QUEST TO BUILD A BETTER FIGHTER

The long and winding road that led to development of the F-16 and F/A-18 had its share of bumps and detours, but it was worth the trip

By Michael Sanibel

LWF face-off: The pilot of a General Dynamics YF-16 glances across at his rival from Northrop, a YF-17.

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In the early 1970s there was a protected area inside Northrop's aircraft plant at Hawthorne, California, that could only be accessed with a special blue security badge. Inside, a cadre of handpicked employees was designing and building the YF-17 Light Weight Fighter (LWF). Northrop's program was cloaked in secrecy because General Dynamics was then hard at work on its own version of the LWF. The winner of the competition anticipated a contract to produce several hundred advanced tactical fighters for the U.S. Air Force, Navy and nations worldwide. In the end, thanks to a radically different approach to procurement, both teams would build innovative fighters that have become the superstars of today's combat arsenals.

The LWF's evolution can be traced back to lessons learned in the Vietnam War, experience that was applied to a new generation of specialized weaponry. McDonnell's F-4 Phantom II—among the workhorses in Vietnam—served as an interceptor, fighter-bomber and reconnaissance plane. Originally developed by the Navy, the F-4 overcame initial reluctance by the Air Force to become its principal air superiority fighter. While Phantom pilots achieved favorable kill ratios in that conflict, their combat experience revealed that American aircraft needed improvement to successfully challenge the latest generation of Soviet fighters.

The F-4 was not optimized for air-to-air combat. Due to its size, weight and design, the "lead sled," as some called it, lacked the acceleration and maneuverability required for dogfighting with Soviet fighters such as the Mikoyan-Gurevich MiG-21. Phantom crews' difficulties were exacerbated to some extent by the rules of engagement, which restricted the use of long-range missiles without visual target identification. Those restrictions had been imposed due to the weapons' unreliability and the need to limit collateral damage.

Air-to-air missiles are ineffective in close-combat encounters, and the Phantom was not equipped with internal guns until the latter part of the war. The North Vietnamese tended to avoid dogfights, which made it very difficult for American fighters to gain air superiority. When close combat did occur, it exposed the F-4's maneuverability shortcomings. After careful analysis, the need for a more nimble fighter became obvious.

In January 1969, Grumman Corporation was awarded a contract to develop the Naval Fighter Experimental (VFX), which evolved into the F-14 Tomcat. Used for tactical reconnaissance and air defense, it was later retrofitted with an infrared targeting system for precision strike missions. While the VFX was intended to be light and nimble, neither objective was achieved. Design changes, performance upgrades and additional avionics combined to make it the biggest fighter of that era, and too expensive to replace all existing fighters. Another, cheaper option would be needed.

During the same time frame the Air Force, looking for a long-range air superiority fighter, rejected the VFX, convinced it wouldn't meet performance requirements. The goal of having both services share a single fighter platform to reduce costs seemed noble in light of the F-4's success. However, that objective became more elusive as technological advances and new mission profiles kept pushing the state of the art, and the Soviet Union developed fighters with specialized mission capabilities that surpassed their U.S. counterparts.

In December 1969, the Air Force chose McDonnell Douglas to develop its Fighter Experimental (FX), officially designated the F-15 Eagle. It would share the twin-tail design of the F-14, but not the variable-sweep wing. One aspect of the F-15 that would play a pivotal role in the future was the selection of Pratt & Whitney to supply its new F100 jet engines.

While the F-14 and F-15 were important additions to the U.S. fighter arsenal, both were still considered too large and heavy for traditional air-to-air combat. An informal group of advocates known as the "Fighter Mafia" supported the Energy-Maneuverability theory advanced by Colonel John Boyd, an exceptional fighter pilot and military strategist who had developed quantitative performance parameters to facilitate comparison of proposed aircraft designs.

Boyd served in the U.S. Army Air Forces during World War II, and later as a flight instructor known for his standing bet that he could beat any pilot in a mock dogfight in 40 seconds or less. "Forty Second Boyd" never lost that bet. While his disciples admired him, the brass deplored his confrontational methods and attempts to expose waste and corruption. Boyd acquired several nicknames, including "Genghis John" and the "Mad Major." Despite his abrasive personality, he became a central figure in the development of future fighter aircraft.

While Boyd favored small, nimble fighters, his tradeoff analyses helped to rescue the F-15 program when it foundered early in its development. The final product was still costlier and heavier than he had envisioned. At U.S. Air Force Headquarters, Boyd teamed with analyst Pierre Sprey and fighter pilot Colonel Everest Riccioni to lay the groundwork for a smaller, more maneuverable fighter. The result was the FXX, better known as the Light Weight Fighter.

Acceptance of the LWF was hastened by Congressional refusal to spend money on upgrading and purchasing more F-14s and F-15s. The idea of a cheaper aircraft that could be built in large quantities was appealing because of the economies of scale. Boyd's concept called for a gross weight of about 20,000 pounds, half that of the F-15. It would be designed to minimize drag, and be light enough and produce enough thrust to accelerate in a vertical climb. With a higher-lift wing to reduce wing loading, the aircraft would have increased

maneuverability and payload capacity while sacrificing top speed.

Ironically, it was the unveiling of the Soviets' big MiG-25 in 1967 that helped push the idea of the smaller fighter into the limelight. With a ceiling of 90,000 feet and maximum speed in excess of Mach 2.8, the MiG-25 was fitted with powerful radar and four air-to-air missiles. Its massive engines provided quick acceleration and a climb rate superior to that of any American fighter. To counter the new MiG, the F-15 was redesigned to accommodate bigger engines, advanced radar, increased fuel capacity and more weapons—changes that made it heavier and more expensive, which meant fewer aircraft to stay within budget limits. As a result, some squadrons would be left without replacements unless a cheaper fighter was developed. The Air Force made it clear that any LWF procurements would be in addition to the F-15 orders, essentially terminating any serious opposition to the new fighter.

The idea of a small, highly maneuverable fighter gained political support under Deputy Secretary of Defense David Packard, who favored awarding development contracts to two companies and having them build full prototypes that would participate in a "fly before you buy" competition. In January 1972, proposals were sought for a fighter with excellent acceleration, turn rate and range in the 20,000-pound weight class. The goal was to design an aircraft that could be produced in sufficient quantities for a unit cost significantly less than the F-14's and F-15's. There was no commitment that a production contract would ever be awarded after the prototypes were built and tested.

In February 1972, Lockheed, General Dynamics, Boeing, Northrop and Ling-Temco-Vought (LTV, later Vought) submitted proposals. Northrop's proposal was based on its twin-engine P-530 design, an evolutionary version of the F-5 that would fly at Mach 2. Design work had commenced in 1966, and the intent was to actively market the airplane to international customers. There were few prospective buyers, likely a result of the continuing success of the F-5 and the fact that the U.S. Air Force was not a potential user, since it considered the P-530 a potential threat to its F-15 funding. Without Air Force participation, the aircraft was less attractive to foreign buyers due to reduced economies of scale.

The Air Force selected General Dynamics and Northrop in April 1972 to design and build two prototypes each. Northrop Aircraft Division General Manager Welko Gasich chose Walt Fellers, manager of advanced systems and a key player on the P-530, to lead the new program, now designated the YF-17. Fellers was a central figure in the advanced design group responsible for the highly successful T-38 Talon (the first supersonic jet trainer) and the F-5 fighter series. The General Dynamics prototype was designated the YF-16.

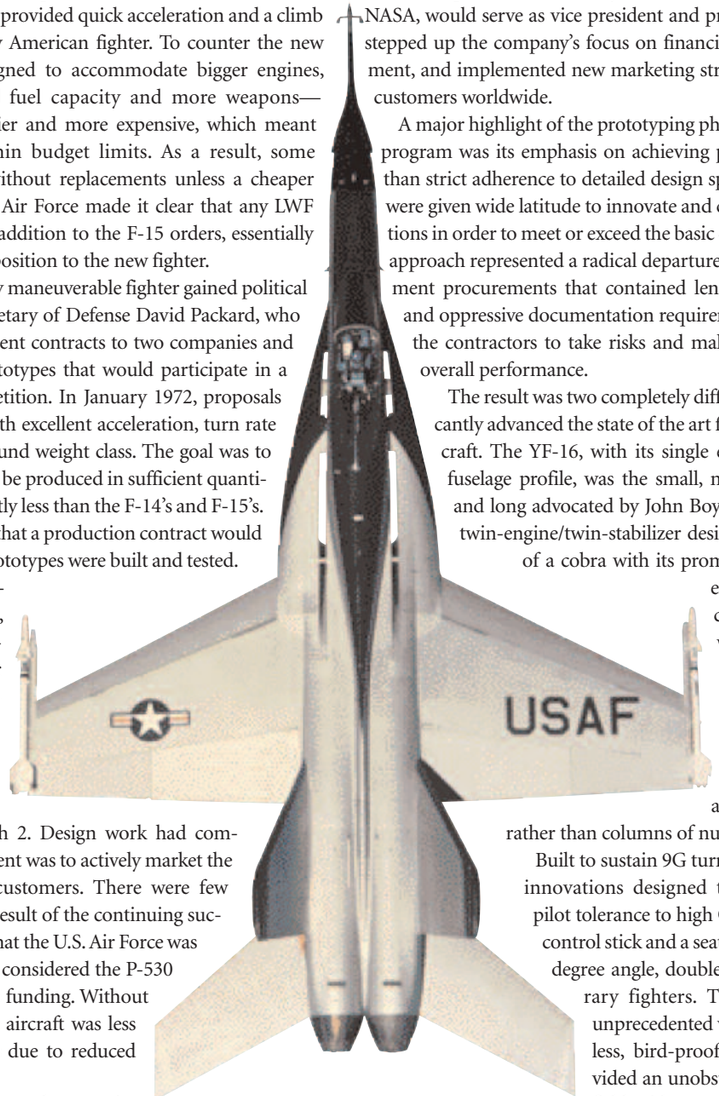
As the YF-17 moved out of the design phase and entered fabrication, technical issues caused Northrop's schedule to slip—while General Dynamics was running ahead of schedule. In late 1973, Northrop decided to bring in a new manager to oversee the production and flight test phases. Roy Jackson, a former Northrop employee who had spent the last four years as an associate administrator at NASA, would serve as vice president and program manager. Jackson stepped up the company's focus on financial and schedule management, and implemented new marketing strategies designed to reach customers worldwide.

A major highlight of the prototyping philosophy used in the LWF program was its emphasis on achieving performance goals rather than strict adherence to detailed design specifications. Contractors were given wide latitude to innovate and create new technical solutions in order to meet or exceed the basic contract parameters. This approach represented a radical departure from traditional government procurements that contained lengthy statements of work and oppressive documentation requirements. It also encouraged the contractors to take risks and make tradeoffs to maximize overall performance.

The result was two completely different fighters that significantly advanced the state of the art for high-performance aircraft. The YF-16, with its single engine and "coke bottle" fuselage profile, was the small, nimble fighter envisioned and long advocated by John Boyd. The YF-17, featuring a twin-engine/twin-stabilizer design, had the hooded look of a cobra with its prominent leading-edge wing extensions. Such significant design differences would not have been conceivable without the flexibility of the prototyping philosophy. The payoff was two excellent fighters that could be evaluated against real goals, rather than columns of numbers on a spec sheet.

Built to sustain 9G turns, the YF-16 boasted two innovations designed to dramatically increase pilot tolerance to high G-forces: a side-mounted control stick and a seat that was reclined at a 30-degree angle, double the angle of contemporary fighters. The aircraft also offered unprecedented visibility due to its frameless, bird-proof bubble canopy. It provided an unobstructed 360-degree visual field with a 40-degree look-down angle to either side of the aircraft. The Pratt & Whitney F100-PW-200 turbofan, the same power plant used in the F-15, was rated at almost 24,000 pounds' thrust with full afterburner, which gave the YF-16 a thrust-to-weight ratio greater than 1.0, allowing it to accelerate in vertical flight.

The YF-17 featured high-strength aluminum alloys as its primary fabrication material, and employed titanium and steel in space-limited areas of high loading and temperatures. To save weight, graphite-epoxy composites were used for the engine bay doors and several other access doors and panels. Two independent hydraulic systems, each driven by one engine, supplied mechanical power. Flight control was via a combination of hydraulics and fly-by-wire electronics. Its two General Electric YJ-101-GE-100 turbojet engines with afterburners each provided almost 15,000 pounds of thrust, resulting in a thrust-to-weight ratio greater than 1.0.



Besides its cobra-like wing extensions, the YF-17 had twice the engines and vertical stabilizers of its competition.

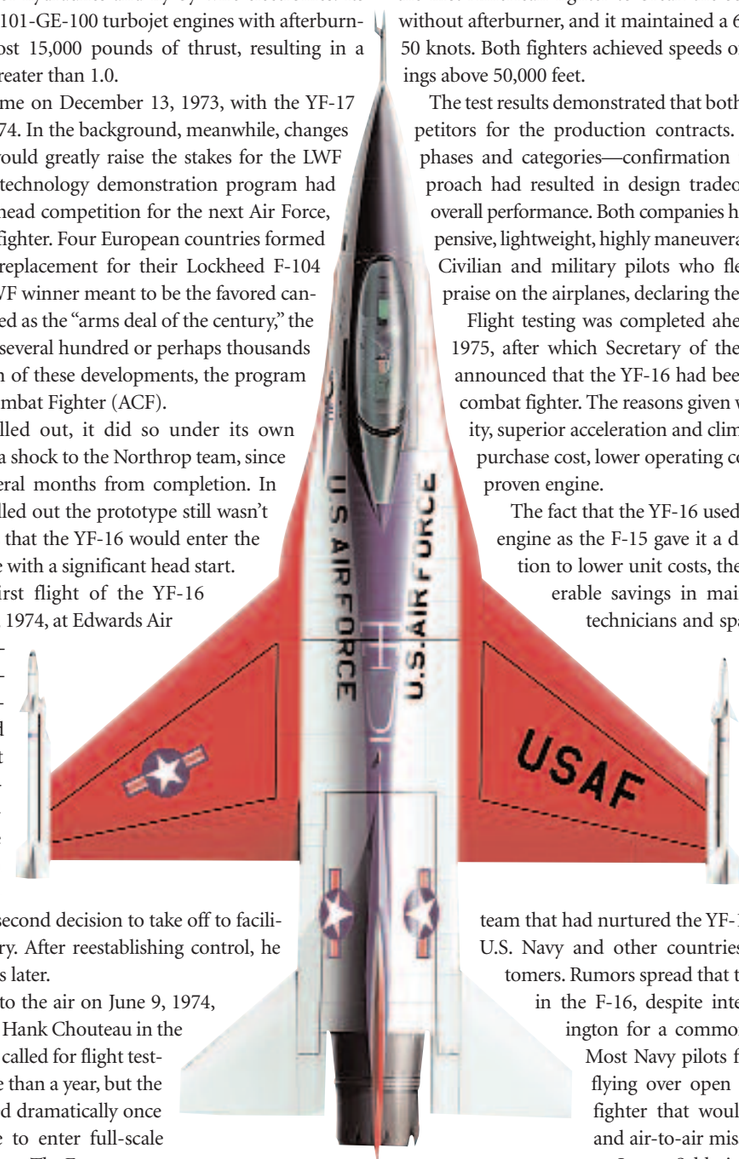
AIR FORCE ASSOCIATION

The YF-16 rollout came on December 13, 1973, with the YF-17 following on April 4, 1974. In the background, meanwhile, changes were transpiring that would greatly raise the stakes for the LWF program. The original technology demonstration program had evolved into a head-to-head competition for the next Air Force, Navy and international fighter. Four European countries formed a coalition to select a replacement for their Lockheed F-104 Starfighters, with the LWF winner meant to be the favored candidate. In what was touted as the "arms deal of the century," the winner stood to receive several hundred or perhaps thousands of orders. In recognition of these developments, the program was renamed the Air Combat Fighter (ACF).

When the YF-16 rolled out, it did so under its own power—which came as a shock to the Northrop team, since the YF-17 was still several months from completion. In fact, when the YF-17 rolled out the prototype still wasn't finished. It was obvious that the YF-16 would enter the flight competition phase with a significant head start.

While the official first flight of the YF-16 occurred on February 2, 1974, at Edwards Air Force Base, the prototype had lifted off unexpectedly 12 days earlier during high-speed ground tests. Test pilot Phil Oestricher accidentally scraped the tailplane as he raised the nose, precipitating a dangerous lateral oscillation. He made a split-second decision to take off to facilitate an airborne recovery. After reestablishing control, he landed safely six minutes later.

The YF-17 first took to the air on June 9, 1974, with Northrop test pilot Hank Chouteau in the cockpit. Plans originally called for flight testing to continue for more than a year, but the schedule was compressed dramatically once the decision was made to enter full-scale production with the winner. The European consortium was angling for a decision by December 1974, while the Air Force planned to make its choice in May 1975.



The YF-16, powered by a single engine, better exemplified the lightweight aircraft that Colonel John Boyd's "Fighter Mafia" had in mind.

LOCKHEED MARTIN

The fly-off consisted of putting both aircraft through a series of ground and aerial tests, and recording performance data that would be compared head-to-head. While the prototypes never engaged in mock combat against each other, they did fly against contemporary USAF and Soviet fighters.

The two YF-16 prototypes underwent 417 hours of testing during 330 flights, during which the aircraft withstood 9G maneuvering forces and reached altitudes exceeding 60,000 feet. The two YF-17 prototypes underwent 345 hours of testing during 288 flights. It was the first American fighter to break the sound barrier in level flight without afterburner, and it maintained a 63-degree angle of attack at 50 knots. Both fighters achieved speeds of Mach 2 and combat ceilings above 50,000 feet.

The test results demonstrated that both aircraft were worthy competitors for the production contracts. Each fighter won certain phases and categories—confirmation that the mission goal approach had resulted in design tradeoffs that achieved the best overall performance. Both companies had produced relatively inexpensive, lightweight, highly maneuverable air superiority fighters. Civilian and military pilots who flew the prototypes heaped praise on the airplanes, declaring them "fighter pilot's fighters."

Flight testing was completed ahead of schedule in January 1975, after which Secretary of the Air Force John McLucas announced that the YF-16 had been selected as the future air combat fighter. The reasons given were greater maneuverability, superior acceleration and climb rates, better range, lower purchase cost, lower operating costs and the utilization of a proven engine.

The fact that the YF-16 used the same Pratt & Whitney engine as the F-15 gave it a decided advantage. In addition to lower unit costs, there would also be a considerable savings in maintenance, since the same technicians and spare parts could be used on both aircraft. The Air Force announced that it would order at least 650 of what was now called the F-16 Fighting Falcon, with the order growing to as many as 1,400.

The news was devastating to everyone at Northrop, especially the team that had nurtured the YF-17 from its infancy. But the U.S. Navy and other countries were still potential customers. Rumors spread that the Navy was not interested in the F-16, despite intense pressure from Washington for a common buy with the Air Force. Most Navy pilots favored twin engines when flying over open water, and they needed a fighter that would fill both ground-attack and air-to-air missions. Secretary of Defense James Schlesinger directed the Navy to further evaluate the two competitors with an eye toward maximizing the new technologies evolving from the LWF and reducing overall costs.

The idea of the Air Force and Navy sharing a common fighter platform looked promising on paper, and the F-4 had certainly proved the feasibility of the concept. That idea was carried to the extreme with the production of the General Dynamics F-111, which failed to satisfy either service. By compromising on critical elements such as weight, power and mission configuration, the F-111 did not provide the

Two F/A-18 Super Hornets from U.S. Navy strike fighter squadron VFA-31 fly a combat patrol over Afghanistan in December 2008.

USAF

maneuverability and performance needed to successfully engage enemy fighters. Only seven naval F-111Bs were produced before the program was shut down. When it came to the Light Weight Fighter, the Navy would not forget this experience of having an airplane it didn't want stuffed down its throat by the Defense Department.

Northrop, which had never built a naval fighter, knew it could not be competitive without a partner that had extensive experience with carrier-based aircraft. The company formed an alliance with McDonnell Douglas to submit its proposal to the Navy. While the designers retained the same basic configuration, they knew the YF-17 would need to be modified with a widened and beefed-up landing gear to withstand the rigors of carrier operations. Folding wings and catapult attachments would be added, and the entire undercarriage, airframe and arrestor hook had to be strengthened.

AIR FORCE ASSOCIATION

A head-on view of the YF-17 shows the family resemblance between the prototype and its successful progeny, the F/A-18.

As prime contractor for the F-4, McDonnell Douglas possessed the expertise to make the new fighter a success. The two companies agreed to evenly split the parts manufacture, with McDonnell Douglas doing final assembly. In turn, General Dynamics teamed with Ling-Temco-Vought, the prime contractor for the A-7 Corsair II, to propose a carrier-optimized version of the F-16.

The Navy fought for and won Congressional approval in May 1975 to pursue development of the F-18 Hornet, as the navalized YF-17 was known. McDonnell Douglas would produce the Hornet, with Northrop as associate contractor for the airframe. It first flew on November 18, 1978, and became fully operational in January 1983, when it was redesignated the F/A-18, in recognition of its fighter/attack role.

The F-16 has figured prominently in several military actions since 1981, when an Israeli F-16 scored its first kill, against a Syrian helicopter. That encounter was followed a few months later by an air-to-air victory against a Syrian MiG-21.

During Operation Desert Storm in 1991, Fighting Falcons flew more than 13,000 sorties against Iraqi targets. Only seven aircraft were downed, with none lost in air-to-air combat. The F-16 was also used to patrol Iraq's no-fly zone from 1991 to 2003. In 1992 the U.S. Air Force scored its first F-16 air-to-air victory, against an Iraqi MiG-25. During the 2003 Iraq invasion, the F-16 was a prominent component of the air superiority effort. It has also seen extensive service in Afghanistan and smaller conflicts involving foreign air forces. The F-16 has compiled an exceptional record of 72 kills with no losses in air-to-air combat. The Thunderbirds adopted the Fighting Falcon in 1982 and have used it ever since.

The F/A-18 first saw combat in 1986, during attacks on Libyan missile sites and air defenses. On Operation Desert Storm's first day, two F/A-18s destroyed two Iraqi MiG-21s, then went on to complete their bombing mission—a clear demonstration of their dual-role effectiveness. Hornets flew more than 4,500 sorties in that campaign, with two lost and eight damaged. They were used in Kosovo, Bosnia and the liberation of Iraq in 2003. The latest version, called the Super Hornet, is an extensive redesign that is 25 percent larger, and has replaced the aging F-14s. The Blue Angels swapped their A-4 Skyhawks for Hornets in 1986.

Over the years, the F-16 and F/A-18 have gone through several block changes that added advanced avionics and significant improvements to armament capability. The fighters' continued stellar service more than 35 years after the introduction of their prototypes is a testament to the soundness of their designs. Both innovative fighters have become legends in the annals of jet aviation. ✠

The author was assigned to the Northrop Aircraft Division after graduating from the U.S. Air Force Academy in 1973. He served as part of a team that monitored YF-17 development on behalf of the Aeronautical Systems Division at Wright-Patterson AFB. Suggested reading: The Lightweight Fighter Program: A Successful Approach to Fighter Technology Transition, *by David C. Aronstein and Albert C. Piccirillo; and* Northrop's YF-17 Cobra: A Pictorial History, *by Don Logan.*

Build Your Own F/A-18A

DICK SMITH

Even before the McDonnell Douglas, now Boeing, F/A-18 Hornet made its maiden flight in November 1978, model manufacturers had kits of the dual-role fighter ready for sale. The first offerings, patterned after the prototype, were soon replaced to reflect the production aircraft that would take the place of the F-4 Phantom II and A-7 Corsair II.

Hasegawa's 1/72nd-scale release of the Hornet in 1985 was one of the first to include all the "A" model modifications of the aircraft. The kit's cockpit is sparse but adequate in this scale when painted aircraft gray, FS-16473. The Martin-Baker SJU-6 ejection seat frame is interior black, FS-37031, with cushions painted tan, FS-30219. Thin slices of masking tape serve as seat belts.

While the cockpit colors are drying, flip over the top section of the fuselage and insert the underside pieces of the wing leading edge extensions. This kit's upper fuselage section is from the same mold as that for the two-seat model. To make it a single-seater, glue parts D-12 and A-10 into place, covering the area that would accommodate a rear crew member.

Paint the engine faces silver and set them aside to dry. Spray the inside of the engine bay tunnels gloss white, FS-17875, then glue the engine faces into place. Dry fit and carefully glue the engine bay parts into place on each side of the lower fuselage. It's very important that these pieces are exactly glued into place or you'll be facing a major filling and sanding job.

Set the cockpit in place in the bottom fuselage section, then glue the fuselage pieces together. This step also requires exact alignment; you may need to tape the pieces to hold them in position until the cement dries.

Glue the wings into their corresponding slots. Again, you may need to use tape to hold these parts in place until the adhesive dries. It's also a good idea to set the model aside at this point and let all the glued joints set up overnight.

Once you've made sure all the joints are solid, fit the weapons pylons to the underside of the wings. The external fuel tanks ride on the inner pylons and munitions on the outside. Do not attach the tanks in this step.

This kit includes markings of strike fighter squadron VFA-113 aboard USS *Constellation*. The carrier air group (CAG) commander's aircraft sports a more attractive color scheme than the rest of the planes that make up *Constellation*'s attack wing. As such, it is partially exempt from the Navy's overall subdued schemes. A special painting guide, included with this kit, indicates that the VFA-113 CAG's aircraft was painted overall gray, FS-36375, with the nose cone a slightly darker gray, FS-36320.

Before applying the markings, spray a coat of clear gloss over your model, to make sure the decals will adhere. The vertical stabilizers on the CAG's "bug" should be painted gloss black, FS-17038, and will serve as the backround for the signature "Stingers" bumblebee and rainbow of squadron colors.

F/A-18As were armed with AIM-9L Sidewinder and AIM-7F Sparrow missiles for self-defense. As an attack aircraft, the Hornet carried a number of different bombs and guided munitions. The kit supplies Sidewinders as well as Sparrow missiles, but you'll need to purchase any other weapons from aftermarket sources.

Once you've finished applying the overall color of the aircraft, all that remains is to paint the wheel wells, the landing gear, the gear doors and the airbrake bay gloss white. The wheels should be tire black. Next assemble the landing gear and attach the bay doors.

Seal the markings with a dusting of dulling spray. Once you mask and paint the canopy, your model of the VFA-113 commander's Hornet is ready for display.

Dick Smith