continue to climb?

History does not prove that all commonality and multi-role desires are misguided. In certain limited applications they are quite efficient. For instance, all services now field bombs of the same Mk-80 series with common unguided and guided versions proven very effective. In addition, multiple military aircraft have shared common avionics subsystems to good effect. Once in production, weapons systems can be modified as financially feasible when intrinsic performance allows for the incorporation of other missions. DOD has consistently fumbled program cost, schedule and performance goals when disparate requirements for multiple missions and multiple services are folded into a technologically challenging platform requiring concurrent development of both airframe and engine.

The Hidden Cost of High Tech

Efficient procurement is only part of the issue; efficient utilization is the other half. Relying on JSF to be the major strike arm of tactical air power results in a stable full of nothing but expensive thoroughbreds, with limited payloads. This is a wasteful use of capability for many missions that require a pack mule or draft horse. Using B-1, B-2, B-52 or F-15E aircraft in a close air support role in a permissive air environment is a mission mismatch and economically unsustainable. Without better low-tier options, the United States today is forced to make do. The operating costs in Table-1 below do not reflect the higher depot maintenance and contractor support costs for the B-1 and B-2, as well as other hidden costs such as flight hour costs incurred by tankers to in-flight refuel these thirsty jet aircraft.

Cost Per Flight Hour vs. Platform[55]

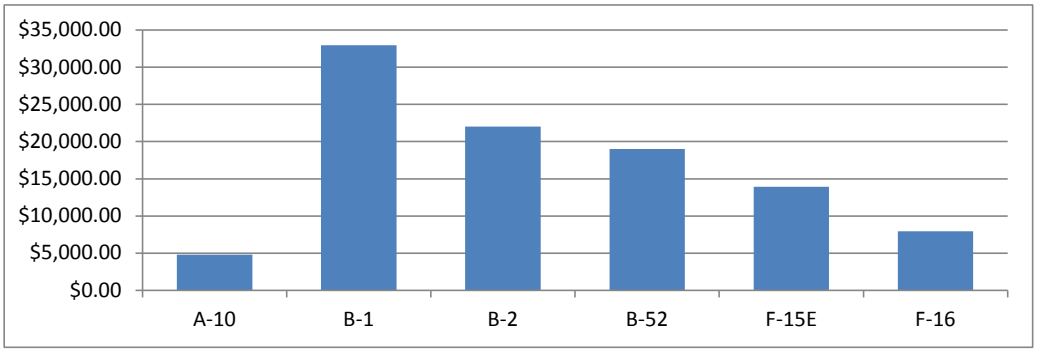

Table 1

Using up valuable limited strategic bomber and strike-fighter airframe life in irregular warfare missions wastes money. Current projections show JSF cost per flying hour will be higher than the F-16, continuing this pattern. Delayed JSF acquisition also increases US risk for future peer competitor conflicts since legacy assets may be retired after reaching the end of their allocated service life without replacements yet fielded.[56]

The current pursuit of silver-bullet aircraft capable of many missions causes the services to wastefully employ them when lower cost aircraft would be a better fit. Historically, both low-intensity warfare and lower-tier aircraft find it hard to garner congressional and industry support. As Colonel David Kilcullen observes:

> And because capabilities for irregular or unconventional conflict are much cheaper to acquire than those for conventional conflict, and require less hardware and industrial capacity, they are paradoxically less likely to be developed. This is because, through the "military-industrial complex," a substantial portion of the American economy, and numerous jobs in almost every congressional district, are linked to the production of conventional war-fighting capability.[57]

In times of constrained budgets the United States can ill afford to waste the precious high-tech assets it does have, or to ignore critics whose forewarnings have proven quite accurate.

Recommendations

DOD leaders should take steps to rein in unconstrained cost growth and insure Air Force programs receive the funding they need and deliver the capabilities promised.[58] Adopting the following changes will reduce the risks that future programs will overpromise and underdeliver:

1. Split major technological leaps in airframe and engine development from each other, and in turn from major aircraft production. Begin production airframe design around mature engine technology. There are numerous airframe specific challenges, such as avionics and software development that will take up valuable time.[59] Using mature engines in the design phase will lower development time and therefore cost.

2. Enforce discipline on the requirements process. The historical record of pushing beyond state-of-the-art technology to achieve an incremental improvement over currently fielded designs directly reinforces Augustine's Law Number XV; "The last 10 percent of performance generates one-third of the cost and two-thirds of the problems."[60]

3. Pursue commonality in modular components such as avionics and sensor weapon replaceable assemblies (WRAs), not by stacking expansive performance requirements upon a single airframe.

4. Plan for long airframe service lives and incremental upgrades in engines and avionics that will increase performance and commonality as well as possibly expand airframe capabilities *after* airframe operational fielding. Discipline must be maintained to make

sure that the new capabilities added do not degrade the aircraft's ability to perform its original mission unless that mission is no longer needed.

5. Pursue a force structure with a high-low mix of platforms that provides DOD with the required technical capabilities and numerical depth to address the full spectrum of conflicts, from low intensity to full-scale, peer competitor wars.

6. Reduce the amount of all-aspect stealth and other niche capability requirements for large scale manned aircraft acquisitions. Stealth is to the programs of the 21st century what supersonic speed was to programs of the 1960's and 1970's – a dramatic cost-driver of debatable utility to the bulk of the force.

7. Reevaluate the Joint Strike Fighter program's scope and schedule and develop alternatives as required. Future dollars may best be spent to update current designs and possibly restart successful lower-tier programs from the past. New programs should be started for more narrowly focused requirements for each service that are technologically feasible in the near term, and have reduced costs to allow greater numbers to be bought. Should a platform show utility for another service it can be expanded to a joint program after it is fielded.

Conclusion

In 2006, Ralph Peters commented in *Armchair General* that the US military was pursuing a strategy that would lead to "Quantitative Incompetence" and was buying "Maseratis and Ferraris when we need a fleet of pickup trucks and minivans."[61] The historical record of the last

century is clear. The military cannot budget correctly for its future programs if it starts with a clean sheet of paper and then designs a "car" to haul a semi-trailer at 250 miles an hour in the fog while getting 65 miles to the gallon, evading speed traps and fording rivers. The bullheaded pursuit of commonality, concurrent development and multi-role capability has led the United States into a do-loop death spiral of military acquisition:

> "We can't afford that many – therefore we need the plane to do everything for everybody – therefore development and procurement costs per unit exceed those budgeted – therefore we can't afford that many…"

The time to get out of the loop is now, and the requirement to do so is more critical than it ever has been in our past.

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End Notes

(All notes appear in shortened form. For full details, see the appropriate entry in the bibliography.)

[1] Combined Air Opeartions Center, *Balancing the Force.*
[2] Augustine, *Augustine's Laws,* 107.
[3] Sorensen, *Process and Politics,* 12-13.
[4] Aviation-History.com, *Pratt and Whitney R-2800.*
[5] Hess, *P-47 Thunderbolt,* 47.
[6] Ibid., 53.
[7] Ellis, *World War II Databook,* 288.
[8] Morgan, *Me 262*, 8, 38.
[9] Boyne, *Messherschmitt Me 262,* 36.
[10] Ibid., 36.
[11] Morgan, *Me 262*, 30.
[12] Ellis, *World War II Databook,* 268.
[13] Morgan, *Me 262*, 11.
[14] Sorensen, *Process and Politics*, 149.
[15] United States Commission, *Five Staff Papers,* A-31.
[16] Ibid., A-77.
[17] Booth, Chepolis and Howard, *TFX*, 1.
[18] Art, *The TFX Decision*, 2-4. These pages provide an excellent summary of the political problems that the TFX program encountered as early as 1963 because of congressional accusations of conflicts of interest against the those in DOD who made the contract decision.
[19] Coulam, *Illusions of Choice,* 94. Excellent discussion in early parts of this book on how the supersonic dash requirement was added by senior USAF leaders to make the TFX "better" than the F-105. This was due to a feeling that procurement of the TFX could not be justified unless the TFX was able to go higher, faster and farther than the F-105.
[20] Grantham, *The Quest for Commonality,* 6.
[21] Dr. David S. Sorensen (Air War College), interview by the author, 13 December 2010.
[22] Art, *The TFX Decision,* 31-33.
[23] Statement of Brig. Gen. William Georgi, 5 June 1973 in Werrell, *Chasing the Silver Bullet*, 28.
[24] Coulam, *Illusions of Choice*, 93.
[25] Ibid., 126, 176.
[26] Ibid., 184-195.
[27] Stevenson, *The Pentagon Paradox*, 196.
[28] Gillcrist, *Tomcat*, 57-59.
[29] Ibid., *Tomcat*, 123.
[30] Delahoussaye, "Modification of the F-14", 64.
[31] Delahoussaye, "Modification of the F-14," and North, "Navy Opts to Cut," 18. Conversion to 2003 dollars by author.
[32] Congressional Budget Office, *Tomorrow's Tactical Air Forces*, 48.
[33] General Accounting Office, *Defense Acquisitions*, 39.

[34] Stevenson, *The Pentagon Paradox*, 200 & 252.
[35] Hess, *Aircraft Airframe Cost Estimating Relationships*, 115.
[36] Campbell, *The Warthog*, 81.
[37]Chuck Myers, interview by the author, 27 November 2010.
[38] Brown, *The Future of Air Power*, 239.
[39] Leverington, *Vital Guide to FIghting Aircraft*, 23 & 62.
[40] Sweetman, *Ultimate Fighter*, 39-40.
[41] Defense Science Board, *Task Force on Defense Acquisition Reform*, i-ii
[42] General Accounting Office 2010, *Significant Challenges Remain*, 4.
[43] Congressional Budget Office, *Tomorrow's Tactical Air Forces*, 1.
[44] Goodman, "Off The Deck," 64.
[45] Congressional Budget Office, *Tomorrow's Tactical Air Forces*, 78.
[46] Keijsper, *Joint Strike Fighter*, 196.
[47] F-15A and F-16A information from National Museum of the US Air Force "Fighter Aircraft Datasheets," http://www.nationalmuseum.af.mil/factsheets
[48] National Commission on Fiscal Responsibility and Reform, "$200 Billion in Illustrative Savings."
[49] General Accounting Office, *Significant Challenges and Decisions Ahead*, 13.
[50] Lockheed Martin. "F-35 Lightning II Program Update and Fast Facts." *Lockheed Martin.* November 22, 2010. http://www.lockheedmartin.com/data/assets/aeronautics/products/f35/F-35FastFacts.pdf (accessed December 14, 2010).
[51] Spinney, "The JSF", 96.
[52] Wheeler and Sprey, "A Tale of Two Pigs."
[53] Congressional Budget Office, *Tomorrow's Tactical Air Forces*, 48.
[54] Wheeler and Sprey, "Glossing Over the F-35 JSF Aircraft Project." In the bottom right corner of the article is a box titled "Lockheed Martin responds: the world's best air forces choose the world's best aircraft" by Stephen F O'Bryan, Vice President of Business Development and Customer Engagement, Lockheed Martin F-35 Lightning II Program. O'Bryan states that, "It is unfortunate that there are so many misrepresentations and distortions of fact in the opinion piece offered by Mr. Wheeler and Mr. Sprey." Further on he makes the claim that "The F-35 procurement costs to date are meeting programme [*sic*] cost objectives…" Under a year later the JSF program would have its second Nunn-McCurdy breach which means that costs had risen by at least 15 percent from what was programmed.
[55] Wheeler, Winslow T., Email to author with Excel file on costs per hour based off of AFI 65-503, July 24, 2008.
[56] General Accounting Office, *Additional Costs*, 13.
[57] Kilcullen, *The Accidental Guerilla*, 27.
[58] AURIMS Abbreviation Code 11A8006
[59] Harrington, "Software Problems."
[60] Augustine, *Augustine's Laws*, 103.
[61] Peters 2007, "Quantitative Incompetence," in *Wars of Blood and Faith*, 78.