



An M1A1 at full gallop.

General Dynamics

Terrific TANK

Feared by its enemies,
revered by our side:
the Abrams M1

In the sixth installment of CTE's "Made In America" series, Mike Principato takes you behind the scenes and inside the "Apex Predator" of ground warfare: the Abrams M1 Main Battle Tank.

There's something about the sight of an Abrams M1 tank on the move that stirs the most primal of reactions, the nature of which depends on your perspective.

If you're behind, aside or inside it, chances are you're a U.S. Marine, a U.S. Army soldier or one of the citizens of countries U.S. troops helped liberate or protect. Then your reaction

would likely be awe because of the Abrams' extraordinary lethality and combat survivability.

If you have the misfortune to be in front of an Abrams, odds are that you're the enemy and thus on the wrong end of U.S. military might. If so, don't think. Run. As fast as you can.

Iconic War Machine

Born for the plains of Europe during the Cold War but famed for its heroics in Middle East wars, the Abrams reached iconic status during the 2003 invasion of Iraq and the subsequent "Thunder Run" into the heart of Baghdad. The Abrams M1 Main Battle Tank, and its various configurations, has been called "the Apex Predator of Iraq," "the Beast," and even "Whispering Death" by U.S. forces. It is named for the late Gen. Creighton W. Abrams, former Army chief of staff and commander of the 37th Armored Battalion.

The nicknames are appropriately respectful for 140,000 lbs. of building-blasting weaponry and gee-whiz computerized navigation, communications and fire-control systems wrapped up in a depleted-uranium-armored, extreme off-road vehicle that can reach speeds of 45 mph.

Plant in Transition

Since 1982, General Dynamics Land Systems (GDLS) has operated the Lima, Ohio-based Joint Systems Manufacturing Center (JSMC) in a mammoth industrial complex that's the only tank chassis, hull and turret fabrication and final systems integration facility in the U.S. General Dynamics has manufactured or remanufactured about 9,000 Abrams tanks there since being named the exclusive supplier of the fighting vehicle to the U.S. Army and Marines in 1980. During the Cold War, the plant once employed almost 4,000 workers and manufactured 30 Abrams tanks per month. Since then, defense budget cuts, the changing military landscape and productivity and technology enhancements have whittled the GDLS

workforce to about 800.

On the day of my visit, I drove up to the plant after navigating a series of barriers and warning signs. I then entered a security checkpoint where I was duly registered as an authorized visitor and met Dick Sutliff, Abrams program management specialist.

The genial and quick-moving Sutliff, a 32-year General Dynamics veteran, along with young engineering specialist Paul Edie, were my tour guides during a 2-hour walk and golf cart ride around a manufacturing complex that, at 369 acres and 1.6 million sq. ft. under roof, is bigger than my hometown. Accompanying us for the morning would also be Security Specialist Richard Hull, who works for the guys who actually own the JSMC: The Department of Defense's Defense Contract Management Agency. Well, technically, you and I and a few hundred million other taxpayers own the plant, but it's the job of Hull's team to protect our interests.

"I'm flattered that all three of you guys are taking the time to be my guides," I said, beaming my most ingratiating grin at Hull, whose 6'3", lean-muscled frame and close-cropped hair screams "former military."

"I actually *have* to be here," responded Hull with a thin smile, the first sign of what I found to be a dry but warm sense of humor, no doubt honed over his 20 years in the Marine Corps, 16 of them in intelligence.

The Lima plant produces other armored vehicles, including the Stryker (a vehicle with two variations, infantry carrier and mobile gun system); the Wolverine Heavy Assault Bridge (an armored vehicle designed to carry, emplace and retrieve an assault bridge capable of handling heavy loads such as the M1 Abrams tank); and the MK46 weapon station (an expeditionary fighting vehicle that incorporates a 30mm MK44 automatic gun and a 7.62mm COAX machine gun). However, according to Sutliff, the bulk of the JSMC's revenue still comes from the Abrams program or, more specifi-

cally, the remanufacturing and upgrading of Abrams tanks.

“The last ‘new’ Abrams was produced about 10 years ago,” explained Sutliff, who described the Lima facility as a “plant in transition,” working hard to diversify its products, enhance machining and welding technologies and, most importantly, build teamwork and cross-functional cooperation.

“We’re bringing everyone into the decision-making process on the manufacturing floor,” he said, “particularly those who are actually performing the work.” Sutliff’s emphasis on the last point wasn’t lost on me. With no all-new Abrams contracts in sight, General Dynamics is counting on the plant’s new production efficiencies,



General Dynamics

If you can see my bore, you’re too close! Down the bore of the Abrams’ 120mm main gun.

Inside the belly of “the Beast”

Just the idea of getting inside an Abrams put me in touch with my Inner Tank Commander.

Driving across Pennsylvania and half of Ohio on my way to Lima, the home of the legendary armored fighting vehicle, I could think of little else but the mere possibility that the nice folks at General Dynamics would let me take a spin in an Abrams M1 Main Battle Tank.

I got goosebumps from the idea of being in one of the world’s most accurate and powerful weapons, at being inside the ultrasophisticated, amazingly fast and undeniably intimidating rolling armored cocoon that is the Abrams.

Alas, I wasn’t offered a ride. Perhaps it was for security reasons or because even a short jaunt in the 67-ton armored vehicle could burn enough fuel to heat my neighborhood for the winter. Given what happened to Michael Dukakis when he was photographed “driving” an Abrams during his ill-fated campaign for president, maybe not getting a ride was a blessing.

I did, however, get to sit in all four seats in an Abrams, thanks to Gary Leutz, a technician in General Dynamics’ JSMC final assembly department. Leutz first showed me how to contort myself into the driver’s seat via a hatch in the front of the Abrams’ hull. Once seated, he powered up the

“dashboard,” reclined my seat and extended the motorcycle-style handlebar. If I closed my eyes, I could imagine I was sitting in a building-crushing, jet engine-powered Corvette.

After extracting myself, I climbed down into the main compartment, home away from home for the tank crew’s commander, gunner and loader. I instantly understood why Leutz told me the driver’s seat was the “most comfortable seat in the tank.” On the upside, however, the three guys that are crammed into the main compartment get to manage the weapons systems, including the 120mm main gun that shoots either a HEAT (High Explosive Anti-Tank) round or a Sabot, basically a metal arrow with a depleted-uranium head. Both weapons will destroy an enemy tank on impact or just about anything else.

Sitting inside the compartment, it occurred to me that I was taking up space that would soon be occupied by brave Marines or soldiers who had sacrificed much to earn a spot in the Abrams. Their battle in this tank might be just weeks or months away, so I said a silent prayer for them and in thanks for the made-in-America craftsmanship that I hoped would keep them safe inside this incredible fighting machine.

And then, reluctantly, I clambered out. —M. Principato

specialized machinery and armor plate manufacturing expertise to lock in contracts for the next generation of armored fighting vehicles, such as the Marine Corps’ sleek new expeditionary fighting vehicle. This EFV alone could add hundreds of new jobs and, in the view of General Dynamics’ head honchos, is a perfect fit for Lima’s manufacturing capabilities.

“Large plate cutting, welding and fabrication are our core capabilities,” explained Sutliff, noting that the JSMC’s 231 certified welders average more than 5,000 hours each of production welding experience. That welding capability, combined with some of the largest direct numeric control laser and waterjet cutting gear in the world, is put to good use on the Abrams.

Building ‘Survivable Lethality’

At first glance, a tank is a blunt instrument compared to a fighter jet or a submarine. A basic tank includes a hull, turret, tracks, propulsion system and a weapons system. Until the Abrams M1, a battle tank was just that—basic. In World War II, for example, it would take a stationary Sherman tank about 17 rounds from its main gun, fired at up to 700m, to destroy a German Panzer.

An Abrams can take out an enemy tank from 2,000m with a single round while on the move thanks to its computer-controlled 120mm smooth-bore gun, forged and tested at the Army’s

Substantial machining

Engineering Specialist Paul Edie supervises a team of 11 tool engineers at the Joint Systems Manufacturing Center in Lima. The team provides operator work instructions, CNC programs, fixture design and other engineering services.

Machining in the Abrams tank refurbishment programs is not as extensive as for new production. “We do a little bit of machining on the turret, but nothing substantial,” he said. Substantial, however, is a relative term. Made of armor steel plate from ¼" to 5" thick, the Abrams turret is about 4' high × 10' long × 8' wide and weighs 14 tons. Handled with overhead cranes, the turret is flipped on its side, mounted on a pallet, and presented to a Lucas horizontal boring mill.

Edie said machining armor steel—comparable to 26- to 34-HRC 4140PH steel—“has complexities, but we’ve been machining it for 27 years so, for us, it’s just typical work.” A routine operation is milling a 10"×6" opening in an area of the turret about 1" thick to create a space to fit updated equipment. The opening is created on a compound 7°×7° angle by a 1"-dia. indexable cutter tooled with two inserts, run at 900 rpm, a 5-ipm feed and a ⅜" DOC, followed by a finish pass with a ⅝" HSS endmill. A 1⅞"-dia. indexable drill also makes a dozen holes around the opening during the 90-minute operation.

New products that employ the JSMC’s

capabilities include the turret for the mobile gun system variant of the Stryker vehicle. It is fabricated from high-hardened steel, cut from 96"-wide × 144"-long plates on a 5-axis CNC ESAB laser. The plate segments are welded into a turret structure, which is then machined on the Lucas HBM.

Huge, Precise Parts

The parts made at the JSMC are big and tough, but not imprecise. According to Edie, typical true-position hole tolerances are about 0.7mm or less, over a 7' diameter. To maintain that tolerance, positive part location is crucial. CAD/CAM data tells the machine tool to control turret dimensions. Then, “on the pallet we have zero points, so we know exactly where the pallet is relative to the machine,” Edie said, “and we have solid stops for the pallet at known locations from our zero points.” When the turret is bolted down against the stops, the machine knows exactly where it is and what its dimensions are and, therefore, can machine it precisely.

On the cutting edge of technology, from both a military and manufacturing standpoint, is the hull structure of the new expeditionary fighting vehicle, a high-speed amphibious assault vehicle for the U.S. Marines. JSMC will machine the hull on a new Euro Machinery Specialist machining line consisting of two Doerries Scharmann Technologies 5-axis boring mills and a Doerries Scharmann/

Watervliet (New York) Arsenal.

Hull, the former Marine, said such capabilities are the tank’s claim to fame, and that the “lethality and survivability” of the Abrams isn’t just skin deep. The U.S. deployed almost 1,900 Abrams tanks in the first Gulf War. None were destroyed in battle, and, more importantly, just three tank crewmembers were wounded in attacks. Even in Iraq today, where urban combat is the rule, the tank has established itself at the top of the armored food chain.

In ancient, narrow Iraqi alleyways in military “hot zones,” Abrams commanders have adopted different tactics

to maximize the tank’s overwhelming power, including swivel steering the tracks to crush walls while firing at insurgents. With some relatively minor modifications, General Dynamics has morphed this armored “cold warrior” into a formidable and feared urban assault vehicle. As a sign of the times, the modifications include a nuclear, biological and chemical (NBC) protection system and additional reactive and underside armor to neutralize improvised explosive devices.

Rehab and Repair

For the past decade, the JSMC

Droop & Rein 5-axis gantry mill.

The 8'×11'×28' welded aluminum structure will move through the line on a pallet. Machining will be done to lighten the hull and cut windows and pockets, and will include thread milling, drilling, counterboring, reaming and tapping. Installation of the line was taking place at press time.

Volatile world politics play a large role in determining the JSMC’s output and production schedules. “Every day is a new challenge,” said Edie. “You don’t know what’s going to come your way. We have core work, but with the conflict in Iraq, we’ve been called upon to produce some short-term projects as well and speed up our processing times.” He’s fine with that because “what we do here can save lives and affect families. That’s our No. 1 concern.”

A typical rush project, announced in October, was for 150 mine roller systems for the Marines. An MRS mounts on the front of a vehicle and detects and neutralizes mines and improvised explosive devices before the vehicle passes over them. The system’s importance is clear to Edie. His nephew returned safely from a tour of duty in Iraq on Sept. 14. Just 2 weeks before that, however, an IED blew off the front end of the Humvee in which he was riding. The Humvee did not have an MRS, and Edie’s nephew was fortunate to have survived the blast.

—Bill Kennedy, Contributing Editor

has focused on remanufacturing and upgrading the tanks that were, for the most part, originally built in Lima (early on, some tanks were produced in Detroit).

“The basic components of a tank don’t wear out,” said Sutliff, as he pointed to the first stop on our tour, a lineup of stripped Abrams hulls. “Aniston (Alabama) Army Depot receives tanks scheduled for remanufacturing, and strips them down. They ship us the hulls and turrets, and we rebuild the tanks from there, replacing, remanufacturing and upgrading as specified [by the military contract].”

The cost savings are considerable. When built new, an Abrams M1 cost about \$4.5 million, a price that would be much higher now. Also, the remanufacturing process allows old tanks to be upgraded with the latest weapons systems, armor and computerized equipment. Over the 26 years since the Abrams program launched, improvements in drivetrains, weapons, armor, and navigation and communication systems have been incorporated in new configurations, usually designated M1A1 or M1A2.

Whatever designation, the stripped hulls don't look like much before processing, even after they're mounted on gigantic, specialized fixtures that hold them upside down. In fact, it was hard to picture the rusted hulk as the platform for the beige mechanical monster I'd seen whooshing through the desert in History Channel documentaries.

Similarly, when Sutliff showed me the turret line, the stripped tank tops resemble nothing so much as rusty shells from giant tortoises. After machining, the turrets, like the hulls, are mounted to custom fixtures and wheeled to a prep department, where they are shot-blasted, painted with primer and oven-dried.

Back to Combat-Ready

In addition to the Anniston partnering program, the JSMC also receives, by railcar, whole battle-scarred tanks. These tanks are run through the plant's "reset" program, designed to restore worn tanks to current Army standards.

"The Anniston program tanks go through what we call 'AIM,' for 'Abrams Integrated Management,' which delivers a zero-miles tank. The reset program is designed to turn tanks around fast and get them back into service with the latest equipment," explained Sutliff.

When the Abrams program was launched, tons of rolled steel plate would enter one side of the JSMC, and 92 days later a new tank would emerge from the other. Much of the machinery

used to convert that steel plate is still used to remanufacture Abrams tanks, including one of the largest plasma cutting machines I'd ever seen, capable of cutting 2"-thick plate at 10 ipm. Near it sits a Flo waterjet machine used to cut multiple armor parts and components for the Abrams and other JSMC products.

Nine machines drill, tap and mill the hull and turret, and small metal brackets, called "appurtenances," are tacked and welded to the inside surfaces. Over 800 appurtenances will be used to at-



General Dynamics' Dick Sutliff with a freshly primed Abrams hull ready to join the assembly line.

tach components to each Abrams on the assembly line.

When hulls and turrets emerge from the prep department, they join separate but parallel assembly lines where the tank's internal systems are installed. We walked to the assembly line area, and I was invited to climb up to a mezzanine that overlooks the installation processes. Ammunition doors, machine gun mounts, wiring harnesses, rubber hoses, fire suppression equipment and other systems were being installed by several line workers who barely noticed our presence. These guys were focused, a state of mind that

I'd noticed throughout the sparsely populated plant.

That's not a surprise, according to Hull. JSMC team members know the stakes are high, and that "total quality" means just that. One handmade sign posted by a workstation features a photograph of a tank commander and reads, "REMEMBER: Everything we do affects this man. He and his buddies will be the first to pay for our mistakes."

A finished turret is an independent assembly at this point, onto which the

hydrokinetic transmission, chosen for its small size, high power-to-weight ratio and ease of service. The engine is built for power, not fuel economy—the M1 gets about 0.6 mpg.

Where the Tracks Meet the Road

After exiting the assembly line area, Sutliff chauffeured our group by golf cart to the final assembly, paint and test area. Here, the hull and turret are "married" with 48 bolts that run through the turret, the race ring on which the turret spins and the hull. Ready for testing, the remanufactured Abrams M1 will be driven to the JSMC inspection and testing departments.

Before the Army, Marines or a U.S. ally takes delivery of a like-new Abrams, General Dynamics' testing team will conduct over 600 checks. They will drive each M1 30-plus miles on the JSMC's oval test track; negotiate a 4'-deep ford; drive over a bump course, a 60 percent vertical slope and a 40 percent side slope; test fire the gun; and check the tank's NBC system.

A Defense Department inspection team then runs its own tests of up to 180 items for conformance to military specifications. Assuming no deficiencies—and according to Sutliff, there rarely are—the tank is accepted by the government, painted and loaded on a railcar, destined for another battle.

From where we were standing, I looked down on a dozen Abrams M1s. At rest, they were still a fearsome sight. On a wall behind them a huge banner proclaimed "The world's best: M1A2, built by and for professionals." I didn't doubt it for a moment. Like the men and women who fight in and alongside them, these tanks are good to go. Δ

About the Author

Mike Principato is a metalworking industry consultant and former owner of a midsized CNC and EDM shop in Pennsylvania. He can be e-mailed at ctemag1@netzero.net.