

ARCHIVED REPORT

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Artillery System 90 155mm Self-Propelled Howitzer

Outlook

- Serial production of AS90B for British Army complete
- HSW low-rate production of 48 Krab systems for the Polish Army reportedly completed
- No new production of AS90 systems or Braveheart turrets forecast at this time

Orientation

Description. A tracked 155mm self-propelled artillery system.

Sponsor. The prime contractor initiated the AS90 program as a private venture. The British Army sponsored the development and procurement of the AS90.

Status. Development through serial production.

Total Produced. Through 2023, we estimate the prime contractor produced two prototypes and 179 production AS90 systems.

The prime contractor and the Polish licensee reportedly produced 48 Krab systems.

Application. Mobile indirect fire artillery support for maneuver forces at the battalion through division levels.

Price Range. In 2024 U.S. dollars, the complete 155mm AS90B self-propelled howitzer carries an estimated unit price of \$6.958 million.

The AS90 Braveheart turret (with 155mm/52-cal ordnance), as a separate unit, reportedly carries an estimated unit price of \$3.58 million.

Contractors

Prime

| | |
|--|---|
| BAE Systems, Combat Vehicles (UK) | http://www.baesystems.com , Scottswood Rd, Newcastle upon Tyne, United Kingdom, Tel: + 44 0191 273 8888 , Fax: + 44 0191 273 2324, Prime |
| Huta Stalowa Wola SA | http://www.hsw.pl , ul Kwiatkowskiego 1, Stalowa Wola, Poland, Tel: + 48 15 813 42 15, Fax: + 48 15 842 19 08, Email: hsw@hsw.pl , Licensee |

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Subcontractor

| | |
|--|---|
| Collins Aerospace Systems, Sensors & Integrated Systems, Kidde Graviner | http://www.collinsaerospace.com , Mathisen Way, Poyle Rd, Colnbrook, Berkshire, United Kingdom, Tel: + 44 1753 766 261, Fax: + 44 1753 685 126 (Fire Detection & Extinguishing System) |
| Zahnradfabrik Friedrichshafen AG | http://www.zf.com , Graf von Soden Platz 1, Friedrichshafen, Germany, Tel: + 49 07541 77 0, Fax: + 49 07541 77 908000, Email: postoffice@zf.com (LSG 2000 Automatic Gearbox) |

Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 75 Glen Road, Suite 302, Sandy Hook, CT 06482, USA; rich.pettibone@forecast1.com

Technical Data

Design Features. Modular design incorporating an automatic loading system and advanced fire control components, including an automatic gun-laying system.

Crew. Four plus driver.

Muzzle Brake. Double-baffle.

Recoil Mechanism. Hydropneumatic.

Breech Mechanism. Split block with Crossley pad.

Ammunition. The Artillery System 90 can fire all NATO-standard 155mm artillery rounds, including Extended Range Full Bore munitions. The 52-caliber ordnance is optimized for the British Army's L12 and L14 modular charge technology.

Dimensions. The following data reflect the British Army's production-standard AS90B. Data for the AS90A are in parentheses where different.

| | <u>SI Units</u> | <u>U.S. Units</u> |
|------------------|--------------------|--------------------|
| Length overall | 9.89 m | 32.45 ft |
| Width | 3.40 m | 11.15 ft |
| Height | 3.0 m | 9.84 ft |
| Combat weight | 45.0 (36.0) tonnes | 49.6 (39.68) tons |
| Fuel capacity | 746 (600) liters | 198.4 (159.57) gal |
| Ordnance caliber | 155 mm | 6.10 in |
| Ordnance length | 39 cal/6.05 m | 39 cal/19.83 ft |

Performance. The maximum vehicle speed and range data reflect use on a paved road. The ordnance performance data reflect the 39-caliber cannon, firing non-assisted ammunition; data for the 52-caliber cannon firing non-assisted ammunition are in parentheses where different. The maximum rate of fire is for three minutes; a burst rate of three rounds in less than 10 seconds is possible.

| | <u>SI Units</u> | <u>U.S. Units</u> |
|------------------------|-------------------|--------------------|
| Maximum speed | 60 kmph | 37.26 mph |
| Maximum range | 650 km | 403.7 stat mi |
| Step | 88 cm | 2.88 ft |
| Trench | 2.8 m | 9.18 ft |
| Slope | 30% | 30% |
| Gradient | 60% | 60% |
| Fording | 1.5 m | 4.92 ft |
| Elevation | +70° | +70° |
| Depression | -5° | -5° |
| Traverse | 360° | 360° |
| Maximum ordnance range | 24,700 (30,000) m | 27,012 (32,808) yd |
| Maximum rate of fire | 6 rpm | 6 rpm |
| Sustained rate of fire | 2 rpm | 2 rpm |

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Engine. Cummins VTA-903T-660 four-stroke V-8 diesel engine. This supercharged, liquid-cooled engine generates 492.36 kW (660 hp), with a power-to-weight ratio of 11.73 kW per tonne (14.25 hp/ton).

The 24-V electrical system consists of four 12-V/100-ampere-hour batteries in the turret, and four more 12-V/100-ampere-hour batteries in the hull. The auxiliary power unit employs an unidentified two-stroke diesel engine, located in the forward part of the hull interior.

Gearbox. Zahnradfabrik Friedrichshafen LSG 2000 automatic gearbox, with four forward and two reverse gears.

Suspension and Running Gear. Hydropneumatic suspension, with six dual-tired roadwheels and three return rollers on each side. The drive sprocket mounts at the front; the idler is at the rear. The vehicle incorporates an automatic track tensioner/overload protection device with the idler gear.

Fire Control. The AS90 fire control suite features a ring laser gyroscope-based internal navigation system, an Avimo (Thales) DFS90 day/night direct-fire telescope, and an automatic gun-laying system integrated with the AS90 onboard computer.



Krab 155mm Self-Propelled Howitzer

Source: Huta Stalowa Wola SA

Krab

The Polish Krab system features the AS90 Braveheart turret, integrated with a tracked chassis. We estimate fuel capacity.

| | <u>SI Units</u> | <u>U.S. Units</u> |
|------------------|-----------------|-------------------|
| Length overall | 11.72 m | 38.46 ft |
| Width | 3.48 m | 11.42 ft |
| Height | 3.41 m | 11.19 ft |
| Combat weight | 46.68 tonnes | 51.46 tons |
| Fuel capacity | 900 liters | 239.4 gal |
| Ordnance caliber | 155 mm | 6.10 in |
| Ordnance length | 52 cal/8.06 m | 52 cal/26.43 ft |

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Performance. The maximum vehicle speed and range data reflect use on a paved road. The ordnance performance data reflect the 52-caliber cannon, firing non-assisted ammunition. The maximum rate of fire is for three minutes; a burst rate of three rounds in less than 10 seconds is possible.

| | <u>SI Units</u> | <u>U.S. Units</u> |
|------------------------|-----------------|-------------------|
| Maximum speed | 60 kmph | 37.26 mph |
| Maximum range | 650 km | 403.7 stat mi |
| Step | 80 cm | 2.62 ft |
| Trench | 2.8 m | 9.18 ft |
| Slope | 30% | 30% |
| Gradient | 60% | 60% |
| Fording | 1.7 m | 5.58 ft |
| Elevation | +70° | +70° |
| Depression | -3.5° | -3.5° |
| Traverse | 360° | 360° |
| Maximum ordnance range | 40,000 m | 43,744 yd |
| Maximum rate of fire | 6 rpm | 6 rpm |
| Sustained rate of fire | 2 rpm | 2 rpm |

Engine. The 2001 Krab prototype mounted the 850 KM PZL Wola S-850 diesel engine. This powerplant reportedly generates 624.9 kW (838 hp), with a power-to-weight ratio of 13.39 kW per tonne (16.28 hp/ton) in the Krab application. Production vehicles reportedly mount an MTU-881 KA 506 diesel engine.

Gearbox. An unidentified hydraulically controlled planetary gearbox, with one reverse and seven forward gears.

Suspension and Running Gear. Torsion bar suspension, with seven dual-tired roadwheels and three return rollers on each side. The drive sprocket mounts at the front; the idler is at the rear.

Fire Control. Same as the standard AS90.



British Army AS90B Fire Mission during Operation Telic

Source: British Army

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Variants/Upgrades

Variants. The prime contractor has developed the Artillery System 90 in two basic versions:

- The complete AS90 system for the British Army and export.
- A turret-only product, the AS90 Universal Turret, for export.

The 52-Caliber Braveheart. This latest version of the AS90 mounts the 52-caliber ordnance and features the Desert AS90 components (see following). The modular nature of the system allows customers to mix and match components to suit their requirements.

AS90 Universal Turret. In 1991, the prime contractor began development of a slightly modified AS90 turret for integration with a T-72 tank chassis. An interface ring allows direct attachment of the turret to the T-72 chassis; all turret, ordnance, and fire control functions remain the same. The AS90 Universal Turret weighs about 1.0 tonne more than the standard AS90 turret. Following contractor trials, the AS90 Universal Turret made its debut at the Royal Navy/British Army Equipment Exhibition in September 1993.

Desert Artillery System 90. In response to the unique requirements of the Middle East (and several potential customers in the region), the prime contractor has developed a desert version of the basic AS90 system. The Desert AS90 features include:

- An enhanced engine cooling system, featuring an aluminum radiator in place of the standard copper-zinc model. In addition, the radiator features more cooling fins, higher efficiency fans, and modified air inlet louvers. Also, components of the engine exhaust system have been relocated.
- Enhanced gearbox cooling, with the addition of an air-to-oil cooler.
- A gearbox with five forward gears.
- Enhanced cooling for the auxiliary power unit, featuring a larger coolant pump and improved self-sealing couplings for greater flow.
- An enhanced vehicle air conditioning system, featuring a larger compressor and heat exchanger. New-design louvers improve airflow. The Desert AS90 mounts an additional motor for the air circulation system. This version also dispenses with the crew heater and silencer.
- Various covers, mounted in several positions, that prevent sand from entering the vehicle.

- The Diehl-type 940 track (fixed horn with a taller profile), which improves performance in sand.

- Solar-reflective paint and a roof-mounted insulating cover that reduce heat buildup in the vehicle.

The Polish Krab. In 1999, Poland selected Chrobry as the name for its version of the AS90 Braveheart; the name was subsequently changed to Krab. The Krab consists of a 52-caliber AS90 turret integrated with a tracked chassis (reportedly designated the Kalina).

The original Krab prototypes mounted the AS90 turret on an indigenously developed hull. However, in September 2013, Huta Stalowa Wola (HSW) signed a letter of intent with Turkey's Mechanical and Chemical Industries Corporation (MKEK) for T-155 Firtina hulls. The Firtina is Turkey's license-produced version of the South Korean K9 Thunder.

Modernization and Retrofit Overview. The Joint Ballistic Memorandum of Understanding between Germany, Italy, the United Kingdom, the United States, and (later) France outlined the parameters of future artillery systems. Among its provisos, the document specified a 52-caliber length for 155mm artillery.

Although developed around the NATO-standard 155mm/39-caliber ordnance, the AS90 design from the outset could integrate the new 52-caliber ordnance, then under development by the Royal Armament Research and Development Establishment. This ordnance – initially designated the EXP36, or Extended Range Cannon – can (with assisted projectiles) achieve a range of 40 kilometers (43,744 yd), with a muzzle velocity of 921 meters per second (3,021.6 ft/sec). The 52-caliber AS90 variant can engage targets out to 30 kilometers (32,808 yd) firing unassisted projectiles.

AS90 ERO Program. In 1994, the U.K. Ministry of Defence initiated the Extended Range Ordnance (ERO) program, using the EXP36 (now designated L7A1) 52-caliber barrel integrated with the AS90 for initial trials. The L7A1 employs the same breech assembly, muzzle brake, and fume extractor as the original 39-caliber ordnance. Concurrently, the Modular Charge System (formerly the Unimodular Propelling Charge System) program was under competitive development. In 1994, the MoD selected Vickers Shipbuilding & Engineering as the prime contractor and systems integrator for the program.

On December 15, 1998, the U.K. MoD officially awarded the Extended Range Ordnance/Modular Charge System (ERO/MCS) contract to Marconi Marine Land and Naval Systems (now a component of

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BAE Systems). Marconi subsequently awarded major subcontracts as follows:

- To (then) RO Defence for the new 52-caliber L7A1 ordnance.
- To SOMCHEM (a subsidiary of Denel of South Africa) for the firm's M91 and M92 modular charge systems, designated L12 and L14 by the British Army.

The physical changeover from the 39- to the 52-caliber barrel actually takes less than two hours. In October 2002, RO Defence opened a new production facility in Barrow-in-Furness to produce L7A1 barrels.

Though the L7A1 contract was initially a boon to RO Defence, the award of the modular charge system to SOMCHEM effectively doomed the RO Defence Bishopston propellant manufacturing facility. It closed at the end of 2000.

The final development of the 52-caliber L7A1 and new charge system and integration with the AS90 are largely complete. However, ongoing problems qualifying the modular charge system prompted the MoD to set aside the ERO program in May 2004. The MoD is considering the MCS in conjunction with the now-separate Tubed Artillery Conventional Ammunition System (TACAS) program.

AS90 CEP. The AS90 Capability Enhancement Program (CEP) is investigating a number of other upgrades for the AS90. The MoD is currently executing the upgrade program through two Technology Insertion Packages, which replace the earlier Mid-Life Improvement program.

Technology Insertion Package 1 was the near-term portion of this effort, consisting of electronics-related enhancements to supplement the retrofit/integration of the Bowman communications system in the AS90. The prime contractor reportedly completed the AS90 CEP Technology Insertion Package 1 in 2009. Specific components include:

- An onboard ballistic computation system.
- A barrel bend measurement component.
- A centralized control and display unit.
- A GPS component.

This upgrade package also features an enhanced data processing capability, automatic fuze setting, and embedded training capabilities. The Technology Insertion Package 2 effort began in 2010 as a long-term program, involving unspecified survivability enhancements.

Program Review

Background. In 1982, Vickers Shipbuilding & Engineering Ltd began developing the GBT 155 modular howitzer turret. With an eye toward the export market, Vickers designed the turret for rapid integration with existing tank chassis.

Practical Limitations

However, the weight of such a turret-tank chassis configuration imposes severe operating limitations. The original design exceeded the weight capacity of many bridges, especially those in less developed countries. Further, integration of an artillery turret with a conventional tank chassis reduces the amount of interior space available for the crew and ammunition.

From V²C to AS90

Around 1984, Vickers began to investigate the development of a purpose-built chassis mounting an enhanced GBT 155 turret. Market studies had forecast a potential market for 3,500 units, many of them replacements for the ubiquitous M109. As the primary market for this new system would be outside the U.K., Vickers set up an international consortium to develop

and market the new weapon system, designated the V²C.

The Vickers-led consortium completed the first prototype in 1986. The Artillery System 90A made its public debut at the British Army Equipment Exhibition later the same year. In 1987, the second prototype (the Artillery System 90B) was rolled out, featuring a new turret for British Army requirements. By the early 1990s, the two programs had lost their distinctiveness, merging into a single AS90 effort.

Shifting Corporate Identity

Since 1998, Vickers Shipbuilding & Engineering has undergone several acquisitions and name changes, ultimately becoming a component of RO Defence. Since September 2004, RO Defence has operated as a component of BAE Systems plc.

Description. The Artillery System 90 is a modular design, stressing ease of manufacture, maintenance, and operation. The system makes wide use of standard off-the-shelf components. This design easily accommodates system upgrades, greatly enhancing the long-term effectiveness of the weapon system.

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Conventional but Modular

The AS90 exhibits a conventional self-propelled howitzer interior layout. The engine and gearbox mount in the right-front of the hull; the driver sits in the left-front. The Cummins powerpack is essentially the same as in the M2/M3 Bradley Fighting Vehicle and the M270 multiple launch rocket system (MLRS). The engine compartment features a Graviner fire detection and suppression system, with automatic and manual operating modes. The fuel tank mounts to the right-front of the fighting compartment. The hydropneumatic suspension occupies less vertical space than a conventional torsion bar system, thus reducing the overall height of the vehicle.

The driver's station, accessible through the hatch or through the fighting compartment, features a rearward-swinging hatch cover and three periscopes; the center periscope is interchangeable with a passive night driving periscope. The driver uses a steering wheel instead of the dual track levers of earlier vehicles.

The fighting compartment, with turret and ammunition storage, occupies the remainder of the vehicle. At the rear of the hull, a large door facilitates ammunition resupply. The commander and gunner (gun-layer) sit to the right of the gun; ammunition handlers sit to the left. Turret traverse (360 degrees) and cannon elevation (-5 degrees through +70 degrees) – controlled by the commander – are electric. The only hydraulic components are the ordnance balancing mechanism, the loading tray, and the flick rammer. All turret operations have manual backups.

The commander's station features a hatch and cupola on the turret roof. A roof hatch above the ammunition handlers' station provides access to a pintle-mounted 12.7x99mm (.50-cal) M2HB heavy machine gun. The hull and turret consist of all-steel armor with a maximum thickness of 1.7 centimeters (0.67 in). Each side of the turret features an access door and external protected storage.

The BAE Systems (RO Defence) Nottingham facility provides the 39-caliber cannon. This ordnance features a hydropneumatic recoil system, with a maximum recoil length of 88 centimeters (34.64 in). The barrel features a double-baffle muzzle brake and a fume extractor. The breech mechanism is a split-block design, with a Crossley pad obturation system. The AS90B carries 48 rounds of 155mm ammunition. Four magazine modules in the turret bustle store 31 ready rounds. The remaining rounds stow in the vehicle hull.

AS90B as Production Standard

The AS90B version of the Artillery System 90 addresses British General Staff Requirement 3399/1, issued following the demise of the Panzerhaubitze 155-1 (SP-70) program. In June 1989, the Ministry of Defence selected the AS90B to fill this requirement, ordering 179 units.

The B version features a number of changes and enhancements to the original A version, including:

- A more powerful version of the VTA-903 engine, rated at 492.36 kW (660 hp).
- A single wide-angle periscope for the driver, replacing the three periscopes of the A model.
- A double-thickness floor.
- Crew heating and air conditioning.
- A nuclear, biological, and chemical (NBC) protective suite.
- New Diehl tracks, with replaceable pads.

A main feature of the Artillery System 90 is the automatic gun-laying system, which allows the AS90 to receive target information from the Battlefield Target Acquisition System, a product of Marconi Radar and Command Systems (now a component of BAE Systems). A muzzle velocity system is standard equipment on the Artillery System 90.

Funding

The U.K. Ministry of Defence, through the British Army, funds the AS90 program. The Polish Ministry of National Defense funds the Polish Army's Krab program.

Contracts/Orders & Options

The initial British Army procurement contract for the AS90B, awarded in Jun 1989, was worth \$464.7 million.

In Jun 2005, the U.K. Defence Logistics Organization awarded BAE Systems a five-year partnering contract worth about \$105.8 million to provide logistical support for the British Army's six AS90-equipped field regiments of the Royal Horse Artillery and Royal Artillery.

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On May 12, 2008, the Polish Ministry of National Defense signed a contract worth \$101.36 million with Huta Stalowa Wola SA for the initial two-battery (eight-tube) Krab low-rate initial production order.

On Dec 14, 2016, the Polish Ministry of National Defense signed a contract worth \$1.1 billion with Huta Stalowa Wola SA for 96 Krab self-propelled howitzers of the Samsung Techwin K9 Thunder design.

Worldwide Distribution/Inventories

Export Potential. The modular design of the AS90, featuring proven off-the-shelf components, could be a significant marketing advantage. Yet, while this *combat-proven* system is competitive in terms of price on the international market, it still has to contend with the bargain-basement offerings of the Russian Federation. Further, the AS90 must compete with the ubiquitous M109, which will likely see at least another decade of service.

The most significant export potential for the AS90 lies with the AS90 Braveheart Universal Turret, as a retrofit to an existing chassis. The Polish Krab program represents the only export sale thus far. BAE Systems continues to aggressively market the complete AS90 and the Universal Turret on the international market.

Countries. **Poland** (48 Krabs); **United Kingdom** (two AS90 prototypes and 179 AS90Bs).

Forecast Rationale

With production of AS90B self-propelled howitzers complete, the center of gravity for the British Army's AS90 program has shifted to the modernization and retrofit of the remaining operational systems.

SDSR Leads to Reorganization

In the wake of the October 2010 Strategic Defence and Security Review, the British Army's AS90B active inventory suffered a 35 percent cut, leaving 116 units in service.

In early 2013, the Royal Artillery reorganized its surviving active AS90 assets into three close support regiments. Each of these regiments supports an armored brigade, and consists of three AS90 batteries and one precision-fire GMLRS (guided multiple-launch rocket system) battery.

Retooling the Krab

Poland's licensed low-rate production of the AS90 Braveheart Universal Turret for the Krab self-propelled howitzer is complete. The Krab program delivered 48 Krab systems, with a contract value of \$323 million.

The original Krab prototypes mounted the AS90 turret on an indigenously developed hull. However, in September 2013, HSW signed a letter of intent with Turkish manufacturer Mechanical and Chemical Industries Corporation (MKEK) for T-155 Firtina hulls.

The Firtina is Turkey's license-produced version of the South Korean K9 Thunder.

Scratching the Krab

In December 2014, South Korea's Defense Acquisition Program Administration (DAPA) and Samsung Techwin signed a contract with Poland for the purchase and licensed production of 120 K9 Thunder systems for the Polish Army. Thus, Poland is now relying on the K9 prime contractor for the K9 Thunder.

Under the terms of the contract, Samsung Techwin built the initial 24 K9 systems. Deliveries to the Polish Army were to have been complete by the end of 2018. After that, HSW would assume licensed production of the remaining 96 K9 systems.

On December 14, 2016, the Polish Ministry of National Defense signed a contract worth \$1.1 billion with Huta Stalowa Wola for 96 Krab self-propelled howitzers of the Samsung Techwin K9 Thunder design. This contract effectively terminated the Krab program at the end of 2019, after delivery of 48 systems.

Without new export sales, BAE Systems will likely find its AS90 line limited to producing components and spares for ongoing AS90 modernization and retrofit.

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