Northrop Grumman photo

Eleven 2,000-pound JDAMS fall from a B-2, which actually can carry 16. The stealth bomber can carry up to 80 of the 500-pound variety.

The J

Precise, versatile, and relatively cheap, the Joint Direct Attack Munition today is a mainstay Air Force weapon system. Twenty years ago, it was something else entirely: a science project that was running out of time.

The Air Force Armament Laboratory had been studying a possible new inertial guidance system for bombs since the early 1980s. The USAF scientists had produced some demos—add-on tail kits that looked much like JDAM does now—and scored good results in test drops.

But it was still the years of the Cold War. Air Force tactics still emphasized low-level penetration of Soviet-developed air defenses. Service leaders were not looking for a high-altitude, all-weather, near-precision guided weapon.

"There was not a whole lot of interest in it, frankly," remembers Louis Cerrato, chief engineer of the JDAM Squadron at Eglin AFB, Fla., who has worked on the weapon since its earliest days.

Then, in the space of a few years, the world changed.

The capability and availability of Global Positioning System data exploded, making GPS a reliable and constant source of bombing coordinates. The 1991 Gulf War showed that flying high was the best way to fight post-Cold War adversaries. Operation Desert Storm also showed the Air Force that it needed more than just laser guidance alone, as bad weather or

JDAM Revolution

The low-cost, highly accurate Joint Direct Attack Munition has revolutionized bombing in just a few short years.

By Peter Grier

sand and dust storms could foil laser designators.

The new inertial guidance weapon was chosen as an acquisition reform pilot program, giving it flexibility and independence. The program that eventually became JDAM was rushed into development and production.

The Joint Direct Attack Munition is a combination of "dumb" bomb and a set of add-ons, a low-cost guidance kit that converts free-falling bombs into guided weapons. The kit's major parts are a tail section, which contains an inertial navigation system and Global Positioning System equipment, and body strakes that provide extra stability and lift.

Desert Storm was the crucial turning point in JDAM's fortunes, even though the Air Force had been working on the idea for years.

Of the approximately 250,000 munitions dropped by US aircraft in the first Gulf War, some 210,000 were "dumb" iron bombs. The lack of accuracy of these unguided gravity bombs proved a problem. In the first two weeks of fighting, results fell far below projected rates—in part because of poor weather but also because of poor aim.

A postwar analysis showed that unguided munitions fell only within about 200 feet of their intended targets, on the average.

Laser guided weapons were far more effective. They accounted for 75 percent of the destruction wrought by US attacks. But laser guided bombs were expensive and could be used only in good weather. Not all US airplanes could carry them.

Clearly, the US needed a low-cost precision alternative. In May 1991, Gen. Merrill A. McPeak, then Air Force Chief of Staff, wrote a memo stating "a requirement for an all-weather precision guided munition."

That was where JDAM came in. In 1992, a demonstration strike using a 1,000-pound bomb steered by inertial guidance and GPS data was a complete success. Initial development contracts were awarded in 1994.

An Acquisition Success

Cost was a big issue, as the flush years of the Reagan-era defense buildup were long gone. McPeak insisted that the Air Force would not buy this new weapon if its cost rose one penny beyond the $40,000 per-unit estimate of the JDAM program manager.

But the new program had one big thing going for it: Congress had selected it to be a test of acquisition reform. This allowed JDAM managers to waive some costly and burdensome regulations for the competing contractors.

Companies would not have to hand over extensive pricing data demanded on most other contracts, for instance. They could use some off-the-shelf parts, instead of relying only on military-specification components.

Eventually, the initial seven competitors were whittled down to two: Martin Marietta (subsequently merged into Lockheed Martin) and McDonnell Douglas (later absorbed by Boeing). The technology was fairly simple, so this battle would be won by the firm that could produce JDAM kits at the lowest price.

McDonnell Douglas decided, in essence, to act as if it had already won. "They spent their time actually doing the design for manufacture," said Cerrato.

The St. Louis-based firm brought in JDAM suppliers and promised them long-term contracts in return for low costs. Over 18 months, estimated unit cost was cut in half.

In September 1995, the Air Force tapped McDonnell Douglas as its JDAM producer. The final unit cost was $18,000—less than half the $40,000 ceiling set by McPeak. (As of January, Boeing had delivered 145,000 JDAM tail kits to the US military. The current production rate is around 3,000 per month.)

In March 1999, NATO launched Operation Allied Force in the Balkans. Its goal was to force Yugoslav President Slobodan Milosevic to halt his attacks on ethnic Albanians in the province of Kosovo.

For the Air Force, operations in this foggy corner of Europe were difficult. During the first two months of combat, the weather was so poor that airplanes could mount strikes against fielded forces only about one-quarter of the

USAF photo by SSgt. Jessica Kochman

The GBU-31 JDAM consists of a bomb body, taken from inventory, a tail kit guidance section, and a set of strakes that help it maintain a precise aim angle. The near-precision weapon has changed the calculus of air attack.

time. Many fixed-structure targets were in urban areas, where collateral damage was a big concern. USAF needed an all-weather, precision guided weapon.

At this point, JDAM production was just starting. There had also been rocky patches along the way—flimsy tail fins had been redesigned, for instance. Some Air Force officials were concerned that JDAM's fiberglass shipping and storage crates were too fragile.

B-2s Over Kosovo

The B-52 and F/A-18 were to be the first airplanes to carry JDAMs. But Pentagon officials decided that the B-2, then going through operational tests to develop non-nuclear capabilities, would be the best choice. The B-2 stealth bomber, based at Whiteman AFB, Mo., was designed to deliver nuclear weapons against heavily defended targets in the Soviet Union, and it needed a non-nuclear weapons enhancement. JDAM was the answer.

"All these things came together at the right time," said Cerrato. "We had some test [JDAM kits] here at Eglin, and they actually said, 'No, no, you've got to send them to Whiteman.'"

At Whiteman, 2,000-pound JDAMs were loaded into the stealth bombers, 16 at a time. Then the B-2s flew combat missions to Kosovo and back—a 30-hour round-trip. (See "With Stealth in the Balkans," October 1999, p. 22.)

These missions destroyed high-value targets such as an oil refinery wedged in among civilian buildings, but JDAMs were used in other ways as well, ways that the program office had not anticipated.

For instance, one mission took out the Zezeljev Bridge, which spanned the Danube River at Novi Sad.

"We didn't expect [the weapon] to be used against bridges," said Cerrato, but "the pinpoint accuracy amazed all of us."

After-action reports showed that 98 percent of the 652 JDAMs used in the campaign hit their targets.

Accuracy can't make up for bad intelligence data. During OAF, B-2s severely damaged the Chinese Embassy in Belgrade, hitting it with five JDAMs. The bombs had been steered to coordinates that mission planners mistakenly thought located an arms agency.

Still, JDAMs proved so useful that they were rapidly used up. During the Balkan air war, "they used almost the whole first lot," said Cerrato.

Going Winchester

In the middle of the conflict, Gen. Richard E. Hawley, head of Air Combat Command at the time, went so far as to warn that it was "really touch and go as to whether we will go Winchester [run out of] on JDAMs before we get the next delivery."

As Allied Force drew toward a successful close, Pentagon officials announced that JDAM production would soon be tripled.

The Air Force continues to refine JDAM kits. The bombs are more accurate than they used to be, in part because GPS signals are more accurate and in part because GPS receivers have improved.

"It is really [the accuracy of] the source of the target coordinate that is the limiting factor now," said Cerrato.

Antijam capability has been added. Saddam Hussein actually deployed jammers intended to disrupt the system, though they ended up being of little use.

US forces expended some 6,500 JDAMs during Operation Iraqi Freedom, hitting a wide variety of targets. (See "Precision: The Next Generation," November 2003, p. 44.) For instance, in fierce fighting against insurgents for

AP/USAF photo

This is a test JDAM about to ruin the hulk of an A-6 Intruder. JDAM operates by inertial measurement, coupled with updates from the Global Positioning System. The result is a bomb that routinely hits within 10 feet of the aim point.

NATO photo

JDAMs were widely used during Operation Allied Force in 1999. These images illustrate how a single aircraft with JDAMs dropped a span over the Danube River.

control of the cities of Fallujah and Ramadi, Marine F/A-18s made extensive use of a variant of the 500-pound JDAM that minimizes collateral damage. The marines hit buildings, barriers, and even roadblocks with JDAMs.

Earlier, in Afghanistan, loitering US aircraft stocked with JDAMs proved highly effective in attacking the Taliban ground forces that chose to stand and fight rather than melt away into the bleak landscape.

In fact, JDAMs were in such demand in Afghanistan that, by mid-December 2001, following nine weeks of air strikes, the US Air Force had dropped 5,000 of them, using up about half the inventory. Boeing's facility in St. Charles, Mo., had to go to three shifts to rebuild JDAM stocks.

The rest is history. The Air Force has now used nearly 20,000 JDAMs, which are prized for their cost-effectiveness. Virtually all US warplanes can carry them.

Currently, the guidance kit is available in variants that fit everything from the 2,000-pound Mk 84 down to the 500-pound Mk 82. The new 250-pound Small Diameter Bomb itself draws on JDAM concepts for its guidance system.

A JDAM can be launched as much as 15 miles distant from its target, in any weather. Once released, the inertial navigation system takes over, autonomously steering the bomb toward pre-entered coordinates. Location information beamed down from GPS satellites updates and corrects the course of the weapon.

By itself, the INS system can steer a JDAM within 100 feet of a target at least half the time. With the help of GPS, this circular error probable is reduced to about 40 feet, and the weapons often land a single bomb-length away from their target.

JDAMs can be launched from high or low altitude. They can be released from a dive or level flight or be tossed from a climbing aircraft. Future versions of the weapon might have wings, for extended range. The addition of wings would extend JDAM range by 300 to 400 percent, adds Cerrato.

More Firsts

JDAM keeps scoring firsts. For instance, last May a B-1B for the first time dropped a JDAM in combat, hitting a Taliban compound near Kandahar, Afghanistan, with a 500-pound GBU-38. Carrier-based Marine AV-8B Harriers employed JDAMs for their first time that same month.

Another GBU-38 was one of the two bombs dropped on a mujahedeen safe house near Baquba, Iraq, on June 7, killing the notorious leader of al Qaeda in Iraq, Abu Musab al-Zarqawi.

JDAM and other near-precision and precision weapons are more valuable than ever, now that the chief adversaries of the United States are terrorists, say Air Force officials. As in the Zarqawi strike, air weapons can destroy their safe houses without destroying their surrounding neighborhoods.

"The incredible precision of the munitions we've developed helps to ensure collateral damage is kept to a minimum," said Maj. Gen. Jeffrey R. Riemer, commander of the Air Armament Center at Eglin, after Zarqawi's death.

One upgrade that might loom in the weapon's future is the addition of a laser. The JDAM Squadron at Eglin is working with the Navy on laser seeker technology. Boeing is funding some of the work.

Lasers would make JDAM a multimode weapon. US aircraft now often fly patrols without knowing what their eventual targets might be, making such flexibility a virtue.

Laser-capable JDAMs would mean that aircraft could carry one kind of munition. Lasers would let JDAMs track moving targets, as well as targets for which the US does not have exact coordinates.

The JDAM Squadron is also considering the addition of a data link; this would allow the weapon's course to be updated by data from E-8 Joint Surveillance Target Attack Radar System aircraft.

The newly operational Small Diameter Bomb, which is also GPS guided, has wings. It can penetrate 13 feet of concrete from a distance of 70 miles.

In May, an F-22A performed the highest and fastest delivery of a JDAM ever. The test featured the release of a 1,000-pound weapon dropped from 50,000 feet, with the airplane traveling at Mach 1.5.

The transition from bomb bay to supersonic air stream is "quite a dramatic one," noted the JDAM chief engineer, and it took a lot of effort to get the dynamics right.

The F-22 weapon system will be crucial to the Air Force for years to come, and it will expand JDAM production even further.

Current plans call for a buy of at least 230,000 JDAMs, and the 250-pound Small Diameter Bomb promises even more flexibility in a less-destructive package.

"We've produced many more than we originally anticipated," Cerrato said. "That's very unusual in this business." ■

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