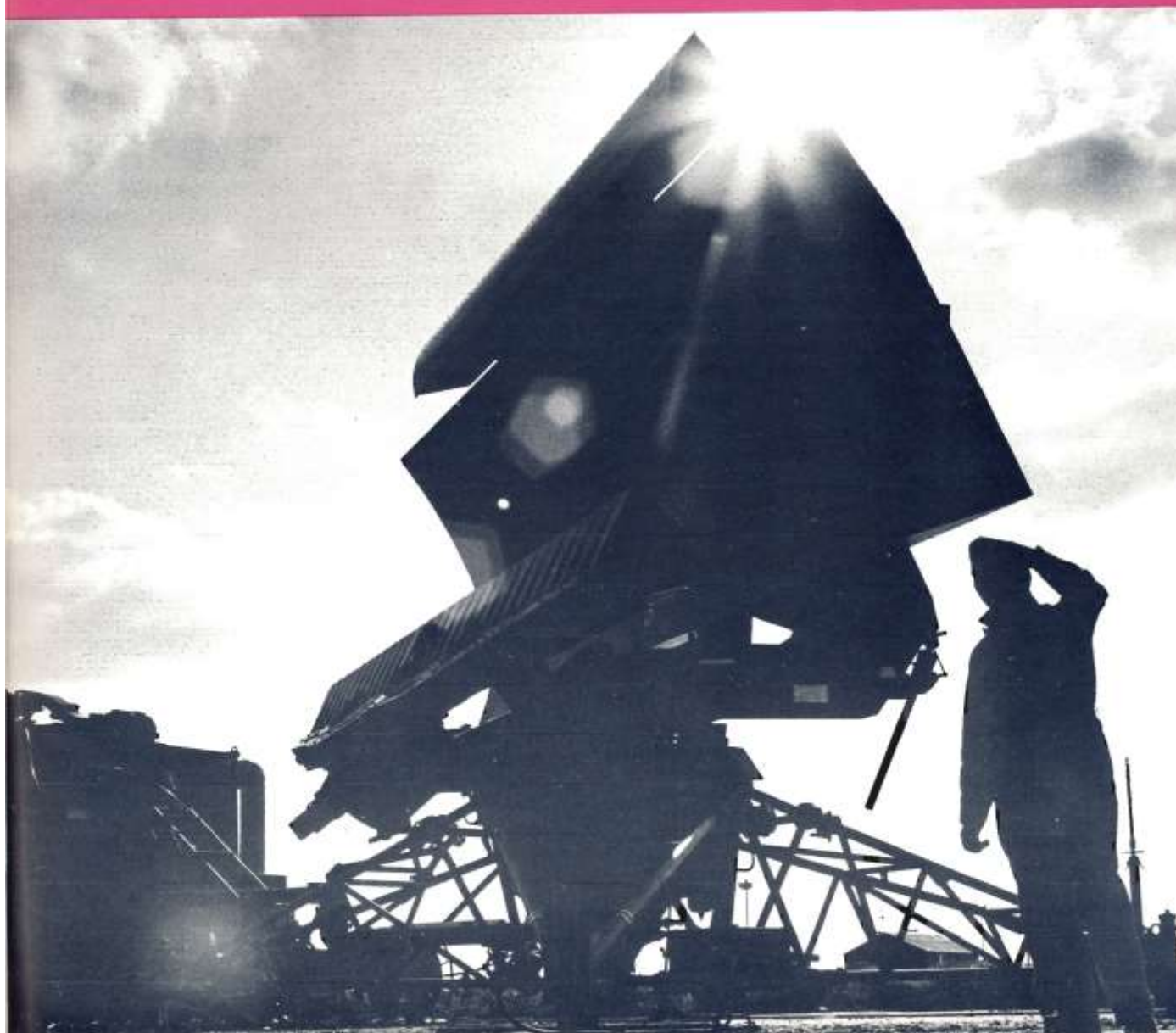


**Marconi  
Radar**

Defence Radar  
Systems



# Area Defence

The effective defence of sovereign territory and installations depends upon an accurate knowledge of the air situation at any given moment. Adequate warning of hostile movements in the air can best be obtained by provision of full radar cover.

The latest Marconi range of radar equipment can provide this vital cover. The range is comprehensive and contains both two- and three-dimensional systems, in static or transportable versions, all with improved range capability on small targets, greater flexibility in operation, and more refined techniques to combat enemy Electronic Counter Measures (ECM).

## System Philosophy

The choice of the main parameters of a radar air defence network must be governed by consideration of the operational environment and total air defence organization within which the

network is to function.

Such considerations include the nature and magnitude of the threat, the defensive weapons available, the size and topography of the area, and the radar counter measures likely to be encountered.

By selecting suitable elements from the Marconi range, systems can be provided to cover all contingencies. Facilities may be built up in a tactical situation from a simple mobile surveillance component to a full strike-and-intercept Air Defence Centre operating with wide supporting services and communications.

## Transportable Radar Systems

### Surveillance Radars Types S604 and S605

Modern tactical airspace control with its emphasis on rapid deployment of forces demands the continuous

reporting of air movements by transportable, fast-into-action radar stations.

The Marconi Radar Types S604 or S605 form the surveillance element of such a station providing plan position data on a medium bomber aircraft within a 160nm radius.

The robust, conventional, highly reliable design coupled with excellent performance and high ECM resistance has led to the choice of this equipment by armed forces throughout the world.

The radars employ highly efficient, low sidelobe linear fed antennas of patented design to provide excellent ECCM characteristics. The S604 has a single high-power L-Band transmitter/receiver with a tunable magnetron and digital MTI for maximum clutter rejection. The S605 has a second such transmitter/receiver and MTI system operating in frequency diversity for enhanced performance and jamming resistance.

Major equipment items:

Antenna Type S1016.

2MW 23cm L-Band transmitter/receiver Type S2011.

Signal processing equipment Type S7100.

Antenna control unit Type S6011.

Ancillary equipment S600 Series.

Video combining unit Type S7102 (S605 only).

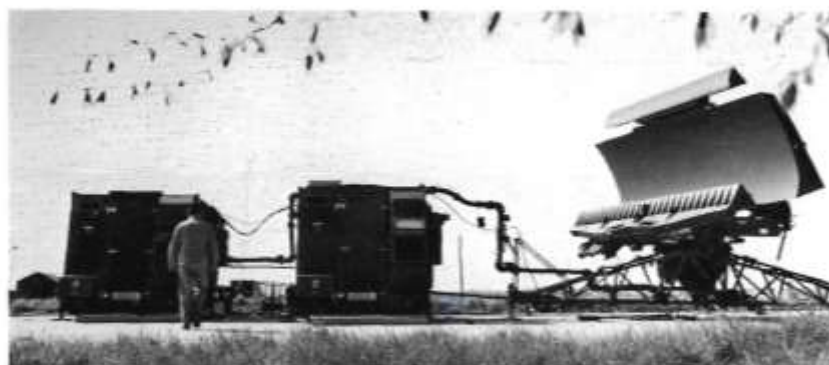
### Options

IFF antenna and interrogator/responder.

Primary radar plot extractor Type S7200 and associated link buffer Type S7210.

IFF plot validation unit Type S7300 and associated decode unit Type S7310. Monitor display.

The antenna module Type 1016 comprises a single-curvature cosec<sup>2</sup> reflector, a squintless linear feed, a turning gear with data take-off elements, a high-power rotating joint and associated slip-ring unit mounted on a combined gantry/chassis. The unique squintless feed assembly permits diversity operation and also enables a radiation pattern to be achieved with first sidelobes better



A portable diversity radar (S606H) in operation



An S600 Series transportable surveillance antenna ready for the road



than  $-28\text{dB}$  and an average sidelobe level of better than  $-40\text{dB}$ .

The IFF antenna when required may be mounted above the primary radar reflector.

The transmitter/receiver Type S2011 provides the radio frequency power and video output in the S604/S605 surveillance radar systems. It comprises a single cabinet, engineered to give an extremely compact assembly whilst maintaining easy accessibility to all components. The receiver system includes a special ECCM receiver for use in conditions of jamming.

The signal processor Type S7100 uses digital techniques and can interface directly with a primary radar plot extractor Type 7200. It provides moving target indication, area clutter switching, clutter constant false alarm rate control, pulse recurrence frequency stagger and pulse recurrence frequency discrimination.

The major items of electronic equipment are housed in an electronic cabin Type S5016. In the S604 system one cabin S5016 (Main) is required; in the S605 system an additional cabin S5016 (Diversity) is also required.

The S5016 (Main) houses an L-Band transmitter/receiver, a digital signal processor and an antenna control unit. If the options of IFF, primary/secondary radar plot extraction and monitor display are required these equipments are also mounted in this cabin.

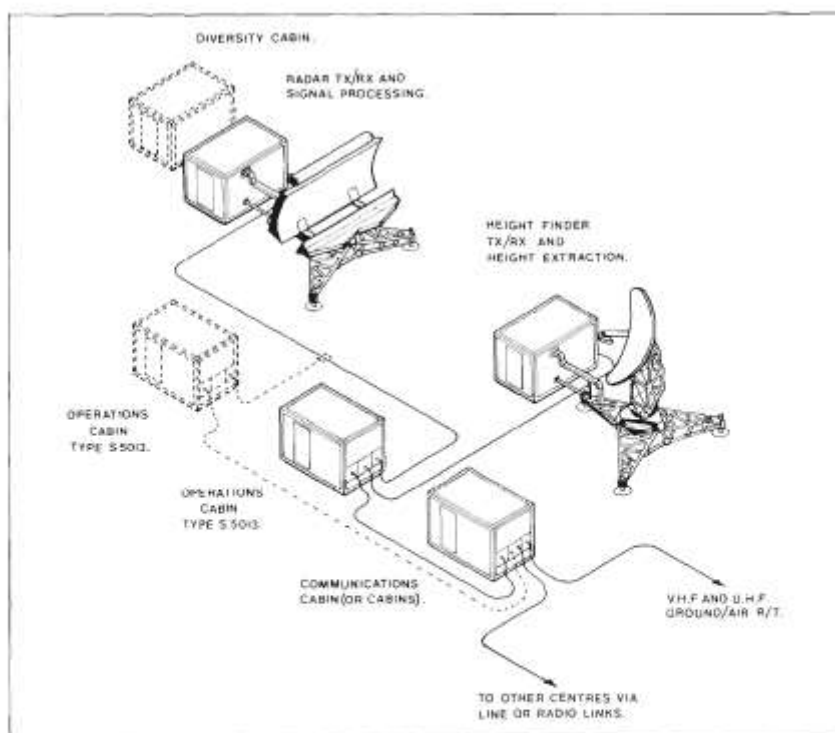
The S5016 (Diversity) houses the second L-Band transmitter/receiver and associated digital signal processor, a video combining unit, a diplexer and an antenna control unit.

In the S605 diversity arrangement the diplexer combines the signals from the two L-Band transmitter/receivers for application to the common antenna. Both transmitter/receivers produce IF signals and log and linear video signals. The IF signals are fed to the associated digital signal processor for MTI processing, and all videos are fed to the video combining unit to produce combined log, linear and processed video signals.

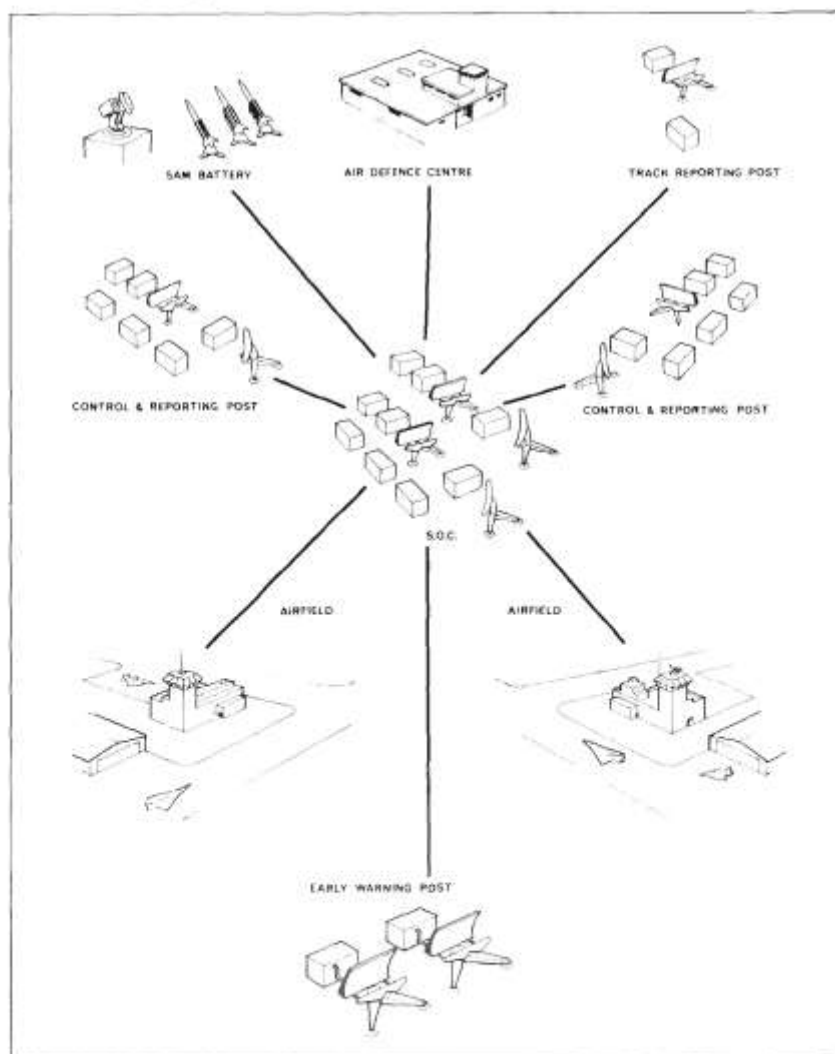
Changeover units are automatically controlled by signals from the transmitter/receivers, digital signal processors, and video combining unit to select the appropriate main, diversity or combined video signals.

The link buffer accepts plot information from both the primary and IFF plot extractors, correlates primary and IFF replies from the same target, and transfers the plot data in serial form suitable for transmission over telephone lines or data links.

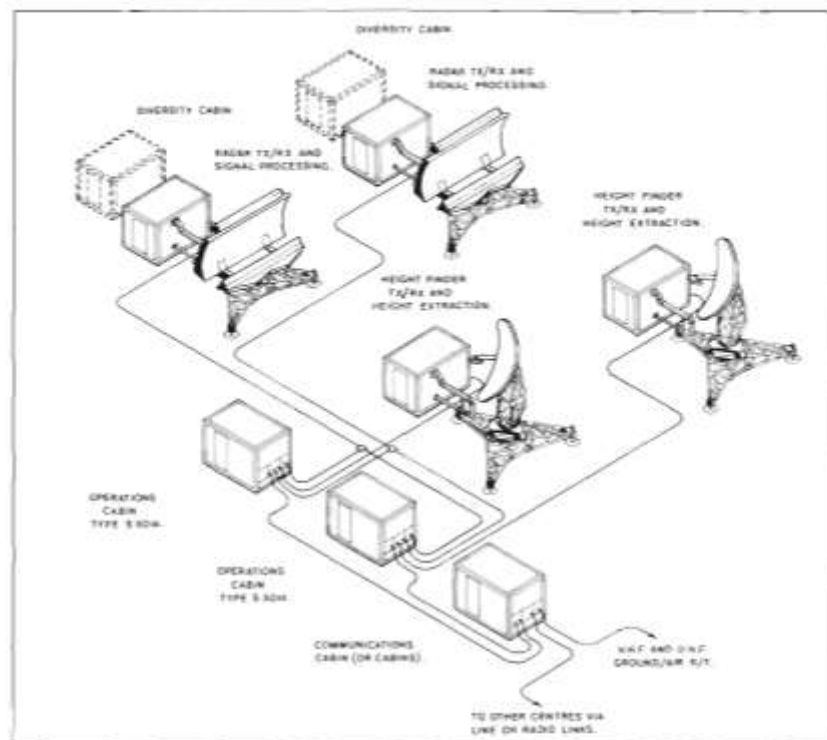
The monitor display, if fitted, is used to monitor both analogue and digital videos at selected parts in the



Control and reporting station



Integrated tactical control system



Area control station

video/processing chain. This allows confidence checks to be carried out on all system components.

Air dryers are housed in both the main and diversity cabins to operate with the waveguide air supply system. The associated compressors and air conditioning units are not fitted within the cabin. For ease of replacement they are carried separately and mounted adjacent to the cabins when deployed.

#### System Performance

To illustrate the performance of any radar the parameters are fitted into a range calculation equation. Account is taken of the duty cycle, range requirements, system transmission losses, receiver bandwidth, display collapsing and operator losses, antenna beam shape and atmospheric losses. All of these factors combine to determine the optimum values of the variable parameters.

#### Operational Parameters

Target size 5m<sup>2</sup> (typical fighter aircraft)  
Single look probability 80 per cent  
False alarm rate of 10<sup>-6</sup>  
Fluctuating target loss - Slow  
fluctuating target (Swirling Case 1)

#### Fixed System Parameters

Wavelength 23cm  
Peak power 2.0MW  
Receiver noise factor 2.5dB  
Antenna beamwidth 3.14°  
Static clutter suppression 36dB

Note: nm denotes nautical mile(s).

#### Variable Parameters - Early Warning/GCI Role

Pulse length 5μs  
P.R.F. 290 p.p.s.  
Rotation rate 6 rev/min

	S604	S605
Calculated slant range, free space 5m <sup>2</sup> target	206km (113nm)	271km (145nm)
Clutter Cancellation ratio (including scanning effect)	35.5dB	35.5dB

#### Surveillance Radar Types S624 and S625

To enhance the performance in both radar detection of small aircraft and

ECCM of the radars Type S604 and S605 the antenna equipment can be replaced by a Type 1061 7.62m (25ft) squintless feed cosec<sup>2</sup> antenna, to form radars type S624 and S625.

This antenna system has been designed to be transportable by road, rail or air, but it can also be used as a static radar.

The main advantages are the exceptional sidelobe performance and the increase in range. The squintless feed enables a radiation pattern to be achieved with first sidelobes better than -30dB and an average sidelobe level of better than -45dB.

An IFF antenna may be mounted above the primary radar reflector.

As in the case of S604/S605 radar systems, the S624 and S625 transportable surveillance radars use single or diversity transmitter/receivers Type S2011. All other options and facilities are equally available.

#### System Performance

Using the same operational transmitter/receiver parameters as for the S604/S605 the improved performance is:

	S624	S625
Calculated slant range, free-space 5m <sup>2</sup> target	267km (144nm)	343km (185nm)
Clutter Cancellation ratio (including scanning effect)	34.6dB	34.6dB

#### Heightfinder Radar Type S613

The Marconi Type S613 is a transportable nodding heightfinder radar operating at 5.5cm C-Band and using techniques and components common to the surveillance radars in the S600 series.

A digital angle extractor and height computer combined with very rapid electrically actuated slew and nod



Surveillance antenna S1061





A deployed S600 series radar convoy (S613 in foreground)

servo drives provide high data rate, high accuracy automatic height measurement on targets commanded from the display system.

Special scan modes give long dwell time and volumetric search capability for the tricoordinate detection of targets under heavy jamming.

Major equipment items are:

Antenna Type S1017

1MW 5.5cm C-Band

transmitter/receiver Type S2013

Servo control and height extractor

Type S6013

Ancillary equipment S600 Series

The transmitter/receiver, servo control and height extractor are housed in an electronics cabin Type S5012.

The Type S1017 mobile antenna comprises a double-curvature reflector, a horn feed, an elevation scanning gear with a data take-off element, a turning gear with data take-off elements, two rotating joints and a slip-ring unit mounted on a combined gantry/chassis.

The S613 heightfinder derives its radio frequency power and its video signals from the transmitter/receiver S2013, contained within a single cabinet which is engineered to give an extremely compact assembly, whilst maintaining easy accessibility to all components. The receiver system includes a special ECCM receiver for use in conditions of jamming.

The antenna can be operated in four modes:

In the normal mode, the antenna slews to a command bearing and performs a nod, the angle and velocity of which are appropriate to the target range as determined by the surveillance radar and the maximum height capability. This provides a number of pulse returns from a target proportional to target range. The sequence is performed each time a command is received. With this mode of operation the data rate is up to 22 heights per minute dependent upon the azimuth separation and range of each

successive height request.

In the sector scan mode, the antenna slews to the counter clockwise end of a required sector. The antenna then azimates slowly through the sector, at the same time nodding through a preset angle. When scanning of the sector is complete, the antenna repeats the sequence, unless commanded otherwise. In this way, the radar can provide surveillance facilities to cover sectors subjected to ECM action or give limited support when a surveillance radar is not operational.

The volumetric scan mode is an extension of the sector scan mode in which the antenna azimates through 360°, while nodding through a preset angle.

In the park mode, the antenna slews to a preset bearing, then nods up to a preset elevation angle and stops where no operational or personnel hazard exists due to radiation. This action occurs automatically after a time out period.

The automatic height extractor is functional only when the antenna is in the normal mode. The extractor samples the angular position of the antenna every p.r.f. and passes the result to the elevation processing stage. The extractor also accepts the received returns from the transmitter/receiver, compares the video against a threshold which is controlled to maintain a constant false alarm rate, and stores the returns falling within a four mile gate centred on the target input range.

The contents of the store are compared with the returns from subsequent radar periods to establish the presence of a target. The centre of the target returns together with range correction is transmitted in digital form to the display system.

An air dryer is fitted in the cabin to operate with the waveguide air supply system. The associated compressors and air conditioners are not fitted within the cabin. When deployed they

are mounted adjacent to the cabin.

#### Operational Parameters

Target size 5m<sup>2</sup> (typical fighter aircraft)

Single look probability 80 per cent

False alarm rate 10<sup>-6</sup>

Fluctuating target loss - Slow

fluctuating Target (Swerling Case 1)

#### Fixed System Parameters

Wavelength 5.5cm

Peak power 1.0MW

Receiver noise factor 4.5dB

Antenna beamwidth (Vertical) 0.9°

#### Variable Parameters - Early

##### Warning/GCI Role

Pulse length 5μs

P.R.F. 290 p.p.s.

#### Performance

Calculated slant range, free space 5m<sup>2</sup> target 128 nautical miles

## Martello Long Range 3-D Radar

Martello is an advanced technology 3-D radar operating in L-Band (23cm), the result of many years of research, design and development by Marconi. The system provides long range automatic three-dimensional radar cover under conditions of severe Electronic Counter Measures (ECM) and is suitable for both static and transportable roles.

Martello utilizes the latest antenna design and signal processing techniques to provide fully automatic detection and plotting of targets in hostile environments. The simply constructed planar type array is self-erecting and easy to maintain.

Performance is the same for both static and transportable roles and the system has a capability normally found only in the permanently installed static type of radar.

#### Martello Features

The principal features of the Martello system are:

1. *A Phased Array with Superior Sidelobe Performance*  
Superior sidelobe performance is achieved by precise control of the amplitude and phase of the signal to each antenna element.
2. *Unrestricted Frequency Flexibility*  
Since the radar frequency is not used in any way to determine the beam position, there is no restriction, within the band, on the operating frequency of the radar. Consequently, any enemy contemplating the use of active jamming must spread his jamming power over the band.

3. **Excellent Clutter Suppression**  
Excellent clutter suppression is achieved by the use of pulse compression and digital doppler processing. These two features give improvement in this respect:

(a) Pulse compression is employed to improve visibility in clutter, both natural and man made. The pulse is compressed from  $10\mu\text{s}$  down to  $0.26\mu\text{s}$  as part of the processing in each beam. This allows a smaller radar cell to be used so that there is less clutter competing with the target signal.

(b) The MTI system uses digital doppler filtering in conjunction with adaptive thresholds to maintain a constant false alarm rate at the output of the processing system and to obtain the best possible combination of sub and super-clutter visibility at all velocities including zero doppler.

4. **IFF/SSR System**

Martello contains a complete IFF/SSR system providing sidelobe suppressed automatic plot and mode-code data on military and civil modes 1, 2, 3/A, B, C and D.

The IFF/SSR range performance is matched to that of the primary radar.

5. **Radar Management Suite**

The Radar Management Suite is used for monitoring and controlling the 3-D radar facilities, including frequency agility, pulse compression, digital doppler signal processing and plot extraction. It comprises a PPI type display and a programmed Locus 16 processor with associated input devices.

**Equipment**

Martello consists of the following units:

1. L-Band (23cm) 3-D Antenna S1067 complete with IFF antenna.
2. Electronics Container S5034 containing the high-power 3.3MW frequency agile coherent Transmitter S2019, the signal processor and plot extractor equipment, the Radar Management Display Suite and the IFF/SSR equipment.
3. Services Container S5035 containing all the necessary equipment to cool and air-condition the transmitter container.
4. Two Power Containers S5036.
5. Deployment Container S5037.

**Martello Antenna Type 1067**

The planar antenna of Martello consists primarily of a hollow metal spine carrying a set of 12 horizontal element assemblies. The hollow spine houses the vertical power divider, the beam forming network and the horizontal element duplexers and receivers, allowing easy access for servicing purposes.

The 12 horizontal element assemblies slide on to the front face of the spine, each element assembly consisting of 5 dipole strips, each strip carrying 32 dipoles. The complete planar array is carried by a strong, reliable turning gear fitted with two drive motors, a high-power rotating joint, a set of slip-rings and a data take-off system.

The planar array and associated turning gear are supplied mounted on to a specially modified ISO pallet, 12.2m (40ft) long, which is itself carried by a special ISO trailer unit. The trailer is fitted with stabilizing arms and levelling jacks. For transport purposes the antenna spine is lowered to the horizontal position and the horizontal elements are removed and carried in a second pallet.

Where the ISO transport terminal facilities are to be used, the pallet is dismounted from its trailer. In this condition it complies with ISO regulations.

When deployed, with the trailer levelled and stabilized by means of its integral arms and jacks, the antenna is raised to its vertical operating position by use of a self-contained hydraulic ram unit. The antenna rotational speed is 6 revolutions per minute.

**L-Band (23cm) Transmitter Type S2019 (Part of Electronics Container Type S5034)**

Type S2019 is a frequency agile, coherent transmitter with a peak power of 3.3MW. The transmitter consists basically of three equipments;

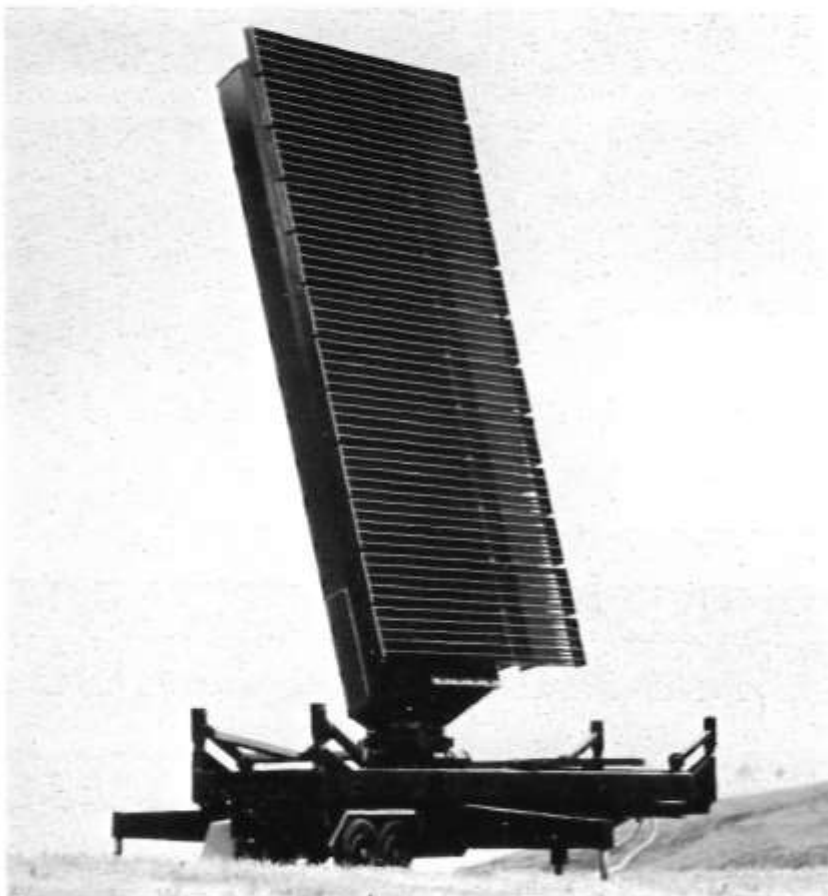
- (a) The modulator
- (b) The e.h.t. control and power supply
- (c) The transmitter drive.

The modulator comprises the hybrid power amplifier, the modulator itself, the focus magnet supplies, and the overall transmitter control system.

The e.h.t. control and power supply houses the complete e.h.t. power unit and its associated solid-state control systems.

The transmitter drive contains a travelling wave tube power amplifier and also the frequency synthesis system.

The three equipments are housed in styled cabinets, designed so that all access is from the front.



Martello antenna in deployed condition





Martello turning gear, etc.

Adequate cooling is provided from the Services Container S5035, which supplies forced air cooling for the general components and water cooling for the Output Tube, Electro-Magnet Assembly, Pulse Transformer and Isolator.

#### Signal Processing

Martello uses an array signal processing system for the elevation plane in which the signal contributions from the individual rows constituting the array are passed separately to a beam forming network.

The beam forming network takes the signals and forms them into nine simultaneous beam patterns to achieve the required vertical cover and heightfinding accuracy. Beams, numbers one to eight inclusive, are pencil shaped, stacked in elevation; beam number nine is a cosec<sup>2</sup> pattern, similar to the transmit elevation pattern. Short and medium range surveillance is obtained by using the cosec<sup>2</sup> pattern, while long-range early-warning is supplied by the lowest pencil beam, number eight, which is a high gain low angle beam.

Height data is extracted from the eight stacked beams. The lower beams have an elevation width of approximately 1.6° increasing to approximately 11.5° for the top beam.

All beams are 2.8° in azimuth. Plan Position information is obtained by conventional scanning with the antenna rotating at 6 revolutions per minute. Elevation data is obtained by monopulse processing of the signals in adjacent beams. Since this processing is carried out on a common radiated frequency, even when the transmitter is in a frequency agile mode, accurate height measurements are achieved.

The signals from the nine beams are carried from the antenna to the Electronics Container S5034. The

cosec<sup>2</sup> beam is processed by the measures selected to deal with the prevailing clutter, chaff and ECM conditions. Plot extraction completes the signal processing on the cosec<sup>2</sup> beam and these signals are correlated with the IFF/SSR data. The combined data is then passed direct to a local tracking and data handling system or to a remote operations centre via a modem and telephone line or radio link.

The eight stacked beams feed the height extractors after pulse compression, and height data is available to the local and/or remote tracking and data handling facilities.

The outputs from Martello are:

1. L-Band primary radar plot data comprising position in azimuth, range and height.
2. IFF/SSR plot data comprising position in azimuth, range and mode/code information. This output is combined with the primary output.
3. A combined output comprising video signals, sync and turning data.

These outputs can be provided to operate a radar display system via either broad band or narrow band links or suitable cable.



Assembly of Martello horizontal antenna elements



Martello power divider network



## Static Radar Systems

### Long Range Surveillance Radar Type S631

The Marconi Radar Type S631 high power, static, air defence surveillance radar provides plan position data within an airspace bounded by the radar horizon and a ceiling in excess of 30.5km (100,000ft) on small military aircraft.

Diversity transmitters radiating in S- and L-Bands simultaneously through a highly efficient off-set linear fed back-to-back antenna system together with extensive digital signal processing provides outstanding performance under adverse conditions of electronic jamming, weather and ground clutter.

This radar is a modern derivative of equipment supplied for the NATO early warning system.

Except for r.f. power valves and cathode ray tubes, all electronic circuitry is solidstate making extensive use of micro-miniature digital techniques with the consequent improvement in reliability, performance and ease of repair and maintenance.

Major equipment items are:

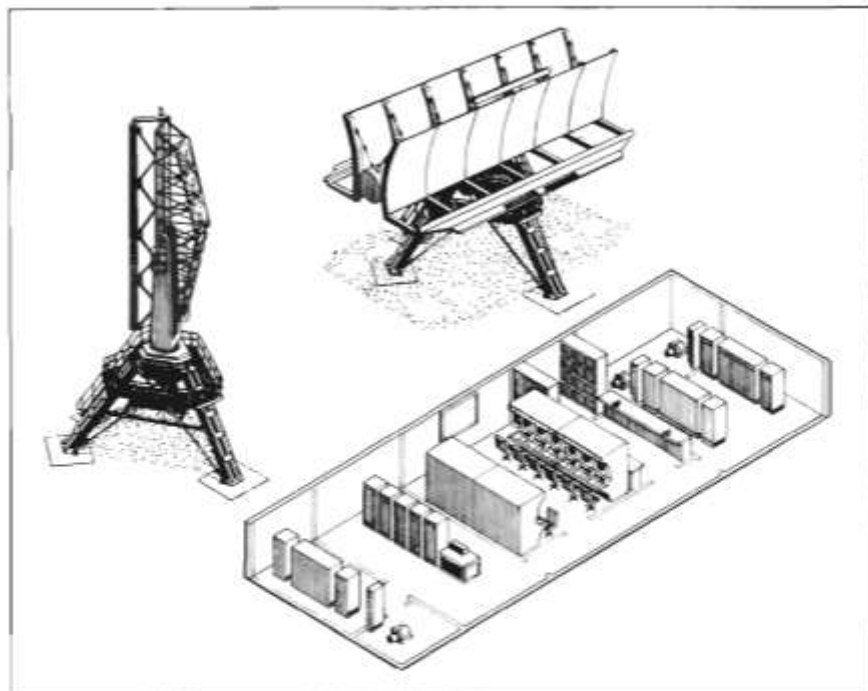
- Antenna Types S1011 and S1014 mounted back to back
- Two 2MW, 23cm L-Band transmitter receivers Type S2011
- Two 2.25MW, 10cm S-Band transmitter receivers Type S2012
- Two signal processing equipments Type S7100
- Two video combining units Type S7102
- One signal processor Type S7101
- One set ancillary equipment S600 series.

#### Options

- Primary radar plot extractor Type S7200
- IFF plot validation unit Type S7300 and decode unit Type S7310
- Additional transmitter/receivers Type S2011 and S2012
- IFF antenna and interrogator/responder.

The antenna system comprises a 14m cosec<sup>2</sup> L-Band reflector and 14m parabolic S-Band reflector mounted back-to-back. These antennas are suitable for all static installations and can be mounted on a gantry, plinth or building roof.

Both reflectors are of the single curvature type and are energised via linear non-squinting feeds. The squintless feed permits diversity operation to be employed by using a Marconi multiplexer, whereby several transmitters can be operated simultaneously into a single antenna. The squintless feed also enables a radiation pattern to be achieved with



Area control station

first side lobes better than -28dB and an average side lobe level of better than -40dB.

The IFF antenna may be mounted above either of the primary radar reflectors.

The S-Band system provides long range low cover for early warning applications and the L-Band system provides the high-angle cover necessary at shorter ranges.

Two 2MW transmitter/receivers Type S2011 operating in frequency diversity are used on the L-Band channel and two 2.25MW transmitter/receivers Type S2012 operating in frequency diversity are used on the S-Band channel. ECCM receivers are integrated with each transmitter/receiver for use in conditions of jamming.

The use of selected frequencies within a wideband provides protection against enemy jamming by compelling the jammer to distribute his available power across the band. The S631 provides diversity in two widely

separated bands, the L- and S-Bands, thus presenting the airborne jammer with a very much greater problem. The situation is even further improved by the use of ECCM Receivers.

The video combining units Type S7102 are used to control the diversity operation of the transmitters and to combine the video outputs of the receivers prior to further processing. The units monitor system functional states and select the processor video and trigger outputs according to the monitored situation. They also provide automatic selection of the best video, if one of the diversity pair of transmitters is being affected by ECM.

Digital signal processing equipments Type S7100 are connected to each of the L-Band transmitter/receivers. The S7100 utilizes digital techniques and can interface directly with a primary radar plot extractor Type S7200. It provides moving target indication, area clutter switching, clutter false alarm rate control, pulse recurrence frequency stagger and pulse recurrence frequency discrimination.

Two video outputs are available from each of the S7100 equipments:

1. MTI video range gated and clutter switched against a second video which may be either logarithmic or linear video.
2. Either logarithmic or linear video (the same as the second video referred to above) after pulse recurrence frequency discrimination processing.

The logarithmic and linear videos from the S-Band video combining unit receive further processing in the signal



Back-to-back surveillance antennas S1011/S1014



processor Type S7101. Pulse recurrence frequency discrimination is applied before being transferred to the display system. Also in the S7101 one of the L-Band videos is mixed with one of the S-Band videos to produce 'integrated' video which allows the operators to display video returns from both on a 'cartwheel' or 'rotating diameter' display presentation. Any ground clutter attributable to the S-Band video is removed by video blanking within the MTI region before 'integration' with the fully processed L-Band video.

Ancillary equipment is provided for pressurization of the waveguide and antenna system and to remove excess heat from the magnetron in the S-Band transmitter/receiver S2012.

The basic S631 system can be expanded by the inclusion of the following options:

Additional transmitter/receivers and signal processing equipment can be integrated into the system to extend the diversity performance. A maximum of three transmitter/receivers can operate in frequency diversity on the L-Band and four on the S-Band.

An IFF antenna and interrogator/responder can be integrated into the system.

Plot extractors can be fitted to the L-Band, S-Band and IFF systems.

#### Operational Parameters

Target size 5m<sup>2</sup> (typical fighter aircraft)  
Single look probability 80 per cent  
False alarm rate 10<sup>-6</sup>  
Fluctuating target loss - Slow  
fluctuating target (Swirling Case 1)

#### Fixed System Parameters

	L-Band	S-Band
Wavelength	23cm	10cm
Peak power	2.0MW	2.25MW
Receiver noise factor	2.5dB	3.5dB
Antenna beamwidth	1.24°	0.55°
Static clutter suppression	36dB	NA

#### Variable Parameters - Early Warning/GCI Role

Pulse length	5μs	5μs
P.R.F.	220 p.p.s.	220 p.p.s.
Rotation rate	6 rev/min	6 rev/min

#### Performance

Calculated slant range,  
free-space 5m<sup>2</sup> target 424km 696km  
(238nm) (389nm)

Clutter cancellation  
ratio (including  
scanning effect) 24.3dB NA

#### Long Range Surveillance Radar Type S690

The introduction of high-power coherent transmitters and advanced signal processing completes the enhancement of the Marconi range of 2-D static surveillance radars. Based on the principle of two highly efficient

antennas operating simultaneously in L- and S-Bands in a co-mounted back-to-back configuration, they provide a detection capability on small aircraft which for practical purposes is limited by the radar horizon, together with unmatched ECM resistance.

As for the radar Type S631 the antennas are 14m linearly fed single curvature reflectors fitted with non-squinting linear feeds, to give low sidelobes and a wide frequency bandwidth.

The coherent transmitter/receivers have been designed to exploit these characteristics by providing complete frequency agility to which can be added Dickie Fix receivers and/or pulse compression. If pulse compression is fitted, an adaptive radar processor (ARP) S7110 is used.

#### Major equipment items are:

Antennas Type S1011 and S1014 mounted back-to-back,  
3.3MW 23cm frequency agile coherent L-Band transmitter/receiver Type S2019  
3.3MW 10cm frequency agile coherent S-Band transmitter/receiver Type S3018  
Adaptive radar processor Type S7110  
Plot extractor Type S7202  
One set ancillary equipment S600 series

#### Options

IFF antenna and interrogator/responder  
IFF plot validation unit Type S7300 and decode unit Type S7310  
Additional transmitter/receiver Type S2018

#### S2018/S2019 Transmitters

The basic system comprises four main equipments:

- (a) The main modulator and r.f. power output section;
- (b) the e.h.t. control and power supply;
- (c) the transmitter drive cabinet;
- (d) the receiver cabinet.

The main modulator and r.f. power output section houses the hybrid power amplifier, the main modulator, the focus magnet supplies and the overall transmitter control system.

The e.h.t. control and power supply section houses the complete e.h.t. power unit and its solid-state control system.

The transmitter drive cabinet contains a travelling wave tube power amplifier and also houses the frequency synthesis system.

The receiver cabinet is a completely self-contained unit and has space provision for a Dickie Fix Receiver if required.

Two forms of cooling are employed within the overall transmitter system:

- i) forced air for all general components, the air flow being fed from the transmitter mounting plinth.
- ii) water cooling for the output tube, Electro-magnet assembly, Pulse-transformer and Duplex Isolator.

The water cooling and waveguide pressurization systems are external to the cabinets.

#### Power Amplifier

This is a two-stage wideband power amplifier, the output stage being a hybrid power amplifier driven by a medium-power travelling wave tube.

#### The E.H.T. Control and Power Supply

This cabinet houses the complete power unit for the main modulator,



Transmitter/Receiver S2018



including complete control of the transmitter, and contains its own safety interlocks.

#### Transmitter Drive

The transmitter drive cabinet houses the complete low-power drive system for the hybrid power amplifier. The output is derived from a cathode pulse modulated medium-power travelling wave tube and is sufficient to fully drive the hybrid power amplifier over its entire frequency range without adjustment of its operating parameters.

#### Basic Frequency Synthesis

Also housed in the transmitter drive cabinet, the frequency synthesizer consists of a group of sub-units in which the basic receiver local oscillator and transmitter drive signals are produced.

All frequencies within the synthesizer are combinations of multiples and sub-multiples of a single frequency. The synthesizer also provides the basic 'clock' signal with which p.r.f. generation and signal processing logic are performed.

#### 23 cm L-Band Receiver

The first stage of the receiver is a low-noise wideband transistor r.f. amplifier followed by an image filter. A mixer is used to convert signals to i.f. and is followed by a wideband, low-noise transistor head amplifier. When used in an ECM environment, a bank of electronically switched band pass filters fitted in front of the r.f. amplifier permits rapid selection of filter centre frequency to match the transmitter frequency agility. When ECM is not present, the filter bank is by-passed by a low-loss electro-mechanical switch, thus preserving the overall low noise figure.

#### 10cm S-Band Receiver

The first stage of the receiver is a low-noise amplifier.

The pump is a varactor-tuned Gunn oscillator which allows fast electronic tuning and high stability. A mixer is used to convert signals to i.f. and is followed by a wideband, low-noise transistor head amplifier. A bank of ECCM filters is fitted as for the 23cm L-Band receiver.

#### Dickie-Fix Receiver

Provision is made in both the L-Band and S-Band receiver systems for the fitting of Dickie Fix receivers and associated ECCM filters. Control of this type of receiver and of its use is a function of the control system.

#### Pulse Compression

Fitting of pulse compression is achieved by an additional sub-unit in the transmitter drive cabinet. Its function is to provide the necessary frequency sweep of the transmitter pulse.

On reception the i.f. is fed via a pulse compression filter which reduces the input pulse of 10µs to 0.25µs. The compression filter, along with a separate filter for use when the radar is used in the non-compressed mode, is fitted into the cabinet containing the signal processing equipment.

#### Multi-Filter MTI Type S7110

The purpose of such a processing system is to provide a response which adapts automatically so as to give a constant false alarm rate in variable clutter and jamming conditions while at the same time providing the maximum probability of detection of wanted targets.

In a traditional MTI system only one filter is provided. This eliminates returns with a low doppler component and passes returns which exhibit sufficient doppler shift. With this system there exists a possibility of losing targets with low doppler components (tangentials) and an inability to provide sub-clutter visibility in moving clutter such as chaff and weather. By using a number of narrow filters spread across the doppler band it is then possible, through the application of threshold techniques to the filter outputs, to provide the best possible combination of sub- and supra-clutter visibility. Spatial and temporal integration techniques are used to maintain a constant false alarm rate with both moving and fixed clutter, and a slow threshold for controlling the basic system false alarm rate. Provision is made for the external control of the operating sensitivity from the radar control system.

The signal processing equipment is housed in its own cabinet which also contains the pulse compression filter (if fitted) and phase detectors for both phase and quadrature MTI.

#### Plot Extractor S7202

With signal processing equipment of the adaptive type, advantage may be taken of the coherent integration of the video. This permits a plot extractor to operate at a relatively low false alarm rate at its input. Hence a Locus 16 is used to perform plot forming, plot correlation and message forming.

Correlation of plots is generally between primary and secondary radar information. However, in the case of

back-to-back radar systems correlation is also necessary between primary and primary radar information.

On completion of the correlation processing the plot messages are assembled into a form suitable for transmission on telephone lines or narrowband link equipment. The control system can control the plot extractor and signal processing to either enhance or diminish the sensitivity of selected areas according to the needs of the system.

#### Control System

The complexity of the control system depends upon the complexity of the search radar system. The more basic systems only require a switch panel. As the search radar increases its capability to detect targets in both variable clutter and jamming conditions the control system also needs to become more sophisticated. For search radar facilities such as low sidelobes, frequency agility, Dickie Fix receivers, pulse compression, adaptive radar processing and plot extraction, it is required that the control system comprises not only displays but also a programmed processor such as Locus 16 with associated input devices. With such a control system dialogue is available between operator and machine to obtain the best possible selection or combination of the facilities available to improve the detectability of the wanted targets.

#### Operational Parameters

Target size 5m<sup>2</sup> (typical fighter aircraft)  
Single look probability 80 per cent  
False alarm rate 10<sup>-6</sup>  
Fluctuating target loss - Slow  
fluctuating Target (Swirling Case 1)

#### Fixed System Parameters

	S-Band	L-Band
Wavelength	10cm	23cm
Peak-power	3MW	3MW
Receiver noise factor	3.5dB	2.5dB
Antenna beamwidth	.55°	1.24°

#### Variable Parameters - Early

Warning/GCI Role		
Pulse length	10µs	10µs
P.R.F.	220	220
	p.p.s.	p.p.s.
Rotation rate (rev/min)	6	6

#### Performance

Calculated slant range, free space		
5m <sup>2</sup> target	698km (369nm)	418km (234nm)

Note: nm denotes nautical mile(s)





The 10cm(S) Band static heightfinder radar S669

### High-Power Heightfinder Type S669

The high-power static nodding heightfinder Type S669 complements long range surveillance radars by providing accurate, high data rate, automatically extracted height measurements on targets within the surveyed airspace.

Special scan modes give burnthrough, long dwell time and controlled volumetric search capability for the tri-coordinate detection of targets under heavy jamming conditions when other radars are totally disabled.

These features combined with superior height accuracy and discrimination have led to the choice of the forerunner of this equipment throughout NATO as a necessary supplement to 3-D and 2-D radars.

Major equipment items are:

- Antenna Type S1006
- Starter and servo Type S7002
- Transmitter/receiver Type S2012
- Automatic Height Extractor Type S7201
- Ancillary equipment S600 series

#### Option

Additional Transmitter Type S2012.

Antenna Type S1006 which is of the nodding type is used for the S669 heightfinder system. The operational performance at long ranges imposes great accuracy standards on the equipment. To achieve a narrow vertical beamwidth with extremely low sidelobes, the reflector is part of a parabolic cylinder 12.2m in length, fed by a slotted waveguide linear array.

The complete antenna structure is held rigidly to minimize displacement at the nod axis. The movements in azimuth and elevation are operated hydraulically which permits the antenna to have a rapid and accurate response.

The S669 heightfinder derives its radio frequency power and its video signals from the transmitter/receiver S2012, contained within a single cabinet which is engineered to give an extremely compact assembly, whilst maintaining easy accessibility to all components. The receiver system of the S2012 includes a special ECCM receiver for use in conditions of jamming.

Control of the S1006 is by means of the starter and servo S7002. The starter controls the hydraulic pump motors and provides interlocks to guard against damage in the event of a fault. The servo controls the antenna in the various modes by turning the antenna to the required bearing of the target and controlling the vertical mode amplitude and velocity with relation to the target range.

Ancillary equipment is provided for pressurization of the waveguide and antenna system and to remove excess heat from the magnetron in the transmitter/receiver.

The S669 can be employed in six different modes of operation;

Auto-height, auto-searchlight, manual searchlight, burnthrough, volumetric scan, and sector volumetric scan.

Selection and control of a particular mode is made from a display system normally remotely situated from the radar head. The volumetric scan modes enable the antenna to be employed as a surveillance radar if required.

The data rate depends on the mode of operation. In the auto-height mode it is 8 to 15 heights per minute dependent upon both the azimuth separation and the range of each successive height request.

With other modes, such as auto/manual searchlight and burnthrough, data rate does not apply in the same manner, as the main function is to provide either a computer or a particular operator with control of the heightfinder to assist in obtaining heights either in the closing stages of an interception or as a means of obtaining the position of a jamming aircraft.

*Auto-height:* One nod cycle on target bearing with the amplitude of nod automatically controlled by the target range. Duration of nod dependent



An operations room equipped with Marconi radar displays



upon target range. Absolute height accuracy is  $\pm 457\text{m}$  ( $\pm 1500\text{ft}$ ) at 150 nautical miles. Incremental azimuth updating is permissible whilst nodding. Azimuth slew rate is  $90^\circ$  in 2.6 seconds,  $179^\circ$  in less than 4 seconds.

**Auto searchlight:** As auto-height except there is a continuous nod motion on target bearing at a rate of 3 seconds per cycle.

**Manual searchlight:** Continuous nod motion at 3 seconds per cycle with azimuth positioning, nod amplitude and elevation centre angle independently controlled manually from a remote display system.

**Burnthrough:** As Manual Searchlight except that nod amplitude is fixed at  $3^\circ$  and duration of nodding cycle is 1 second per cycle.

**Volumetric Scan:** Continuous azimuth rotation with stepped interlace elevation scan over a fixed angle with fast flyback to datum. Azimuth rotation  $16 \pm 1$  revolutions per minute.

**Sector Volumetric Scan:** Continuous sector azimuth sweep centred on positional information from display system. Sector angle is variable and also remotely controlled from the display system. Elevation scan motion is the same as for volumetric scan with elevation steps initiated at the extremes of azimuth sector.

The S669 heightfinder system can be operated with an automatic height extractor and/or a height range display. In the auto-height and auto-searchlight modes of operation a height extractor is normally used.

The manual modes of operation such as manual searchlight and burnthrough are normally used in conjunction with a height range display. Their purpose is to assist the ground environment to position a jamming aircraft by manually controlling the heightfinder in the general direction of the target and by so concentrating the power in a small portion of the sky obtain the target position.

Modes of operation such as volumetric scan and sector volumetric scan are normally used in conjunction with a PPI type display to provide a surveillance role in the event of failure/maintenance of the search radar.

The S669 system is capable of expansion to include a second transmitter/receiver. This can be used either as a standby to the first or as an alternative frequency.

#### Operational Parameters

Target size  $5\text{m}^2$  (typical fighter aircraft)  
Single look probability 80 per cent  
False alarm rate  $10^{-6}$   
Fluctuating target loss – Slow  
fluctuating target (Swirling Case 1)



40 Series antenna

#### Fixed System Parameters

Wavelength:	10cm
Peak power:	2.25MW
Receiver noise factor:	3.5dB
Antenna beamwidth:	$0.6^\circ$

#### Variable Parameters – Early

##### Warning/GCI Role

Pulse length:	$5\mu\text{s}$
P.R.F.	220 p.p.s.

#### Performance

Calculated slant range, free space  $5\text{m}^2$  target 470km (263nm)

Note: nm denotes nautical mile(s)

#### Long Range 3-D Surveillance Radar Type S640

The Marconi Radar Type S640 3-D, high-power, static, S-Band air defence radar provides plan position and height data covering a range of 400km (216nm) and a height of 30.5km (100,000ft) on targets of not less than  $4\text{m}^2$ . A computer obtains height data automatically each antenna revolution on every target being tracked within the radar cover.

The S640 radar incorporates the most advanced transmitter/receiver and signal processing system available. Anti-jamming is achieved by the use of a stacked beam antenna system with a separate receiver for each beam, wide frequency diversity, high mean transmitted power, pulse compression techniques and a combination of special ECCM receivers and compatible MTI. These features together with circular polarization also make the radar highly resistant to interference from ground clutter and rain.

#### Major equipment items:

40 Series antenna  
Two 3.3MW frequency agile coherent transmitter/receivers Type S2018

Adaptive radar processor Type S7110  
Plot extractor Type S7202  
Ancillary equipment S600 series

#### Options

IFF antenna and interrogator/responder  
IFF plot validation unit Type S7300 and decode unit Type S7310

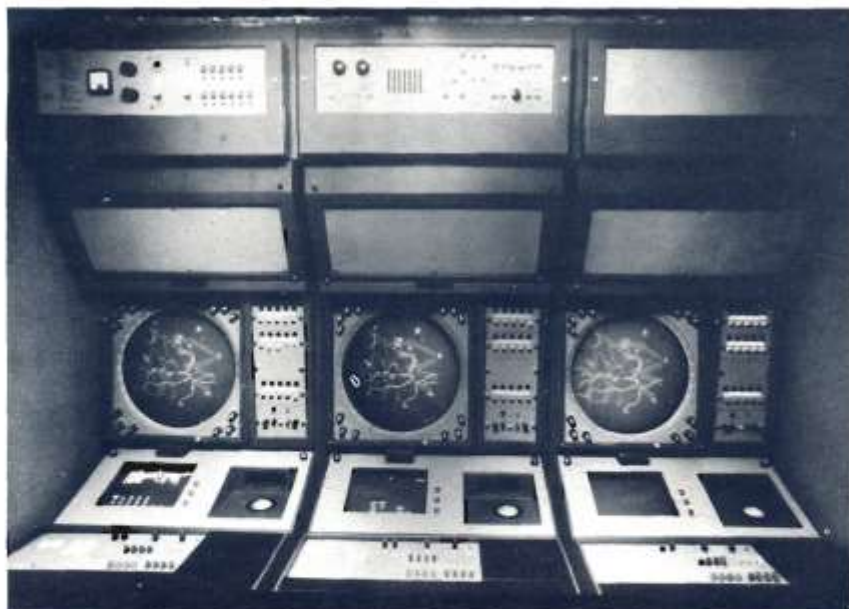
#### 40 Series Antenna

The antenna consists of a reflector and horn feeds in a stacked beam system. The reflector is paraboloidal in contour and measures 12.2m across by 4.67m high. When transmitting, the power is divided in the waveguide system and fed to twelve horns. The relative phase of r.f. energy at each horn is such that co-phasing is achieved in the far field. The beamwidths of the lower beams are  $0.62^\circ$  horizontal and  $1.25^\circ$  vertical. The maximum gain of the antenna is 44.5dB with azimuth sidelobes 27dB down on the peak of the main beam.

When receiving, each horn feeds its own receiving system. Elevation coverage provided by the common transmitter/receiver system is continuous up to  $30^\circ$ . Circular polarization of the bottom four beams can be employed to give improved performance in rain and is controlled from the radar supervisor's console. An IFF antenna can be mounted on the reflector.

The high power waveguide system is contained in three racks fulfilling the functions of combination of power from the two transmitters, splitting the combined power, establishment of the correct phase relationship between the twelve channels, duplexing and monitoring. Sections of the waveguide system are pressurized where necessary.





Operation cabin S5014



Static operation centre

The transmitter/receiver and signal processing equipment descriptions are as for the S690 radar.

#### System Performance

##### Operational Parameters

Target size 5m<sup>2</sup> (typical fighter aircraft)  
Single look probability 80 per cent  
False alarm rate 10<sup>-6</sup>  
Fluctuating target loss – Slow  
fluctuating target (Swerling Case 1)

##### Fixed System Parameters

Wavelength:	10cm
Peak-power:	3MW
Receiver noise factor:	3.5dB

##### Variable Parameters – Early Warning/GCI Role

Pulse length:	10μs
PRF:	250 p.p.s.
Rotation rate:	5 rev/min

#### Performance

Calculated slant range, free-space 5m<sup>2</sup> target: 236nm

#### Display and Data Handling Systems

The basic elements of the Marconi display and data handling systems are the operations cabins S5013 and S5014. Static installations are derived from the same basic equipment elements and are amalgamated as required for the air defence environment.

Both systems contain as a basic module three PPI type displays and communications services for ground-to-air and ground-to-ground communication. The difference between the two systems are the S5013 has only limited data handling such as:

1. Interconsole marking
  2. Heightfinder control
  3. Manual interception
  4. Track reporting
- while the S5014 has fully programmable data handling facilities which include:
1. Automatic tracking and intercept facilities
  2. Transmission/reception of track data to/from remote sites via digital data links
  3. Calculations for planning and controlling aircraft on strike missions
  4. Heightfinder control
  5. SAM Control

The system configurations and operational facilities of the fully programmable module are expandable to meet all levels of requirements.

A single module provides a display and data handling system of the most sophisticated kind with automatic tracking and intercept facilities. By associating modules together into groups the system capability can be extended to any level of Control and Reporting Post (CRP) and up to a complete Sector Operations Centre (SOC).

Each module contains three operational display positions fitted with a 16-inch PPI and 11-inch TV monitor, and a touch mask and tracker ball to enable the operators to communicate with a Locus 16 processing system. Each operational display position has comprehensive voice communication facilities for both operational and administrative services.

A fourth position, fitted with a video data terminal on-line to the Locus 16 processing system and with telephone equipment, is provided for an operational assistant.

All operational display positions are fitted with identical equipment. This provides a flexible operating system in which any display position can be used to perform any operational task and any position can take over the functions of another merely by requesting the display data required by that position.

The processing system for each module contains two Locus 16 multi-processors incorporating the necessary elements to meet the system requirements and including disc storage for holding all system programs.

A module can be re-configured to act in different roles by calling the appropriate operational programs from disc store and changing the system patching arrangements to 'pick-up' the correct communications lines.

A single module CRP arrangement provides sufficient computing power to



cater for 60 auto-followed tracks and 6 simultaneous interceptions/recoveries. If further modules are added, this increases the overall system capability since each module has computing power for 6 simultaneous interceptions/recoveries.

By adding further modules CRP systems can be expanded to become complete Sector Operations Centres. These have the capability for 160 tracks, correlation of incoming tracks from other sources, threat assessment, weapon assignment and missile executive control.

#### *Operational Features in the CRP Modules*

Auto-follow tracking and track store for 60 tracks. Track initiation may be automatic or manual. The auto-follow system may be constrained to initiate tracks automatically in designated areas.

Output of track data, mission data, met. data, etc. to an SOC.

Intake of system track store data from an SOC.

Storage provided for 20 mission stores based at 2 airfields.

Trial interceptions.

Interception program operating in each of the modules catering for 6 simultaneous interceptions/recoveries with a limit of 2 simultaneous interceptions at any one display position.

Passive and active SSR/IFF decoding available at all operational positions using touch mask sequences.

10 channels of the ground-to-air communication system available at each operational position.

Inter-console voice communication

between all displays in the CRP.

Airfields states, input from either local or remote VDTs.

#### *Operational Features in the SOC Modules*

Intake of track data, mission data and met. data from up to 5 CRPs.

Track correlation on incoming tracks from the CRPs.

Track store for 160 tracks.

Transfer of system track data to the CRPs.

Transfer of system track data and resources to a remote or co-located ADOC.

Raid recognition.

Mission stores held at the CRPs and duplicated at the SOC, with a limit of 50 mission stores.

Threat assessment.

Weapon assignment.

Trial interception.

Executive control of remote SAM sites.

Control of strike and combat air patrol (CAP) aircraft.

Intercept Executive control.

Inter console voice communications between all displays in the SOC.

Input of flight plans using the VDTs.

#### **Air Defence Operations Centre (ADOC)**

Up-to-date information on deployment of forces, availability of resources and the extent of engagement is essential to the higher command executive responsible for strategic battle decisions.

In an air defence operations centre, a computer accepts data from remote operations centres via narrow band digital data links. Co-ordinate

conversion is carried out to allow the positional information to be referred to a common reference for presentation purposes. The extent of the equipment in the centre is determined by the assessment of the threat in terms of tracks to be handled and the extent of the defensive structure in terms of hostile engagements. A large screen projector or rapid processing photographic machine provides conference facilities. Individual user displays provide information in both graphical and tabular form allowing the higher command staff to call down further information on any aspect of the defence situation such as availability of transport, logistics, data on maintenance, reserves and effects of force re-configuration. Gathering of data and exercising the system under practice conditions is an important feature and these systems may be programmed for simulation studies to establish effective co-ordination of the entire defence organization.

#### **Configurations**

The basic configurations for the most usual operational roles are:

1. Track Reporting Post (TRP)
2. Control and Reporting Post (CRP)
3. Sector Operations Centre (SOC)
4. Air Defence Operations Centre (ADOC)
5. SAM Control Centre (SCC)

#### *TRP (Transportable)*

Radar S604/S605 on its own or with S5013 with limited data processing.

#### *CRP (Transportable)*

Radar S604/S605 or S624/S625 with 1 or 2 Radars S613 with either S5013, with limited data processing, or S5014 with full data processing.

#### *CRP (Static)*

Radars S631 or S690 and S669 with either limited or full data processing.

#### *SOC (Transportable)*

Radar S624/S625 with 1 or 2 Radars S613 and S5014 with full data processing.

#### *SOC (Static)*

Radars S631, or S690, with 1 or 2 S669, or S640, and full display and data handling facilities.

#### *ADOC (Static)*

Full display and data handling facilities for integration and co-ordination of total air defence ground environment.

#### *SCC*

Data handling facilities for threat assessment, weapon assignment and allocation when integrated with the appropriate CRP or SOC.



Sector operation centre



# Point Defence

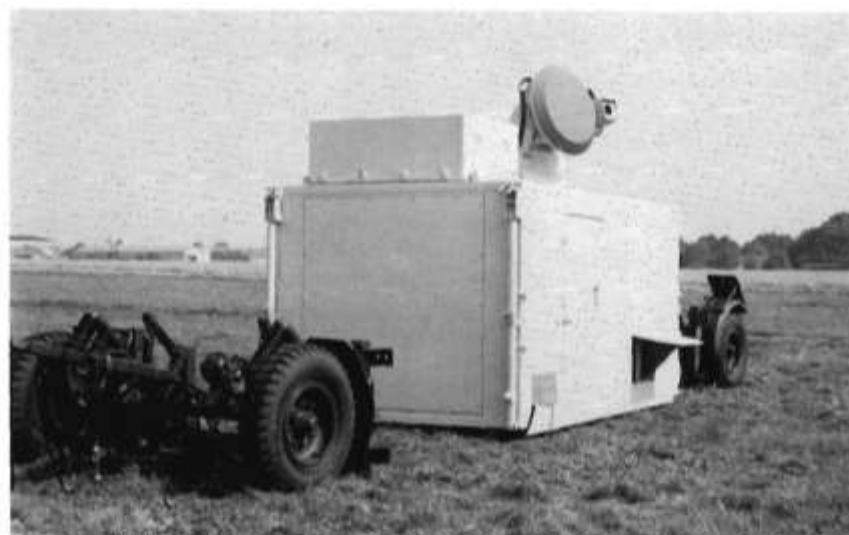
Anti-aircraft point defence systems have become increasingly necessary for the defence of strategic installations because of the use of the low-level approach by hostile aircraft. In adopting the low-level profile, attacking aircraft minimize the possibility of detection by long range surveillance radars, and consequent controlled interception by fighters at high and medium altitudes.

A static installation such as an airfield, located by its geographical co-ordinates can be attacked by strike aircraft by night, as well as by day from any direction. It follows that an A.A. defence system to defend such an installation should employ radar to detect targets and define the co-ordinates of those targets to be engaged by weapons. These radars can now use doppler techniques to reduce clutter echoes from the terrain, track aircraft with the necessary accuracy to provide a high probability of kill and provide an automatic system from target detection to the gun opening fire.

With low-level attack an A.A. defence system is confronted by dead ground made up of low altitude air spaces (valleys and other geographical holes in the topography) which offer ideal penetration corridors to hostile aircraft.

In flat country the horizon for the detection system will typically be 30/40km. This gives the defence some 90 seconds to react against a low flying hostile with a speed just in excess of Mach one. If the hostile can take advantage of folds in the ground, targets may be first seen at ranges between 10 and 20km and the time available to react is reduced to 30 seconds or less. Additional weapons should be deployed if the landscape is such that the target can approach in a sector to within a few kilometres before being detected. The mix of guns with missile systems will frequently provide the optimum solution to this problem, with missiles operating in the clear and guns controlling the concealed approaches.

Thus the main limitation imposed on the defence system by low-level attack



ST850 Sapphire radar cabin with running gear removed

is a very short time in which to react. The radars used with these defence weapons do not therefore require a long range capability, but the time from first detection to actual engagement must be kept to a minimum.

Defence against low-flying strike aircraft is therefore best provided by surveillance radars which detect hostiles at some 20km and fire-control radar systems which respond rapidly to direct weapons with a range of several kilometres. For combat in this situation Marconi Radar has developed a surveillance radar Type S860 capable of detecting a strike aircraft at ranges greater than 20km, and a fire-control system Type ST850 which can control missiles and up to six guns.

## Sapphire Lightweight Gunfire Control System

Marconi Radar has co-operated with Sperry Gyroscope to create Sapphire, the most versatile and cost-effective lightweight gunfire control system available today.

Sapphire incorporates a Marconi Tracking Radar and a Sperry Predictor. The system is capable of maintaining rapid and accurate control over small and medium calibre guns against air, land and sea targets. It provides data

for a controlled slew of the gun mounting, followed by an accurate aim-off which takes account of the various ballistic effects. The system can also be used to give surveillance information by means of a spiral scan search mode.

Control of gun firing and selection of pre-engagement parameters takes place at an integrated radar/gun control console. The system is fully automatic, with only one operator required, enabling manning requirements to be kept to an absolute minimum.

The main components of the Sapphire system are:

1. The Marconi autonomous tracking radar Type ST850.
2. The Sperry digital predictor DWC 100, consisting of the Sperry 1412 computer and associated interfaces.
3. A Marconi Type V0051 Television Camera and control system.
4. A weapon control console incorporating the display and control units for the operation of the radar, predictor and guns.

The equipment has been designed to exacting Military Standards and is fitted in a mobile cabin which can be fitted with mobilizers, or helicopter lifted or carried on a standard flat truck.

The Marconi Radar Type ST850 has been selected from the Marconi 800



series of weapon radar systems; it is an X-band monopulse search/tracking radar with MTI signal processing and extensive ECCM facilities. It is autonomous in its operation, being designed to function independently of control by a central computer and requiring only the input of designated target range and bearing. Additional modes of operation are also provided, giving manual passive tracking or automatic passive or active selection.

The Sperry Predictor Type DWC 100 (Digital Weapon Controller) incorporates the Sperry 1412 general purpose military computer which is in service in many countries and with the Royal Navy in the co-ordinate converter for the Exocet missile system.

A television camera is mounted on the radar and provides an alternative control mode, as well as target identification and damage assessment. A TV automatic tracking unit may be incorporated and a low-light type TV camera specified.

The Control Console is an integrated unit for the radar, television, predictor and gun. After setting the initial conditions a single operator maintains overall supervision of the tracking radar and predictor, and fires the gun.

Since 'pop up' targets approaching at low level allow little time to respond, system reaction time is a critical system parameter. The time from nominating the target for engagement until a valid prediction is achieved is typically seven seconds.

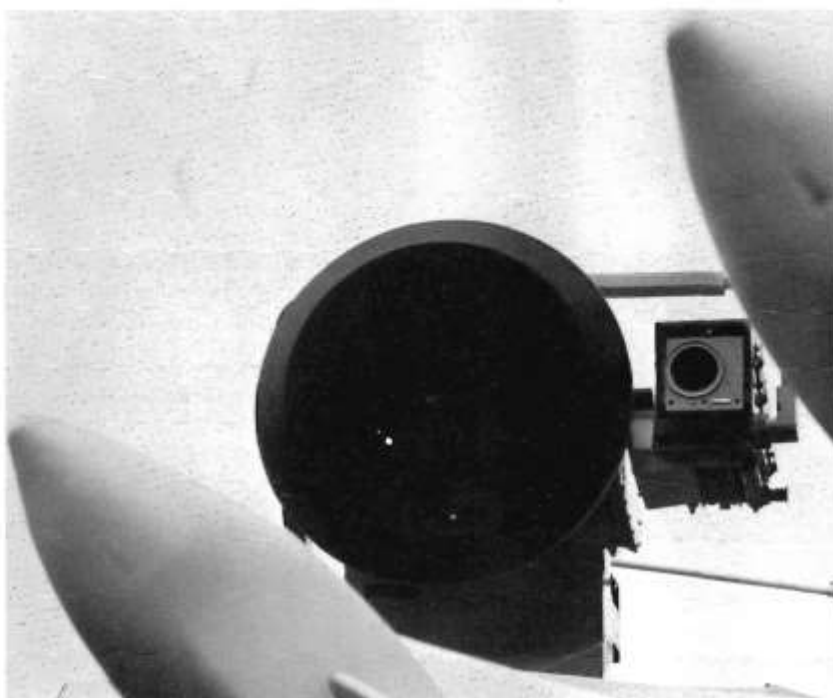
During its 'live' firing trials at the British Ministry of Defence Gunnery range at Wembury, the Sapphire system demonstrated rapid target acquisition and highly-accurate control of a 4.5-inch Mk8 gun, shooting at a variety of airborne and surface targets. As a measure of this success, every operable shell fired was observed to be on target – a 100 per cent record of accuracy almost unparalleled in fire control systems.

The Sapphire system may control up to 6 gun mountings, where necessary making appropriate offset correction for individual mountings.

#### **Radar Enhanced Tigercat System**

Short Brothers and Harland and Marconi Radar have combined their resources to produce the Radar Enhanced Tigercat Low-Level Weapon System: for quick, lethal response to fast low-flying intruders by day or by night.

The radar enhanced system offers significant advantages over the earlier optical system and has a radar control unit to provide dark fire capability. Radars are incorporated for both surveillance and target tracking, using



ST850 tracker antenna and Tigercat missiles

television for automatic gathering and guidance of the missile. This control system gives a superior performance from minimum to maximum range, with the necessary short reaction time to counter a surprise low-level air attack. The system is able to respond to a Mach 1 low-level approach in as little as nine seconds.

The radar channel comprises an ST850 Radar Control Unit and two associated Fire Units to provide all-round dark-fire capability. The radar control unit selects which fire unit is under radar control, depending upon the attack situation. The radar automatically gathers and guides the missile on to the line-of-sight of the target. The other fire unit reverts to optical control.

The Marconi ST850 Radar Control Unit consists of a fully automatic pulse doppler tracking radar and a television system. The radar operates in X-band which gives high target tracking accuracy with excellent performance and acquires targets out to a range of 40km. Digital MTI is used to minimize ground clutter and allow the tracking of low-level aircraft; using this mode, the maximum MTI range is 24km. The radar has been designed to operate effectively even when attacking aircraft are using ECM techniques.

The Type V1000 missile gathering and guidance system employs a special television data processing technique to gather the missile to the sight-line and then control the missile to impact. Thus guidance may be an automatic or manual function. The camera mounted on the director is

provided with a zoom lens and incorporates a ruggedized vidicon tube enclosed in a temperature-controlled housing.

The radar director automatically retracts into a mobile air-conditioned cabin which is designed to be transported by road or across country; alternatively it may be carried on a standard Army vehicle. Inside the cabin are the transmitter, receiver, signal processing and acquisition circuitry, together with the weapon control console which accommodates the control panels and monitors associated with the radar tracker and missile guidance. The radar control unit may accept target designation data from an external surveillance radar or can provide its own low-level surveillance mode.

#### **S860 Surveillance Radar**

Type S860 in the Marconi 800 series of advanced technology lightweight radars is a mobile surveillance radar which provides target indication data for missile systems such as Tigercat and gunfire control systems such as Sapphire. The vertical cosec<sup>2</sup> beamshape of this radar ensures good coverage against air targets, while the narrow horizontal beamwidth gives accurate target indication data for pointing weapons and putting on tracker radars.

The S860 operates in X-band with a 200kW peak power and has digital MTI processing to reduce the ground clutter from the surrounding terrain. Provision is made for the fitting of IFF if required. The detection range is up to 60km



## Coastal Defence



S858 radar antenna

against high-level targets or 40km against a 4m<sup>2</sup> strike aircraft and an MTI mode is provided for use against very low-level targets. This performance allows ample time for targets to be allocated to any associated fire channels and to be intercepted at maximum range.

Two computer-controlled consoles with 406mm (16-inch) PPI display unit are provided, one for target detection and tracking and the other for threat assessment, target allocation and weapon assignment. A weapon status panel is included which indicates the status of the channels throughout the engagement. Target designation is automatic for radar-controlled fire channels but provision is also made for manual designation to optical fire channels by 'reading' target offset corrected data from numeric indicators.

In recent years the increase in violation of territorial waters has made the provision of coastal surveillance a necessity for many countries. Threats to national security from insurgents as well as the social threat of illegal immigration and smuggling etc, can be reduced by the provision of simple coast-guard surveillance radars. The defence of vulnerable coastlines against hostile forces is the task of the Coastal Defence system, which may include fire control systems for guns (and SAM missiles) and the deployment of surface-to-surface missiles from a shore-base.

Coastguard surveillance radars are based on the marine 'Radiolocator' transceivers and displays to provide simple cost-effective systems. The equipments may be supplied mobile in their own cabin fitted with running gear, or as a fixed installation on cliff tops, towers or convenient domestic and commercial buildings close to the shore. A variety of antenna sizes is available giving a complete range of surveillance radars to suit most coastguard applications.

### S840 Radars for Coastal Defence

Where the violator of territorial waters or coastal air space is likely to employ ECM techniques the use of the more sophisticated coastal defence radar is required.

The S840 range of equipments are the coastal defence derivatives of the



S840 2.4m antenna mounted on a tower

Marconi 800 series of advanced technology radar systems. They provide high-performance sea surveillance and low-level air cover to realize maximum effectiveness in coastal defence. The radars may be tower-mounted for long range cover, or may be supplied in mobile/transportable air-conditioned cabins for flexibility of deployment.

The range is of modular construction and there are several antenna configurations available for selection depending on the nature of the target and the topography of the site. The standard 200kW transmitter can be used with or without doppler MTI, and advanced signal processing techniques are used to counter radar clutter and ECM. Single, dual and diversity configurations are available.

The PPI display unit may be either a marine radiolocator display unit or a computer-assisted display suite which provides extensive operator tracking facilities, and provision may be made for passing target co-ordinate data to associated weapon systems or from site to site.

Surface targets can be engaged by gun batteries or by shore-based surface-to-surface missiles of the Exocet, Otomat or Penguin type, directly from the data provided by the S840 display suite. For engagement of aerial targets, data is fed to a fire control unit such as the Marconi ST850 which provides accurate control of surface-to-air guns or missiles.



A mobile Coastguard radar

# Instrumentation Radars

The use of tracking radars on Weapon Ranges as a source of accurate positional data has become standard practice.

The high accuracy and reliability standards of the 800 Series together with the self-surveillance capability requiring no separate target indication radar, has led to the development of specially adapted versions of the basic tracking radar for instrumentation on weapon testing and proving ranges.

Marconi Radar have developed the 800 Series of radars for use in weapon control systems on board ships and on land. An important feature of the basic tracking radar is the use of doppler processing to suppress the effects of surface and weather clutter. This feature is of great value when the range task is the evaluation of low-level attack profiles for bombing runs and rocket fire. In this case, the use of an instrumentation radar which is derived

from a modern weapon control radar can yield important information about the likely performance of defence systems.

The 800 Series radars are continually developing and expanding in capability for the military applications. Additional



Instrumentation radar antenna showing television unit

facilities, available as options and likely to be important for instrumentation purposes, are:

- i) Integration of an optical tracking TV System with the radar director (Daylight or all-light TV Camera)
- ii) Infra-red sensors
- iii) Laser range finder

The 800 Series of instrumentation radars are designed to provide accurate positional data for such purposes as:

- i) range safety
- ii) trajectory analysis
- iii) ammunition testing against range tables
- iv) fuze setting
- v) analysis of attack profiles and 'drops' (e.g. bombs, parachutes, ejector seats, etc.).
- vi) wind profile measurement
- vii) bird hazard investigations

The main instrumentation radar types are:

1. Shell tracking and ballistics measuring radar, with data processing facilities for on-the-spot analysis, contained in mobile cabin or cabins depending upon the complexity of the data processing facilities.
2. General purpose instrumentation radar with 1m diameter antenna and transponder tracking facilities (max. range 40km).
3. Extended range instrumentation radar with 1.4m diameter antenna and transponder tracking facilities. (max. range 80km).

Although the first type is normally supplied in mobile cabins, all equipments can be provided either as mobile units or in forms suitable for fixed installation in a building.

All radar types employ doppler processing to suppress clutter echoes and are provided with automatic search and detection facilities so that they can operate without target designation data from a remote radar, if necessary.

The general purpose radars provide serial digital output data to external recording equipment and XYZ signals suitable for analogue plotting tables.

The tracker employs a tunable X-band transmitter and uses a



Control Console of the ST858





Instrumentation radar cabinets



ST858 installed at RAE Larkhill

monopulse antenna feed. The basic radar director is a two-axis mount employing a light-alloy fabricated yoke. A box, mounted behind the antenna, contains the microwave equipment and head amplifiers. The radar transmitter servo drive equipment and signal processor are contained in an air-cooled two-bay cabinet.

Control of the radar is from a separate console unit which may either be mounted close to the radar cabinet or remote from it.

The data processing equipment available includes a GEC 2050 digital computer, magnetic disc units, tape reader, teletype, tape punch, line printer and digital plotter.

The main features of the radars are:

- Compact and versatile
- Static or mobile installation
- Precision auto-tracking in range and angle
- Transponder tracking ability
- Monopulse angle sensing
- Moving Target Indication (MTI)
- Self-surveillance mode
- Selection of acquisition scan patterns
- Automatic operation with manual override facilities
- Choice of maximum range capability
- Polar to Cartesian co-ordinate conversion
- Choice of data processing facilities for trajectory analysis
- Optional director-mounted television
- Optional displays.

## Ships' Defence

Marconi Radar Systems Limited have been designing and manufacturing naval radar systems for many years and possess an unparalleled pool of expertise dating back to the pioneering days of radar. This hard-won expertise, combined with long collaboration with the United Kingdom's Royal Navy, has resulted in the production of a series of radar equipments that are accurate, reliable, and simple to maintain. The major radar equipments supplied are: surveillance systems, tracking systems, weapon control systems, and radar data processing, display and data handling systems. The systems are modern, of proved lineage, and particularly well suited to the requirements of the current types of naval vessel.

The latest weapon control system for the Royal Navy is GWS25/Seawolf,

now in full production and in process of being installed in RN vessels. GWS25/Seawolf is a close-in, air-defence system designed to handle automatically all phases of an engagement from initial detection right through to final destruction. The system gives ships of frigate size and above the ability to defend themselves against the missile and close air and surface threats of the 1980's. GWS25/Seawolf has high reliability and has proved itself in many trials, even to the extent of destroying shells in flight. Other modern radars are the Types 1022 and 1030 (STIR). Both systems are for the Royal Navy. Type 1022 being an interim development, is intended as a replacement for the widely used Type 965; while 1030 (STIR), part of the S1800 range, is an advanced Surveillance and Target Indicating Radar.

All the previously discussed radar equipments are intended for ships of frigate size and above. To serve the needs of the smaller vessel, Marconi Radar has designed a range of lightweight, easy-to-install, radar equipments. These radars are known as the 800 series.

### 800 Series Radars

The Marconi Radar's 800 series of radars are advanced-technology, light-weight equipments and form the basis of a range of ultra-modern weapon systems that are suitable for small ships from the size of the smaller fast patrol boat upwards. The range of operational requirements for these types of small ships ranges from the comparatively lightly armed fast patrol boat, with the emphasis on offshore protection, to the high speed strike craft with a strong



Type 82 destroyer HMS Bristol



surface-to-surface capability.

For defence against aircraft, these types of craft often utilize anti-aircraft missiles, in addition to, or instead of, rapid fire anti-aircraft guns.

It is against this spread of requirements that Marconi Radar has designed and produced the 800 range of radar systems.

The 800 series radars are lightweight and modular, and draw upon Marconi's considerable naval design experience. The systems provide efficient surveillance, successful detection, rapid acquisition and accurate target tracking. The modern signal and data processing techniques that are utilized ensure rapid, accurate, transmission of target co-ordinates to the guns and missiles of the present day light warships. The systems come complete with PPI displays, computer control and all necessary interface equipments, and will control guns of all calibres from 20mm to 130mm, surface-to-surface missiles and self-defence missiles of many types.

The systems comprise surveillance radars, of several sizes, operating in X- and S-band; tracking radars operating in X-band, PPI display systems, weapon control consoles, digital fire control predictors, optronic sights and vertical reference equipment. Compatible Marconi Radar training aids are also available.

#### 800 Series Surveillance Radars

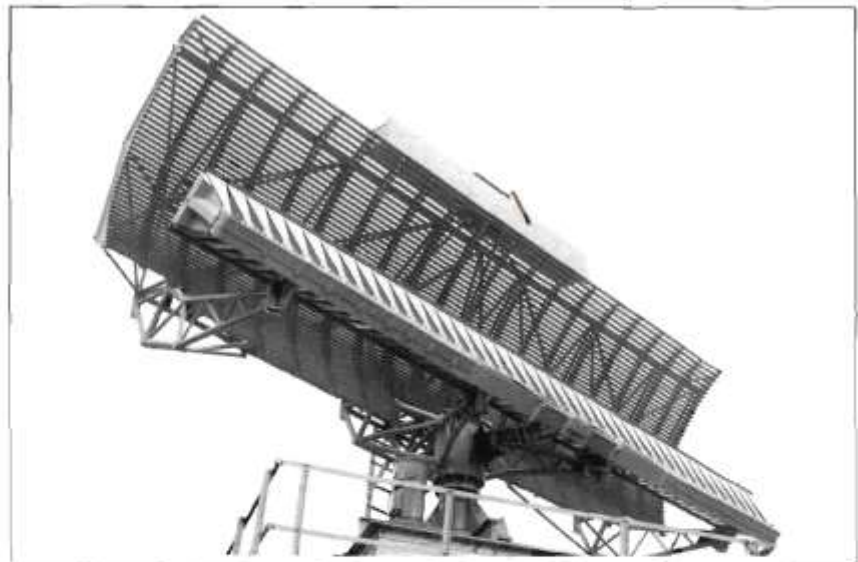
The surveillance radars are lightweight, stabilized devices, and consist of several variations to cover all sizes of small ships.

An especially effective MTI and three channels of video are provided:

- logarithmic, to present the surface picture,
- digital MTI, to remove sea clutter and to present a good air picture,
- a linear channel to maximize the detection range.



ST802 antenna



Type 1022 antenna



A 46m FPB fitted with Marconi S800 radar

(Courtesy Brooke Marine)

#### 800 Series Tracking Radar

The X-band tracking radars are monopulse and are stabilized by rate gyros on the mount. MTI processing is incorporated to reduce clutter and to make low-level targets visible to the radar for continuous tracking. Together with the Sperry digital predictor, the systems can be used to control the Vickers 4.5-inch Mk8 gun mounting, BMARC, Grantham 30mm rapid fire gun, the widely fitted Otomelara 76mm gun, the 40mm twin Breda and other weapons including Bofors and Oerlikon equipments.

The X-band tracker also provides an additional tracking method by utilizing the Marconi Type V0084 all-light television system, fitted as standard. This system monitors the action of radar target tracking and also provides automatic television tracking.

Television is also a useful facility for tracking low-level targets and for tracking in conditions of radar silence.

#### 800 Series Display Systems

The PPI display systems mount Marconi Radar 40cm (16in) displays, which are controlled by the Locus 16 distributed data processor and provide automatic tracking on up to eight targets per display position, a necessary ingredient to obtain accurate target data for the operation of the Exocet or Otomat missiles. One, two, three and more display positions are supplied and the systems are extendable to provide conference display positions for the larger type of vessel.

### Weapons Control Console

The Marconi Radar Weapon Control Console carries the control panels for the tracking radar, the television and the ship's weapons. The console is specific to the actual ship's weapon fit and is constructed, as is the PPI console, on a modular pattern. The modularity enables all types of control to be provided by an assembly comprising a series of standard vertical panels, each chosen to suit the appropriate weapon, radar etc.

### Digital Fire Control Predictor

The Digital Fire Control predictor has been developed by Sperry in collaboration with Marconi Radar Systems Limited. The unit incorporates linear prediction, a novel method of storing gun tables and can accept the target co-ordinates from up to four different types of target tracker.

### V-0063 Optronics Sight

The V-0063 optronics sight is a recent development of a mount to carry an automatic television tracking camera. The unit is lightweight, fully stabilized, and operates in three-axis.

The platform is capable of carrying a variety of electro-optical and other packages, such as; daylight, colour or low-light television cameras; infra-red sensors; laser illuminator or range finders; pyro-electric television camera etc.



A typical weapon control console layout

### NCS1 Vertical Reference Equipment

The NCS1 vertical reference equipment is manufactured by Marconi-Avionics and is a stabilized gyro compass designed to provide three-axis stabilization to all ship and weapon systems. The unit provides high accuracy on roll, pitch and heading throughout a manoeuvre and in all sea states. It is currently in full production for the RN and other navies.

The various 800 series equipments described all combine to form especially effective weapon control systems. A typical example provides radar surveillance and tracking, low-light television tracking, gun and missile control, TV autotrack, optronics

sight, NCS1 reference equipment, weapon control and display consoles. Such a fit would be suitable for the larger size of patrol boat.

Marconi Radar Systems Limited specialize in providing complete weapon control systems for all types of ships and have a comprehensive systems department fully experienced in the design of modern weapon control and radar fits. A full back-up support facility is available and training, training aids, tactical teachers, maintenance aids and similar units and services are readily supplied.

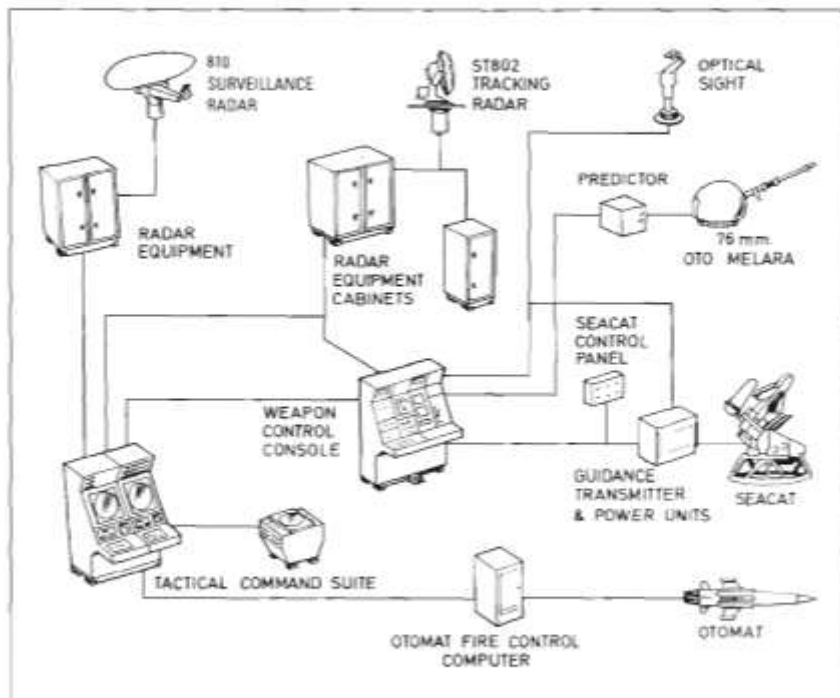
### Sapphire

Sapphire is the lightweight, fast reaction, gun control system created by Marconi Radar in collaboration with Sperry Gyroscope.

The system consists of two proven equipments, the Marconi ST802 tracker and the Sperry DWC 100 digital weapon controller. Sapphire provides rapid and accurate control for small and medium calibre guns against air, surface and shore targets and is suitable for fitting to any size of warship and light enough for the smallest fast patrol boat and hovercraft. It is in full production and features many modern techniques including fully automatic detection, acquisition and tracking, and radar and electro-optical tracking. An all-light television system is also fitted, providing a complementary control mode for use during conditions of radar silence, etc.

Sapphire has extensive ECCM (Electronic Counter Counter Measures) facilities including passive tracking and automatic active-passive changeover.

The system will integrate with any search radar and ship's action information organization and provides



A typical weapon control system



configurations that will satisfy all operational requirements.

#### **Radar and Weapons Systems for the Larger Vessel**

Marconi Radar Systems Limited is the leading supplier of surveillance and tracking radars to the United Kingdom's Royal Navy. Most of the larger RN vessels are fitted with Marconi early warning or target indicating radars types 965 and 992. The Company developed and produced the type 909 tracker/illuminator radar for the Sea Dart System to provide fleet defence against a variety of targets. Installed in pairs on T42 and T82 destroyers the radar may be used for gun direction as well as its role in the guidance of the Sea Dart missile. The latest systems for the Royal Navy are the types 1022 and 1030 (STIR); the 1022 is a replacement for the existing type 965, while the 1030 (STIR) is an advanced Surveillance and Target Indicating Radar.

The 800 series radars and in particular the missile and Sapphire systems are also eminently suitable for fitting to the larger vessel, giving them the same short range defensive capability that these systems give to the smallest craft.

#### **GWS25/Seawolf**

Marconi Radar has management responsibility for the complete electronics of GWS25/Seawolf and is also the supplier of the highly advanced surveillance and tracker antennas.

GWS25/Seawolf is the Royal Navy's close-in air-defence anti-missile missile system, designed to give ships, of frigate size and above, an effective means of defence against the missile and close air and surface threats of the 1980's. The system is fully automatic, and capable of effective operation under severe environmental conditions. The fully automatic response to threatening targets ensures that no incoming missile or other target goes unengaged due to human fallibility and the system is also highly reliable, a factor which must always be associated with fully automatic performance.

GWS25/Seawolf is designed to cope with the latest developments in the field of submarine, aircraft and surface-launched missiles.

Many modern missiles fly at speeds in excess of Mach 2 and their trajectories vary from a straight-in approach a few metres above sea level to a steep dive at an angle well in excess of 45°.

They may also carry out terminal manoeuvres designed to optimize their



HMS Birmingham, Type 42 destroyer

(Crown copyright)



HMS Penelope, the GWS25 trial ship

striking angle and render the task of self defence weapons more difficult. The threat they represent can only be countered by a sophisticated anti-missile system such as GWS25/Seawolf.

The main features of the system are: all weather performance; effective against small supersonic missiles; very short reaction time; fully automatic engagement sequence; short minimum range; coverage to high angles of sight; and small missile, easily handled by two men. The system is also effective against aircraft targets and surface targets.

GWS25/Seawolf is divided into three sub-systems:

- (a) tracking radar
- (b) surveillance radar
- (c) missile launcher

Each sub-system is largely self-contained, and incorporates its

own dedicated data processing system. The surveillance radar sub-system combines a conventional radar, Type 968, with a special self-adaptive pulse doppler radar, Type 967. The two radar antennas are mounted back-to-back on a roll and pitch stabilized masthead platform, and give complete cover from low level to very high angles of sight. The IFF antenna is also included with this sub-system and the whole rotates at 30 r.p.m. Type 968, a conventional pulse radar, is used for surface target allocation; Type 967 has as its prime objective the vital automatic detection of small hostile missiles anywhere between the surface and high angles of elevation, and in severe radar clutter.

The tracking radar sub-system is the Type 910 differential tracker, exploiting the pulse doppler concept to achieve a high level of clutter suppression. Type

910 uses monopulse techniques, giving all-weather performance against the smallest attacking missile in the most exacting radar clutter conditions. High quality servos are used to provide precise control of the tracker and ensure rapid acquisition of the target in response to accurate positional data received from the surveillance system.

After launch the Seawolf missile is immediately acquired by the wide angle gathering beam of the tracking radar and automatically and quickly gathered on to the established target sightline, this feature giving GWS25/Seawolf its excellent minimum range performance.

After launch, both target and missile are tracked together using the same antenna and receiving system in a time-multiplexed mode with the electronic angle tracking feature, the means by which the target and missile sightlines are compared differentially and the resulting angular difference and rate of turn used to generate commands to control the missile. Depending upon whether only one or a salvo of two missiles is fired, there may be up to three separate channels of electronic angle tracking in operation simultaneously.

The GWS25 answer to low level target tracking problems is to co-mount a television system on the radar tracker and to accurately align the camera to the radar bore sight. Target acquisition is normally carried out using the radar tracker and control then passed to the television system. The television equipment includes split optics to provide separate tracking channels for target and own missiles and the method of operation is analogous to the radar mode.

#### **Aimer Trainer and Performance Assessment**

A Television Operator Training Console forms part of each GWS25 system ship-fit, and provides both training and performance assessment for the television system operator at the Missile Control Console. The Type 910 tracker mount servo response, missile manoeuvre simulation functions are generated in the Training Console. Other features such as reduced visibility, glare, spray and ship-motion can be introduced into the simulation.

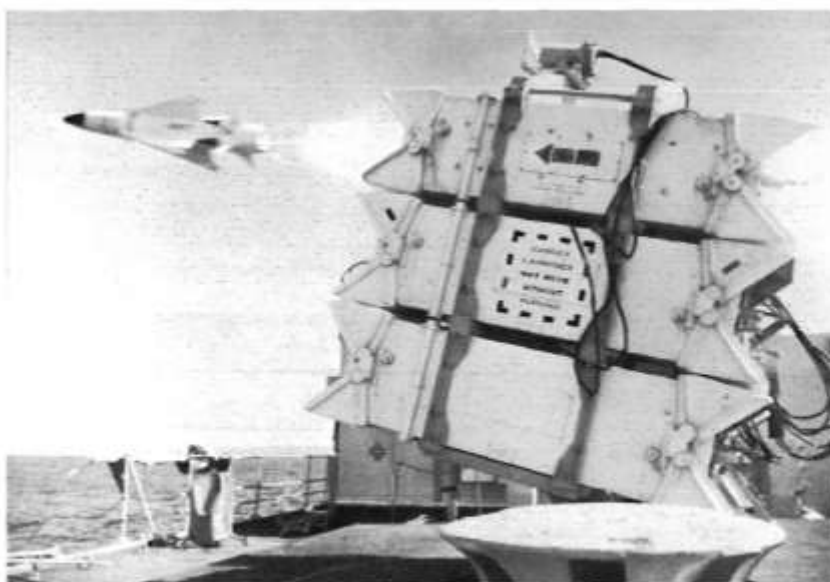
#### **Missile and Launcher**

The missile installations include a six-round launcher, which is capable of rapid rates of fire and of firing salvos. Hand loaded, auto-controlled, with high slewing rate and pointing accuracy, the launcher also provides all-weather protection for the Seawolf missile.



GWS25 Seawolf system

(Crown Copyright)



Seawolf missile in flight



GWS25 Aimer Trainer





HMS Broadsword, the first of Type 22 frigates

(Crown copyright)

The missile has a solid propellant boost motor and is capable of supersonic performance. The complete launcher system is kept in a state of immediate readiness over long periods with a very high degree of reliability by an automatic monitoring system and built-in test equipment, all under control of the system computers.

Royal Navy evaluation has confirmed that GWS25/Seawolf meets its specification, a wide variety of fully representative missile and aircraft targets having been successfully

engaged. Both the missile and ship systems have been the subject of intensive trials carried out both on land and sea. These trials have included stringent climatic and durability tests carried out on prototypes of the equipments. Both surveillance and tracker radars have proved their worth against various targets in heavy clutter environments. The targets used have included Mach 2 Petrel rockets, 4.5-inch shells, conventional towed targets and Jindivik drone aircraft.