Building Tanks at Lima

For more than 50 years, this Ohio plant has forged the Army's heavy metal

by Captain Todd Tolson

As World War II approached, the U.S. Army developed a plan to utilize industrial firms to manufacture armored vehicles. The urgent need for these vehicles was not fully recognized until the Germans' Blitzkrieg across Europe in 1939 and 1940. This situation presented a staggering mission for the Army Ordnance Department's new (1941) Tank and Combat Vehicle Division. In one year, over one million vehicles, including 14,000 medium tanks, were to be produced and ready for shipment.[1]

The Lima Army Tank Plant traces its 55-year history back to May 1941, when the Ohio Steel Foundry began building a government-owned plant to manufacture centrifugally-cast gun tubes. The site was chosen for its proximity to a steel mill, five railroads, and national highway routes.[2] Before construction was completed, the Ordnance Department redesignated the site as an intermediate depot for modifying combat vehicles, to include tanks.

In November 1942, United Motors Services took over operation of the plant to process vehicles under government contract. The plant prepared many vehicles for Europe, including the M-5 light tank, the T-26 Pershing tank, and a "super secret" amphibious tank intended for use on D-Day.[3] During World War II, the Lima Tank Depot had over 5,000 employees, including many women, and processed over 100,000 combat vehicles for shipment.

Activity slowed during the post-WWII period, and the plant temporarily became a storage facility. In 1948, tanks were dismantled and deprocessed there. Numerous tanks were "canned" and stored in cylindrical gas containers with dehumidifiers.

When the Korean War broke out, the depot expanded and industrial operations resumed. Over the next few years, the facility rebuilt combat vehicles and fabricated communication wiring harnesses. The Korean truce led to the depot's eventual deactivation in March 1959 with little other activity taking place over the next 16 years.[4]

A technician guides the giant crane that marries the hull and turret of an M1A1 tank. The two major components move down separate assembly lines — and the hull is test driven as a "convertible" —before this final assembly step.

In August 1976, the government selected Lima Army Tank Plant (LATP) as the initial production site for the XM-1 tank, and Chrysler Corporation was awarded the production contract. The method of production differed from previous armor programs; the hull and turret sections were to be fabricated from armored plate, rather than castings, allowing Chrysler to produce a lighter, stronger tank.[5] Since this was a government-owned, contractor-operated (GOCO) manufacturing facility controlled by the Army's Tank-Automotive and Armaments Command (TACOM), the installation was expanded and specialized industrial plant equipment purchased. A sister plant was established in Michigan, the De-

TANKS	QUANTITY		PRODUCTION DATES
M1 Tanks	2,374		1979-1985
IPM1 Tanks	894		1984-1986
M1A1 Tanks	4,753	(U.S. Army)	1985-1993
M1A1 Tanks	221	(U.S. Marines)	1989-1991
M1A2 Tanks	62	(New)	1991-1992
M1A2 Tanks	206	(Upgraded)	1993-Present (Oct 96)
M1A1 Tanks	18	(AIM XXI)	1996-(Jan 97)

Figure 1

troit Tank Plant, to assist with the assembly of M1 sections fabricated at Lima.

On February 28, 1980, the first M1 tank rolled out of LATP. It was designated the M1 Abrams, in honor of General Creighton W. Abrams. The name, Thunderbolt, recalled the name Abrams gave to each of his seven tanks in WWII.

One of the original XM-1 prototype tanks is permanently on display in front of the Patton Museum of Armor and Cavalry at Ft. Knox.

In 1982, General Dynamics Land Systems (GDLS) bought Chrysler Defense Corporation and began producing the M1 at a rate of 30 tanks a month. By January 1985, the last M1 had rolled off the assembly line, and production began on the improved M1 (IPM1) the following October. The plant later transitioned to manufacture the M1A1, with the first pilot vehicle built in August 1985.[6] By the end of 1986, the plant's equipment was increased to meet a maximum monthly production capability of 120 M1A1 tanks. At that time GDLS employed over 4,000 workers in Lima with over 100 TACOM personnel monitoring the production and facilities contracts.

In June 1990, all government contract administration services at Lima were placed under the Defense Logistics Agency, Defense Contract Management Command, with TACOM as the procuring activity. During this period, the Marines received over 200 M1A1 tanks, and the first Abrams foreign military sales occurred. The plant supported Desert Storm by sending technical experts to Saudi Arabia for M1A1 fielding to units previously equipped with M1s.

The 1990 DOD base closure plan ordered the Detroit tank plant to reduce its operations, and in August 1991, the Lima Army Tank Plant became the only facility in the U.S. that is a hull/chassis/turret fabricator and final systems integrator of the M1.

The first M1A2 tanks rolled out of LATP in 1992 with upgrade versions produced in 1994.

LATP Facilities

The commander of the Lima plant, a government-owned, contractor-operated facility, is an Army lieutenant colonel. The installation includes 370 acres and 47 buildings, it's own railroad network, and two government-owned railroad locomotives. There is also is a 2-mile test track, steam plant, deep water fording pit, 60% and 40% test slopes, and an advanced armor technology facility. The main manufacturing building has over 950,000 square feet of enclosed space, equivalent to approximately 30 football fields. The government owns all of the real property and over 96% of the plant equipment, to include computerized machines, robotic welders, plate cutters, large fixtures, and special tooling. General Dynamics is under contract to operate the facility and produce the Abrams with government oversight.

U.S. Production

Abrams production originally occurred at the earlier mentioned two sites with over 9,000 Abrams having rolled off the assembly lines of these facilities, including those produced for domestic and foreign sales. Currently, GDLS is under a multi-year Army contract to upgrade approximately 600 M1/IPM1 tanks to M1A2. The plan is to upgrade 10 tanks a month over a five-year period. The cost of a new M1A2 tank is approximately $4.3 million.[7] Listed at Figure 1 is the current status of U.S. M1 tank production/distribution.

Foreign Military Sales (FMS)

The M1's technological and tactical successes in Desert Storm made the tank the envy of the world armor community and generated foreign interest. Both Saudi Arabia and Kuwait now own M1A2 tanks produced at LATP. In a co-production program, M1A1 tank kits (hulls, turrets, components, etc.) are manufactured at LATP and shipped to Egypt for final assembly. Commercially, GDLS also produces "special armor" packages for the South Korean K1 tank. Abrams current foreign military sales are listed in Figure 2.

COUNTRY	QUANTITY	PRODUCTION DATES
Saudi Arabia	315 M1A2	1993-1995
Kuwait	218 M1A2	1994-1996
Egypt	100+ M1A1 (kits)	1990-Present
South Korea	1000+ Special Armor Packages	1984-Present

Figure 2

Personnel

The government and contractor managerial staffs work together monitoring monthly production requirements while maintaining quality control. A partnership environment ensures the highest quality equipment is produced at a fair cost to the government. General Dynamics currently has over 400 employ-

ees at LATP to produce the M1. There are four military and over 60 civilian personnel assigned to Defense Contracts Management Command-General Dynamics, Lima (DCMC-GD, Lima). Government duties range from contract administration to production surveillance, quality control, and facilities management. The commander's vision is that DCMC-GD, Lima is committed to being a national center of excellence through innovative methodology implemented by motivated, qualified, empowerment teams.

M1A2 Manufacturing, Machining, and Assembly

Rolled homogeneous steel plates go in one side of the plant, and 92 days later, a new M1A2 comes out the other.

The tank starts out as metal plates that are 3/8 to four inches thick and 8 by 12 feet in length and width. Two different machines cut the plates into tank parts. The oxyacetylene cutter uses a mixture of oxygen and propane gas burning at 3000 degrees Fahrenheit to cut metal plates. The machine is capable of cutting up to six-inch plates at about one foot a minute. There are two triple-head burners that have the ability to make 60-degree angle cuts and rotate 360 degrees.

Another machine, a plasma cutter, uses nitrogen gas to cut steel plates up to two inches thick at ten feet a minute. The cutter's flame burns at over 18,000 degrees Fahrenheit, which is over twice as hot as the sun's surface. Plates are flame cut underwater to disperse the heat of the flame and to reduce noise. Both the oxy fuel and plasma cutters are computer controlled, and templates verify that the cuts are made within tolerance. After cutting, the plates are ground to remove oxide prior to welding.

The turret is fabricated on a precast race ring. A hydraulic fixture aligns the six interior steel plates for welding. Three different types of welding are used for the turret: high deposition, pulse, and stick. Welders fill the gaps between the plates with enough weld wire to make the weld as strong as the adjoining steel.

The turret must be rotated vertically and horizontally to weld each joint on a horizontal surface. Normally, it takes several passes of weld wire to meet ballistic specifications. Overall there is

"Rolled homogeneous steel plates go in one side of the plant, and 92 days later, a new M1A2 comes out the other."

Above, stacks of steel plates, ranging from an inch to four inches in thickness, will eventually be cut and formed into M1-series tanks.

At right, the oxyacetylene cutter, which slices through steel with its 3000-degree torch.

Below, turrets have now been fabricated and sent to a secured area where the special armor has been installed.

New M1s negotiate the 60-degree slope and the 40-degree side slope during final testing. At left, an M1's seals are tested by fording in 4 feet of water. More than 600 checks are made by the contractor even before the government's final acceptance tests.

approximately 500 lbs. of weld wire in the turret.

The turret then goes to the secured armor technology building for special armor. Every M1A2 tank, foreign or domestic, has a brand new turret manufactured from "scratch."

The M1A2 hull is created similarly to the turret, except it starts upside-down. The side plates are locked into a fixture and the floor plates, nose and tail sections are welded in place. The nose section already has special armor enclosed. There is over 1000 lbs. of weld wire used in hull manufacturing. The hulls are placed in rollover fixtures and rotated horizontally to flame cut the openings for the final drive, torsion bars, driver's hatch, and floor holes.

Currently, the plant is only upgrading old M1/IPM1 hulls to M1A2, so hull manufacturing no longer occurs. The M1 hulls arrive by rail from Anniston Army Depot "sanitized" with all components and suspension removed. LATP cuts off the left side hull sponson to install the new sponson that is capable of supporting the improved NBC system. The original hull structure and serial numbers remain unchanged. Although all hull structures were fabricated at LATP, your tank was assembled in Detroit if the tank serial number starts with a D, and assembled in Lima if it starts with an L.

Machining

Nine large milling machines drill, tap, and cut the top and sides of the manufactured hull. The torsion bar windows, final drives, and driver's hatch openings are all machined to a smooth surface. The hull race ring has 48 holes drilled and tapped to connect it to the turret.

The 15-ton turrets are machined in an upright position and held by a fixture transported on air pads (hovercraft-like) so they can be moved by one person. The turret's top, underside, and race ring are all machined in this fashion.

Appurtenances are the small metal brackets that attach components to the tank. These appurtenances are tacked and stud welded to the inside of the turret and the hull (sub-turret) floor. There are over 800 appurtenances used in the Abrams: 500 in the hull and 300 in the turret.

Prior to initial painting, the turrets and hulls are shot-blasted with metal particles to remove rust, markings, dirt, and oil. Shot blasting gives texture to the steel, creating a better surface for paint adhesion. The hulls and turrets then receive a primer coat, are dried in an oven, and finally receive a base coat of paint.

Assembly

The hull and turret assembly lines move parallel to each other. Turrets begin assembly on fixed stands, where the ammo doors are installed. The 120mm cannon has already been fired three times at Aberdeen Proving Ground, Maryland, prior to installation. The turret is then placed on a mobile dolly, which is pulled down the line by an in-ground conveyor system. Components, cables, and the assembled turret basket are added during this period. Fully assembled, the turret is a completely/functional separate unit. The turret is then independently boresighted to align the sights and check the functions of the turret components.

The hull begins assembly on a fixed stand, where the torsion bars, roadwheel arms, and roadwheels are installed. Then the hull rolls down the assembly line on its own roadwheels. Rear fuel tanks, hydraulic lines, cables, slip ring, engine, and the track are

LIMA VIEWS

ABOVE: The entrance to the new tank plant in 1942.

ABOVE RIGHT: In a 1952 view, bare cast hulls await installation of suspension components. Today's tank hulls are not castings, but are made up from plates of steel armor.

RIGHT: An impressive aerial view of the sprawling plant.

BELOW: In a 1950s photo, several divisions' worth of stored tanks form an almost abstract composition in this view of a large storage area at the Lima plant.

added next. Skirts are then attached and the hull is driven as a "convertible" to ensure that all components are working properly, and that there are no oil or fuel leaks.

Upon completion of the separate hull and turret tests, the structures are "married" with 48 bolts connected through the hull and turret race rings. With the connection of the slip ring, the component that communicates all electronic and hydraulic functions between the hull and turret, the vehicle is ready for testing.

M1 Abrams Test and Final Acceptance

Before the government begins inspection, General Dynamics takes each M1 through extensive testing. The contractor makes over 600 checks to ensure safe operation. Each tank is driven 30 miles on an oval test track with a radar gun to verify vehicle speed. The tank then negotiates a four-foot water ford, drives over a bump course, travels on a 40% side slope, stops and starts on a 60% vertical slope, and completes prep-to-fire checks. A three-hour NBC test then verifies that the tank will maintain an overpressurized condition for long periods of time. After General Dynamics testing, the contractor turns the vehicle over to the government for acceptance.

On a full government inspection, over 180 checks are made to guarantee conformance to specifications. Normally, the government conducts between 40 and 60 checks, based on historical data and recent vehicle faults. Each M1 is driven an additional ten miles and tested by the quality specialist. If there are no deficiencies, the government accepts the tank. The vehicle then receives its final coat of paint, has decals added, and is loaded on railcars for transport within the U.S. or to overseas terminals.

New M1A2 Developments

The pulse-jet air propulsion system (PJAS) was added to February 1996 M1A2 production vehicles. This system cleans the three air filters (V-Packs) automatically while moving through dust/sandy terrain. With the PJAS system, there is no longer a need to manually clean the V-Packs after a hard day of fighting at the National Training Center (NTC); PJAS will have cleaned the filters for you.

Several efforts have been made to reduce the weight of the M1A2. Aluminum has successfully been used to replace steel in the bustle rack, oil cooler cover, and other parts. Titanium is the latest metal introduced to the M1A2. Titanium is approximately 40% lighter than steel at five times the cost. Plans are to substitute titanium for the NBC sponson covers, turret blow-off panels, and Gunner's Primary Sight (GPS) covers in M1A2 tanks by the end of the year.

The Future of Abrams

Modernization is essential for the Army; a smaller force requires increased lethality, and replacement of obsolete equipment. The Army will spend dollars saved by cutting selected programs on developing and improving critical systems, to include the Abrams tank. The technological advantage displayed in Desert Storm will be maintained by supporting soldiers with modern, advanced weapons.[8]

M1A2 Domestic

There are two programs that will produce more M1A2s for field units. The Abrams upgrade program has received funding for five years to upgrade an additional 600 M1/IPM1 tanks to M1A2s for completion in 2001. The Abrams Integrated Management 21st Century program (AIM XXI) will modernize over 1,200 M1A1 vehicles starting in 1998. By 1999, the M1A2 Systems Enhancement Program (SEP) will upgrade the M1A2 fleet to a single enhanced configuration, horizontally integrating the Abrams within the Force XXI community with common hardware/software. Specifically, the M1A2 (SEP) will:[9]

- Enhance target detection with 2nd-generation FLIRs
- Store terrain maps and improve navigation
- Upgrade vehicle displays to color
- Improve communication within Force XXI
- Add a thermal management system to keep electronics cool
- Add an under-armor auxiliary power unit for extended surveillance operations with the engine off, reducing fuel and battery use.
- Provide growth potential for future technologies

Future Abrams Family of Vehicles

The Army has pushed the common component chassis approach, using the same or similar M1 components for all Abrams variants. Current vehicle initiatives include the Wolverine Heavy Assault Bridge (HAB). This vehicle is capable of deploying a temporary bridge in combat, and is strong enough to support the Army's heaviest equipment. Production of over 599 vehicles will start in the year 1999 with the hulls possibly built at LATP. The Corps of Engineers is considering an Abrams chassis Combat Mobility Vehicle (CMV-Breacher). The Crusader, the Army's advanced field artillery system, and the Air/Ground Dual Role Defense System (AGDS, the Sergeant York replacement), may both be built with a modified Abrams hull.

In June of 1996, the Navy awarded GDLS the contract for the demonstration and evaluation phase of the Marine Corps' Advanced Amphibious Assault Vehicle (AAAV), a 37-ton armored personnel carrier designed on an Abrams chassis. This vehicle has a three-man crew and is capable of transporting 18 marines from 25 miles out at sea to shore in one hour.[10] Production of over 1,000 vehicles is projected to start in 2005. These initiatives capitalize on the benefits of chassis commonality, reducing developmental, production, and sustainment cost.

Future Foreign Military Sales

Future foreign M1A2 sales are dependent on how the Abrams stands up to the competition. Our Allies all make modern battle tanks, but none compare to the current M1A2. Primary tank competitors to the Abrams are the Challenger II (Britain), Leo 2 Step II (Germany), Leclerc (France), and the Type 90 (Japan). The M1A2 outshines all armored rivals with its many unique capabilities and demonstrated superior performance.

Overseas opportunities for sales of over 1,200 new Abrams tanks look bright in the near future. In addition to its 315 M1A2s, Saudi Arabia has asked for pricing on another 150 tanks. Egypt recently contracted for 31 co-production M1A1 tank kits and asked for pur-

chasing data on another 100 vehicles. Kuwait has the potential for 38 M1A2 follow-on orders. During 1995, GDLS demonstrated the M1A2 in Turkey with stellar results. Turkey is expected to purchase more than 800 tanks initially in a co-production arrangement, and the Abrams is aggressively competing for the contract.[11] There is a potential for upgrading an additional 500 M1 tanks to M1A1 for sales abroad. Five European nations have expressed interest in obtaining upgraded M1A1s for their countries.[12] The Abrams may soon be the standard tank seen all over the world.

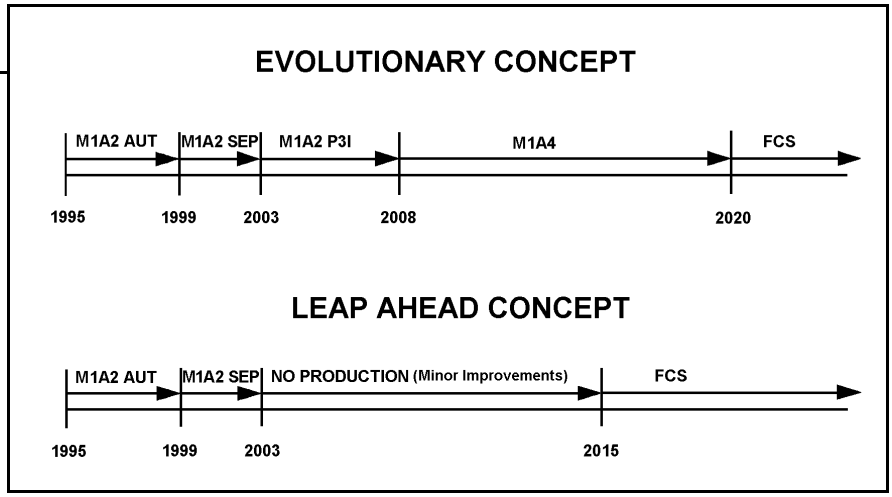

Figure 3. Tank Modernization Options

Future Combat System (FCS)

The Future Combat System will be a tank radically different from the current Abrams design. The goal is a vehicle that weighs no more than 43 tons when fully combat loaded, operable by a two-man crew from a safe compartment. Other initiatives are an electromagnetic gun with an eight kilometer effective range, high-power-density engines, voice-activated system, and indirect vision technologies, giving the commander a 360-degree "virtual" vision system while sitting inside the tank. Many of these technologies are going to be fueled by the commercial industry; however, there is a concern on how quickly these complex systems will be available to produce a functional combat system at a reasonable cost.[13]

There are two competing "trains of thought" inside the Army on how to move to the next-generation tank (Fig. 3). The first school of thought is the "evolutionary" concept backed by the Army Science Board (ASB). The ASB wants to make incremental improvements to the Abrams until the technology is available to produce the FCS. Their concerns are that while a search for new technologies could bring improvements to the Abrams family, no such technology is currently on the horizon that would make it necessary and cost-effective to opt for a new tank prior to 2020.[14] Additionally, if the tank production line stays idle for about a decade, renewing production activities would be both very difficult and expensive. A "warm" production line must be maintained or defense contractors and sub-contractors will lose technological expertise and production capability in this critical sector of the defense industrial base.

ASB officials want to initiate two, successive interim Abrams improvements after the SEP and prior to introducing the FCS. The next tank could be a three-man-crewed M1A2 SEP preplanned product improvement (P3I) model, which could be fielded in 2003. The P3I package would include extended-range fire control systems, automatic target detection, helmet mounted displays, battlefield combat identification systems, autoloaders, and speech recognition systems, increasing the tank's lethality by 30 percent. In 2008, industry recommends an Abrams block upgrade (M1A4), which may include a an improved main gun, hit avoidance countermeasures system, top attack protection, countermine system, and engine upgrades. Another 30 percent improvement in combat effectiveness would result from those changes.[15]

A second school of thought is the "leap ahead" concept backed by Ft. Knox's Armor Center. The Center drafted an armor modernization plan that called for a FCS to be developed by 2015 and recommends that no further M1A2 Abrams production beyond 2003. All future research and development funds would be funneled to the new tank, making the M1A2 SEP the most advanced tank the Army will field until 2020, before the FCS is fielded in numbers.[16]

Ft. Knox has recommended that the Army initiate two studies to examine operational and industrial-based concerns. The armor community's tactical concerns are that units trained on M1A2s may be required to deploy overseas and operate pre-positioned M1A1s. Also, the aging of the Abrams fleet could reduce U.S. deterrent credibility in the world. Industrial concerns are the possibility of ceasing Abrams production at LATP and the adverse impact on the U.S. production base for armored systems.[17] General Dynamics builds tanks with the support of 146 contractors and 400 vendors in nearly 40 states. The "leap ahead" option has higher risk, but is potentially the lower cost option and allows for using all available armor funds to achieve a next generation battle tank in the earliest amount of time. A Congressional Budget Office (CBO) report stated that canceling the M1A2 production and preserving the production facilities in a "mothballed" status could save the Pentagon significant dollars over the next six years.

Recently the Armor Caucus, composed of the Army's senior leadership, concurred with Ft. Knox's "leap-ahead" recommendation to start development on the FCS. However, the program executive officer for armored systems modernization (PEO ASM) has supported the ASB results and advocated to the Army's Vice Chief of Staff, an incremental "evolutionary vs. revolutionary" approach to an FCS through continuous improvements to the Abrams tank. The belief is that the Army should continue to produce tanks at a rate of 120 per year until the force is ready to begin procurement of the FCS. Additionally all M1A1s and M1A2s should be refurbished through the AIM programs with continuous technology improvements for the Abrams fleet through 2010. Financially, the Army will eventually have to commit to either the Abrams improvement or an FCS development: the service cannot afford two tank systems.[18]

Ft. Knox is crafting a modernization plan in cooperation with PM Abrams, TACOM, and the Army acquisition executive's office to address the future

needs of the armor force.[19] Technology studies are occurring now to support this effort. No matter which path the Army take towards tank modernization, the FCS will undoubtedly be the most lethal ground vehicle the world has ever known.

Conclusion

From 1941 to the present, the Lima Army Tank Plant has established a record of mission readiness and accomplishment through teamwork with employees, contractors, and the surrounding community. This effective partnership has built a critical industrial base for national security in Lima, Ohio, including a reservoir of skilled and flexible workers. These workers — Army, contractor, and civilian — produced the M1 Abrams tank along with some of its predecessors in U.S. tank lineage and contributed directly to military victories from WWII to Operation Desert Storm. They are capable of meeting new challenges in an equally successful fashion.[20]

You now have insight on the past, present, and future production of the M1 tank and Abrams family of vehicles. Although there is talk of new technology, unmanned machines, and light armored vehicles, the M1 tank will be around for at least the next 20 years and presumably will be manufactured in Lima. The contractor and government personnel at the Lima Army Tank Plant are dedicated to providing you with the highest quality tank products as we move into the 21st century. If you are in the Midwest, try to take a detour to the birthplace of the modern Armor Force, the Lima Army Tank Plant.

Notes

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