The shape began with a lump of clay at Disneyland—and led to stealth advances that live on in the B-2 and the F-22.

The (Tacit) Blue Whale

By Peter Grier

As ungainly as a platypus, Tacit Blue nonetheless made 135 test flights and proved that curvilinear surfaces were valuable in foiling radar.

IN THE late 1970s, the California headquarters for Northrop's advanced projects division was filled with pictures of whales. There were whale paintings in the lobby, whale drawings on letterheads, and whale logos stamped on all kinds of company equipment. Northrop employees sometimes referred to each other as "whalers." Top managers had models of whales on their desks.

Visitors often wondered about the meaning of all these images. Their inquiries were gently rebuffed. "It was something you couldn't talk about," remembered John Cashen, a top Northrop engineer at the time. "People would ask, and we'd say, 'Well, the whale is a noble animal.'"

In fact, the pictures symbolized a classified Air Force effort to build a

Burying the engines deep in the fuselage—one of the advances incorporated into the B-2—helped the Whale thwart detection. Note the single inlet near the center of the fuselage.

stealthy, long-range, radar surveillance aircraft. In official parlance, the secret project was known as "Tacit Blue," but to those who designed, built, and flew it, the unusual aircraft's fat, boxy profile earned it a lasting and affectionate nickname: "The Whale."

The Whale never made it into production. Northrop built only one complete Tacit Blue aircraft, which the Air Force used for 135 test flights between 1982 and 1985. After the last flight, the airplane was stored and spent a decade hidden at a classified facility before Defense Department officials revealed its existence this spring.

Tacit Blue's real contribution was as a technology test-bed. It was one of the most successful high-tech demonstrator programs ever funded, according to the Air Force.

Extraordinary Advances

The flights it undertook led to crucial advances in low-observable (LO) and radar technologies. For instance, its curved surfaces live on in the shape of the Air Force's B-2 stealth bomber. Certain aspects of its ultrasophisticated intercept radar helped lead to the powerful electronic "eyes" on today's E-8 Joint Surveillance and Target Attack Radar System (Joint STARS) aircraft, among other systems. The now-defunct Triservice Standoff Attack Missile (TSSAM) was basically a small Tacit Blue turned upside down.

"This program has provided the Air Force and the nation with extraordinary advances," said Arthur L. Money, assistant secretary of the Air Force for Acquisition, at an April briefing. "This technology continues to protect our men and women in uniform, now and for years to come."

The Tacit Blue/Whale story began in the late 1970s. At the time, the Defense Advanced Research Projects Agency (DARPA) was just beginning to understand the implications of a new technology called "stealth" that promised to greatly reduce the radar return of airborne aircraft. DARPA officials asked Northrop (now Northrop Grumman) the fundamental question: Could this new stealth approach be used to develop a reconnaissance aircraft that could operate safely in orbits near enemy defenses?

If so, such an aircraft might prove to be a valuable adjunct to another project that was then just beginning—the long-range, long-endurance, radar platform known as Joint STARS. The E-8 Joint STARS aircraft could concentrate on the forward line of battle, while the stealthy airplane could move further forward and look deeper into an adversary's second echelon.

The task of meeting this requirement was a challenge. In essence, DARPA was asking Northrop if it would be possible to design an invisible airplane that could carry an undetectable radar. It was one of the first times that engineers working in the stealth area had faced the need to take their theoretical knowledge of radar reduction and apply it in the real world, to a specific weapon system problem.

The Tacit Blue program actually had started in 1978 as part of an overall secret Air Force effort called Pave Mover. Northrop worked under a sole-source, $136 million contract. In time, test and support expenses pushed the total Whale cost to $165 million.

When they sat down to sketch out preliminary airframes, Northrop engineers realized they were facing some daunting design problems.

For one thing, they found that the radar reduction needs of a surveillance aircraft were turning out to be far more demanding than those of a bomber or strike fighter. The latter two types of aircraft generally fly straight toward targets and defending radars and then turn and fly away. The theory behind their designs was to minimize the radar returns of their front and rear views. Tacit Blue's concept of operations, however, called for it to loiter behind enemy lines while flying in circles. It would be exposed to detection devices operating on all sides and thus required an all-aspect stealth design.

The Box That Flew

In addition, the Tacit Blue mission required it to carry a large, highly capable radar. The task of shoehorning the radar's big antenna into a relatively small aircraft, while making the antenna's field of view large enough, turned out to be the most difficult technical challenge the airplane's designers faced. "Integrating the antenna created the boxy nature of the body," said Mr. Cashen, who shared principal design authority with Northrop's Steve Smith. "The rest of the design was driven around trying to get this box to fly and to make it all-aspect [stealthy]."

At first, the design team considered using faceted surfaces on the airplane's exterior. The Have Blue strike fighter demonstrator was in development at the same time as Tacit Blue, and it was reducing radar signatures by using these surfaces, as can be seen in the program's final

product, today's F-117 Nighthawk aircraft.

The Whale team could not get the faceted approach to work for its aircraft, so it tried something else—curvilinear, or Gaussian, surfaces to redistribute a radar beam's electrical energy. The result was a sort of whale with wings—a long box with a sloping back, curved belly, and shovel nose. The design worked, making the Whale at least as radar-resistant as the developing Have Blue/F-117 aircraft.

The Whale's radar cross section (RCS) was "below that of a bat, somewhere down in that area," joked Lt. Gen. George K. Muellner, now principal deputy assistant secretary of the Air Force for Acquisition, at Tacit Blue's unveiling. "I haven't looked at the RCS of a bee recently."

The perfection of the Gaussian approach to stealth was the most important breakthrough of the Tacit Blue program and was one of the most important developments in defense technology of the post–World War II era. "The B-2 exploits it, as does the F-22 [USAF's next-generation air-superiority fighter] and a lot of other vehicles," said General Muellner, who commanded the Air Force's 6513th Test Squadron during Tacit Blue's first flight tests. Because this approach to stealth was applied on these other platforms, Tacit Blue "never went operational."

Photos by Nate Leong

Blending the curved top and bottom surfaces proved to be a thorny problem for Northrop's engineers—one they solved without regard for traditional aircraft designs. Their solution gave rise to many unusual shapes around the aircraft.

The designers saved the state-of-the-art stuff for the outside of the aircraft and its radar. The roomy cockpit contained mostly off-the-shelf technology, including the standard ACES II ejection seat.

The breakthrough did not come easily. The blend of precisely curved surfaces is a difficult exercise in geometry—particularly at an airframe's ends.

Tacit Blue's nose is a case in point. During the design phase, the engineer working on the forward fuselage had trouble with the shape of the cockpit area. The top was supposed to be flat and the sides inclined at fifteen degrees. Meanwhile, the whole thing had to flow smoothly into the nose's projecting, shovel-like chines.

Out of Disneyland

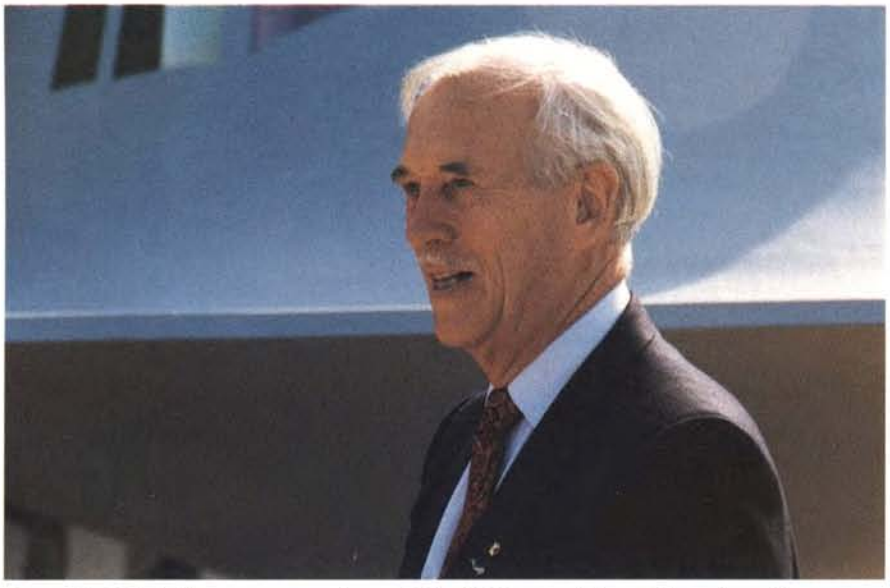
All of the designs produced by the engineer, Fred O'Sheara, caused unacceptable radar reflections to the side. Then one day, he was sitting on a bench at Disneyland, waiting while his children stood in line for a ride. He had a lump of modeling clay in his pocket and started playing with it to idle away the time. He put it in his fist and squeezed—and produced a shape that he thought might work. The next day, the shop foreman took the clay and sculpted a model nose that eventually became not only the front of Tacit Blue but the base shape for the B-2 cockpit area.

Some of the old Tacit Blue team still have plaster casts of that lump of clay, as a reminder of the days when they were working on a cutting-edge program they thought might make history.

Of Mr. O'Sheara's breakthrough, Mr. Cashen recalled, "The shape had been running around in his head, and he couldn't do anything but mold it. It was a very complex geometry."

In the early 1980s, Northrop workers at the Hawthorne, Calif., plant produced a 30,000-pound Tacit Blue test-bed, plus a second airframe shell as a backup. The single-seat airplane had some radar-absorbing composites on its surface but was largely aluminum and was built with the standard fabrication technology of the time. The airplane was about fifty-six feet long. Its wingspan was just under fifty feet.

Photo by Tony Sacketos



Test pilot Dick Thomas, seen here at the 1996 unveiling of the aircraft, was so keyed up on the eve of the Whale's first flight that he needed two beers and a strenuous game of one-on-one basketball in order to get to sleep.

Northrop's use of off-the-shelf parts helped cut the Whale's construction costs. For landing gear, the firm used stock F-5E units. The ejection seat was a McDonnell Douglas ACES II. Power came from twin Garrett ATF3-6 turbofans similar to those used on small Falcon 20 aircraft. The Whale's engines were buried in the airframe to reduce infrared signature. Much as a whale breathes through its blowhole, the engines breathed through a single engine inlet set flush with the top, an approach that worked well enough in flight but sometimes led to difficulties in starting the aircraft.

According to General Muellner, the Whale was "designed to operate up in the medium altitudes—25,000 to thirty-plus thousand feet—and at the relatively slow speed of 250 knots."

The airplane was purely a reconnaissance design, with no thought given to equipping it with weapons. The side-looking radar on the aircraft was a Hughes model optimized for ground surveillance and a low probability of intercept (LPI). Capable of detecting moving targets, the radar was supposed to give Tacit Blue the ability to spot enemy ground formations operating deep behind the battlefield.

Unlike Joint STARS, Tacit Blue wasn't outfitted to carry operators capable of running the radar on board. Its concept of operations called for the radar to be run by a ground station in line-of-sight contact with the airborne aircraft, similar to how today's unmanned aerial vehicles operate.

Designed for stealth and radar capacity, it was one test-bed that was not going to win any aerobatics contests. Unstable in both pitch and yaw, it depended on a quadruple-redundant, General Electric fly-by-wire control system for safety. It was, after all, the Whale.

If a model of Tacit Blue was balanced on its point of gravity and placed in a wind tunnel, it would weathervane around until it was pointing tail first into the onrushing wind. The airplane's nose did not have to be pulled up very much before the whole thing would threaten to flip over.

"You're talking about an aircraft that at the time was arguably the most unstable aircraft man had ever flown," said Mr. Cashen.

Knowledge of these handling characteristics only added to test pilot Dick Thomas's tension on the night before Tacit Blue's first flight in early February 1982. He and other key members of the development team were waiting out the hours in a bar near a classified airfield somewhere in the desert of the American West. Two beers did not make Mr. Thomas any less keyed up, so he and Mr. Cashen went to a sports complex next to the bar and played one-on-one basketball until they both dropped.

"It was kind of absurd, two guys in their forties just going at it," remembers Mr. Cashen. "The idea was just that Dick would get loose, so he'd get some sleep."

The next day, Mr. Cashen stood on the edge of the runway as a tired and sore test pilot made a successful first flight.

Despite its cumbersome handling, the Tacit Blue test-bed flew safely throughout its 135 missions and a total of around 250 hours in the air. The average Whale flight lasted about two and a half hours.

Early in the program, it became clear that a production phase was, in

Photo by Tony Sacketos

From any angle, the aircraft looks odd. That's because, unlike fighters and bombers, the fifty-foot-long Tacit Blue had to be stealthy from every angle—not just front and back.

fact, unlikely. Whatever its merits as a technology demonstrator, the Whale encountered several factors that weakened its promise as a weapon system and eventually proved fatal to Northrop's full-rate production hopes.

First, Tacit Blue's intended mission meant that it probably would have to be invisible to more than radar. To avoid visual detection, stealth bombers and fighters operate at night, but a reconnaissance airplane would have to do much of its work in the daytime, when real-time information can be of more use to ground forces. The large Tacit Blue airframe was visible from the ground and would likely have required fighter protection if it stayed airborne behind enemy lines during daylight hours.

Second, it became clear that Joint STARS, with its large twenty-nine-foot-long antenna and superior depth of view, could perform much of Tacit Blue's mission by itself. Compounding the problem for the Whale was that Joint STARS cost less, had longer endurance, was air refuelable, and could scan a wider area.

"The [Tacit Blue] program turned into a test-bed because its low-observable technologies proved to be more valuable than its [mission] contribution," said General Muellner.

Learning From the Whale

These LO characteristics involved the airplane's radar as well as its shape, said General Muellner. Technicians from Hughes and DARPA used Tacit Blue test flights to increase their knowledge of such radar-cloaking techniques as the use of low-power signals and the spreading of signals around the spectrum. These methods, and others, are intended to fool an enemy into believing that the transmissions he detects are simply blips in electronic background noise.

The Joint STARS multimode radar does not need such LPI techniques. It achieves survivability by standing off behind the front lines, with the combat power of US fighters between it and danger.

Photo by Tony Sackelos

The Whale is now on display at the US Air Force Museum, Wright-Patterson AFB, Ohio. Though it never went operational, the technologies developed and perfected by the program continue to define today's aircraft.

Other modern US aircraft do make use of Tacit Blue–pioneered LPI. "Obviously, the B-2 has exploited that technology," said General Muellner.

Northrop engineers never really designed a Whale production version, which likely would have had a larger tail than the test version and would have featured more of a mid-wing design. Nor did they get around to integrating planned electronic eavesdropping equipment into Tacit Blue, which would have allowed it to perform some of the electronic intelligence functions now carried out by USAF's RC-135 Rivet Joint aircraft.

The Air Force will not say exactly where it kept the Tacit Blue prototype during the past eleven years or from which airfield or airfields the airplane flew. All that is publicly known is that it was shut up in a storage building, along with all its program files, until its existence was declassified this spring, following an eight-month review process.

For years, some hinted privately that the Air Force had produced a more stealthy Joint STARS aircraft. Officials admit that ordinary citizens may have spotted Tacit Blue during its open-air testing, as it flew exclusively during the day—normal for developmental testing. Overall, however, the program seems to have been a secret the Defense Department kept well for almost two decades.

Officials say the airplane program was declassified because there was no longer any need to keep its technology secret. Of the weapon systems that drew most heavily on its advances, the B-2 bomber is now operational and in public view. The TSSAM, designed by the same Northrop team and looking so much like Tacit Blue that some called it "The Killer Whale," has been canceled. Northrop's YF-23 Advanced Tactical Fighter prototype, which shared Tacit Blue's butterfly tail and buried engine outlet, lost the next-generation fighter competition to the Lockheed (now Lockheed Martin) F-22.

"The taxpayers invested money in it, and we're trying to declassify things," said General Muellner.

Meanwhile, the original Whale has been put on display at the US Air Force Museum at Wright-Patterson AFB, Ohio. Despite the fact that only one was built, the program's semi-retired co-leader maintains that Tacit Blue still is the project he remembers most fondly.

"It was the first," says Mr. Cashen, who went on to a leading role in the B-2 stealth project. "It was pioneering work. Every day was a discovery." ■

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