Spiral Development and the F/A-18

Parallels from the Past Emerge in Spiral Development of the F/A-18A through F Variants

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Spiral development is being invoked as the preferred current method of procuring weapon systems. Although it is generally accepted that spiral development was first articulated by Barry Boehm in 1988, some of its distinguishing features, such as a cyclic approach for incrementally growing a system's degree of definition and implementation, can be found in the archives chronicling the Navy's development of the F/A-18 strike fighter, with particular attention to this aircraft's most recently enhanced variants—the single-seat F/A-18E and the dual-seat F/A-18F Super Hornets.

F/A-18E Super Hornet. U.S. Navy Lt. Corey Pritchard earned a place in aviation history books July 24, 2002, when he became the first pilot to land a *Super Hornet* during its first deployment onboard an aircraft carrier. After a 45-minute flight from Naval Air Station Lemoore, Calif., Pritchard brought his F/A-18E Super Hornet onto the deck of the *USS Abraham Lincoln.*

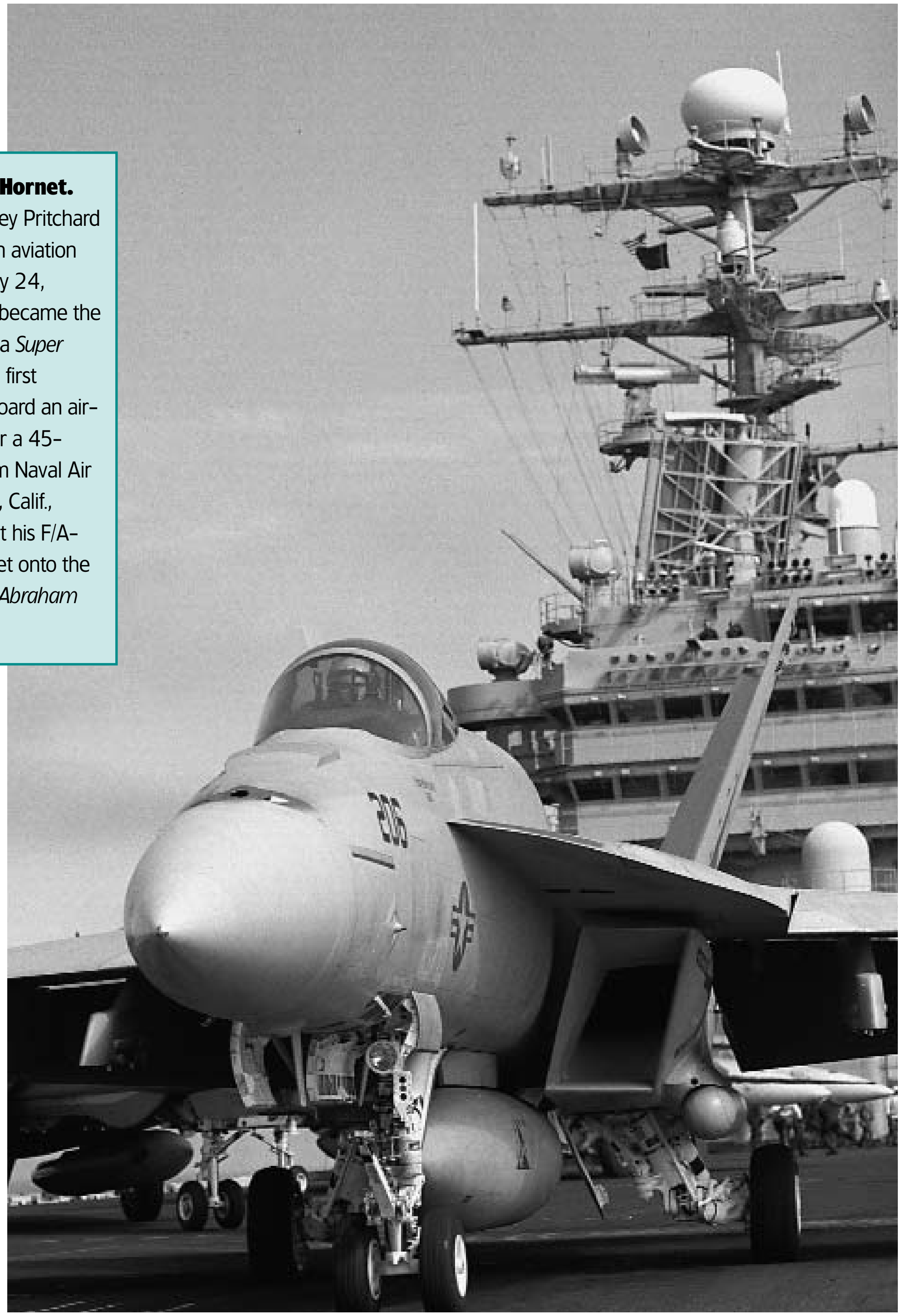

Photo Courtesy Boeing Media

Historical Background

Parallels from the past may be worthy of study by those in charge of spiral development in the future. Interesting comparisons can be made between the Navy's developmental efforts with F/A-18E/F, a truly evolutionary development, and more revolutionary developments in weapon systems attempted over the years. Those who are to implement spiral development in the future might gain valuable insight from a study of the F/A-18E/F. Even the original F/A-18A, which

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first flew on Nov. 18, 1978, was in some ways a precursor of spiral development. It had started out with the objective of producing a truly multimission strike fighter, one that could replace both the aging F-4 Phantom in the fighter role, and the aging A-7 Corsair II in the light attack role. In addition to being truly multimission, the F/A-18 was also designed to be affordable, not only in developmental and acquisition cost, but even more importantly in life cycle cost where the key to success was a significant improvement in both reliability and maintainability. All of these goals were achieved.

The original F/A-18 continued to evolve successfully, partly because it was designed from the outset with future improvements in mind. Pre-Planned Product Improvement (P3I) was that era's buzzword-equivalent of spiral development. The P3I purists, however, insisted that the F/A-18 wasn't an authentic example of P3I because its designers, developers, and managers got started without really knowing for sure precisely which enhancements it was to incorporate or exactly when or how they were intended to be incorporated.

Today these very uncertainties are considered by some to be highly useful traits in spiral development. One authority on spiral development puts it this way: "When you do spiral development, you do not know ahead of time when you start at the beginning of spiral zero where you're going to come out. As you resolve the risks, you may even redesign what you are trying to accomplish."

Digital Architecture

One of the keys to the Hornet's success, and to that of the F/A-18E/F Super Hornet as well, was its digital architecture. The ingeniously designed multiplex bus, with its ability to integrate the evolving software of the mission computer, the flight control computer, and approximately 30 additional microprocessors located throughout the airplane, gave the original F/A-18 the potential for more than 20 years of growth and enhancement in weapons, sensors, countermeasures, and other systems. It had spiraled so vigorously that by the time the larger, longer range, more survivable, more versatile Super Hornet came to be designed, 80 percent of the Hornet's avionics had been updated so successfully that they could be used for the Super Hornet. By this time, however, the original F/A-18A/B had spiraled up through C and D versions and no longer had the electrical, cooling, and volume capacity to handle all the new weapons, sensors, countermeasures, and other systems that were becoming available for the Super Hornet.

Just as the original Hornet depended on spiral development for its success, the Super Hornet has followed the same path. The first Super Hornets, deployed on board *USS Abraham Lincoln* last summer, signify simply the first turn of their own spiral, but a very hefty segment at that: they embody the additional range, payload, and bringback that were the aircraft's initial objectives; they incorporate considerably greater survivability than their predecessors; and they are capable of serving as airborne tankers.

Even though the F/A-18E/F and its evolving systems and subsystems may not fit everyone's definition of evolutionary acquisition and spiral development, anyone attempting a spiral development in the future would benefit from a study of them.

Other Systems/Subsystems

One of the more interesting subsystems of the F/A-18E/F is its Integrated Defensive Electronic Countermeasures suite. An outgrowth of the countermeasure systems that evolved on the F/A-18A/B/C/D versions, it in turn will continue its spiral through a phased approach.

Block 1

Its Block 1 includes a proven jammer, the ALQ-165—an operationally successful jammer incorporated in late-model F/A-18C/D aircraft and now also included in the F/A-18C/D aircraft flying with the air forces of allied nations. Additional protection is provided by the ALE-50 towed decoy.

Block 2

In Block 2, the ALQ-165 will be replaced by the ALQ-214 radar frequency countermeasures system, a "techniques generator" that determines an appropriate signal to counter an attacking missile.

Block 3

In Block 3, the ALE-50 will be replaced by the ALE-55 fiber-optic towed decoy. With this combination, the ALQ-214 will generate an optimal signal to counter the incoming threat, to be transmitted by the ALE-55 towed decoy. The phased, spiral approach of the Super Hornet's electronic warfare capability is designed to increase survivability in proportion to the evolving threat.

Other systems and subsystems of the F/A-18A/B/C/D/E/F will be of equal interest to future spiral developers. The General Electric F400-GE-400 engine powered the original F/A-18 aircraft. On later model F/A-18C/D aircraft it was replaced by the F400-GE-402, the enhanced performance engine. Profiting from lessons learned in designing an engine for the A-12 program, General Electric developed a larger and even more powerful engine for the F/A-18E/F, the GE-414-400.

Parallel Evolutions

Parallel evolutions in radar, forward-looking infrared sensors, landing gear, weapons launchers, and reconnaissance systems for the Super Hornet each provide fascinating areas for explorations in spiral development, even though probably none of them would satisfy the precise philosophical criteria for this definition. But for those interested in "Applied" rather than "Theoretical" spiral development, the F/A-18 evolution from A to F models will provide a fertile field.

Because of the F/A-18E/F's carefully designed-in capacity for growth, each successive deployment of Super Hornets will see additional spirals of enhanced capability, primarily through the incorporation of still newer weapons, sensors, countermeasures, and other systems currently in test, under development, or simply on the drawing boards of aeronautical engineers.

Even though the F/A-18A/B/C/D/E/F variants were designed without the conscious use of the invariant characteristics of the spiral development process, they did incorporate many of these characteristics. They employed in each cycle, concurrent rather than sequential determination of key artifacts: operational concept, requirements, plans, and design, thus avoiding premature sequential commitments. Each cycle took into consideration critical stakeholder objectives and constraints, product and process alternatives, risk identification and resolution, and stakeholder review and commitment to proceed, thus avoiding commitment to alternatives that were risky or unacceptable to stakeholders.

The level of effort and degree of detail in each activity within each cycle was driven by risk considerations, avoiding too little or too much of each activity and avoiding overkill or belated risk resolution. Stakeholder life cycle commitments were managed through the establishment of realistic milestones, avoiding analysis paralysis, unrealistic expectation, requirements creep, architectural drift, Commercial Off-the-Shelf shortfalls or incompatibilities, unsustainable architectures, traumatic cutovers, and useless systems. Emphasis was placed on system and life cycle activities and artifacts rather than initial development activities and artifacts, thus avoiding premature suboptimization on hardware, software, or development considerations.

Students of spiral development can find a wealth of information on exactly how the Hornet and Super Hornet blazed the spiral trail by referring to three comprehensive books on these aircraft: Orr Kelly, *HORNET: The Inside Story of the F/A-18*, Presidio Press, 1990; Dennis Jenkins, *F/A-18 Hornet: A Navy Success Story*, McGraw Hill, 2000; and Brad Elward, *THE BOEING F/A-18 HORNET and SUPER HORNET*, Specialty Press, 2000.

Editor's Note: The author welcomes questions or comments on this article. Contact Jackie Johnson at JohnsonJK@navair.navy.mil.

REAR ADM. (SEL) JEFFREY A. WIERINGA

F/A-18 Program Manager
April 2000—May 2003

Rear Adm. (Sel) Jeffrey A. Wieringa's naval service began in 1973 through the Aviation Reserve Officer Candidate (AVROC) program. He graduated from Kansas State College, Pittsburg, Kan., with a Bachelor of Science in Physics in 1975. Following his commissioning as an Ensign in 1976, he was designated as a Naval Aviator in 1977.

Following A-6 *Intruder* training at VA-128, he reported to Attack Squadron One Four Five where he completed two cruises on board *USS Ranger*. His next assignment was to Air Test and Evaluation Squadron Five (VX-5) as an Operational Test Director for numerous bomb, missile, and fuze projects. This tour culminated with the Fleet introduction of the *Skipper II* missile with air wings on board *USS John F. Kennedy* and *USS Independence* stationed off the coast of Beirut, Lebanon.

After A-6 refresher training at VA-128 he reported to Attack Squadron One Six Five where he completed two cruises on board *USS Kitty Hawk*. During this tour he conceived and executed a program that established a tactics department within the squadron. As a result of his performance on this tour, he was selected as "The Outstanding Naval Aviator U.S. Pacific Fleet." Starting in July 1987, he was selected to attend the U.S. Naval Test Pilot School (TPS). He completed the curriculum as class leader for TPS Class 93, and was designated an Engineering Test Pilot in June 1988. His following tour was with the Naval Air Test Center, Strike Aircraft Test Directorate, as Ordnance Systems Department Head and project test pilot. His flight test responsibilities included ordnance carriage and separation as well as carrier suitability envelope expansion flights on A-6 and A-7 aircraft.

In July 1990 he was designated an Aeronautical Engineering Duty Officer and reported to the Naval Air Systems Command as the A-12 Avionics Systems Project Officer and later the AX Program as Assistant Program Manager (Systems Engineering) or "Class Desk Officer." In June of 1993 he completed F/A-18 flight training at VFA-106 and reported to Patuxent River Naval Air Station, Md., where he was assigned as the F/A-18 Project Coordinator. His responsibilities included the coordination of all F/A-18-related efforts throughout the Naval Air Warfare Center Aircraft Division.

Wieringa screened for selection as Deputy Program Manager, PMA-265 as the co-leader for the F/A-18E/F Integrated Program Team until July 1998. He then held the office of Executive Director for Operations in the Research and Engineering Department within the Naval Air Systems Command. Wieringa commanded the F/A-18 Program, PMA-265 from April 2000 through May 2003. Capping the numerous accomplishments during his command was the successful first combat deployment of the *Super Hornet* in Operation Iraqi Freedom and 250 F/A-18s. In May of 2003, he was selected for Rear Admiral (Lower Half).

Wieringa has flown 40 different types of aircraft, including the F/A-18F *Super Hornet*, accumulating over 4,000 flight hours and 534 carrier landings. His personal awards include the Legion of Merit, Meritorious Service Medal (two awards), Navy/Marine Corps Commendation Medal (four Awards), and the Navy Achievement Medal.