

Blended Wing UAV

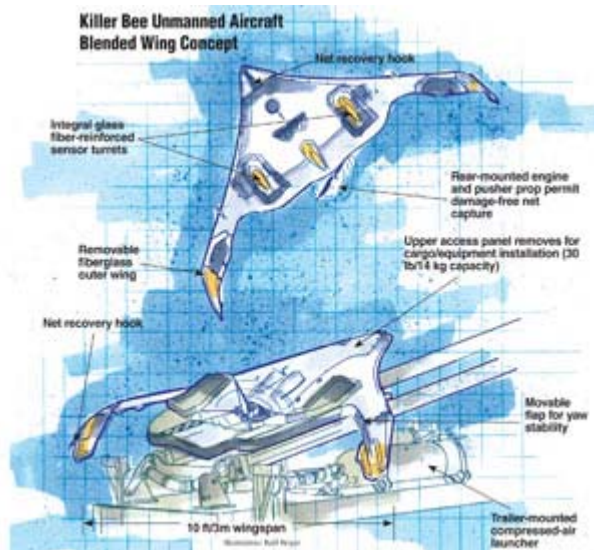
Unique unmanned craft's robust composite design a plus for rough duty.

By Staff | [May 2007](#)

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The booming unmanned aerial vehicle (UAV) market continues to expand with hundreds of designs competing for military and civilian contract dollars worldwide. While UAV wingspans range from commercial airliner size down to palm-sized micro flyers, small long-endurance "tactical" UAVs, those that support intelligence, surveillance and reconnaissance (ISR), are becoming key components of military and homeland security missions. One of the more innovative tactical UAVs on the market is the compact (10-ft/3m wingspan) "blended wing" Killer Bee Unmanned Aircraft (KB-UA) produced by Swift Engineering Inc. (San Clemente, Calif.).

Swift, founded in 1983, is well known among automotive enthusiasts for its winning open-wheel race car chassis designs and composite components. But, says Larry Reding, Swift's Killer Bee program manager, the company wanted to diversify. "Our car-racing legacy and staff skills gave us solid experience that we were able to apply to other markets."



Mark Page, the company's chief scientist and aerospace designer, together with aerospace engineer Matt McCue, developed the KB-UA. The current model, KB-UA-4, builds on previous experimental prototypes that first flew in 2003. Although a marketing partner relationship with Northrop Grumman Corp. (El Segundo, Calif.) ended several months ago, Swift continues to develop the KB-UA-4, says Page. "We've developed an inexpensive way to make a rugged UAV, and we think there's a market for it." Fusing the fuselage with the wings Page, who once worked at NASA and is the company's expert on blended wing concepts, claims that Swift was the first to develop a blended wing UAV, which is similar to but subtly different from the "flying wing," a design that has existed since the early days of aviation. A flying wing has no separate fuselage and is made up only of wing structure. Several flying wing variants have flown successfully, including Nazi Germany's Horten Ho-229, Northrop's YB-49 and probably the

best-known example, the B-2 Spirit bomber developed by Northrop Grumman in the late 1980s. The KB-UA differs in that it has a distinct fuselage, which is flattened to form an aerodynamic airfoil. Its aft-swept wings merge smoothly with the fuselage body to form a tail-less, arrowhead-like shape with slender, downturned outer wings. NASA is considering a similar blended wing design for future large cargo aircraft (see photo at right). While flight stability can be tricky minus a traditional tail, with its moveable control surfaces, Swift has addressed this by incorporating movable flaps at the back of the craft's outer wings, whose droop assists in yaw stability.

Swift adopted the concept for the KB-UA for several reasons. First, merging the wings and fuselage into a single airfoil significantly reduces aerodynamic drag, improving fuel economy. Second, KB-UA is considered a "thick" airfoil when compared to traditional thin-skinned, fragile flat wings, says McCue, giving it better structural efficiency: "The aircraft's thicker airfoil and triangular shape means less material is needed to achieve required airframe stiffness as compared to a traditional rib-and-spar wing design, which saves material and manufacturing cost," he explains. It makes the craft inherently rugged and much less susceptible to damage.

McCue also notes that the design maximizes the aircraft's volume-to-wingspan ratio, allowing a disproportionately large payload capacity — comparable to UAVs with a 30 to 50 percent larger wingspan — in a compact package. For example, the ScanEagle UAV, built by The Insitu Group (Bingen, Wash.) in partnership with The Boeing Co., Seattle, Wash. (see end note), is a small, traditional tube-and-wing design now in military service with a 10 ft/3m wingspan that carries about 7 lb/3 kg of equipment in combat missions. By contrast, he says, the KB-UA, with the same wingspan, has a 30-lb/14-kg payload capacity. Design for rough duty

For the Killer Bee, the Swift team had to meet several key project objectives: a manageable system for launch and recovery in the field; a lightweight airframe to maximize the aircraft's long-term loiter capabilities in day or night operations; and structural durability to withstand extreme environments. McCue and Page used a suite of software to optimize the KB-UA's shape, aerodynamics and composite structure. SolidWorks 3-D CAD software (SolidWorks, Concord, Mass.) helped define the craft's initial shape, while NEiNastran, supplied by Noran Engineering Inc. (Westminster, Calif.), was used to size and develop the airframe structure and laminate schedule to meet anticipated loads.



NASA's blended wing body (BWB) for large civil and military cargo craft has been under consideration since 2000. A 1/10th scale remotely controlled concept built by The Boeing Co., dubbed the X-48B, was scheduled for a test flight in April at Edwards Air Force Base (NASA is partnered with The Boeing Co. and the Air Force Research Laboratory). The concept continues to generate interest because its shape would mean 20 percent less fuel consumption than today's tube-and-wing aircraft. The wingspan would be comparable to a Boeing 747 and could operate at existing aircraft terminals. It would also weigh less and generate less

noise. The NASA study will determine flight and handling characteristics and how propulsion systems would be integrated.

In contrast to other tactical UAVs, Swift's operates without a runway. The KB-UA is launched via a trailer-mounted, compressed air-powered catapult and is retrieved with a net deployed from the trailer, enabling operation anywhere that a truck and trailer can travel, an advantage the military calls "organic" capability. The aircraft's small, two-cylinder, 100-cc gasoline-powered engine sits at the rear of the craft with a pusher propeller, which simplifies retrieval with the net. The craft is fitted with primary net hooks on its nose and secondary hooks on the ends of its winglets (see middle photo, p. 80) that provide for "three-point recovery" to ensure that the craft does not tumble out of the net and incur damage. Its autonomous control system doesn't require a ground pilot, and the craft can be maneuvered easily via a joystick. (Multiple aircraft can be controlled using a single controller.)

For this launch/recovery scenario, the team considered flight loads (launch and propulsion thrust, lift, drag, wind gusts, net-recovery loads), mass inertial forces (produced by payload equipment and the fuel load) and ground forces — the inevitable abuse incurred during handling. Reding says that between 15 and 20 "strenuous" load cases were developed, incorporating launch and recovery accelerations/decelerations of 15 Gs and safety factors ranging from 1.3 to 3. To facilitate handling and shipping, the downturned outer wings are removable via reusable screw-type metallic fasteners. "We adopted a spiral design approach — when the model showed that stresses were too high on areas of the airframe, like the outer wing joints, we adjusted the layup and added plies, then reran the FEA analysis."

To minimize weight yet obtain the highest strength and stiffness for sustained operations, the airframe was designed with carbon/epoxy composites, using a combination of cored and solid laminates made from unidirectional and plain-weave prepregs. Total laminate thickness varies from as little as 0.030 inch to 0.100 inch (0.75 mm to 2.5 mm) depending on location. Ply buildups are added along the leading edges of the wings and fuselage nose, for example, for added strength.

The optimized airframe permits the KB-UA to loiter over a target for up to 24 hours at low altitudes of around 3,000 ft/914m or as many as 15 hours at higher elevations, says the company. When its fuel is spent, the KB-UA automatically flies back to its launch site for capture in the net.

A triangular spar, resembling a billiards rack about 3 ft/1m on a side, provides the primary structure for the main fuselage/wing body. Made from phenolic honeycomb-cored sandwich panels with unidirectional carbon/epoxy prepreg skins, the spar creates a large interior area for a payload, which can include cameras, radar equipment, ordnance or other cargo. Fuselage and wing skins, leading edges, trailing edges and the outer wings are solid laminates. A large access panel on the craft's upper fuselage skin allows easy loading and unloading of cargo and equipment. Like the outer wings, the access panel is attached with removable metallic fasteners.

Two bulbous sensor “turrets” that protrude from the aircraft’s underbelly house the cameras and sensors. Reding notes that the turrets, which must be made of fiberglass to permit electromagnetic transparency, were designed as integral parts of the airframe rather than as removable components requiring separate layup and cure. “We devised a lamination plan that transitions from the primary carbon/epoxy used for the airframe to the fiberglass of the turrets or radomes, with overlap plies and ply drops, so that everything can be fabricated and cocured in one tool.” Flight operations can occur from daylight hours into night because one turret can be equipped with a visible light sensor and the other with an infrared sensor, a big plus for potential customers. Reding says that the detachable outer wings, which are solid fiberglass laminates, can be fabricated with embedded sensors to function as antennae or radomes.



Source: Swift Engineering

This view of the underside of the Killer Bee shows the two integral fiberglass turrets or radomes, cocured with the rest of the structure.

“We’ve tried to create a system that is very functional and modular for field operation — wings, engines, fasteners are line-replaceable,” states Reding.

The flat triangular shape of the craft, with few complex curves or shapes, means that fabrication is straightforward. Tooling for the KB-UA was designed in-house with an eye toward simplifying layup and minimizing secondary bonding and finishing operations as much as possible. While some of the tools are steel, most are composite, built using carbon/epoxy tooling prepreg from Airtech International Inc. (Huntington Beach, Calif.).



Source: Swift Engineering

A Killer Bee, ready for launch on a compressed-air-powered launcher. Net recovery hooks can be seen at the tips of the downturned fiberglass outer wings.

The standard- and intermediate-modulus prepregs for the airframe layup are supplied by Advanced Composites Group (ACG, Tulsa, Okla.) and Ten Cate Advanced Composites USA (formerly Bryte Technologies Inc., Morgan Hill, Calif.). McCue notes that an automated ply cutter from Gerber Technology Inc. (Tolland, Conn.) helps reduce production time by nesting and precutting prepreg plies. Wherever possible, he adds, subassemblies are cocured in the same tools, thereby minimizing postcure assembly and finishing. Shape of things to come? KB-UA-3, the previous prototype, was successfully demonstrated to the U.S. Air Force in mid-2006 at Creech Air Force Base in Nevada. Now the company is competing against many others to win a joint U.S. Navy/U.S. Marine Corps Small Tactical UAS/Tier II unmanned aircraft system contract, which would place UAVs in service by 2010. Reding says the current KB-UA-4 model has flown successfully and is ready to enter production. Several hundred could be built on the existing tooling at a rate of two or three per day.



Source: Swift Engineering

A Killer Bee approaches the recovery net. The pusher propeller arrangement ensures that the propeller and engine aren't damaged during recovery.

“The Killer Bee is strong and robust enough that it could be dropped from a moving aircraft,” notes Reding. One defense writer predicts swarms of small UAVs like the KB-UA may be used to overwhelm an enemy’s defenses. Swift’s entry in this rapidly evolving market is a game-changing design.