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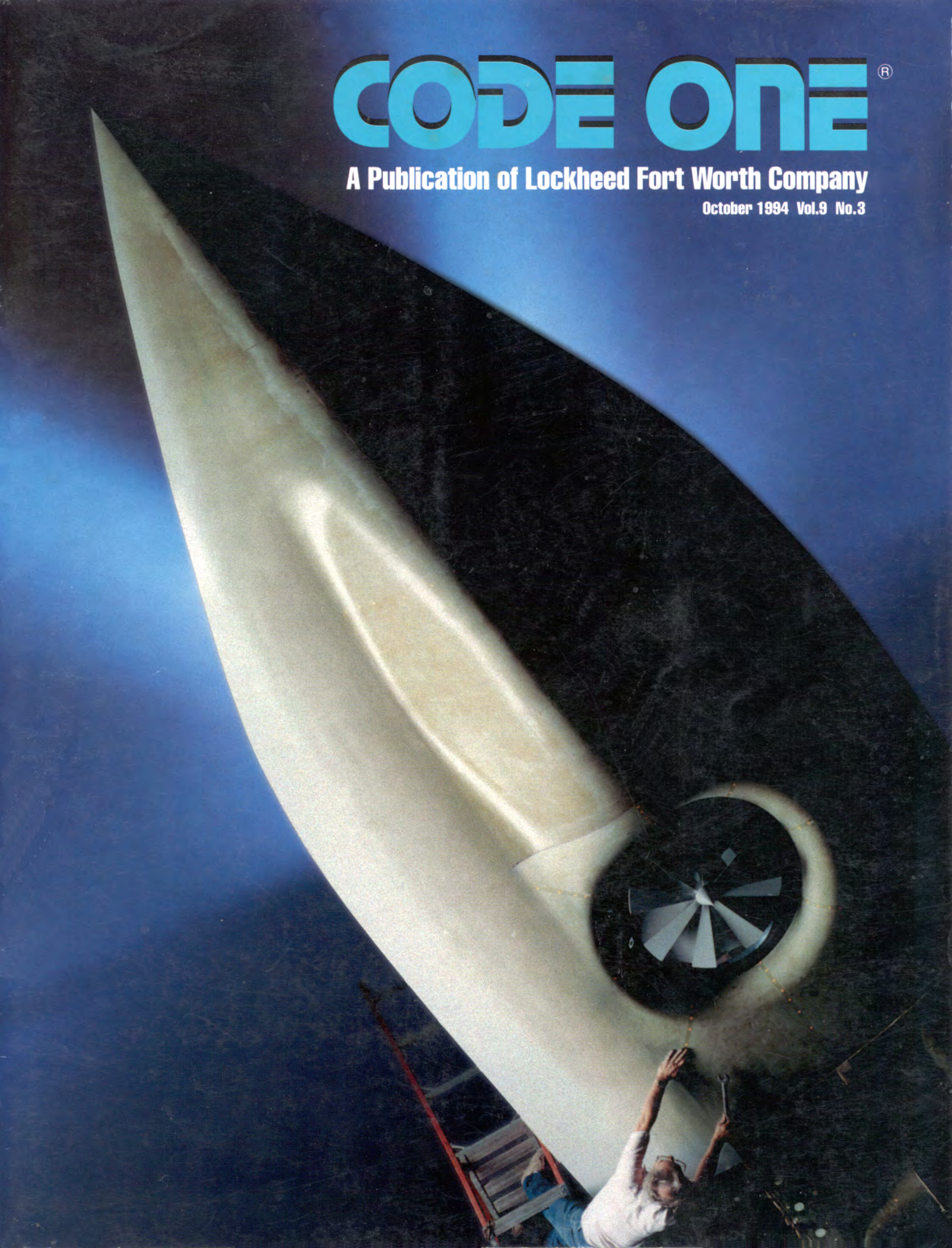

PHOTO MICKEY WINCHESTER / LFWC

VISTA RETURNS

The F-16/MATV has been fully restored to the VISTA configuration and is going through flight testing at Edwards AFB in California. *VISTA* stands for variable-stability inflight simulator test aircraft. The VISTA/F-16 will be used to provide training for new test pilots and to develop new flight control laws for many different types of aircraft. Developmental flight testing of the airplane will continue through 1994.

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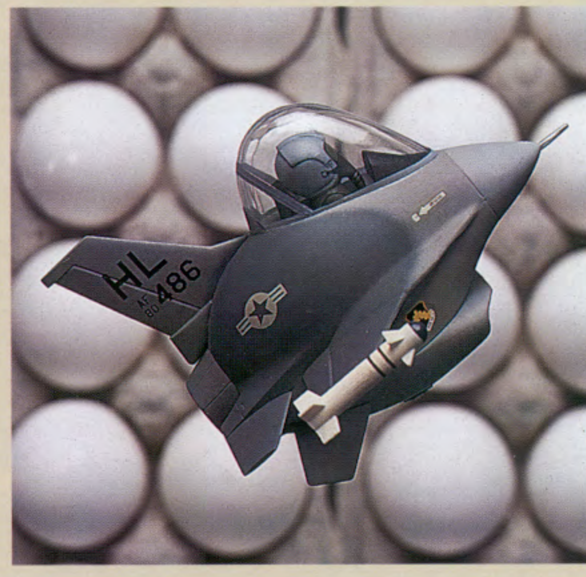
Send your name, address, and $12 for a one-year subscription (four issues) to *Code One* at the address above. Foreign subscriptions are $25 (US). Some back issues are available.

ABOUT OUR COVERS

Front: The full-size wind tunnel model of Lockheed's design for the X-32 has been shrouded in mystery. Until now. The design incorporates a lift fan to convert the Air Force version to a short takeoff and vertical landing version for the Navy and Marines. The aircraft represents the next generation of lightweight multirole fighters. For more on this unique airplane, see page 2. Photo by Denny Lombard/LADC and Peter Pham/LFWC.
Back: The RNLAF heads to Canada for Maple Flag exercises. Photo by Theo van Geffen/IAAP.

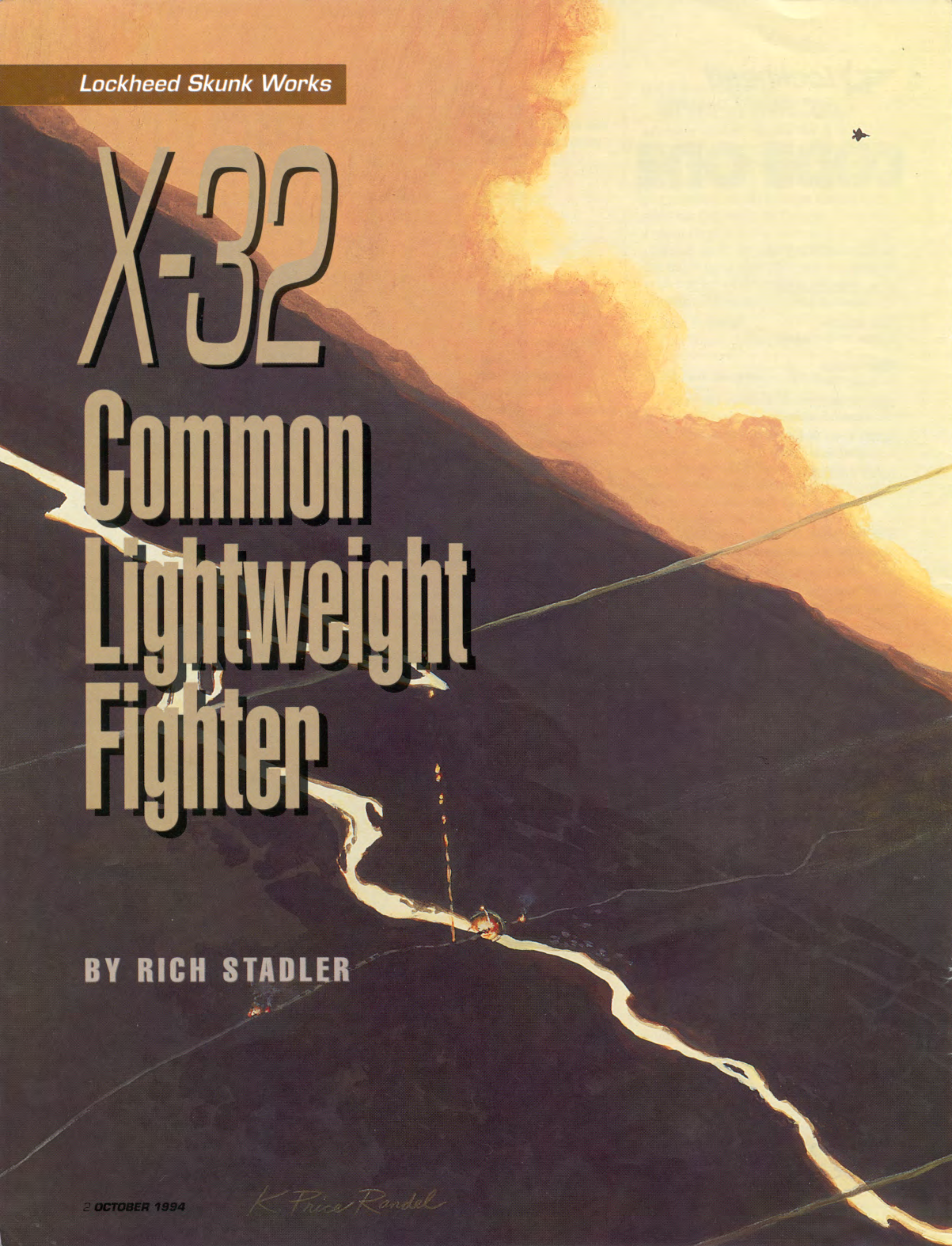
IN THIS ISSUE—OCTOBER 1994



Next-generation fighter?
No. It's the *Egg-16*—one of many F-16 model kits marketed in the United States. For more, see page 16.

X-32 Common Lightweight Fighter

BY RICH STADLER



X-32 Common Lightweight Fighter

The full-scale wind tunnel mock-up for the X-32 is being built at Lockheed Advanced Development Company in Palmdale, California.

It is the year 2010. A terrorist nation has invaded a former Soviet republic to acquire nuclear weapons. The Russian president, unable to defend his ally, asks the United States for military help. While the US Navy and Marines assault the coastline, the US Air Force launches an interdiction campaign against command and supply centers deep in hostile territory. A wave of F-22 Advanced Tactical Fighters goes in first to sweep the skies of hostile aircraft. Right behind them comes the primary attack force—fighter/bombers armed with precision-guided weapons. The sleek, delta-winged aircraft of the attack force are something new. Even while ingressing at medium altitude, their speed and stealth make them almost impossible for hostile defenses to target.

Deep in enemy territory, this USAF strike force is alerted to an inbound pair of surviving bandits. Two of the strike aircraft jettison their air-to-ground payloads and face the threat. Before the bandits detect them, the strike aircraft launch their AIM-120 missiles. The lead bandit goes down, but his wingman evades and runs. Accelerating rapidly to supersonic speeds, the strike fighters run down the last bandit and finish the engagement with their AIM-9s. The path cleared, the strike force hits its target and returns to base. Mission accomplished.

Acquiring new attack aircraft like those described in this scenario presents the Air Force with a real dilemma. Even though it needs to modernize its F-16 attack force, the Air Force faces a declining defense budget with less money for modernization. The same problem faces the Marines in replacing their F-18 and AV-8 aircraft. Some defense experts say that the Defense Department is confronted with the impossible: simultaneously developing three aircraft to meet future threats.

The challenge of developing such aircraft has been taken on by ARPA, the Advanced Research Projects Agency. ARPA's solution to the affordability problem is a lightweight, single-engine aircraft for the Air Force that can be converted to a short takeoff and vertical landing aircraft for the Navy and Marines. By spreading the development and production costs over a larger number of aircraft, each version becomes more affordable. And because the Navy version does not have to be designed for catapult launch or arrested landings, the Air Force does not have to pay a weight or performance penalty for commonality.

NASA engineers did feasibility studies for ARPA and concluded that technology has advanced to the point that such a joint strike aircraft is possible. ARPA then asked industry for ideas. It received five proposals and awarded contracts to two teams with similar lift fan concepts: the Lockheed Advanced Development Company, better known as the Skunk Works, and McDonnell Douglas. LADC will demonstrate a shaft-driven lift fan system. McDonnell Douglas will demonstrate a gas-driven lift fan system. Boeing and Northrop Grumman are studying alternative concepts under cost-sharing research agreements.

The Lockheed design is a single-seat aircraft with a canard and delta-wing planform. The airplane is powered by a higher bypass ratio version of the same Pratt & Whitney F-119 engine that powers the F-22. The higher bypass ratio means it develops about twenty-five percent more thrust than the basic F-119 engine in intermediate and military power. The USAF version has an empty weight somewhat greater than that of the F-16 and an internal fuel fraction near one-third.

Built to be light, yet affordable, the aircraft blends conventional materials, such as aluminum and titanium, with carbon fiber composites already proven on other Lockheed aircraft.

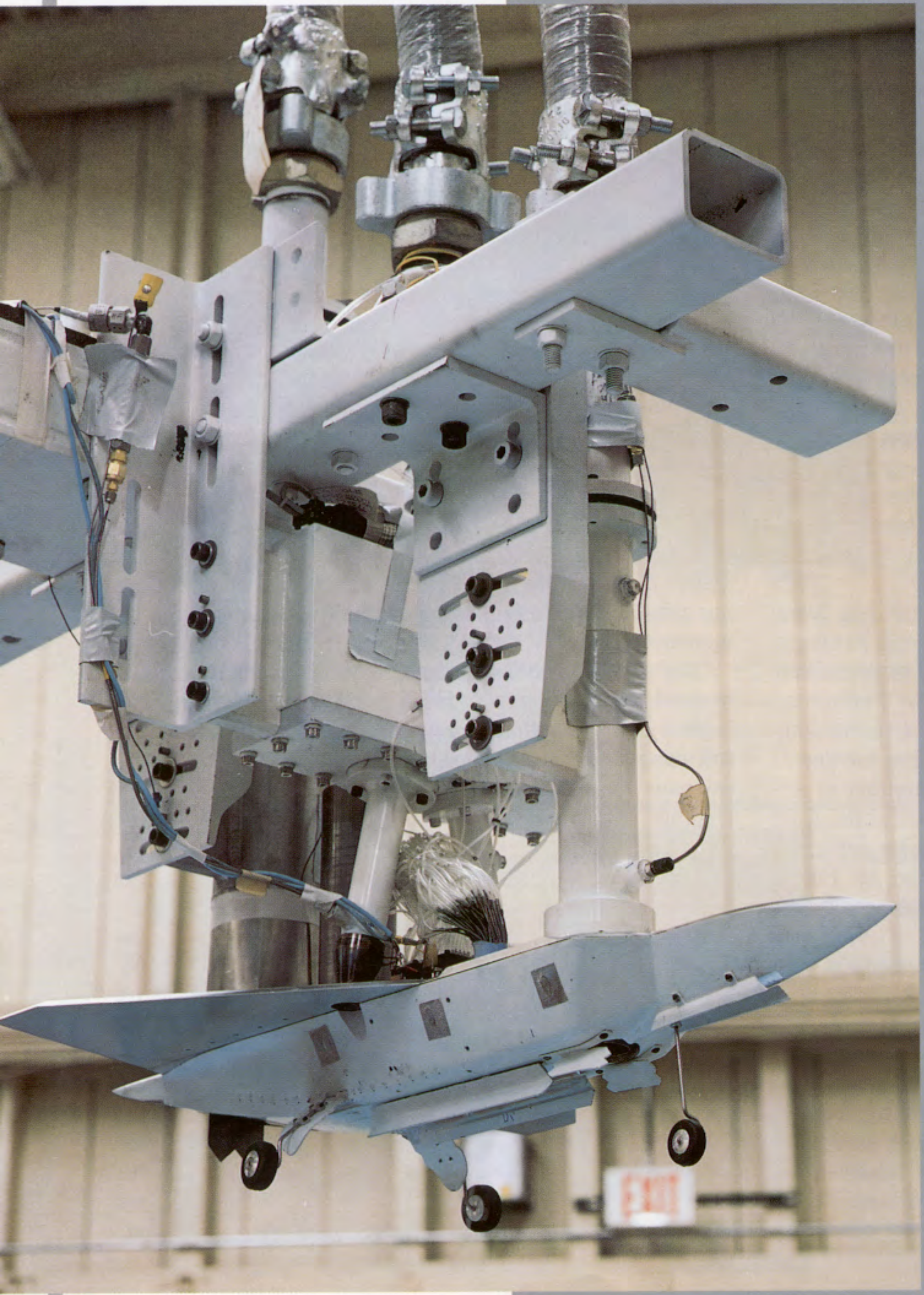
For performance and signature control, the airplane's fuselage is blended with the wing and the inlets are similarly integrated with the forebody. Its aerodynamic design allows it to get into the target area quickly—and to get out even faster. The delta wing provides planform area for maneuverability and volume for fuel yet is aerodynamically thin to minimize supersonic drag. A fly-by-wire system continuously adjusts the canard to trim wing lift efficiently and to optimize the lift-to-drag ratio at all speeds, improving subsonic range and supersonic persistence as well as maneuverability.

The airplane can carry two AIM-120 missiles or similarly sized bombs, plus two AIM-9 Sidewinders, in its weapon bays. In addition, it can carry a 20mm gun internally. The full range of conventional, guided, and antiradiation weapons can also be carried on external wing and fuselage stations. It has a smaller radar than that of the F-22, but the radar includes air-to-ground modes. Target designators for precision-guided weapons are integral to the design.

Built to be light, yet affordable, the aircraft blends conventional materials, such as aluminum and titanium, with carbon fiber composites already proven on other Lockheed aircraft. Composite materials are used for the wing skins, flaps, ailerons, canards, tails, inlets, and for many of the access panels.

Designers at the Skunk Works used technologies developed for the F-22, plus some advanced concepts of their own, to reduce signatures and to let the pilot focus on the target rather than on enemy defenses. The designers have not neglected the other half of the survivability equation,

X-32 Common Lightweight Fighter



reduced vulnerability. "Get home" features include self-sealing tanks and lines, onboard fire suppression equipment, jettisonable weapons, and backup systems. For example, the canard and thrust-vectoring nozzle back up the wing flaps for pitch control.

With the combination of blended-body aerodynamics, internal weapons, composite structure, and the F-119 engine, this aircraft will outperform the aircraft it replaces. On internal fuel, it has the interdiction mission radius of current Air Force fighters with a centerline tank. It has the same radius when armed as an escort fighter, carrying a pair of AIM-120s instead of bombs. On a defensive counter air mission, it loiters twice as long as current fighters. Although it does not have the combat performance of an F-22, it pulls nine g's and accelerates to supersonic speeds faster than any current fighter. In addition, it can sustain supersonic flight almost three times as far as current aircraft carrying the same weapons.

Faster, more stealthy, and having a greater range than the aircraft it replaces, Lockheed's design gives pilots and their commanders greater capability. But no matter how capable an aircraft may be, if it can't fly, it can't fight. Therefore, the Skunk Works designers emphasized reliability and maintainability in the design. The airplane has an auxiliary power unit, a self-contained boarding ladder, and integral weapons loading to minimize the need

Lockheed's lift fan concept makes it possible to design a single aircraft for all three services without the weight or performance penalty usually associated with such commonality.

for support equipment. All turnaround servicing can be performed at a single point. And the engine can be removed in less than thirty minutes.

The aircraft has on-board oxygen and inerting gas generating systems, so that these gases do not have to be recharged. A single panel in the wheel well displays system status and isolates faults. It also gives go/no-go indications of fluid levels, including oil, hydraulic fluid, and avionics coolant. This single panel permits a quick preflight check without the need to open numerous doors to inspect gauges.

The aircraft's engine is a refanned version of the P&W F-119 engine. It does not require any technology beyond that available in the basic engine. The engine is efficient, lightweight, and simple. It has fewer compressor and turbine stages, fewer structural frames, and fewer bearings than the previous generation of engines. Such simplicity of design equates to greater reliability and easier maintainability.

Lockheed's lift fan concept makes it possible to design a single aircraft for all three services without the weight or performance penalty usually associated with such commonality. In the past, the design of a common Air Force and Navy aircraft was driven by carrier takeoff and landing requirements. For example, the F-18 needs almost 2,500 pounds of additional equipment and structure to reduce its carrier approach speed and to absorb the shock of carrier landings. Since this weight is integral to the design, a USAF version would pay a twelve percent weight penalty. Historically, this penalty has been on the order of ten to fifteen percent.

In addition to the cost savings obtained from airframe commonality, development costs are further reduced by using equipment and technologies developed for the F-22.

On the other hand, Lockheed's concept gains commonality by adding approximately 2,500 pounds of lift fan and drive gear to the USAF version to provide a short takeoff and vertical landing capability for carrier operations. Since the lift fan is not integral to the structural design, the basic USAF version pays virtually no penalty for commonality. Further, STOVL is a more flexible way of operating from carriers, and it is already in routine use by the Marine Corps and the British, Spanish, and Indian navies.

Skunk Works engineers estimate that the USAF aircraft, without the lift fan, would weigh about ten percent less than the Marine variant with the lift fan. The USAF aircraft carries about 3,000 pounds of additional internal fuel in the space where the lift fan is installed in the Marine variant. The additional weight for commonality in the USAF aircraft is about 200 pounds, most of it in the fuselage structure and in the wing fold. Even this weight could be eliminated by building slightly different aircraft, but that would probably not be cost effective.

In addition to the cost savings obtained from airframe commonality, development costs are further reduced by using equipment and technologies developed for the F-22. For example, using a derivative of the F-119 engine saves several billion dollars, along with additional savings obtained by using avionics, materials, coatings, instruments, and other equipment from the F-22.

Full-size powered models of both Lockheed and McDonnell Douglas concepts will be tested at the NASA Ames Research Center next year. In 1996, one team will be chosen to build two demonstrator aircraft—a conventional USAF version and a Marine variant with the added lift fan. Current plans call for both aircraft to fly in 1999, though the conventional USAF version could fly sooner.

Planning for construction of the demonstrator aircraft, which will be referred to as the X-32, has already begun. The Skunk Works will build the demonstrator aircraft, conduct the flight test program, and initiate low rate production for an operational evaluation squadron. High rate production will be carried out at Lockheed Fort Worth Company. Thus, the company that built the P-80, SR-71, and F-117, the Air Force's first, fastest, and stealthiest jets, is teamed with the company that builds the F-16, the Air Force's best multirole fighter. Together, Team Lockheed will demonstrate the possibility of creating an affordable aircraft that can serve all three services into the twenty-first century. ❑

Rich Stadler is a freelance writer based in California.

The ARPA Solution

A Common Affordable Lightweight Fighter

The Advanced Research Projects Agency recognized the need for affordable military aircraft by creating the Common Affordable Lightweight Fighter program. Dr. William J. Scheuren, a Marine aviator with 1,000 hours in Harriers, is the program manager. Scheuren commanded the first AV-8A squadron and helped develop the requirements for the AV-8B.

What has your experience taught you about developing a new short takeoff and vertical landing aircraft? I can sum that up with *KISS:* Keep It Simple, Stupid. The main thing you need to do with a STOVL machine is not get too elaborate. Also, I understand the greatest challenge is making the transition from jet lift to wing lift. Flight controls, therefore, must be a top priority.

Although your program addresses lift fan technology, you view the Air Force airplane as the baseline. Why? That's the way I think the design needs to be approached. We are trying to come up with a common airplane to replace USAF F-16s and USMC F-18s and AV-8s. The solution cannot require the US Air Force to pay a penalty for accepting a common design. The way to go about that is to design the airplane to Air Force structural requirements and then navalize it by adding a propulsive lift system the Air Force doesn't have to carry around. We're able to take the weight out of the Air Force airplane because we're applying STOVL technology. Navalizing an aircraft for catapult launches and arresting gear landings requires a heavier overall structure.

If the basic design is the same for all services, isn't the volume for the propulsive lift system wasted in the Air Force aircraft? We take the volume for the propulsive lift system and turn it into increased fuel capacity for the Air Force, without having to resort to external tanks. This adds 3,000 to 4,000 pounds of internal fuel, increasing the combat radius by about one third.

The principal requirement for this aircraft is to keep the weight below 24,000 pounds. Why 24,000 pounds? We still buy airplanes by the pound. Airplane cost is highly correlated with size and weight. That 24,000-pound figure represents our desire for a fighter no bigger than an F-18C. We know what kind of performance you can get out of that class of aircraft.

Sure, we want top performance. But rather than create a long list of performance requirements and thresholds that may not be achievable, we're keeping it simple.

We've formulated performance as "goals to be pursued" within the constraints of a very few top-level requirements. Our simple directive is, "Build us the best damn fighter/attack airplane you can within these top-level requirements. Don't make it bigger than an F-18C. Don't make it heavier than an F-18C. And don't give us more than one motor."

Where is the program now, and where is it going? We are conducting critical technology validation. We're doing the usual things done in designing an airplane, including design tradeoffs and the usual computational fluid dynamics analyses to predict drag, lift, performance, and so on. We're doing a lot with models. We're testing inlet models to ensure proper intake performance and using the usual array of wind tunnel models to estimate drag and flying qualities.

Then we'll go a couple steps farther. We'll build and test large-scale propulsion components like lift fans, gear boxes, and clutches. Those will go into an almost full-scale model that will look much like the concept for the operational airplane. In 1995, we'll hang it on the outdoor aircraft research facility at NASA Ames, light the motor, and turn the nozzles down to see if it produces the lift we predicted. Then we'll "fly" that model in the wind tunnel.

This part of the program reduces the risk involved in building the technology demonstrator airplanes. We're helping ourselves select which industry concept has the most promise. Based on what we learn, we'll choose one contractor's proposal and build two technology demonstrator aircraft.

Why start this program now? Because of the time it takes to develop a program, and because there's a real future need. The AV-8Bs are getting real tired, and the F-16s are not going to last forever. These aircraft need something to replace them between 2005 and 2010.

If we maintain our schedule, our prototypes will fly around October 1999. But even if everything goes smoothly and we go right to EMD [engineering and manufacturing development, the program phase just before production], we won't have an operational airplane in the air until around 2005. But it may be later. The way things go in EMD, even with a streamlined effort, we might not have an operational capability before 2008. So is now too early? Not the way the system works.

Part of what this program is about is changing this system. In addition to commonality, we are stressing integrated product and process development. That way, when we field the prototype, we'll already have a solid aircraft design that we know can be manufactured affordably.

We hope to demonstrate affordablity. In addition to the prototypes, which are essentially handmade, we'll build ground test components of the operational airplane to show how few work hours it takes. We will put together an avionics architecture to show that our avionics will not break the bank.

What are the program drivers? More than anything else, this program is driven by the current fiscal environment. But it will take success in the current phase and a lot of hard work on the part of this program office, the customers, and contractors, as well as interest in Washington.

Fortunately, we have all of those things. We have an environment where the services, Congress, and the Department of Defense all recognize that the way we've been doing business just isn't going to hack it anymore. We have to come up with new and innovative approaches.

What is the relationship between the Joint Advanced Strike Technology program and your ARPA program? JAST is a Defense Department program created to identify and develop technologies for reducing the cost of performing the strike mission. The central theme expressed by JAST program director, USAF Maj. Gen. George Muellner, is the need for making airplanes more affordable. We at ARPA are investigating one of those technologies, short takeoff and vertical landing. We think the best way to control costs is to develop a joint aircraft that will provide economies of scale.

That's why Gen. Muellner and I are discussing a memorandum of understanding whereby we would pursue the ARPA effort in conjunction with JAST. In other words, the Common Affordable Lightweight Fighter would become a joint effort sponsored by ARPA and JAST.

The completion of our risk reduction phase in 1996 corresponds with the JAST decision date for selecting concepts to be developed and demonstrated. JAST could provide funding for the following phase.

How important is this program? This might be our only chance to get a next-generation lightweight fighter. I don't see another viable alternative. The Multirole Fighter didn't sell. The F-18E/F is not next generation. The F-22 is a wonderful machine, but we're not going to get many of them. And it can't do the job alone.

If we don't make the lightweight fighter affordable and common to the services, I think we won't get it either. We'll have to live with what we have—extend their service lives, apply bandaids. In the meantime, you can be sure other countries will step into the gap we've left.

If we don't get this aircraft, it could put us in a position where we no longer control the skies. Then we can't control the tempo of battle or even avoid battle through air superiority. You can't gain that advantage without modern airplanes. ❑

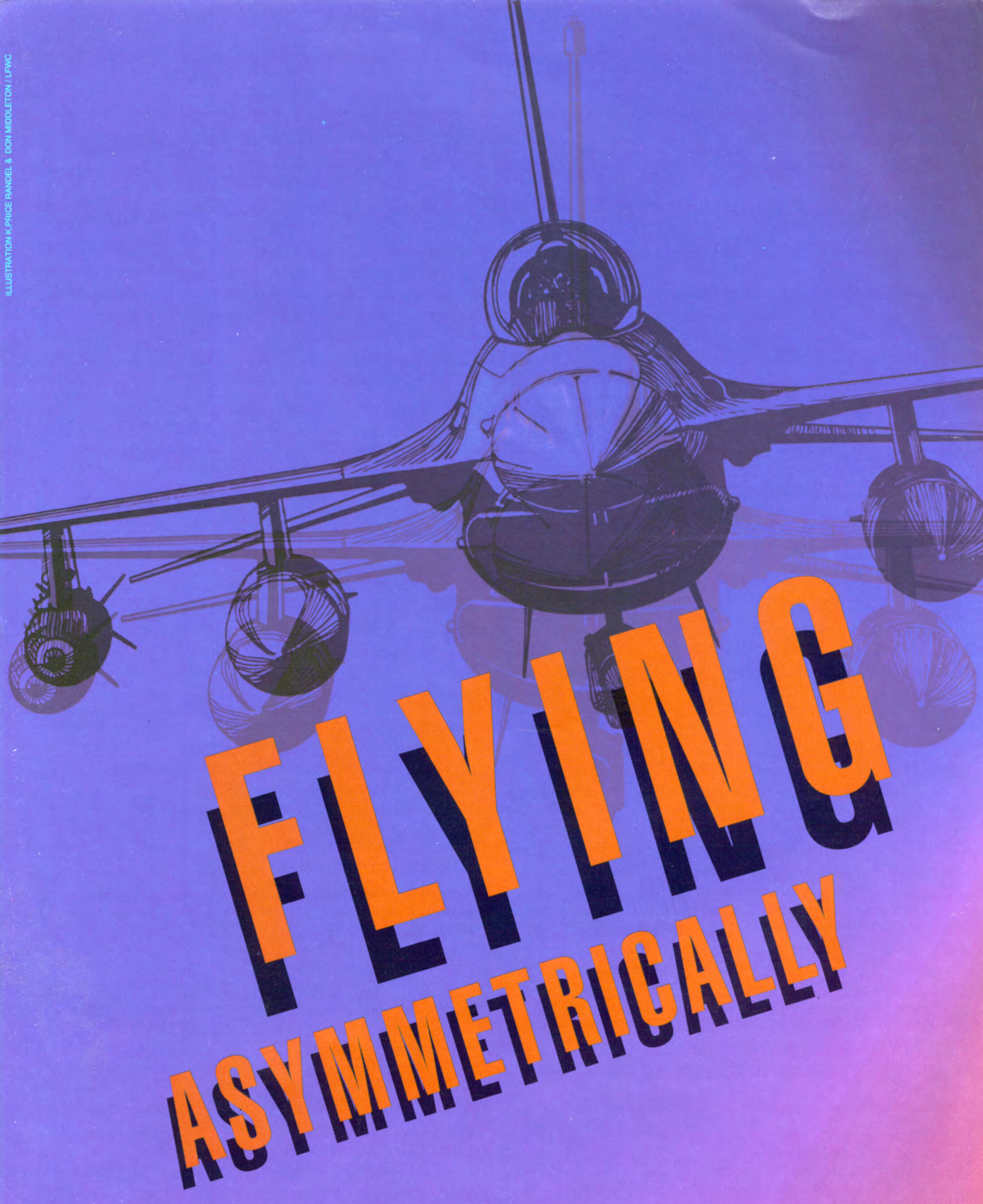
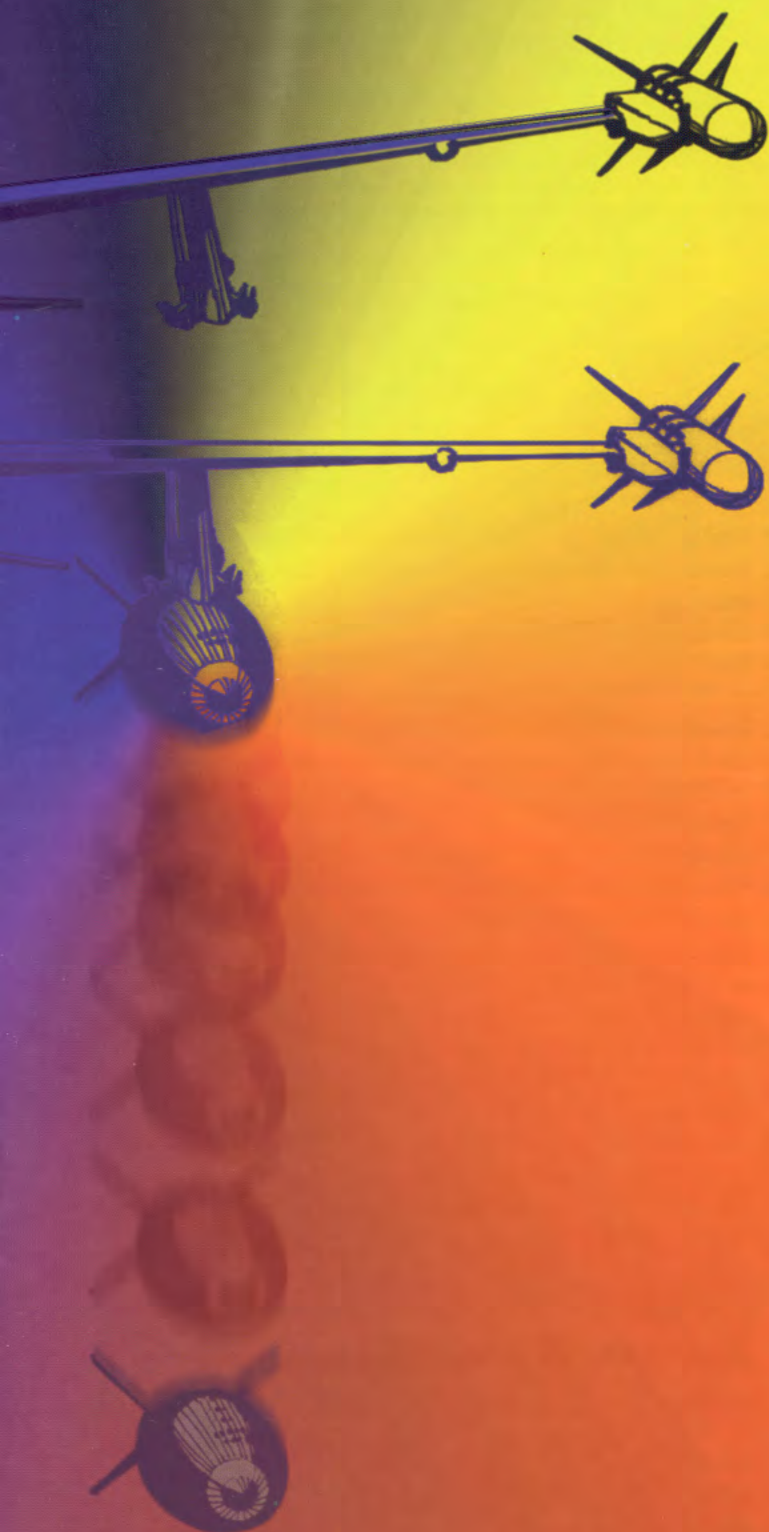


ILLUSTRATION K.PRICE RANDEL & DON MIDDLETON / LFWC

FLYING ASYMMETRICALLY



By John A. Fergione

You've just come off target after delivering a couple of 2,000-pound bombs and you're feeling pretty good. After checking your airplane, though, you notice that one of the big boys is still on board. And the stores management system is indicating that the station is in a failed state. What to do? You could try to deliver again, but it will probably result in another no-release. You could also elect to jettison the store, but discarding an expensive war reserve asset, while an option, is not mandatory. So, you're left with the prospect of bringing the bomb home. A quick mental calculation says your asymmetry is over 20,000 foot-pounds, but well inside the handbook limit of 25,020 foot-pounds. Returning to base and landing with this load safely and gracefully, however, is another story. It requires understanding some unique aspects associated with large asymmetries on the F-16.

When the airplane first becomes asymmetric, it rolls away from the station being released and yaws towards it. Releasing a weapon from the left wing, for example, results in a right roll and a left yaw. The roll can be explained easily. The wing is responding to the force generated by the explosive cartridge that slams the ejector foot down on the station to release the weapon. The yaw can be explained by the aileron-rudder interconnect, or ARI. More on that later.

To maintain wings-level flight, both wings must generate an amount of lift equal to the total weight of the airplane. At the same time, the sum of the rolling moments about the airplane's center of gravity must equal zero. To remain level, the heavy wing must generate more lift than the light one. (Your physics textbook might say the upward force generated by the heavy wing must be greater since its moment arm, as measured from the center of pressure on the wing, is shorter.) I hope you're still with me. To produce more lift and re-establish a zero roll rate, the heavy wing has to lower its flaperons.

This loading represents a 28,700 foot-pound asymmetry. Note that the heavy wing flaperon is somewhat lower than the flaperon on the light wing.

The amount of lift the wings can produce is a function of airspeed, among other things. At any given asymmetry, as airspeed decreases and air over the wings lessens, the airplane eventually reaches the flaperon trim limit. Lateral trim becomes insufficient to balance the rolling moments generated by each wing. At this point, you must apply lateral stick pressure along with full lateral trim to maintain a wings-level condition. (Note: At the handbook limit, the F-16 does not encounter this condition. In flight tests with asymmetrical loads at the F-16 Combined Test Force at Edwards AFB, we encountered this condition at 27,500 foot-pounds and 250 knots or less on final approach and near 200 knots up and away.)

Continuously applying lateral stick quickly fatigues your arm. Trimming the rudder away from the heavy wing reduces or eliminates the need for lateral stick pressure. In other words, when the left wing is heavier and you've supplied full right lateral trim and you're holding right stick, you should trim the rudder right. After trimming the airplane, you're flying somewhat sideways. But this beats the strain and distraction of forearm isometrics.

Up to this point, you've set the throttle and trimmed the airplane for the return flight home. You probably still need to turn. And any discussion on turning requires a better understanding of the aforementioned ARI.

The function of the ARI is to supply rudder inputs automatically to counter adverse yaw—a characteristic exhibited by most airplanes when you initiate a roll. Most airplanes react to a roll input by yawing away from it. So if the airplane is rolled left, it initially yaws right. In a light airplane, you compensate for left rolls by supplying left rudder to maintain balanced flight. This compensation (also known as coordinating a turn) is designed into the flight control system of most fighter aircraft. In other words, the aircraft's flight control system supplies rudder automatically as a function of lateral stick (as well as flaperon commands) to maintain balanced flight when you turn.

When the airplane initially rolls away from the station being released and you try to stop this roll with lateral stick, the ARI reacts as it would to a turn—it supplies rudder in the same direction as the stick. The overall scenario goes like this: Release bomb from Station 3 (left wing), the airplane rolls right, the pilot commands left stick, the ARI supplies left rudder in proportion to the amount of left stick, and the airplane yaws left. When the wings are back to level and roll rate is zero, you can either hold the left stick command or trim left to reset a zero roll rate. Either way, the ARI is commanding left rudder. So, in wings-level asymmetric flight, the airplane is in a sideslip away from the heavy wing if the rudder trim is neutral. You must then trim the rudder to center the balance ball and then retrim the flaperon.

Note also that the yaw away from the heavy wing upon release of a store occurs even if you don't supply roll stick to counter the roll into the heavy wing. Since hands off means roll rate commanded as a function of flaperon trim, the airplane will automatically supply flaperon to slow or stop the initial roll rate. This flaperon movement is viewed by the ARI as a requirement for rudder. The airplane, again, yaws away from the heavy wing.

What about turns? In established constant bank angle turns, g is greater than one. The lift generated by each wing increases proportionally so that the vertical components of lift summed equals the weight of the airplane (the weight of the airplane being ramp weight times g). To maintain a constant angle of bank, the moments about the center of gravity must, of course, be equal and opposite. At some point, the heavy wing flaperon reaches its mechanical limits, as g is increased. Beyond this point, i.e., pulling harder, the airplane continues to roll into the heavy wing even with full opposite flaperon supplied. To regain control, you need to relax back stick pressure. Fortunately, even at 31,250 foot-pounds at 5.5 g, we have never encountered the mechanical limitations of the flaperons. It is obvious that you need to use smooth, moderate control inputs to stay away from it.

In turns above one g, the airplane yaws away from the heavy wing with increasing g. To maintain a constant angle of bank as g increases, you must continue to increase lateral stick away from the heavy wing. With the left wing heavy, increasing g causes the airplane to roll further left. Supplying right stick stops the roll. But this additional lateral stick works through the ARI to command right rudder automatically, which makes the airplane yaw away from the heavy wing.

The more g you supply, the more lateral stick is required. And the more the sideslip you generate away from the heavy wing. Just remember, sideslip is always *away* from the heavy wing. And it gets worse with increasing g.

When you go into a turn with an asymmetry and the airplane yaws, your typical reaction to the discomforting sideforce cues generated by the yaw is to back off on the stick. You can add rudder to maintain a balanced flight condition. But most of us fighter pilots are not used to stepping on the rudder in a turn. Nor do we care to start doing this now.

A more acceptable way of countering this yaw away from the heavy wing is to add power. Adding thrust supplies a counter-yawing moment to the yaw away from the heavy wing. The ability to yaw an asymmetric airplane with the throttle, while not remarkable by any stretch, is explained by the shift in the center of gravity. Most of the time, the center of gravity stays on the airplane's longitudinal centerline. Asymmetric loadings shift the center of gravity to the heavy wing. Since the thrust axis stays on the airplane's centerline, any increase or decrease in thrust increases or decreases the rotational moment about the center of gravity. An asymmetric loading of 28,700 foot-pounds (a 2,870-pound weapon on Station 7 and no weapon on Station 3) shifts the center of gravity about fourteen inches from the longitudinal axis. Fourteen inches doesn't sound like much. But the shift is enough to force you to retrim the rudder

Remember, sideslip is always *away* from the heavy wing. And it gets worse with increasing g.

to get the balance ball back into the center every time you change throttle position.

We've used this throttle-yawing technique in turns with large asymmetries, above the Dash One limits up to 5.5g, without any problems. In fact, at 31,250 foot-pounds, at any g up to the 5.5g limit, adding power (including afterburner) significantly decreased sideslip (and increased my comfort level as well).

At this point, you know enough to handle the approach to landing with an asymmetric load. Since you have to pull the throttle to idle in the flare and since the flare is a good place to have the ball centered, I recommend dropping the gear and trimming the airplane with the throttle at idle at eleven degrees AOA *before* beginning the approach. Thereafter, leave the rudder trim constant, trim the flaperon as required, and fly the approach in a throttle-idle, rudder-trimmed condition. You should be ready to accept any sideslip during the approach when the throttle is above idle and your airspeed is higher. The sideslip on the airplane may feel a bit uncomfortable on final, but, trust me, the airplane flies just fine.

The ability to yaw an asymmetric airplane with the throttle is explained by the shift in the center of gravity.

ILLUSTRATION K.PRICE RANDEL / LFWC

If you are forced to go around, remember that adding power causes the airplane to yaw into the heavy wing. Use the rudder pedal to keep the ball centered initially. Once comfortable in the climb-out or level-out, you should note the rudder trim position before you re-trim the ball. Then trim all controls and relax while Approach Control vectors you around. Later, when you turn to final and drop the gear, move the rudder trim back to the gear-down, throttle-idle, ball-in-the-middle position that you noted when you moved the rudder trim. Retrim laterally and longitudinally.

Airspeed on final is fast. The handbook states that you should use either two degrees below the AOA where loss of roll authority is experienced or ten degrees AOA, whichever is less. At asymmetries up to 31,250 foot-pounds, roll authority is adequate at ten degrees. I recommend flying the approach at eight degrees AOA initially for a variety of reasons—the primary one being comfort level. The airplane responds and feels better with a few extra knots.

Fly the approach at eight degrees AOA, which corresponds to an airspeed around 190 knots. Fly the standard two-and-one-half-degree glideslope, but get low as you approach the runway. Your goal is to arrive at the commencement of the flare at a lower flight path angle and closer to the ground. Smoothness is the key. Avoid rapid pitch changes.

What about crosswinds? We have tested the F-16 at high asymmetries with crosswinds up to only ten knots. So, I'll provide a bit of advice for dealing with higher crosswinds: *Be very careful!* Divert to a better runway or jettison the store if you can. With crosswinds lighter than ten knots, putting the crosswind under the heavy wing is essential—even if doing so gives you a slight tailwind component. Obviously, the wing seeing the crosswinds has cleaner air flowing over it. The other wing is partially masked by the fuselage. Crosswinds under the heavy wing produces a heavy wing-up rolling moment. Your ability to hold the wings level is definitely improved with the crosswind under the heavy wing. Take my word for it, even small crosswind components under the light wing are difficult to manage.

The key to the flare and touchdown is, again, smoothness. If you aggressively pull the nose up to reduce your rate of sink and simultaneously slap the throttle to idle (as in normal operations), all the ARI and throttle effects I've discussed here will put your heart in your throat. These effects translate into a Dutch roll and nose oscillations left and right. In a flare close to the ground, these motions can be described, diplomatically, as disconcerting. If you "erred" low on the approach, as I recommend, the flare actually begins power on. Continue the flare and *slowly* reduce the throttle towards the idle stop commensurate with your rate of sink. You do not have to touch down at idle. It is more important to touch down with minimal Dutch roll oscillations and a low sink rate. Flare to arrive at the touchdown point at ten degrees.

At touchdown, the wheels spin up and the ARI cuts out, centering the rudder. The airplane will yaw, but not badly. From touchdown and during the landing rollout, however, the workload increases. This is no time to relax. You still have to stop the airplane.

If the throttle is not at idle at touchdown, *slowly* retard it to idle after touchdown. Your tendency is to establish a thirteen-degree attitude for aerobraking. *Don't do this!* Stay at ten to eleven degrees AOA. At weight on wheels, you experience a pitchup caused by the airplane transitioning from in-flight to ground gains. This transitioning occurs at main landing gear WOW. You experience this pitchup on every landing; it is just more pronounced with asymmetries. The airplane is still very responsive in pitch. As the airspeed slows, larger stick deflections are required to overcome the inertia in the pitch axis when the nose is moving up or down. Ground gains provide more horizontal tail for the same amount of stick force. Thus, in the aerobrake, with the stick constant, the horizontal tail deflection increases, giving you a pitchup of about two degrees at WOW. If you initially hold eleven degrees in the aerobrake at WOW, the pitchup puts the airplane at twelve to thirteen degrees. And that's where you want to be.

As airspeed decreases during rollout, more and more lateral stick force is required to maintain the wings level. If you're initially trying to establish thirteen degrees AOA, your reaction is to push the nose back down at pitchup. So push and add lateral stick to keep the wings level, then pull to reestablish the aerobrake, then push because the airplane is responding well, and so on. (Don't forget the lateral stick requirement between pushing and pulling.) Large control inputs are required because of pitch inertia and an aft center of gravity. After a short time, you complete more than one entire set of control sweeps. You also hit every corner. Your gains will be high—to say the least.

One potential fix to this pitchup phenomenon is to delay the transition point from in-flight to ground gains. We have evaluated a software fix for Block 40 and subsequent aircraft with digital flight controls in which we delayed the transitioning point to nose gear (instead of main gear) WOW. Sure enough, no pitchup. Workload was *significantly* reduced, as was rollout distance requirements. Unfortunately, the fix hasn't been fielded yet.

The real, no-kidding asymmetric limit of the airplane was determined to be a function of lateral stick authority vs established AOA during the rollout phase, which we learned conducting tests to 31,250 foot-pounds. Flying at this extreme asymmetry, and during aerobrake and rollout, the lateral stick required to keep the wings level at eleven degrees AOA exceeded seventy-five percent of full flaperon deflection. It would be somewhat catastrophic to need more than 100 percent of available flaperon to hold the wings level. Rather than press the issue, we elected to stop testing at this point. Any pilot ever facing an asymmetry above 31,000 foot-pounds is pretty far fetched anyway, even if the airplane is cleared to that condition. At and below the handbook limits (below 31,250 foot-pounds, actually) the airplane has more than enough control authority in every axis at or below thirteen degrees AOA.

During our test program with asymmetric loads at Edwards, we avoided the pitchup altogether by aerobraking at four to six degrees AOA. Basically, we kept the nose gear off the runway and allowed the parasitic drag of the airplane to aid in slowing down. We did this more to increase lateral stick authority than to avoid the pitchup. We had good results with this procedure, but we used it at a time when the limits were not yet established. I would not recommend this procedure within the handbook asymmetric limits. Not everyone has a 15,000-foot runway to land on.

When do you get on the brakes? As late as possible and commensurate with runway length. The weight you're trying to stop is higher and the brake energy required increases with increased application speed. Thus, the slower you are when you apply the brakes, the better. I'm continually impressed with the brake system on this airplane. In close to 2,000 hours of F-16 time and in a lot of landings, which includes a lot of landings with heavy weights and high asymmetries, I have only one set of brake fuse plugs to my credit.

The bottom line is that you can bring an expensive failed asset home, get it fixed, and deliver it again.

The Dash One states that you should aerobrake at ten to eleven degrees until 120 knots. (The only issue I take with this is that maximum aerobraking occurs at thirteen degrees, which works best when the winds are calm. With gusts, I prefer the Dash One numbers.) If your touchdown speed is in the 170-knot range, the more AOA you can achieve, the better. So lower the nose to the runway at around 120 knots, depending on runway remaining, and get on the binders with maximum effort. This works well for you every time, unless you're unlucky enough to have rain, snow, or ice. Obviously, use the departure end cable if it's available and you need it. Use a dragchute as well (if you have one and the crosswinds are low).

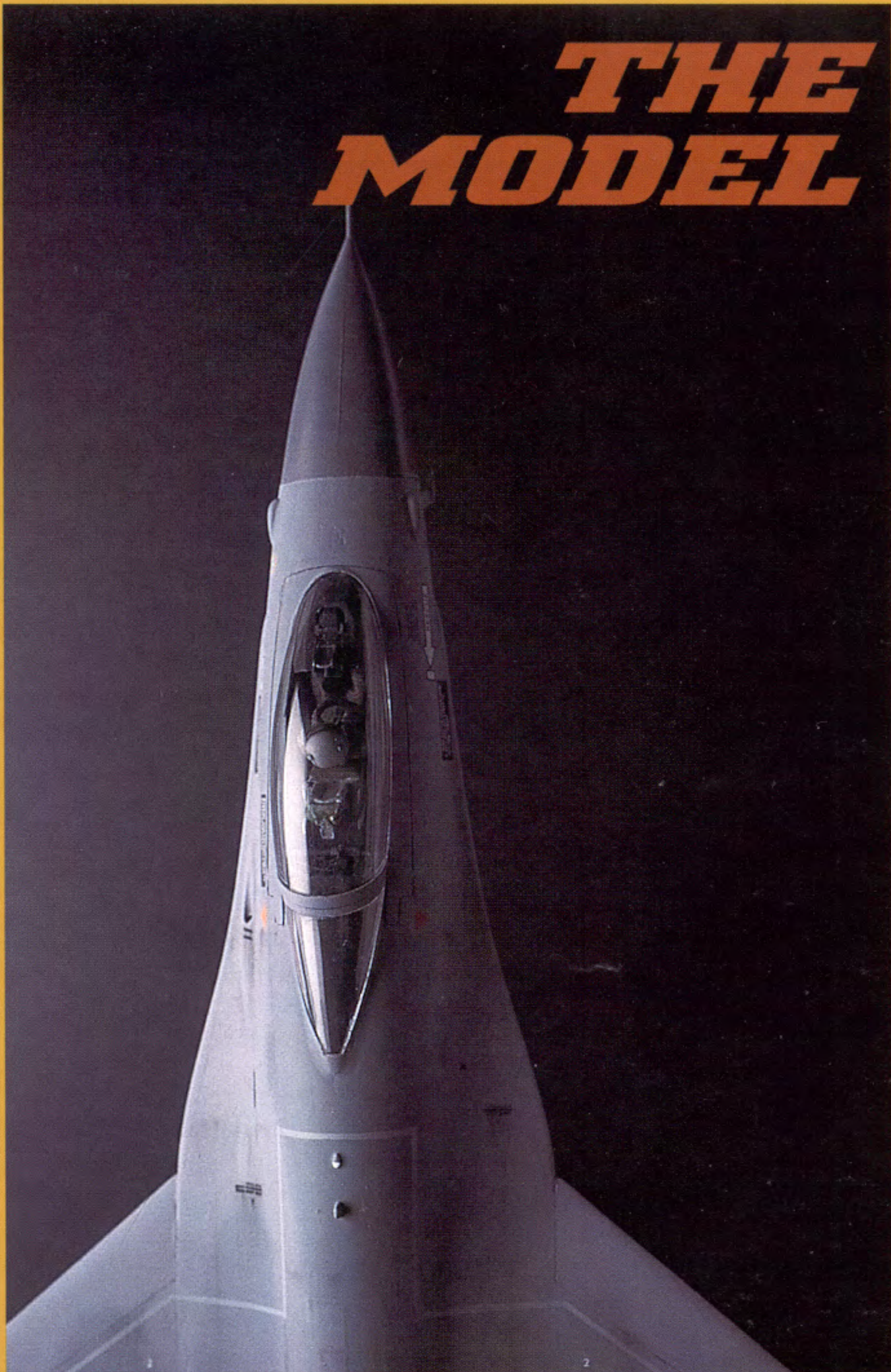
The bottom line is that you can bring an expensive failed asset home, get it fixed, and deliver it again. Successful landings begin with a good approach. Start the flare early and controlled. Don't touch down long. Aerobrake at eleven to thirteen degrees. And get on the brakes as late as possible. This strategy keeps your gains down and your wits up. Chances are you'll get only one opportunity to do this since nobody practices landings with asymmetries above 20,000 foot-pounds. When that first time comes, these tips may increase your odds for success. ❑

John Fergione is a Lockheed test pilot and site manager for Lockheed Fort Worth Company at the F-16 Combined Test Force at Edwards AFB in California.


DML
F-16C AIR COMBAT COMMAND
MIDNIGHT FALCON
GENERAL DYNAMICS F-16XL
MATCHBOX
F-16a Fighting Falcon
BALSA DISPLAY MODEL KIT
MODELBUILDING... just for the fun of it!
F16A PLUS FIGHTING FALCON
Norwegian A.F.
GENERAL DYNAMICS YF-16/CCV


GENERAL DYNAMICS F-16A
F-16XL FIGHTER
Revell
F-16C Wild Weasel
YEAGER
F16A PLUS/C FIGHTING FALCON


FORCE ONE
F-16A FIGHTING FALCON
ERTL
1/48 MODEL KIT MODELE REDUIT
GENERAL DYNAMICS F-16
ACADEMY
MONOGRAM F-16XL FIGHTER
F-16A
F-16C BLOCK 30
F-16N TOP GUN
F-16 A/B FIGHTING FALCON
MONOGRAM F-16 AIR FORCE FIGHTER
THUNDERBIRDS F-16C FIGHTING FALCON
F-16C FIGHTING FALCON
Revell SnapTite
F-16C/D Night Falcon
F 16 VIPER
F-16C NIGHT FALCON
1/48 GENERAL DYNAMICS Fighter F-16 FALCON
U.S. AIR FORCE
F-16B PLUS FIGHTING FALCON
1/48
F-16 FIGHTING FALCON ISRAEL AIRFORCE



THE MODEL F-16

Editor's Note: It's October. With department stores worldwide gearing up for the holiday season, a two-part series on F-16 model kits seems appropriate—a perfect gift for the Code One *reader who has everything, including a 9-g sled parked in his or her hangar. This first part covers the F-16 model kit market. The second part, in the next issue, will include some expert step-by-step F-16 construction tips.*

Before the US Air Force began taking deliveries of the first production models of the F-16, a Japanese firm was already pumping out Fighting Falcons for the masses—in model kit form, that is. Hasegawa's 1/72nd-scale YF-16 prototype was the first F-16 model to hit the US market (June 1976). Modeling enthusiasts applauded the kit for its attention to detail and its clean, crisp mold. Even though other manufacturers followed with their own YF-16 models, Hasegawa's initial effort is still considered to be the most accurate F-16 prototype.

As F-16s began rolling off production lines, more and more companies soared into the F-16 model market. The F-16 swiftly became one of the most (re)produced aircraft in the history of modeling, joining perennial fighter favorites like the Me-109 Messerschmitt, P-51 Mustang, and F-4 Phantom. The list of manufacturers of plastic F-16s includes AMT/Ertl (US), ARII (Japan), Academy/Minicraft (Korea), Ace (Korea), Airfix (UK), Crown (Japan), DML (Korea), Eidai (Japan), Entex (Japan), ESCI (Italy), Fujimi (Japan), Italeri (Italy), LS (Japan), Linberg (US), Lo (Taiwan), Matchbox (UK), Monogram (US), Otaki (Japan), Revell (US), Tamiya (Japan), and Testor (US).

The preceding list is a little misleading since many kits have been repackaged under more than one company name through the years as companies mixed, merged, and consolidated. Revell and Monogram, for example, combined forces in 1985. Minicraft, the original US importer for Japan's Hasegawa models, joined Korea's Academy Models in 1985 and now markets its own line of Korean-produced F-16 kits. ARII became an F-16 manufacturer when it acquired Otaki's F-16 molds after Otaki went out of business in the late 1980s. Testor's current 1/48th-scale F-16 Night Falcon is manufactured by Italeri, which markets the same model under its own name. Revell of Germany sells a 1/32nd-scale F-16XL produced from an Ace mold.

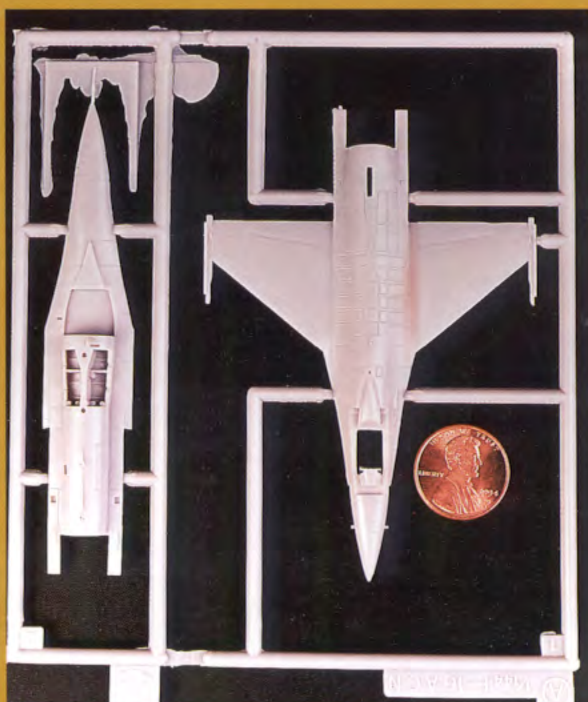
Hasegawa's original 1/72nd YF-16 model (bottom) is still available as a YF-16/CCV kit (top). The model has an accurate planform, the smaller tail and nose of the prototype as well as a Y-shaped pitot tube, split front gear doors, and blade antennas on the spine.

Today, F-16 model kits are still manufactured in a variety of scales and types by about a dozen companies. Many of the latest kits reflect various upgrades, versions, and derivatives of the F-16 as well as of the various USAF (and Navy) units and foreign air forces that fly the aircraft. Model companies account for these varieties of the F-16 in different ways. Some go to the trouble of addressing structural and payload changes by modifying or adding to their molds. Other manufacturers take more minimal, and less expensive, approaches by simply updating the box art and throwing in some new decals. What may look like a newly released model may in fact be an old kit wrapped in new box art. Builders, beware!

The first thing you'll notice upon opening a kit is packaging. Some companies go to great lengths to protect their product from scratches, wrapping individual trees (or sprues) in cellophane and packing clear plastic canopies separately. Care in packaging is a good indicator for overall quality.

Quality of the plastic itself can vary. It should be relatively dense and not too brittle, thin, or pliable. Look for clean molds and good fit between parts. Engraved or recessed panel lines are preferred over less realistic raised panel lines. These lines should be delicate and to scale. Look for detail and accuracy, especially in the cockpit controls, ejection seat, and landing gear mechanisms. Instructions should be clear and decals complete (and to your liking). Many kits offer a selection of decals. Two-part transparencies allow you to display the model with canopy open and cockpit exposed. Some kits offer canopies for both one- and two-seat models. Ordnance, fuel tanks, pods, and optional dragchute packs are other items you may want to look for.

The most popular aircraft model scale in the United States is 1/48th. Europeans and Japanese tend to favor the smaller 1/72nd scale. You can readily find F-16 models in 1/144th (tie tack) scale and in 1/32nd (foot stool) scale. (1/72nd



The 1/144th-scale F-16 model by DML is small, but accurate.

The beautifully detailed 1/12th-scale F-16A (Block 10) cockpit model by ESCI is another difficult-to-find kit. ESCI is no longer in business.

scale was popularized in the United States in 1942 when the US Navy Bureau of Aeronautics sponsored a program that encouraged school-aged children to build solid wood models of a variety of World War II aircraft in that scale. The models were used in the war effort to train soldiers and civilians in aircraft recognition.)

Aircraft model kits from Revell/Monogram and Testor are the most widely available in the United States. They're common at major discount stores with toy sections that still carry models. Revell/Monogram markets four F-16 kits, all in 1/48th scale: YF-16, F-16A with Hill AFB decals, snap-together F-16C with decals for Ramstein's 512th Fighter Squadron, and a newly released air-defense F-16. (The company discontinued its 1/32nd-scale F-16, though you can still find it.) Raised panel lines make the YF-16 and F-16A kits less appealing to detail-conscious modelers. Both of these kits are made from the same mold. The YF version is molded in white plastic; the F-16A, in gray. Because the models are produced from a common mold, the F-16A has split front gear doors and a Y-shaped pitot tube (details accurate for the YF, not for operational F-16s). Both models contain two-piece canopies and good instructions. The peel-and-stick decals and snap-together construction of the F-16C make it better suited for the beginning modeler. The snap-together model also has a one-piece canopy and recessed panel lines that are a bit thick. (The ADF F-16 was not reviewed.)

Most manufacturers split the F-16 fuselage into top and bottom halves for molding (left). Tamiya is one of the few companies that chose to split the fuselage into left and right halves (right).

Testor markets only one F-16 kit, an F-16C Night Falcon in 1/72nd scale. The kit has recessed panel lines, Spangdahlem decals (with tigershark teeth), and canopies to build a one- or two-seat version. Italeri produces the model from an older F-16A mold and adds the larger F-16C tail and some additional weapons on a new sprue. The pilotless kit contains one-piece canopies and good instructions.

Several Japanese model manufacturers are known for their accuracy and super-clean molds. Import tariffs and exchange rates, however, make these kits more expensive. And finding them will require a trip to a hobby shop. Of the Japanese manufacturers, Hasegawa maintains the largest selection of F-16 models. Their product line comprises at least twenty kits. These include four 1/32nd scale, nine 1/48th scale, and seven 1/72nd scale kits. All of Hasegawa's F-16 kits are top-notch with excellent detail, premium plastic, a selection of decals, good instructions, and exceptionally clean molds.

Japan's Fujimi markets nine kits: Thunderbirds, F-16C, F-16C/D, F-16A with Wolfpack decals (8th Fighter Wing, Kunsan), F-16B Wolfpack, F-16A with Norway decals, ADF F-16 with Puerto Rico decals, F-16N Top Gun School, and a Belgian F-16 with Tiger Meet 1991 decals. Fujimi's kits, all in 1/72nd scale, are of high quality with recessed panel lines. The F-16N Top Gun model contains decals for three Navy adversary units, a smoked one-piece canopy, and good, though generic, instructions.

Academy/Minicraft markets three F-16 models: a Thunderbird, a YF-16, and an F-16A/C. The quality of these 1/48th-scale kits is on a level with Japanese models, and they tend to be less expensive because they are manufactured in Korea. The Thunderbird and F-16A/C models are produced from the same mold (the Thunderbird is in white plastic; the F-16A/C, in a greenish gray). The Thunderbird model includes an excellent decal set. The F-16A/C contains a generous selection of ordnance. Both are single-seat only. The three-piece pilot is similar to the one found in Hasegawa models—body, head, right arm. (The YF model was not reviewed.)

DML, another Korean manufacturer, specializes in 1/144th-scale kits. The company markets six F-16s: a Thunderbird, F-16A, F-16C, F-16A NATO with a variety of decals, and a Belgian F-16 with 1991 Tiger Meet decals. The remaining two kits are multiple-aircraft kits: an Israeli F-16B vs a Syrian MiG-23 (Bekaa Valley) and a USAF F-16C vs a Soviet Su-27. DML kits are relatively simple to build, of high quality, and ideal for someone with limited desk space and small fingers.

For a modeler with an eye for detail and accuracy, no F-16 kit is perfect. Early kits often sacrificed precision and completeness for time. Manufacturers wanted to get their models to market fast when demand was high and competition low. Planform inaccuracies, misshapen drop tanks, missing panel lines, and oddball cockpits were often the result. (Even the highly acclaimed Hasegawa YF-16 kit contains a centerline fuel tank with a tail, misshapen wing tanks, some missing lines for inspection panels, and a peculiarly abbreviated countermeasures pod.) Once a mold for a particular model is cast, it tends to stay on the market for years. Mistakes are rarely, if ever, corrected.

Compensating for deficiencies and deformities, however, presents its own challenge to the modeler and creates opportunities for a thriving aftermarket business. Companies like Verlinden, True Details, and Reheat produce extremely accurate representations of ACES II ejection seats and detailed cockpit inserts for a variety of scales for company-specific model kits. Whereas mass-marketed model kits are created from injected thermoplastics, aftermarket parts are usually made from resins and etched metals—materials more amenable to smaller production runs. Other common items available as aftermarket parts include canopy kits for two-seat F-16s, conversion kits for Israeli (Peace Marble) F-16s, highly detailed afterburners, wide-mouth and seamless intakes, and a variety of weapons, pods, and tanks. Verlinden also makes detailed contents for avionic and weapon bays.

Aftermarket ejection seats come in a variety of scales.

Several companies offer aftermarket decal sets for the F-16.

This aftermarket kit contains items for converting a 1/48th-scale F-16 to an Israeli Peace Marble F-16. The kit, originally produced by David Buttress, is now marketed by Airwaves in 1/48th and 1/72nd scale.

This full-scale model of an F-16 sidestick controller by Trophy Models of Belgium is now out of production.

Some aftermarket kits can cost more than the model itself. A Peace Marble 1/48th-scale conversion kit by Airwaves costs about forty dollars in the United States. An accurate ACES II seat in 1/48th scale will set you back about five dollars. A seamless wide-mouth intake, ten dollars. Add the cost for replacing the tablecloth you just sliced with the hobby knife and you're talking major money.

Specialized decal sets are the most popular aftermarket item. Aeromaster, Expert's Choice, Repli-Scale, and Superscale International all market decals for the F-16. With over twenty sheets for a variety of scales of the Fighting Falcon, Superscale offers the biggest selection. Decals cost about five dollars per sheet. Each sheet may contain decals to cover markings for two or three different units.

Model builders scrambled to buy Hasegawa's Egg-16 when it appeared in the mid-1980s.

Several companies have offered specialty models related to the F-16 through the years. Trophy Models of Belgium marketed a full-scale sidestick controller (older style). ESCI made a very nice 1/12th-scale F-16A cockpit. Hasegawa sold one of the more unusual F-16 models—an egg-shaped "Midnight Falcon" F-16. The amusing model, often referred to as an *Egg-16*, is one of a series of egg-shaped aircraft. The series traces its roots to a modeling fad started in Japan in the mid-1980s. Japanese modelers used egg-shaped hosiery containers for the fuselages for a wide variety of aircraft models. The Midnight Falcon is no longer produced by Hasegawa and, like other specialty models, very hard to find.

F-16XL models are also rare. LS, which recently went out of business, made an accurate 1/144th version. Monogram produced a 1/72nd-scale F-16XL. And Ace had a 1/32nd version, which has been picked up by Revell of Germany. The Monogram and Ace models require some extensive modifications to make them accurate representations of the XL.

The 1/144th-scale F-16XL by LS has an accurate planform, but is now very difficult to find.

The F-16 model market probably peaked in the mid- to late 1980s. Today's aircraft modeling industry is focused on World War II, applying the latest production techniques to long-popular propeller-driven aircraft. Few companies have released any jet aircraft models in the last three years; most are new releases of previously classified Soviet (now Russian) aircraft. Still, no need to worry. A big and steady supply of quality F-16 model kits can be found at your local hobby shop. They're just waiting to be built and ready to fill the vast expanses of shelf space worldwide. ❑

Eric Hehs

Code One *offers a special thanks to Jim Barr of LFWC, Tom Copeland of Aerofax, Inc., and Jeff Kurth in Minnesota for their help with the research and box tops for this article.*

By Jay Miller

Photography by
Katsuhiko Tokunaga

Latest From Sukhoi

Su-35

Sitting on the tarmac at Zhukovsky flight test center, Sukhoi's latest and greatest fighter, the stunning Su-35, gives every impression of a coiled snake. Cocked and prepared to strike at the slightest warning, it hunkers down—poised on its rough-field landing gear, nose low, peering forward through the single off-set eye of its infrared search-and-track ball.

The Su-35 mixes modern technique and technology with a strong dose of Russian mechanical pragmatism.

Su-35

The Su-35 is viewed as the most potent threat facing Western military air forces today. It is a superb combat aircraft, mixing modern technique and technology with a strong dose of Russian mechanical pragmatism.

Sukhoi and the Russian government promote the Su-35 as the chosen champion of non-westernized air forces. They explore export sales opportunities around every international corner. To date, however, no foreign air force has bought the airplane, primarily because it is too expensive and is backed by only the goodwill of a slowly disintegrating government. Without significant financial and trade offsets, the aircraft has little chance of realizing any legitimate international military sales.

Sukhoi has built seven Su-35s; six have flown. None represent fully operational or production configurations. Each has served as a system, structural, or a performance testbed. The airplanes have been continuously modified since the first aircraft (initially referred to as the Su-27M) arrived at Zhukovsky in 1985.

Cockpit configurations have varied from aircraft to aircraft. Multifunction display screens, for instance, virtually standardized in arrangement and presentation symbology in the United States, have been installed in what appears to be random order to accommodate ever-changing combat requirements and ill-defined ergonomic specifications. Even more surprising, the screens are mostly monochromatic. Russia lags the West in color screen technology.

The Su-35 has a digital quadruplex fly-by-wire flight control system comparable to the latest Western aircraft. The airplane, otherwise, is an amalgam of other components and materials that can trace their origins back thirty years. Incorporating older, proven technology and materials, however, is no flaw. Rather, it is an exercise in utilitarianism. For Russian designers, usefulness outweighs the Western propensity for sophistication and complexity.

Aerodynamically, the Su-35 represents little in the way of advanced thinking. It is, however, highly maneuverable and surprisingly agile for its size. Roll, pitch, and instantaneous turn rates throughout most of its sustained 9-g envelope are comparable to Western fighters, though it reportedly requires exceptional physical exertion to maneuver through extensive aerobatics.

Designers made little attempt to lower the Su-35's radar cross-section, which is considerable. Composites have been used sparingly in its construction. The airplanes have no indication of internal structural or external surface materials to reduce radar return. Attempts to blend surfaces have been made only to accommodate aerodynamic requirements.

The Su-35's cockpit contains a large head-up display and a number of multifunction display screens.

The aircraft can carry an electronic countermeasures suite in wingtip-mounted pods (a relatively new development). The pods have been seen on only a few occasions. Russian pilots who have used the system have commented on its limited dependability.

The Su-35's air-to-air radar (it also has an air-to-ground capability) is sophisticated for a Russian unit. Sukhoi claims the radar can track up to fifteen targets simultaneously while engaging any six at ranges of up to 225 miles. Few observers of Russian aircraft truly believe these last figures. But the numbers remain a concern for military strategists.

Sukhoi Design Bureau chief Mikhail Simonov has alluded to a small aft-facing radar mounted in the extreme rear end of the fuselage sting, but no such system has been seen on any of the flightworthy Su-35s currently undergoing test. Aft-facing radar could serve any of several purposes, including early warning of rear attack or active guidance for aft-facing air-to-air weapons.

The Su-35's external finish is substandard. To Western eyes, it appears very rough. Panels are ill-fitting and often dented. Many parts, such as the massive glass-fiber radome, appear to be poorly manufactured. But they work. And they are easier and less expensive to manufacture than more refined Western hardware. Production processes are simplified whenever and wherever possible in Russia to accommodate the skills of the personnel assembling the aircraft. While the finish on the Su-35 is not comparable to that of Western aircraft, such refinement makes very little difference operationally. This construction latitude simplifies the production process and lessens the burden of field repairs during battle.

Su-35

The Su-35 can carry an extraordinary complement of weapons, including a conventional cannon, air-to-air missiles, air-to-surface missiles, anti-ship missiles, air-to-surface rockets, conventional iron bombs, laser-guided bombs, and, most likely, tactical nuclear weapons.

Russian designs for military hardware have always been influenced by the lessons learned during World War II. Equipment must be able to function in extraordinarily harsh climactic and field conditions. The Su-35 is no exception. It is designed to operate from virtually any imaginable unprepared surface—hard dirt, mud, snow, or ice. High-flotation tires, extremely rugged gear struts, mud guards on the nose wheels, independent self-contained main gear disk brake cooling fans, and nose wheel brakes all represent weight and system complexity concessions that would never be acceptable to any other country.

The Su-35 has an extraordinary complement of weapons, including a conventional cannon, air-to-air missiles, air-to-surface missiles, anti-ship missiles, air-to-surface rockets, conventional iron bombs, laser-guided bombs, and, most likely, tactical nuclear weapons. The airplane has at least twelve different stores stations.

This diversity, though impressive, is complex. Each weapon requires a different set of aiming equations (and, sometimes, systems), a different set of launch parameters, special mounting considerations, and calculations that affect aircraft performance. Each weapon also requires separate and totally independent production lines and logistical support systems. As a crowning touch to complexity, the Su-35 can carry a UPAZ inflight refueling "buddy" pod and probably a centerline reconnaissance pod.

The Su-35 is powered by two NPO *Saturn* powerplants, each rated at over 29,000 pounds thrust in afterburner. These exceptionally powerful turbofans appear to be miserly fuel consumers. They permit the Su-35 to accomplish all its missions with internal fuel only. The aircraft, in fact, is not known to be capable of mounting or using external fuel tanks. Internal fuel capacity has been stretched to the limit by installing tanks in the aircraft's vertical fins. Ferry range of the Su-35 is in excess of 2,500 miles without auxiliary fuel of any kind. The airplane is inflight refuelable.

Few observers question the impressive performance of the Su-35. Whether it will ever become a threat to Western combat aircraft is another question. Sukhoi and its director, Simonov, will rarely argue to the contrary. ❑

Jay Miller, a Texas-based aviation writer, is working on a history of Sukhoi.

OCTOBER Events

Around the World

PAINTING BOB CUNNINGHAM

Singapore Selects F-16

The Republic of Singapore announced in July that it will purchase eighteen F-16C/Ds for its air force. The F-16 competed against the F-18 for the purchase. Singapore officials cited cost, capability, and upgrade prospects as the main reasons for choosing the F-16.

PHOTO NICK ALVARADO / LFWC

Lockheed Test Pilot Honored In Berlin

Lockheed's Bland Smith was recognized for best presentation in the fighter category at the ILA '94 Air Show in Berlin. Smith, a senior experimental test pilot, flew a USAF Block 50 F-16C at the show. Other airplanes in the category included the Mirage 2000, MiG-29, Su-27, Su-30, and Su-35.

PHOTO GARY TOLBERT

Israel Receives Pre-Owned F-16s

A total of thirty-five F-16s are expected to be delivered to Israel by the end of 1994. The F-16s are part of fifty aircraft the United States is presenting as a gift for Israel's cooperation in the Mideast peace process. Half of the F-16s are excess to Guard and Reserve units; the rest are coming out of storage from Davis-Monthan AFB near Tucson, Arizona. The aircraft have an average flying time of 3,200 hours. The promise of these airplanes is considered a chief reason why Israel chose the F-15E over the F-16 earlier this year.

PHOTOS THEO VAN GEFFEN / IAAP
DICK PAWLOSKI / LFWC

F-16s At Maple Flag

The annual Maple Flag exercises at Canada's Cold Lake Weapons Range in Alberta are designed to give aircrews realistic training in a modern simulated air combat environment. The exercises promote initiative, leadership, and self-discipline in the air. The most recent exercise, Maple Flag XXVII, was the largest to date. Over 1,500 personnel and ninety aircraft deployed to Canada. Forces from the United States, Canada, England, Germany, and the Netherlands attended. This was the first year for Germany to attend. Last year was the first year for the Royal Netherlands Air Force to participate. Dutch F-16 units participating this year included the 315th Squadron from Twenthe AB, the 322nd Squadron from Leeuwarden, and the 306th from Volkel. USAF F-16 units came from the 414th TS at Nellis AFB, Nevada; 906th FG from Wright-Patterson AFB, Ohio; 119th FG from Fargo, North Dakota; 419th FW from Hill AFB, Utah; 114th FG from Sioux Falls, South Dakota; and the 192nd FG from Richmond, Virginia. Other aircraft participating included the F-15A, F-15C, F-15E, B-1B, C-141, UH-1 (Iroquois helicopter), C-130, E-3 as well as German Tornados and British Jaguars.

At Home

Deutch Flies F-16 With 389th FS

John Deutch, deputy secretary of defense, took to the skies in August in an F-16 Block 52D assigned to the 389th Fighter Squadron at Mountain Home AFB in Idaho. The purpose of the flight was to gain a first-hand appreciation for operations of large-scale composite strike forces. Deutch's aircraft was one of a strike force package of thirty aircraft. The 2.3-hour flight included aerial refueling, low-altitude ingress (and egress) through a fighter air defense zone, afterburner climb, and a thirty-degree high-altitude bomb delivery.

120th FG Wins Maintenance Effectiveness Award

Code One offers a hearty congratulations to the Montana Air National Guard's 120th Aircraft Maintenance Squadron for winning the USAF's Maintenance Effectiveness Award for 1993. The annual award recognizes outstanding maintenance units. This was the first time in five years that a maintenance unit from the Air National Guard won the award. During a year with an impressive number of extensive deployments, the 120th generated 5,085 flying hours and 3,812 sorties with their F-16s, while maintaining a fully mission capable rate of 83.4 percent.

PHOTO SSGT. ROSE BENNETT / USAF

F-16/MATV Program Receives Awards

Congratulations are due for the flight test team for the multi-axis thrust-vectoring F-16. The team won the Society of Flight Test Engineers' Kelly Johnson Award for outstanding achievements in the field of flight test engineering and the Bernard P. Randolph Engineering Award from the Air Force Material Command. The USAF's Lt. Gen. Bobby Bonds Memorial Aviator Award for outstanding contribution to the flight test mission while performing aerial duties went to Maj. Mike Gerzanics, the principal USAF test pilot for the program.

Thunderbirds Meet Safety Dog

While making their appearance at the 1994 United States Air and Trade Show at Dayton International Airport, members of the USAF Thunderbird team met with Safety Dog. The canine is the official mascot of an antidrug and safety program for children. The program is administered by the Adjutant General's office of the Ohio National Guard. The 178th Fighter Group, based in Springfield, Ohio, came up with the idea for Safety Dog. The mascot makes public appearances with his K-9D aircraft (not shown). Over 800 children shook Safety Dog's paw during the two-day air show.

419th FW Establishes Record F-16 Flight

Four seasoned USAF Reserve pilots from the 419th Fighter Wing got together in July to establish a record for cumulative flying hours for pilots on one mission. The mark to beat is 10,000 hours. Maj. Mike Brill (3,219 hours), Maj. Mike Krzynowek (2,554 hours), Maj. Richard Turner (2,195 hours), and Maj. Robert Bartlett (2,124 hours) are members of the 419th's 466th Squadron. Brill, the first American pilot to log more than 3,000 hours in the F-16 and currently the only active pilot in the world with more than 3,000 F-16 hours, had this to say after the flight: "Not only does this mission show the combat readiness of the pilots, it also points out the excellence of our maintenance crews and the F-16. We could never have flown all these hours without having an F-16 ready to go every time we were scheduled to fly."

PHOTO TSGT. NEIL WERCORSKJOLD / USAF

Majors Richard Turner, Robert Bartlett, Michael Krzynowek, and Michael Brill (from left to right) celebrate their record-setting flight.

PHOTO TOM ARBOGAST / LFWC

Carswell's 457th Celebrates Fifty Years of Flying

The 457th Fighter Squadron of the USAF Reserves, across the runway from Lockheed Fort Worth Company, celebrates fifty years of operation in October. The original 457th was assigned to Hawaii in 1944 and moved its P-51 Mustangs to Iwo Jima in 1945 to join in the war against Japan. The squadron began flying F-105 Thunderchiefs at Carswell in 1972. In 1981, the 457th transitioned to the F-4 Phantom and to the F-16 Fighting Falcon in 1991. The special tail markings on the anniversary F-16 are dedicated to the nine pilots killed in the squadron's first year of operation.

PHOTO SGT. MARTIN HAMILTON / USAF

F-16 Operational With HARM Targeting System

The US Air Force recently declared initial operational capability with the AN/ASQ-213 targeting system on the F-16. The system, enclosed in a small pod that attaches to the right inlet hardpoint, searches for and tracks threat radar emitters and cues the AGM-88 HARM missile prior to launch. The F-16 has been operational with the High-Speed Antiradiation Missile since 1989 and served as an additional shooter in the F-4G/F-16 hunter/killer teams when performing the mission of suppression of enemy air defenses (known as SEAD). The targeting system allows the F-16 to operate independently of the F-4G Wild Weasel, which is scheduled to retire later this decade. Texas Instruments builds the targeting system and missile. Lockheed Fort Worth Company integrated the systems into the Block 50 F-16C/D aircraft. F-16s assigned to the 20th Fighter Wing at Shaw AFB in South Carolina and the 432nd Fighter Wing at Misawa AB in Japan will be the first units operating the new system.

CODE ONE LETTERS

Chameleon F-16

I was skimming through the July issue of *Code One* and came upon the photo of the delta formation of A model F-16s on page 11. Flying in the slot position is aircraft No. 81-0679. The tail number caught my eye because I had been assigned to this aircraft during the 1990 show season with the USAF Thunderbirds. Closer observation of the photo revealed other familiar tail numbers, all from the Thunderbirds. Obviously, I had not read the story yet. The text of "The Best of Both Worlds" confirmed my initial observations.

Your readers might be interested to know that this is not the first time F-16 No. 81-0679 (what I called Thunderbird No. 2) has been painted combat gray. During the 1988 training season, the Thunderbirds were tasked with converting one of their aircraft from a demo jet to a combat jet complete with full armament in less than seventy-two hours. (The combat capability of the

demo team's jets is not public relations hype.) The combat-ready conversion was accomplished in only *forty-eight* hours. After returning from dropping its ordnance and firing the gun, some Thunderbird personnel inscribed "Warbird" into the carbon residue in front of the gun blister.

When this aircraft left the team, it was painted combat gray. It returned during the 1990 training season and was once more transformed into a Thunderbird demo jet. Now it's back at Luke AFB with the 425th Fighter Squadron and in combat gray again.

Three cheers to the only F-16 that has been painted in the Thunderbird colors and in combat gray twice.

TSgt. Mark L. Thome
Air Force Technical Advisor
182nd FG/ANG
Peoria, Illinois

Aardvark Upgrades

The 27th Fighter Wing Operations Group Commander shacked the target when he said the F-111s "have an extremely important role in serving the national interests... when it comes to using military power" ("Aardvarks, Consolidated," July 1994).

The accomplishments of three decades of Aardvark aircrews allow that statement to ring as true today as it would have during Linebacker II, the Mayaguez, El Dorado Canyon, the Cold War, or during Desert Storm. Unfortunately, our senior decision makers are going to allow this national asset to die. By not funding the Stores Management System program or needed engine modifications, the jets will lose their versatility and their cost-benefit tradeoff. For the cost of only five or six F-15Es, an entire wing of highly capable, proven warbirds will disappear.

Maj. Patrick M. Shaw
Fighter Test & Engineering Branch
Sacramento Air Logistics Center
Sacramento, California

Thanks From The 425th

Thank you for the flattering article about the 425th Fighter Squadron in the July issue of *Code One*. We've just returned from four weeks at Nellis AFB where we participated at Red Flag. The deployment was a huge success and allowed our Singapore allies to take part in some valuable training. As before, our outstanding maintainers made sure all our aircraft left Luke together, flew well at Nellis, and returned ready for duty. Our 100 percent deployment record stands unbroken.

Singapore has just announced its purchase of F-16C/D aircraft, so we face new challenges on the horizon. Our pilots are ready to get their hands on some new iron.

Thanks again for a great publication. The arrival of the latest *Code One* always causes excitement around here.

Lt. Col. Michael Hauser
Commander, 425th FS
Luke AFB, Arizona

A-12 Not Forgotten

As a flight test instrumentation engineer who worked on the A-12 program, I was very impressed with the photos of the A-12 that appeared in the July issue of *Code One*. The A-12 program was my first major assignment after starting work for General Dynamics. I spent three years on the program, from proposal work through cancelation. Since the mock-up is about the only piece of evidence left of the program, these photographs mean a great deal to me.

John Ecklund
Fort Worth, Texas

A-12 Not Forgotten, Again

The photo of the A-12 mock-up shown in the July issue of *Code One* brought back a lot of memories for me, both good and not so good. The way the program was canceled left those of us who put several years into the A-12 little tangible evidence of our effort. As a member of the A-12 flight test team, I certainly appreciate the fact that the mock-up will eventually go on public display.

James E. Smith
Fort Worth, Texas

One Big Family

Thank you for the January and April issues of *Code One*. My colleagues and I especially enjoyed the article about NASA flight research (April 1994), as it reflects a lot of the stuff we at the National Aerospace Laboratory are involved with, too. We tend to forget how big the F-16 family actually is when our day-to-day work focuses on only the tail on the fifth row, fifth column of your excellent finflash poster in the January issue. So please keep sending *Code One*. My colleagues at the flight test department and I look forward to upcoming issues.

Arun K. Karwal
Engineering Test Pilot
National Aerospace Laboratory
Amsterdam, The Netherlands

Aviano Additions

This letter will acknowledge, with thanks, receipt of the excellent *Code One* July 1994 issue, which, as usual, I enjoy reading so much for its very up-to-date and informative articles and outstanding photographs. I was impressed with the news of the Venezuelan Air Force recognition of Joe Bill Dryden and delighted with the interesting articles.

I would like to add some information to the article "Activation Aviano." The 401st Fighter Wing transferred to Aviano from Torrejón Air Base in Spain in 1992, replacing the 40th Support Wing, which had been the host US unit since 1966. Torrejón Air Base assumed some of the functions previously performed from French bases after the withdrawal of US forces from France in 1966. At the time, Torrejón was the principal fighter and transport base on NATO's southern flank.

José M. Bryan
Aviation Writer
Alice, Texas

F-16 As Fine Art

I'm pleased to have the opportunity to receive *Code One.* This is the first time I've been exposed to your publication. I'm impressed with the photos, design, and articles.

As the president of the American Society of Aviation Artists, representing 140 artist members, it is easy to say we would like to see more art used in your publication.

The photo on the back of the April issue is pure delight. It should be a painting. The color, mood, and speed captured cross over into the world of fine art.

Paul E. Rendel
President ASAA
Pittsburgh, Pennsylvania

Editor's note: A front view of the first flight of the F-16 prototype was beautifully illustrated by Price Randel in the July 1992 issue of Code One (page 20).

Paintings From Pakistan

I am a student and work as a freelance aviation artist when not going to school. Having attained some copies of your magazine from my cousin who is in our air force, I have to say I haven't seen such an excellent magazine in my life. The articles, layout, and illustrations are beautiful. The photographs are magnificent. Being a long-time fan of the F-16, I haven't seen such rare angles of the airplane in any other magazine. They help me a lot with my paintings.

Enclosed is a photo of one of my F-16 paintings to give you an idea of my work and of my love for this airplane. I love your magazine. I really mean it.

Adnan Siraj
Rawalpindi
Pakistan

Loyal Bahraini Reader

I received your magazine often during my several years while assigned to the Staff 1 Maintenance & Supply, Bahrain Amiri Air Force, Bahrain Defense Force. *Code One* offered so much in the world of flying that it made me a satisfied reader. Your publication remains an invaluable source of information and indeed one of the finest magazines in aerospace.

Lt. Col. Khalifa Ali Al-Khalifa
Defense Attache
Embassy of the State of Bahrain
Washington, DC

On Display

On behalf of our museum, I want to thank you for *Code One* Magazine. As educators, we need to keep up with developments and changing technology in the industry, and your magazine goes a long way in helping us do this. The photos are excellent. We especially like the inserts because they make great display material.

Kirsten Oftedahl
Collections Manager
Pima Air and Space Museum
Tucson, Arizona

Off The Back Burner

We recently received several issues of your magazine. Our cadets love it. I remember reading *Code One* when I was teaching AFJROTC back in Florida and planned to see if we could be placed on your mailing list then. Unfortunately, that letter got put on the back burner.

Thanks for all your support of the AFJROTC program. We appreciate it even if we don't say it very often.

David J. Weissgerber
Aerospace Science Instructor
Kadena High School
South Korea

Top-Draw Fighter

Your magazine was a pleasant surprise in my mail. I enjoy its informative nature and the crispness of its overall design. The photos and illustrations are top draw and a tribute to an equally top-draw fighter.

A. Michael Leahy
Hampstead, North Carolina

Swedish Subscriptions

As part of our electronic warfare equipment testing team, I had the opportunity to visit Lockheed Fort Worth Company. While there, I came across a copy of your excellent magazine, which now everybody here seems to be fighting for. We visit your AFEWS [Air Force Electronic Warfare Evaluation Simulator] and infrared-testing laboratories regularly (although maybe not quarterly) as Swedish government representatives. To serve as a prestige builder at work as well as a way of satisfying our need for well-written aerospace articles (with extremely good photos), we would very much like to subscribe to the magazine.

Torbjörn Gudinge
Swedish Defence Materiel Adm.
Test Range Linköping
Sweden

Jumbo Fighter

I became aware of your publication a couple of years ago and became very interested in the late Joe Bill Dryden's articles and writing style. Add me to the list of those who will miss him.

As you know, there are two types of aircraft—fighters and targets. I don't fly fighters any more. But I do fly the largest target. I have the pleasure of flying the B-747 Flying Test Bed aircraft with the GE-90 series engine. We have been to 88,000 pounds thrust on wing. More is planned.

Now if we could build a *fighter* around the 123-inch fan, we might really have something!

Carroll Beeler
Engineering Test Pilot
GE Aircraft Engines
Mojave, California

In South Africa

Many thanks for *Code One.* It is indeed a first-class publication. And now that the prospect of more contact with the United States looks promising, I look forward to receiving it regularly.

Keith King
Denlyn Test Consultants
Lynwood Ridge
South Africa

We'd like to hear from you. Send letters to:
Editor, *Code One* Magazine
Lockheed Fort Worth Company
PO Box 748, Mail Zone 1793
Fort Worth, Texas 76101

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