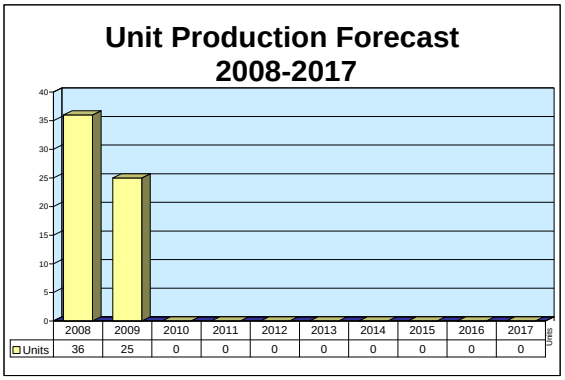
Honeywell AGT1500 - Archived 3/2009

Outlook

- In 2005, the military vehicular gas turbine engine entered Phase 2 of its production life-cycle (Phase 1 ended in October 1995)
- The sole remaining new-build M1A1s are being manufactured for Egypt, into 2009
- Worldwide, current comparably sized diesel engines offer a virtually insurmountable challenge to vehicular gas turbine engines



Orientation

Description. The Honeywell AGT1500 is a two-spool, axial-centrifugal-flow, recuperative, vehicular gas turbine engine developing about 1,500 shp (1,118 kW).

Sponsor. Development of the AGT1500 was sponsored by the U.S. Department of Defense through the (then) U.S. Army, Tank-Automotive Command; Warren, Michigan, USA.

Power Class. 1,500 shp (1118 kW) at 3,000 rpm out-put speed. A power increase to 1,675 shp (1,249 kW) has been proposed.

Status. Initial production ended in 1995. A second production run was begun at the end of the fourth quarter of 2005.

Total Produced. At the start of 2008, more than 12,264 AGT1500 engines had been built for all M1 tank variants, including tanks manufactured in Egypt.

Application. Heavy tracked military vehicles. Current or proposed applications of the Honeywell AGT1500 include the following:

Model Variant	Thrust or Power Rating	Application	Units per Vehicle
AGT1500	1,500 shp (1118 kW)	General Dynamics M1/M1A1/M1A2	1
AGT1500 TME (a)	1,500 shp (1118 kW) (b)	General Dynamics M1A1/M1A2 (proposed)	1
AGT1500	1,675 shp (1249 kW) (c)	General Dynamics M1A1/M1A2	1

(a) AGT1500 Transverse Mounted Engine, a part of the Transverse Mounted Engine Propulsion System (TME-PS).
(b) Power output in excess of 1,700 shp (1,305 kW) is considered possible.
(c) Power increase proposed in 1991.

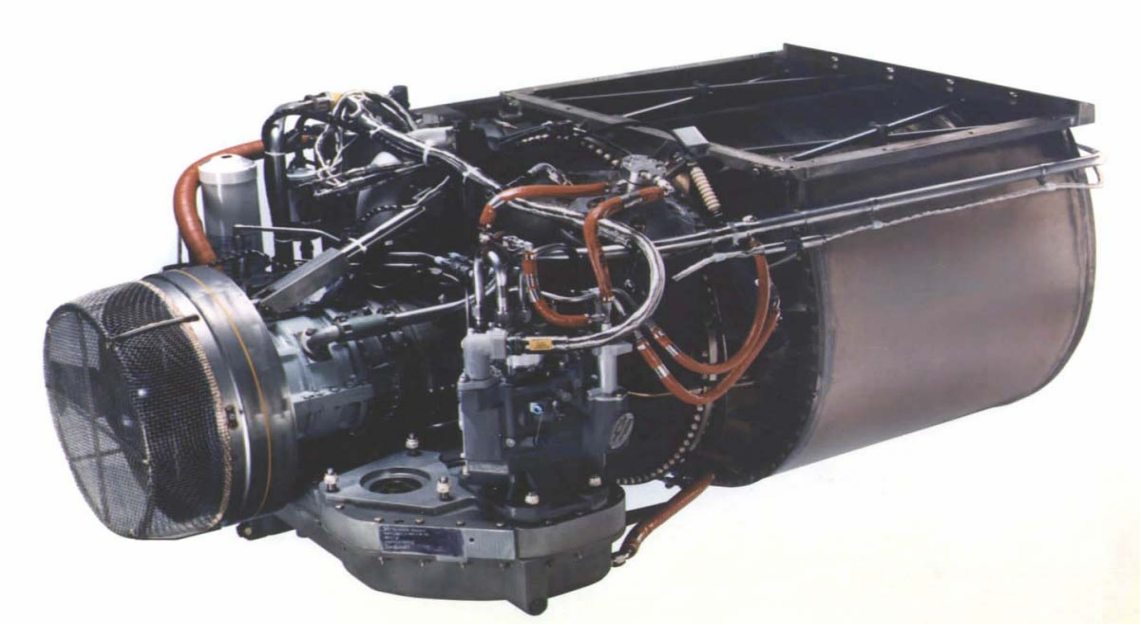
Price Range. FI estimates the 2008 price of a new-build AGT1500 to range from $875,000-$925,000.

Competition. The AGT1500 faced competition from diesel engines for the M1 application – in particular the MTU 783/883, and the Makila TI for rail applications.

As of early 2008, only the Honeywell/GE LV100 vehicular gas turbine is considered a competitor to the AGT1500.

Among the current diesel engines that are considered serious competition to the AGT1500 is the General Dynamics Land Systems AVDS-1790 at 1,500 shp.

Honeywell AGT1500



AGT1500 Tank Engine

Source: Honeywell Aerospace - Engines, Systems & Services

Contractors

Prime

Honeywell Aerospace - Engines, Systems & Services	http://www.honeywell.com/sites/aero/ , 111 S 34th St, Phoenix, AZ 85034-2892 United States, Tel: + 1 (602) 231-1000, Fax: + 1 (602) 231-5713, Prime

Subcontractor

Bristol Aerospace Ltd, A Magellan Aerospace Co	http://www.bristol.ca, 660 Berry St, PO Box 874, Winnipeg, R3C 2S4 Manitoba, Canada, Tel: + 1 (204) 775-8331, Fax: + 1 (204) 775-7494, Email: balccs@bristol.ca (Collector Housing)
Chromalloy Gas Turbine Corp	http://www.chromalloysatx.com, 4430 Director Dr, San Antonio, TX 78219-3299 United States, Tel: + 1 (210) 333-6010, Fax: + 1 (210) 359-5570 (Steel Investment Cast Hardware)
Donaldson Company Inc, Gas Turbine Systems	http://www.donaldson.com, 1400 W 94th St, PO Box 1299, Minneapolis, MN 55440 United States, Tel: + 1 (952) 887-3131, Fax: + 1 (952) 887-3115 (Inertial Separator & Barrier Filter - Strataclose)
General Plasma Associates	12 Thompson Rd, East Windsor, CT 06088 United States, Tel: + 1 (203) 623-9901, Fax: + 1 (203) 623-4657 (Clearance Control Coatings - Compressor Inlet HSNG)
Globe Motors	http://www.globe-motors.com, 2275 Stanley Ave, Dayton, OH 45404 United States, Tel: + 1 (937) 228-3171, Fax: + 1 (937) 229-8531 (Fuel Pump)
Goodrich Turbine Fuel Technologies	http://www.goodrich.com, 811 4th St, PO Box 65100, West Des Moines, IA 50265-0100 United States, Tel: + 1 (515) 274-1561, Fax: + 1 (515) 271-7201 (Flow Divider Valve; Fuel Nozzle; Ignition Lead)
Howmet Castings, Corporate Machining	http://www.alcoa.com, 145 Price Rd, Winsted Industrial Park, Winsted, CT 06098 United States, Tel: + 1 (860) 379-3314, Fax: + 1 (860) 379-4239 (Integral Investment Cast Airfoil & Hardware)

McWilliams Forge Co Inc	http://www.mcwilliamsforge.com, 387 Franklin Ave, Rockaway, NJ 07866 United States, Tel: + 1 (973) 627-0200, Fax: + 1 (973) 625-9316 (Turbine Disc & Sealing Plate - Stage 1)
Precision Castparts Corp	http://www.precast.com, 4650 SW Macadam Ave, Suite 440, Portland, OR 97239-4262 United States, Tel: + 1 (503) 417-4800, Fax: + 1 (503) 417-4817, Email: info@precastcorp.com (Structural Casting)
Special Metals Corp	http://www.specialmetals.com, 4317 Middle Settlement Rd, New Hartford, NY 13413 United States, Tel: + 1 (800) 334-8351, Fax: + 1 (315) 798-2001 (Waspaloy Billet)
Stalker Corp	PO Box 404, Essexville, MI 48732 United States, Tel: + 1 (517) 893-7562 (Compressor Stator)
Turbo Products International Inc	Pond Meadow Rd, Ivoryton, CT 06442 United States (Compressor Rotor Blade)
Unison Industries	http://www.unisonindustries.com, 7575 Baymeadows Way, Jacksonville, FL 32256 United States, Tel: + 1 (904) 739-4000, Fax: + 1 (904) 739-4093 (Cable & Ignition Lead)
Woodward FST Inc	http://www.woodward.com, 700 N Centennial St, Zeeland, MI 49464 United States, Tel: + 1 (616) 772-9171, Fax: + 1 (616) 748-7704 (Fuel Nozzle)
Wyman-Gordon Investment Castings Inc	839 Poquonnock Rd, PO Box 999, Groton, CT 06340 United States, Tel: + 1 (860) 445-7421, Fax: + 1 (860) 449-8052 (Investment Cast Airfoil & Hardware)

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Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Technical Data

Note: *The technical data that follow also pertain to the former AlliedSignal Engines and Textron Lycoming AGT1500.*

Design Features. The Honeywell AGT1500 has the following design features:

Intake. Air enters vertically through a vehicle-mounted two-stage air filter, composed of an inertial particle separator and a barrier filter, and is turned 90° to flow axially through the compressor.

Low-Pressure Compressor. Five-stage, axial-flow stainless-steel LPC of constant outside diameter, with variable inlet guide vanes. Stage 1 blades are mid-span shrouded, and are of wider chord (low aspect ratio). Two-piece compressor case.

High-Pressure Compressor. The HPC consists of a four-stage, axial-flow unit followed by a single centrifugal compressor. The HPC counter-rotates relative to the LP compressor. Overall pressure ratio is 14.0:1. Axial stages are of stainless steel, centrifugal unit of steel. HPC case houses four brazed stator assemblies, the last stage of which has a double row of vanes to remove all swirl to the centrifugal compressor.

Recuperator. High-pressure air from the centrifugal compressor travels radially and is turned 90° to flow through the internal passages of the recuperator. The air recovers some of the heat from the exhaust and is passed forward to enter the combustion chamber. The cylindrical recuperator surrounds the output shaft/ reduction gear assembly, and consists of stacked hydroformed plates which are resistance/laser-welded together. Air enters the recuperator with a temperature of over 850°F (454°C) and, after removing some of the heat from the exhaust gases, is channeled to the combustor. Recuperator material is IN625.

Combustor. Single tangential scroll-type reverse-flow annular combustor, with a Unison Industries (early built by AlliedSignal Controls & Accessories) exciter, single spark igniter and fuel nozzle. Combustion air enters at 1,050°F (566°C) at 206 psi (1,420 kPa). A bolted cover provides easy access to the combustor.

High-Pressure Turbine. A single, air-cooled HP axial turbine drives the high-pressure compressor. Disc is forged Waspaloy. Cooling air enters the roots of the 28 turbine blades and exits through trailing edge holes. Turbine Inlet Temperature (TIT) is approximately 2,180°F (1,193°C).

Low-Pressure Turbine. A single, uncooled axial stage drives the LPC via the inner coaxial shaft. The LP turbine nozzle has 23 nozzle vanes integrally cast with their inner and outer shrouds.

Honeywell AGT1500

Power Turbine Assembly. Two-stage, uncooled axial-flow-design power turbine drives the aft-mounted output shaft; a reduction gearbox reduces the 22,500 rpm to 3,000 rpm. Both stages are tip-shrouded. A variable power turbine inlet nozzle controls power output with shifting loads, thereby preventing overspeed and over-temperature.

Accessories. The auxiliary gearbox is located beneath the compressor housing and is driven from the HP compressor shaft. A vehicle hydraulic pump is driven by the gearbox, which provides hydraulic pressure for the vehicle's systems. FADEC is standard on the AGT1500A.

Dimensions. The standard AGT1500 has the following dimensions:

	Metric Units	English Units
Length, maximum	1,629 mm	66.5 in
Width, maximum	991 mm	39.0 in
Height, maximum	807 mm	31.8 in
Weight, dry	1,134 kg	2,500 lb

Performance. The Honeywell AGT1500 has the following performance parameters:

	Metric Units	English Units
Normal Power	1,120 kW	1,500 shp
Torque @ 3,000 rpm	3,754 Nm	2,750 lb/ft
Output Shaft Power:		
Nominal 100%	3,000 rpm	3,000 rpm
Mass Polar Moments of Inertia:		
Power Turbine Rotor	0.141 kgm^2	0.104 $ft/lb/sec^2$
Gas Producer Rotor	0.074 kgm^2	0.055 $ft/lb/sec^2$
Gas Flow Parameters:		
Pressure Ratio, Nominal	14.0:1	14.0:1
Mass Flow, Nominal	5.36 kg/sec	11.8 lb/sec
Exhaust Temperature	499°C	930°F
SFC of Standard AGT1500:		
At Full Power	0.30 kg/kWh	0.495 lb/shp/hr
At 1,200 shp	0.289 kg/kWh	0.475 lb/shp/hr
SFC of AGT1500 with DECU:		
At Full Power	0.274 kg/kWh	0.45 lb/shp/hr
At 1,200 shp	0.261 kg/kWh	0.43 lb/shp/hr

Variants/Upgrades

AGT1500. The AGT1500 is the basic engine version in the AGT1500 program. It develops approximately 1,500 shp (1,118 kW). Power increase to 1,675 shp (1,249 kW) was at one time proposed.

AGT1500A. The AGT1500A is a product-improved AGT1500 identified for use in the Transverse-Mounted Engine (TME) power package developed for possible use in upgrades of the U.S. Army's M1 tank series. See **Program Review** for a description of the TME package.

Program Review

Background. In November 1976, the U.S. Army awarded the XM1 Main Battle Tank contract to Chrysler Corp, Detroit, Michigan. That decision marked a milestone in that the Chrysler entry used the Avco Lycoming (now a part of Honeywell International and its now-invisible entity AlliedSignal Inc) AGT1500 vehicular gas turbine engine. The contract also initiated the first large-scale gas turbine-powered vehicle program in the United States. The total procurement of the engine by the U.S. Army and U.S. Marine Corps at that time was envisioned to exceed the 12,000-unit mark.

AGT1500 Development. Development of the AGT1500 began in the mid-1960s. Lycoming had put over 12 years into the program prior to its acceptance in

1976. Originally conceived as an alternate engine for the MBT 70 tank, the AGT1500 received initial funding from the Army Tank-Automotive Command and competed against two diesel designs for the contract. However, escalating costs, delays, and political constraints generated by the joint Germany/USA program resulted in the MBT 70 effort being scrapped.

Faced with the need for an M60 replacement, Congress and the Army began a new program, with Chrysler and General Motors as competitors. The effort was designated XM1, and Chrysler selected the Connecticut-made gas turbine powerplant for its design. GM offered a Teledyne Continental diesel-powered advanced design with increased acceleration characteristics.

In the late 1970s, Chrysler came close to bankruptcy as the result of sagging auto sales. In order to raise funds under provisions of the U.S. Government Loan Guarantee Program, Chrysler was forced to sell off its Defense Products Division in March 1982 to General Dynamics; the change in management had no impact upon production. The tank program is currently run by GD's Land Systems Division; Detroit, Michigan. Production took place in Warren, Michigan, and Lima, Ohio.

AGT1500 Applications. To date, the sole application of the AGT1500 has been the Chrysler/General Dynamics M1 Abrams tank series, designed by Chrysler Corp, Defense Products Division, and later sold to General Dynamics Corp, Land Systems Division (Detroit, MI). The M1 combat weight is 61.5 tons (55.79 metric tons) as originally equipped, while the M1A1 with the 120mm M256 cannon and depleted uranium armor has a combat weight of 67.59 tons (61.3 metric tons), and the M1A2 version, a weight of 68.75 tons (62,48 metric tons). All are 32.3 feet (9.85 m) in length, 12.0 feet (3.66 m) in width, and 9.48 feet (2.89 m) in height. The M1/M1A1/M1A2 has a maximum speed of 41.7 mph (67.1 kmph) and a range of between 240 and 310 miles (386-499 km), depending on model and whether or not NBC (nuclear, biological, chemical) equipment is in use. The last price quoted for the tank for the U.S. Army was $4.285 million in FY92/93, while the FY90 price for the M1A1 for the U.S. Marine Corps was $2.517 million.

U.S. Army M1 Procurement. Despite attempts at multiyear funding by the U.S. Army, Congress has changed the tank authorization quantity virtually on a year-by-year basis. Prior procurement quantities were: FY86, 790; FY87, 810; FY88, 689; FY89, 555; FY90, 481; FY91, 240; and FY92, 18. No procurement funding was authorized by Congress in FY93 and beyond. Recent funding has focused on M1A1/A2 block upgrade efforts.

Prior to FY86, historical M1 procurement by the U.S. Army was as follows: FY79, 110; FY80, 309; FY81, 569; FY82, 700; FY83, 855; FY84, 840; and FY85, 840.

U.S. Marine Corps Funding. The U.S. Marine Corps, in 1985, announced that it would replace its M60A1 tanks with the M1A1, with funding starting in FY88. The total procurement amount at the time was listed as 545 units, with the possibility of 15 additional units for attrition. Minimal funding was authorized in FY88, and the procurement started in FY89. While the service, in January 1988, sought 66 tanks in FY89, the Amended FY89 Budget Request, submitted in February 1988, requested $36 million in procurement funds for 14 vehicles. A total of 66 vehicles were finally funded for FY89, and 155 in FY90. No vehicles were sought in the service's FY91 or later budget submissions.

M1 Block III Tank. In 1986, the U.S. Army began investigating the next step beyond the M1A1/M1A2 Block II system, intended for service in the late 1990s and beyond. The Army's Block III tank is, at present, only a design concept. Forecast International's *Military Vehicles* Forecast indicates that the tank could be radically different from the current M1 tank. Among the options being explored are new engines, including diesels and a John Deere Model 580 three-rotor rotary powerplant.

Export Sales of M1A1. The M1 series of main battle tanks has garnered export sales.

Egypt. The first export sale of the M1A1 came nearer to fruition in June 1987 when it was announced that an agreement had been made with Egypt whereby that nation would acquire 555 M1A1s. The program called for General Dynamics to deliver 25 fully assembled tanks in 1991 (the vehicles were delivered by the end of 1991), followed by co-production of 530 tanks over a 10-year period beginning in 1992. Egypt would initially assemble the tanks from kits provided from the U.S., but would gradually produce components such as sprockets, wheels, and tracks. An estimated 81 percent of the total work content, however, would remain in the U.S., with Egypt not producing components having a critical or classified technology such as armor, fire control systems, engines, and transmissions. In 1996, Egypt requested an additional 31 M1A1 kits from the U.S.

As told to *Gas Turbine* Forecast on November 30, 1988, Egypt acquired the AGT1500 engine as part of the M1A1 package. Engines were shipped to GD.

Saudi Arabia. The second export sale was recorded in the summer of 1987 when Saudi Arabia ordered 315

M1A1s. A follow-on order for an additional 150 tanks was subsequently placed.

Kuwait. Kuwait selected the M1A2 in October 1992. As many as 285 engines were built in support of the 218-tank requirement.

Other Potential Customers. The United Arab Emirates (UAE) requested an emergency evaluation of the M1A1 in mid-1990, and shortly thereafter requested 337 tanks. Early in its investigation of competing tank designs, the UAE considered competing the M1 buy against the British Challenger and French LeClerc main battle tanks. The UAE finally decided on the LeClerc.

The M1 series has also been evaluated by Canada, Israel, Spain, Sweden, and Switzerland.

AGT1500 Continuing Engine Improvement Program. Under U.S. Army RDT&E funding, the AGT1500's low-power fuel economy was improved, as was its air filtration system. Through FY82, the AGT1500 Fuel Economy Program (FEP) component hardware was fabricated and rig tested. One full engine was tested offering a fuel mission improvement of 10 percent. This funding was extended to include improvements to the module interchangeability feature. From 1982-1984, the new self-cleaning air filter was tested and verified and the development of the new Pulse Jet Air Cleaner proceeded. Additionally, work on a more efficient ceramic recuperator, more temperature-tolerant turbine blades, and improved oil/bearing temperature tolerance began.

In May 1988, Textron Lycoming set up a task force to reduce the cost of training tank crews. It was determined that the excessive amount of time the M1 tank spent at idle provided an opportunity to reduce fuel costs. An initial series of tests was begun at Fort Knox, Kentucky, with an M1 modified to accept a new Lycoming Digital Electronic Control Unit (DECU) and the standard analog control unit. A series of follow-up tests were conducted at Aberdeen Proving Grounds, Maryland, in June 1989. Compared with existing engines, the tests demonstrated 11 percent to 26 percent lower fuel consumption at idle.

AGT1500 Increased Power? The possibility exists of additional government funding for an increased-horsepower AGT1500 to support vehicle weight growth in the future. While major U.S. Army R&D efforts are confined to advanced work in radial turbines, ceramic components and coatings, and with the LV100, Lycoming had held talks with the Army about raising the power of the AGT1500 to 1,600 shp, and has done design studies on its own of the merits of raising the power to 1,700 shp (267 kW). Indeed, with weight growth of the weapon system having generated an all-up weight of 67 tons, and over 70 tons (63.5 metric tons) for an M1A1 variant, an increased-performance AGT1500 might be deemed necessary if both the Army and Marine Corps wish to maintain their requirement for a tank with a power-to-weight ratio of 25 horsepower (18.64 kW) per ton. At that figure, 1,700 shp would be required for a 70-ton vehicle and 1,675 horsepower for a 67-ton vehicle. The AGT1500 is inherently capable of such growth without external dimension change or weight growth. Such growth would likely occur as a Component Improvement (CIP) effort.

In 1991, Textron proposed a Performance Recovery Program (PRP) for the AGT1500 which would raise the engine's power by up to 1,675 shp, resulting in 40 percent better fuel efficiency during training and 15 percent better efficiency during battlefield conditions. The increase in power would be attained by increasing the power turbine speed by 20 percent and improving the HPT efficiency. A two-stage reduction gearbox would enable the transmission to handle the same input speed as before.

A 75-horsepower Combat Support Module (CSM) would also be incorporated. The CSM consists of an auxiliary power unit (APU), exhaust duct and air inlet. It would be mounted as a fifth module of the tank engine; would be connected to the engine accessory gearbox through a two-way clutch; and would use the main engine oil, fuel and filter air.

AGT1500 Transverse Mounted Engine (AGT1500 TME). Textron Lycoming has been developing a product-improved version of the AGT1500 engine, designated the AGT1500 Transverse Mounted Engine, for use in the Transverse Mounted Engine Propulsion System (TME-PS) for the U.S. Army. The new propulsion package is mounted sideways, with the TME engine's centerline parallel to the transmission output centerline. For the AGT1500, the front power input module of the transmission is eliminated and the left side output housing is modified to accept power input. A power link from the AGT1500 TME (the AGT1500A) engine to the Allison (now Rolls-Royce) XT1100-3 transmission was accomplished using simple spur gears, which are located in a transfer gear case. In addition to housing the power link, the transfer gear case serves many purposes in that it also functions as a rear engine mounting structure, houses the torque converter, and acts as an accessory gearbox as well as a power takeoff (PTO) system. A Full Authority Digital Engine Control (FADEC) system replaces the current electrohydraulic transmission and engine control units. A more compact and efficient air induction system,

incorporating a self-cleaner, was developed by the Donaldson Company Inc, Minneapolis, Minnesota.

Also incorporated into the TME-PS is an 80-horsepower (59.6-kW) John Deere spark-ignition rotary engine, which generates electrical power and drives the NBC system. The elimination of the turbine bleed air requirement thereby improves engine life and dramatically reduces the need to run the main engine at idle.

The complete TME-PS power package weighs approximately 7,800 pounds (3,538 kg), and is 2.13 meters long, 1.98 meters wide and 1.18 meters high. The hull space freed up approximately 56 cubic feet (1.58 cu m) that can be used to carry add-itional fuel, ammunition, electronic countermeasures, NBC equipment, or an autoloader.

The XT1100-3 transmission is reportedly only 46 percent common to the in-service X1100-3B unit. The newer unit has seven, as opposed to four, forward gears, plus two reverse gears.

TIGER Program Launched

With the Army's M1 series Abrams tanks expected to remain in the force beyond 2030, the service tapped Honeywell, in early 2006 – under a contract with a potential value of $1.4 billion over 48 months – to improve the Abrams' engine performance as well as save money.

The Total InteGrated Engine Revitalization (TIGER) program for the AGT1500 turbine calls on the company to provide performance-based logistics and engineering design improvements.

Under the teaming arrangement, the company will bring its expertise to bear and work in a complementary role.

The TIGER contract has been signed, and the first year will mainly comprise putting the program in place. Honeywell will provide engineering support, design improvements, integrated supply chain management, material management, field repair support, field and overhaul data collection, and fact-based maintenance. The contract includes field support services in Kuwait and South Korea and at U.S. locations.

The goal of the program is to reduce operating costs while doubling the service life of overhauled AGT1500 engines to 1,400 hours.

While the Abrams modernization plan calls for moving from five or six variant to two variants, the M1A2 System Enhanced Program (SEP) variant and the Abrams Integrated Management (AIM) variant, the TIGER program is unaffected by this proposal.

With enough data, a future logistician involved in fleet management can determine that a part or engine needs maintenance prior to a mission, or make better decisions on deployment, support and material management.

The data can also determine, for example, if there is a consistent problem with a particular part. The TIGER program will look at the quality of the parts provided and help suppliers improve their products. Through a Web-based database, FBM will enable maintenance and parts management. For example, the database will be able to provide information on a particular part failing, which could lead to a fix or to a determination that another supplier needs to be found.

Honeywell is already starting to explore performance-based logistics at the macro level. In a separate program, Honeywell works on diagnostics and prognostics for the Army's Future Combat Systems program.

The Army will transition the responsibility for on-time acquisition and delivery of all engine parts to Honeywell during TIGER's first phase. This integrated approach is expected to lower operating and sustainment costs, improve parts availability, and boost the overall quality of engine components.

Funding

No major U. S. Army funding for the Honeywell AGT1500 has been awarded recently.

Contracts/Orders & Options

Contractor	Award ($ millions)	Date/Description
Honeywell International	321.464	Feb 2006 – FFP/CPFF contract for the revitalization of the automotive AGT1500 engine fleet under the TIGER program. (W56HZV-06-C-0173)
Honeywell International	69.421	Jan 2006 – FFP/CPFF contract for the TIGER program. (W56HZV-06-C-

Honeywell AGT1500

Contractor	Award ($ millions)	Date/Description
		0173)
Honeywell International	27.643	Jul 2005 – FFP contract for rebuild work on the AGT1500. (DAAE07-00-C-N131)
Doncasters Group	4.897	May 2005 – Delivery order amount of $4.897 million as part of a $49.741 million FFP contract for AGT1500 compressor blades. (W56HZV-05-D-0199)
Honeywell International	13.804	Apr 2005 – Modification to an FFP contract for rebuild work. (DAAEE07-00-C-N131)
Triumph Precision Castings Co	1.281	Apr 2005 – Delivery order amount of $1.281 million as part of a $32.972 million FFP contract for Stage 1 turbine rotor blades. (W56HZV-05-D-0176)
New Hampshire Balls Bearing Inc	0.298	Feb 2005 – Delivery order amount of $0.289 million as part of a $7.938 million FFP contract for ball bearings. (W56HZV-05-D-0036)

Timetable

Month	Year	Major Development
	1964	Avco awarded initial design contract
Oct	1965	Prototype AGT1500 engine development funded by U.S. Army
Jun	1973	XM1 Tank Validation Phase initiated (GM/Chrysler);
		Chrysler selects AGT1500 for the XM1
Nov	1976	Tank FSED Phase initiated
Mar	1978	First 11 full-scale engineering development engines delivered
May	1979	Army AGT1500 production
Nov	1979	First production AGT1500 engines delivered
Jan	1981	First M1-equipped unit formed in USA for testing
Sep	1981	U.S. DoD full-scale M1 production decision
	1983	M1 production reaches 60-per-month rate
Jun	1983	U.S. House of Representatives rejects second-source AGT1500 proposal
Nov	1983	Avco announces industrial AGT 1500
	1984	M1 production reaches 70-per-month level
Jan	1984	Avco ships 1,000th AGT 1500
Aug	1985	First M1A1 delivered to U.S. Army
Oct	1986	AGT1500 TME effort begun
Nov	1986	Multiyear engine contract (to 1991) awarded
Jun	1987	Approval granted for M1A1 licensed assembly/production in Egypt
May	1988	Lycoming task force established to reduce tank training costs: DECU effort begun
Nov	1988	7,000th engine delivered
Jun	1989	DECU follow-on tests begun at Aberdeen Proving Grounds
Sep	1989	8,000th engine delivered
Jul	1990	Saudi Arabia buy of 315 M1 tanks announced
Sep	1990	9,000th engine delivered
Late	1990	Initial deliveries of M1A1 tanks for U.S. Marine Corps
Late	1991	First deliveries of M1A1 to Egypt
	1992	First tanks delivered to Saudi Arabia
	1994	First tanks delivered to Kuwait
May	1994	AlliedSignal and Textron sign MoU on AlliedSignal acquisition of Textron Lycoming
Oct	1995	Last series-production AGT1500 completed (October 30)
	1997	Stratford Army Engine Plant closes
4Q	2005	AGT1500 production resumes for Egyptian requirement
3Q	2007	Egypt purchases 125 M1A1 tanks, bringing its inventory to 1,005
	2007-15	Further production of AGT1500 for other applications investigated

Month	Year	Major Development
	2009	Current batch of M1A1s expected to be completed in Egypt
Thru	2016	Continued aftermarket support of AGT1500

Worldwide Distribution/Inventories

At the start of 2008, almost 9,400 M1/M1A1/M1A2 vehicles had been built, including 765 vehicles by GD/Egypt Tank PL for Egyptian use. The 9,400 tanks have required over 12,268 engines.

The worldwide inventory of M1/M1A1/M1A2 vehicles is as follows: **Australia** (59); **Egypt** (1,005); **Kuwait** (218); **Saudi Arabia** (315); **U.S.** (8,040).

Forecast Rationale

With no new-build M1 series tank production planned for the U.S. military, Honeywell had, until mid-2005, been relegated to merely producing spare AGT1500 parts for the U.S. Army and a few nations outside the U.S. to assure adequate supplies. A number of engines for Foreign Military Sales (FMS) needs – for example, for Kuwait – were taken from U.S. military inventory.

After nearly 12,170 engines were produced, production of the AGT1500 ended, and the Stratford Army Engine Plant where the engine was built closed in 1997. For quite some time, Honeywell did not overtly pursue further vehicular turbine engine development since neither the AGT1500 nor the LV100 was selected for the next generation of U.S. armored vehicles, leaving these engines without vehicular applications.

In July-August 2005, the AGT1500 was reloaded onto the production line in Phoenix for a few hundred more new-build engines for Egypt – plus, we believe, a few (quickly and quietly sidelined) engines for U.S. needs.

This engine has generated considerable interest and a large following in military circles due to the fact that it is easily maintained.

A more powerful version of the AVDS-1790 diesel engine family has long been proposed for the M1 series of Abrams tanks. An improved version is now being developed as a private undertaking. The new version of the AVDS-1790 has an electronic common rail fuel-injection system in place of the mechanical fuel-injection of earlier engines. It also has larger after-cooling turbochargers, but is similar in weight to earlier versions. The uprated engine can be coupled to a number of transmissions, including the Rolls-Royce X1100 series installed in the M1 and other heavy armored vehicles.

With the only new-production M1A1 tanks coming off the line being those in Egypt, our forecast calls for 61 new AGT1500s, by Honeywell in Arizona, extending into 2009. The total could increase should the U.S. remain in Iraq and Afghanistan for years to come.

The GE/Honeywell LV100 may be substituted as a lighter and more efficient drop-in replacement as the steady sand-blasting takes its toll on the engines in the field.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION

Designation or Program	High Confidence				Good Confidence			Speculative			
	Thru 2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Honeywell Inc												
AGT 1500 <> SHP 1,500 to < 2,500 <> Drive for Heavy Tracked Vehicles												
	12,264	36	25	0	0	0	0	0	0	0	0	61
Total	12,264	36	25	0	0	0	0	0	0	0	0	61

Honeywell AGT1500