

ARCHIVED REPORT

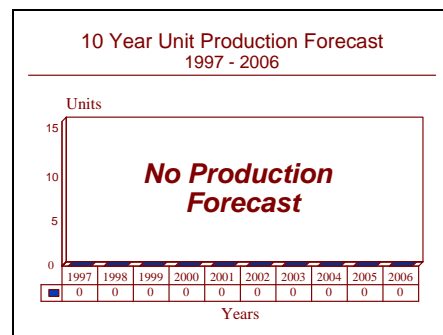
For data and forecasts on current programs please visit

www.forecastinternational.com or call +1 203.426.0800

Cymbeline -Archived 7/98

Outlook

- \$6.4 million upgrade & refurbishment contract received in 1997
- Total worldwide production nearly 400 sets
- Upgrade activity to Mk 3 in some countries is possible



Orientation

Description. I/J-band mortar detection, location and counter-battery artillery fire adjustment radar.

Sponsor

United Kingdom Ministry of Defence (Procurement Executive)

CB/Admin 3
St Georges Court
14 New Oxford Street
London WC1A 1EJ
United Kingdom

Contractors

Racal Radar Defense Systems

Radar House
Dawley Road
Hayes
Middlesex UB3 1HZ
United Kingdom
Tel: +44 181 573 3888
Telex: 22417

Raychem Limited

Edison Road
South Dorcan
Swindon
Wiltshire SN3 5HH
United Kingdom
Tel: +44 1793 861485
Telex: 449597

The English Electric Valve Co

106 Waterhouse Lane
Chelmsford
Essex CM1 2QU
United Kingdom
Tel: +44 1245 261777
Telex: 99103

GKN Defence Operations

PO Box 20
Hadley Castle Works
Telford
Shropshire TF1 4RE
United Kingdom
Tel: +44 1952 44321
Telex: 35248/9

CIBA-Geigy Bonded Structures

Duxford
Cambridge CB2 4QD
United Kingdom
Tel: +44 1223 833141
Telex: 81250

Racal Radar Defense Systems is responsible for development and manufacture, with Raychem Limited the harness suppliers. The English Electric Valve Co supplies the magnetron. GKN Defence Operations is responsible for trailer and FV 432 integration. CIBA-Geigy Bonded

Structures produces the reflector. Walter Jones & Co Ltd and Muirhead fulfill unspecified functions.

Licensee

Bharat Electronics Limited (BEL)
Trade Center
29/4 Racecourse Road
Bangalore 560001
India
Tel: +91 812 2751/2
Telex: 043477

Status

Cymbeline Mk 1 In service

Cymbeline Mk 2 In service

Cymbeline Mk 3 Production and service

Total Produced. Total worldwide production of Cymbeline including licenses production does not exceed 400 sets.

Application. Cymbeline Mk 1 and Mk 3 are towed systems mounted on a specially built trailer. In British Army service the 1-t Land Rover acts as prime mover. Cymbeline Mk 2 is configured for deployment aboard the FV 432 in British Army service.

Price Range. A current estimate of the unit cost of a new-production Cymbeline Mk 3 is US \$2.0 million.

Technical Data

Dimensions	Metric	US
Height		
Folded in transit:	1.07 m	42.5 in
In operation:	2.29 m	91 in
On trailer--folded	1.8 m	71.5 in
On trailer--in use:	3.02 m	120 in
Width		
Folded in transit:	1.68 m	66.5 in
On trailer--folded	1.78 m	70.5 in
Length		
Folded in transit:	1.5 m	59.6 in
On trailer--folded:	2.9 m	115.2 in
Weights		
Radar + power supply:	390 kg	858 lb
Trailer bare:	520 kg	1144 lb
Equipment on trailer:	980 kg	2156 lb
Performance		
Maximum displayed range:	20 km	12.5 miles
Minimum detection range:	1 km	0.6 miles
Location time:	15/20 seconds	
General		
Frequency:	I/J-band	
Peak power:	100 kW nominal	
Azimuth limits:	1200 mils	
Slew rate:	200 mils per second	
Scanned sector azimuth:	720 mils	
Elevation:	-90 to + 360 mils	
Elevation set up angles:	25, 45, 65 mils	
Alert beam separation:	40 mils	
Double beam separation:	90 mils	

Design Features. The Cymbeline radar system is composed of 12 major units. The antenna consists of a parabolic reflector illuminated from beneath by a triple-cone Foster scanner. Other antenna units include a

telescope attachment. Antenna characteristics are described above in the data section. The system produces a pencil beam scanning in azimuth. The reflector folds down flat for transport.

In the Radar head group, the azimuth ring fits onto the frame radar mounting unit, to which the leveling jacks and the azimuth drive are attached. The radar head group is fitted in and around the radar head frame rotating above the azimuth ring. The radar head group comprises most of the major radar subsystems, including a generator set, electronic assembly main unit (transmitter/receiver), distribution box, scanner, reflector, and elevation resolver. In transit, the operator posts are also stowed in the trailer, together with the associated remote cabling.

On the trailer mounted version the radar head unit is mounted on a four-legged structure supported by screw jacks fitted with hydraulic shock absorbers. The equipment may be deployed either on the ground or on the trailer. Leveling is achieved by means of adjustment using two simple spirit levels attached to the chassis at opposing angles of 90 degrees. The towed version can be carried as a slung load by medium lift battlefield helicopters. In British Army service the Mk 2 tracked version is fitted on top of the FV432 hull. Operator positions are inside the vehicle, and shut down, if necessary, is almost instantaneous. Cymbeline can be fitted to most APCs in the current NATO inventory, and retrofit potential exists for many in service tracked vehicles serving with armies outside NATO. In the tracked version, leveling is achieved automatically by hydraulic means.

All variants of Cymbeline have built-in power generation provided by a Wankel engine driving a 400 Hz generator. An integral fuel tank provides for eight-hour running. The engine employs rope start and runs in a silent housing, which can cause overheating. Thermal cut-outs are built in to overcome this problem.

The operator posts may be deployed up to two meters apart up to a distance of 15 meters from the radar head. Controls consist of a short persistence B scope (incorporating all the controls necessary for the operation of the radar), and a second unit on which the target coordinates are displayed. Operation is usually a two-man job. It is possible to site the two displays adjacent to a single operator, however, and an alerter beam may be employed to notify the user of target information. This reduces operator fatigue by eliminating the need for constant vigilance.

Cymbeline operates on a fairly straightforward principle. It detects mortar bombs in flight at two points on the trajectory as they pass through the radar beam(s). The operator then plots, by pencil marking, slant range and bearing. Elapsed time is measured and the total data

package passed to an analogue computer which combines this data (together with pre-set elevation angles) to determine the hostile mortar's position. The process takes place in approximately half a minute.

The normal crew is composed of four men, with two more on listening patrol forward of the radar to identify aurally the most profitable likely sector for radar scanning. Detection range on an 81 mm bomb is in the region of 10,000 m, while a 120 mm bomb is detectable at up to 14,000 m. The Russian 160-240 mm mortars are detectable at greater range.

The position of the located mortar is given in the form of an eight-figure grid reference on the second display. For long-range missions a switched single beam is used. For short-range work a dual beam can be employed to assist accurate timing and enhance the multi-target tracking ability. Provision has also been made for the fitting of an optional digital data storage module, to facilitate storage of radar returns for enhanced persistence.

A data memory unit is available as an optional extra. When fitted, it is incorporated into the main electronic assembly. The data memory unit dispenses with the need for manual plotting, with continuously displayed signal and electronically generated slant and range marker lines aligned directly on the signals. A Moving Target Indicator (MTI) unit is also available as an optional extra, suppressing returns from stationary or slowly moving targets.

Operational Characteristics. The Cymbeline counter-battery radar in all its configurations is primarily intended to detect hostile mortar fire, compute tube location and present the operator with a fire control solution. Although Cymbeline was designed as a mortar-locating radar, it also has the following secondary mission capabilities: adjustment of artillery fire by air and ground burst; adjustment of artillery fire by in flight trajectory analysis; local control of helicopter movement; and meteorological balloon tracking.

Cymbeline can be demounted, and is man-portable over short distances using poles and slings stowed aboard the trailer. Particular attention has been paid to ensuring Cymbeline is as light as possible. The mounting, radar head frame, scanner and reflector frame are all fabricated from aluminum honeycomb sandwich, with solid metal employed only for stress or fixing points. Cymbeline is predominantly solid state, with the CRT, magnetron, and thyratron being the sole thermionic components.

Consistent with NATO practice, Cymbeline is designed for first line repair by subsystem replacement. BITE

facilities generate instructions to the operator detailing which unit to replace. The BITE facilities may instruct the operator to report the fault to a rear echelon field repair vehicle, while a base repair workshop handles subsystem (unit) overhauls. The field repair workshop is configured in a standard ISO container mountable on any suitable prime mover (in British Army service a Bedford MK is used). It is air-conditioned and has bench and storage facilities. As a result of a repair concept which advocates the exchange of complete units, skilled personnel are not required forward of the field repair unit.

A target simulator is available for field training purposes. It presents realistic synthetic signals to the operators' CRT, randomly generated at intervals of up to 15 seconds. Marking and fire control solutions can be practiced in the field with this equipment. For base work an operator trainer is also available and uses video taped returns from a live system to train up to three operator crews simultaneously.

Variants/Upgrades

Cymbeline Mk 1 Original production trailer-mounted version now supplanted by Cymbeline Mk 3

Cymbeline Mk 2 Cymbeline Mk 1 repackaged for installation on the FV-432 APC.

Cymbeline Mk 3 Radically improved and upgraded variant of Cymbeline Mark 1. Major improvements include a new solid state phased array antenna, increasing sector coverage from 40 to 60 degrees. An

MTI unit (see above) is incorporated as standard equipment. Digital processing and video data storage replace the previous analogue components. The man-machine interface has been improved by the use of high quality liquid crystal displays and input via digital keyboards. Remote operation is now possible up to 30 m from the set. A 50 percent increase in displayed range is also provided. A new high resolution display capable of alphanumeric presentation completes the upgrade.

Program Review

Background. The first British mortar locating radar program was an offshoot of the 3Mk7 AA Fire Control Radar system and was designated 3Mk7F. As 3Mk7F began to enter service, the British Radar Research Establishment (RRE) began project Blue Diamond, a program which was to culminate in the British Army's Yellow Fever AA fire control system. Although once again an AA fire control system, it was deemed to have potential for development as a mortar location radar. Out of Project Blue Diamond EMI Electronics, with the close cooperation of the Royal Signals and Radar Establishment (RSRE), came the development of the Green Archer system. A development contract was awarded in 1955, and after prototype evaluation, Green Archer entered service with the Swedish and British armed forces in 1962. Green Archer has been superseded by Cymbeline, but it is still in service with the armies of Argentina, Denmark, India, South Africa and Germany. Cymbeline deliveries to the British Army commenced in 1973, followed by initial deliveries of tracked versions in 1975. Total deliveries to the British Army and overseas clients had reached 100 sets by March 1976. The Cymbeline radar systems were deployed during the Falklands War. By 1982 Cymbeline had generated over 100 million pounds worth of business for Thorn EMI. By 1984, over 300 sets had been delivered, and the system was in the service of 16 armies. Up to 1985, Cymbeline's British service had been confined to field artillery regiments.

Project Zenda was a multinational program to develop a gun locating radar using phased array technology. By the early 1970s Britain and Denmark were the only countries left and the program faltered. The British Army's next generation weapon location radar program, designated Cervantes, was also canceled in the early 1980s. It had been based on a highly modified Cymbeline radar, and the requirement was to extend the capabilities of Mk 1/2 to incorporate effective rocket battery location.

A significant product improvement program led to the introduction of Cymbeline Mk 3 in 1988. Thorn EMI has received a number of contracts to upgrade older Cymbeline radars to the Mk 3 standard. No export contracts for this new variant have been received but the radar continues to be bid for emerging requirements. Most recently, this included an Indian requirement for twelve counter-battery radars.

Between January and April 1994, Cymbeline counter-battery radars were deployed to Bosnia in order to provide counter-battery capability to British forces supporting UN initiatives. During early 1995, Thorn-EMI sold its defense interests to Racal Radar Defense Systems who have taken over responsibility for the Cymbeline program.

In April 1997, Racal received a contract worth \$6.4 million from Arab International Optonics to refurbish and upgrade twelve Cymbeline radars now in service with the Egyptian Army. This contract represents the largest

amount of activity this program has generated in the last 10 years.

Funding

Cymbeline was developed under UK MoD contract. Up to 1987 known Cymbeline expenditures totaled US \$207 million. This is certainly only a small fraction of the true total.

Recent Contracts

Contractor	Award (\$ millions)	Date/Description
Thorn-EMI		December 1987 — New Zealand MoD contract for Cymbeline upgrade to Mk 3 standard
Thorn-EMI	3.2	July 1989 — Upgrading Cymbeline radars used by two Middle East countries to Cymbeline Mk 3 standard
Racal-Thorn Defense	6.4	April 1997 — Contract issued by Arab International Electronics (in conjunction with the Egyptian Ministry of Defence) to refurbish and upgrade 12 Cymbeline radar sets in service with the Egyptian Army. Includes spares, training and support. Also includes options for additional systems (number unspecified)

Timetable

Jul	1973	First British Army Cymbeline Mk 1 entered service
Jan	1975	First British Army Cymbeline Mk 2 entered service
Mar	1976	Home and export deliveries reached 100
	1977	Cervantes program announced
	1983	Cervantes canceled, Cymbeline update planned
	1985	Thorn EMI announced orders had totaled 300
Dec	1987	Contract for upgrading New Zealand Cymbeline
	1988	Cymbeline orders reached 350
	1991	Cymbeline orders totaled "just under 400"
	1995	Cymbeline taken over by Racal Radar Defence Systems
Apr	1997	Racal-Thorne Defence secured a \$6.4 million refurbishment and upgrade contract for 12 systems

Worldwide Distribution

A total of just under 400 Cymbeline radars are in service with 19 countries. It is believed the following countries are users:

Switzerland , Norway , Denmark , and Finland are believed to be operators of the Cymbeline radar system.

India Bharat Electronics Limited (BEL), a subsidiary of Hindustan Aeronautics Limited (HAL), reportedly manufactures Cymbeline under a license granted by the UK MoD and Thorn EMI. The indigenous Multi-target Field Artillery Radar (MUFAR) program is intended to replace Cymbeline in Indian Army service. It has a reported range of 16 kilometers and has been developed from the basic architecture of the Cymbeline. It incorporates several Cymbeline components.

Far East Singapore, Australia and New Zealand are confirmed operators of Cymbeline with New Zealand at least known to have upgraded to Mark 3 standard. Malaysia and Indonesia are believed to be Cymbeline users.

Middle East Iraq and Oman have been confirmed as Cymbeline operators although the number of sets operated by Iraq was highly exaggerated in a 1991 report. Saudi Arabia, Egypt, and Kuwait are, or were, believed to operate Cymbeline. Any surviving Kuwaiti sets presumably ended up in Iraq.

Africa Nigeria has been confirmed as a Cymbeline operator; South Africa and Malawi are also thought to operate Cymbeline.

Forecast Rationale

While no orders for new systems have been placed since 1990 (production ceased more than four years ago), in April 1997, Racal received a contract to refurbish and upgrade 12 existing Cymbeline sets in service with the Egyptian Army worth approximately \$6.4 million. This order represents the most activity this program has seen this decade. Other orders of this sort may follow from Cymbeline users, considering that the radars still work adequately and the cost of refurbishing the equipment is only a fraction of the cost of a new system. With almost 400 Cymbelines in 19 inventories, Racal can expect to be providing a high level of support activity for many years to come.

The Cymbeline has only limited capability as an artillery location radar. Operation in the I/J-band is a major obstacle to further enhancement of the Cymbeline system for this application. The range of the system is adequate for all foreseeable mortars, and the effects of heavy clouds can be minimized by low angle scanning, bringing an early target interception.

The current US counter-battery radars, TPQ-36 and TPQ-37, employ the G/H-band. The main rival to Cymbeline is the US TPQ-36 mortar location radar, which has made impressive inroads into the overall market for mortar

location radars. The problem for Racal is that TPQ-36 is part of the wider US FIREFINDER system, a total artillery fire control solution package which includes the TPQ-37 artillery location radar.

In the current market, emphasis is being placed on counter-artillery radars optimized for detecting the long range, relatively flat trajectory guns now favored by many armies. Mortar detection radars are virtually ineffective against these weapons and attempts to use them in tracking such fire have been uniformly unsuccessful.

The latest generation of lightweight battlefield surveillance radars have mortar detection and localization as one of their assigned roles. These two factors make the purchase of new Cymbelines difficult to justify and probably explains the current emphasis on upgrades rather than new procurement.

The Royal Artillery's current Cymbeline inventory is sufficient for the time being. It is believed that Britain will operate the Cymbeline radar well into the next century, being supplemented rather than replaced by COBRA. Over 70 Cymbeline radars are in service with the British Army representing useful revenue in Post Design Service contracts and continued subsystem manufacture. More upgrade contracts are expected in the coming years.

Ten-Year Outlook

No production is forecast

* * * * *