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Lessons Learned from the

F/A–22 and F/A–18E/F Development Programs

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Summary

Two Multirole Fighter Aircraft Programs Emerged at the End of the Cold War

From the late 1980s through the present, the U.S. Air Force and the U.S. Navy have been acquiring two multirole fighter aircraft platforms. The Air Force has pursued the F/A-22, the world's first supersonic stealth fighter, while the Navy has developed the F/A-18E/F, a carrier-capable fighter with air-to-air, interdiction, and close air support capability. Currently, the F/A-22 is in the late stages of development, while the F/A-18E/F is in full production and has already been deployed in Operation Enduring Freedom and Operation Iraqi Freedom.

The design of the F/A-22 includes advancements in all the major areas of the aircraft, including airframe, avionics, and propulsion. The airframe incorporates an advanced stealth design to lower its radar cross section and uses large amounts of advanced materials, such as composites and titanium. The integrated avionics suite of the aircraft brings together information collected from several sensors on the aircraft to be displayed to the pilot. The propulsion system features two high thrust, Pratt and Whitney, F119 jet engines to allow the F/A-22 to supercruise above the speed of sound without using the fuel-consuming afterburner. The airframe design, flight controls, and thrust vectoring are also used to improve the maneuverability of the aircraft.

The F/A-18E/F Super Hornet was designed to be an upgrade to the existing F/A-18A/B/C/D multirole aircraft fleet. The program

sought to increase the aircraft's range, payload, and survivability. The program was an outgrowth of a Secretary of Defense memorandum from July 1987, directing the Navy to investigate advanced versions of the F/A-18 for 2000 and beyond. The trade studies, known as Hornet 2000, led to a Milestone IV/II review in March 1992 to begin formal Engineering and Manufacturing Development (EMD) of the program in July 1992. The F/A-18E/F is 4.2 feet longer than the legacy platform, has a 25 percent larger wing area, and can carry 33 percent additional internal fuel. The airframe design was largely new with very little commonality with the original design. It incorporated some limited radar cross-section reduction techniques, such as new inlets and attention to door and panel edges. The avionics for the initial release of the F/A-18E/F incorporated the suite from the C/D model. Provisions were made for a series of avionics upgrades to be performed subsequent to the basic air vehicle development. The propulsion is provided by two General Electric F414 jet engines.¹

These Programs Reflect the Challenges of Developing Major Weapons Platforms

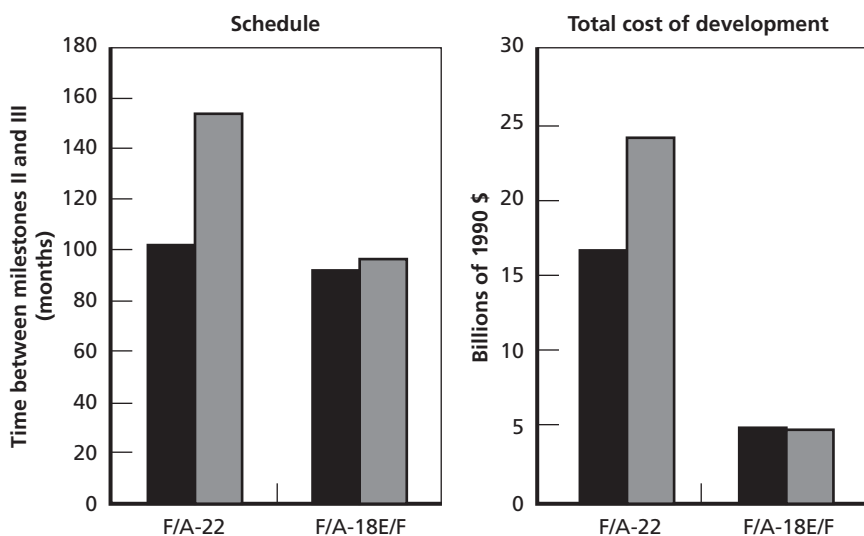
The F/A-22 program has experienced significant cost growth and schedule delays, whereas the F/A-18E/F program completed its development on cost and without any significant delays. As shown in Figure S.1, the F/A-22 program had exceeded its original schedule by more than 52 months as of the date of the last Selected Acquisition Report (SAR) examined (December 31, 2001), while the F/A-18E/F was virtually on time. The total cost of developing the F/A-22 grew by \$7.6 billion in Fiscal Year 1990 dollars, compared to the F/A-18E/F program, which met its original cost estimates. The schedule and cost overruns in the F/A-22 program have generated considerable

¹ The information is from the F/A-18 Selected Acquisition Report (SAR), F/A-18E/F Cost Analysis Requirements Description, and the Naval Air System Command's Hornet hyperlink, available at <http://pma265.navair.navy.mil/Public%20Affairs/stores/shornet/shornet.html>, accessed February 2004.

concern from the Department of Defense and Congress, leading to close scrutiny of the program and reductions in the number of aircraft to be produced.

The office of the Assistant Secretary of the Air Force for Acquisition asked RAND Project AIR FORCE (PAF) to investigate the reasons behind the cost growth and schedule delay of the F/A-22 program and those contributing to the cost and schedule stability of the F/A-18E/F program during EMD. This report examines the acquisition strategies employed by the F/A-22 and F/A-18E/F programs from their inception through the demonstration and validation (Dem/Val) and EMD phases. The analysis is based on various cost and schedule reports available to PAF as well as data and information available in open sources. For instance, the SARs, Contract Cost Data Reports (CCDRS) and Cost Performance Reports (CPRs) were the

Figure S.1
F/A-22 Experienced Schedule Slips and Cost Growth, While the F/A-18E/F Completed Development on Time and on Cost



*Includes government costs.

SOURCE: Selected Acquisition Reports.

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main sources of data for the cost and schedule growth analysis. Other documents, such as Cost Analysis Requirements Description (CARD), contractor's weight reports, General Accounting Office (GAO) reports, and published articles and reports were also examined. The purpose of this analysis is to derive lessons for improving future Air Force acquisitions.

Multiple Factors Contributed to Problems or Stability in Each Program

The F/A-22 and F/A-18E/F programs pursued different approaches to securing contractors, encountered various technical challenges during development, and employed distinct methods to monitor contract performance data during the EMD phase. All of these factors contributed to the separate cost and schedule outcomes seen in Figure S.1:

- **Each program used different methods to solicit contractor proposals and to divide work among contractors during their development phase.** Concerns about the needed mix of technical expertise and other industrial base issues led the F/A-22 program to distribute the work equally among three contractor team members. This arrangement resulted in an artificial distribution of work during the EMD phase and may have contributed to the schedule and cost problems experienced. Other business base concerns with respect to the program teaming structure as well as a move from Burbank to Marietta may have contributed to the program's instability and ultimately to its cost growth and schedule delays. By contrast, the F/A-18E/F program drew on preexisting relationships and contractor expertise to minimize the technology risks involved in the project. The program also implemented a number of acquisition reform strategies designed to control costs and schedule, such as the principle of cost as an independent variable (CAIV). These

measures helped keep the F/A-18E/F program on schedule and within cost during EMD (see pp. 13–27).

- **Concurrent development of new technology created greater technical challenges for the F/A-22, while incremental improvements reduced technical risk in the F/A-18E/F.** The F/A-22 cost growth was mainly the result of design challenges in the airframe (arising from stealth requirements), the integrated avionics suite, and the new propulsion system. Some of these challenges were either assumed to be low risk or were not accounted for in the initial program cost estimates. Also, concurrent development and integration of all aspects of the F/A-22 may have compounded the cost growth and schedule slippage. In contrast, the F/A-18E/F requirement was met by incremental improvements with minimal stealth requirements, a mostly existing avionics system from its predecessor aircraft, and a derivative engine design. This low-risk approach may have contributed to the F/A-18E/F's stable cost and schedule (see pp. 29–46).
- **The programs allocated different portions of their budgets for management reserve.** Management reserve is a budget withheld for management control purposes and is mostly used to cover unknown problems in a development program. The F/A-22 program allocated only about 2 percent of its budget to management reserve. This reserve was depleted in about the first year of the EMD effort because of the technical challenges described above. By contrast, the F/A-18E/F program maintained a substantial management reserve, roughly 10 percent of contract value. As the program proceeded through its development and unforeseen problems arose, the amount of management reserves covered these problems and was decreased accordingly (see pp. 47–53).

This report provides the Air Force and other services with lessons learned to improve the acquisition of such future and current weapon systems as the Joint Strike Fighter and such other hardware systems as unmanned aerial vehicles and missile programs. Our major

lessons learned for the Air Force acquisition decisionmakers are the following:

- Early, realistic cost and schedule estimates set the program on the right path for the rest of the development program.
- A stable development team structure, proper team expertise, clear lines of responsibility and authority, and a lead contractor responsible for overall program progress are critical to program success.
- An experienced management team and contractors with prior business relationships help eliminate early management problems.
- Concurrent development of new technology for the airframe, avionics, and propulsion adds significant risk.
- Reducing the cost and risk of avionics should be a key focus of the concept development phase. Avionics is a considerable cost driver of modern weapon systems, and new concepts should be demonstrated along with the new airframe designs.
- Preplanned, evolutionary modernization of high-risk avionics can reduce risk and help control costs and schedules.
- Careful monitoring of airframe weight is important. Airframe weight instability is an early indicator of problems.
- Earned value management (EVM) data should be used to monitor and manage program costs at the level of integrated product teams (IPTs).

Appropriate use of management reserve can help address program cost risk and can mitigate cost growth.