

REQUIREMENTS AND COST STABILITY: A CASE STUDY OF THE F/A-18 HORNET PROGRAM

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Most government and industry leaders involved with Department of Defense acquisition programs emphasize the importance of requirements and cost stability. However, despite all the stated support for program element stability and acquisition reform, frequent changes are experienced in acquisition programs that affect the final end product in terms of changes to unit design, number of units procured, system and subsystem capability, as well as affecting the overall cost of the program. This study analyzes the U.S. Navy's F/A-18A model to identify requirements changes; discern the reasons for change and the impact the resultant change made on the program (funding, schedule, capacity, etc.); and develop recommendations for limiting requirements creep, instability, and cost growth in future programs.

Keywords: *Acquisition Reform, Cost Growth, Requirements Stability, Requirements Creep, F/A-18 Hornet*

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F/A-18

HORNET



“AMONG THE CHANGES MADE IN THE ACQUISITION PROCESS IN THE LAST 20 YEARS HAVE BEEN THE GREATLY INCREASED EMPHASIS ON PROGRAM MANAGEMENT, WITH CAPITAL LETTERS. IT COULD BE NOTED THAT THERE SEEMS TO BE A FAIR DEGREE OF CORRELATION BETWEEN THAT GROWTH IN EMPHASIS WITH SEVERITY OF THE ACQUISITION PROBLEM IN TERMS OF LENGTHENED SCHEDULES AND INCREASED COSTS.”
(SPANGENBERG, 1981)

—GEORGE SPANGENBERG

Ironically, the most successful modern U.S. Navy aircraft began its life as a U.S. Air Force prototype. Therein lies the lineage of the F/A-18 Hornet. Indeed, the F/A-18 evolved from what can only be termed as a bizarre set of circumstances, tracing its beginnings back to the 1960s when the Air Force began looking for a lightweight fighter (Jenkins, 2000). By the mid-1970s, the Navy and Air Force were directed to work together and field a common lightweight fighter. Following a fly-off between the final two competing prototype aircraft, the Air Force chose its champion, which ultimately became the F-16 Fighting Falcon. At the time and inexplicably, the Navy demurred and chose the loser of the competition.

This article examines the topics of acquisition reform, requirements stability, and cost growth to determine the forces behind changes in major acquisition programs and what drives the changes—threats, technology, schedule, budget, or performance. While acquisition reform presently gets plenty of headlines, it has been an issue in the defense arena for years, as highlighted by the ongoing annual assessments of defense weapon programs by the Government Accountability Office (GAO, 2009). Yet despite the stated desire for requirements stability, frequent changes are experienced in acquisition programs that affect the final end product in terms of significant changes to unit design, number of units procured, system and subsystem capability, and unit costs to name but a few variables.

This study scrutinizes the initial fielded version of the Hornet, the F/A-18A, as a basis for study of the acquisition process and the requirements and capabilities changes that occurred between program approval and final product fielding. It will investigate why the F/A-18 was needed and the timeline for development, what the initial program requirements and cost estimates were, and what changes and adjustments were made. In examining these changes and adjustments, it delves into the causes and effects, namely why changes were necessary and what were the costs of the changes.

Finally, this article attempts to analyze and suggest a means for improving future program performance by identifying these past concerns. Specifically, it will attempt to discover the reason and amount of change from the initial plan in terms of time, cost, or product performance and capability. Additionally, it will categorize the impact of the changes on the program and develop lessons learned and recommendations for limiting requirements creep, instability, and cost growth.

Preparing for Launch

For a number of years, the Navy moved along toward filling its fleet of fighter aircraft with the highly capable F-14 Tomcat. But in 1971, the deputy secretary of defense, following the recommendations set forth in the Five Year Defense Plan, limited the Navy to only 313 F-14A fighters (F-18, 1975). At about the same time, the Air Force opened competition for design of a lightweight fighter. In mid-1973, the Department of Defense (DoD) and Congress placed strong pressure on the Navy for significant cost increases occurring in the F-14 fighter program. Additionally, Congress felt that the Navy should pursue a lightweight fighter as well, and the secretary of defense directed the Navy to assess the Air Force lightweight fighter designs (Jenkins, 2000). By the spring of 1974, two prototypes were ready for test flights—the General Dynamics YF-16 and the Northrop YF-17 (Kelly, 1990).

The Navy and Air Force both ultimately battled back-and-forth with the DoD over what they felt their needs were, and what DoD wanted them to have. The Air Force abruptly changed course and attempted to make the lightweight fighter effort go away by underfunding it, while a Navy fighter study group recommended several variants of the F-14 without the expensive Phoenix air-to-air missile (Stevenson, 1993). Despite its efforts, the Air Force was thwarted when the Office of the Secretary of Defense (OSD) decided to procure the YF-16 lightweight fighter for the Air Force. This was done by inserting funding in the Fiscal Year (FY) 1975 budget request sent to Congress in January 1974—1 month before the YF-16 conducted its first test flight (Stevenson, 1993).

In spite of direction from both Congress and DoD, the Navy released a Presolicitation Notice (PSN) to industry for its own lightweight fighter—the VFAX (V-fixed wing, F-fighter, A-attack, and X-experimental). However, Congress turned it down in August 1974 and placed it under a new program name called the NACF, or Navy Air Combat Fighter (F-18, 1975). As the Air Force continued toward acquisition of its new fighter, in September 1974 the Joint

Committee on Appropriations weighed in on this issue. The committee directed that the Navy would make appropriate modifications to the winner of the air combat fighter competition (Stevenson, 1993). This process to achieve commonality between the Services for their lightweight fighter needs made as much sense then as it does today because it would reduce overhead and simplify support issues. Unfortunately, as the late Senator Barry Goldwater observed at the time, “the only way...to get the Navy and Air Force to agree on a common fighter aircraft, is to...lock Navy and Air Force designers in the same room until they could agree...” (F-18, 1975).

When the YF-16 was announced as the winner of the Air Force lightweight fighter competition in January 1975, the Navy was not happy. According to Gaddis (2003), too much modification was required to “naval-ize” the aircraft, such as widening the distance between the rear landing gear, adding a keel, strengthening the airframe and all landing gear, and installing a tailhook—all to accommodate catapulting and arrested landings on aircraft carriers at sea. This would essentially result in a new aircraft that would definitely not have the commonality that Congress and others desired, and would weigh considerably more as well. Consequently, the Navy requested and received approval to develop the YF-17, the loser of the Air Force fly-off competition, and “[i]n a rare bout of bureaucratic honesty, ...redesignated the aircraft F-18 in recognition of the substantial differences” (Jenkins, 2000).

“IT IS MY OPINION THAT THE AIR FORCE WITH THE F-16 AND THE NAVY WITH THE F-18 FIND THEMSELVES TODAY IN THE POSITION OF DEVELOPING AN AIRCRAFT FOR WHICH NEITHER HAD AN ORIGINAL REQUIREMENT. THIS DOESN’T MEAN EACH SERVICE CANNOT USE THESE AIRCRAFT... FORTUNATELY, THE SERVICES HAVE GREAT FLEXIBILITY WHICH ENABLES THEM TO SURVIVE OUR COLLECTIVE, BUT SOMETIMES NOT TOO WISE, POLITICAL WISDOM.”

—SENATOR BARRY GOLDWATER
STATEMENT TO THE SENATE APPROPRIATIONS
COMMITTEE, OCTOBER 21, 1975

Initial Vector-Requirements and Cost

When it came time for contracts to be written for the development of the F-18, the Navy program manager called for something

unique at the time. Newly hired from the National Aeronautics and Space Administration, he called for specifications written into the contract for reliability in addition to performance. Previously, reliability had been addressed in contracts as goals, but never as specifications. When finalized, the contracts indeed captured the first ever agreement by a contractor to deliver reliability, maintainability, and performance (Kelly, 1990).

Those first contracts were issued in January 1976 for development and production for the first 11 planes. However, there were plans to deliver three versions of the aircraft—an F-18 fighter and A-18 light attack aircraft for the Navy, and dual-purpose aircraft for the Marine Corps that was very close to the F/A-18 that was finally fielded (Kelly, 1990). Initially, 780 aircraft were planned to go to the Navy and the Marine Corps. Some exceptional engineering and development of a dual-use radar for both air-to-air and air-to-ground use allowed the F-18 and A-18 designs to merge. As a result, the Hornet began to be called the F/A-18 in 1980, and was fielded in two versions: the single-seat F/A-18A and the two-seat F/A-18B (Jenkins, 2000). Initial operational capability (IOC) was scheduled for 1983 (Dyer, 1981, p. 13).

As previously stated, this article examines the F/A-18A model, which was developed, produced, and delivered from FY1975 to FY1985. During this timeframe, 371 total F/A-18A aircraft were delivered before the changeover to production of the next model—the F/A-18C. Additionally, 41 of the F/A-18B versions were delivered during the same period. Foreign military sales of F/A-18A and B versions were also produced and sold to Australia (52 aircraft), Canada (115 aircraft), and Spain (30 aircraft) during the same period (Jenkins, 2000).

The requirements, or performance standards, for the F-18 were initially described in the PSN of June 1974. The PSN described the initial, or threshold, requirements as well as the final, or goal, requirements. (Goal requirements are currently referred to as objective requirements.) Though all requirements are important, ultimately some can tend to be more important than others. However, several requirements proved difficult to attain during development and flight testing, such as operating range (specifically how far the aircraft could fly on internal fuel), acceleration, and overall aircraft weight (General Accounting Office, 1980a).

The threshold operating radius for the F-18 was 400 nautical miles (NM), with a goal of 550 NM. It was to be able to accelerate from 0.8 Mach to 1.6 Mach in 120 seconds at 35,000 feet threshold, and 80 seconds goal. Finally, it was to have gross takeoff weight of 30,000 pounds or less (Stevenson, 1993). These three performance requirements were not the only ones to cause problems, but they

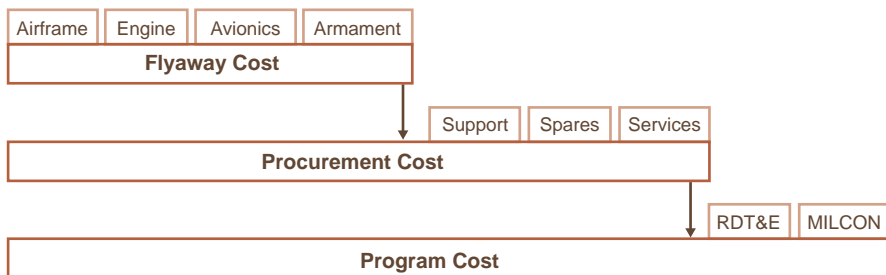
will be the main focus within this article due to their significance for fighter aircraft. In addition to performance concerns, cost growth caused just as much apprehension then as it does today.

When the Defense Systems Acquisition Review Council approved full-scale development of the F-18 in December 1975, the desired flyaway design-to-cost goal was \$5.6 million in FY1975 dollars (Cooper, 1978). The first quarterly reports for the F-18, titled Selected Acquisition Reports, or SARS, began shortly thereafter. SARs were transmitted to Congress to report on the progress and cost estimates of DoD major acquisition programs. The first report on the F-18 (Office of the Under Secretary of Defense, 1976) stated that:

The initial F-18 SAR...provides for a program of 11 R&D and 800 production aircraft at an overall cost of \$12,831.1M, comprised of \$8,005.6M in FY 1975 constant dollars and \$4,825.5M in escalation, based on an average annual rate of 5.2%. This equates to a FY 1975 constant dollar program unit cost of \$9.871M and an escalated unit cost of \$15.821M. (p. 2)

Costs for major aircraft acquisition programs can be classified in three ways: flyaway cost, procurement cost, or program cost. These costs are depicted in the Figure. Flyaway cost includes the basic airframe, the engine, avionics, self-contained armament, and any equipment furnished by the government to the contractor for inclusion in the aircraft. Procurement cost takes flyaway cost and adds support and training equipment, technical data and publications, technical services provided by the contractor, and initial spare parts required. Program cost then takes procurement cost and further adds research and development and any military construction costs to reach a total acquisition cost.

FIGURE. ACQUISITION PROGRAM COSTS



A problem that exists with expressing cost in three different ways is that it can get very confusing to those charged with oversight of the complete program. For example, the cost that seems

most often described in congressional testimony reviewed for this study was flyaway cost. While not truly a misrepresentation, flyaway cost does not tell the complete story. As the table shows, flyaway cost can play down the true cost of the program effort, sometimes by as much as 50 percent.

TABLE. MAJOR AIRCRAFT ACQUISITION PROGRAMS—THREE MAIN COST CLASSIFICATIONS

	FY77 Budget		FY78 Budget		FY79 Budget	
	FY75 \$ M	TY \$ M	FY75 \$ M	TY \$ M	FY75 \$ M	TY \$ M
Flyaway	6.14	10.33	6.13	10.21	6.33	11.8
Procurement	8.19	13.71	8.15	13.52	8.33	15.3
Program	9.87	15.82	9.95	15.8	10.16	17.6

Note. Adapted from *Congressional Research Service*, Report No. 78-224-F, December 15, 1978.

TY = Then year; \$ M = Dollars (in millions)

As the SAR excerpt previously described, costs are mainly expressed as a combination of program costs and escalation costs. Program cost variance can be due to changes in quantity, changes in requirements or capabilities, inflationary or deflationary cost changes, contractor overhead rates, delivery date changes, or even foreign military sales (General Accounting Office, 1981). Current programs experience change mainly due to increased research, development, test, and evaluation costs, program growth costs, delay in delivery of initial capabilities, and decreases in planned quantities (Government Accountability Office, 2009).

Mid-Course Corrections—Causes and Effects

The F/A-18A program experienced cost growth relatively early in the development phase as well as throughout its production run until FY1985, when block changes were incorporated to upgrade the F/A-18A and B versions to C and D versions (Elward, 2000). However, early program growth was mainly due to a mismatch between the inflation rates the program office was required to use by OSD. Guidance from the Office of Management and Budget (OMB) directed OSD to use inflation rates from the economic assumptions contained in the President’s Budget (General Accounting Office, 1981). For example, the March 1976 SAR listed a 5.2 percent rate, but the General Accounting Office found in 1980 that OSD inflation rates ranged from 5.4 percent to 6.3 percent. Yet for the same time period, the Bureau of Labor Statistics calculated a 13 percent

inflation estimate, and the Air Force derived a 19 percent aerospace industry inflation rate (General Accounting Office, 1980b).

This required use of low inflation rates had two detrimental effects. It made the Service appear to be understating program costs, and it made budgeting difficult. In one case, a Navy official stated that the FY1981 budget submission would have been 15 percent higher if the aerospace industry inflation rate had been used (General Accounting Office, 1981). This correlates to an explanation in the notes for the December 1980 SAR (Office of the Under Secretary of Defense, 1980).

Program costs increased by \$8,177.9M, from \$29,712.3M to \$37,890.2M, due to (1) the application of higher anticipated escalation rates in program outyears (\$+451.0M), (2) procurement schedule stretchout (\$+907.0M), (3) support increase as a result of revised basing plan and repricing of support program (\$+728.7M), and (4) reestimate of the R&D and procurement programs (\$+6,091.2M). Of the \$6,091.2M estimating increase, \$3,855.8M represents the difference between Government inflation projections and actual experience on the FY 1979-1981 production contracts and proposals. As a consequence, support purchases have been deferred and seven aircraft are being dropped from the FY 1981 buy. Both actions contribute significantly to the schedule and support purchases identified above. (p. 2)

An evaluation of the numbers just cited clearly reflects that 63 percent of the cost for the re-estimate of the R&D and procurement programs was due to the difference in inflation rate projections and actual costs experienced during previous years.

Another program cost, though not monetary, occurred in the form of reduced performance capabilities. During the flight test phase of development, there were demonstrated shortfalls in a number of key areas. The acceleration threshold of 120 seconds from 0.8 to 1.6 Mach described in the PSN was lowered to 110 seconds in the contract specification. At the first flight evaluation in March 1979, it took 156 seconds. By May 1980, the contractor achieved the acceleration in 116 seconds, but could not reach the target specification (Stevenson, 1993). Additionally, range thresholds were not met during the demonstration phase. Despite an operating radius threshold of 400 NM on internal fuel, the best range eventually achieved was 380 NM after significant work by the contractor and testing by both the contractor and the Navy (Jenkins, 2000).

In 1981, a report on the F/A-18 explained that OSD (and thus the Navy as well) had decided that "the demonstrated acceleration and

range were acceptable,” despite being well short of threshold specifications (General Accounting Office, 1981). However, one cause for concern here in retrospect is why substandard performance of program thresholds and contract specifications was accepted. The perception given is that the F/A-18 was wanted at any cost, even with reduced performance. Quite simply, it was an instance of specifications not being met and then changed, or de-scoped, because they could not be met.

The F/A-18 was also nearly 2,000 pounds over its initial specification weight according to a General Accounting Office (1980) report. Some of this weight growth was due to combining the designs for the F-18 and A-18, as the attack variant was 144 pounds heavier than the fighter version. Nearly 500 pounds was added due to reliability and maintainability features, and another 1,300 pounds for engineering estimates to attain reliability and maintainability goals (General Accounting Office, 1980a). These goals were added after the PSN was issued as part of the new program manager’s attempt to write reliability into the contract as well as performance. Although the specification called for a gross takeoff weight of 33,652 pounds, the weight of the aircraft demonstrated during evaluation was 35,363 pounds. Eventually, the Navy changed the weight specification because it became nearly 36,000 pounds (Stevenson, 1993). This is an example of requirements creep on an upward scope. So once again, a specification was changed to meet a design shortcoming.

Final Destination—Hitting the Requirements Target

Though the F/A-18A Hornet proved its worth in war and peace, it was a very different aircraft from what was initially envisioned, designed, and estimated for cost. Indeed, when evaluated in terms of schedule, cost, and performance, the F/A-18A only attained one of the three criteria to effective standards. The Hornet was produced with minimal slippage in terms of development and production timeline, delivering the first production model in April 1980, and the first aircraft to IOC in January 1983 (Boeing, n.d.). This compares extremely well with present day major programs, where only 28 percent manage to achieve IOC on time (Government Accountability Office, 2009).

Cost was an area where better execution should have been attained. The F/A-18A began as a \$12.8 billion program (\$8 billion for the base program and \$4.8 billion for projected escalation costs) in FY1975. Ten years later, in FY1985, it had grown immensely to

become a \$39.3 billion program. This was partly due to an additional buy of 566 aircraft that added \$6.8 billion in base year dollars and \$19.7 billion in actual and projected escalation costs, but that portion of the cost growth is not really a major concern in this case. However, the choice to purchase more aircraft, while it does raise the cost of the program, is certainly not indicative of program mismanagement, and can often lower the unit cost through economy of scale.

Escalation costs were the single largest factor for cost increases in the F/A-18A program, an observation made in nearly every General Accounting Office report on the Hornet. While the December 1985 SAR shows the percent of cost growth attributed to total adjustment for quantity as 99 percent, a quick calculation shows the growth of Actual and Projected Escalation under Current Estimate-Program Cost was over 400 percent (Office of the Under Secretary of Defense, 1985). Though it may appear that the Navy was grossly deficient in their budgetary management for allowing this cost growth, the culpability lies with the required use of OMB inflation rates that were lower than real inflation.

Lastly, while the F/A-18A became a top-performing fighter/attack aircraft, the Navy made tradeoffs during development and accepted less performance than was originally specified in both the PSN and the contract. The Navy approved reductions to the contract specifications of 9.4 percent for range and 11.2 percent for level flight acceleration (General Accounting Office, 1980a). Additionally, it was forced to change the weight specifications when engineering and design, as well as the requirements for reliability and maintainability, caused the weight of the aircraft to grow beyond contract specifications.

Post-Flight Debrief—Finding and Fixing Grips

On the whole, the F/A-18A program had several successes. First, it was produced without major adjustments to the development and delivery schedule. In fact, it went from contractor selection to the first-delivered production model in just under 5 years. Second, it featured the first instance where a contractor was tasked to deliver reliability, maintainability, and performance as part of the contract. This was a fair achievement for the F/A-18 in general. Though reliability and maintainability exceeded expectations and significantly reduced life-cycle costs, it also caused the overall system weight to increase. Finally, it achieved all this while undergoing a number of significant engineering changes, such as merging the F-18 and A-18 models into a single aircraft and developing a next type of radar.

Thus, from a program management perspective, the F/A-18A was exceptionally well-managed.

Conversely, the study that formed the basis of analysis for this article identified two key problems experienced between concept and fielding of the final product that are causes for concern. The first issue was cost growth due to “uncontrollable factors,” as the General Accounting Office (1980b) report called them. As discussed previously, escalation cost increases driven by inflation rates were a key factor in overall cost growth. Yet the inflation rates used by the Navy were stipulated by OSD, as directed by OMB (General Accounting Office, 1980b). This issue was well documented in General Accounting Office reports from 1980 to 1998, and even for the latest version of the Hornet—the F/A-18E/F. The



1998 report stated that OSD-directed rates were still lower than the industry averages (General Accounting Office, 1998). Further review of more recent OSD guidance from February 2005 found guidance to use a 2.0 percent inflation rate for FY2006 (Office of the Under Secretary of Defense, 2005), while the Bureau of Labor Statistics shows aerospace industry inflation rates of 4.8 percent for aircraft manufacturing for the same period (U.S. Bureau of Labor Statistics, 2006).

Reduced performance capabilities are the second key issue. The F/A-18A was not able to meet several specified performance requirements during testing and demonstration. The choice presented was to either require the contractor to deliver the aircraft as specified—running a risk of cost and schedule overruns—or accept an aircraft with reduced capabilities. The Navy chose to accept the reduction in capabilities, and this was not a new instance of doing so. Historically, the Navy had similar problems with the F-14 Tomcat. A comparison of requirements to fielded capabilities revealed that the F-14 was 5,000 pounds overweight, failed to meet required

ranges, could not attain combat ceiling, and missed required maintenance and reliability as well as several other requirements. The F-14 did not meet its cost target either (F-18, 1975).

Accordingly, these two key issues can be considered as major “gripes” of enduring significance that need to be fixed. In aviation terms, a gripe is a maintenance problem that must be repaired before the aircraft can fly again. For the first gripe, as shown previously, OSD is using OMB inflation rates that are statistically too low. These inflation rates resulted in two substantial problems for the Navy. It made the Navy appear to be minimizing program costs, and thus caused the Navy to be suspect in the eyes of those charged with program oversight. It also caused problems for those responsible for preparing budgets, especially when they knew through past experience that the inflation rates would not meet real economic averages. At a minimum, Bureau of Labor Statistics inflation rates should be used. Ideally, Air Force aerospace industry rates should be used.

The second gripe focuses on requirements instability. It was expected that this study would show requirements being added after program start—a phenomenon referred to as requirements creep that is common in present-day programs. This was not the case. Instead, the instability was in the Navy and DoD holding firm on the specifications given to the contractor for delivery. As described previously, the F/A-18A came up short in a number of performance capabilities. For future programs, the Navy (or any Service for that matter) and DoD should decide before program start whether to accept performance standard shortfalls, and if so, how much variance is acceptable. This can be done by setting threshold and final performance goals that focus on attainment of a short range of parameters in the contract. For example, instead of specifying a top performance speed of 1.8 Mach, a range of 1.6 to 1.8 Mach is specified, with the lower number considered minimally acceptable and the higher number desired. To encourage the contractor to reach the higher standard, a scaled award fee or incentive fee could be used to reward the contractor for achievements above the minimum requirement. Alternatively, if there is not a desire to accept reduced performance, there must be consideration to how much additional time or cost growth, or even both, is acceptable to reach the desired performance standards.

Concluding Thoughts and Recommendations

The F/A-18A Hornet was born of a process that started with clean sheets of paper and a need to field a lightweight fighter to complement the F-14 Tomcat. Along the way, it went up against the highest levels of DoD and Congress, danced around the Air Force lightweight fighter competition, and emerged as a truly exceptional fighter/attack aircraft. The fact that it managed to stay on schedule and achieve IOC in light of the myriad engineering changes required to merge the F-18 and A-18 models is a testament to the dedication of the designers, engineers, and program manager.

However, in spite of these dedicated efforts, the program dealt with several major obstacles in the form of escalation/inflation costs and the inability of the aircraft to meet required specifications. Though the escalation costs did not detract from the ability to see the program through to the end, they gave the perception of a program that was not being managed properly and was being deliberately understated in order to continue to receive funding. Additionally, though the performance shortcomings did not stop the F/A-18A from achieving IOC and success in the fleet, concern remains over the reasoning behind accepting less than what was called for in the contract specifications.

To ensure the Services and taxpayers get the most for their money, the DoD needs to make two major changes: (a) revise the way it calculates and allows for inflation in major acquisition programs, and (b) base such calculations on more realistic values, such as those provided by the Bureau of Labor Statistics. It must also reevaluate and enforce established processes for situations where programs cannot meet specified requirements. This includes options of whether to agree to a lower performance level or to push for the established requirement to be met, with the acknowledgment and acceptance of the fact that it could take more time, incur a higher cost, or both. The words of George Spangenberg at the beginning of this article are as true today as they were when written in 1981. One additional quote of his bears repeating and brings this conclusion to a proper closing: “We should return to optimizing the naval aircraft acquisition process, rather than accepting compromise in the name of federal procurement standardization” (Spangenberg, 1981).

Author Biography



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