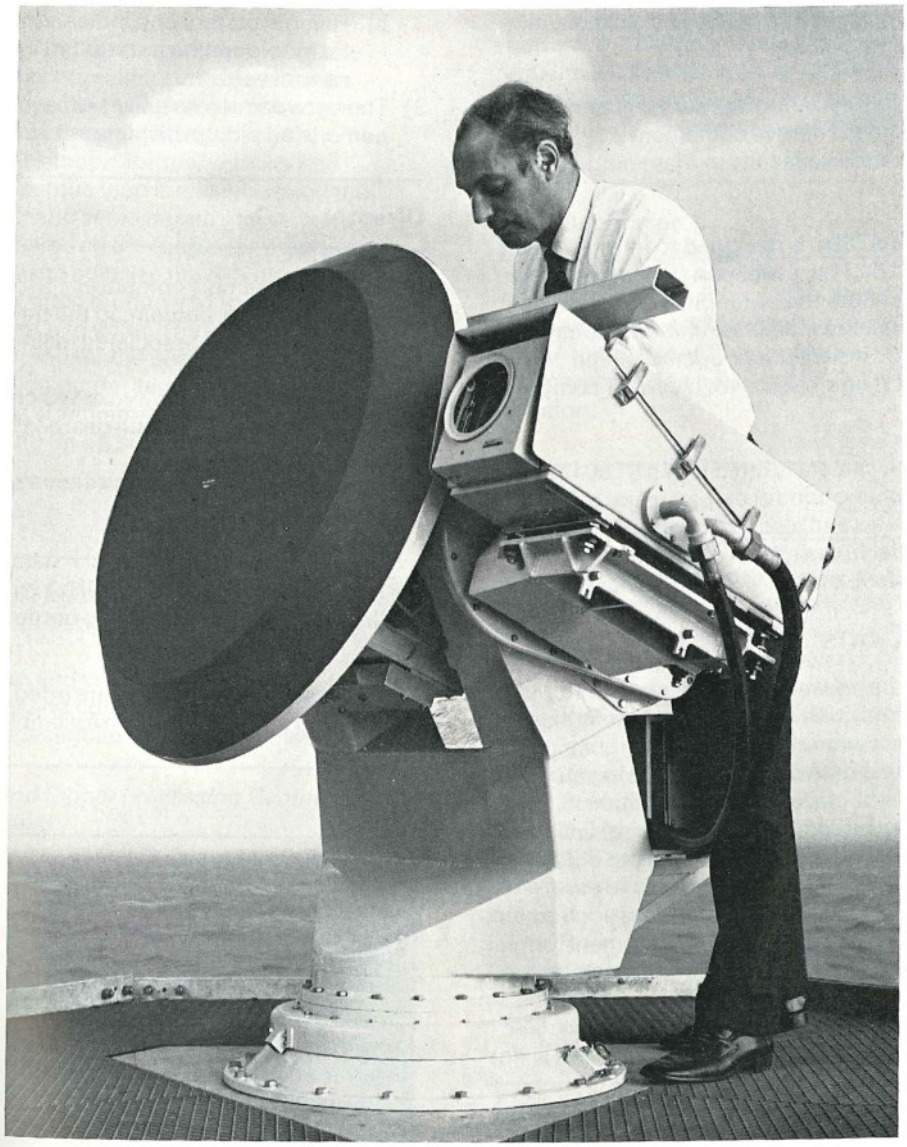
Marconi Radar Data Sheet L1

Naval 3cm X-Band Search and Tracking Radars Type ST801 and ST802



Lightweight, X-band, monopulse radar for directing small and medium calibre guns and for use as the target tracking element within guided missile systems

Marconi Naval Radar Type ST801 is an X-band Monopulse Search/Tracking Radar for use as the auto-tracking element in gunfire direction systems and in missile launching and guidance systems. Any air or surface target which has been detected either by the ship's surveillance radar, or by the ST801 in its own search mode, can be automatically acquired and tracked with the sightline stabilized against the roll and pitch motions of the ship.

In the search mode, the ST801 aerial rotates about a stabilized vertical axis at 20 rev/min providing a 'true horizon' search. The performance of the radar in low angle air search, particularly when sea clutter conditions are present, can be enhanced by selection of moving target indication (MTI) signal processing.

Built-in electronic counter counter measures (ECCM) facilities improve equipment performance and availability in a jamming environment.

Radar type ST801 is designed to interface with, and be controlled by, a weapon systems computer. Radar type ST802, the autonomous version of the ST801, includes facilities and additional equipment for independent operation and control in systems not equipped with a central computer complex.

A television camera is fitted to the ST801 to provide automatic control of 'command to line of sight' missiles and also the means of viewing along the radar boresight. In a basic gunfire direction system, the television need not be fitted.

Applications

1) Surface and low angle air search.
2) Radar acquisition and tracking of a surface or air target to provide the necessary polar co-ordinate data on the target during an engagement by gunfire. This function is backed up by a shell splash spotting facility.
3) Radar tracking of an air target in the different modes of engagement by surface to air 'command to line of sight' missiles such as SEACAT, with the television equipment forming part of the automatic missile gathering system, namely :
   a) Visual mode.
   b) 'Dark-fire mode', i.e. when the target is not visible.
   c) 'Blind-fire mode', i.e. when neither the target nor the engaging missile are visible. To meet this requirement, a second receiver channel is fitted so that both target and missile can be tracked and their offset presented to provide missile guidance information.
4) Radar tracking of surface targets to provide the initial data for the launching of surface to surface missiles such as EXOCET, with the television system available to provide visual tracking in support of radar.

General Description

The Marconi Type ST801 Naval Radar consists of :
1) A lightweight two-axis director fitted with rate gyros and controlled by precision servos. The elevation head, mounted on the training base, carries the antenna, the r.f. portion of the receiver and the mounting for the television camera. Rotating joints and slip rings connect the director electrically to the between-decks equipment.
2) The between-decks radar equipment, comprising :
   a) A two-bay cabinet bolted to a shock mounted plinth, one bay containing the receiver and signal processing equipment and the other the X-band transmitter and the servo equipment. A heat exchanger is fitted in the plinth and a waveguide air dryer unit is mounted separately.
   b) Remote control and indication panel units for incorporation as required in a weapon control console.
3) The between-decks television equipment, comprising picture display and control units.

Director

The director assembly comprises :
1) A training base, containing the training motor and bearing with associated main and data gearboxes.
2) A fabricated light alloy yoke which carries the elevation motor and data gearbox.
3) The r.f. head and aerial.
4) Mounts for the television camera and its control box.

Outputs of training and angular data are provided by 1 :1 and 36:1 synchros (400Hz) with an additional 1 :1 synchro training output for display drive.

Electrical de-icing heaters are fitted to both the training and the elevation assemblies.

Aerial

The aerial is of the twist cassegrain type and is 1 metre in diameter. A four horn monopulse feed and comparator provide three separate r.f. outputs (viz. sum, elevation difference and training difference signals) for processing in the i.f. receivers to produce acquisition and auto-follow data. High accuracy of angular data results from the combination of a 2·4° pencil beam and the monopulse signal processing.

Slip-ring Assembly

This provides power and signal connections between the fixed and moving parts of the director, enabling it to rotate continuously when in the surveillance mode.

The slip rings are of the drum type, the power rings being silver with silver braid brushes and the signal rings gold plated brass with gold alloy brushes.

The rotating section is supported at top and bottom by sealed bearings and the whole slip

ring assembly is mounted on the lower side of the training base.

Below the assembly a dual channel X-band rotating joint is fitted to carry the transmitter and local oscillator signals.

Servo Drives

Motion in elevation and training is provided by low speed torque motors acting through single reduction gears. The servos use Type 2 control so that there is no velocity lag. Stabilization data is provided by precision gyros.

The training and elevation drive motors are powered and controlled by solid state servo amplifiers housed in the lower section of the between-decks transmitter bay. Each servo has three feed-back loops, torque, velocity and position. The torque loop is closed around the drive amplifier and servo motor. The velocity loop is closed around the torque loop using rate gyro feed-back to stabilize the director against ship's roll and pitch motion and to counter disturbances due to wind. The velocity loop also provides damping for the position loop in its function of aligning the aerial boresight with the target sightline when auto-tracking or when following up on acquisition data.

Transmitter

The transmitter, housed in one bay of the between-decks electronic equipment cabinet, comprises :

1) Magnetron and waveguide assembly.
2) Modulator and control circuits.
3) A.C. voltage regulator and e.h.t. power supply.

Transmitter and Signal Processing Cabinet (in two sections)

The magnetron delivers a typical power of 180kW peak (160W mean) and is mechanically tunable over the frequency band 8·6 to 9·5GHz by a geared motor drive with overall band coverage in 12 seconds. The frequency control, with meter indication, is fitted on the control console.

The e.h.t. power supply circuit is protected against malfunction of the magnetron or the thyratron and the input to it is stabilized against variations in the mains supply.

The line type pulse modulator employs d.c. resonant charging and a hydrogen thyratron switch, which supplies the magnetron with a pulse of 0·3 microseconds at pulse repetition frequencies of either 3000 or 4400Hz in the non-MTI mode. In the MTI mode the p.r.f. is staggered with a mean value of 4400Hz.

Local Oscillator

The local oscillator, fitted in the signal processing bay, is a solid-state microwave source with voltage tuning for automatic frequency control and possessing the necessary stability for MTI operation.

R.F. Head Assembly

Transmitter and local oscillator outputs are fed by waveguide via rotating joints to the r.f. head which is enclosed in a housing mounted on the director elevation assembly. A high power duplexer separates the transmitted and received signals, with gas discharge tubes providing additional protection for the three receiver channels. The three balanced mixers are contained in a single unit with an integral local oscillator distribution system. Solid-state i.f. head amplifiers provide outputs via co-axial cables and the slip-ring unit to the main i.f. amplifiers in the between-decks equipment.

An r.f. test signal can be injected into the receiver channels through an injection coupler in the feed.

I.F./Video Receiver

This section of the receiver system provides :

1) D.C. error signals proportional to the antenna misalignment to the angle servo systems
2) Video signals to the target acquisition and range tracking circuits.

Two matched phase sensitive detectors, fed with the signal in the sum channel together with the difference signal in the training/elevation channels, produce outputs proportional to the angular errors in training and elevation. These outputs are integrated to provide d.c. error signals for the angle servos.

The sum channel signal is also processed separately in a logarithmic amplifier which provides signals to the auto-detection system and to the range tracking circuits.

Signal Processing

Automatic acquisition and range tracking are carried out by the signal processing circuits. Extensive use of digital techniques ensures the optimum accuracy with the minimum of routine setting up and adjustment.

The sequence of events within the radar is controlled by the master programming unit. For automatic acquisition of an indicated target, a search in range and bearing is initiated. When the target is found, a 'Target Seen' signal is generated to stop the search and switch to the 'track' condition.

Range tracking is digital and incorporates a 'hold rate' mode to ensure that targets are not lost due to signal fading. The hold rate continues until either the signal is re-detected and normal tracking continues or until, after a pre-set time, a search sequence is reinstated using either new or the memorized target data.

Moving Target Indication (MTI)

A switchable MTI facility is provided in the ST801 radar to reduce the effects of surface clutter and weather returns on the display and to minimize false acquisitions and interference when tracking low flying targets.

The MTI processing is of the 'coherent on receive' type employing a stable X-band local oscillator (STALO), a coherent oscillator in the output of the i.f. receiver (COHO) and a digital MTI filter with shift register storage and feed-back.

To allow for the relative movement between the ship and clutter, velocity compensation derived from ship's log data is applied to the COHO.

ECCM Features

The electronic counter counter measures (ECCM) features of the ST801 include:

1) A tuneable magnetron.
2) Monopulse signal processing.
3) MTI facility (effective against chaff).
4) Ability to track passively on targets using ECM.
5) Constant False Alarm Rate detection (c.f.a.r.).

Television

The ST801 has been designed to incorporate the Marconi television missile autogather system, as specified for installation in the weapon systems of existing and new construction Royal Navy frigates and destroyers. The V323 television camera is mounted on the director elevation assembly, so that its optical axis may be collimated with the mechanical and electrical axis of the director and then locked into position.

For automatic missile control, the television system acquires the missile flares as they enter the camera field of view after launch, and the data extraction unit, mounted in the below decks control console, automatically determines the error between missile position and target sightline. This error is fed to the missile command transmitter to bring the missile quickly and smoothly on to the target sightline. Automatic television control of the missile may then continue until range coincidence.

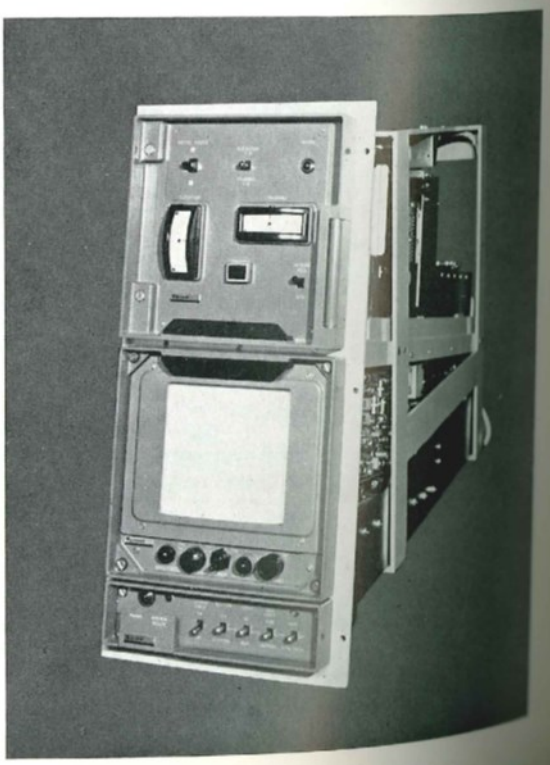
Television autogather has the following advantages:

1) Removes responsibility of this critical phase from the human operator.
2) Removes operator from the above-decks environment.
3) Provides a fast, smooth gather of missile on to target sightline.
4) Improves short range capability.
5) Improves overall effectiveness of the weapon system.

Alternatively the television may be used as a support to radar tracking for the following functions:

1) Acquisition of targets at low angles of elevation.
2) During conditions of radio silence.
3) In an ECM environment.
4) Target identification and damage assessment.
5) Checking radar system accuracy.

Television control and display unit



Control and Display

Control and display facilities for the ST801 are provided in the weapon control console (normally situated in the operations room) in the form of switches, indicator lamps, meters and signal displays. For ease of incorporation in control consoles these components have been designed as six separate units with dimensions compatible with the versatile console system units as designed for the Royal Navy. They can also be fitted into any control console configuration to meet customer requirements.

The facilities provided include :

1) A flow-line to indicate the state of the radar.
2) A coarse range A-scope display, with a trough to indicate the extent of the range search gate.
3) A fine range A-scope, displaying the range search with a step marker to indicate the position of the range gate. A shell splash gate can also be displayed when required.
4) A 216mm ($8\frac{1}{2}$in) television display and system control panel.
5) An elevation error meter.
6) A training error meter with the alternative function of indicating the offset angle of shell splash.
7) A shell splash manual gate control to position the shell splash gate over the splash echo on the fine range display.
8) A push button to cause the shell splash offset to be indicated.
9) A 'go to standby' button which interrupts the radar action and returns it to the 'standby' condition.
10) Transmitter frequency control and indication.
11) Manual hold rate select.
12) Receiver sensitivity switch for the shell splash mode.

Monitoring and Testing

Operational Checks

Built-in test and monitoring facilities are provided to enable the following checks to be made on the function of radar and television sub-systems :

1) Transmitter output.
2) Elevation and training error sensitivity.
3) Servo response.
4) Receiver functioning.
5) Operation of acquisition and range circuits.
6) Television camera and missile control circuits.

Maintenance Checks

For more detailed routine checking or fault finding, provision is made for local control of the operation of the ST801 by means of a portable test set which can be connected to the radar equipment cabinets. This test set provides simulated external data and commands to enable monitoring/checking of detailed functions and parameters in the individual sections of the equipment.

Typical Performance

Radar

Detection range (aircraft):
25km on a $4m^2$ target (90% probability of detection single scan).

Detection range (surface):
30km on a fast patrol boat (limited by the radar horizon).

Range tracking accuracy:
12m (r.m.s.) with an S/N exceeding +10db.

Angular tracking accuracy:
less than 3 minutes of arc r.m.s. in the range 3km to 13km for both training and elevation on a $4m^2$ target.

Servo (70 knot wind)

Training motion

360° continuous rotation at 20 rev/min. (search mode).

Acceleration:
100°/s² (slew and tracking modes).

Velocity:
120°/s (slew and tracking modes).

Elevation motion

Antenna motion:
−30° to +85°.

Acceleration:
100°/s²

Velocity:
50°/s.

Environmental Conditions

The equipment has been designed to operate and survive in a ship environment. A summary of the main design parameters is as follows :

Shock(above-decks):
upwards 40g, downwards 30g, lateral 24 g.

Shock(below-decks):
upwards 120g, downwards 60g, lateral 40g (equipment cabinets mounted on X-type shock mounts).

Maximum temperature for above-deck equipment:
+55°C ambient (operational), +70°C including solar radiation (operational).

Minimum temperature for above-deck equipment:
−18°C (operational), −40°C (survival).

Wind:
relative velocities of 70 knots (operational), 120 knots (survival).

Ship's motion
the equipment will give full performance under stabilized ship conditions. Some degradation may be experienced for unstabilized ships.

Stabilized ship

Roll:
± 7° period 9s.

Pitch:
± 8° period 6·5s.

Heave:
± 6m period 6·5s.

Yaw acceleration:
0·25°/s².

Yaw velocity:
2·75°/s.

Unstabilized ship

Roll:
± 20° period 9s (shortest period 6s).

Pitch:
± 12° period 6·5s (shortest period 3s).

Heave:
± 6m period 6·5s.

Yaw acceleration:
0·25°/s².

Yaw velocity:
2·75°/s.

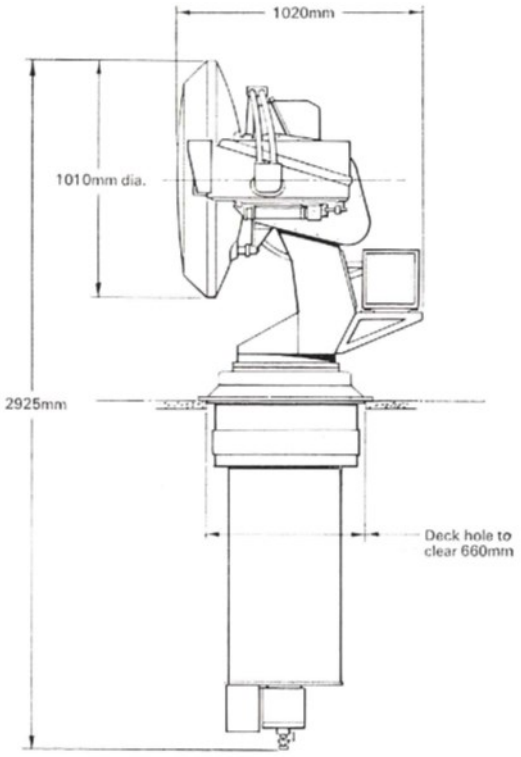
Motion is assumed to be simple harmonic except that, with stabilized ships, roll velocities and acceleration should be multiplied by 1·5

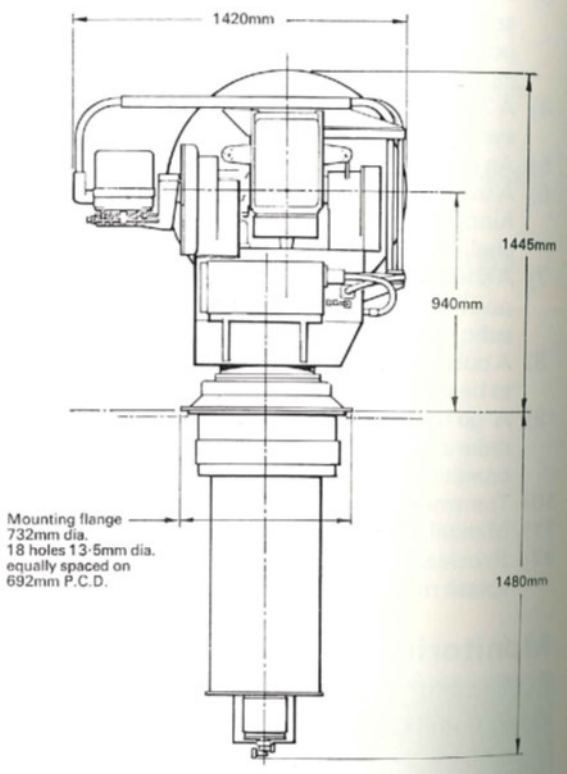
Installation and Maintenance

The equipment has been designed for ease of ship installation. In particular:

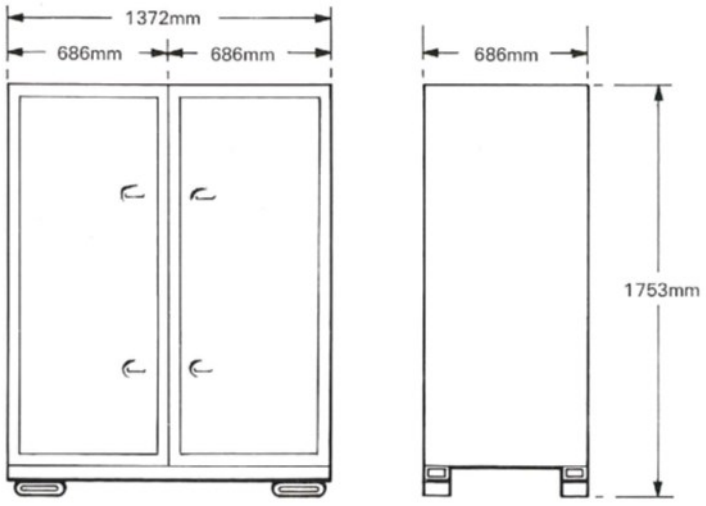
1) All equipment can be passed through a standard ship's hatch.
2) Front access only is required for the maintenance of equipment in the below-decks cabinets.
3) The provision of r.f. screening.
4) The below-decks cabinets can be installed at up to 20 metres from the director.
5) The control console units can be installed at up to 100 metres from the below-decks cabinets.

The maintenance policy adopted is to repair units and printed circuit cards by replacement. Final fault diagnosis, repair and testing can then be carried out ashore.





Director



Transmitter and signal processing cabinet (in two sections)

Data Summary

Antenna
1 metre Twist Cassegrain.
Beam width:
2·4° pencil (to 3 db points).
Gain (each way):
35·5 db.
Polarization:
linear vertical.

Transmitter
X-band:
8·6 to 9·5GHz.
Peak power:
180kW (typical).
Mean power:
160W (typical).
Pulse length:
0·3μs.
Pulse repetition frequency:
3000 or 4400Hz (non MTI mode),
4400Hz mean (MTI mode).

Receiver
Noise figure:
11db (typical).

MTI
Type:
coherent on receive.
Improvement factor:
greater than 20db.

Reaction time
The time from nominating the target for engagement until tracking is achieved is typically 8 seconds (assuming a 45° slew).

Services
Power supply:
440V, 60Hz, 3 phase, 3 wire.

Power input requirements
Normal operation:
4kVA.
Peak operation (director slewing):
6·5kVA.
De-icing heaters (optional):
6kVA

Chilled water:
10 litre/min (2 gal./min.). A separate chiller unit can be supplied if required.
Compressed air:
4 litre/min. (0·14ft³/min.) at 3·4kg/cm²
(50 lb/in²)

Weights and dimensions
Director, including television camera (dimensions on drawing)
Weight:
500kg (1100 lb).

Radar cubicle (2 cabinets on plinth)
Weight:
645kg (1420 lb).
Dimensions:
1·753m×1·372m×0·686m.

Control and indication units
6 versatile console system units.
Total weight:
65kg (143 lb).
Total panel space required:
0·61m×0·762m.

Waveguide dryer
Weight:
28kg (62 lb).
Dimensions:
0·43m×0·355m×0·127m.

Test trolley (optional)
Weight:
45kg (100 lb).
Dimensions:
0·608m×0·508m×0·558m.

The information given herein is subject to confirmation at the time of ordering

Marconi Radar Systems Limited
A GEC–Marconi Electronics Company
New Parks, Leicester, England LE3 1UF
Telephone: Leicester (0533) 871331. Telegrams: Assocelect Leicester.
Telex: 34551.

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