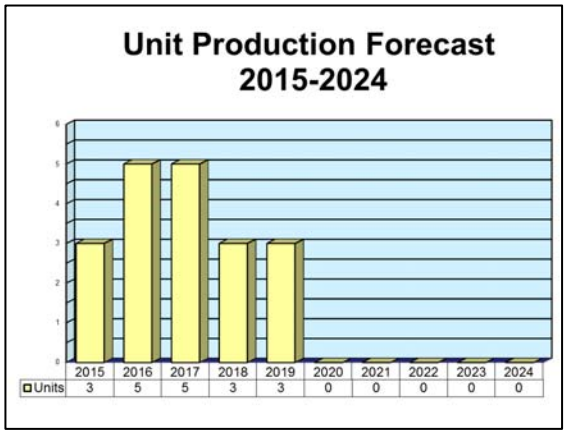
ADEN Aircraft Cannon

Outlook

- Production line for 30mm ADEN Mk 4 cannon available on an as-needed basis
- Center of gravity continues to be refurbishment of existing cannon
- Forecast reflects projected new production of 30mm ADEN Mk 4 cannon only



Orientation

Description. Aircraft cannon.

Sponsor. The U.K. Ministry of Defence, through the Royal Air Force and Royal Navy, sponsored the development and production of ADEN aircraft cannon systems.

Licensees. None.

Status. Development through as-needed production.

Total Produced. Through 2014, we estimate contractors produced 18,919 ADEN Mk 4 and 107 ADEN 25 cannon.

Application. Primary air-to-air and air-to-ground gun armament for a variety of tactical aircraft.

Price Range. In 2015 U.S. dollars, the 30mm ADEN Mk 4 reportedly maintains a unit price of $111,420; the ADEN 25 would cost at least $110,810.

Contractors

Prime

AEI Systems Ltd (Aircraft Equipment International Ltd)	http://www.aei-systems.com, 1 Kings Ride Park, Ascot, SL5 8AP Berkshire, United Kingdom, Tel: + 44 1344 636200, Fax: + 44 1344 636205, Email: sales@aei-systems.com, Prime

Subcontractor

BAE Systems plc	http://www.baesystems.com, 6 Carlton Gardens, Stirling Square, London, SW1Y 5AD United Kingdom, Tel: + 44 1252 373232, Fax: + 44 1252 383991 (ADEN Cannon Barrels)

Comprehensive information on Contractors can be found in Forecast International's "International Contractors" series. For a detailed description, go to www.forecastinternational.com (see Products & Samples/Governments & Industries) or call + 1 (203) 426-0800.

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

ADEN Mk 4

Muzzle Brake. None.

Recoil System. Pneumatic-mechanical.

Breech Mechanism. Enclosed cylinder.

Method of Operation. Mauser revolver, gas operation.

Ammunition. The ADEN Mk 4 fires the NATO-standard 30x113mm ADEN/DEFA cartridge, available in the following ammunition types:

- High Explosive (HE)
- High Explosive-Incendiary (HE-I)
- Armor Piercing (AP)
- Armor Piercing-Incendiary (AP-I)
- Armor Piercing-High Explosive-Incendiary (AP-HE-I)
- Semi-Armor Piercing High Explosive-Incendiary (SAPHEI)
- Multi-Purpose Tracer (MPT)
- Target Practice (TP)

Dimensions. The following data reflect the production-standard ADEN Mk 4 cannon.

	SI Units	U.S. Units
Caliber	30 mm	1.18 in
Length	1.59 m	5.21 ft
Width	24.17 cm	9.51 in
Height	24.61 cm	9.69 in
Weight	87.0 kg	191.4 lb

Performance. The following data reflect firing the standard HE-I ammunition.

Rate of fire	1,400 rd/min
Time to rate	0.02 sec
Time to stop	0.1 sec
Dispersion	<2 mil

The 30mm ADEN Mk 4 cannon carries a reliability rating of 15,000 mean rounds between failures.

Power. The ADEN cannon requires 26-volt direct current electricity for operation (firing-pin activation only). The initial cocking and charging of the cylinder occur via a pneumatically operated mechanism.

30mm ADEN Aircraft Cannon

Source: AEI Systems Ltd

ADEN 25

Crew. Per platform application.

Muzzle Brake. Double conical combined blast/muzzle brake.

Recoil System. Pneumatic-mechanical.

Breech Mechanism. Enclosed cylinder.

Method of Operation. Mauser revolver, gas operation.

Ammunition. The ADEN 25 fires all 25x137mm NATO STANAG 4173 ammunition, available in the following ammunition types:

- High Explosive (HE)
- High Explosive-Incendiary (HE-I)
- High Explosive-Incendiary-Tracer (HE-I-T)
- Armor Piercing (AP)
- Armor Piercing-Incendiary (AP-I)
- Semi-Armor Piercing High Explosive-Incendiary (SAPHEI)
- Semi-Armor Piercing High Explosive Incendiary-Tracer (SAPHEI-T)
- Target Practice (TP)
- Target Practice-Tracer (TP-T)

Dimensions. The following data reflect the production-standard ADEN 25 cannon.

	SI Units	U.S. Units
Caliber	25 mm	0.98 in
Length	2.29 m	7.49 ft
Width	24.99 cm	9.83 in
Height	24.61 cm	9.69 in
Weight	92.0 kg	202.4 lb

Performance. The following data reflect firing STANAG 4173 HE-I ammunition.

Rate of fire	1,850 rd/m
Time to rate	0.002 s
Time to stop	0.01 s
Dispersion	<2 mil

The ADEN 25 cannon carries a reliability rating of 18,000 mean rounds between failures.

Power. The ADEN 25 requires no external power source for operation. Initial cocking and charging of the cylinder occur via a pneumatically operated mechanism.

Variants/Upgrades

Variants. Not applicable; enhanced versions of these cannon carry new subdesignations.

Modernization and Retrofit Overview. Modernization and retrofit remains an ongoing process for this weapon system. The contractor provides enhancements through various retrofit packages and refurbishment services.

Program Review

Background. Mauser-Werke of Germany, historically one of the world's leading small arms firms, was also a prolific aircraft cannon designer from the 1930s through 1945.

The culmination of Mauser's aircraft cannon work was the MG213C, undoubtedly the finest aircraft cannon of

The Seminal MG213C Design

ADEN Aircraft Cannon

World War II. This 20mm cannon employed Anton Politzer's revolutionary revolver design. The MG213C (along with the Alliant Techsystems Chain Gun and the M61 Vulcan Gatling cannon) has been the basis for Western aircraft cannon technology since 1945.

The gas-operated MG213C revolver feed cycle consists of three separate and consecutive actions:

- Stripping a round from the ammunition link-belt.
- Feeding the round via an oscillating rammer into one of five chambers in the revolving cylinder.
- Presenting the round to the barrel located at the 12 o'clock position.

After firing, the cylinder rotates and ejects the case to the rear, again via the oscillating rammer. Firing is electric; initial cocking occurs via a pneumatically operated mechanism.

For the German Luftwaffe, the revolver operation not only accelerated the cyclic rate of the cannon, but it also reduced operating stresses on the various internal components of the cannon, allowing use of inferior materials in place of scarce high-strength alloys. The MG213C soon earned the respect of the Allied airmen who had to face it in air-to-air combat. With its 1,200-round-per-minute rate of fire, the MG213C had a devastating effect on any aircraft that crossed its path.

Emulating the MG213C

Following the war, the Allies scrambled to acquire and evaluate German technology, including the MG213C cannon. The United Kingdom, France, and the United States were each soon testing the MG213C; all three Allied powers subsequently endeavored to produce their own copies of the MG213C.

The U.S. version, the 20mm M39, featured minor design changes by the Illinois Institute of Technology. The Ford Motor Company and, ultimately, the Pontiac Division of General Motors produced the M39 over four decades. Before production finally ended in 1988, the M39 served on later models of the F-86, F-100, F-111, and F-5 fighters.

The French and British were less timid in copying the MG213C. The French version, the DEFA 552A, exhibited only minor changes. The DEFA 552A, as well as the follow-on DEFA 553 and 30-550 F4, remains in production today for such modern aircraft as the AMX and the Mirage 2000.

The British were apparently the least concerned about copying the MG213C. Their 30mm ADEN cannon is virtually a direct copy of the original German ordnance.

ADEN Mk 4

The name for the British copy of the MG213C is actually an acronym for the British design authority, Armament Development Enfield. The Royal Armament Research and Development Establishment at Fort Halstead also had a major role in the ADEN development program. The first British Ministry of Defence order for the ADEN was to arm the Swift, Supermarine's first swept-wing turbojet aircraft; Royal Ordnance (later RO Defence) was the ADEN prime contractor. Both RO Defence and Supermarine are now components of BAE Systems plc.

The first version of the Swift could accommodate only two cannon. Supermarine attempted to extend the inboard leading edge of the wing to carry ammunition for an additional two cannon. However, this installation caused an unacceptable and dangerous pitch-up of the aircraft when turning at high speed; Supermarine subsequently terminated the Swift-ADEN program.

Despite this setback, the ADEN Mk 4 has seen service with a wide range of British tactical aircraft – from the diminutive Folland Gnat through the first and only British-designed supersonic fighter, the Lightning. The highly successful Hawker Hunter represents the largest ADEN application to date. The following is a list of aircraft types mounting the ADEN Mk 4, along with the number of ADEN cannon per airframe:

Aircraft	# Cannons per Airframe
Ajeet	1
Gnat	1
Hawk 50/60/100	2
Harrier/AV-8A	2
Hunter	4
J32	4
J35	2
Jaguar GR.1	2
Jaguar T.1	1
Javelin	4
Lightning	2
Marut	4
Scimitar	4
Sea Harrier	2
Sea Vixen	4
Sk 60/Saab 105	1
Swift	2
Swift F.2	4

Very low-rate production of the original 30mm ADEN Mk 4 continues on an as-needed basis for export, including replacements and spares.

ADEN 25

By the mid-1970s, Royal Ordnance was investigating how to improve on the ADEN, especially in terms of rate-of-fire. After the fruitless design testing of the STRADEN program of the early 1970s, RO

concentrated on exploring options to update the 1940s-era 30mm ADEN/DEFA ammunition. After rejecting a 20mm round, RO found the answer in the new 25x137mm NATO STANAG 4173 round, developed for the M242 Chain Gun of the Bradley Fighting Vehicle.

The higher propellant forces of the new round required RO to beef up various components of the new ADEN. Since Royal Ordnance had planned all along that the new cannon be directly interchangeable with the original 30mm ADEN, any increase in weight was a serious concern. The 25mm ADEN 25 weighs only 5 kilograms (11 lb) more than the original 30mm ADEN. Yet, the ADEN 25 achieves a 24.4 percent higher rate-of-fire and has a 24.77 percent higher muzzle velocity than the 30mm ADEN Mk 4.

Dimensionally, the ADEN 25 is interchangeable with the ADEN Mk 4. The effects of the longer ADEN 25 barrel are mitigated by the combined blast deflector and muzzle brake.

In 1984, the British Ministry of Defence selected the ADEN 25 as the primary armament for the GR Mk 5 Harrier aircraft. The MoD issued the first ADEN 25 contract, for 81 cannon, in June 1987; RO delivered the first pre-production cannon six months later.

Sibling Rivalry

Subsequently, Royal Ordnance promoted the ADEN 25 for all aircraft mounting the ADEN Mk 4 cannon. In addition, the ADEN 25 was in competition for the next-generation Eurofighter program. The Mauser Bordkanone 7, a 27mm direct descendant of the original Mauser MG213C, won the Eurofighter ordnance contract. One cannot avoid the irony of a second-generation copy of the MG213C losing out to the direct descendant of the original MG213C. For further discussion of the Bordkanone 27 program, see the "Bordkanone 27" report in this Forecast.

Corporate Evolution

In 1988, after Royal Ordnance had closed its Enfield facility and transferred the ADEN 25 program to its Nottingham facility, Aircraft Equipment International acquired the technical data package for the entire ADEN aircraft cannon program. This acquisition included all of the intellectual property, as well as production and support rights. Since 1968, AEI has been primarily involved in refurbishing ADEN cannon.

In June 2005, AEI Systems Ltd inherited the production line of the now-defunct Aircraft Equipment International Ltd. BAE Systems plc still acts as a subcontractor, providing 30mm ADEN barrels. BAE Systems can also restart the ADEN 25 production line, if necessary, under the auspices of AEI.

ADEN 25: Odd Man Out

In 1992, as a result of problems with the ammunition feed components in the production cannon, as well as a perceived weight problem, the British Ministry of Defence awarded Aircraft Equipment International a contract to refine the design of the ADEN 25 and its ammunition feed components. Following redesign of the components, AEI resumed deliveries of 75 cannon and 1,055 barrels.

However, problems persisted with the integration of the cannon with the pod, and of the pod with the Harrier GR Mk 5 aircraft. Specifically, the RAF considered the combined weight of two ADEN 25 pods (430 kg/946 lb) to be too heavy for Harrier specifications. Further, the two pods, mounted beneath the aircraft fuselage, interfered with takeoff from the ski ramp of the Royal Navy's Invincible-class aircraft carriers.

The British Ministry of Defence determined the cost of correcting these problems would be an additional $24 million. Rather than spend this amount, the MoD ordered the ADEN 25 cannon removed from the Harrier GR Mk 5 and Mk 7 aircraft in 1999; the aircraft continue to fly without any cannon armament. The RAF and RN returned the hundred-odd ADEN 25 cannon to the MoD, which is offering the cannon for sale on the open market. The British MoD has yet to find any buyers for the ADEN 25 ordnance, however.

Related News

Weapons Acquired through South Africa's Multibillion-Dollar Arms SDPP Becoming Derelict

Weapons acquired via South Africa's Strategic Defence Procurement Packages (SDPP) are not being used and are becoming derelict, according to the nation's Arms Procurement Commission (otherwise known as the Seriti Commission), which was formed by President Jacob Zuma in 2011 to investigate allegations of fraud, corruption, impropriety or irregularity in the packages.

Funding and deliveries for the SDPP, initiated in 1999, ended in September 2012. The primary procurements associated with the SDPP included 28 Saab/BAE JAS Gripen multirole fighters, 24 BAE Hawk 100 lead-in jet

trainers, 30 Agusta A109 light utility helicopters, 4 MEKO A200 Valor frigates, and 3 Type 209-1400M submarines.

The commission noted that:

1. Many of the 30 Agusta A109s purchased "are in storage and unused or rotting at Ysterplaat Air Force Base in Cape Town."
2. The four frigates were reportedly equipped with defective engines and an obsolete combat suite and armory system.
3. The BAE Hawk and BAE/Saab Gripen fighter aircraft had almost no pilots to fly them, mechanics to maintain them, or even the money to fuel them.

Investigations into the SDPP continue. (FI, 10/14)

Production of Omani Air Force Hawk Advanced Jet Trainer Begins – On June 2, 2014, BAE Systems announced that it had begun producing the Hawk Advanced Jet Trainer (AJT) aircraft ordered by the Royal Air Force of Oman (RAFO).

Eight Hawk 128 advanced jet trainers were ordered in December 2012 in a GBP2.5 billion ($3.8 billion) contract that also included 12 Typhoon fighter jets. Delivery of the jets is expected in 2017.

The Hawk is powered by a single Rolls-Royce Turbomeca Adour turbofan.

The new Hawk AJTs are likely to replace the fleet of Hawk 103 advanced ground attack/trainer aircraft ordered in 1993 currently being used for training. (IHS Jane's, 6/14)

Funding

The U.K. Ministry of Defence, through the Royal Air Force and Royal Navy, funded the development and production of the ADEN and ADEN 25 aircraft cannon systems.

Contracts/Orders & Options

Unavailable, as neither the U.K. Ministry of Defence nor the contractors have not released contractual information.

Timetable

Month	Year	Major Development
	1942	Germany begins development of MG213 family of cannon
Feb	1944	German Luftwaffe introduces MG213C in combat
Dec	1947	U.K. begins development of slightly modified MG213C
	1950	Royal Ordnance develops first major ADEN application for the Hawker Hunter
	1950s	RO integrates ADEN with various other aircraft, including Lightning
Late	1975	ADEN 25 development begins
Jun	1984	U.K. MoD selects ADEN 25 for GR Mk 5 version of Harrier
Jun	1987	First production order for ADEN 25
Dec	1987	First production deliveries of ADEN 25
	1989	AEI acquires ADEN technical data package and all production rights
Early	1999	U.K. MoD removes ADEN 25 cannon from GR Mk 5/7 aircraft
Jun	2005	AEI Systems Ltd inherits former Aircraft Equipment International production line
	2015	AEI Systems continues marketing and producing original ADEN on an as-needed basis

Worldwide Distribution/Inventories

Export Potential. The original ADEN cannon did rather well on the export market, especially with the Hunter aircraft. In contrast, the failure of the ADEN 25 to integrate with the Harrier GR Mk 5 and Mk 7 aircraft served to kill any prospects for export sales. The hundred-odd new ADEN 25 cannon have yet to find a buyer.

Countries. The nations flying the aircraft types listed in the **Program Review** (above) also employ the original ADEN 30 cannon. To date, only the **United Kingdom** has employed the ADEN 25 cannon.

Forecast Rationale

The center of gravity for the 30mm ADEN Mk 4 aircraft cannon program remains the production of spare components for existing weapons. Now in its seventh decade of service, the basic ADEN design remains a viable product on the international market.

Limited Prospects

There are only limited prospects for production of complete new weapons systems, to meet attrition requirements and new orders for the various users of the cannon. The contractor maintains expectations for a limited production run of completely new ADEN Mk 4 cannon, supporting the popular Hawk aircraft.

Given the continued popularity of the Hawk aircraft worldwide, as well as the increasing age of existing ADEN cannon, the Forecast International Weapons Group maintains that a potential demand for at least some new-production ADEN Mk 4 cannon exists on the international market. In the meantime, however, we expect the refurbishment of existing cannon to remain the primary focus of the ADEN program.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program		**High Confidence**				**Good Confidence**			**Speculative**			
	Thru 2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
AEI Systems Ltd												
Aden MK 4												
	18,919	3	5	5	3	3	0	0	0	0	0	19
Total	18,919	3	5	5	3	3	0	0	0	0	0	19