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TA-ENG: SESC - FFG DIVISION

FFG COMBAT SYSTEM LEARNERS GUIDE

VERSION 2.01, DATED 10 Dec 2014

SECTION 2 – SENSORS

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1. Section of this learners guide provides an overview of the sensor systems used on the RAN FFG. This section has the following structure:

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d. Ch4 AN/SPS-55 Surface Search and Navigation Radar

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(1) Under Water System (UWS)

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(3) Underwater Telephone (although not a technically a sensor, UWT is included in this section due to it’s similarity to sonar systems).

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Chapter 2. Practical Radar Theory

Introduction

1. This chapter is written assuming the reader has existing knowledge of Radar Theory and intended only as a 'memory jogger'. This chapter supplements the PowerPoint slide show presentation on the FFG Combat Systems Course (200796) and is focused on the capabilities of FFG specific radars.

2. Pulsed Radar provides the ability to calculate range by timing how long a Radio Frequency (RF) pulse takes to be reflected and detected. Below is a basic generic pulsed Radar block diagram.

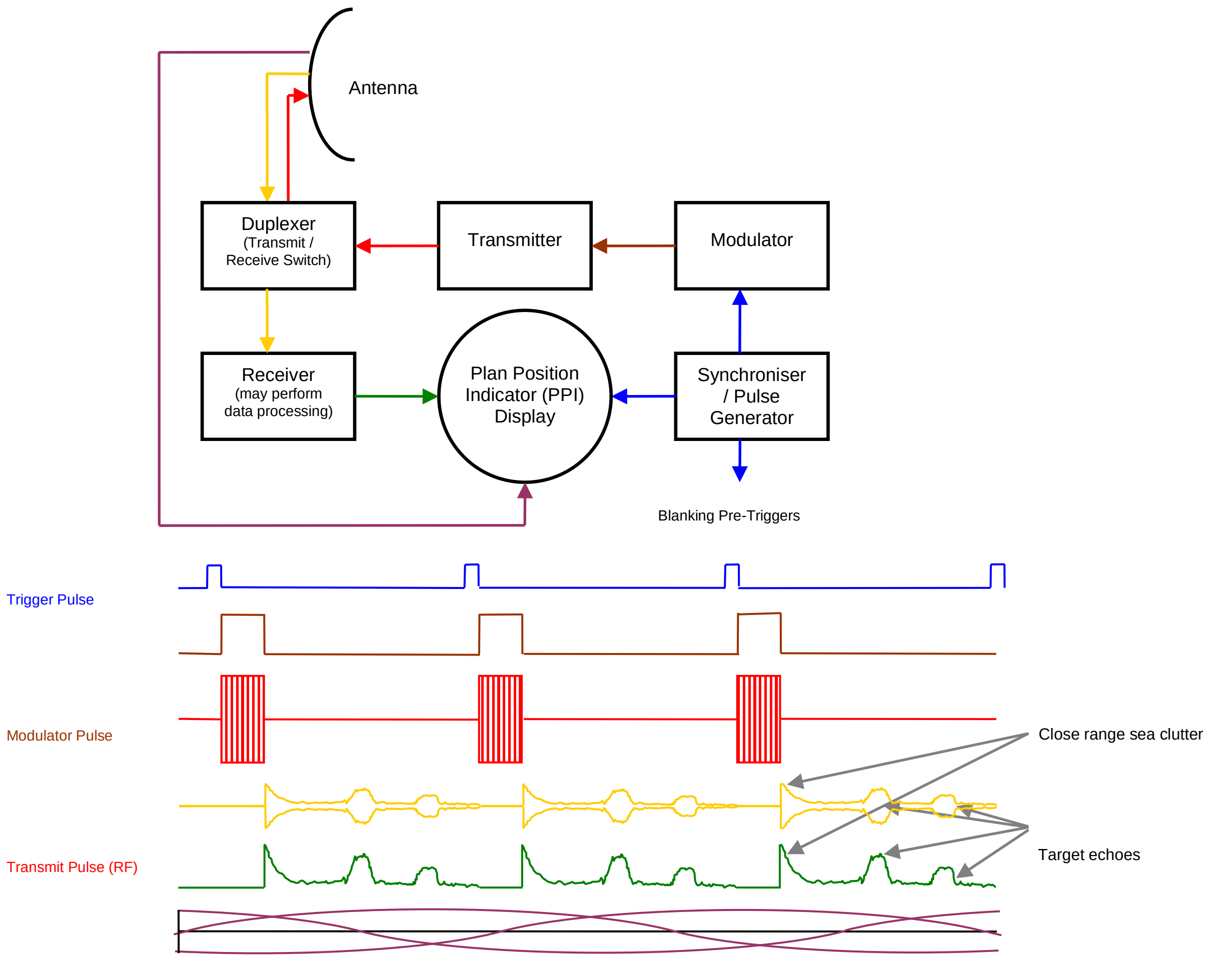

Figure 2-1: Generic Mono-Static Pulsed RADAR Block Diagram

3. **Synchroniser** – supplies synchronising signals (triggers) to initiate timing for transmit pulses, IFF interrogations and blanking.

4. **Modulator** – when the modulator gets a trigger pulse, it charges up a high voltage pulse with the pulse width of that which is intended for the Tx RF pulse. (Modulator is sometimes seen as part of the Transmitter)

5. **Transmitter** – produces high power RF pulses of energy, with timing determined by the modulator pulse.

6. **Duplexer (T/R Switch)** – Switches the antenna between the Transmit RF path and Receive RF path. Can't have both on simultaneously because the Tx pulse would saturate and damage sensitive Rx equipment.

Carrier Frequency Properties

7. The Frequency Spectrum is subdivided because as the carrier frequency changes, so do the physical qualities of the radar. These can be desirable or undesirable depending on the intended use of the Radar.

8. There are two main standards:

   a. IEEE standard Radar bands

   b. NATO, US, EU ECM frequency designations

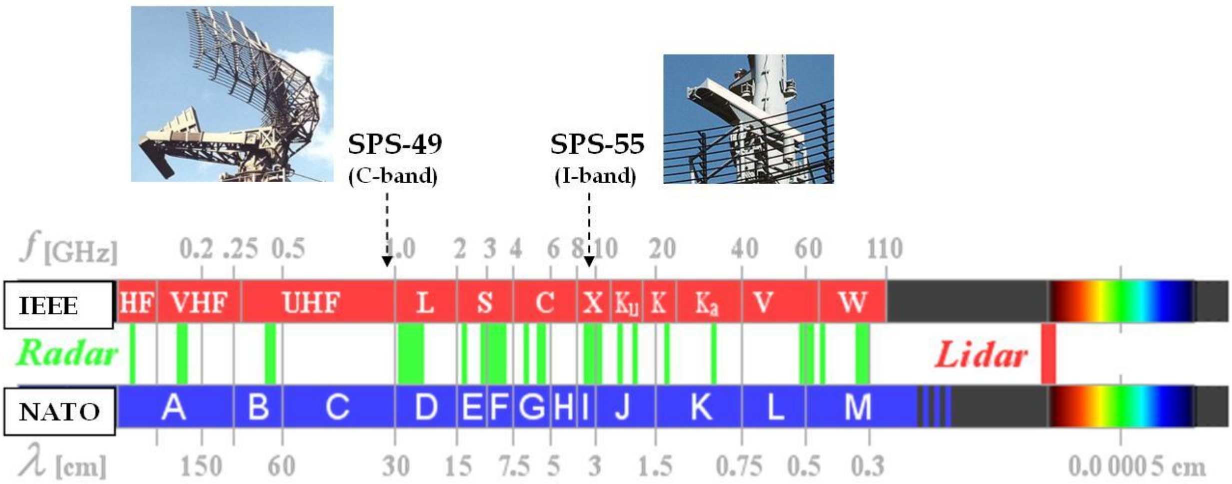

Figure 2-2: RF Spectrum Standards

9. Frequency based radar applications include:

   a. A- and B- Band (HF- und VHF- Radar)

      i. Very long range early warning radars

      ii. Over The Horizon (OTH)

   b. C- Band (UHF- Radar)

      i. detection & tracking of satellites & ballistic missiles over a long range

      ii. Ground Penetrating Radar

   c. D- Band (L-Band Radar, ‘L’ for Long range)

      i. long-range air-surveillance

      ii. Air traffic control

   d. E/F-Band (S-Band Radar)

      i. Moderate range surveillance

      ii. Terminal air traffic control

      iii. Long range weather radar

   e. G- Band (C-Band Radar)

      i. Satellite transponders

      ii. Compromise between X and S band

      iii. Weather

      iv. Long range tracking

   f. I/J- Band (X and Ku-Band Radars)

      i. Missile guidance

      ii. Marine radar

      iii. MASTIS (note the other applications within this frequency band that MASTIS may interfere with)

   g. K- Band (K- and Ka- Band Radars)

      i. short range, very high resolution

ii. Surveillance

iii. Cloud detection

iv. Police radar guns

h. V-Band

i. Strongly absorbed by atmospheric radiation

ii. Ranges of only a few metres

i. W-Band

i. Car parking assist radar

ii. High resolution metrological observation

iii. Imaging

10. The choice of Carrier Frequency for a Radar will affect:

a. Antenna Size / weight.

i. Lower freq (longer λ) = larger (and heavier) antenna size

ii. Higher freq (shorter λ) = smaller (and lighter) antenna size

b. Transmitted Power (affects probability of detection)

c. Antenna Beam Width (and hence bearing accuracy)

d. Atmospheric attenuation (range)

Carrier Frequency Advantages & Disadvantages

11. For a Higher carrier frequency:

a. Advantages

i. Smaller antenna

ii. Narrower beamwidth (better angular resolution)

iii. Smaller side lobes

iv. Better target resolution

b. Disadvantages

i. Shorter ranges (more atmospheric attenuation)

ii. Limited power transmission

iii. Narrower beamwidth (fewer pulses per sweep and may require antenna stabilization)

iv. More blind speeds

v. More clutter

12. For a lower Carrier Frequency:

a. Advantages

i. Longer ranges (less atmospheric attenuation)

ii. Less clutter

iii. Higher power output

iv. Wider vertical beamwidth (can be un-stabilised)

v. Fewer blind speeds

b. Disadvantages

i. Larger antenna (mechanical limitations)

ii. Wider beamwidth (less angular resolution)

iii. Poorer target resolution

iv. Bigger side lobes

Carrier Frequency Agility

13. Using a selection of Carrier frequencies at different times is called Frequency Agility. This can:

a. Account for atmospheric effects;

b. Afford Jamming resistance;

c. Avoids mutual interference;

d. Increase transmitter and receiver complexity.

Power

14. The more energy the radar system transmits:

a. The greater the probability of detection

b. The greater the target detection range $R_{Max} \propto \sqrt[4]{P_T}$

15. Levels of power that can be reasonably handled by a radar transmitter are largely limited by voltage gradients and heat dissipation requirements. Therefore:

a. Lower Carrier freq (longer λ & larger antenna) can transmit larger amounts (Megawatts) of average power.

b. Higher Carrier freq (shorter λ & smaller antenna) may be limited to only a few hundred watts of average power.

Radar Cross-Section

16. **Radar cross-section** (RCS) is a measure of how detectable an object is with a radar. A larger RCS indicates that an object is more easily detected. An object reflects a limited amount of radar energy. A number of different factors determine how much electromagnetic energy returns to the source such as:

a. material of which the target is made;

b. absolute size of the target;

c. relative size of the target (in relation to the wavelength of the illuminating radar);

d. the incident angle (angle at which the radar beam hits a particular portion of target which depends upon shape of target and its orientation to the radar source);

e. reflected angle (angle at which the reflected beam leaves the part of the target hit, it depends upon incident angle);

f. the polarisation of transmitted and the received radiation in respect to the orientation of the target

17. While important in detecting targets, the output power of a radar and the range to the target are not factors that affect the calculation of a RCS because the RCS is a property of the target reflectivity.

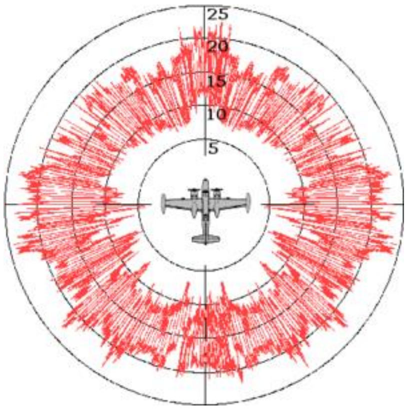

Figure 2-3: Radar Cross Section (not distributed evenly)

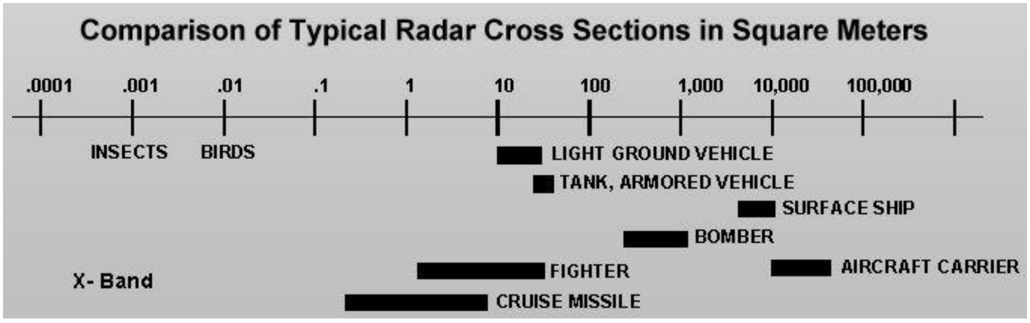

Figure 2-4: Comparison of Typical Radar Cross Section (in X-band)

Gain

18. Focusing transmitted power into a beam increases the Power Density (PD). The increase in PD (gain) is measured in decibels (dB) which compares PD in the beam to the PD if the transmitted power was equal in all directions (isotropic).

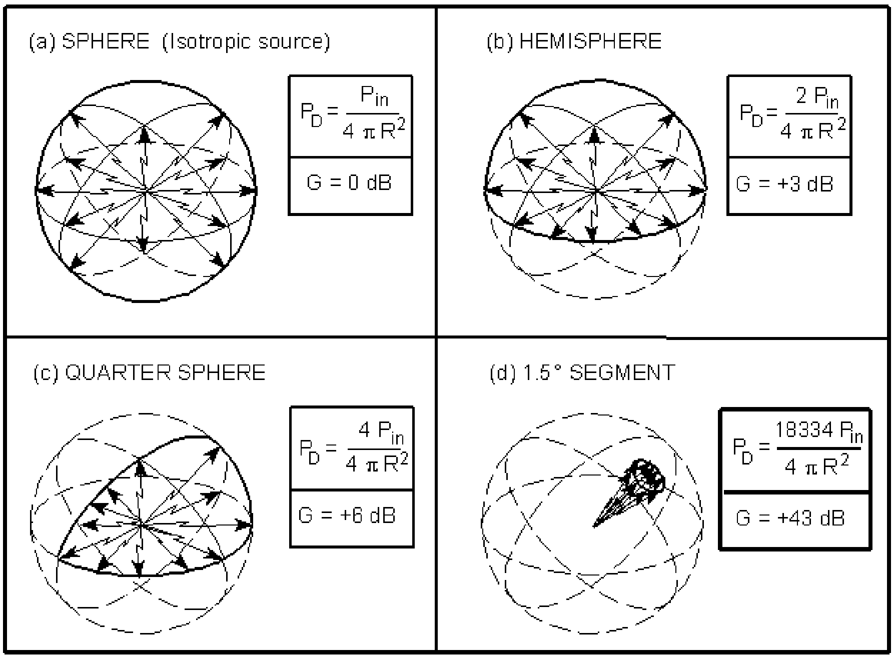

Figure 2-5: Antenna Gain

19. Gain is dependant on the Beam Shape. The Beam Shape is dependant on the Antenna.

Parabolic Antenna

20. Focuses the transmitted RF energy into a 'Beam'. The ideal beam is perfectly collimated 'pencil' beam, however in practice, irregularities in the production of the antenna result in a conical beam with side lobes.

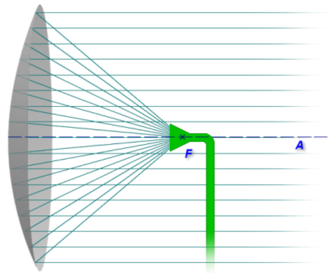

Figure 2-6: Parabolic 'Focusing'

Figure 2-7: Imperfect 'Pencil' Beam

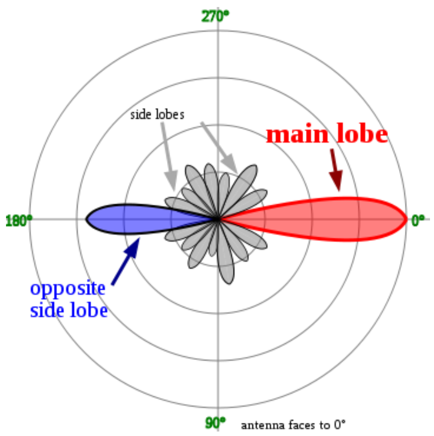

Figure 2-8: Side Lobes

21. The Beamwidth is measured as the angle between the 3dB points - where power drops to half that of the maximum power in the centre of the beam.

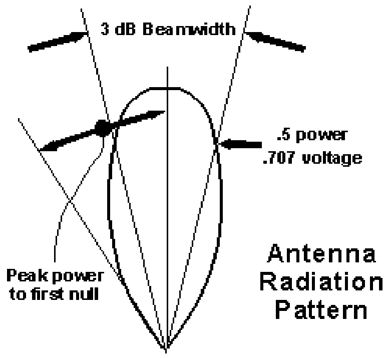

Figure 2-9: 3dB Beamwidth

Fan Beams

22. If a parabolic antenna is 'truncated', i.e. cut short in one dimension, this will change the beam shape. A common example is 'Orange Peel' antennas similar to AN/SPS-49.

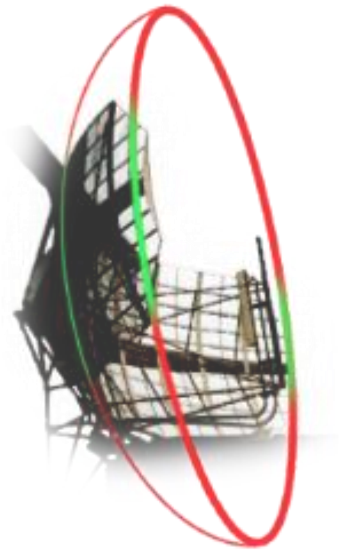

Figure 2-10: Orange Peel Antenna

23. The affect on the beam is that it will not be as focused in the truncated axis, so the beam will be wider. So the Beamwidth in one axis is inversely proportional to the Antenna shape in that axis.

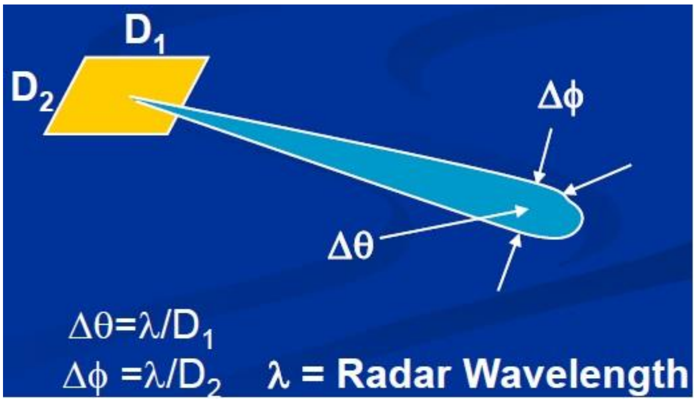

Figure 2-11: Relationship Between Antenna Shape and Beam Shape

24. For the orange peel antenna pictured above, which is truncated in the vertical axis, this will result in an 'unfocused' wider beam in the vertical axis. The horizontal axis of the antenna is wider which focuses the beam into a narrower horizontal beamwidth. This beam shape is known as a 'Fan Beam'. The fan beam is particularly useful for surveillance radars which search a large area very quickly by rotating (moving the fan beam horizontally around the antenna) in a "horizon search" pattern. It would take a pencil beam considerably longer to search the same area because it would have to scan up and down as well as rotating.

25. Any targets detected in a fan beam will provide a relatively accurate bearing based on the narrow horizontal beamwidth, but very inaccurate elevation (height) due to the wide vertical beamwidth.

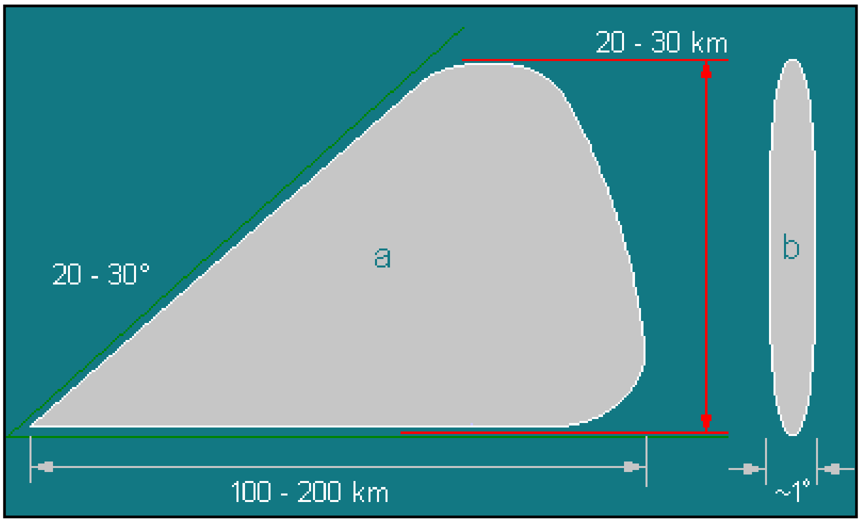

Figure 2-12: Fan Beam

26. The Horizontal Beamwidth determines the Radar's angular (bearing) resolution. Two targets flying side be side may only appear as a single contact for a radar with a wider horizontal beamwidth, because they both fall within the beam as it scans round. A narrower beam would be able to discriminate between the two targets.

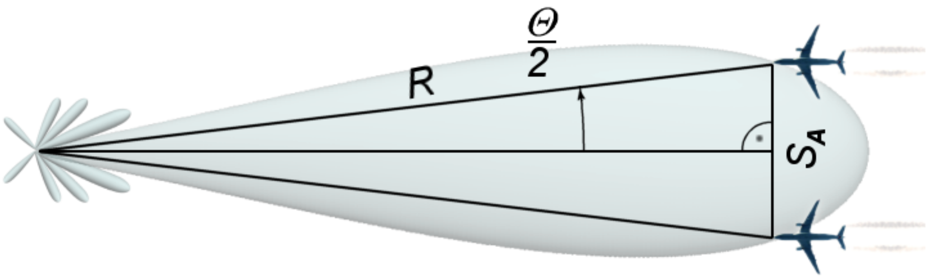

Figure 2-13: Bearing Resolution (Beamwidth)

Cosecant Squared Beam

27. Antennae employing a cosecant squared pattern are specially designed for air-surveillance radar sets. These permit an adapted distribution of the radiation in the beam, causing a more ideal space scanning.

28. In practice, a cosecant squared pattern can be achieved by a deformation of a parabolic reflector. The radiator (feed horn) is in the focal point of a parabolic reflector and produces a relatively sharply bundled radiation lobe since the rays leave the reflector roughly parallel. To get the cosecant squared pattern, a part of the radiated energy must be turned up. This can achieved by displacing the reflector surface from the original parabolic shape:

a. less bending at the top of the reflector, so the part of the rays which fall on the less bent area is reflected up; or

b. bend the lower part of the reflector tighter than the parabolic curve, to reflect rays from the bottom of the antenna higher.

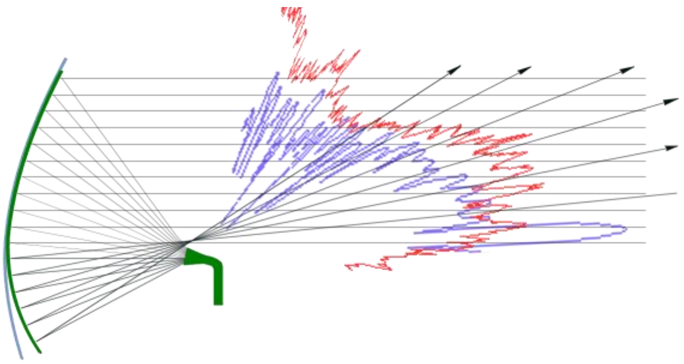

Figure 2-14: Cosecant-squared pattern achieved by Antenna Deformation

29. The rays turned up don't have a large power density, so the maximum range in the higher elevation is limited. This is desirable because it more closely approximates the Idealised cosecant-squared pattern:

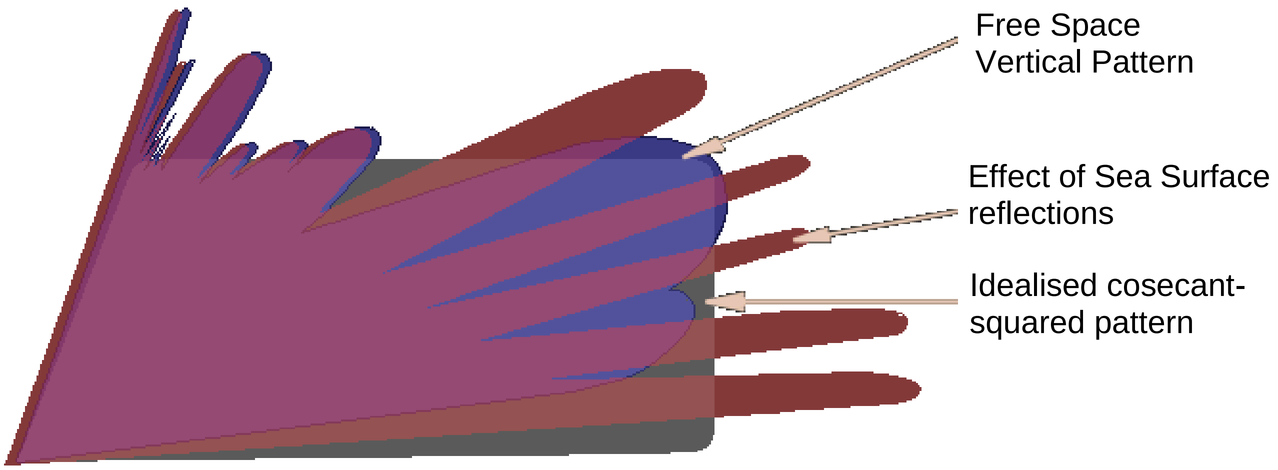

Figure 2-15: Cosecant-squared pattern

30. The 3dB vertical beamwidth for AN/SPS-49 is 10º shaped to 30º using cosecant-squared beam pattern. Below is a representation of the vertical beam pattern of a Radar with similar shaping properties to AN/SPS-49:

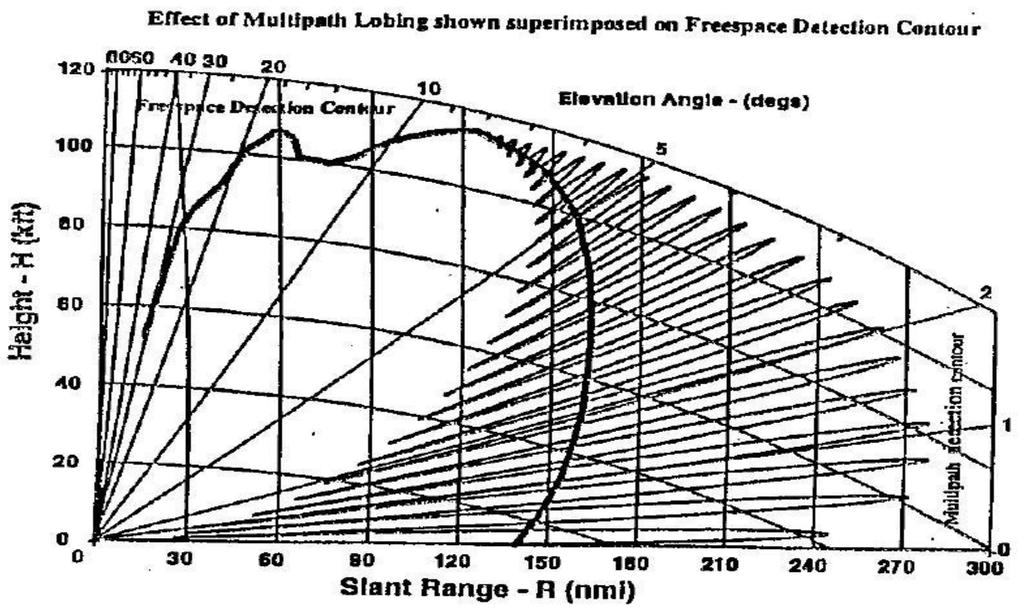

Figure 2-16: Cosecant-squared Pattern Shaped from 10º to 30º

Feed Positions

31. Parabolic Antennas are also classified by the type of feed:

a. Axial or front feed - (STIR)

i. Most common.

ii. feed antenna located in front of the dish at the focus, on the beam axis.

iii. Disadvantage: feed and its supports block some of the beam, limiting the aperture efficiency to only 55 - 60%.

b. Offset or off-axis feed - (SPS-49)

i. feed structure out of the beam path, so it doesn't block the beam.

c. Cassegrain - (CAS Track)

i. Feed located on or behind dish, radiates forward, illuminating a convex secondary reflector at the focus of the dish. Radio waves reflect back off secondary reflector to the dish, which forms the main beam.

ii. Advantage: the feed, with its waveguides and "front end" electronics does not have to be suspended in front of the dish, (used for antennas with complicated or bulky feeds).

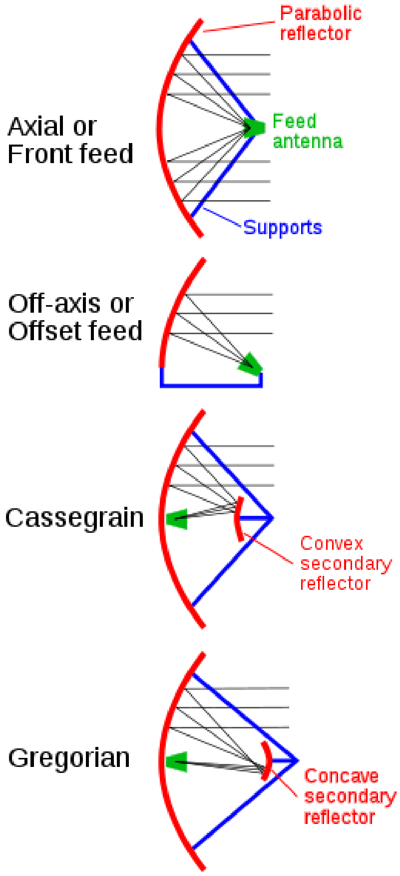

Figure 2-17: Antenna Feeds

Slotted Waveguide Antenna

32. A Slotted Wave Guide Antenna has no reflector but emits directly through slots cut into the waveguide.

33. Spacing of the slots is critical and is a multiple of the wavelength used for transmission and reception.

34. Slotted Wave Guide Antennas are a high gain antenna that is highly directional in the plane of the antenna. They are not as efficient as a parabolic reflector, lacking an ability to focus in the vertical plane (i.e., a fan beam), but is much more durable and is less expensive to construct

Figure 2-18: Slotted Waveguide Antenna

35. AN/SPS-55 is constructed with two slotted waveguides back to back with different polarisation. When the Radar Controller decides to change the polarisation, the RF feed is switched from one slotted waveguide to the other. This results in the SPS-55 sweep on the PPI 'jumping' 180º when the polarisation is changed.

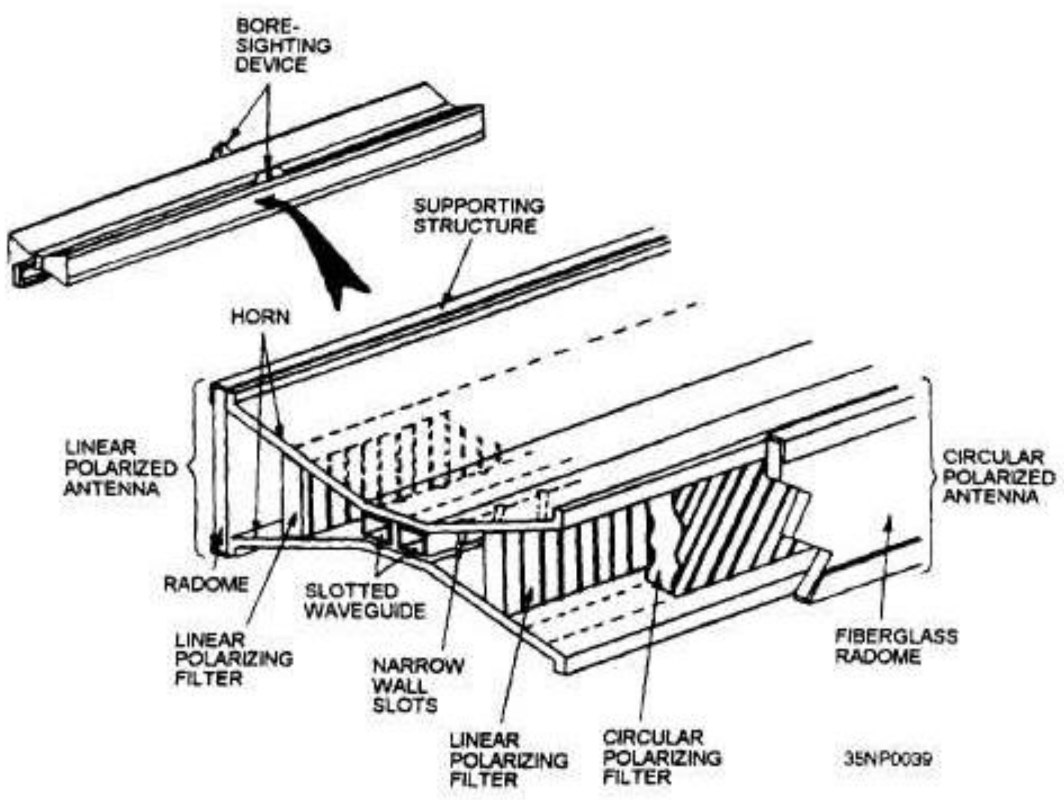

Figure 2-19: AN/SPS-55 Slotted Waveguides

Polarisation

36. Electromagnetic waves have electric and magnetic lines of force at right angles. The electric field determines direction of polarisation.

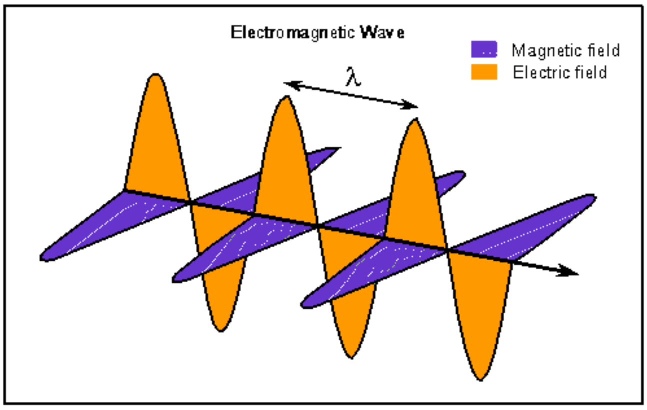

Figure 2-20: EM Wave Polarisation

Linear Polarisation

37. A wave is said to have linear polarisation when the plane of the electric field is perpendicular to the direction of travel of the wave (as illustrated in Figure 2-21).

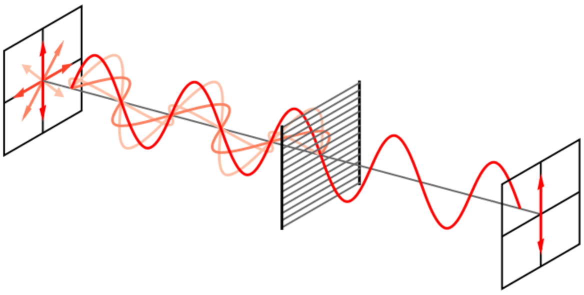

Figure 2-21: Linear Polarisation

Circular Polarisation

38. Circular Polarisation can be right-handed or left-handed.

39. The main advantage of circular polarisation is that it reduces the clutter seen by the operator in a rainy environment. A circularly polarised wave is reflected by a spherical raindrop in the opposite direction. The antenna rejects waves of the opposite direction, hence minimising the detection of rain.

40. Reflection from a target will have significant components in the original polarisation direction because aircraft and vessels are not spherical. Therefore, valid returns will be provided from these structures.

41. The effective range and resolution of returns is not as good as using linear polarisation in clear weather.

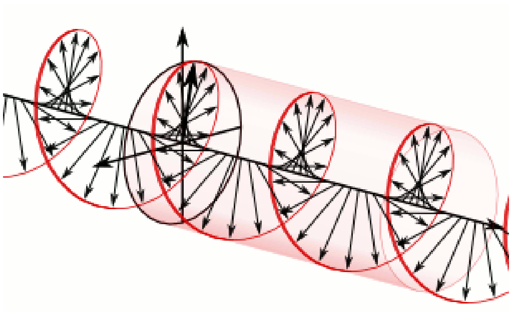

Figure 2-22: Circular Polarisation

Pulse Properties

42. Pulses add some more Radar properties to be considered. RF pulses and Pulse Repetition Frequency can affect the probability of detection and range parameters including; minimum range, maximum unambiguous range and Range resolution.

Terminology

43. Radar Blind Speeds: When operating in Moving Target Indicator (MTI) mode, the radar processes consecutive return signals and samples to see if there is a phase shift in the returns. A phase shift would indicate a return from a moving target. Consecutive returns in phase indicate a stationary target. If the target was moving at a velocity that causes a 360° phase shift in the return signals, the processor would see that return as a stationary target and not pass it through to the PPI. The blind velocity is a function of the wavelength of the transmitted frequency and the Pulse Repetition Time (PRT).

$$v_{blind} = \frac{\lambda}{2 \cdot T_s}$$

where: v_{blind} = one of the blind speeds

λ = wavelength of the transmitted pulse

T_s = pulse repetition time (PRT)

44. The diagram below helps define:

   a. Pulse Repetition Time (PRT)

      i. Time between pulses

      ii. Measured in micro seconds (μS)

   b. Pulse Repetition Frequency (PRF)

      i. Number of pulses per unit of time

      ii. Measured in Hertz (Hz)

   c. Pulse Width (PW)

   d. Rest Time

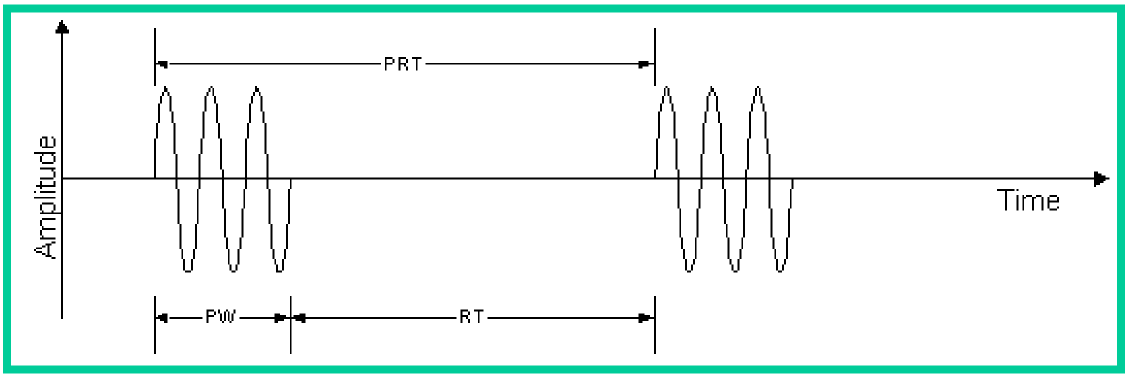

Figure 2-23: Pulsed Radar Terminology

Pulse Repetition Frequency

45. A Higher PRF means:

   a. More hits per sweep

   b. Higher probability of detection

   c. Maximum theoretical range decreases

   d. Range ambiguity more likely

46. Fire control radars use a high PRF as a high data rate is required.

47. Multiple PRFs can be used, changing slightly every few pulses. This has the advantages of:

   a. ECCM feature

   b. Resolves range ambiguous targets

   c. Shifts blind speeds.

Pulse Width

48. Pulse width determines a radar's:

   a. Minimum range

   b. Range resolution

49. It can also affect the probability of detection because the total pulse energy is affected by:

   a. Peak transmitted power

   b. Pulse width

50. As pulse energy increases, probability of detection increases.

Minimum Range

51. During transmitting time the radar cannot receive (this protects the sensitive receiver electronics). The transmitting pulse must leave the antenna completely before the receiver can be switched on. The longer the pulse width, the longer the blind range.

Range Resolution

52. The longer a pulse, the less range resolution. Two targets on the same bearing that are close together will appear as a single contact if the pulse width is wide enough to reach the further target before the tail end of the pulse and cleared the closer target. A shorter pulse width would discriminate between the two targets. The diagram below illustrates this.

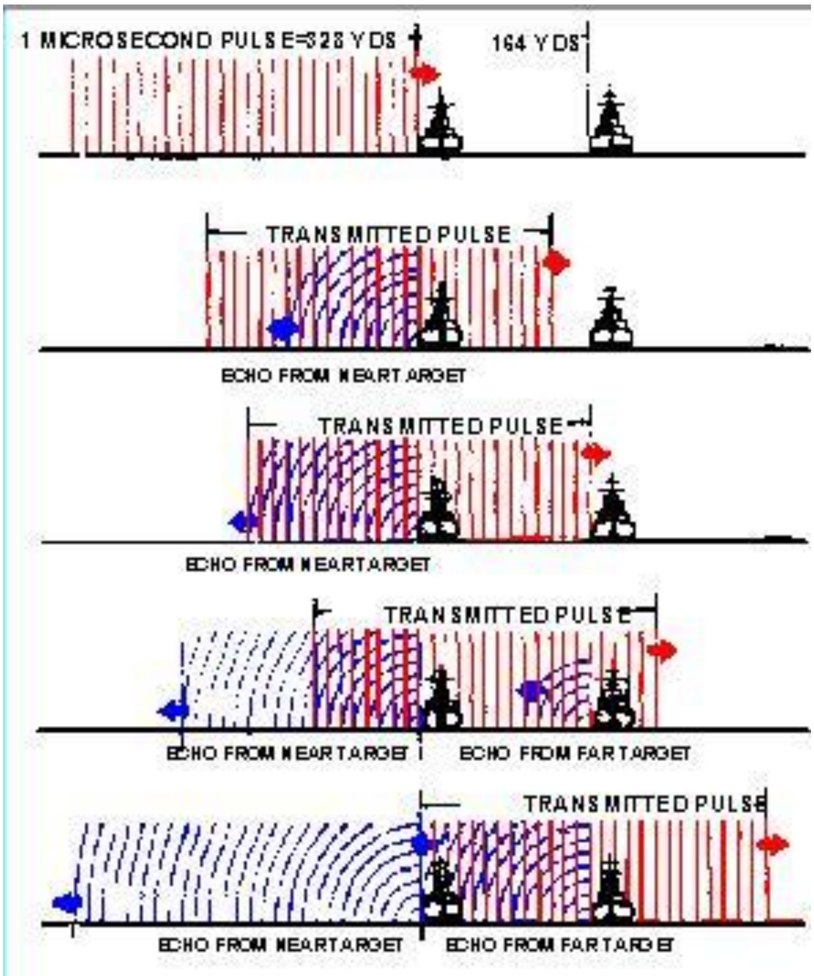

Figure 2-24: Effect of Pulse Width on Range Resolution

Pulse Energy

53. The Peak Power (P_{PK}) is the maximum power in each pulse.

54. The total energy in the pulse (P_{PK} * PW) increases probability of detection (*and the maximum range – but to double the max range would require a 16 fold increase in transmitted power IAW the Radar Range equation, note that this doesn't take PRF into account*).

$$R_{max} = \sqrt[4]{\frac{P_S \cdot G^2 \cdot \lambda^2 \cdot \sigma}{P_{E_{min}} \cdot (4\pi)^3 \cdot L_{ges}}}$$

$$R_{max} = k \cdot \sqrt[4]{P_S}$$

$$R_{max} \sim \sqrt[4]{P_S}$$

Figure 2-25: Effect of Pulse Energy on Max Radar Range

55. Peak Power is measured in kilowatts (KW) or megawatts (MW)

56. The Average Power (P_{AVE}) is the peak power spread over entire pulse interval. Higher average power requires greater heat removal. Average Power is measured in kilowatts (KW). Communications equipment is measured in watts.

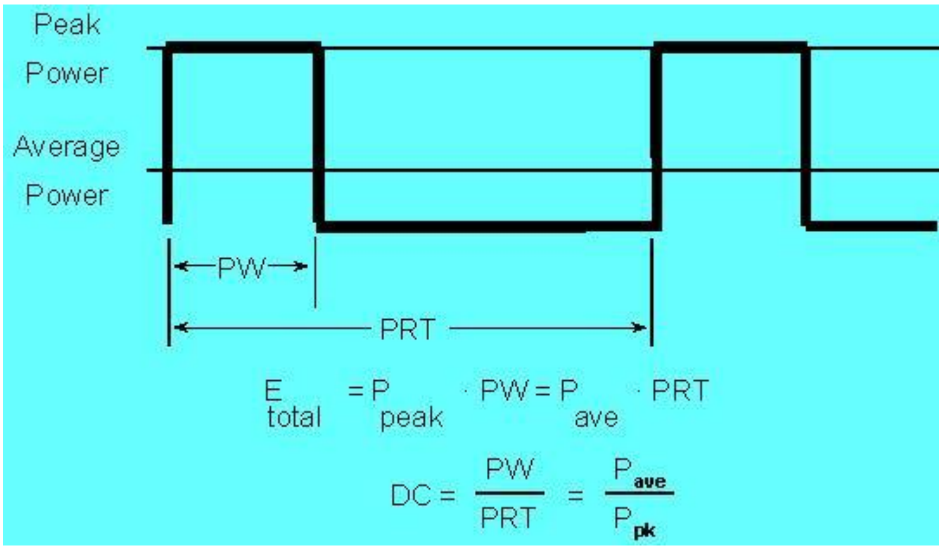

Figure 2-26: Peak and Average Power

Pulse Width Summary

57. Short pulse width

a. Shorter minimum detectable range

b. Better range resolution

c. Reduces Probability of Detection (less energy out)

58. Long pulse width

a. Longer minimum detectable range

b. Degrades range resolution

c. Increases Probability of Detection (more energy out)

Radar Summary

59. The following table summarises the Radar Characteristics and Parameters covered so far in this chapter:

Radar Characteristic	Determined by		Radar Characteristic	Determined by
Range	P_{PK}, PW, Gain, target RCS & Anaprop		Max unambiguous range	PRF (& PW)
Antenna Gain	BW		Probability of detection	Energy in pulse (PW & P_{PK}), PRF & scan rate
BW	f_c & Antenna size/shape		Angular Resolution	Horizontal BW
Antenna Size	f_c & desired BW		Range Resolution	PW
P_{PK} & P_{Ave},	PW, PRT, f_c		Min Range	PW

Figure 2-27: Summary of Radar Characteristics and Parameters

Chapter 3. AN/SPS-49A(V)1 Long Range Air Search Radar

References: ABR 6509 Section 2 Chapter 3,

NAVSEA SPS-49A Surveillance Radar Interactive Electronic Technical Manual

General

1. Radar Set AN/SPS-49A(V)1 is a two-dimensional air surveillance radar for long range and high accuracy air target detection. It features a single mode with advanced Doppler processing to provide enhanced performance against both long and short range threats with an instrumented range extending to 256 miles. A long 32 microsecond (μs) chirped pulse combined with a high Pulse Repetition Frequency (PRF) of 1 kHz provides high average power for improved capability of detecting small targets in the presence of clutter. Single scan detection and velocity determination of low flyer pop-up targets is enhanced by the implementation of Sensitivity/Velocity Control (SVC). Radial velocity measurement permits firm track promotion in two scans. High elevation coverage and low altitude detection are improved by the elimination of the Sensitivity/Time Control (STC) function, which attenuates short range targets.

2. The radar provides target range and bearing information to the combat system in the form of video, range triggers, and antenna bearing data. The radar also provides automatic target detection information to both ADS and the Radar Integrated Automatic Detection and Tracking (RIADT) system.

System Inputs

3. SPS-49 requires the following inputs from the ship:

a. 440V 60Hz 3Φ

b. 115V 60Hz 3Φ

c. 115V 60Hz 1Φ(Antenna Heater)

d. Electronic Dry Air

e. Firemain supply to the Cooling Equipment Group with a flow rate of 45 gallons per minute at a maximum sea water inlet temperature of 35ºC

f. Own Ship’s Heading (Cqo)

g. Own Ship's Pitch (Eio)

h. Own Ship's Roll (Zdo)

i. Gyro Go & SSA Alarm signals

Functional Characteristics

4. Functional Characteristics of the radar are listed below:

Characteristic	Capabilities & Limitations
Operating Frequency	851 to 942 MHz at 48 preselected frequencies, arranged as 3 bands of 16 channels each.
Range	Minimum: 3 nmi Maximum: 256 nmi
Range Resolution	±0.3 mile
PRF	847 to 1176 Hz staggered
Pulse Width	32 microsecond (μs) (1 MHz non-linear chirp)
Pulse compression	1 MHz chirp across 32 μs pulse compressed to 1.5 μs
Peak Power	280 kW minimum, 360 kW nominal
Average Power	10 kW minimum, 13 kW nominal
Antenna Gain	28 dB minimum
Beamwidth (3dB)	Vertical: 10° minimum shaped to 30° (See below for cosecant^2 beam pattern) Horizontal: 3.3 ± 0.4°
Sidelobe	-30 dB beyond ±14° off peak main beam
Antenna scan rate	Off, 6, or 12 rpm, scan rate of 6rpm is only used for maintenance or high sea states to prevent Ae from driving into stops and shutting down.
Antenna speed limits (with Stab on)	< 15° pitch/roll: 6 or 12 rpm 15° - 25° pitch/roll: 6 rpm only > 25° pitch/roll: stab off wind speed > 90knots: rotation off wind speed > 120knots: possible loss of antenna
Antenna stabilisation	Accuracy: ±1° of horizontal plane Electrical Drive limit: 25° Physical Drive Limit: 35° (buffer stops)
Operational Performance (theoretical)	A 1m^2 target shall be detected at a range of 250 nmi from 0.1° above the horizontal to an altitude of 150,000 feet when closing at 150,000 foot altitude until its elevation angle is 20° and when the elevation angle is between 20° and 30° and the target altitude is 100,000 feet or less.

Figure 3-1: AN/SPS-49 Functional Specs

System Outputs

5. SPS-49 provides the following outputs to the combat system:

a. Raw Video – Raw video output of radar set is unprocessed video as detected by the receiver circuits. All clutter and chaff returns, and most types of interference or jamming, will be displayed with raw video. Raw video can also be displayed for comparison with selected synthetic video outputs by adjusting the VIDEO INTENSITY CONTROLS-RAW VIDEO ON SYNTHETIC knob at the RSC. This allows the raw video to be displayed superimposed on the selected synthetic video that is already displayed and provides a useful means of investigating returns, such as land masses, clutter, interference or jamming, which may be causing an excessive false alarm rate at the output of the ATD system.

b. Moving Target Indicator (MTI) Video – Moving target video output is the result of processing the separate moving target returns into the filters of the moving target channel. Moving target video is processed by the CFAR circuits to reduce noise, weather, clutter, or chaff and certain types of interference. The moving target video will display moving target information with effective suppression of land clutter (similar to a conventional MTI video).

c. Automatic Target Detect (ATD) Synthetic Video - ATD synthetic video is the combination of the fixed and moving target channels after the complete signal processing, target thresholding and alarm suppression processing. Both fixed and moving targets are displayed with ATD synthetic video. This video is subject to all inhibit commands from the Combat System. A target seen on the ATD synthetic video will result in a constant message being sent to the Combat System.

d. Medium PRF Upgrade (MPU) Synthetic Video – MPU synthetic video is the final video output of the signal data processor and is the ATD synthetic video after processing by a hardware velocity discrimination function which edits the video to be displayed based upon radial velocity and radar cross section.

e. Antenna rotation (θ's) – Analogue signal to the Dual Signal Data Converter (DSDC) for conversion to the RADDS data stream.

f. TBI - True Bearing indicator (Lβ) – Analogue signal to the DSDC for inclusion as a single bit within the RADDS data word to indicate true or relative bearing.

g. IFF Pre-triggers – output is required to ensure IFF pulse generation and transmission timing is matched to antenna rotation.

h. Radar Status to ADACS and RIADT (NTDS-D) – provides indication in the event of a fault situation within SPS-49A.

i. SPS-49A outputs MPU and MTI analogue signals that are amplified by AM-7115A Video Amp No.1 before being fed through the SB-4229A(V) RSDS for further distribution. RAW and ATD signals are amplified by AM-7115A Video Amp No.2. Triggers and azimuth data that has been converted to RADDS is able to be decoded and displayed on the C&Di consoles however for 49A to be displayed on either the WCC or CTD consoles further processing is necessary. The signal is fed through the RADDS to ACP/ARP decoder for distribution to the WCCs and fed through the RADDS to Synchro decoder for distribution to the CTDs.

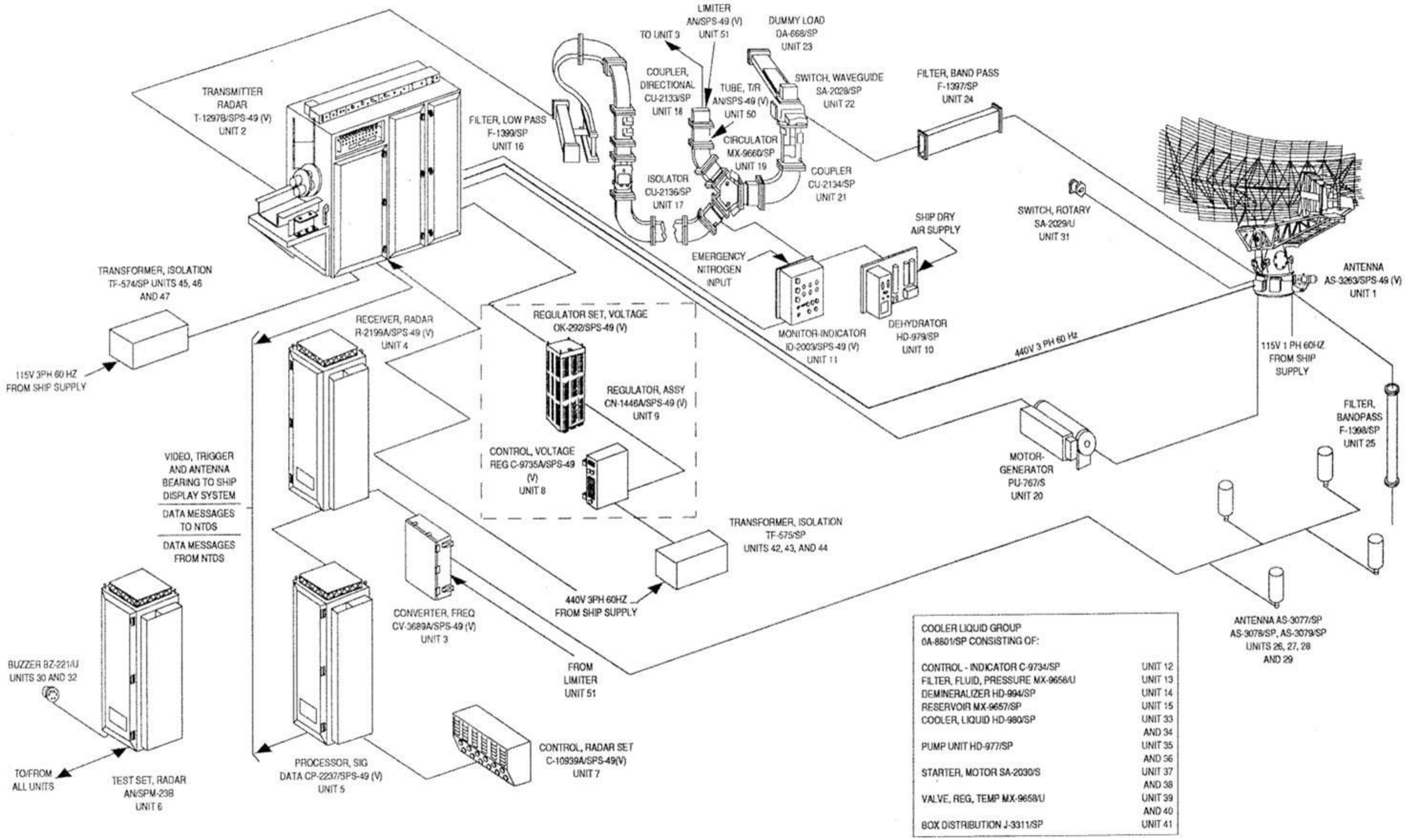

Figure 3-2: AN/ SPS-49A(V)1 Interconnection Diagram

6. Below is a cosecant-squared vertical beam pattern showing a 10° 3dB vertical beam shaped to 30° much like AN/SPS-49.

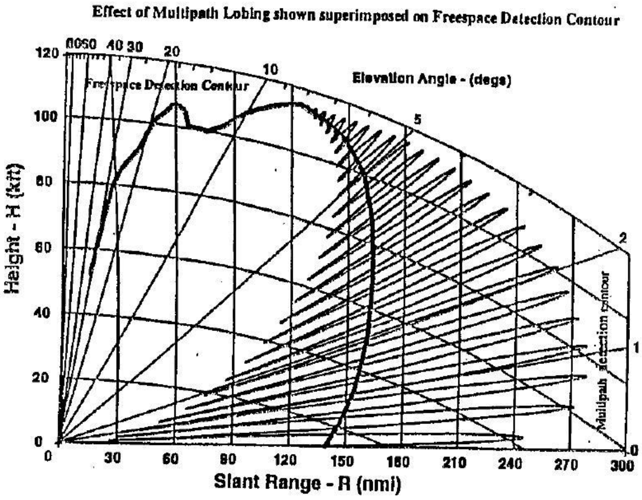

Figure 3-3: Cosecant-squared Beam - 10° beam shaped to 30°

Location of Equipment

7. The following major SPS-49 assemblies are located as indicated:

Unit No	Name	Location
2	Radar Transmitter	RICER
3	Electronic Frequency Converter	RICER
4	Radar Receiver	RICER
5	Signal Data Processor	RICER
6	Radar Test Set	RICER
8	Voltage Regulator Control	RICER
9	Voltage Regulator Assembly	RICER
	Waveguide Pressurisation Group	RICER
	Liquid Cooling Group	SPS-49 Cooling Equip Rm
	Waveguide Group	RICER
1	Antenna	SPS-49 Mast
7	Radar Set Control	Operations Room
20	Motor-Generator	AC Machinery Room

Table 1: SPS-49 Equipment Location

Operation

8. Control is assumed at the Radar Set Control (RSC), Figure 3-4, after activating the CIC CONTROL/RER CONTROL pushbutton indicator at Unit 5 (in RICER). The normal delays experienced during system flashup are:

a. STANDBY INITIATE order to STANDBY COMPLETE status is 9 minutes.

b. RADIATE INITIATE order to RADIATE COMPLETE status is from 5 to 15 seconds.

c. STAB INITIATE order to STAB ON status is 5 seconds.

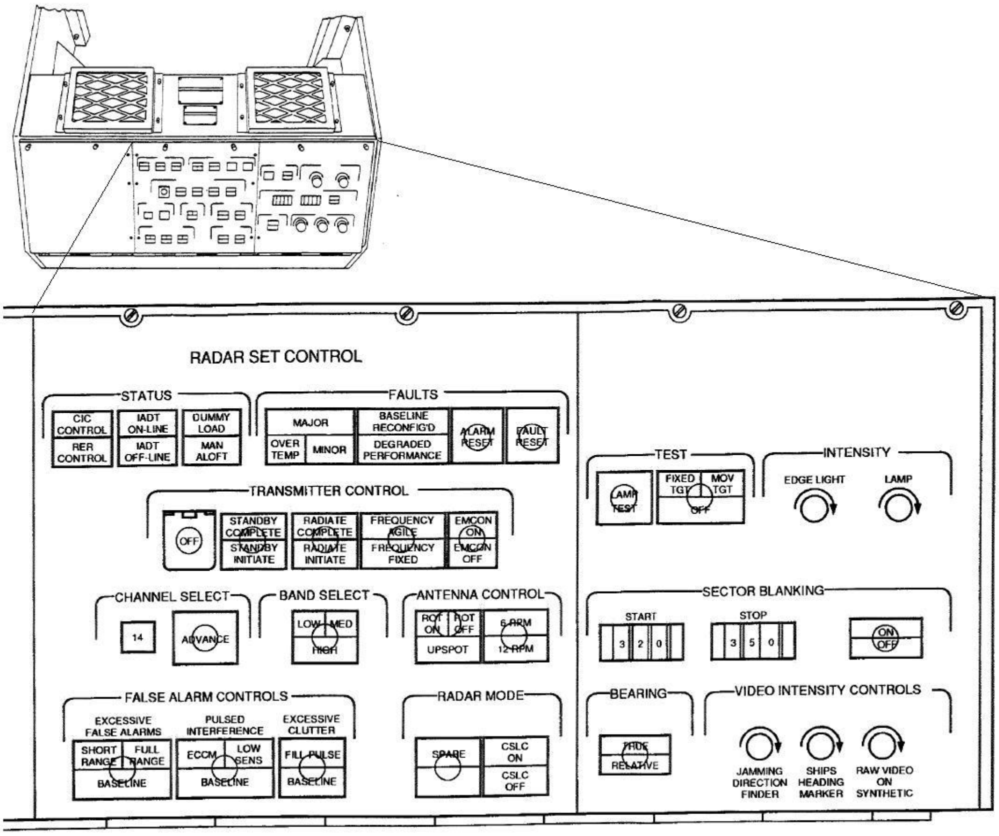

Figure 3-4: AN/SPS-49 Radar Set Control (Unit 7)

Clutter Reduction & ECCM Features

9. The Electronic Counter-Counter Measures (ECCM) features of SPS-49A are:

a. Coherent Side-Lobe Cancelling (CSLC) channels. CSLC is a radar signal processing application used to cancel jammer signals that appear as side-lobes in the frequency domain. The signals returned in side lobes are reduced to increase the directivity of the antenna and hence efficiency.

b. Mean Constant False Alarm Rate (MCFAR) Processing. Cycles through Short Range, Full Range, and Baseline options. This is used to reduce false alarms caused by sea and land clutter, weather and/or chaff, and can be used as an Electronic Protection feature against some jamming. Short Range can reduce weather and chaff out to 32 NM by enabling the moving channel clutter map circuitry. Full Range extends the moving channel clutter map to 256 NM.

c. Random frequency programming When in Frequency Agile (FA) mode, the radar operating frequency is switched in a pseudo-random fashion every third PRI. The frequencies selected are those active (not locked-out) frequencies in the selected band; a maximum of 16 different frequencies can be transmitted in FA mode. This can counter deliberate interference as the jamming must either match the frequency changes or spread its power output over a wider band of frequencies, reducing effectiveness for a given power output.

d. Sector Blanking This feature enables the blanking of transmission in the selected sector to cause the jamming source to believe that the radar is not operating and/or prevent disclosure of the radar set signature.

e. Excessive Clutter – Cycles through Fill Pulse and Baseline options to reduce false alarms from very long range land returns caused by abnormal propagation and ducting. Fill Pulse allows suppression of second time around clutter returns by transmitting one additional pulse at the start of each Coherent Processing Interval (CPI). The returns from this first pulse are not processed. Baseline disables the Fill Pulse circuitry

f. EMCON Operation - The EMCON ON state can be ordered at any stage of operation and is active immediately. In this state the RF drive to the final power amplifier is removed and modulator pulses are inhibited; this will also strangle the associated IFF Interrogator

g. Jamming Direction Finder (JDF) Strobe – indicated on display as 'spokes' radiating out from ownship, with the longest spoke indicating the bearing and relative strength of the jamming. It does not give an indication of the range of the jamming platform itself. Knob on RSC adjusts intensity of displayed JDF indication. Turning knob fully CCW will reduce JDF display to one in every 8-10 scans.

h. Pulsed Interference – Cycles through ECCM, Low Sensitivity, and Baseline options. ECCM enables pre-compression blanking and RF pulse extension circuitry to reduce pulsed interference from other radars and/or transponder jamming. Low Sensitivity further reduces the effect of excessive false alarms by applying a higher detection threshold that results in slightly lower target detection sensitivity. ECCM and Low Sensitivity can be applied together to give increased protection from pulsed interference. Baseline disables ECCM and Low Sensitivity circuitry.

- Note - interference and jamming may not be readily apparent on processed video

10. The Combat System operator can also command up-spotting of the antenna in a specified sector through the antenna control microprocessor. This provides increased detection capability against high elevation targets at bearings that are being screened by a low elevation standoff jammer.

11. SPS-49 Antenna. The antenna has a double curved surface comprised of a series of horizontal members or slats that form the reflective surface for the horizontally polarised radiation. The following operator selectable features are available:

(1) Rotation Rate The antenna azimuth drive rotates the antenna at either 6 or 12 rpm, with antenna relative bearing being provided to the Signal Data Processor by an azimuth synchro.

(2) Antenna Stabilisation Elevation drive signals move the antenna to provide horizontal plane stabilisation; a drive limit of ±25° is set, with physical stops at the ±29° limit. The antenna will lock at the ±29° limit if the travel limit fails. A motor generator set, located in the AC Machinery Room, provides the field excitation current for two DC elevation drive motors.

RIADT Array Controls

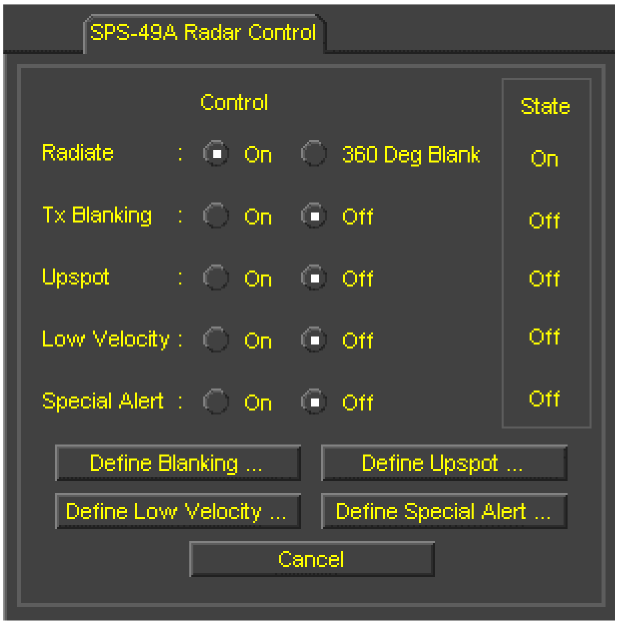

Figure 3-5: RIADT Control Window for SPS-49

12. The following controls are available via the RIADT Array / SPS-49 Radar Control VAB at the C&Di console:

a. Radiate - On/360 Deg Blank: this allows the operator to radiate the radar, or set an all round blanking sector. The default is 360-degree blanking. Selecting 360 degree blanking does not actually turn the radar off; that must be actioned at the RCU;

b. TX Blanking - On/Off: selects whether the defined blanking sectors are to be turned on or off. The blanking sectors are defined using the Define Blanking pushbutton which allows the operator to enter, edit or delete transmission blanking of up to four sectors for SPS-49 radar;

c. Upspot - On/Off: these allow the antenna upspot function to be turned on or off. The antenna upspot parameters are set using the Define Upspot pushbutton, which allows the operator to define one true or relative Antenna Upspot sector. This functionality is only available through ADS, with an indication light on the RCS;

d. Low Velocity - On/Off: these allow the Low Velocity Zones to be activated or turned off. The Low Velocity parameters are set using the Define Low Velocity pushbutton. A Low Velocity Zone defines a zone, in bearing and range, over which the SPS-49A will detect targets of low velocity, for example helicopters. When Low Velocity Zones are active, the SPS-49A Moving Channel Clutter Map will be deactivated in the specified regions. Up to seven zones can be defined through ADS as true, relative, or a combination of both

e. Special Alert - On/Off: these allow the Special Alert Gates to be turned on or off. The Special Alert Sector parameters are set using the Define Special Alert pushbutton. This functionality is only available through ADS. A Special Alert Sector defines an arc over which a special alert will be generated for threatening targets. A contact will be declared a Special Alert when all of the following conditions are met:

(1) The contact lies within an active Special Alert Gate,

(2) The contact quality is greater than a quality indication threshold,

(3) The contact velocity estimate is greater than 200 knots closing,

(4) The contact radar cross section is greater than XXX metres squared, and

(5) The contact Time To Go is less than the specified Time To Go

On receipt of a Threat Alert contact report from the SPS-49 radar, RIADT will immediately generate a new track at the reported position and uses the SPS-49's speed estimate assuming the target is directly closing. RIADT passes this new track to ADACS with a flag raised saying that it is of the type "Threat Alert".

Received Signal Processing.

13. The received signal is converted to a 32 MHz IF by the Frequency Converter (Unit 3).

14. The receiver passes a 4 MHz MTI IF signal to the Data Processor (Unit 5) for 'short pulse' MTI processing. When processing the received long pulse, the 4 MHz IF is compressed by the Dispersive Delay Line to a pulse of 1.5μs duration prior to being sent to the Data Processor for 'long pulse' MTI processing.

15. The 4 MHz IF is also processed by a logarithmic amplifier in the receiver to produce JDF video for the Data Processor.

16. The short pulse and compressed long-pulse 4 MHz IF are detected within the receiver to produce Log Video. The short pulse and compressed long-pulse 4 MHz IF are also routed through a Log Amplifier followed by an antilog amplifier (for improved noise suppression). The antilog amplifier contains a Fast Time Constant (FTC) circuit which is controlled by the CFAR ON/OFF switch.

17. The Data Processor functions to process the MTI and Normal video signals digitally to produce the best target video presentation possible. The MTI circuit contains two adaptive loop circuits for weather/chaff (fast loop) and land/sea (slow loop) clutter rejection.

18. A range circuit controlled by the front panel MTI/NORMAL RANGE switch determines the range at which the Integrated Video display will switch from MTI to Normal Video. When selected, RVP can exercise control over the MTI/Normal changeover range; this can lead to numerous MTI/Normal and Normal/MTI video changeovers in a single sweep depending on the clutter conditions determined by RVP.

19. All videos undergo a time align process within the data processor so the outputs for each video type are time aligned.

Fault Monitoring

20. Continuous and automatic monitoring of many functions is performed with the results displayed on the FAULTS group of indicators on the Data Processor, Transmitter, Receiver, Cooling System, Dehydrator and Test Set. The following areas are monitored:

a. Data Processor

    (1) Processor Faults

    (2) MTI, Normal and Integrated Video levels

    (3) Data Processor Over-temperature

    (4) Power Supply

    (5) PCB malfunction

b. Transmitter

    (1) Klystron malfunction and over-temperature

    (2) Modulator malfunction

    (3) Low Coolant flow

    (4) Voltage Regulator over-temperature

    (5) High Voltage Power Supply over-temperature

    (6) Loss of Pitch & Roll reference voltage

    (7) Loss of Gyro Go signal

    (8) SSA #2 malfunction

    (9) Antenna Azimuth Drive System over-temperature

    (10) Antenna Elevation Drive System over-temperature

c. Receiver

    (1) Local Oscillator malfunction

    (2) MTI IF power level to DP low

    (3) RF Drive Signal level to transmitter low

    (4) JDF signal level low

    (5) Log video level low

    (6) Log FTC video level low

    (7) Over-temperature

d. Power Supply

e. Cooling System

f. Dehydrator

g. Test Set

h. Power levels to TR Tube excessive

i. RF Peak Power out below tolerance

21. Four summary fault indicators are provided. The significance and interpretation of these are as follows:

a.	MAJOR	The radar set is in an inoperative condition.
b.	OVERTEMP	One or more of the units in the radar set is at 15°F below an over-temperature condition. At the over-temperature condition, a major fault occurs.
c.	MINOR	A fault has been detected which does not affect the operational characteristics of the radar set; however, if not corrected, the fault could lead to a more serious problem.
d.	DEGRADED PERFORMANCE	A fault has been detected which affects some feature of the operational characteristics of the radar set. The fault should be investigated in order to determine which feature is not fully operational.

Table 2: SPS49 Fault Indications

Casualty Modes

22. Casualty modes of operation include:

a. Loss of Radar Set Control (Unit 7) The controls at the Data Processor (Unit 5) may be used to control the radar set. Control is achieved from the LCU in RICER. RIADT provides some operator functionality.

b. Loss of Stabilisation In the event of a malfunction which prevents normal operation of antenna stabilisation, the radar set can be operated with some degradation of performance by reverting to the STAB OFF condition.

c. Loss of Video Output If a malfunction or damage prevents the use of one of the video outputs of the radar set, one of the other three types of video may be selected. RIADT processing of video may also provide higher picture and track quality.

d. Coolant System Three types of malfunction in the coolant system can be circumvented by the following procedures:

(1) Loss of coolant pump. Use the alternate coolant pump.

(2) Heat Exchanger malfunction. Use the alternate heat exchanger.

(3) Loss of Firemain. Sea water can be supplied to the coolant system by connecting the emergency sea water input.

e. Waveguide Pressurisation If the dewpoint of the ship supplied Electronic Dry Air rises above -40°F, the ship supplied low pressure air at the SPS-49 dehydrator is automatically selected as the source. Should the dewpoint rise above -20°F, air supply to the waveguide will be shut off until the problem is rectified. The system will function without waveguide pressure, but circulator pressure must be maintained. An emergency Nitrogen connection is provided to enable continued pressurisation when the air sources are inadequate or unavailable.

Chapter 4. AN/SPS-55 Surface Search and Navigation Radar

Reference: NAVSEA 0967-LP-531-5010

General

1. AN/SPS-55 is a two-dimensional, non-stabilised, surface search and navigation radar capable of detecting targets from as close as 50 yards. The major components are identified in Figure 4-1.

2. The AN / SPS-55 radar consists of four major units:

a. Antenna Group.

(1) Consists of two waveguide slotted arrays mounted back to back. One array provides linear horizontal polarisation and the other circular polarisation.[1]

(2) The antenna pedestal contains the antenna drive, slip rings, rotary joint and synchro assembly.

b. Transmitter / Receiver Cabinet.

(1) Contains all system power supplies, the transmitter, the receiver and microwave assembly. It also contains all necessary controls, indicators and fault detection circuits needed to operate and monitor the radar from the local position.

c. Radar Set Control Unit (RSC)

(1) Contains all necessary controls and indicators needed to operate and monitor the radar from a remote locality.

d. Switch Box.

(1) 'Man Aloft' switch, 'Safe to rotate' switch. Removes primary power from the antenna drive circuits as well as the transmitter modulator.

[1] A configuration change has been approved during 2014 to remove the Linear / Circular Waveguide switch. This will result in 55 transmitting in Linear Polarisation only.

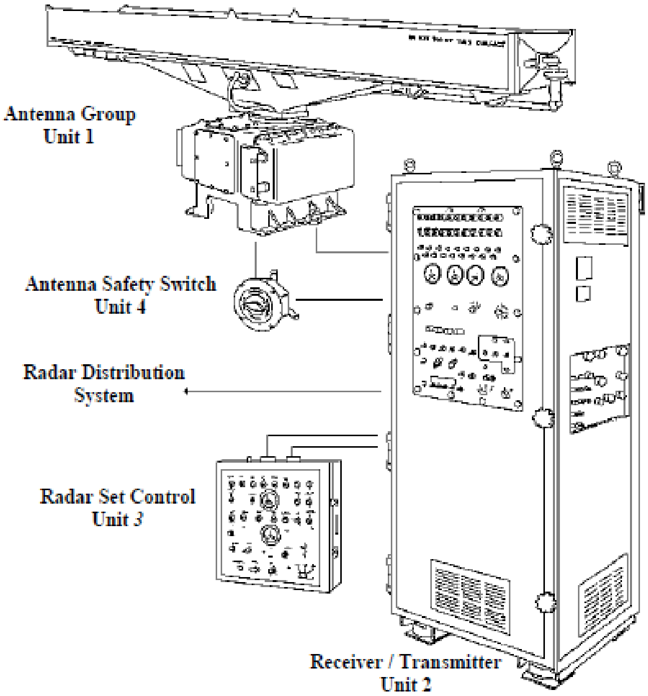

Figure 4-1: AN/SPS-55 Navigation Radar Major Units

System Inputs

3. SPS-55 requires the following inputs from the ship:

a. 115V 60Hz 1Φ

b. Electronic Dry Air

c. SSA Alarm

d. Own Ships Heading (Cqo) from Gyro

System Outputs

4. SPS-55 provides the following outputs to the combat system:

a. SPS-55 Video as

(1) Log, or

(2) Lin/Log

(3) Processed through RIADT

b. Antenna rotation (θ's)

c. Master Trigger (T_m)

d. True Bearing indicator (L_b)

Functional Characteristics

5. Functional Characteristics of the radar are:

Characteristic	Capabilities & Limitations
Operating Frequency	9.05 to 10 GHz
Range	Minimum: 50 yards (SP), 200 yards (LP) Maximum: 100 nmi Unambiguous
Range Resolution	±75 feet (SP) ±550 feet (LP)
PRF	750 pps (LP) 2250 pps (SP) ±5% in Swept Mode
Pulse Width	Long: 1.0μs Short: 0.12μs
Peak Power	130 kW minimum
Beamwidth	Vertical: 20° minimum Horizontal: 1.5°
Sidelobe	-30 dB beyond ±5° off peak main beam
Antenna scan rate	16 rpm

Table 3: AN/SPS-55 Functional Characteristics

Location of Equipment

6. The following SPS-55 assemblies are located as indicated:

Unit No	Name	Location
1	Antenna	Main Mast
2	Receiver/Transmitter	SPS-55/AIR NAV/ECM
3	Radar Set Control	CIC

Table 4: AN/SPS-55 Equipment Locations

Operation

7. SPS-55 can be operated from the Radar Set Control, through ADACS via RIADT control or the Transmitter/Receiver Cabinet.

8. The normal delays experienced during system flashup are:

a. OFF to SYSTEM STANDBY (TRANSMITTER READY) status is 3 minutes.

b. TRANSMITTER READY to RADIATE status is instantaneous

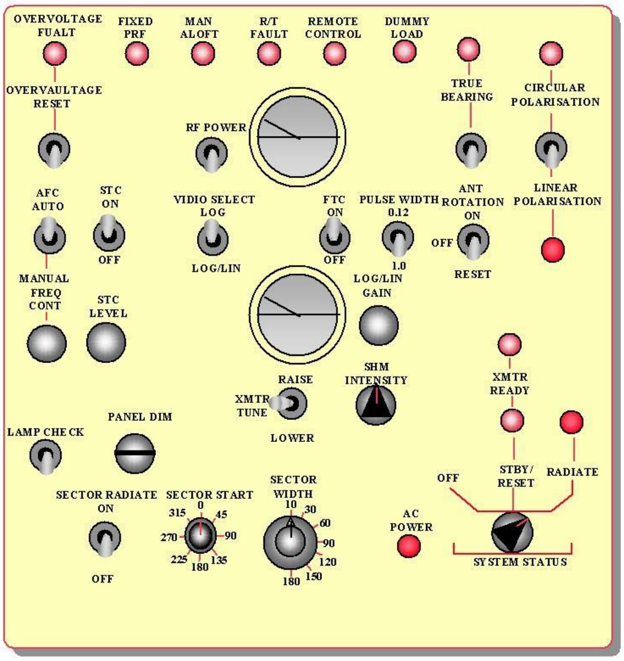

Figure 4-2: AN/SPS-55 Radar Set Control

Functional Operation

9. Pulse width selection is made at the Radar Set Control. The video available at the C&Di console can be selected by either VAB action or, without RIADT, the video select switch on the Radar Set Control. Either Log or Lin/Log video can be selected.

10. Lin/Log is the normal setting as it is desirable for the detection of weak targets in low clutter areas. Log is selected during heavy interference (eg Jamming) or high clutter environments. Linear receiver processing maintains a constant amplification level for all inputs. Logarithmic amplifications decrease as the returned signal strength increases, i.e. weak returns are amplified more than strong returns.

11. Frequency of operation, between the upper and lower limits, can be set at the Radar Set Control.

12. Sector radiate operation is selected using a start bearing and sector width.

13. A man aloft indicator on the Radar Set Control indicates the man aloft switch beneath the antenna platform has been activated. Antenna rotation and radar transmission is prohibited.

Clutter Reduction & ECCM Features

14. The clutter reduction features of SPS-55 are:

a. Sensitivity Time Control (STC) STC attenuates signals at lower ranges to reduce sea returns and to compensate for the greater echo strength from nearby targets.

b. Fast Time Constant (FTC) FTC reduces the size of the block returns by passing the video through a high pass filter. This reduces block clutter to its leading edge, allowing small increases in video return due to a target in clutter to be seen.

c. Log and Log/Lin Video Either Log or Log/Lin video is selectable at the radar set control.

d. Gain Control Receiver gain can be manually adjusted by the operator.

e. Circular Polarisation Either linear (horizontal) or circular polarisation is available. Circular polarisation improves performance in rain by reducing clutter returns.

15. SPS-55 has one ECCM feature: Swept PRF. This is not an operator selectable mode. It is activated by the WE maintainer by a switch within the Rx/Tx Cabinet in ECM. It is only switched off for maintenance purposes. Swept PRF aids the receiver to discriminate between returns from its own radar transmissions and those of similar frequency radars or jammers in the area.

Q70 and RIADT Control

16. On the Q70 console, SPS-55 has two separate video selections available: Normal and Processed.

a. Normal. Not used by RIADT. The receiver gain and STC is controlled on the RSC and directly fed to the CTD's and has no effect on RIADT.

b. Processed. Used by RIADT to create tracks. RIADT has its own receiver embedded with SPS 55 which controls receiver gain and STC; it has no effect on the settings on the RSC.

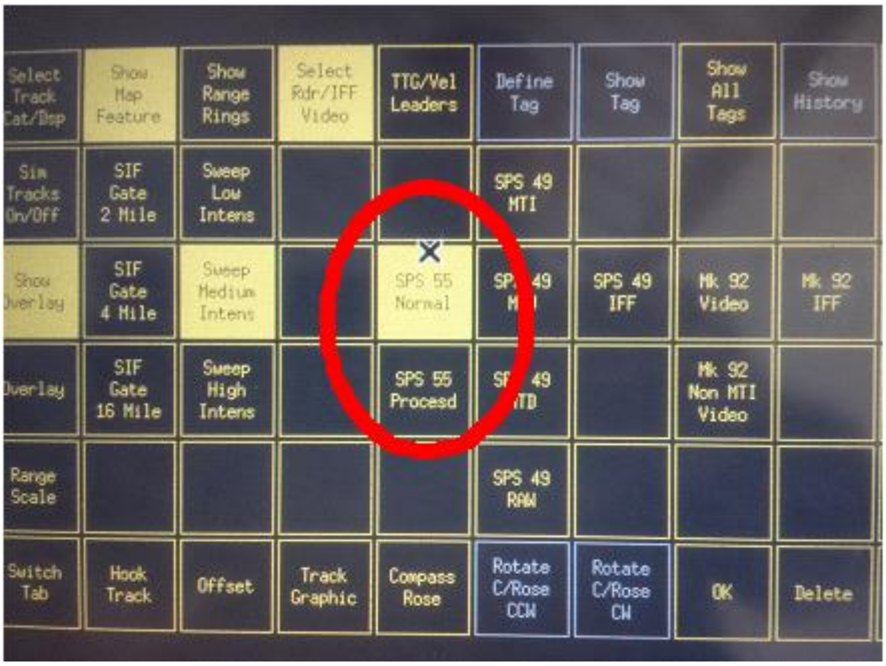

Figure 4-3: C&Di Console Landscape Display to Select Normal or Processed 55 Video

17. The RIADT has a receiver embedded with the SPS-55 which has controls for receiver gain and STC (55 Processed Video). They are available on the C&Di console from the RIADT array or at the RIADT console in the RICER. These controls do not affect the radar's own receiver (Normal Video) which can be controlled on the radars RSC in the operation room.

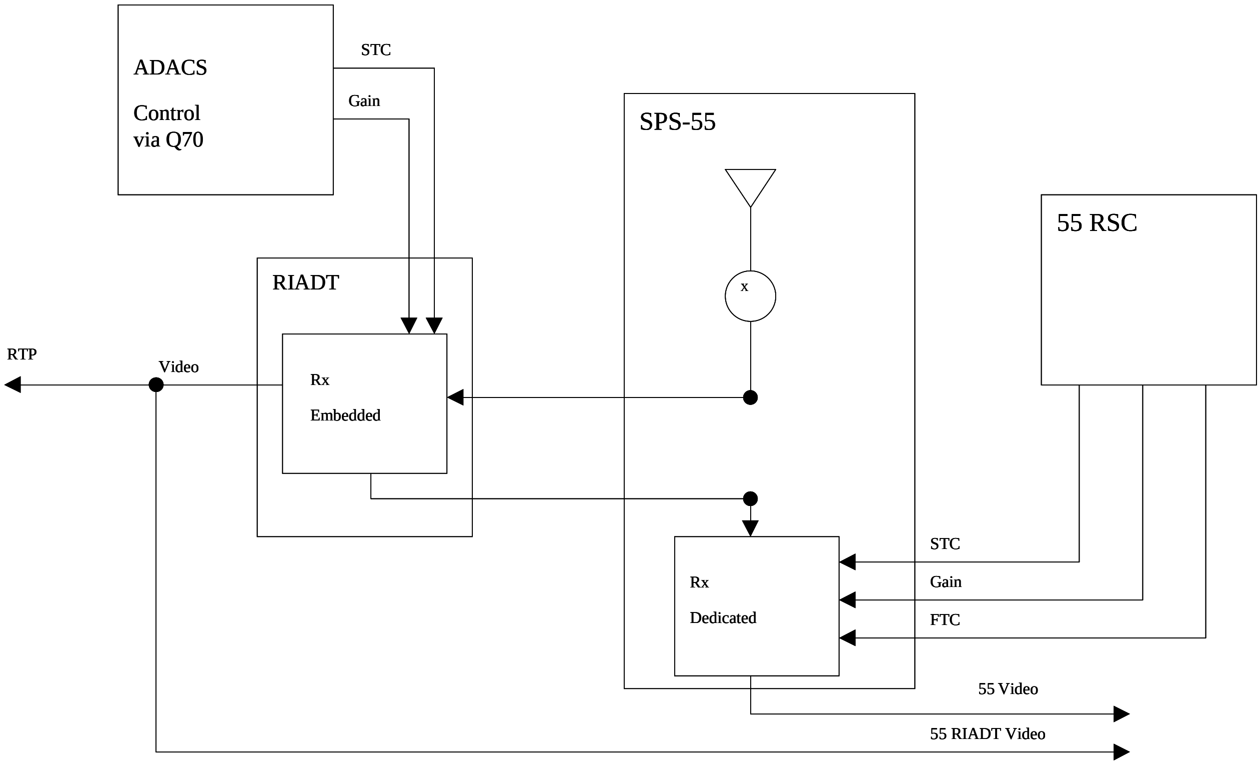

Figure 4-4: SPS-55 / RIADT 'Dual' Receiver

18. The features available to the operator via RIADT control of the SPS-55 Radar are;

a. Remote Control – Radio buttons to place control of the radar with the Combat System (C2) or the RSC. If RSC is selected, none of the changes made in this Tab Window will affect the radar until C2 is selected.

b. Radiate – Radio buttons to radiate the radar (On), place the radar in Standby or turn the radar Off. If Off is selected, the normal wait of 3 minutes is required after Standby is selected before Radiating again.

c. Rotation – Radio buttons to turn antenna rotation On or Off. Once again, the antenna should never be stopped while the radar is radiating, and the radar should never be radiated whilst the antenna is not already rotating.

d. Pulse Width – Radio buttons to select Short or Long Pulse.

e. Polarisation – Radio buttons to select Linear or Circular Polarisation.[2]

f. RIADT STC – Slider bar from 0 to 100 to set STC for RIADT itself. This only affects Processed Video, with the RSC affecting Normal Video STC, so operators must ensure processed video is being displayed on their consoles before adjusting RIADT STC. The slider bar functions the same as in Microsoft Windows, with 3 ways to adjust the current setting:

(1) Click on the arrows at either end

(2) Click on the Slider itself and drag to the desired location

(3) Click on the area of the Slider bar you wish the Slider to move to and it will jump there.

g. RIADT Gain – Slider bar from 0 to 100 to set Gain for RIADT itself. Again this affects Processed Video only, with the RSC affecting Normal Video Gain. The methods to adjust the current setting are the same as for RIADT STC.

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[2] A configuration change has been approved during 2014 to remove the Linear / Circular Waveguide switch. This will result in 55 transmitting in Linear Polarisation only.

h. Rec. Freq. – Radio buttons to select either Automatic or Manual Frequency Control. Below is a slider bar to tune the receiver if manual is selected, but this will be greyed out with “N/A” in State if AFC is selected.

i. TX Blanking – Radio buttons to turn Transmit Blanking On or Off. Note that unlike the RSC, which has Sector Radiate, this Window uses Blanking, the same as SPS-49. Again these Blanking Sectors are independent of the Sector radiate settings applied to the RSC, and are set via the Define Blanking button.

j. Define Blanking – Bring up the Transmitter Blanking Zone Tab Window as shown on page 958, exactly the same as the one for SPS-49. Again up to 4 Blanking Sectors can be defined, using the same entries as we went through in the last module.

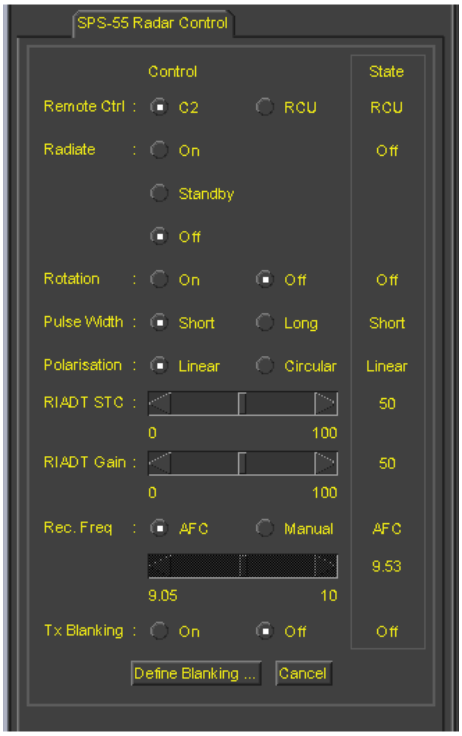


Figure 4-5: RIADT Control Window for SPS-55

19. Transmitter Frequency, FTC, Normal Video STC and Lin / Log functions remain with the RSC and are not controllable through the Tab Window.

Fault Monitoring

20. Continuous monitoring of many SPS-55 functions is performed with the results displayed on the FAULTS group of indicators on the main radar set. The following areas are monitored:

a. Receiver Transmitter

b. VSWR

c. Video Levels

d. Receiver Sensitivity

e. Triggers

f. Magnetron Operation

g. Overvoltage

h. R/T and OVERVOLTAGE faults can be cleared at the Radar Set Control by setting the system back to the STBY/RESET state.

Casualty Modes

21. In the event of a malfunction causing loss of the Radar Set Control (remote control) control of the radar can be established from a C&Di console through the RIADT interface or at the Receiver Transmitter Cabinet itself.

Chapter 5. Mk92 CAS Surface/Limited Range Air Search Radar

References:

- ABR 6684 Mk92 Mod 12 FCS Maintenance Manual – Section 1, Ch 1
- ABR 6511 FFG Combat System Operator Manual – Section 1 Ch9 Pg 3
- ABR 6511 FFG Combat System Operator Manual – Section 4 Ch2 Pg 17
- ABR 6509 FFG Combat System Manual – Section 2 Ch 6 Pg 3

General

1. The Mk 92 CAS Search Radar is a fast rotating, short-range radar designed to detect fast moving, low altitude targets close to own-ship, such as sea skimming missiles. Rotating at 60 RPM and having a relatively narrow horizontal and vertical beamwidth, the MK92 CAS Search radar is optimised for short-range detection of these pop-up targets. The Mk 92 CAS Search Radar operates in the I Band, very close to the frequency of SPS-55. It is designated as a surface/limited range air search radar.

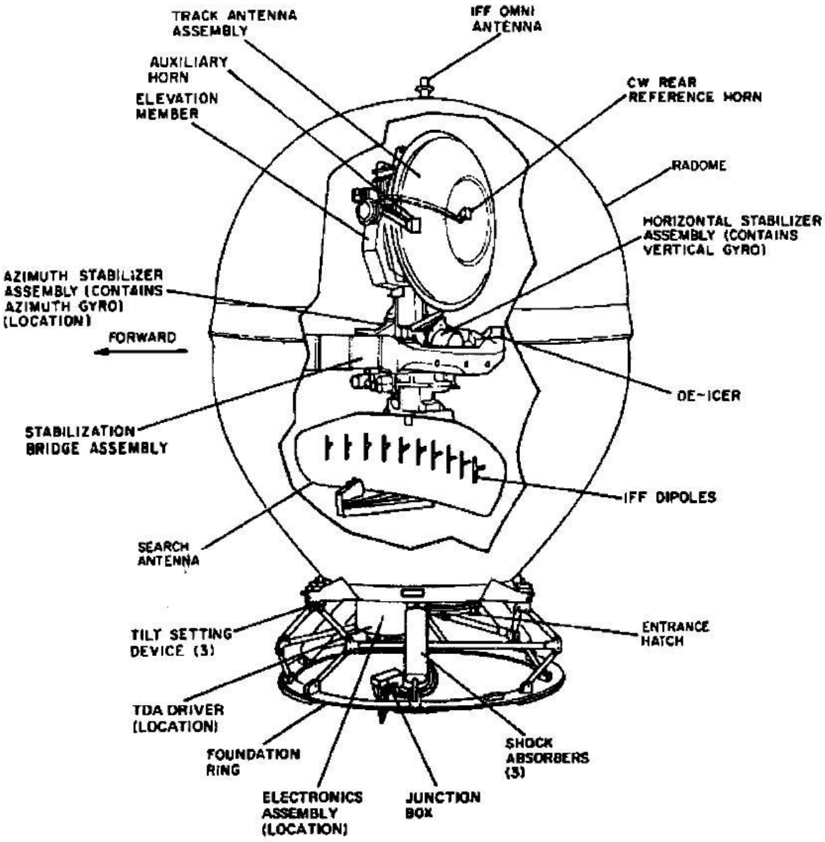


Figure 5-1: CAS Antennas

System Inputs

2. Mk92 CAS requires the following inputs from the ship:

a. Power:

(1) 440 V 3-phase, 60 Hz and 400 Hz

(2) 115 V 3-phase, 400 Hz

(3) 115 V single phase, 60 Hz and 400 Hz

(4) 50v Dc from CSSB (SSCWI only)

b. Cooling water from Low Pressure Cooling System (requiring ship's chilled water)

c. Cooling water from the High Pressure Cooling System (requiring ship's chilled water) for SSCWI cabinet only.

d. Electronic Dry Air

e. Own Ship's Pitch (Eio) and Roll (Zdo), Heading (CQO) and Speed (DMHO)

System Outputs

3. Mk92 CAS provides the following search radar outputs to the combat system:

a. Mk 92 Search video as:

(1) COHO 20 or 30 (MTI)

(2) NON-COHO 32 or 64 (Non MTI)

b. Raw Video

c. Antenna Train

d. ACP/ARP (Azimuth Change Pulse / Azimuth Reference Pulse to WCCs)

e. θ's (synchro data to RADDS converter)

f. IFF Pre-triggers

Functional Characteristics

4. The functional characteristics and performance parameters of CAS Search radar are classified CONFIDENTIAL. They can be found in Reference A, B & D.

Search Processor Functions

5. The Search Processor only has 5 receive modes, COHO 20 or 30, NON-COHO 32 or 64 and NAV. Selection of these modes is done at WCC-1. The number indicates the range of the search radar, whilst COHO/NON-COHO is the type of processing used. NAV is raw video only.

6. PLEASE NOTE THE TRACK PROCESSOR IS THE MASTER PROCESSOR. By this – if the operator has selected COHO 20 as the search mode and FC-1 is designated to a target that is at 62nm, the track processor will change the search mode to NON-COHO 64 WITHOUT operator intervention. There is also a function "Second Time Round Processing." If the operator has selected COHO 20 as the search mode and the track mode is set to COHO and FC-1 is designated to a target that is at 35nm, the track processor will NOT change the search mode to COHO 30 (Both are easier when seen than explained)

a. COHO 20 – Least power, highest clutter reduction

b. NON-COHO 64 – Highest power, least clutter reduction

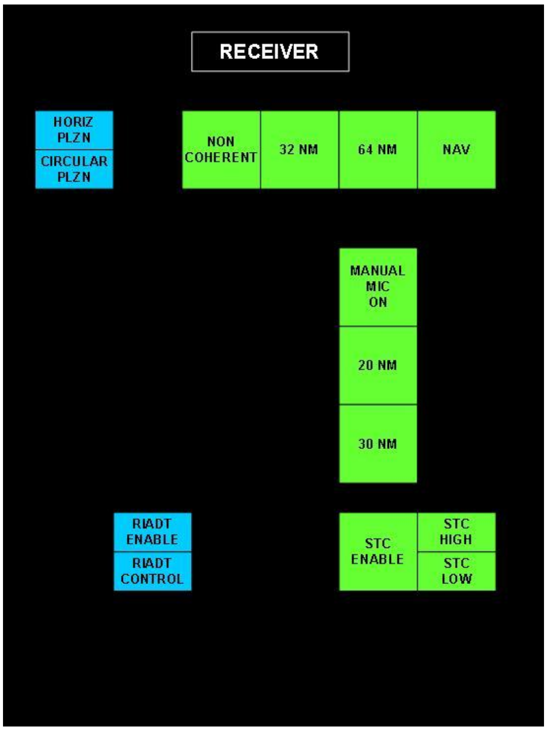


Figure 5-2: CAS Receiver Processor Control

Manual MIC (Multiple Interval Clutter)

7. Is used to remove clutter in the second and subsequent even range intervals.

RIADT Enable/RIADT Control

8. This enables RIADT to control the search processor. If this function is to be used, it is recommended that CAS be brought to the radiate condition approximately ½ hr prior to serial start. This will enable the CSO operators to set the clutter within the RIADT system. RIADT also has the ability to clean the clutter around own ship. Currently this is controlled from the RIADT console in RICER, however, there is possibility of being manually set through the TOTE at a future date.

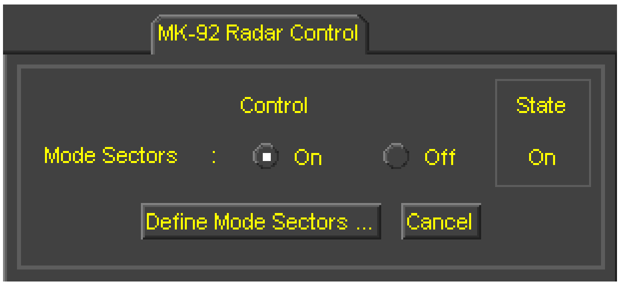


Figure 5-3: Mk92 RIADT Radar Control

9. When RIADT has control of the processor, the CSOs are able to set 'sectors.' A sector may be set up to transmit Non-COHO 32 from relative bearing R120 through G160, with another sector being COHO 20 from true bearing 020 through 030. The STC can be different for each sector. This functionality is both helpful and a possible hindrance. As stated above, CAS was designed to detect fast moving, low altitude targets close to own-ship, such as sea skimming missiles and as such is optimised for short-range detection of these pop-up targets. With the changing modes this has the potential for the WCC operator to miss these targets. Command is to be aware of this and consult with the section CPO.

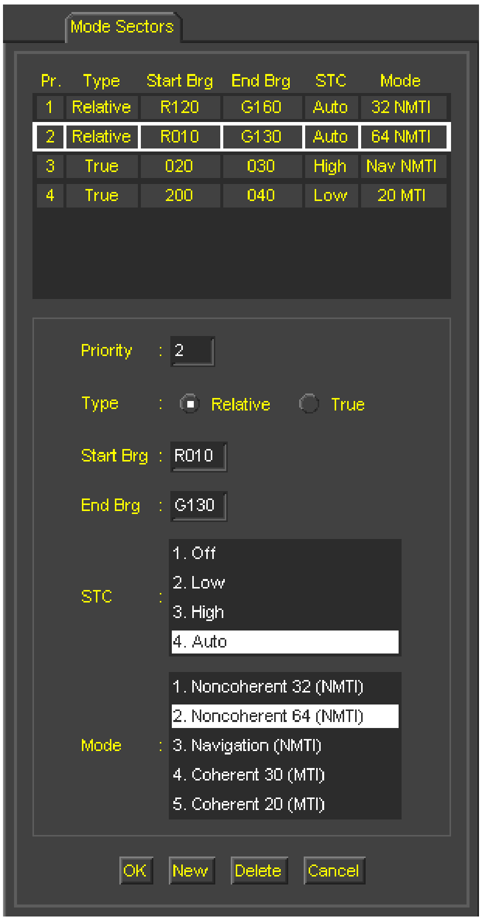


Figure 5-4: Mk92 RIADT Control - Define Mode Sectors

Track While Scan (FC-4/FC-5)

10. The functionality of these is the same as the previous Mod 2 system. The TWS circuitry operates in the NON-COHO 32 mode only. If the WCC-1 operator has selected COHO 20 as the processor mode, when the sweep is 11 degrees from the target to be tracked, the mode will switch to the NON-COHO 32 mode for 22 degrees (11 Degrees off the centre/target bearing) and then revert back to COHO 20.

FC 11-16

11. FC 11-16 is a pseudo automatic tracker built within the WCP software. The functionality is similar to FC 4/5, however, there is no means of visually seeing the target in the B-Scope. It enables command to 'watch' targets of interest without actually making the target aware that it is being tracked. The parameters that are displayed include; course, speed, CPA, range etc. No engagements are able to be conducted from FC 11-16. Both air and surface targets are able to be tracked by this method.

Transmitter Functions

12. During the equipment turn-on procedure, the CAS Search Radar is brought to the CMD WARMUP/WARMUP COMPLETE condition. This will take approximately 4½ minutes. Ninety percent of maintenance, including DSOT, can be run in the WARMUP mode. Once at Warmup Complete, the maintainer can proceed to CMD STBY/AVAIL. This will take approximately 30sec. During this 30sec period, filament voltage to the Travelling Wave Tubes (TWT) is brought from the 85% value to full voltage and the search antenna is brought up to rotate. WHEN IN WARMUP THE DIPLAYED SWEEP IS GENERATED FROM WITHIN WCC-1. Once at STBY AVAIL you can proceed to the CMD RADIATE/RADIATE mode. It is possible to select all three CMD modes (Warmup, STBY and Radiate) and the transmitter will transition to each mode as the previous is obtained.

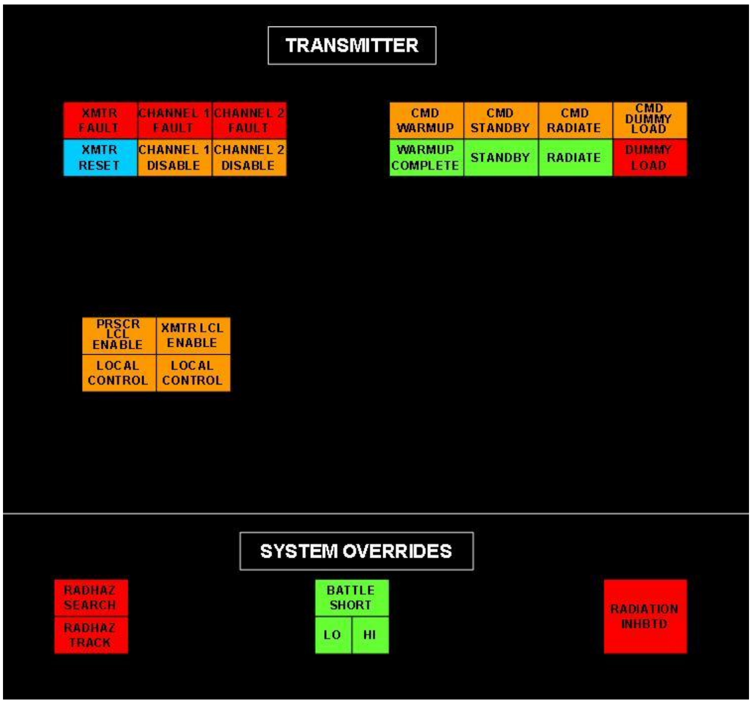


Figure 5-5: CAS Transmitter Controls

13. Polarisation. Circular or Horizontal polarisation may be selected using the pushbuttons at WCC 1.

14. Frequency Agile. The system operates in Frequency Agile. Fixed Frequency is a test and maintenance mode only.

15. PRCSR and XMTR LCL Enable. These enable the maintainers to have control of the processor and transmitter cabinets from within the equipment rooms. It is recommended that these ARE NOT ENABLED prior to serial start, preventing inadvertent control being passed to the equipment rooms. Due to circuitry design, maintainers are NOT able to select antenna from the equipment rooms on the transmitter cabinet.

Positive Control

16. Positive control is defined as two distinct operator actions required to radiate into free space. As an extra step the track antennas are placed into manual to prevent inadvertent designations. To place CAS and STIR into positive control the following is to be followed:

Setting Positive Control

a. If the transmitter is radiating, indicated by "RADIATE" lamp lit bright (GREEN), then press the STANDBY CMD pushbutton. The Standby lamp will light (GREEN) and Radiate will extinguish.

b. Once the transmitter is in Standby, press the CMD DUMMY LOAD pushbutton. Observe that the DUMMY LOAD lights bright (RED) indicating the waveguide switch has rolled from the Antenna position to the Dummy Load position.

c. Press TRACK ANTENNA MANUAL pushbutton (Figure 5-6) and ensure that it lights bright Orange.

d. Ensure that the SSCWI is in STANDBY (ORANGE lit bright) and DUMMY LOAD set (RED lit bright)

e. Place POSITIVE CONTROL tag on console so it is visible.

Recovery from Positive Control

f. Ensure the transmitter is not radiating into waterload, indicated by "RADIATE" lamp lit bright (GREEN), if so select CMD STANDBY and ensure that STANDBY lights green.

g. Press CMD DUMMY LOAD and ensure that the DUMMY LOAD section extinguishes. If approval has been granted to radiate live, press CMD RADIATE and confirm that the RADIATE section lights bright green.

h. Set CWI AUTO on and ensure that is lights bright green. Leave SSCWI DUMMY LOAD set unless otherwise commanded.

i. Press TRACK ANTENNA MANUAL (Figure 5-6) pushbutton and ensure that it extinguishes.

j. Remove POSITIVE CONTROL tag.

Error! Objects cannot be created from editing field codes.

Figure 5-6: Track Antenna Manual Control

Rotate and Radiate Keys

17. With the introduction of MOD 12 and OBTS there has also been an introduction of both Man Aloft and radiate keys. The problems caused and suggested work rounds are listed below.

18. CAS ROTATE (Man Aloft) Key – With this key removed, power is removed from the CAS Stabilisation Bridge within the CAS Dome. The result is the stabilised column will topple. If you are at sea DAMAGE WILL OCCUR. It is recommended that this key be danger tagged and not removed. With this key in and on, all maintenance is able to be conducted the pulse transmitter receiver/processor and SSCWI systems including radiating into Dummy Load.

19. CAS RADIATE Key – This key enables live radiation.

20. STIR ROTATE Key – With this key removed, power is removed from not only the servo drive amplifiers but also the exciter. This prevents even the most basic of defect investigation or PMS to be conducted, including inability of radiating into Dummy Load. Once this key is in and on, maintainers are able to conduct maintenance on the receiver/processor and SSCWI, including radiating into SSCWI Dummy Load. You are UNABLE to radiate into Dummy Load on the pulse transmitter.

21. STIR RADIATE Key – With this key in and on, maintainers have full system capability. The down side is that it is now possible to radiate live. Command is to be aware that maintainers will ask for the STIR RADIATE Key to conduct maintenance when alongside.

BATTLE SHORT

22. There are now 3 Battle Short conditions; Off, Low and High.

a. Off – No system safeties are bypassed.

b. Low – Only personnel safeties are bypassed (High Voltage interlocks etc)

c. High – All System safeties are bypassed (Loss of water cooling, High Voltage interlocks etc)

23. The system will automatically progress to the next level when a weapon is assigned and the fire button is pressed. The system can also be manually taken to the Battle Short Low condition.

Chapter 6. Radar Distribution System

References:

- ABR 6511 FFG Combat System Operator Manual
- ABR 6509 FFG Combat System Manual – Section 10
- Technical Manual for SB-4229A(V)3/SP, Radar Switchboard P/N 380032-1
- Technical Manual for CV-3989(V)1/SP, Signal Data Converter P/N 204500-1
- SE020-AA-MMO-010 Video Amplifier AM-7115/UP
- Technical Manual for UYA-4 Interface Control Unit P/N 402850-1
- Technical Manual for RADDS to ACP/ARP Decoder P/N 380001
- Technical Manual for RADDS to PDT Decoder P/N 302101
- Technical Manual for RADDS to Synchro Decoder P/N 204222

General

1. The Radar Distribution System (RDS) incorporates the signal distribution from the three fitted radar systems, to multiple elements of the ships Combat, Navigation and Command systems. The SPS-55, SPS-49A and CAS Search radars interface with the combat system through the RDS for subsequent display on consoles on the Bridge, and in the Ops room.

2. Radar triggers and azimuth are fed into the CV-3989 Dual Signal Data Converter’s (DSDC) where the information is converted and multiplexed into a single data stream known as RADDS for further distribution. Each DSDC has two discrete converters, and each ship has two DSDC’s fitted. DSDC #1 converts information from SPS-55 and SPS-49A whilst DSDC #2 converts CAS Search and provides a spare unit for redundancy. Each DSDC outputs a separate RADDS data stream for each radar input, meaning there is one SPS-55 RADDS stream, one SPS-49 RADDS stream, and one CAS Search RADDS stream.

3. Whilst the Triggers and Azimuth information is passed through the DSDC’s, the radar video is fed directly into the SB-4229A(V)3/SP Radar Signal Distribution Switchboard (RSDS), for subsequent distribution to selected display consoles. The RADDS stream output from the DSDC is distributed to both sub-system elements and to the RSDS.

Inputs

4. All sub-systems within the RDS are located in RICER, are powered by 115VAC 60Hz 1Φ and are air cooled.

CV-3989 Dual Signal Data Converter's (DSDC)

5. The CV-3989 DSDC performs the conditioning, acquisition, calculation, formatting and multiplexing of radar sensor data into a single data stream that is applied to a switchboard for further distribution to the display consoles.

Figure 6-1: CV-3989 DSDC

6. The DSDC has two channels per assembly. This enables it to accept two distinct radar inputs per unit. The FFG configuration utilises two DSDC assemblies,

a. DSDC #1 receives signals from SPS-55 and SPS-49A,

b. DSDC #2 receives signals from CAS Search, with the remaining channel being spare,

Note: The spare can be reconfigured in the event of one of the other three channels becoming unserviceable.

7. DSDC operations are triggered by the receipt of the radar Master Trigger (Tm) pulse, as such if the DSDC does not receive a Tm pulse, it will not output a RADDS data stream.

8. Each DSDC has 4 CCAs and two Power Supplies (second one for redundancy).

a. A3A1 – FORMATTER ASSEMBLY

b. A3A2 – SYNCHRO DIGITIZER

c. A3A3 – SERIALIZER ASSY

d. A3A4 – SERIALIZER ASSY

e. A3PS1 – POWER SUPPLY

f. A4PS1 – POWER SUPPLY

9. The DSDC is primarily used to convert synchro information from the radar sources into a digital data format. (RADDS II). The inputs to the DSDC include Te, Tiff, Tm and Az. The video data from the radar is NOT converted by the DSDC and is fed directly to the RSDS switchboard for distribution.

RADDS Distribution Standard

10. RADDS is the acronym for the USN Radar Display and Distribution System, and is defined as MIL-STD-751(B). The RADDS standard was created to establish a common communications protocol, simplify and minimise the cabling between the radar sub-systems and the overall combat system elements with regards to radar distribution.

11. There are two versions of the RADDS data stream, RADDS I and RADDS II. The RAN configuration utilises RADDS II.

12. The RADDS II data stream format is a multiplexed signal that incorporates the following information:

a. Radar Azimuth data (Az),

b. Radar Master Trigger (Tm),

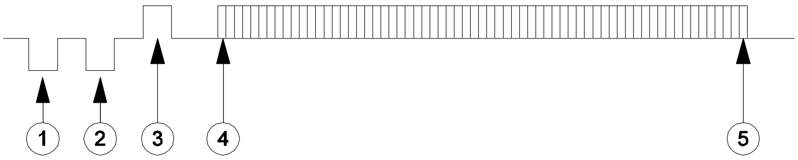
c. Radar Early Trigger (Te),

d. Radar IFF Trigger (Tiff), and

e. Radar Ident (Type).

13. The RADDS II standard is capable of multiplexing the aforementioned signals and own-ship navigation information, including Latitude and Longitude (Lat/Long) positional data, ships speed and heading. This navigational data is not incorporated in the RAN configuration.

14. The RADDS data stream is a digital word format that begins with Radar Tm, followed by a 64 bit digital data stream that contains the radar azimuth data, true/relative bearing information, ships heading marker and sensor identification code, followed by the radar Te and Tiff (if applicable).



1. Radar Te – Early Trigger
2. Radar Tiff – IFF Trigger
3. Radar TM – Master Trigger
4. Bit 1 – beginning of 64 bit data stream
5. Bit 64 – parity bit, and end of 64 bit data stream

Figure 6-2: RADDS II Data Stream Structure

15. The RADDS data stream contains in the 64 bit data word various configuration bit structures for determining the type of radar being used, navigation data fields, azimuth fields etc. A breakdown of the bit structure for the RADDS II data stream content is provided below.

Bit Number	Bit/Field Description	Bit/Field Status
1	Video present bit for current Tm	0 = present; 1 = not present. Always clear for RADDS II
2 thru 16	LSW Navigation Data	Not used in RAN configuration
17	True or Relative Bearing	0 = Relative; 1 = True
18	Azimuth Data Valid	0 = Valid; 1 = Not Valid
19 thru 30 (Bit 19 is MSB)	Best Azimuth data for next Tm. Stabilised Azimuth will be selected instead of Synchro if both are present.	All 0 = 0°; all 1 = 359.9° Each incremental step equals .088°
31	RADDS I or RADDS II select	0 = RADDS II; 1 = RADDS I Always clear in RAN configuration
32 thru 37	Navigation Data	Not used in RAN configuration
38	Radar or Other Sensor	0 = Radar; 1 = Other Sensor
39 thru 43	Sensor Identification	Refer Table 6: Sensor ID
44	NAVDATA Available	Not used in RAN configuration
45 thru 47	Navigation Word Selection Table	Not used in RAN configuration
48 thru 63		Not used in RAN configuration
64	Even Parity Bit	

Table 5: RADDS Data Stream Content

Radar	Bit 39	Bit 40	Bit 41	Bit 42	Bit 43
AN/SPS-55	0	0	1	0	1
AN/SPS-49A(V)1	0	1	1	1	1
MK 92	1	1	1	1	1

Table 6: Sensor ID

SB-4229A(V)3/SP Radar Signal Distribution Switchboard (RSDS)

Figure 6-3: Radar Signal Distribution Switchboard (RSDS)

16. The SB-4229A(V)/SP radar switchboard is utilised to provide automatic remote selection of discrete radar system signals for display on command and control, and auxiliary displays throughout the combat system. It consists of an enclosure, a Master Control Panel for power switching, an upper chassis housing the switching, configuration and control modules, a lower chassis housing redundant power supplies, and side panels fitted with input/output connectors.

17. The unit is comprised of modules which either distribute, control or monitor distribution of the input signals.

18. The switchboard performs distribution of the following low level signals:

a. Radar Video,

b. RADDS II Data Stream,

c. IFF Composite Video,

d. IFF Mode Tag,

e. IFF Control Signals, and

f. Remote Select Signals.

19. The switchboard is arranged into Input and Output Channels, which may be configured independently, and allows for daisy chaining RADDS inputs to other inputs internally to the switchboard. The current configuration allows the following;

a. Radar 16 Input to 16 Output, (This enables the switchboard to receive up to 16 radar inputs, and provide radar switching to up to 16 displays) and

b. IFF – 5 Input to 8 Output (The IFF side enables up to 5 IFF interrogators (FFG only has 2 – SPS-49A and CAS) and 8 IFF decoders located at WCC 1 & 2, C&Di consoles 1-3, 4 (passive only), 5 and 8.

RADDS Decoders

20. The RADDS Decoder units as fitted to the FFGs are of a modular design, and allow for various configurations to be utilised depending upon the required signal distribution for each different installation. There are eight RADDS Decoders in the FFGUP configuration, of which there are 4 different configurations. These configurations are:

a. RADDS to Synchro Decoder with Radar Video Select

b. RADDS to ACP/ARP Decoder with Radar Video Select

c. RADDS to ACP/ARP Decoder

d. RADDS to Parallel Digital Theta (PDT) Decoder

Figure 6-4: RADDS Decoders (and Video Amplifiers)

RADDS to Synchro Decoder with Radar Video Select

21. The RADDS to Synchro Decoder with Radar Video Select is used for the distribution of radar signals and information from the radars and switchboards, to the Colour Tactical Display (CTD) consoles. This enables the operator to select the Radar and appropriate video type at the console, which then passes via the RADDS Decoder where the video selection occurs. The switching control signal is then passed to the Radar Signal Distribution Switchboard, where the correct radar and input is selected and routed to the appropriate output, to the RADDS Decoder and interrogating console. RADDS to Synchro decoder also feeds NDS, but without the RVS function.

RADDS to ACP/ARP Decoder with Radar Video Select

22. The RADDS to ACP/ARP Decoder with Radar Video Select works similarly to the Synchro variant, with the exception being the type of output signals distributed from the RADDS Decoders. The ACP/ARP decoder outputs Azimuth Change Pulse (ACP) and Azimuth Reference Pulse (ARP) signals to the MK92 Weapons Control Console's (WCC) for SPS-49A and SPS-55 radars.

RADDS to ACP/ARP Decoder

23. The RADDS to ACP/ARP Decoder provides ACP/ARP signals for processing by the Beacon Video Processors (BVP). The BVPs utilise the ACP/ARP pulse information as derived from SPS-49A and CAS Search and their associated IFF systems for tracking and processing functions.

RADDS to Parallel Digital Theta (PDT) Decoder

24. The RADDS to Parallel Digital Theta (PDT) Decoder converts the RADDS data stream information from the SPS-55, SPS-49A and MK92 radars to produce North Crossing signals. These North Crossing signals are then applied through the combat system as a reference pulse to correlate radar return positioning with reference to the ships bow.

25. Each of the RADDS Decoders main chassis are identical, with power supply, power switch and power test points housed in the bottom, and the A1A1 – A1A3 positions are available for the various modules to populate as required.

26. The fitted Decoders with and without Radar/Video Select (RVS) are designated as Enclosures and are listed below:

Enclosure	Decoder Type	Equipment
#1	ACP/ARP + RVS	WCC 1
#2	ACP/ARP + RVS	WCC 2
#3	Synchro + RVS	CTD3
#4	Synchro + RVS	CTD2
#5	Synchro + RVS	CTD1
#6	ACP/ARP	BVP
#7	PDT	SDC
#8	Synchro	NDS

Table 7: RADDS Decoder Designations

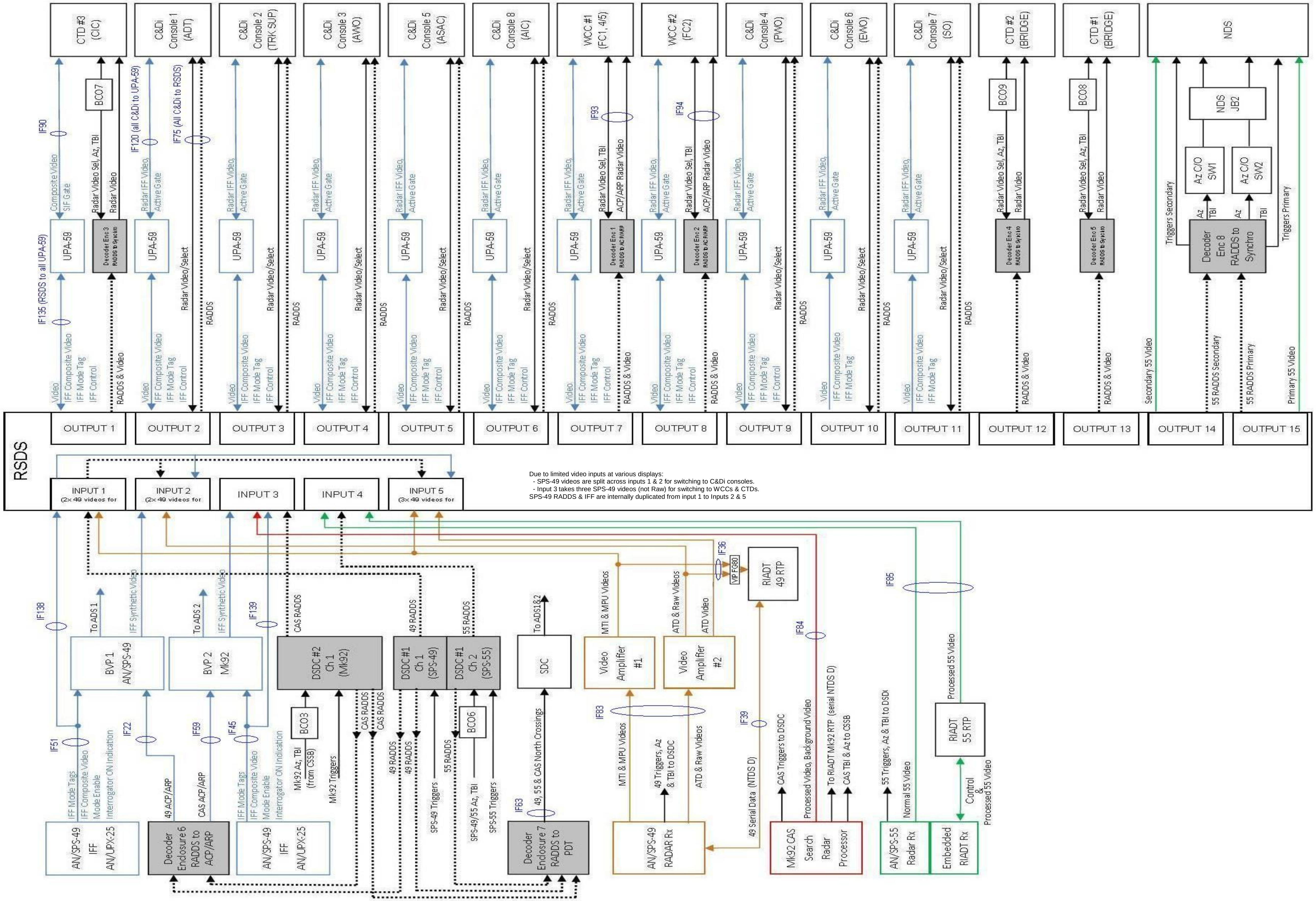


Figure 6-5: FFG Radar Signal Distribution System

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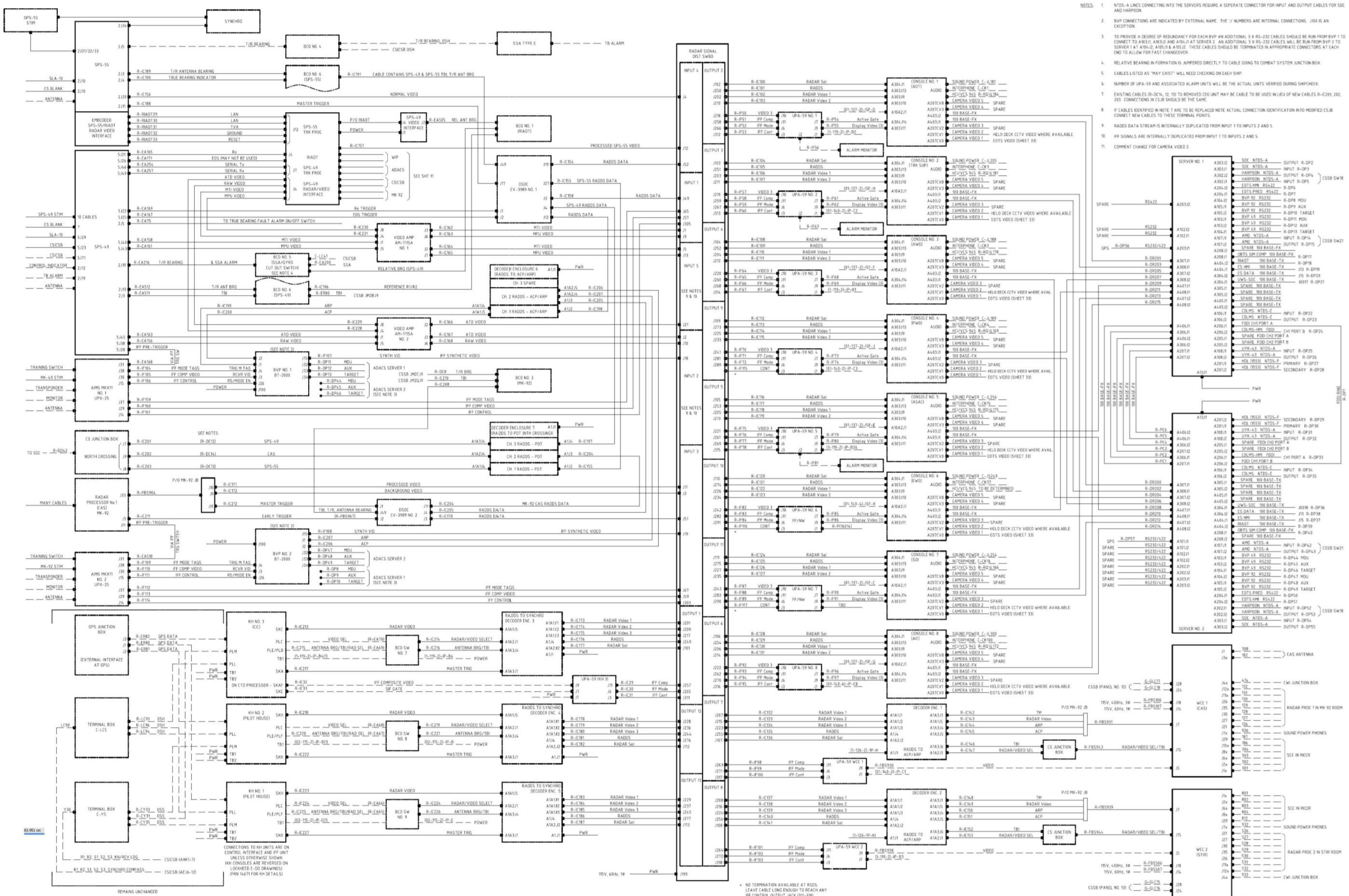

Figure 6-6: FFG Radar Signal Distribution Cabling

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Chapter 7. AIMS Mk XII Interrogate Friend or Foe (IFF)

Reference: ABR 6511 Combat system Operators Manual Section 1 Chapter 3

General

1. AIMS Mk XII is the principal method of unit identification. AIMS is an acronym standing for Air Traffic Control, Identification Friend or Foe, Mk 12, System.

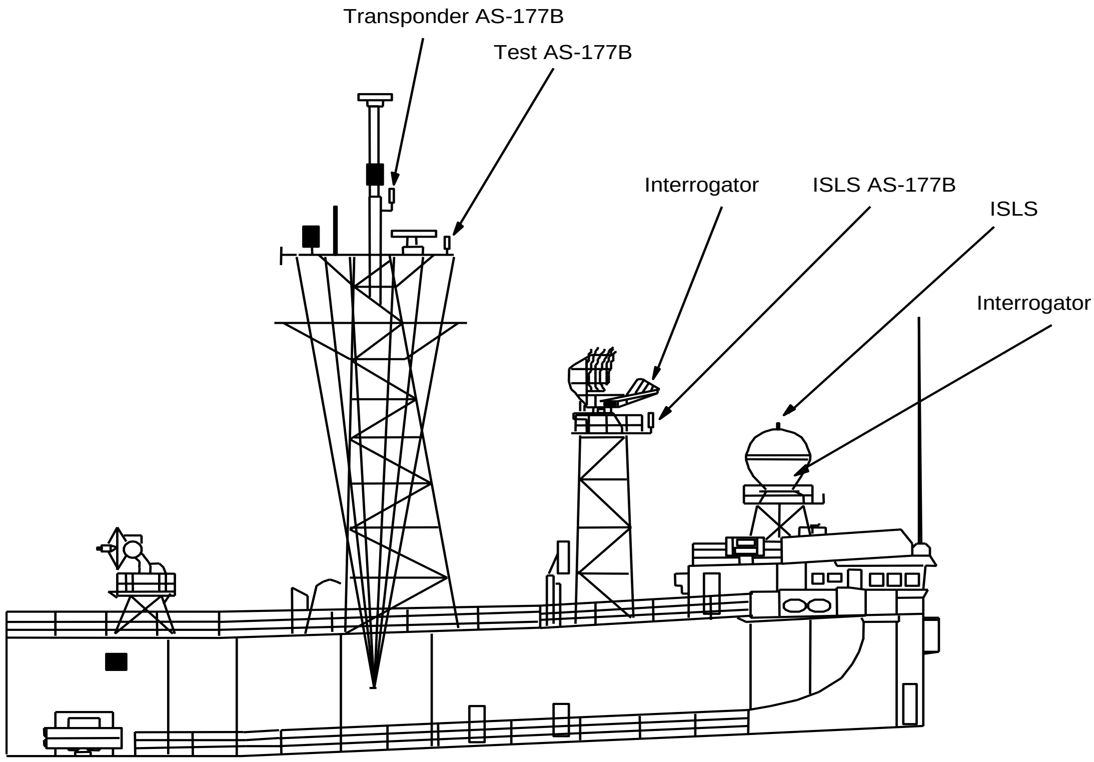


Figure 7-1: FFG AIMS Mk XII IFF Antenna Suite

Theory of Operation

2. The interrogating unit transmits a 1030MHz coded "who goes there" message to which the interrogated unit responds with a 1090MHZ coded reply.

3. There are four different modes of interrogation, each capable of triggering a transponder reply containing identification data from friendly, co-operative units. Interrogations consist of pulse trains, with the mode of interrogation determined by the pulse timing. The identification data available from transponder replies is:

a. MODE 1 General Military Identification

b. MODE 2 Personal Military Identification

c. MODE 3/A Civilian/Military Identification

d. MODE C Civilian/Military Altitude

e. MODE 4 Secure Military Identification

4. Emergency reply codes are available in the following modes:

a. 4X Emergency (Military Only) Modes 1, 2, 3/A

b. 7700 General Emergency Mode 3/A

c. 7600 Communications Emergency Mode 3/A

d. 7500 Unlawful Interference Emergency Mode 3/A

5. A unit will only reply in response to an interrogation if it is fitted with IFF equipment and has enabled the generation of such replies. Additionally, valid MODE 4 replies can only be transmitted and decoded by units with matching cryptographic key material.

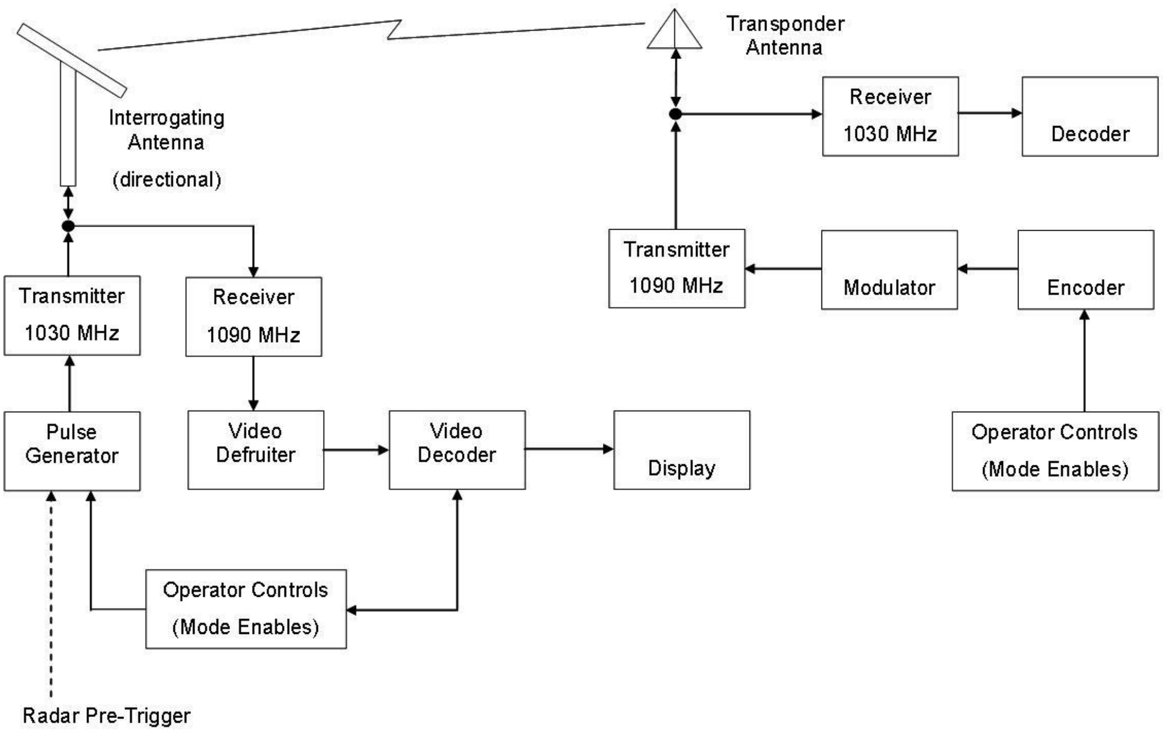


Figure 7-2: Basic ATC System Conceptual Block Diagram

FFG Equipment Fit

6. The equipment comprising the FFG IFF system is shown below:

No of Units	Nomenclature	Description
2	AN/UPX-25(V)4	Interrogator system (2kW pp for SPS-49, 0.5kW pp for Mk92)
1	AN/UPX-28(V)2	Transponder system
1	TS-1843B/APX	Test Set
3	UPA-59B(V)1	Passive Decoder
6	UPA-59B(V)2	Active Decoder
2	C-8430/UPX	Interrogator Control Monitor
1	C-6280A(P)/APX	Transponder Control Set
3	AS-177B/UPX	Omni-Directional Antennas
1	AS-2188/UPX	Interrogator Antenna (SPS-49)
1	Mk 92 CAS Search	Interrogator and ISLS Antenna suite

Table 8: IFF System Equipment

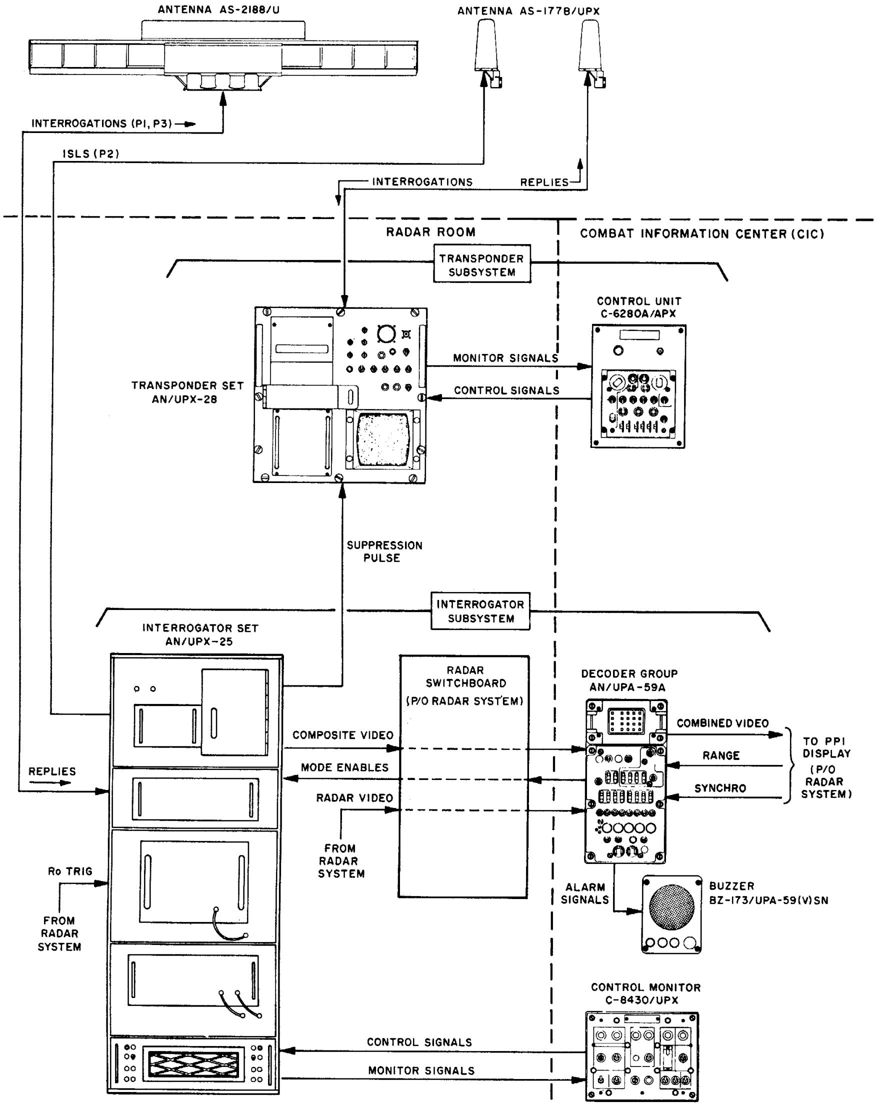


Figure 7-3: AIMS Mk XII System Pictorial

AN/UPX-25(V)4 Interrogator

7. The AN/UPX-25(V)4 interrogator transmits at 1030 MHz, and receives replies at 1090MHz. Demodulated video, along with mode tags, is provided to the UPA-59 and BVP system for decoding of the reply and for display on operator consoles.

8. Maximum PRF of 400 pps (approx) is synchronised to high PRF radars (CAS Search) using a countdown technique that locks out interrogation until a countdown period of 2.5 msec has expired.

10. Interrogations in modes 1, 2, 3/A, and C consists of three 0.8µsec pulses. P1 and P3 are directional pulses that are transmitted from an IFF antenna slaved to the primary antenna (SPS-49 or CAS Search). The timing of the P3 pulse in relation to P1 determines the mode of interrogation. This is shown in Table 9: Interrogation Mode Timings

9. . Another pulse, P2, is transmitted from an omni-directional antenna for use in a technique of side lobe suppression. The relative power level of the P2 pulse is checked by the interrogated transponder unit to try and ensure it only responds to valid interrogation pulses i.e. when it is in the main lobe of the interrogating radar beam.

P1-P3 Pulse Spacing	Recognised Mode
3 µsec	MODE 1
5 µsec	MODE 2

8 μsec	MODE 3/A
21 μsec	MODE C

Table 9: Interrogation Mode Timings

10. Mode 4 interrogations consist of four 0.5 μsec pulses spaced 2 μsec apart, plus a number of encrypted pulses originating in the mode 4 cryptographic computer.

11. Only one interrogation can be transmitted at any time, therefore interrogation of different modes is interlaced on successive synchronised radar transmissions. One of four mode interlace (MI) patterns can be selected.

MI	Modes Interrogated	Sequence
A	Modes 1, 2, 3/A, C	1 2 3/A C 1 2 3/A C
B (normal setting)	ALL Modes	1 4 2 4 3/A 4 C 4
C	Mode 4 Only	-
D	As programmed	Program Card (Not Implemented in RAN)

Table 10: IFF Mode Interlace Patterns

12. To avoid displaying IFF replies that are as a result of a third party interrogation the Interrogator Set employs a device called a ***Defruiter*** ('fruit' is the term given to the spurious returns that are displayed if not filtered out). Its function is to filter out non-synchronous replies, i.e. replies that are as a result of other ship interrogations. In order to perform the defruit process multiple repetitions of the same interrogation need to be performed. The selectable options are Pulse Counts of 1, 2, 4, 8 or 16 repetitions of each interrogation mode. The normal setting is 4 (e.g. MI=B, PC=4 gives 1111 - 4444 - 2222 - 4444 etc).

AN/UPX-28(V)2 Transponder

13. The AN/UPX-28(V)2 transponder receives interrogations at 1030 MHz, and transmits encoded replies at 1090 MHz. The requirements that are tested before the transponder will respond include:

a. both P1 and P3 are received,

b. P1 to P3 and P1 to P2 (if received) spacing is within 0.1µsec of the specification,

c. P3 is from 1dB down to 3dB above P1,

d. P1 is at least 9dB above P2 (if P2 received), and

e. both P1 and P3 are at least 10dB above ambient noise power.

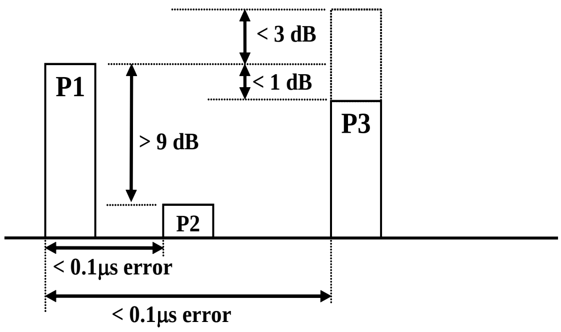


Figure 7-4: IFF Transponder Pulse Parameter Requirements

14. Transponder replies are comprised of 0.45μsec width pulses, with start and end pulses called Framing Pulses or Bracketing Pulses. The Framing Pulses are always 20.3 μsec apart. The codes of the responses are determined by the presence or absence of pulses at designated positions within the Framing Pulses; a pulse represents binary 1, an absent pulse represents binary 0. These pulses (or their absence) make up a SIF digit using octal code.

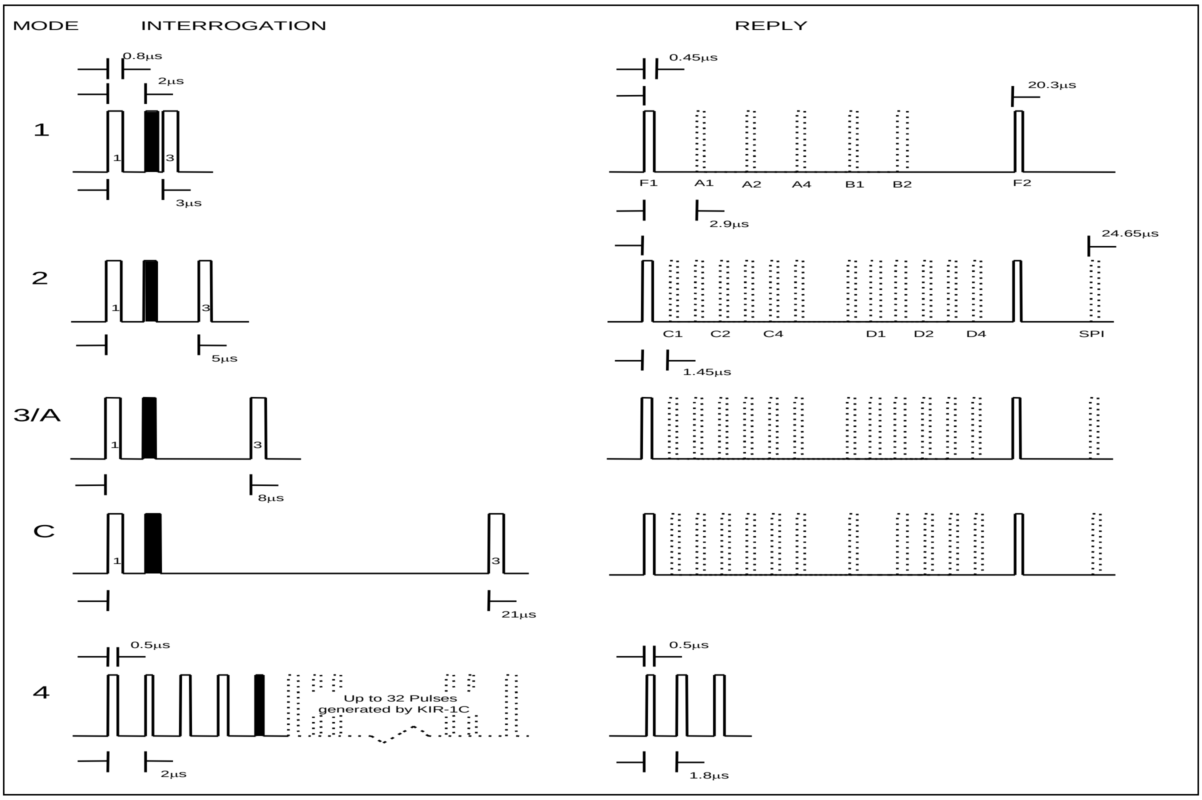


Figure 7-5: AIMS Mk XII Interrogations and Replies

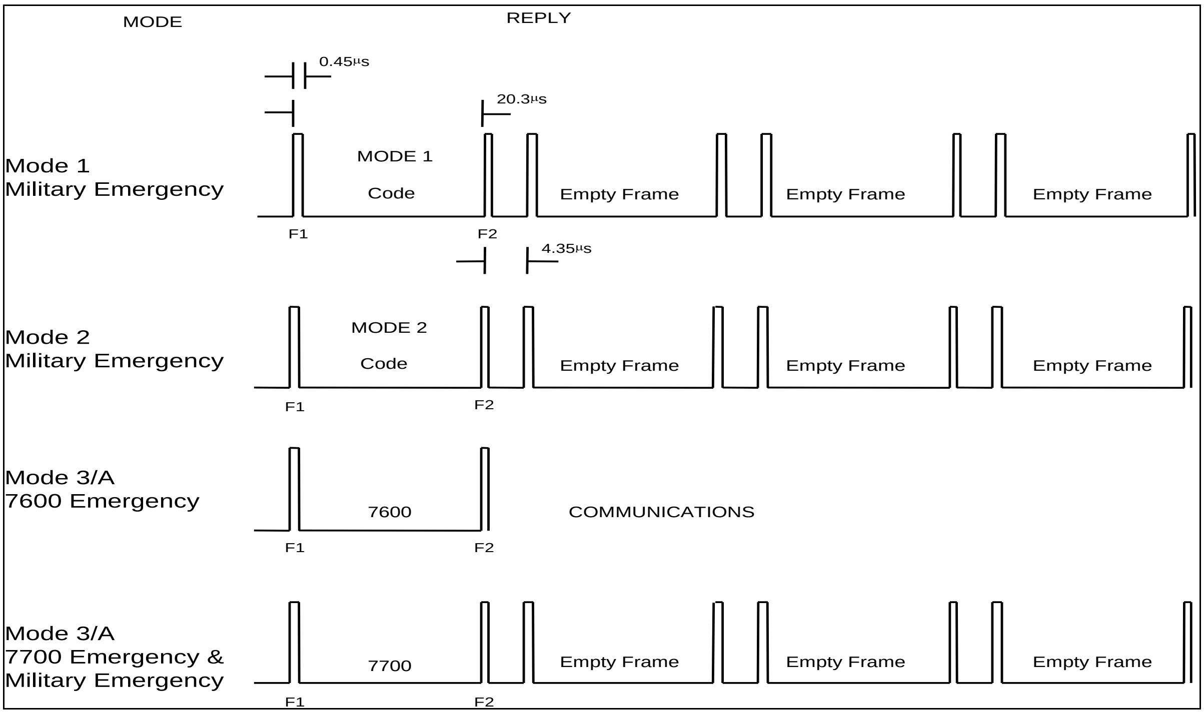


Figure 7-6: AIMS Mk XII Emergency Replies

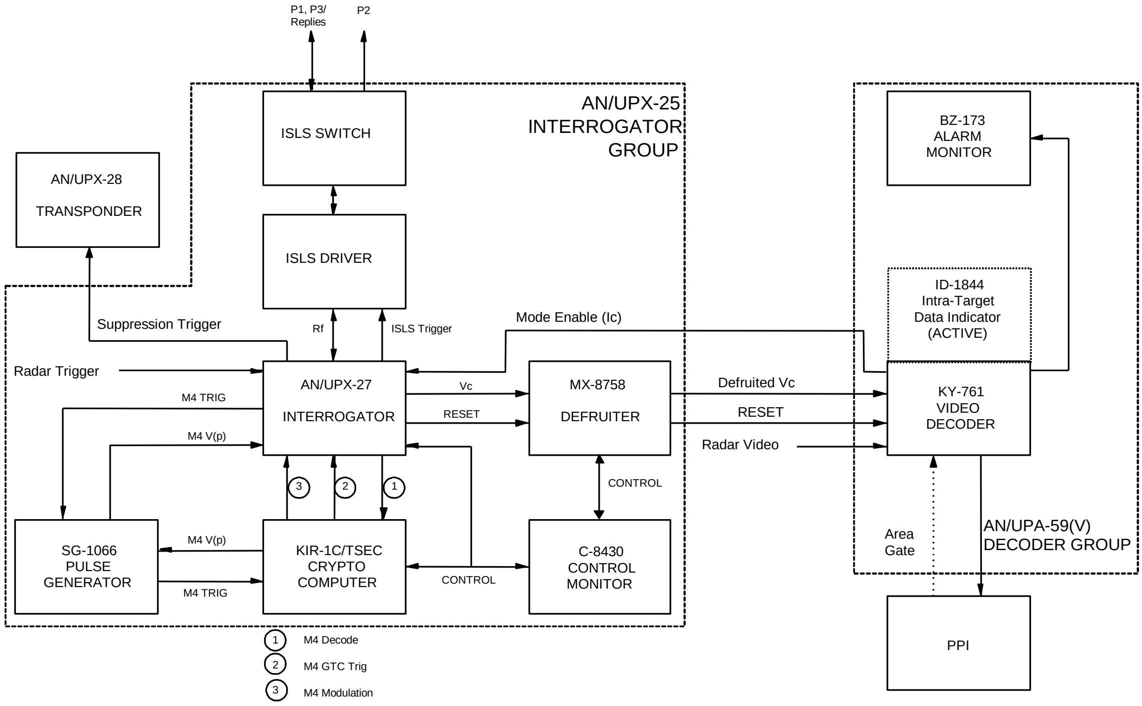


Figure 7-7: Interrogator System Block Diagram

TERM	MEANING
AIMS	**A**TC Radar Beacon System, **I**dentification Friend or Foe, **M**ARK XII **S**ystems
Bracket Pulses	The framing pulses (F1, F2) which surround the information (A, B, C, D) pulses of a transponder reply to Modes 1, 2, 3/A, C interrogations.
Bracket Decode	A decoding system which looks for pulses spaced 20·3μsec apart without regard for any information pulses.
Bracket Defruit	A method of removing non-synchronous replies (fruit) by comparing bracket pulses of successive sweeps for range mis-alignment (see Pulse-to-Pulse Defruiting).
Composite Video	The reply video to all modes of interrogation combined on one line (Mode Tags are on another).
Countdown	A process within the SG-1066 whereby a high rate radar trigger is "counted down" to provide triggers at a lower rate suitable for 200 nm IFF operation.
Decoder	A part of the interrogator system that examines replies to determine the reply code etc.
Defruiter	A part of the interrogator system designed to remove non-synchronous replies (fruit) from the received video.
Framing Pulses	The F1 and F2 pulses of the transponder reply. Also called bracketing pulses.
Interlace	Refers to interrogating more than one mode and the pattern in which modes are combined.
Interrogation	The coded pulses radiated by an interrogator.
Interrogation Cycle	The period of time between successive interrogations.
ISLS	**I**nterrogation **S**ide **L**obe **S**uppression. An action taken by the transponder to prohibit the production of a reply unless it is in the main lobe of the interrogator.
I/P	**I**ndication of **P**osition. A special reply (SPI) for modes 1, 2, 3/A and C.
Mode 4	A secure identification mode.
Mode Tags	Are video pulses of identical characteristics to the interrogation pulses that produced the transponder reply.
P2 Pulse	The ISLS Pulse. Is used by the transponder in determining main lobe interrogation.
Pulse-to-Pulse Defruiting	A method of removing non-synchronous replies (fruit) by comparing each pulse of the received video between successive sweeps for range mis-alignment.
Ring Around	Results when close targets reply to side and back lobe interrogations (ISLS prohibits the generation of such replies).

Table 11: AIMS Mk XII Definitions

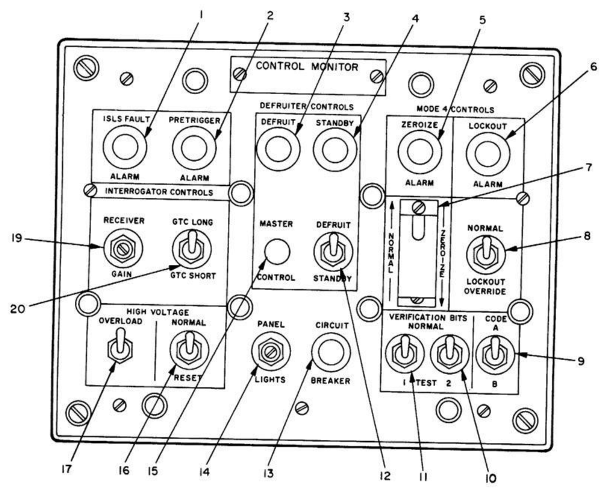


Figure 7-8: Interrogator Set Control Monitor C-8430

No.	Control/Indicator	Function
1	ISLS FAULT indicator	Lit when ISLS circuits have failed in either the RF Switch Driver or Interrogator Set.
2	PRETRIGGER ALARM indicator	Lit when pre-trigger has faulted in the parent radar system or the Pulse Generator SG-1066.
3	DEFRUIT indicator	Lit when DEFRUIT/STANDBY switch is set to DEFRUIT.
4	STANDBY indicator	Lit when DEFRUIT/STANDBY switch is set to STANDBY.
5	ZEROIZE ALARM indicator	Lit when KIR computer code is released.
6	LOCKOUT ALARM indicator	Lit when KIR computer detects a Mode 4 malfunction and further Mode 4 operation is inhibited.
7	NORMAL/ZEROIZE switch	Momentary switch that, when placed in the ZEROIZE position releases the code in the KIR computer.
8	LOCKOUT OVERRIDE switch	In the LOCKOUT position Mode 4 operation is not inhibited due to a Mode 4 malfunction.
9	CODE Switch	Sets KIR computer code for Mode 4 operation.
10, 11	VERIFICATION BITS 1 & 2	In NORMAL position, Mode 4 operation is normal. In TEST position, verification bit 1 is enabled, verification bit 2 switch not connected.
12	DEFRUIT/STANDBY switch	In DEFRUIT position, enables defruiter operation. In STANDBY, places defruiter in standby condition (no defruiting).
13	CIRCUIT BREAKER	Provides overload protection for C-8430.
14	PANEL LIGHTS dimmer	Screwdriver adjustment of panel light brightness.
15	MASTER CONTROL indicator	Lit when defruiter is set for remote operation.
16	NORMAL RESET switch	Momentary switch used to reset interrogator set high voltage circuits.
17	HV OVERLOAD indicator	Lit when interrogator set high voltage circuit has failed.
18	GTC LONG/SHORT switch	Selects long or short Gain Time Control operation.
19	RECEIVER GAIN control	Not connected.
20	GTC Select Switch	Use Long GTC if close targets are causing problems else Short GTC.

Table 12: Control Monitor C-8430 Controls and Indicators

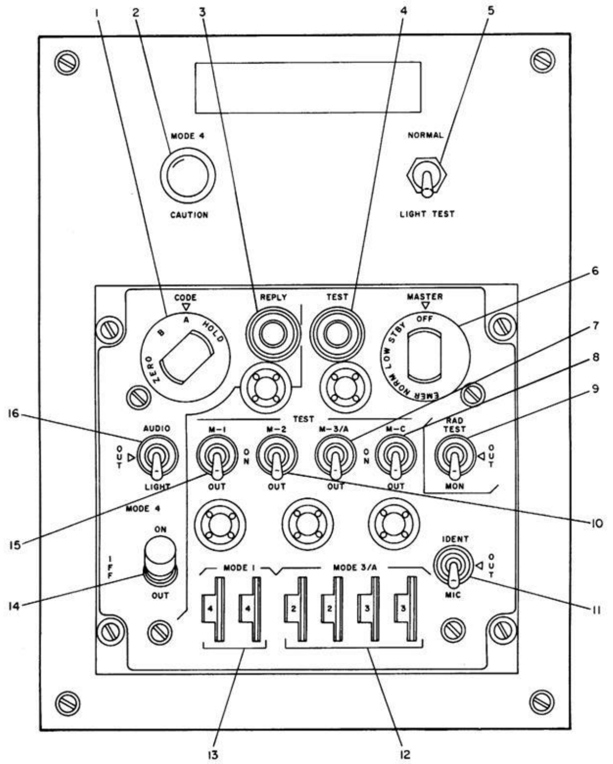
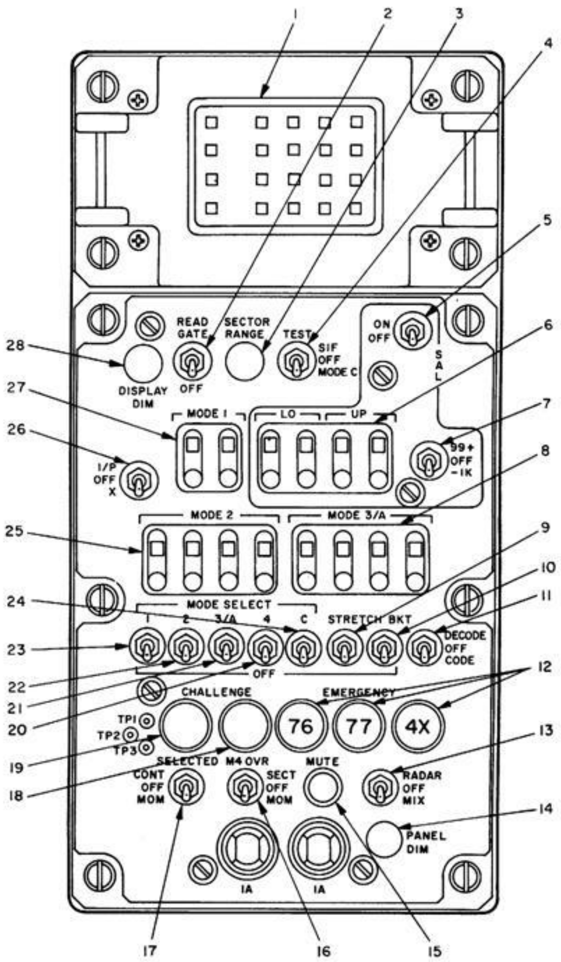


Figure 7-9: Transponder Set Control Unit C-6280

No	Control/Indicator		Function
1	CODE switch	ZERO	Dumps Mode 4 program of KIT computer.
		B	Set KIT computer to CODE B program.
		A	Set KIT computer to CODE A program.
		HOLD	Not implemented.
2	MODE 4 CAUTION indicator		Lit when transponder Mode 4 operation is abnormal.
3	REPLY indicator (green)		Lit when Mode replies are being generated.
4	TEST indicator (green)		Lit when RAD TEST/OUT/MOM switch is set to TEST or MOM and transponder is replying to Test Set.
5	NORMAL/LIGHT TEST switch		In NORMAL, operation of lights is normal. In LIGHT TEST position, MODE 4 CAUTION indicator lights.
6	MASTER switch	OFF	Power is removed from RT-859A.
		STBY	Power is applied, but transmission inhibited.
		LOW	RT-859A enabled with reduced sensitivity (≈ 20 dB down on NORM).
		NORM	RT-859A enabled with normal sensitivity.
		EMERG	All reply modes enabled and 4X emergency replies are transmitted upon mode 1, 2 & 3/A interrogation.
7	M-3/A switch	ON	Enables Mode 3/A replies upon interrogation.
		OFF	Disable Mode 3/A replies.
		TEST	Enable Test Set to locally interrogate RT-859A in Mode 3/A.
8	M-C switch	ON	Enables Mode C replies upon interrogation.
		OFF	Disable Mode C replies.
		TEST	Enable Test Set to locally interrogate RT-859A in Mode C.
9	RAD TEST/OUT/MON switch		
		RAD TEST	Enables RT-859A replies to TEST Mode interrogation and to enable Mode 4 verify bit 1 for identification.
		MON	Enables monitor circuits of test set; Test indicator lights when replying.
		OUT	Disables RAD TEST and MON.
10	M-2 switch	ON	Enables Mode 2 replies upon interrogation.
		OFF	Disable Mode 2 replies.
		TEST	Enable Test Set to locally interrogate RT-859A Mode 2
11	IDENT/OUT/MIC switch		
		IDENT	Enables IP reply for approximately 25 sec.
		OUT	Disables IP reply.
		MIC	Not implemented.
12	MODE 3/A switches		Mode 3/A code selection.
13	MODE 1 switches		Mode 1 code selection.
14	MODE 4 switch	ON	Enables Mode 4 replies.
		OUT	Disables Mode 4 replies.
15	M-1 switch	ON	Enables Mode 1 replies upon interrogation.
		OFF	Disable Mode 1 replies.
		TEST	Enable Test Set to locally interrogate RT-859A Mode 1.

No	Control/Indicator	Function
16	AUDIO/OUT/LIGHT switch	
	AUDIO	Enables aural and REPLY light monitoring of Mode 4 replies.
	OUT	Disables monitoring of Mode 4 replies.
	LIGHT	Enables REPLY light monitoring of Mode 4 replies.

Table 13: Control Unit C-6280 Controls and Indicators



1 Intertarget data indicator
2. READ GATE/OFF switch
3. SECTOR RANGE control
4. TEST SIF/OFF/MODE C switch
5. SAL ON/OFF switch
6. SAL LO and SAL up switches
7. SAL 99+/OFF/-1K switch
8. MODE 3/A code switches
9. STRETCH/OFF switch
10 BKT/OFF switch
11. DECODE/OFF/CODE switch
12. EMERGEMCY 76, 77, and 4X switch-indicator
13. RADAR/OFF/MIX switch
14. PANEL DIM control
15. MUTE switch
16. M4 OVR SECT/OFF/MOM switch
17. SELECTED CONT/OFF/MOM switch
18. CHALLENGE M4 OVER indicator (Blue)
19. CHALLENGE SELECTED indicator (Blue
20. MODE SELECT 4 switch
21. MODE SELECT 3/A switch
22. MODE SELECT 2 switch
23. MODE SELECT 1 switch
24. MODE SELECT C switch
25. MODE 2 code switches
26. I/P OFF/X switch
27. MODE 1 code switches
28. DISPLAY DIM control

Figure 7-10: UPA-59 Decoder

Chapter 8. Electronic Support (EW Sensor)

References: ABR 6511 Combat System Operators Manual, Sect 1 Chap 8.

General

1. The Electronic Support (ES) system is an enhanced Raphael C-Pearl system, designated simply as FFG ES System. It is a combination of wideband receivers and analysers used for the detection, location (bearing only), and identification of radio frequency (RF) transmissions. ES is operated as an x-window session on a C&Di console. The Electronic Warfare Operator (EWO) can switch between the ADS displayed tactical picture and the ES HMI. Only one operator can view ES HMI at any given time, the controls must be released by VAB to allow access to a different operator role. In normal operations, ADACS must be operating to allow access to ES HMI and display (i.e.: ES HMI is unavailable when ADACS is not operating).

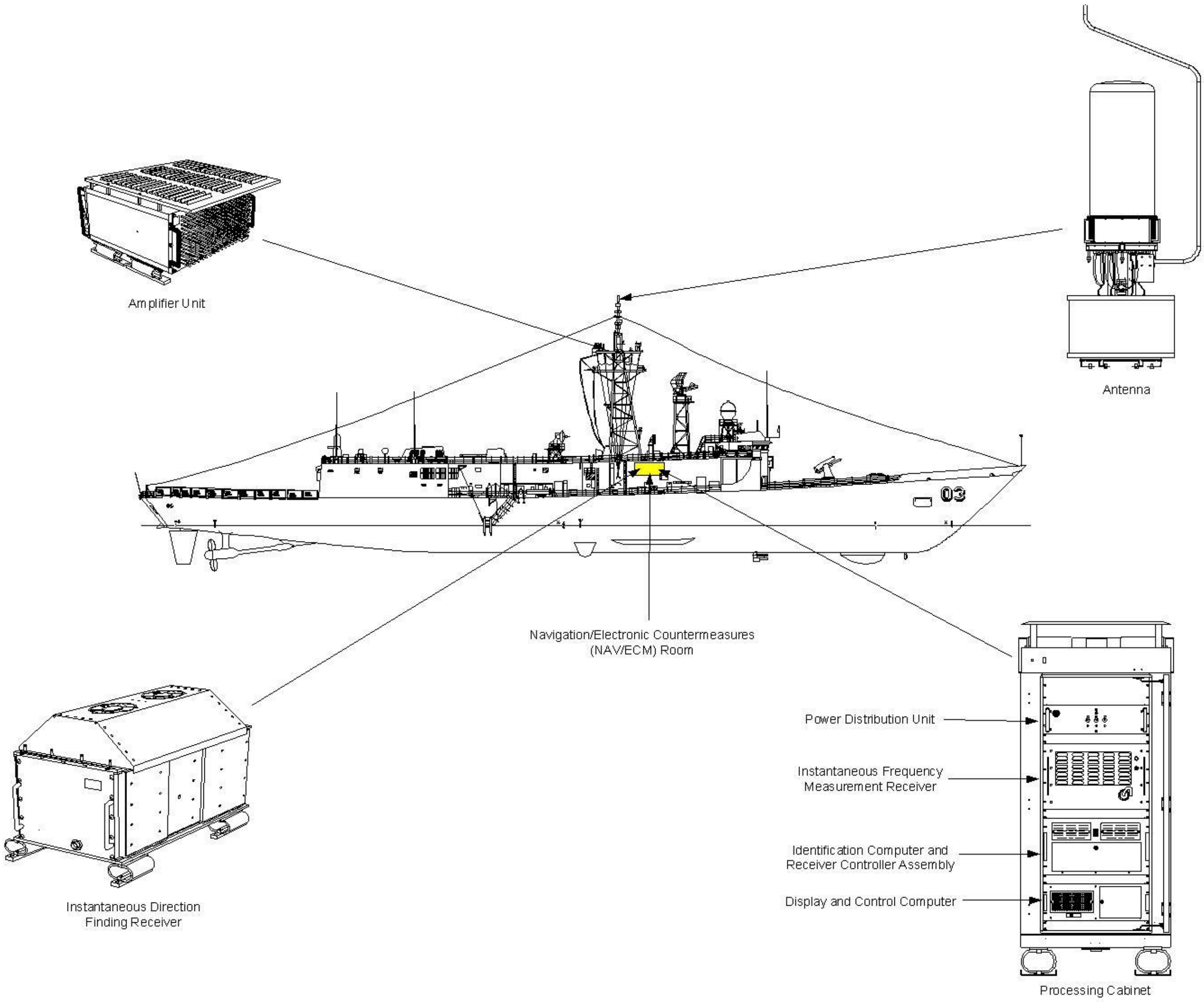


Figure 8-1: FFG ES Components

Functions

2. The primary functions of the ES system are to:

a. Intercept emissions within its bandwidth;

b. Convert these intercepts into data which defines the parameters of intercepted pulses/continuous wave (CW) signals;

c. Determine the direction of arrival (DOA) of intercepts;

d. Group intercept data coming from the same emitter;

e. Use this data to identify the emitter and the originating source; and

f. Display emitter data and emitter and platform identifications to operators at the C&Di consoles.

3. The ES system is composed of the following major components:

a. Antenna;

b. Amplifier unit;

c. Instantaneous direction finding (IDF) receiver; and

d. Processor cabinet containing:

(1) Instantaneous frequency measurement (IFM) receiver,

(2) Identification computer (IDC),

(3) Receiver controller (RxC),

(4) Power distribution unit (PDU), and

(5) Display and control (DC) computer.

4. The ES system can detect and classify sea-borne, air-borne and land-based emitters of the following types:

a. Airborne early warning radars,

b. Airborne multi-mode radars,

c. Airborne search and map radars,

d. Surface acquisition radars,

e. Fire control radars, and

f. Missile radar seekers

Sub-Systems

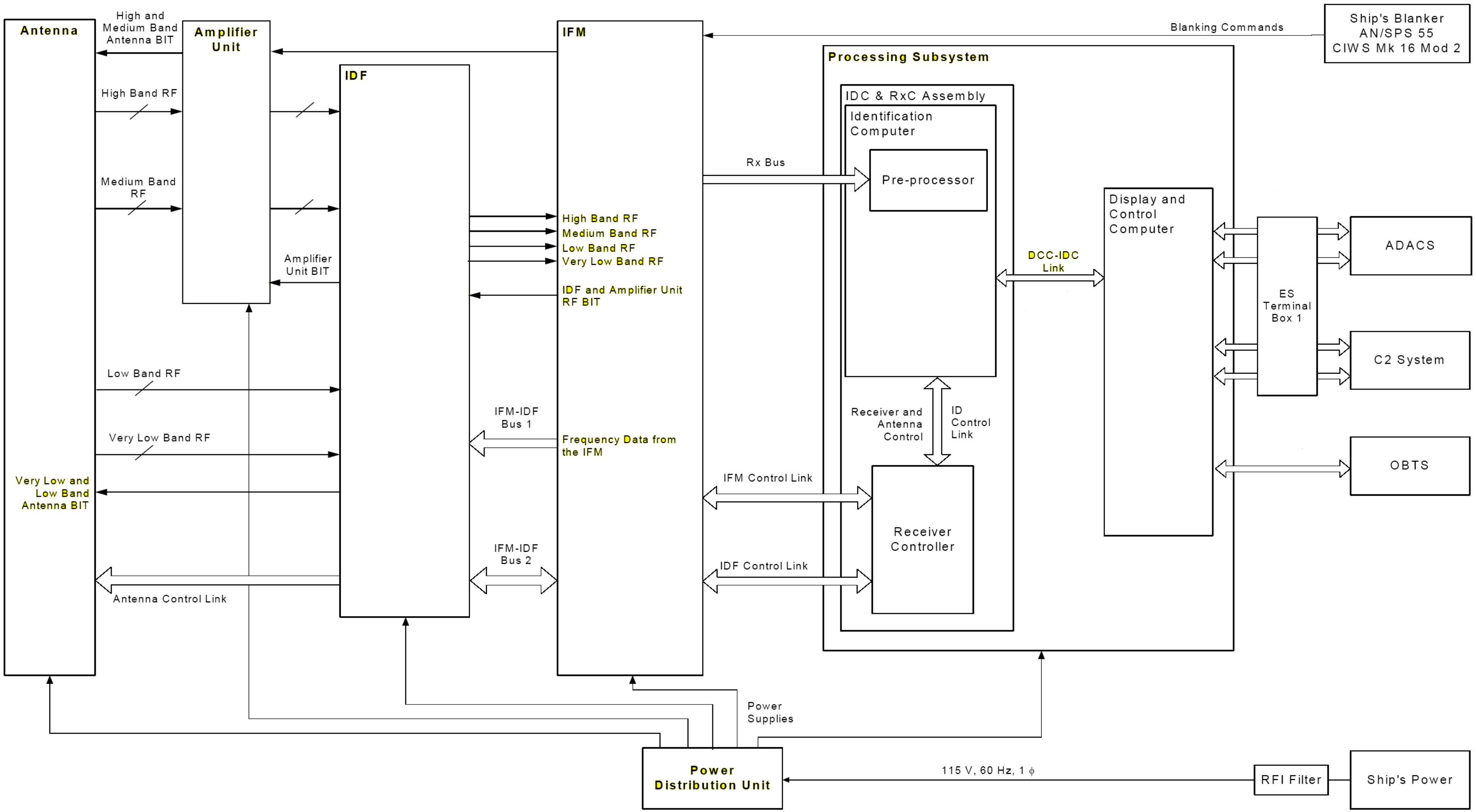


Figure 8-2: ES System Functional Block Diagram

ES Antenna

5. The antenna is mounted at the very top of the main mast and consists of the following three sub components:

a. Upper radome,

b. RF compartment, and

c. Very low Band (VLB) section.

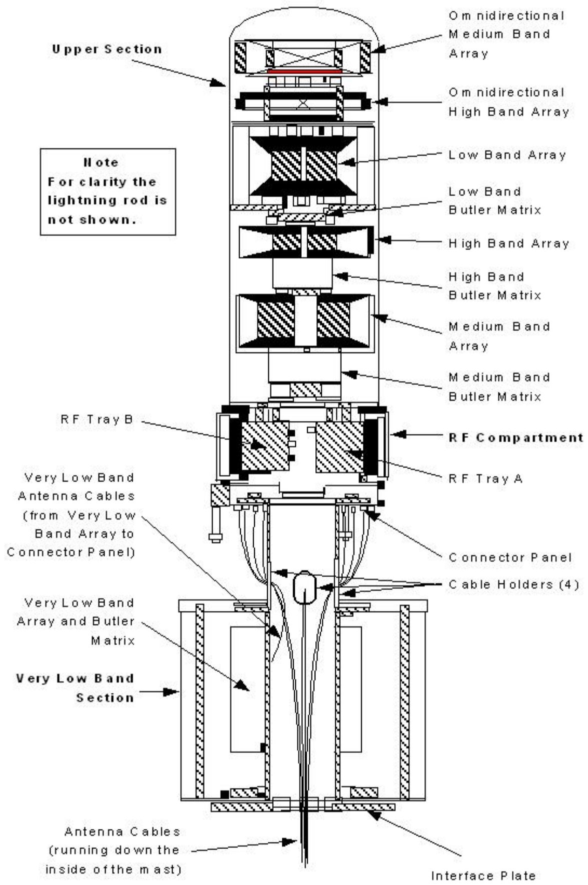


Figure 8-3: ES Antenna

6. The ES antenna for the very low, low, medium and high frequency bands, is based on a circular array feeding a butler matrix. Signals intercepted and amplified by the antenna and its RF front-end are routed to the IDF and IFM receivers to measure their parameters. RF pulses are intercepted by the system via one set of receiving antennas. The set contains both an omni mode for IFM and other mode channels for IDF functions. The upper radome houses the arrays and butler matrices for each of the low, medium and high bands. The very low band section houses the very low band array and butler matrix.

7. The RF compartment houses the RF trays and other circuitry associated with the provision of power and control signals. It also includes EMI protection circuits as well as several RF, power and control signal distribution networks.

8. RF signals that are within the system bandwidth and dynamic range are intercepted by the receiving elements of the circular array in each band and are then passed to a passive beam-forming network that outputs the received RF as ‘modes’. The DOA of the intercepted signal can be determined by measuring the phase difference between the modes. There are three modes for the low band and four for each of the other bands.

9. To improve system sensitivity the high and medium bands each incorporate an omnidirectional antenna, the output of which bypasses the beam-forming network. Low and very low bands are passed directly to the IDF and the high and medium bands are passed initially to the amplifier unit, located just below the antenna on the main mast, and then on to the IDF unit. This is to overcome losses in the high and medium frequency bands that would be induced in the RF cables.

IDF/VLB Receiver

10. The IDF (instantaneous direction finder) receiver operation is based on utilising the various output modes provided by the antenna assembly. The antenna array modes are based on phase measurements to process each pulse’s direction with high accuracy. For the VLB the IDF uses a scanning receiver for improved interference rejection.

Figure 8-4: ES IDF/VLB Receiver

11. The IDF consists of the following sub components:

a. High band receiver,

b. Medium band receiver,

c. Low band receiver,

d. Very low band receiver,

e. IDF controller,

f. Motherboard, and

g. Power supply radio frequency interference (RFI) filters.

Processing Cabinet

12. The processing cabinet is physically located in the SPS-55/AirNav/ECM room. It is comprised of the following primary elements:

a. Instantaneous Frequency Measurement (IFM) receiver,

b. Identification Computer (IDC) and Receiver Controller (RxC) assembly,

c. Power Distribution Unit (PDU), and

d. Display and Control (DC) computer.

Figure 8-5: ES Processing Cabinet

IFM Receiver

13. The IFM receiver provides frequency, amplitude, timing and other parameters, combines this information with DF data from the IDF receiver and sends it as pulse descriptor words (PDW) through the Rx Bus to the ID computer. The IFM receiver also includes the blanking interface for own ship emitters.

IDC and RxC Assembly

14. The IDC and the RxC are completely independent computers housed in a common assembly and sharing a dual-redundant power supply. This common assembly is called the IDC & RxC Assembly. The main functions of the IDC are:

a. Instantaneous sorting of signals according to measured parameters,

b. Identification of emitters using predefined criteria and algorithms,

c. Tracking known emitters,

d. Inhibiting the reception of particular signals,

e. Delivering emitter data to the DC computer for further processing and display,

f. Transferring control messages to the RxC, and

g. Handling operator commands received from the DC computer.

Power Distribution Unit

15. The PDU receives primary power from the ship supply and distributes all the necessary voltages to other ES units. The PDU contains on/off switches.

DC Computer

16. The DC computer serves as the ES system communication server. It receives operator commands sent from the C&Di console and transmits threat data and system information to be displayed in ADS. The major functions of the DC computer are to:

a. Maintain the identification parameters library (IPL) and platform parameters library (PPL);

b. Display emitter information on the C&Di console (as an x-term session);

c. Store emitter information;

d. Transmit threat warnings to the operator;

e. Interface with ADS and OBTS;

f. Interface with the IDC;

g. Display system status;

h. Select and control operation and display modes;

i. Set system hardware set-up parameters such as thresholds; and

j. Record and replay real-time scenarios.

ES System Modes of Operation

17. The ES system has four modes of operation:

a. **EW mode** - the EW mode is the main operational mode. It enables threat identification, threat display, threat library view and edit, and the display of the status of external system interfaces. EW mode is the only on-line mode where the ES system is detecting and reporting emitter tracks to the operator and to ADS;

b. **Playback mode** - the playback mode enables a review of a scenario previously recorded during EW mode. Playback mode is an off-line mode in which the ES system does not detect or report emitter tracks either to the operator or to ADS;

c. **Test mode** - the test mode enables testing of the ES system to the level of single assembly or small group of assemblies. Test mode is an off-line mode in which the ES system does not detect or report emitter tracks either to the operator or to ADS; and

d. **Utility mode** - the utility mode provides the operator with file loading, saving and deleting functions. Utility mode is an off-line mode in which the ES system does not detect or report emitter tracks either to the operator or to ADS.

EW Mode

18. In EW mode the operator can control various aspects of system set-up and the information that is displayed. Controls are provided through the use of Touch Input Device (TID) buttons, the trackball and the keyboard. The controls vary slightly depending on which display type has been selected by the operator. In EW mode all the buttons on the top level TID layout are active except for ‘play options’. The TIDs replace the VABs and FABs of the C&Di console Display Control Panel (DCP).

19. EW mode provides controls to the EWO to conduct:

a. Select display,

b. Change display azimuth orientation,

c. Set up the ES system,

d. Threat table sorting,

e. Threat display filtering,

f. Zooming the Frequency/Bearing display,

g. Select and deselect threats,

h. Selecting hidden threats and platforms,

i. Delete threats,

j. Designate/drop threats to/from the C2 system,

k. Control very low band scanning,

l. Threat library editing,

m. Data recording,

n. Change role from ES to ADS, and

o. Terminate ES system data display.

Playback Mode

20. Playback mode is used for the playback of scenario files recorded during EW mode operations. The recorded files contain all operational data received from external systems and from the operator during EW mode. Playback of data terminates when a new mode of operation is selected.

21. Scenario files can be played back at four different speeds:

a. Real time speed,

b. Twice real time speed,

c. Four times real time speed, or

d. Eight times real time speed.

Utility Mode

22. Utility mode is used to perform file management and system level control functions. Selecting 'utility' on the TID initialises it. Selecting a new mode of operation, or shutting the system down will terminate utility mode operations. The operator can use utility mode to perform the following functions:

a. Load system files from the DC computer floppy disk drive to its hard disk,

b. Save system files from the DC computer hard disk to diskette,

c. Delete system files from the DC computer hard disk,

d. View system software version information, and

e. Shut down the ES system.

23. The saving and loading of files to/from diskette is controlled from the C&Di console, but requires diskettes to be inserted into the DC computer floppy disk drive. The DC computer is located in the SPS-55/ AirNav/ECM compartment. Disks are classified; refer to Defence Security Manual (DSM) for registration, handling and storage instructions.

Test Mode

24. The purpose of test mode is to test the whole system or parts of it in an offline session. The operator can select certain groups of tests from the TIDs. The selected test will run continuously until operator action to stop it, either by selecting a new test option, or changing system mode. The results are displayed on screen in the test mode display. The following options are presented in test mode:

a. Computers - tests the DC computer, IDC and pre-processor. This test covers the RAM, ROM, CPU and communication links of each device;

b. Receivers - tests the receiving system and communication links;

c. Peripherals - tests the hard and floppy disk drives of the DC computer; and

d. All - conducts both the 'receivers' and the 'computers' tests but not the 'peripherals' test.

Casualties

25. The ES system has only one operational system configuration. This is with all ES system components switched on and functioning properly. Failures of some system components may still leave some ES system functionality available. For example, a failure of the direction-finding capability will not normally affect the detection capability of the system. There are however no specified casualty configurations.

Blanking

26. Blanking is provided by the AN/SLA-10B Blanker. In general, no degradation of ES system performance will occur in any band in which the blanking of own ship emitters occurs if the duty cycle of those emitters is 20% or less. If this is not the case, blanking in particular bands may begin to affect the detection of emitters in those bands. Because the reception of emitter pulses and the blanking of own ship emitters is asynchronous, this condition will manifest on the C&Di console as the disappearance and re-emergence of some emitters, followed by the disappearance and re-emergence of other emitters in a seemingly random pattern.

27. If this occurs, a reduction in transmission from ownship emitters in the affected band is the only remedy.

Reflections

28. Reflections may occur from large reflective surfaces, such as land masses, the sea surface, other ships or even the structure of own ship. The ES system cannot deal with reflections caused by reflective surfaces other than those caused by own ship. These are dealt with by setting multipath rejection values. These specify time intervals after the receipt of a pulse during which further received pulses, assumed to be reflections, are ignored by the system. Multipath rejection values are operator selectable.

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Chapter 9. Electro-Optical System

Reference: ABR 6341
ABR 6511
ABR 6509

General

1. The RADAMEC 2500 Electro Optical Tracking System (EOTS) is used as a primary sensor for short to medium range detection, tracking, classification and identification of surface craft, aircraft, floating mines, swimmers or saboteurs, missiles or missile launch, submarine snorts or wakes, surface navigation hazards and navigation marks.

2. Other uses may include battle damage assessment, search and rescue, night time Man Overboard, station keeping during in company operations, a means of confirming range safety during weapon practice firing, the monitoring of personnel during boarding operations and in harbour surveillance.

System Inputs

3. EOTS requires the following inputs from the ship and combat system:

a. 115V 1ϕ 60 & 400Hz

b. GPS data

c. Gyro data:

(1) Heading (Cqo)

(2) Pitch (Eio)

(3) Roll (Zdo)

(4) Vertical Reference Unit (Gyro) valid indication.

System Outputs

4. The following outputs are provided by the EOTS:

a. Daylight TV Video

b. Infra-Red Video

c. Fire Control data to the TDT interface:

(1) director train

(2) director elevation

(3) laser range

(4) on target indication

(5) fire indication.

Major Components

5. The major components that constitute the Radamec EOTS system are outlined below.

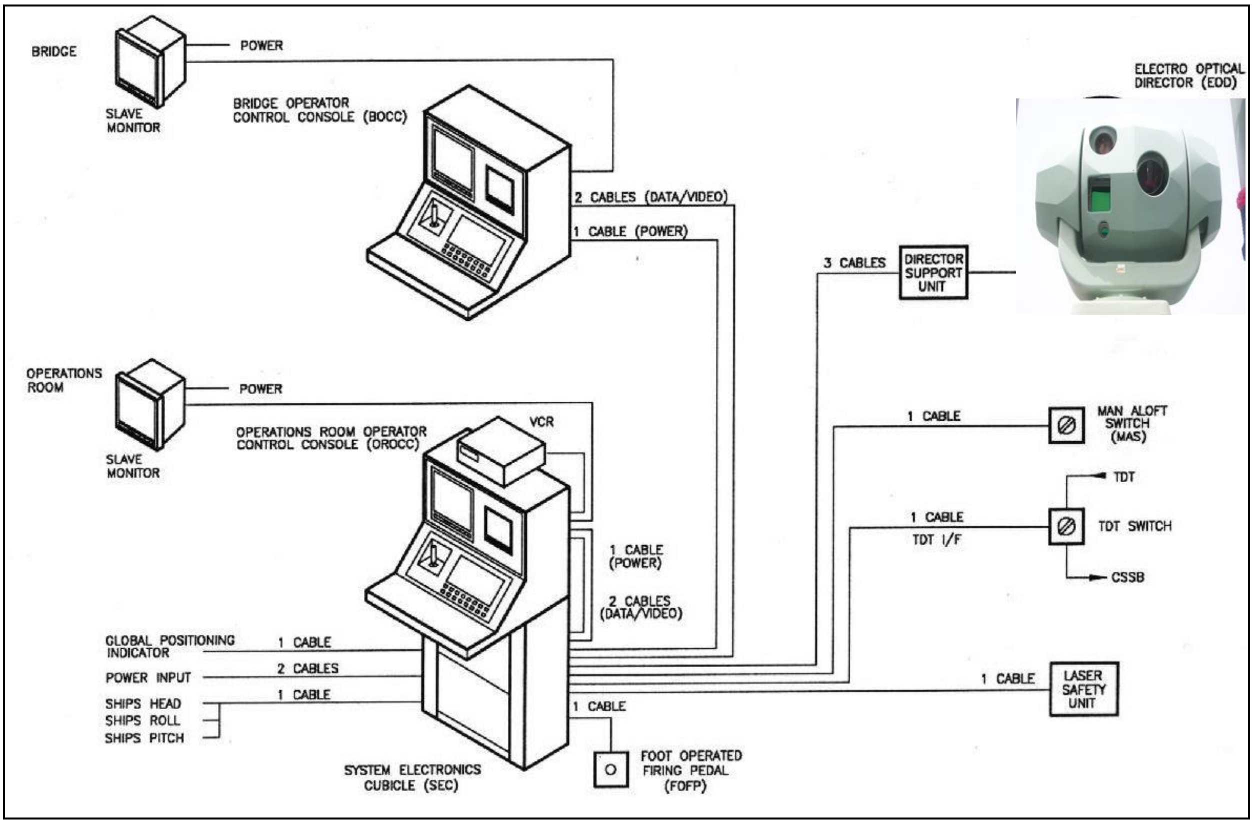

Figure 9-1: EOTS Major Components

6. **Electro Optical Director (EOD).** The EOD is a two axis stabilised director mounted on the bridge top featuring a reduced radar cross section fairing. Mounted on the director are:

a. Radamec HK202 High Resolution Monochromatic TV Camera featuring:

(1) variable zoom lens:

(a) 10:1 zoom

(b) 21. to 21° field of view

(2) High Resolution CCD

(a) 1000 x 576 pixels

(b) anti-blooming

(3) Automatic Iris

(a) Operates from twilight to sunlight

(b) 10 lux to 10^5 lux

b. BAeA 3-5 micron Thermal Imager featuring:

(1) 640 x 486 PtSi Staring Array Detector

(2) Stirling cycle cooler

(3) 12° x 9° or 3.2° x 2.3° surveillance fields of view

(4) 40° x 30° navigational field of view

(5) electronic 2X or 4X zoom

c. BAE Ranger-600 Eye Safe Laser Range Finder featuring:

(1) single shot, 1 Hz (Class 1) or 10Hz (Class 3R)

(2) ±5m accuracy

(3) 0m eye safe for naked eye in single shot or 1 Hz mode

(4) some restrictions for enhanced optical devices (eg binoculars) in 10 Hz Mode (refer to EOTS Laser Safety Paper)

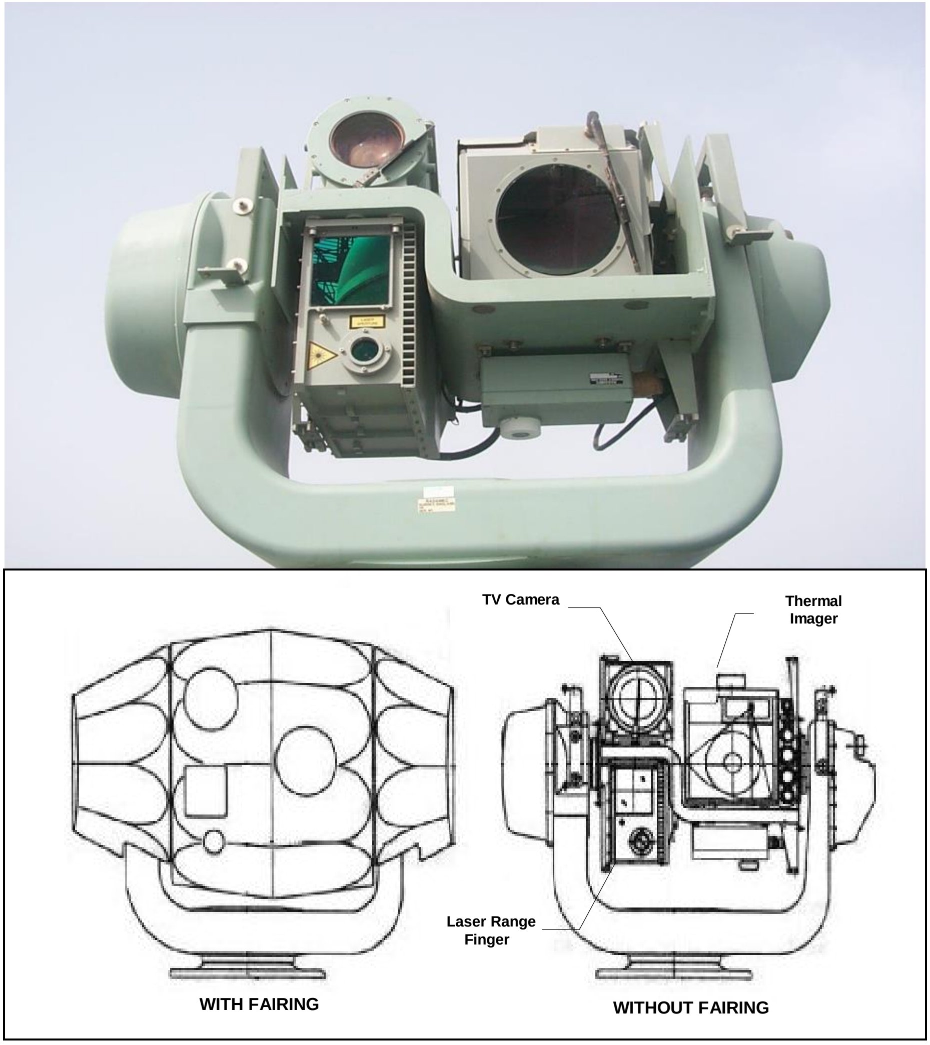

Figure 9-2: Electro-Optical Director

7. **Director Support Unit** (DSU). The DSU contains control logic and power supplies including director motor drive amplifiers, director stabilisation controller and sensor AC-DC power converters. It is mounted on port forward deckhead of the bridge.

8. **Servo Electronics Cubicle** (SEC). The SEC contains power supplies, processing equipment, command support to the director and interface electronics. It is located in the port aft corner of the Ops Room.

9. **Operator Control Console** (OCC). The OCC contains a 14” & a 9” inch monitor, a touch sensitive display, joystick and associated control electronics. There will be two OCCs, one in the Ops Room mounted on top of the SEC and one on the Bridge mounted in the port aft corner. The Bridge OCC differs in layout (it is modularised to fit the available space) and does not have a firing pedal. The firing pedal is used for the current primitive EOTS integration that allows it to be switched in place of the port TDT allowing Direct Optical (DO) or Emergency Optical (EO) modes of operation only.

10. **Video Cassette Recorder** (VCR). The VCR is a remotely operated S-VHS standard VCR used for recording of EOTS picture. It mounts on top of the OCC in the Ops Room.

11. **Man Aloft Switch**. The Man Aloft Switch is a key operated switch, mounted adjacent to the Bridge OCC, that when activated:

a. prevents the Laser range finder from firing; and

b. prevents the EOD platform from moving, by disabling the motor drives and engaging the brakes.

12. **Laser Stopfire Reset Unit** (LSRU). The LSRU is a lockable push button switch that disables the Laser range finder from firing when depressed. It is mounted adjacent to the Bridge OCC.

13. **Bridge Slave Monitor**. The Bridge Slave Monitor displays the same image as Bridge OCC 14” monitor. It is mounted on the fwd deckhead of the bridge.

14. Operations Room Slave Monitor. The Operations Room Slave Monitor displays the same image as the Ops Room OCC 14” monitor. It is located adjacent to the AWO MFD.

Operation

15. Operator options for searching and tracking include:

a. Search Patterns:

(1) Sector Scan

(2) Sector & Elevation Scan

(3) Manual (joystick)

b. Tracking Methods:

(1) Centroid Mode (typically for anti-aircraft mode)

(2) Correlation Mode (typically for anti-surface mode)

(3) Edge Tracking (typically for anti-missile mode)

16. EOTS is capable of tracking/indicating more than one target at a time as long as the targets are all in the sensors field of view.

ADACS Interface

17. Upon initialisation of the EOTS Interface the ADACS software assumes complete control of the EOTS director. No local control is available to the operator. ADACS provides the EOTS with the following control data:

a. Mode Control: Change the EOTS operational mode.

b. Parameter Control: Change the EOTS Parameter data, including Scan limits, tilt, range, elevation etc.

c. Sensor Control: Control the sensor and Intelligent Digital Tracker (IDT), including Laser operation, IDT control, IR and TV control etc.

18. Conversely EOTS provides ADACS with the Mode, Parameter and Sensor tell backs, as well as Ship and Tracking Data.

19. ADACS communicates with the EOTS via two full duplex RS-485 serial interfaces residing on each ADS Server. Both ADS Servers are connected to the EOTS in parallel, via the Combat System Junction Box, using another RS-422 serial link. Although RS-485 allows full duplex communications, it is only utilized as half duplex on the EOTS-ADACS interface. As with most interfaces to ADACS there is dual redundancy through connection to both ADS servers.

20. The Predictor Interface uses a unidirectional RS-422 serial connection to communicate directly with the WCP control system, and as such is not used by ADACS.

21. When ADACS does not have control over the EOTS, ADACS will highlight and de-highlight VABS relating to EOTS control accordingly to reflect the current state of EOTS even though the operator cannot activate/de-activate those VABs, except for Investigate, EOTS Sector Search and EOTS 360 Search VABs.

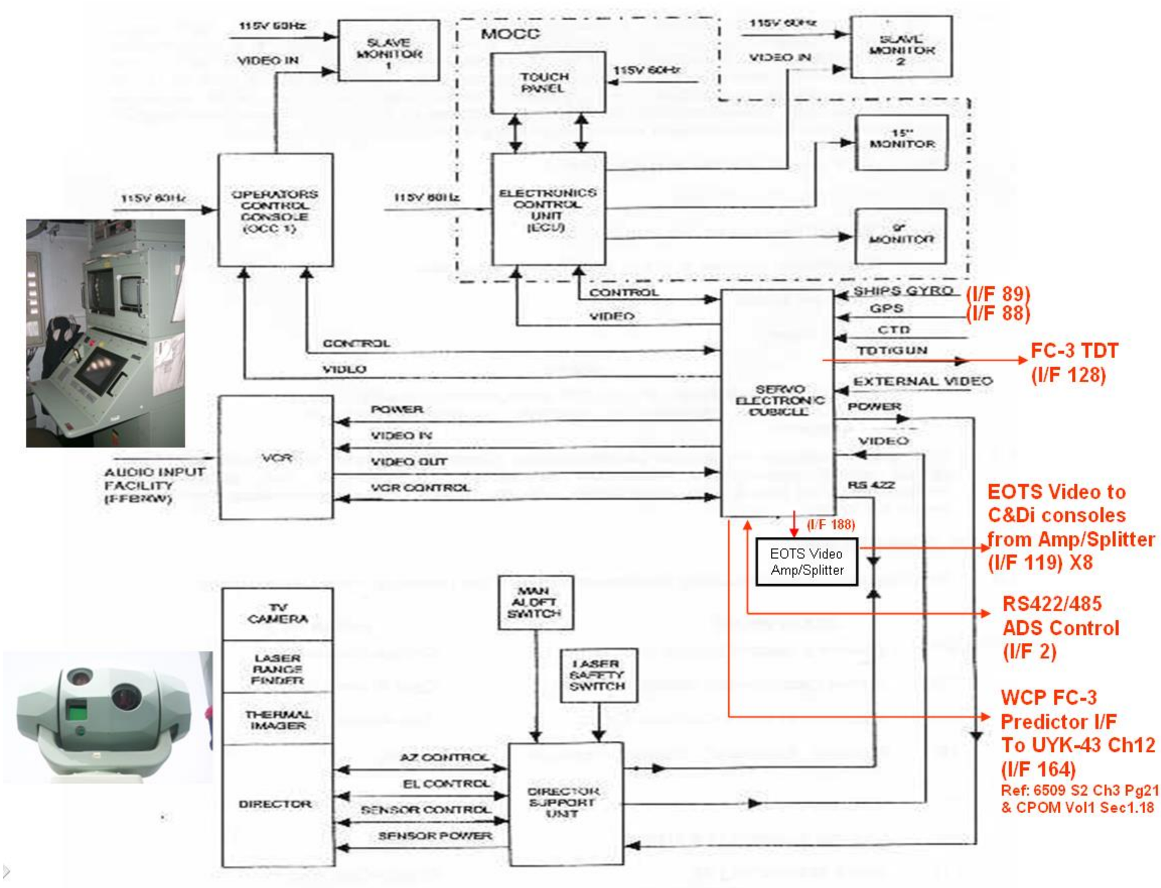

Figure 9-3: EOTS Block Diagram

FC-3 Gun Engagement

- (Ref: ABR6509 Section 2, Chapter 3, pg 20 & 21)
- (Ref: WCP CPOM Vol1 Ch 1.18)

22. FC-3 can be designated from either the AWO role or WCC1 console. The operator must either hook a vehicular track, bearing line or enable and position the Ball Tab on the MDA before selecting the “Designate FC-3” VAB (or “Optical Desig” pushbutton on WCC1).

23. When the EOTS is auto-tracking, FC-3 processing will be initiated in WCP. To engage an air or surface target, the gun can be assigned to FC-3 either by the AWO ("Engage Gun" VAB), or manually by the WCC (FC 4/5) operator. Engagements proceed as per gun engagements using the radar fire control channels. The gun fire control solution corrects for ammunition ballistics and parallax errors between the EOTS and the Mk75 gun. Gun fire is performed by the WCC operator using the FC-5 Gun Fire button. For surface engagements, splash corrections are provided via TOTE entry. To prevent EOTS from jumping track during a surface engagement (e.g. from round splash), WCP will issue a manual 'Hold Rates' order if C2 is in control and a High Speed Manoeuvring Surface Target (HSMST) mode has not been selected. Otherwise the EOTS operator will need to set hold rates manually. The gun engagement is terminated by either the AWO selecting the 'Break Engage Gun' VAB or the WCC operator manually releasing the gun. Command can also exercise 'Hold Fire' of 'Cease Fire'.

24. When using FC-3 to fire the Mk75 Gun, operators should be cognisant of the EOTS Laser Safe To Fire Zone (LSTFZ) relative to the gun Safe To Fire Zone (STFZ). Like CAS (FC1), EOTS (FC3) is forward of the main mast, whereas the gun is aft of the main mast. This precludes firing directly forward and aft. However EOTS has the added limitation of being situated between the two forward HF receive whip antennas, which impacts on the ability to fire the gun around 090 and 270 degrees relative to ships head. This can be seen in the diagram over the page which maps the EOTS LSTFZ over the Mk75 Gun STFZ.

25. The casualty Gun engagement mode is 'Emergency Optical' mode. In this mode the Mk75 gun is assigned to the TDT controller. The selected TDT provides bearing and elevation pointing orders to the gun. The port and starboard TDTs include an On Target pushbutton and gun fire button. The EOTS also has a TDT emulation capability and can be selected as a TDT source for Emergency Optical. Whilst EOTS provides stable auto-tracking of targets, the resultant Emergency Optical mode does not correct for parallax or ammunition ballistics. Firing of the gun is performed by the TDT or EOTS operator. This mode of operation is a casualty mode of operation (e.g. if the UYK-43 is not functional).

Casualty Modes

26. The EOTS has minimal casualty modes:

a. In the event of a display casualty, redundancy is available in the form of the alternate operator console.

b. If ship's gyro information is lost the vertical reference information will have the most effect. Searching for targets will be more difficult because of the lack of stabilisation but once lock-on is achieved tracking will be unaffected.

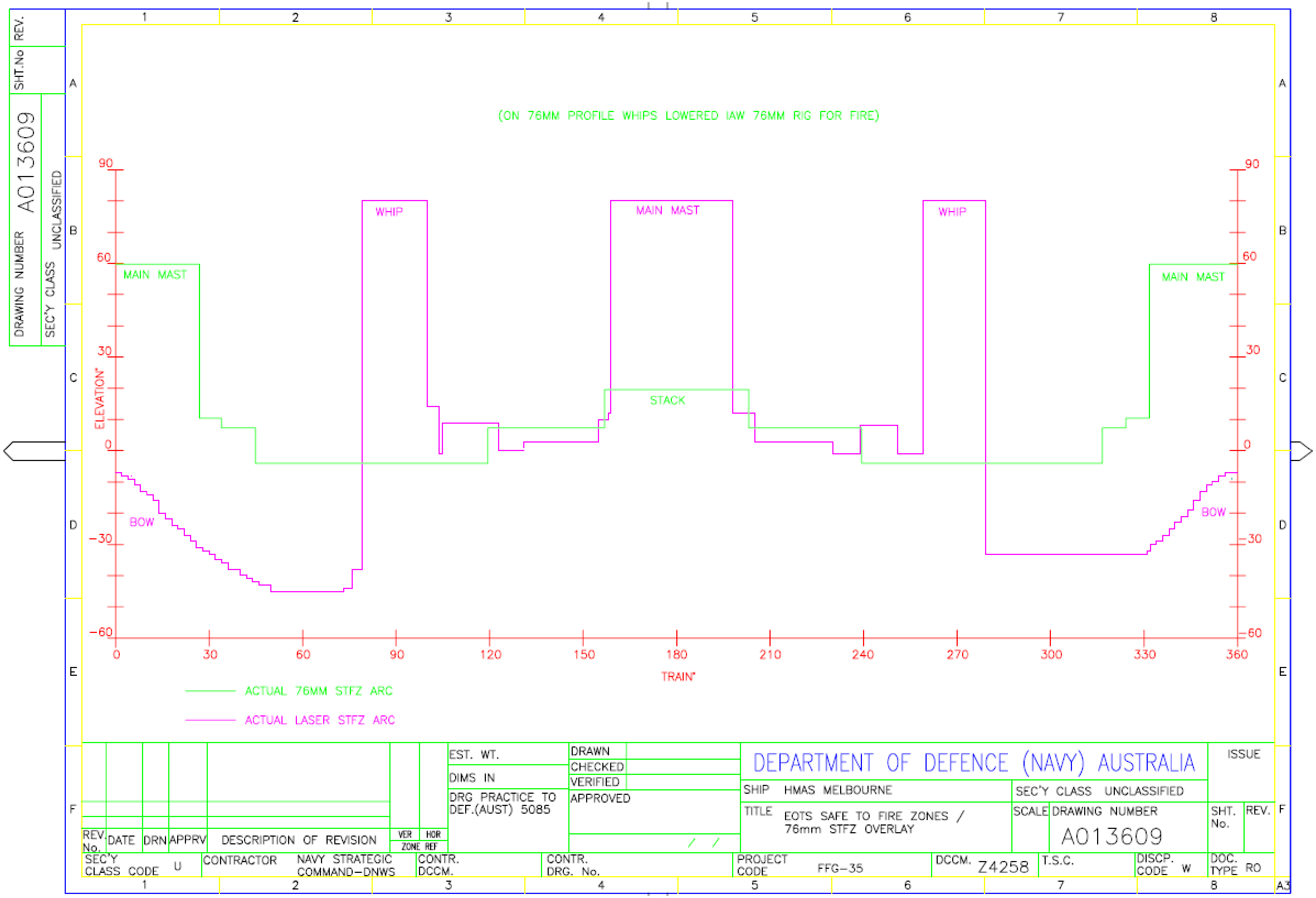

Figure 9-4: Firing Arcs for Gun from FC-3

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Chapter 10. Under Water (Sonar) Sensors

Reference: ABR 6522 Underwater Warfare System Operator Manual

Underwater Warfare System (UWS) - General

1. The UWS is an integrated underwater system providing passive torpedo defence, active and passive Anti Submarine Warfare (ASW), and active mine avoidance capability. The UWS is comprised of the following major subsystems:

   a. Hull Mounted Sonar (HMS),

   b. Torpedo Defence Sonar (TDS),

   c. Mine and Obstacle Avoidance Sonar (MOAS),

   d. UWS Sonar Operating Console (SOC),

   e. Remote Control Unit (RCU), and

   f. On board Trainer (OBT).

2. The UWS has two operational interface units:

   a. The Sonar Operating Console (SOC) is located in the Sonar Control Room (SCR) and is used for passive torpedo defence, active/passive ASW, Performance Monitoring and Fault Localisation (PMFL) function and the Built In Test Equipment (BITE).

   b. The Bridge Display Unit (BDU) is located on the Bridge and used for MOAS operation and MOAS BITE.

3. The UWS operational function requires only three principal operators as follows:

   a. The OOW is the primary MOAS operator and controls all manoeuvres for navigation avoidance.

   b. The PWO is responsible for torpedo defence reaction and/or ASW tactics.

   c. A CSO (UW) is the SOC operator for Torpedo Defence, ASW and UWS PMFL.

4. The UWS provides panoramic coverage for passive torpedo detection, classification and localisation by fusion of passive broadband and narrowband data from the TDS and HMS. Automated Detection, Classification, Localisation, Tracking and Reaction (ADCLTR), capability combined with prioritised automated display hierarchy and automated alarms lowers operational burden and reduces false alarms during littoral operations in shallow and noisy coastal waters. The TDS also allows continued tracking of incoming threats during torpedo avoidance manoeuvres.

System Inputs

5. UWS requires the following inputs from the ship:

   a. 440V 60Hz 3ϕ

   b. 115V 60Hz 3ϕ

   c. Ships LP Air

   d. Chilled Water supply

   e. Own Ship's Heading (Cqo)

   f. Own Ship's Speed (DMho)

System Outputs & ADACS Interface

6. The following outputs are provided to the combat system LAN by two high speed Ethernet links termed to ADACS Link 1 (ADACS1) and ADACS Link 2 (ADACS2). These two ADACS links use the UDP/IP broadcast protocol and provide 100% redundancy, with both conveying identical information as follows:

a. The ADACS sends ADACS states and modes information, navigation data, time information, the ADACS short range tactical situation and track management data (real or simulated), as required to the SOC.

b. The SOC sends PMFL status and UWS configuration messages, UWS track data, and alert and alarm information, including the TDS reaction advice, to the ADACS as required.

c. When the UWS is in replay mode, no messages are sent by the SOC to ADACS, except UWS configuration and PMFL status messages. In replay mode, the ADACS functions in the same manner as in Tactical.

Location of Assemblies

7. The following major UWS assemblies are located on the keel between frames 40 and 63:

a. HMS Transducer

b. Sonar RAYCOR/Rubber Dome

8. The following major UWS assemblies are located in the Sonar Equipment Room (Compartment 4-32-0-Q):

a. HMS EC

b. HMS TSCU

c. HMS PU

d. TDS EC

e. MOAS EC

9. The following major UWS assemblies are located in the Sonar Control Room:

a. SOC

b. RCU

SYSTEM OPERATION

10. The HMS, TDS and MOAS are completely independent, but can also operate together:

a. The functional interfaces between the HMS, TDS and MOAS have been designed to minimise the need for interactions between them, and particularly to limit perturbations caused by HMS active transmissions on other sonars. This limitation is carried out by TX_pulse synchronisation data sent to the TDS and MOAS when HMS starts transmitting.

b. The TDS has been designed to operate in a fully automatic configuration, where TDS tasks are performed in the background during normal ASW operations. The TDS results are sent to the SOC, where the data is stored. When a threat is detected, the TDS generates an alarm that is sent to both the SOC and the Combat System. Regardless of operator response, the TDS continues processing in the background, however, the sonar operator can switch between HMS and TDS related displays without disrupting TDS or HMS operation.

c. The MOAS uses a dedicated display unit on the bridge, and needs only minimum SOC resources to operate. Specifically, the SOC has the capability to send deploy, retract and EMCON commands to the MOAS. As with the TDS, the MOAS can be operated with minimal operator interaction and with a low probability of false alarms. When a mine or obstacle is detected and then confirmed by the bridge operator (or after a time out), an alarm is generated and sent to both the Combat System and the operator at the SOC.

d. Due to the high frequency of operation used by the MOAS, there is no acoustic interference between the MOAS and the other two sonars (HMS and TDS). However, during ASW activities and when potential mechanical interference due to high sound pressure levels occur, the MOAS array can be retracted. In addition, transmit parameters can be set to cope with any possible dual transmit pulse configuration problem.

Sonar Operator Console (SOC)

Figure 10-1: Sonar Operator Console (SOC)

11. SOC Hardware – The SOC provides the displays and controls necessary to monitor and manage the status of the UWS subsystems. The SOC also provides support for Command assessment of threats (e.g. classification of threats) as reported by HMS, MOAS and TDS. The SOC access and security controls restrict access to the HMI, using operator identification and password required to login. Access to the HDD module is restricted, which can be locked in the SOC or removed for storage in a safe.

12. The SOC performs audio signal multiplexing and distribution with analogue audio signals received from the HMS and TDS. The SOC multiplexes the two audio channel inputs, from TDS and HMS to provide two separate audio outputs, each containing left and right channels to the headphones sockets. Each audio output is provided with volume and balance controls. The same audio signals are connected to both headphones. An additional audio output on the SOC console connector panel allows connection to an external recorder for audio recording purposes and two external loudspeakers.

13. The UWS SOC operator is able to control the following audio parameters:

a. beam type, or hydrophone/transducer (selectable from PMFL display only);

b. audio gain, through the keyboard (audio being hardware driven);

c. frequency bandwidth (filtering bounds);

d. steering mode (on track, on bearing) and associated audio bearing; and

e. track number (when hooked to a track).

14. SOC_OBTS Link – The OBTS is connected to the UWS SOC by one high speed Ethernet link, using the TCP/IP protocol. When the UWS is in the Training state, the SOC receives MOAS training track messages from the OBTS.

UWS STATES AND MODES

15. The following states and modes apply to the UWS:

a. Off – The UWS is in the Off state when powered down.

b. Initialisation - The UWS is in the Initialisation state during boot up, immediately after power is applied to the system.

c. Tactical – The UWS defaults to the Tactical state after power up and initialisation. When in the Tactical state, no training simulation is carried out on UWS sensors.

d. Training – The Training state applies only to the TDS and HMS, when the SOC is in communication with ADACS. MOAS remains in the Tactical state. The HMA and TA Training modes are as follows:

i. Mixed Mode. Acoustic data is received from the HMA and TA, synthetic targets are received from the OBT, and simulated MOAS tracks are received from the OBTS. Equivalent to OBTS Live-over-Sim mode.

ii. Substitute Mode. Acoustic data is fully provided by the OBT and simulated MOAS tracks are received from the OBTS. Equivalent to OBTS Sim-only mode.

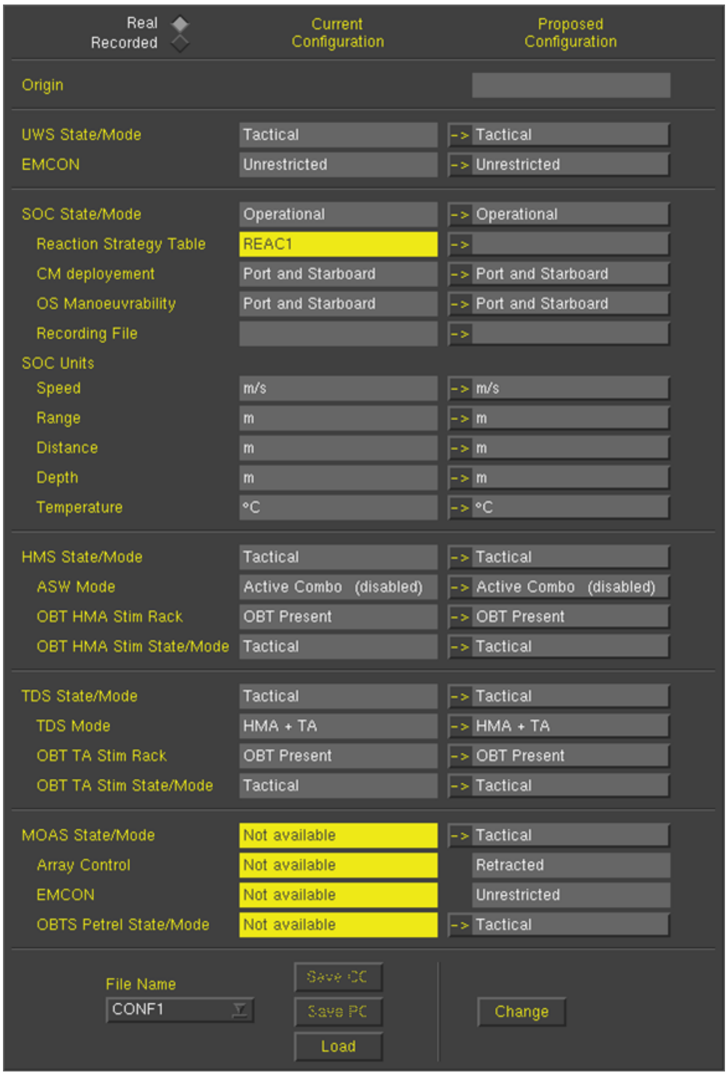

Figure 10-2: SOC Mode Selection page

SUBSYSTEM STATES AND MODES

16. The ‘Maintenance Test’ and ‘Maintenance Support’ states apply to all UWS subsystems and are used for off-line testing by maintainers:

a. Test Mode – All systems are off-line tested in a non-operational state and the system is automatically rebooted and starts back in its operational state. Mode most commonly used by maintainers.

b. Support Mode – All systems are off-line and in a non-operational state for file maintenance and housekeeping purposes. A manual reboot is required. This mode is usually used during Depot Level maintenance.

17. ‘Replay’ state is selected from the SOC State/Mode drop down box. In this state, the SOC is playing back recorded data in a stand-alone configuration. Only current PMFL, configuration and navigational data messages are distributed. The SOC neither displays nor records messages received from the sonar subsystems and ADS.

Torpedo Threat Levels

18. Threat levels for potential torpedoes are assessed and handled by the UWS as follows:

a. The UWS uses three torpedo threat levels:

i. **Normal** no threat has been detected;

ii. **Alert** a threat has been detected but unconfirmed (under threat assessment); and

iii. **Alarm** a threat has been assessed as a potential torpedo.

b. b. Threat levels are triggered in the Torpedo alert functions and passed to the Reaction capability in the SOC.

c. The classification of a contact as a potential threat triggers the transition from 'Threat Normal' to Threat Alert', and assigns a dedicated track designator to the threat track.

d. When no further threats have been identified, the UWS automatically transitions to 'Threat Normal'.

e. The transition from 'Threat Alert' to 'Threat Alarm' occurs when the threat is automatically classified as a potential torpedo or the operator has decided to 'Confirm' that the threat is a torpedo.

f. The transition from 'Threat Alarm' back to 'Threat Normal' occurs when no other threat has been prosecuted and the assumed torpedo is classified as a non torpedo threat, or the operator has manually classified the threat as 'Not Torp'.

g. The UWS automatically reverts to 'Threat Alert' upon confirmation that there are no potential threats, i.e. the threats have already been rejected by the classification process due to a torpedo false alarm or an operator’s 'Not Torp' on automatic classification. However, there is at least one contact remaining threat under assessment.

SYSTEM TRACK NOMENCLATURE

19. All UWS tracks are allocated sensor identification and a track number, a four digit integer. System tracks use two nomenclatures for identifying tracks, Sonar Track Numbers (STNs) or Common Track Store Locator (CTSL). The STN allows ADACS to assess the UWS processing chain that has detected and is prosecuting the contact.

20. The System Track database will compile all the information and update each track with all the information coming from the Combat System, SOC and sensors. The track types are identified as follows:

a. STN - There are two types of STN tracks:

i. Unlocalised Tracks. Unlocalised tracks are identified by a sonar array identifier, i.e. HMA for Hull Mounted Array, TA for Towed Array or MOA for MOAS, followed by a unique four digit integer, e.g. HMAxxxx and TAzzzz.

ii. Localised Tracks. Localised tracks occur when the localisation process has used data from both the Hull Mounted Array (HMA) and Towed Array (TA) to locate the target. In the waterfall plots the Main (Leading Sonar) track is identified by a capitalised identifier, e.g. TDSyyyy, and retains the same integer as when an unlocalised track. Also in the waterfall plots, the Secondary track is identified by a lower case identifier, e.g. tdsyyyy, followed by the same integer as the Main track. Also only the Main track is shown in the Tactical Plot on the SOC.

b. CTSL – The CTSL tracks, generated by ADACS, are identified by six ASCII characters containing the letters CS for Combat System, followed by a four digit integer, i.e. CSuuuu. Note that the integer is not related to any of the unlocalised or localised track integer numbers, but is generated by ADACS. This allows unambiguous track numbering and identification across the overall FFG Combat System.

ON BOARD TRAINER

21. To conduct on board training activities, either at sea or alongside, both the HMS and TDS may be operated in three different configurations:

a. real data processing, the nominal mode, where the sonar inputs are actual sea data;

b. simulated data where the real inputs are substituted by sonar stimuli; and

c. mixed data where simulated target data is mixed with real sea environment data.

22. The UWS is interfaced with the Combat System OBTS which generates the system commands to switch from one training mode to another, and provides the appropriate Navigation information.

Remote Control Unit

23. The RCU remotely activates or deactivates each of the sonar subsystem (i.e. the HMS, TDS and MOAS) from the sonar control room. The RCU is also used to enable or disable the HMA transmit function and the HV DC supply for the TA streamer.

Hull Mounted Sonar (HMS)

24. The HMS detects, localises and classifies submarines using active transmissions, and provides information for ownship protection against incoming torpedoes by means of passive processing to detect, track and automatically alert the operator.

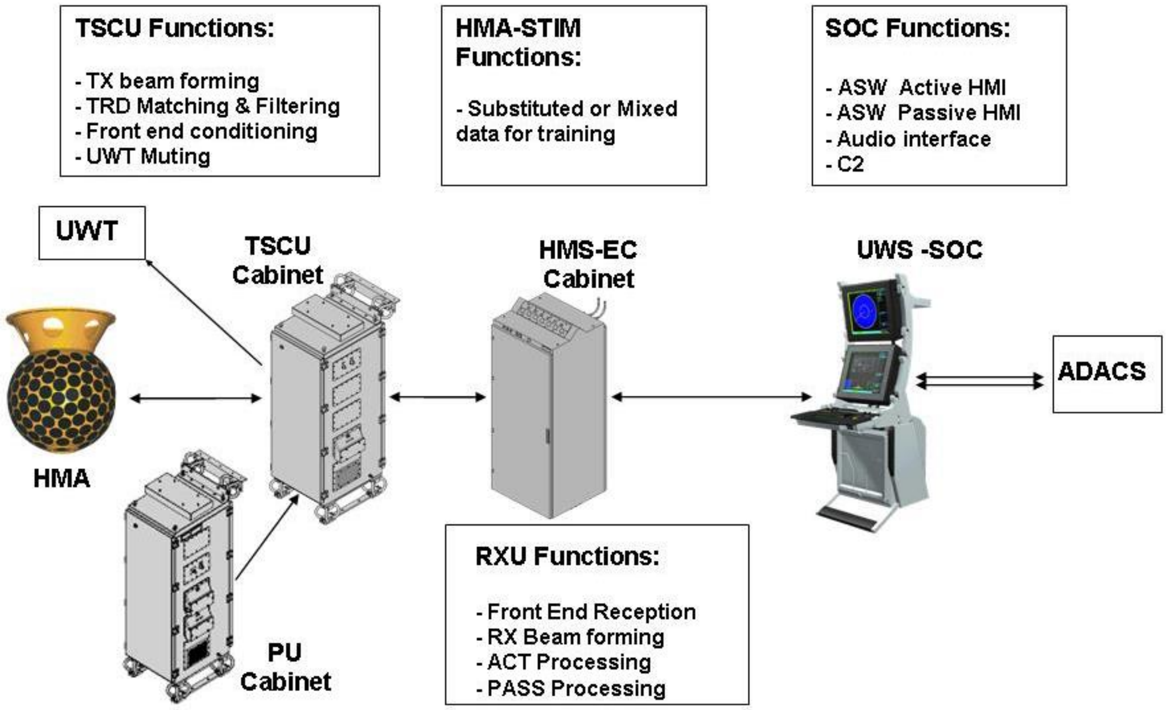

Figure 10-3: HMS Functional Interfaces

Function

25. The main functions of the HMS are:

a. simultaneous operation in two active modes and one passive mode;

b. simultaneous automatic tracking of active and passive targets;

c. omni-directional performance in active and passive modes for early initial detection;

d. directional active modes for increased detection range;

e. electronic stabilisation of the beams both in transmission and reception, independently of own ship's movement;

f. FM active transmissions for accurate range and bearing indication;

g. CW Active transmissions for Doppler detection in high reverberation operation;

h. passive broadband and narrowband detection and tracking of torpedoes;

HMS – Modes of Operation

26. In the tactical state, the HMS functions in the following modes:

a. Passive mode – a receive only function where active transmissions are either not permitted or not required

b. FM – a transmit and receive function whereby the transmitted pulses are frequency modulated. The torpedo alert function is operable in this mode. FM is usually the main search mode as it is better at detecting stationary and low/medium radial speed targets.

c. CW – an active function using continuous wave (CW) pulses. This mode is preferred for detecting medium/high radial speed targets but is ineffective in detecting stationary or stationary relative to Ship's movement targets.

d. Combo – An active function which alternates between FM and CW pulses in consecutive transmissions. This mode should be limited to assisting the operator in track classification and to determining which Tx mode is preferable

HMS – Transmission Types

27. The following transmission types are associated with the above modes of operation:

a. Omni-directional (Omni) – provides a 360 degree sonar coverage. This is the general surveillance mode for the sonar.

b. Directional – this transmission provides a single conical beam that contains high transmit energy and is used when tracking a single target in a smaller more specific area of ensonification.

c. Sectorial – provides a choice of two sectorial coverage angles (90° or 120°) and is used when tracking or operating in confined waters. The sectorial modes can also be selected to avoid interference from ships in company, or when close to land or interfering objects.

d. Triple Rotating Directional Transmission (TRDT) – uses three directional beams for each transmission. 12 separate transmissions are required to achieve 360 degree coverage. Each transmission realises an increase of approximately 10dB over an Omni power transmission. TRDT is used to enhance long range detection capabilities. Disadvantages of TRDT are that targets within 2.7km from ownship will not be detected due to the long 3.6 second transmission period. Also, the received audio does not correspond to the picture as three to four echoes are heard instead of one and finally, if there are two targets in close proximity on a similar bearing, it is difficult for the processing to discriminate between the two.

e. Maintain Close Contact (MCC) – this transmission enables the tracking of a target in deep water while at close range. MCC achieves this by doubling the beam aperture, while applying a fixed tilt angle to the beam. Selection of MCC will reduce the source power level by approximately 6dB.

Hull Mounted Array (HMA)

28. The main function of the HMA is to support the transducer elements and to efficiently act as the sonar system's acoustic antenna. The HMA is housed in a flexible Rho-Cor dome, which is filled with filtered seawater and maintained at a positive pressure. A sonar baffle is included in the dome for the attenuation of own-ship propeller noise and UWT crosstalk. The Hull Mounted Array consists of 160 identical transducer elements spaced around a cast bronze sphere. The transducers are distributed around the sphere in a pattern designed to ensure even coverage and minimise the effects of failures within the transmission electronics. The unique characteristic of the spherical HMA allows consistent operation and performance in rough seas, providing a significant advantage over unstabilised arrays. Theoretically, the spherical shape allows a consistent beam pattern to be maintained regardless of the roll and pitch angles.

Transceiver and Control Unit (TSCU) Cabinet

29. The TSCU cabinet performs the active transmission function for the HMS and acts as an interface between the transducer elements in the HMA and the receiver rack in the HMS EC. Navigation parameters are used by the TSCU cabinet to electronically stabilise the beamformed transmissions, independent of the vessel's motion. The reception, front end conditioning and transfer of data from all channels to the HMS EC is performed continuously in both the active and passive modes. When the 'Safe to Transmit' key is enabled, high voltage Tx pulses for the transmitters in the TSCU cabinet are provided by the PU cabinet. The TSCU cabinet controls Tx pulses from twenty HD8 PCB assemblies through Tx/Rx matching circuits on twenty TDM8 PCB assemblies to the transducers in the HMA. Beam and Tx mode control of the TX pulses is based on parameters in control data received on a 100 Mbits/s Ethernet command/status link from the RXU in the HMS EC. The TSCU cabinet also sends a Tx enable (TXEN) signal, synchronised with each transmission, to the HMS EC.

Power Unit (PU) Cabinet

30. The PU cabinet provides synchronised 0 V to 270 VDC Tx pulses to transmitter power amplifiers in the TSCU cabinet when the HMS is in an active mode. Each high voltage pulse from the PU cabinet is synchronised by a sync signal received from the TSCU cabinet. The peak voltage and amplitude versus time profile is controlled via commands received on a 100 Mbits/s Ethernet control link from the TSCU cabinet. The PU cabinet sends status information to the HMS EC on the control link, via the data switch assembly in the TSCU cabinet. A dome pressure signal from a pressure sensor in the HMA dome is monitored by the PU cabinet. If the dome pressure falls below one bar, relative to the external water pressure, the 0 V to 270 VDC Tx pulse to the TSCU cabinet is reduced to protect the HMA transducers from damage. The transducers can be damaged by transmitting when the water pressure is insufficient to provide adequate load.

HMS – Electronics Cabinet

31. In active modes, the HMS EC provides an interface between the HMI in the SOC and the TSCU cabinet, and between the TSCU cabinet and other subsystems, i.e. TDS, MOAS and UWT. The blanking signal (TXEN) is output from the HMS EC cabinet to the UWT, TDS and MOAS, and while muting signals are being received from the UWT, the HMS EC will command the TSCU cabinet to stop transmitting. The HMS-EC receiver control unit (RXU) is also responsible for beam and mode control for transmitted pulses, front end reception, digital signal and audio processing.

Torpedo Defence System (TDS)

32. TDS incorporates torpedo detection, classification and localisation processing with a multi-sensor element that takes data from the Hull Mounted Array (HMA) and a Towed Array (TA) streamer and associates this data to form TDS tracks.

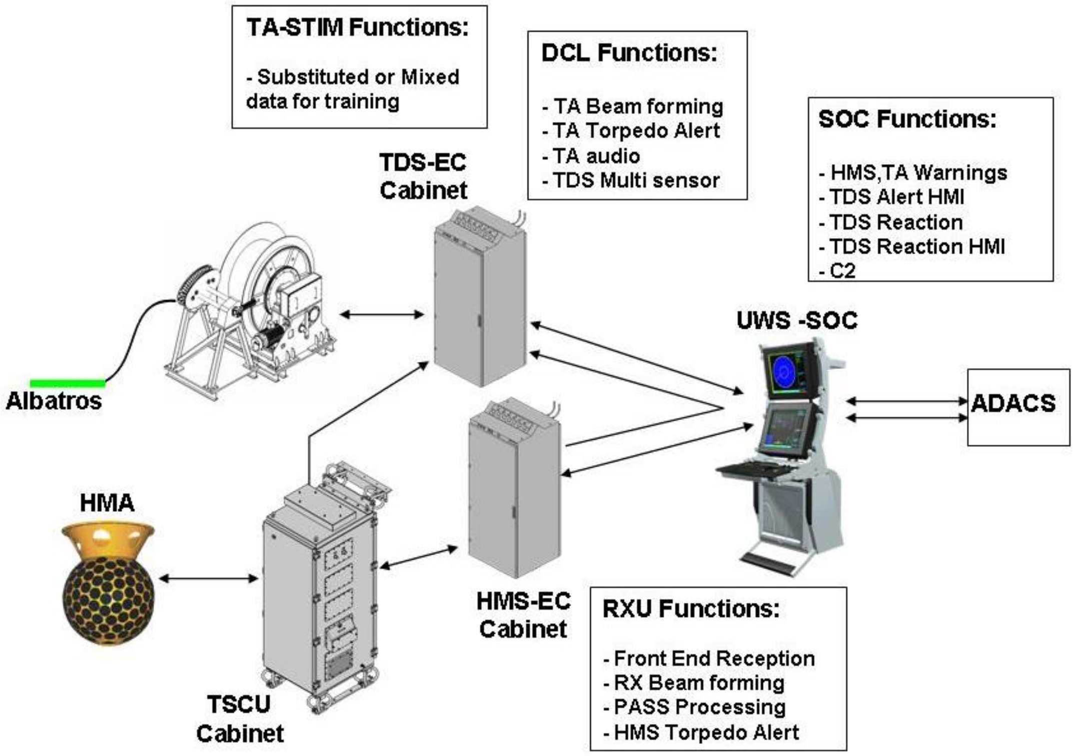

Figure 10-4: TDS Functional Interfaces

TDS – Modes of Operation

33. The default state for TDS is the Tactical state. Within this state there are three individual modes available:

a. TA + HMA Mode – This is the fully functional mode, with torpedo detection data received from both the towed array and the hull mounted array passive function. Full torpedo alert functionality is provided;

b. TA Mode – this mode only uses inputs from the towed array and the torpedo alert function is not enabled. Unless the HMS is degraded or unserviceable, there is no advantage in using this mode over TA + HMA mode; and

c. HMA mode – this mode only uses inputs from the HMA passive function and should be used when the towed array can not be or is not streamed. The torpedo alert function is enabled in this mode.

ALBATROS Towed Array

34. The ALBATROS Towed Array is a passive acoustic array that is deployed from the stern of the vessel, isolated from the shipboard machinery and propulsion noise sources in order to improve the chance of torpedo detection. The depth of the array can be set by varying the towing speed, or the length of cable streamed, or both. The towed array consists of the following components:

a. **Tail Rope** – The tail rope provides array stabilisation and contains a temperature sensor, providing readings that are output to a PRTFFG module in the acoustic module.

b. **Acoustic Module** – The acoustic module contains the 32 hydrophone triplets and five non acoustic sensors for detecting the array telemetry. The acoustic data from each hydrophone triplet is amplified and digitised by an A/D converter module, ready for transmission to the processing elements. Two beams are formed from the array; one to port and one to starboard. By comparing the signal to noise ratio of the contact signals in each beam it is easy to identify the side that the contact is on. The digitisation modules receive synchronisation signals from the MSYNC and LSYNC boards and perform pre amplification and A/D conversion. The processed hydrophone data passes to multiplexer circuits that combine data from eight hydrophone triplets into a single data stream. This process is repeated four times to include all 32 triplets of data into the combined array data stream. Internal redundancy of the array ensures that if any internal circuit fails, the impact on the array performance is only minor degradation and not total failure. A roll sensor is fitted at each end of the acoustic module to sense the attitude and the amount of twist in the array. Processing software compensates for the roll and twist, to ensure that the array is always producing true port and starboard beam data. A pressure sensor is used to accurately calculate the array depth. A heading sensor at the head of the tail of the array provides heading information into the array data stream. A temperature sensor in the array tail provides seawater temperature data for use in the array data processing.

c. **Vibration Isolation Module** – The Vibration Isolation Module (VIM) provides an electromechanical interface between the acoustic module and the extension tow cable and ensures array isolation from mechanical vibrations emanating from the towing vessel. The VIM is a fluid filled hollow structure, where helically wound strength members in the wall of the tubing take the towing strain. The electrical conductors follow a spiral path through the middle of the VIM and are not subjected to mechanical tension. The cylindrical VIM body absorbs any vibration or tension.

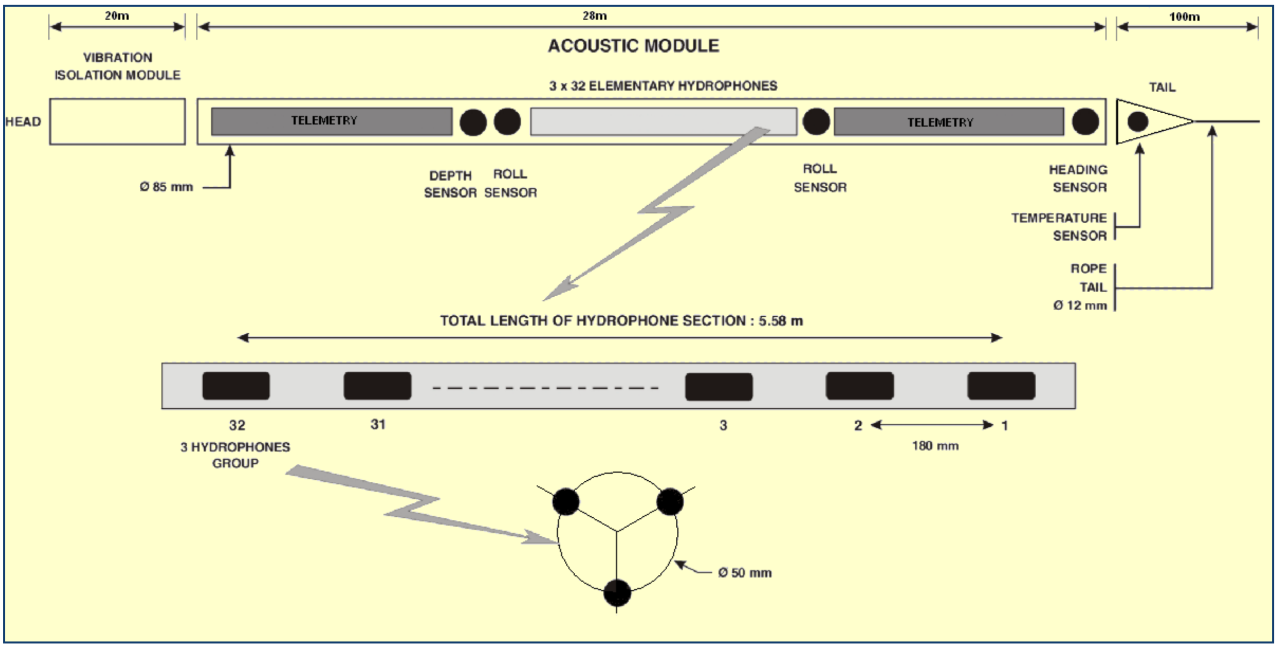

Figure 10-5: Albatross Array Construction

Towing and Handling System (THS)

35. The THS is comprised of the following major subassemblies:

a. **Extension Tow Cable** – The Extension Tow Cable (ETC) is a neutrally buoyant tow cable, designed to interface between the FOTC and the Towed Array. The ETC provides electrical and fibre optic interfaces for the TA and is used to separate the acoustic elements in the towed array from the ship's radiated noise. The head connector is compatible with the FOTC, the tail connector is compatible with the TA VIM. The ETC contains a watertight housing that contains a TAFETOC electrical to optical converter PCB that converts the coaxial array data stream to a fibre optic data stream, for transmission to the array interface unit via the FOTC and winch. Acoustic data from the TAFETOC PCB assembly is transmitted on the fibre optic link to the AIU rack of the TDS EC.

b. **Fibre Optic Tow Cable** – The FOTC is secured to the winch at the forward end. The FOTC has negative buoyancy and is used to depress the ALBATROS towed array to operating depth. The depth of the deployed TA is governed by cable scope and towing speed. The FOTC is also used to transfer array data from the ETC, through the slip ring assembly to the winch terminal block. Five turns of the FOTC remain on the winch drum at all times for mechanical strength and safety.

c. **Winch Assembly** – The winch is used to allow a controlled deployment and recovery of the TA streamer and to stow the TA streamer when not deployed. The winch drum is driven by a spur gear on the pedestal side and is controlled by an operator using a Hand Held Control unit, which sends deployment/recovery commands to the motor controller. The electrical and fibre optic cables are interfaced through a slip ring assembly located inside the drum shaft. The slip ring assembly provides a fibre optic/electrical interface between the FOTC and two deck cables that are used to convey acoustic data to the TDS EC. The Slip Ring Junction Box also contains a limit switch assembly and encoder that are driven by the slip ring assembly, using a toothed belt. The limit switches are enabled by cams and return a closed signal for the HV safety loop when the TA streamer is deployed. The encoder supplies winch drum position and velocity information to the VFD, which requires speed feedback for dynamic braking applications. The encoder information is also supplied to the system controller PLC, which uses the encoder information to calculate cable scope for display on the HHU and to position the levelwind. The winch drum is driven by a reversible electric motor, coupled to a four stage reduction gearbox. The motor has an integral electromechanical brake that is spring activated when motor power is not available and released by an electrical solenoid when motor power is available. A manually operated band brake is fitted around the outside of the drum, which is used as a parking brake when the control system is not in use.

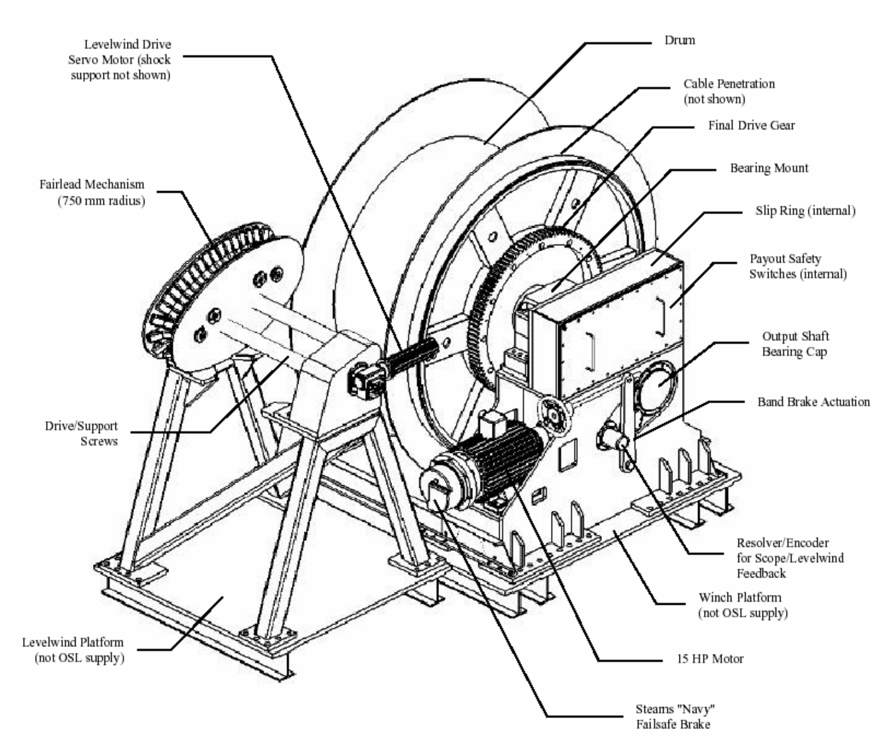

Figure 10-6: Winch Assembly

d. **Levelwind Assembly** – The levelwind is used to correctly position the cable onto the drum during recovery operations, using a series of five limit switches (proximity sensors) to provide positional information of the levelwind assembly. During normal operation, the function of the levelwind is fully automatic, being controlled by the system controller PLC. A joystick on the Hand Held Unit is provided for manual operation of the levelwind.

e. **Harmonic Filter** – The harmonic filter assembly consists of three sets of chokes, and three capacitors and three resistors in an LC configuration. The filter is used to filter harmonics from ship’s lines, preventing interference to control circuits.

f. **Motor Controller** – The Motor Controller (MTR CTR) is the main power unit for the winch system. The MTR CTR is managed by a system controller PLC and Variable Frequency Drive (VFD). The PLC outputs drive signals to the servo amplifier, which will drive the servo motor in the required direction. The enclosure is cooled by the circulation of fan forced air between electronic modules when enabled by a thermal switch set to 38 °C. Ambient air is drawn in through an inlet protected by a wire grill on the lower right-hand side of the enclosure by a 24 VDC fan. Another thermal switch in the enclosure, set to 49 °C, will send an over-temperature message to the HHU when the temperature reaches 49 °C. The brake resistor assembly is used to burn off excess power generated by the winch drive motor during overhauling loads. A motor protection filter is used to suppress noise in the cables between the winch drive motor and the VFD.

g. **Hand Held Unit** - The Hand Held Unit (HHU) is the main operator control console for the winch system. The HHU is used to power on/off the motor controller, switch between automatic and manual modes, adjust deflection range, control the winch and levelwind assemblies in manual mode using joysticks, and perform an emergency stop if required. An LCD panel is used to display tow scope and error messages.

TDS Electronics Cabinet

36. The TDS Electronics Cabinet (TDS – EC) contains the electronic components for processing the acoustic data that has been collected by the wet end components. The electronics cabinet includes Rack 1000 Array Interface Unit (AIU), Rack 2000 Detection, Classification and Localisation (DCL) processing rack and Rack 3000 TA Stimulator, which is part of the On Board Training System (OBTS). Cabinet services are controlled by an Electromechanical Unit (EMU) and the cabinet electronics are cooled by a cooling unit and fan trays. A key switch is fitted to the cabinet front panel that disables the HV supply to the towed array.

MINE OBSTACLE AVOIDANCE SYSTEM (MOAS)

37. MOAS provides the means to localise, process and display detected mines and obstacles in bearing, range and depth. The acoustic array is optimised for use in shallow water, is retracted when not in use and deployed by means of a hoist.

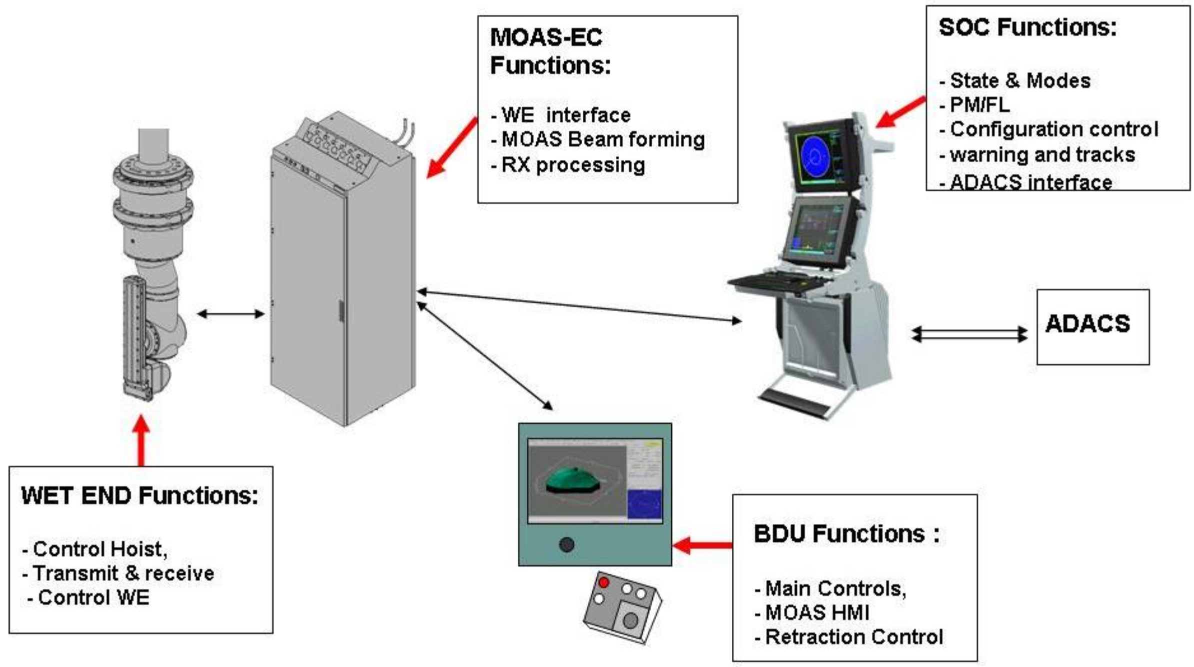

Figure 10-7: MOAS Functional Interfaces

Bridge Display Unit (BDU)

38. The MOAS BDU forms the primary human-machine interface for the MOAS system. The MOAS is designed to be largely autonomous in operation, with contacts being detected automatically and data being passed to the SOC automatically. Operator intervention is only required to classify a contact once detected, or to change operating modes or parameters.

39. The Bridge Display Unit consists of two subassemblies:

a. Processor and Display Unit

b. Control and Indicator Panel.

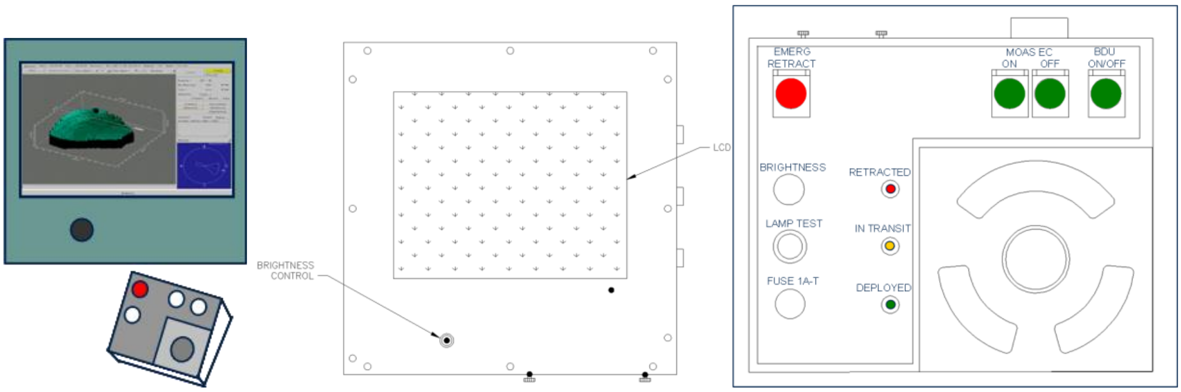

Figure 10-8: MOAS BDU and Control Indicator Panel

40. Commands available on the BDU include:

a. EMCON – indicates the acoustic EMCON status,

b. mode – allows the BDU to be set in either detection or navigation mode (default is navigation)

c. TX – allows the transmit power to be set to Tx Off, Tx Normal or Tx Low (default is Off)

d. state – indicates the MOAS operational state/mode as set from the SOC

e. deploy – deploys the array

f. retract – automatically aligns then retracts the array,

g. bearing – controls and displays the current relative bearing of the acoustic array (0° ± 160°)

h. tilt – controls and displays the current tilt angle of the array (0° to -12°)

i. detection – configures the detection parameters for contact tracking and sea bed extraction

j. nav override – overrides ownship navigational data and dead-reckons with manually entered inputs; and

k. test – turns the quick operability test (QOT) on or off

Wet End Assembly

41. The MOAS wet end assembly (WEA) is deployed and retracted by means of a hydraulic hoist system. Two vertically oriented hydraulic cylinders are used to raise and lower the WEA in the sea tube. The hoist can be enabled from the BDU, from the SOC, or manually by operating the controls in the MOAS – EC. An Emergency Retract button is provided on the BDU and on the hydraulic hoist control panel. In the Retracted state, a transmit safety loop remains open, preventing any output from the HV power supply and inhibiting transmissions. In the Deployed state, and when the transmit safety loop is closed, an output from the HV power supply is enabled and transmissions are possible. In transit between the retracted and deployed states, the transmit safety loop remains open and transmissions are inhibited. The WEA components function as follows:

a. Bearing Mechanism - The bearing assembly is used to provide bearing rotation relative to the ship's heading. A servo motor, controlled by Rack 3000 in the MOAS EC, rotates the main offset body. During rotation of the main offset body, nylon chain link trunking in the top of the bearing mechanism housing protects the Fibre Optic cables from damage due to the minimum bend radius being exceeded. A DC/DC power converter (RX_PS PCB assembly) in the bearing mechanism uses 24 VDC from the servo amplifier rack in the MOAS EC to provide the supply voltages required by the electronics in the acoustic array.

b. Roll Mechanism – The roll mechanism is used to provide roll stabilisation relative to the vertical plane. A servo motor controlled by Rack 3000 in the MOAS EC is used to rotate the roll mechanism. An output from the VRU in the acoustic array is used as feedback in the servo control loop, for the roll axis to maintain the acoustic array housing in an accurate vertical position, regardless of the roll of the vessel.

c. Acoustic Array – The MOAS transmitter array is used to transmit a sequence of eight Frequency Modulation (FM) pulses, which cover the entire water column from the surface to the maximum detection depth. MOAS applies beamforming to the data from the receive array to detect the bearing of a contact. The phase relationships, between the signals received at each receive transducer, allows MOAS to calculate the relative bearing of the received signal. The bearing is referenced to broadside (0 □) i.e. perpendicular to the array. Beams to the left of broadside have negative bearings, and beams to the right have positive bearings. Range is measured by calculating the time from transmission to contact reception. Depth is measured by determining which beam has ensonified the contact, identified by the frequency of the contact return. The RX_16 PCB assembly is then used to condition analogue receive signals to improve signal to noise ratio, and output a 16 bit data stream to the SERV_RX PCB assembly. The SERV_RX PCB assembly is used to digitise the received data and to multiplex the data into a fibre optic data stream that is transmitted to the processing rack in the MOAS EC. The VRU is used for roll stabilisation and provides an analogue output proportional to the absolute vertical position of the array.

MOAS Electronics Cabinet (EC)

42. The MOAS EC contains the majority of the controlling and processing electronics for the MOAS. The MOAS EC provides the transmission pulses, processes the received sonar data, controls the WEA servo system and provides communication and picture generation data with the BDU. Two mains supply filters are connected in series with the main and heater supplies to minimise Radio Frequency Interference.

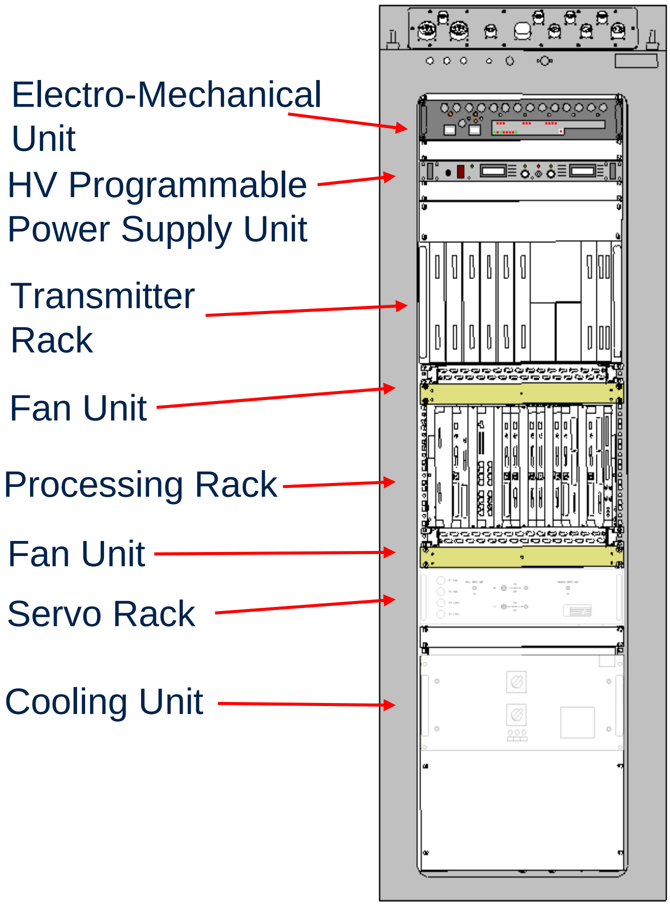

Figure 10-9: MOAS Electronics Cabinet

Underwater Telephone AN/WQC-2A

(Not a real FFG Underwater Telephone)

General

43. The AN/WQC-2A Under Water Telephone (UWT) is one of the principal communications means between surface ships and submerged submarines. The other is the use of Marine Sound Signals.

System Inputs

44. The underwater telephone requires the following inputs from the ship:

a. 115 V, 60 Hz single phase, 35 A maximum.

b. Muting signal from Sonar.

c. Voice.

System Outputs

45. The following outputs are provided:

a. Acoustic energy on an audio carrier in two frequency bands; single sideband.

b. Received audio.

Functional Characteristics

Parameter	Specification
Range	4,000 to 10,000 yards
Frequency	High: 8.3 to 11. kHz
	Low: 1.45 to 3.1 kHz
Power Output	Full: 600 W in high band
	1 kW in low band
	Reduced: 12dB down

Table 14: AN/WQC-2A UWT Functional Characteristics

Equipment Location

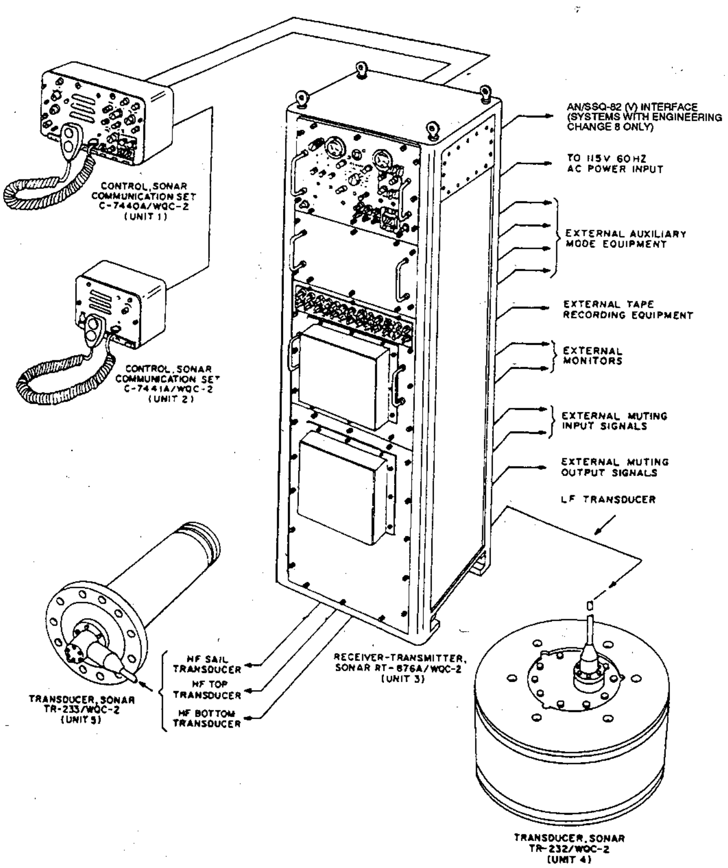

Figure 10-10: AN/WQC-2A UWT

46. WQC-2A units are located as follows:

a. Unit 1: Remote Control Unit Sonar Control Room

b. Unit 2: Aux. Remote Control Unit

i. Bridge, adjacent CO's Chair

ii. (or Ops Room above PWO OSC)

c. Unit 3: Receiver/Transmitter Sonar Equipment Room

d. Unit 4: Transducer, Low Frequency Sonar Dome

e. Unit 5: Transducer, High Frequency Sonar Dome

Miscellaneous

47. Both voice transmission and switched CW (e.g. for Morse) are supported.