TA-ENG: SESC - FFG DIVISION

FFG COMBAT SYSTEM LEARNERS GUIDE

VERSION 2.01, DATED 10 Dec 2014

SECTION 6 – Support and Training Systems and Combat System Alignment

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Chapter 2. Navigation Systems

1. The Navigation Sub-systems on the FFG are provided for the following reasons:
   a. Provide the capabilities to facilitate the safe navigation of the ship under the supervision of appropriately trained and authorised navigation experts, and comply with International Maritime Organisation (IMO) regulations including safety (SOLAS), environmental concerns, legal matters, technical co-operation, maritime security and the efficiency of shipping.
   b. Provide own-ship data to the Combat System to aid in neutralising threats.
2. Major equipment comprising the Navigation and Navigation Support Sub-systems include:
   a. Sensors
      i. AN/WSN-7B Laser Ring Gyrocompass
      ii. Mk 27 Mod 1 Gyrocompass
      iii. DAGR Global Positioning System (GPS)
      iv. AN/UQN-4 Echo Sounder
      v. Electromagnetic (EM) Log Mk 6 Mod 0
      vi. Wind Indicating Equipment Type F
   b. Information Systems
      i. Navigation Display System (NDS)
      ii. Automatic Identification System (AIS)
      iii. Kelvin Hughes Colour Tactical Display (CTD)
   c. Parameter Distribution Systems
      i. Main IC Switchboard
      ii. Combat System IC (CSIC) Switchboard
      iii. Synchro Signal Amplifiers Types E & F
      iv. Signal Data Converter (SDC) CV-2953A

Sensors

AN/WSN-7B Laser Ring Gyrocompass

Reference: NAVSEA S9427-AT-OMP-010/WSN-7

General

3. The AN/WSN-7B is the master gyrocompass fitted to the FFG, and is located in the IC & Gyro Room (2-79-0-C). The Ring Laser Gyro (RLG) is an integral part of the ship's navigation system. Each WSN-7B is a self-contained unit that employs an Inertial Measuring Unit (IMU). The IMU employs three single-axis RLGs and matched accelerometers as the inertial reference to determine ship's position, velocity, roll, pitch, and heading. The RLG continuously accepts ship's speed from a speed log or from the Global Positioning System (GPS), and periodically accepts ship's position information from an external navigation reference, such as GPS, or manually via a keypad on the RLG control panel. The WSN-7B is required to interface with GPS and the EM Log. It provides ship's heading for navigation purposes and ship's heading, pitch and roll for the combat system.

Figure 2-1: AN/WSN-7B

System Inputs

4. The AN/WSN-7B Gyro requires the following inputs from the ship:

   a. 115V 400Hz 3ϕ primary power.

   b. 115V 400Hz 1ϕ synchro reference power.

   c. EM LOG speed (synchro & reference).

System Outputs

5. The Gyro provides the following analogue outputs to the combat system:

   a. Own Ship's Heading (Cqo) on two buses;

      i. Critical, and

      ii. Normal

   b. Simulated Cqo on both Critical and Normal busses for training purposes;

   c. Own Ship's Pitch (Eio);

   d. Own Ship's Roll (Zdo);

   e. Digital attitude data (lat, long and velocity); and

   f. Malfunction Summary Alarms.

6. It also provides an NTDS Type-E serial data (digital) output that can be utilised by the UYK-43 for Weapons Control Processor (WCP) processing.

7. A fibre optic interface is provided between the WSN-7B and the ADS LAN to allow for own ship data transfer to ADACS, SMAP and OBTS control of the WSN-7B.

Modes of Operation

8. The WSN-7B may be configured to operate as either a Gyrocompass, an Inertial Navigation System (INS), or a Battle Force Tactical Trainer (BFTT). When the unit is being operated as an INS, full heading, pitch, roll, latitude (lat), longitude (lon), and velocity data is available as outputs. When the unit is operated as a Gyrocompass, only heading roll and pitch data are available as outputs. Due to the requirements of the SM2 weapon system, the RAN uses the WSN-7B in INS mode only.

9. When the RLG is configured to operate as a Gyrocompass, three operating modes are associated with start-up, settling, and normal on-line operation. These are STANDBY, ALIGN, and GYRO. The Align mode has three possible states. The indications for these states are:

a. ALIGN – Coarse heading align in progress. Levelling of the roll and pitch RLGs occurs, adjusting system roll and pitch values toward actual roll and pitch. Heading is initialized with a value of zero at start-up position of ship fore/aft axis. The operator selects the desired velocity damping source, and inputs ships data into the system, consisting of Julian day and time, and initial position (latitude and longitude).

b. ALIGN-C – Coarse Align complete. At this point in time roll, pitch and heading data are valid for navigation.

c. GYRO – Full specification accuracy Heading, Roll, and Pitch available.

10. When the RLG is configured to operate as an Inertial Navigation System (INS), five operating modes are associated with start-up, settling, and normal on-line operation. These are STANDBY, ALIGN and NAVIGATE (NAV). The Align mode has five possible states. The indications for these states are:

a. ALIGN – Coarse Align mode in progress. Level roll and pitch. Calculate latitude value for align.

b. ALIGN-C – Coarse Align complete, Fine Align mode in progress.

c. ALIGN-F – Dockside Fine Align complete, ready to enter the Navigate mode.

d. NAV-C – At-sea Fine Align currently being performed with system in the Navigate mode supplying reduced accuracy Position and Velocity data.

e. NAV – Full specification accuracy Navigation Mode.

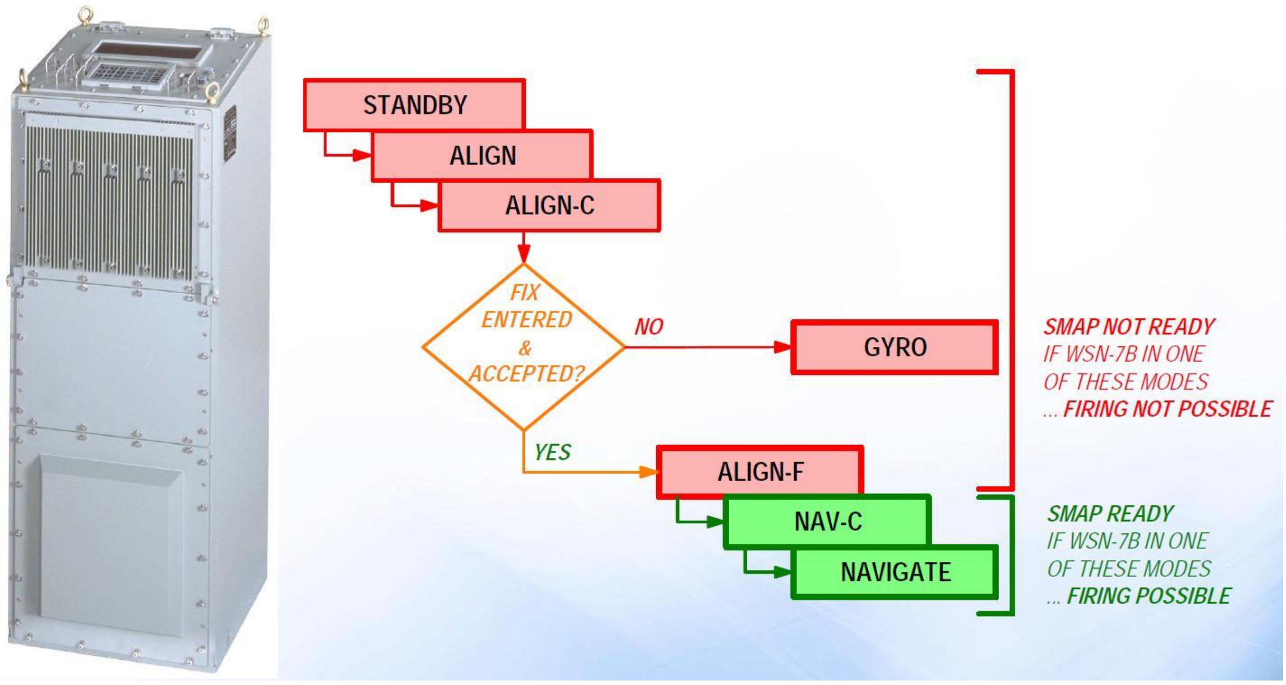


Figure 2-2: WSN-7B Modes

11. In Battle Force Tactical Trainer (BFTT) mode, the OBTS NAVSIM computer provides the WSN-7B with simulation data. The WSN-7B then provides that simulated Cqo & attitude via its analog and digital outputs to the Combat System (pitch 7 roll are not simulated – they are always 'true'). BFTT is ***only*** used when OBTS is operating in 'Sim Only' mode, ie ***when the ship is along-side*** and true navigation data is not required.

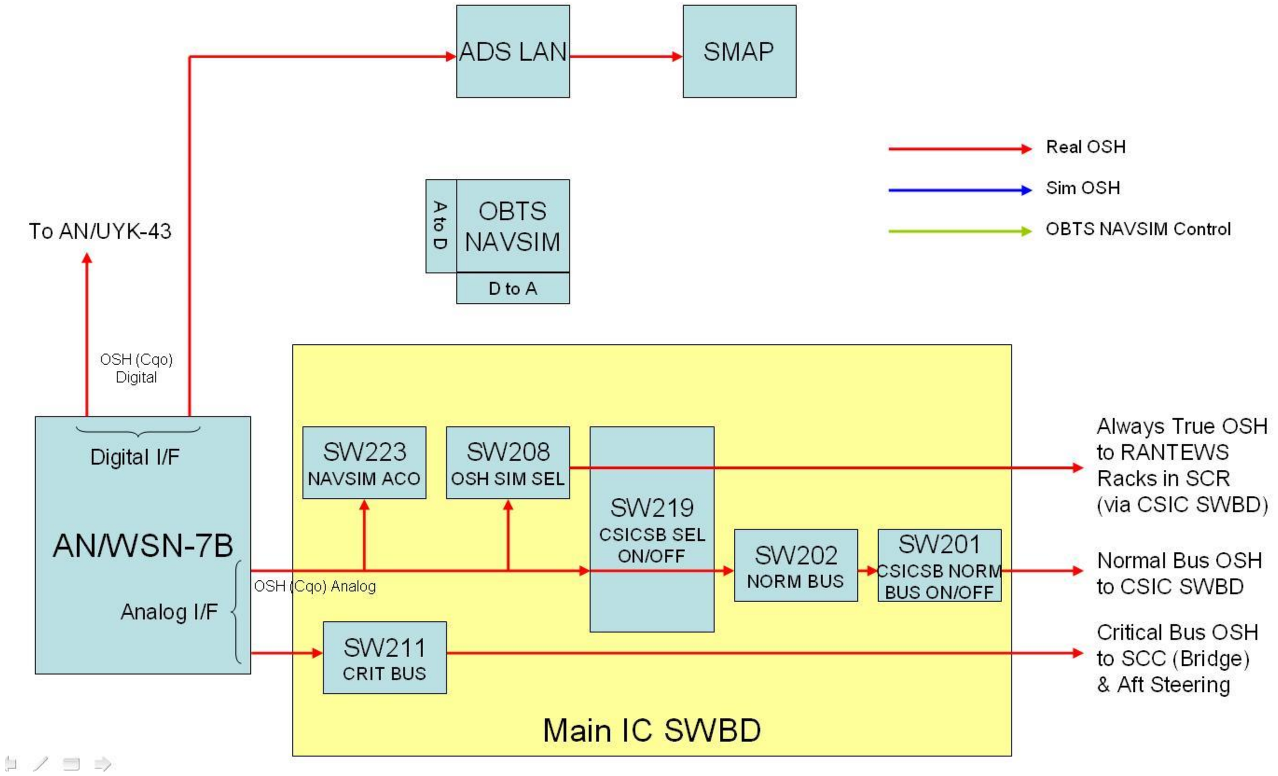


Figure 2-3: OSH (Cqo) Distribution in INS Mode (Tactical or OBTS Live-Over-Sim)

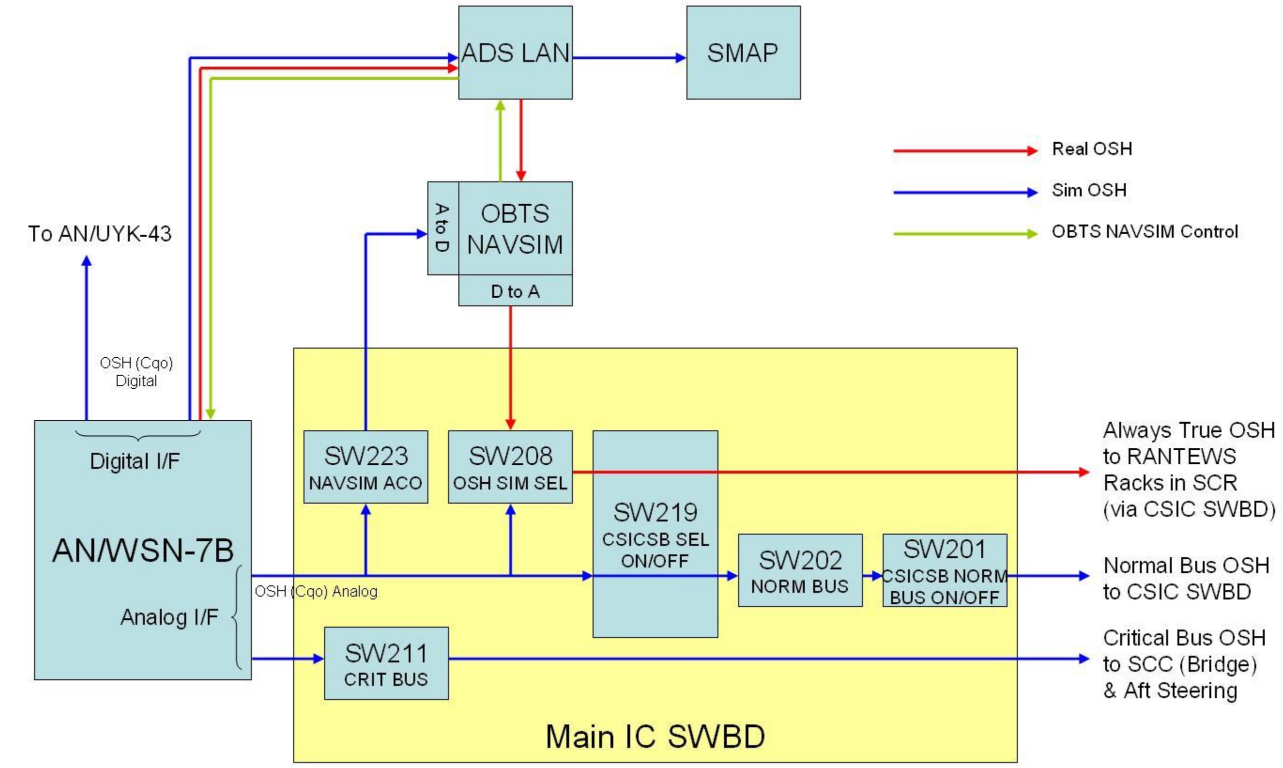


Figure 2-4: OSH (Cqo) Distribution in BFTT Mode (OBTS Sim Only)

Operating Parameters

12. Gyro accuracy is a function of latitude as follows:

a. Cqo ±9 minutes arc X secant(latitude) [max]

(i.e. ±11 min arc at 30ºlat, ±14 min arc at 40ºlat)

b. Eio ±4 minutes arc [max]

c. Zdo ±4 minutes arc [max]

13. WSN-7 parameter limits are:

a. Cqo Unlimited

b. Eio ± 45º

c. Zdo ± 60º

d. DMho 95 knots

Casualty Modes

14. The WSN-7 Gyro is equipped with a battery backup, enabling continued operation in the event of failure of the 400Hz primary power or synchro reference power as detailed below:

Loss	Output
400Hz 1Only	**Critical Cqo** for as long as possible
400Hz 3ϕ Only	**All** for 30 minutes (approx.)
All 400Hz	**Critical Cqo** for 30 minutes (approx.)

Table 1: WSN-7B Power Casualty

15. Battery power changeover is automatic upon detection of 400Hz failure & resupply.

Mk 27 Mod 1 Gyrocompass

Reference: S9426-AA-MMM-010

General

16. The Mk27 gyro is fitted to the FFG as the backup Gyro in case of failure of the WSN-7. It is located in Damage Control Central DCC), 2-292-01-C.

System Inputs

17. The Mk27 gyro requires the following inputs from the ship:

a. 115V 60Hz 1ϕ primary power to Power Converter.

b. 24 VDC from Power Converter.

c. 115V 400Hz 1ϕ synchro reference power.

System Outputs

18. The following outputs from the gyro are supplied to the combat system:

a. Own Ship's Heading (Cqo)

Modes Of Operation

19. The Mk27 gyro has six modes of operation:

a. OFF - De-energises all circuits.

b. SLEW - Energises all circuits with the exception of gyro motor and repeaters. Enables slewing of gyro in latitude or tilt.

c. START - Energises all circuits and spins up gyro motor.

d. RUN - De-energises TILT/AZIMUTH control and enables output of azimuth data.

e. MANUAL LEVEL - Energises TILT/AZIMUTH control whilst gyro spins to enable levelling.

f. AUTO LEVEL - Enables automatic levelling of gyro whilst it spins.

Operating Parameters

20. Settling Time is 2 hours after which the accuracy is ± 1±5º.

Casualty Modes

21. In the event of 400 Hz power loss or SSA failure, ship's head can be read through the gyro's observation window, and reported to the bridge/operations room through an appropriate internal communications circuit to provide an accuracy check for the magnetic compass.

22. There is no redundancy in the event of primary power failure.

23. In the event that both WSN-7 and Mk27 gyros fail, a magnetic compass located on the Bridge (mounted on the Ship Control Console), can be used for navigation.

Miscellaneous

24. If set to OFF, a mandatory period of 30 minutes must elapse (to enable to gyro to spin down) before selecting START mode.

25. Two starting procedures exist:

a. Heavy Sea: Used when roll or pitch exceed 10□.

b. Normal Sea: Used when roll and pitch are less than 10□.

26. Manual controls are provided to level and/or slew the gyro.

Global Positioning System (GPS)

General

27. Joint Project 5408 was tasked with providing GPS Anti-Jamming capability to a number of platforms. The GPS Enhancement System (GES) was identified as the solution for FFGs, however the Kelvin Hughes HK-1020 GPS was not compatible, and so was replaced in 2013 with the Rockwell Collins HNV-660 Defence Advanced Global Positioning System (GPS) Receiver (DAGR). The GES and DAGR system fitted to FFGs is depicted in the diagram below:

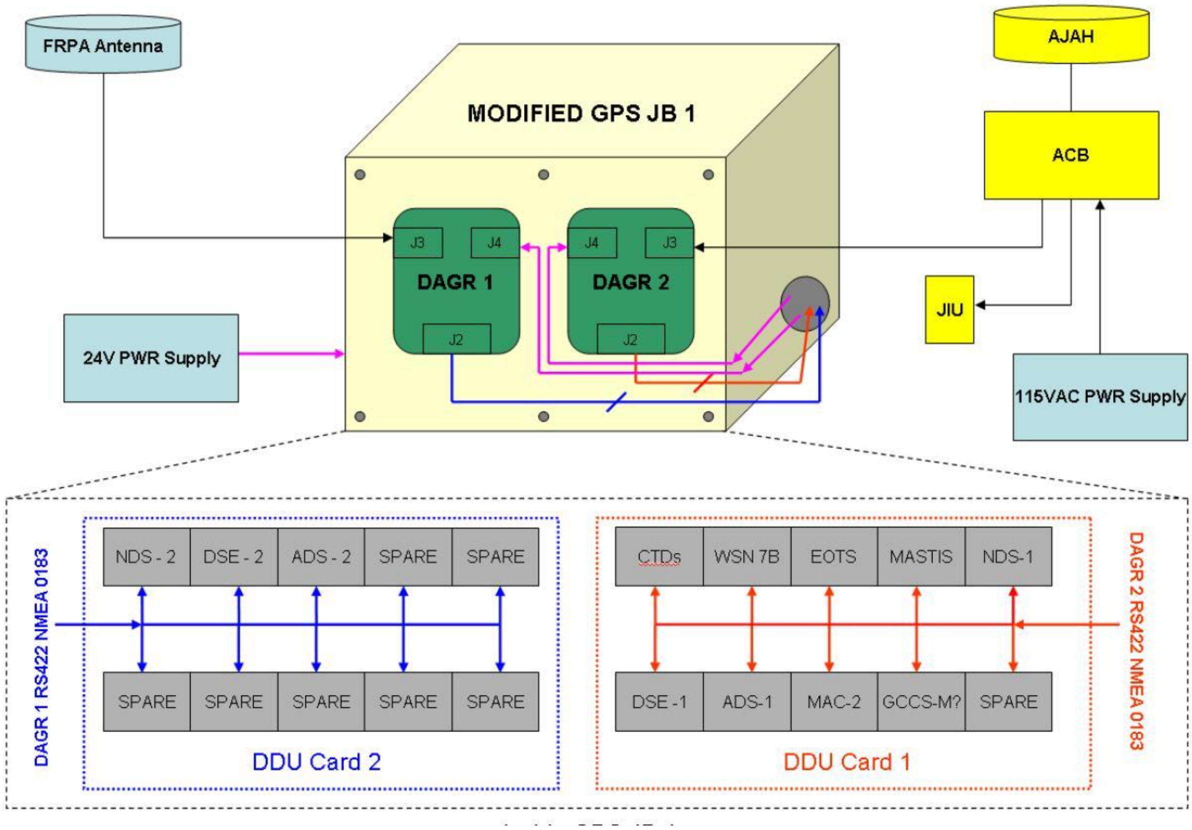


Figure 2-5: FFG DAGR and GES Architecture

Outputs

28. GPS provides serial NMEA 0182 (universal standard GPS time, position, velocity) outputs to:

a. AN/WSN-7B

b. ADS Servers

c. Navigation Display System (NDS)

d. MASTIS

e. CTDs

f. EOTS

Inputs

29. The following inputs are supplied to the GPS:

a. Ship’s power - 115V, 60Hz, 1 phase.

b. Antenna Signals (L1 & L2)

c. Crypto Information

d. Operator Keypad information

GPS Enhancement System (GES)

Reference: ABR 6762

30. The GES system consists of the following parts

  a. Anti-Jam Antenna Housing (AJAH), comprising of:

    i. Controlled Radiation Pattern Antenna (CRPA)

    ii. Electronics Unit (AEU)

    iii. RF Filter

  b. Jamming Indicator Unit (JIU) and

  c. Antenna Control Box (ACB).

31. More information regarding the GES and its operation can be found in the ABR 6762.

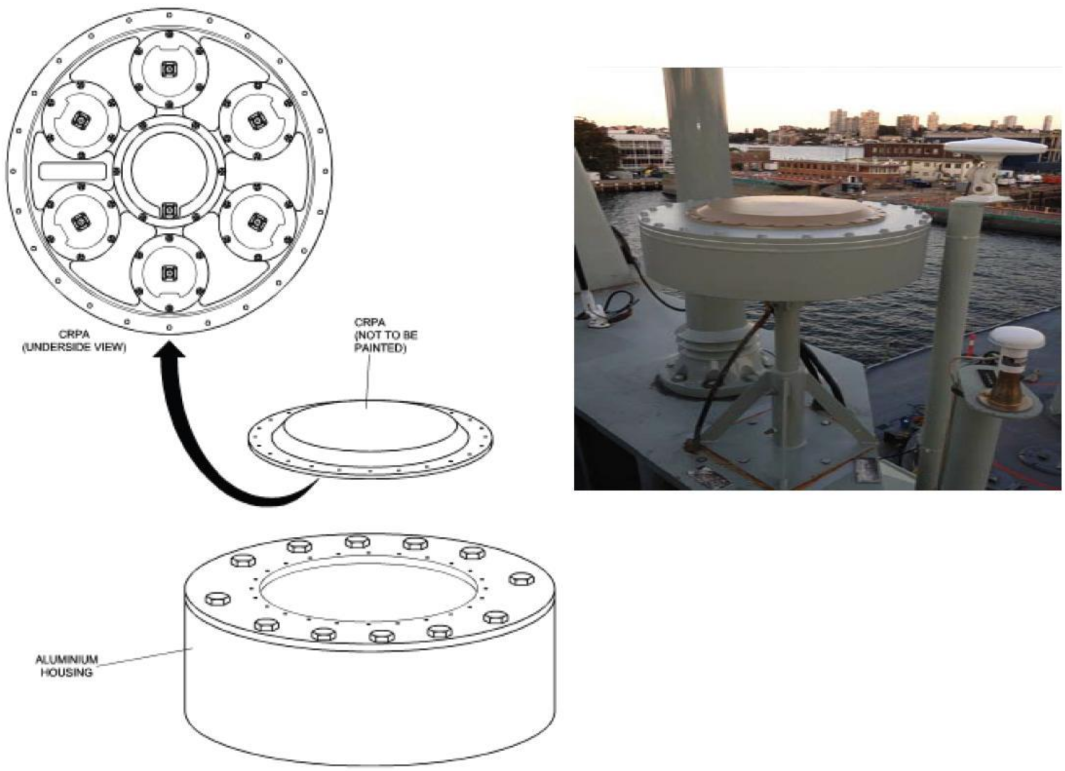


Figure 2-6: Anti-Jam GPS Antenna

32. The Antenna Control Box performs 6 functions:

  a. Amplification and splitting of GPS navigation signal being fed from anti-jam GPS antenna

  b. Control and monitoring of status of anti-jam antenna

  c. Provides visual display of anti-jam antenna assembly status

  d. Processes jamming strength provided by the anti-jam antenna assembly and supplies to jamming indicator unit;

  e. Gain selection of GPS RF signal level from the anti-jam antenna assembly

  f. Selection of L1 or L2 GPS signal bands (DIP Switch 1, switch 1)

33. The GPS JIU has twelve LED's on the top cover, which illuminate to show the strength of the jamming signal to each CRPA. The more LED's that light, the stronger the jamming signal.

Figure 2-7: GPS Jaming Indicator Unit (JIU)

AN/PSN-13A Defence Advanced GPS Receiver (DAGR)

34. The Defence Advanced GPS Receiver (DAGR) is dual frequency 12 channel radio receiver with Selective Availability Anti Spoofing Module (SAASM), Precise Positioning Service (PPS), and Military code (P/Y). When SAASM is not keyed, the DAGR is susceptible to Jamming and Spoofing.

35. The DAGR optionally stores Waypoints, Routes, Alerts and track history.

36. The DAGR outputs NMEA 0182 (universal standard GPS time, position, velocity) which allows it to interface with WSN-7B, NDS, ADACS, MASTIS, and EOTS.

Specifications

37. Key specifications are detailed in the table below::

Frequency	L1/L2 dual frequency tracking L1 - C/A, P(Y) L2 - P(Y)
Acquisition time (times based on 95% probability)	TTFF < 10 sec (Hot) TTFF < 70 sec (Warm) TTFF < 100 sec (Cold) TTSF < 15 sec (RCVR OFF or STBY < 15 min) TTSF < 22 sec (RCVR in STBY < 60 min) TTSF < 70 sec (RCVR OFF < 60 min)
GPS Time Accuracy	52 nanoseconds
Dynamics	Velocity: 250 m/s Acceleration: 20 m/s^2
Position Accuracy	DGPS: < 2.28 m, 95% Horizontal WAGE: < 4.82 m, 95% Horizontal PPS: < 10.5 m, 95% Horizontal
Velocity Accuracy	0.4 m/sec 3D 95%
Coordinate System	30 predefined 6 user-defined
Storage Capacity	999 waypoints, 5 moving waypoints, 15 user-definable reversible routes of up to 999 legs each
MTBF	10,000 hours
Datums	233 predefined 6 user-defined
Compatibility	ICD-GPS-153

Table 2: DAGR Specs

38. Two DAGR units are fitted per FFG – both mounted on the GPS Junction Box.

Figure 2-8: FFG DAGR Mounting

Sonar Sounding Set (KNUDSEN 320N)

Reference: ABR 6962 KNUDSEN 320N ECHOSOUNDER – Operation and Maintenance Manual

System Inputs

39. The KNUDSEN 320N depth sounder requires the following inputs from the ship:

a. 115V 60Hz 1Ø primary power

b. Keel Reference setting

System Outputs

40. The depth sounder provides depth of water below the keel as an Echogram, and as a digital readout.

Modes of Operation

41. Operating modes for the depth sounder are:

a. POWER OFF

b. POWER ON

c. PING SELECTION:

Off: No Transmission

Auto: Automatic transmission under control of 320N presets

Manual: Transmission in accordance with selected parameters

Operating Parameters

42. Operating parameters of the 320N are:

a. Transmission Type: Pulsed CW with pulse width selection (up to 64ms).

b. Frequency: 12 kHz (option 3.5-210KHz)

c. Power: Variable in 5 steps up to a maximum of 2000 Watts into the transducer

d. Pulse repetition rate and pulse widths are a function of range scale and power setting as detailed below:

e. Minimum discernible depth is 3 meters or 10 feet

Table of Presets				
Preset	***In Port (0-50ft)***	***Coastal Region (0-200ft)***	***Continental Shelf (0-1000ft)***	***Full Ocean Depth (>1000ft)***
Tx Power	1	1	2	4
Tx Pulse	0.75ms	1.5ms	6ms	24ms
Proc. Shift	1	2	2	4
Gain	Auto, start at 0dB	Auto, start at 0dB	Auto, start at 0dB	Auto, start at 0dB
Min Depth	3m or 10ft	10m or 35ft	50m or 100ft	100m or 200ft
Range	50m or 50ft	100m or 200ft	500m or 1000ft	2000m or 5000ft
Gate Width	50	50	100	200
Auto Ranging	On	On	On	On

Table 3: KNUDSEN 320N Table of Presets

Casualty Modes

43. There are no casualty modes of operation available in the event of a failure to the Echo sounder or Transducer; however, an extensive spares kit is kept onboard for fault finding and replacement.

Miscellaneous

44. The KNUDSEN 320N is located in the Charthouse. Remote indicators are provided on the Bridge and in the CIC.

45. The transducer is located in the hull at bulkhead 140 adjacent to the keel. This position is aft of the APU's, rendering the system degraded when APU's are being used for manoeuvring and docking.

46. Echo Sim can be used to monitor transmitted pulse voltage, current, power, pulse length, and frequency. Provides simulated echo in response to transmit pulse (to test validity of depth measurement) and measures and displays transducer impedance.

Electromagnetic (EM) Log Mk 6 Mod 0

Reference: SE178-AL-MMM-010

System Inputs

47. The Mk6 EM Log requires the following inputs from the ship:

a. 115V 60Hz 1ϕ from Main IC SWBD

b. 115V 400Hz 1ϕ from Main IC SWBD

System Outputs

48. The following outputs are provided to the combat system:

a. Own Ship's Speed (DMho) 60Hz synchro.

b. Own Ship's Speed (DMho) 400Hz synchro.

c. Own Ship's Distance (Mho) 60Hz synchro.

Modes of Operation

49. The log has three modes of operation:

a. UNDERWATER Speed input is derived from the signal (325 □VAC/knot) returned from the rodmeter.

b. MANUAL Speed input is derived from the Manual Drive Hand crank located on the Indicator Transmitter.

c. DUMMY Speed input is derived from the DUMMY LOG Increase/Decrease switches located on the Indicator Transmitter or Dummy Log Remote Control (located in CCS).

Operating Parameters

50. The operating parameters of the EM log are:

a. Displayed speed of 0 - 40 knots.

b. A quoted accuracy of 0.05 knot of true speed relative to the water. In practice the accuracy depends on calibration and other influences, and will not normally be better than ±2 knots.

c. Displayed distance 0 – 9999.99 nm.

d. Compensation accuracy of ±1.0% between dial calibration and entered non-linearity correction.

e. Degraded performance below through water speeds of 5 knots.

Casualty Modes

51. In the event of a rodmeter failure, or failure of speed determination circuitry failure, the following casualty modes are available:

a. Manual log mode: from the Indicator transmitter

b. Dummy log mode: using raise/lower switch located in CCS.

Miscellaneous

52. The rodmeter cannot be retracted into the hull. Divers are required to remove the rodmeter from the hull, which should be accomplished prior to proceeding into drydock.

53. A calibration assembly in the Indicator Transmitter enables manual adjustment of variable performance factors; non-linearity in rodmeter response.

54. Three display response rates (FAST, SLOW, AUTO) are provided. AUTO operation selects between the FAST and SLOW responses as determined by the speed dial error from the input; FAST of the error > 0□5 knot.

55. The Electromagnetic Log Voltage Simulator (ELVS) can be used to test system operation. It simulates the voltages produced by the rodmeter, and plugs into the input at the Indicator Transmitter or into the cables at the rodmeter output.

56. When going astern, the log should be set to MANUAL to prevent damage to the speed dial indicator.

Wind Indicating Equipment Type F

Reference: NAVSEA 0365-LP-280-4010

57. Inputs:

    a. 115V 400Hz

    b. 115V 60Hz

58. Outputs:

    a. Relative Wind Speed (Wha) in 400Hz & 60Hz formats

    b. Relative Wind Direction (Bwda) in 400Hz & 60Hz formats

General

59. Port & Starboard anemometers provide Relative Wind Speed and Direction to indicators located on the BRIDGE, CIC and HCO. This data is also provided to AMD and to ADACS (via the SDC).

60. A barrel switch on the Bridge is used to make selection of the port or starboard anemometer. The anemometers are mounted on the forward arms of the mainmast gantry.

61. A transmitter unit located in the RICER converts the 400Hz Wha & Bwda synchro signals into 60 Hz format for use by remote indicators.

Information Systems

62. Navigation systems are no longer just sensors with indicators. Computer based systems now integrate navigation data to allow much greater navigation capability. The Navigation Information Systems currently employed on the FFG are:

a. Navigation Display System (NDS);

b. Automatic Identifications System (AIS); and

c. Kelvin Hughes Colour Tactical Displays (CTD).

Navigation Display System (NDS)

63. The Navigational Display System (NDS) displays electronic charts, navigational information and the own ships position in real time on a visual display. The NDS provides bridge personnel with the ships position relative to a planned route and navigational hazards.

64. The NDS is primarily used by members of the ships Bridge Team, e.g. Navigator and OOW as a navigational aid. The NDS may be used to assist in the following ship evolutions:

a. Navigation and manoeuvring

b. Docking

c. Route planning and monitoring

d. Search and rescue

e. Data recording, and

f. Overall voyage management.

Inputs

65. The NDS on FFGs takes the following inputs:

a. Gyrocompass (Cqo)

b. Global Positioning System (GPS) – DAGR

c. Secondary GPS (AIS)

d. Automatic Identification System (AIS)

e. EM Log speed

f. Wind Speed & Direction

g. AN/SPS-55 Radar Video

h. Echo Sounder (future Knudson fit)

66. Outputs:

a. ECDIS data

b. Automatic Radar Plotting Aid (ARPA)

67. The NDS is a PC based Electronic Chart Display and Information System (ECDIS). The system software runs on the Microsoft windows XP operating system.

68. The NDS consists of a primary system, a backup system and a planning station (Laptop / notebook computer) all connected together via a network hub to enable data exchange . The primary and backup systems are fed by uninterruptible power supplies (UPS)

69. The NDS uses Electronic Chart Precise Integrated Navigation System (ECPINS) ECDIS software produced by Offshore Systems Ltd (OSL) and is IMO compliant. The software supports all official chart formats.

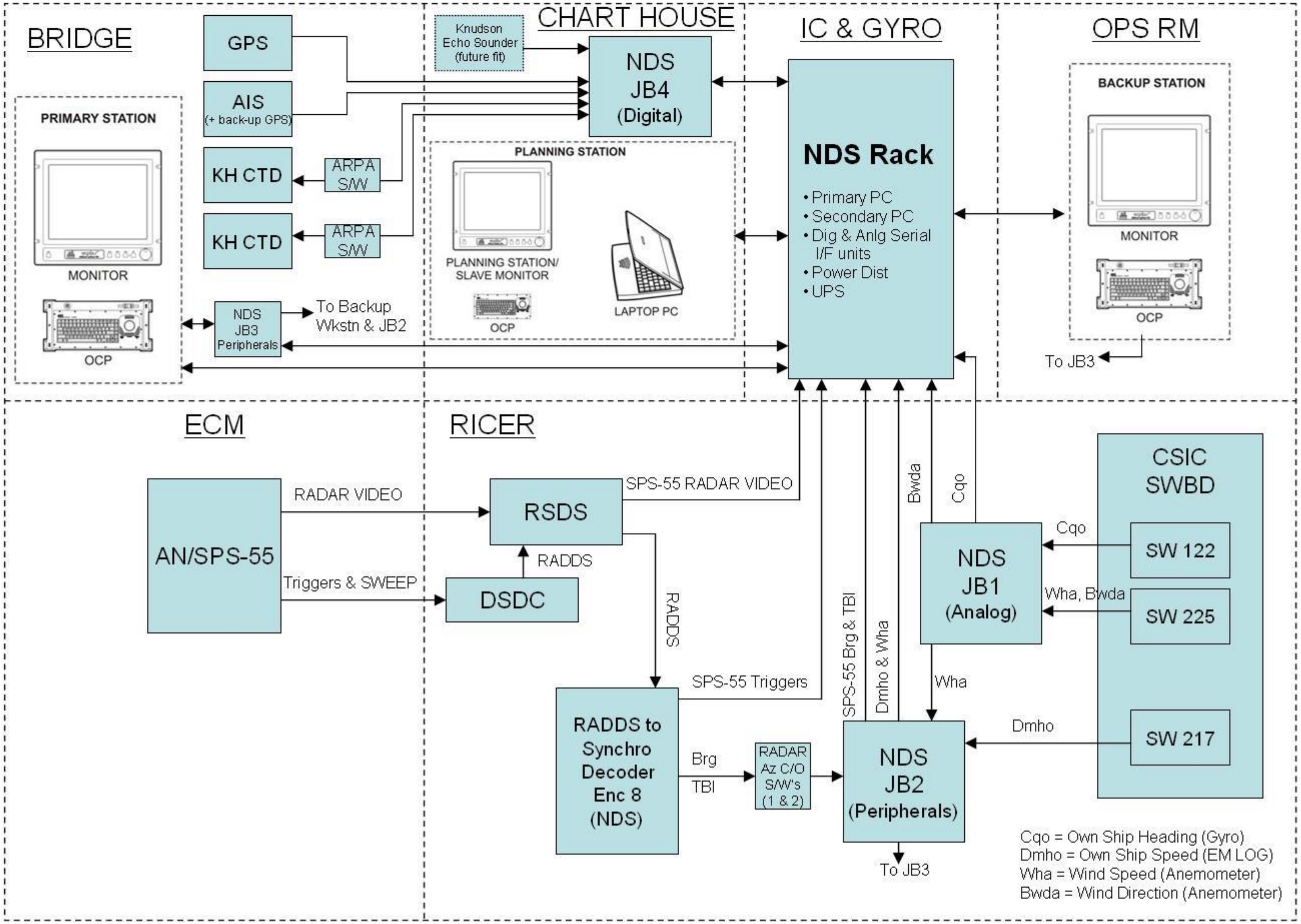


Figure 2-9: FFG NDS Configuration

Automatic Identification System (AIS)

Introduction

70. The Automatic Identification System (AIS) is an automatic tracking system used on ships and by vessel traffic services (VTS) for identifying and locating vessels by electronically exchanging data with other nearby ships, AIS base stations, and satellites. When satellites are used to detect AIS signatures then the term Satellite-AIS (S-AIS) is used. AIS information supplements marine radar, which continues to be the primary method of collision avoidance for water transport.

71. Information provided by AIS equipment, such as unique identification, position, course, and speed, is displayed on the FFG on ECDIS (NDS). AIS is intended to assist a vessel's watchstanding officers and allow maritime authorities to track and monitor vessel movements. AIS integrates a standardized VHF transceiver (Channel 87 – 161.975 MHz and Channel 88 – 162.025 MHz) with a positioning system such as a LORAN-C or GPS receiver, with other electronic navigation sensors, such as a gyrocompass or rate of turn indicator. Vessels fitted with AIS transceivers and transponders can be tracked by AIS base stations located along coast lines or, when out of range of terrestrial networks, through a growing number of satellites that are fitted with special AIS receivers which are capable of deconflicting a large number of signatures.

72. The International Maritime Organization's International Convention for the Safety of Life at Sea requires AIS to be fitted aboard international voyaging ships with gross tonnage (GT) of 300 or more tons, and all passenger ships regardless of size.

73. AIS position data are available on the Internet through privately operated geographic information systems. The link is: http://www.marinetraffic.com/ais/

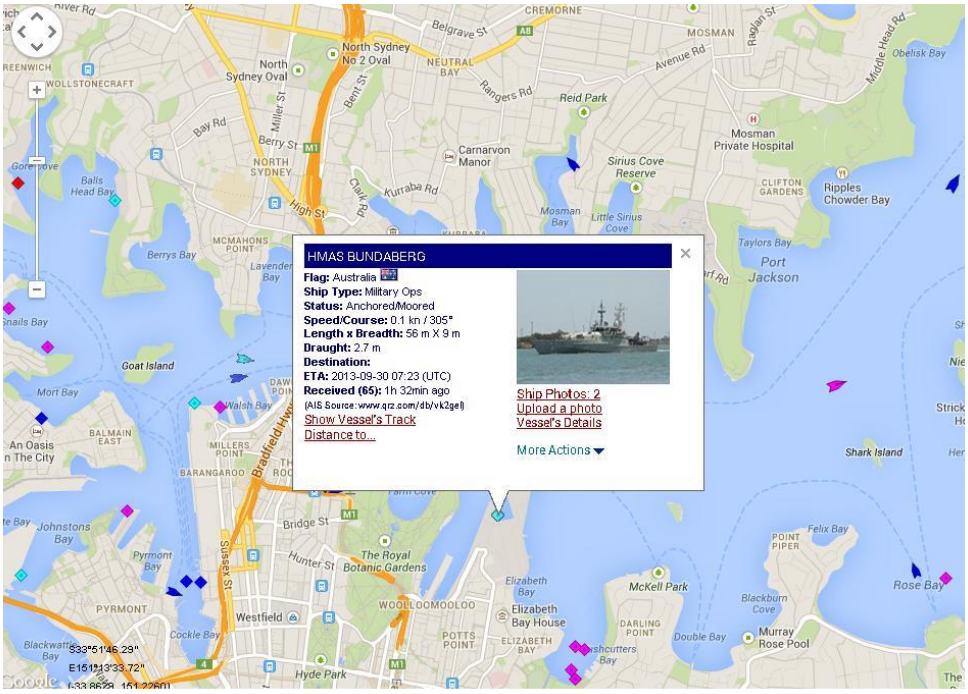


Figure 2-10: Screenshot of AIS information Available on the World Wide Web

74. Applications of AIS include:

  a. Collision avoidance - AIS standards include a variety of automatic calculations such as Closest Point of Approach (CPA) and collision alarms;

  b. Vessel traffic services - In busy waters and harbors, a local vessel traffic service may use AIS to aid management of ship traffic;

c. Maritime Security - AIS enables the identification of specific vessels and their activity within or near a nation's Exclusive Economic Zone. When AIS data is fused with existing radar systems on NDS, it is easier to differentiate between vessels. AIS data can be automatically processed to create normalized activity patterns for individual vessels, which when breached, create an alert highlighting potential threats for more efficient use of security assets.

d. Aids to navigation - (AtoN) broadcasts the positions and names of objects other than vessels, such as navigational aid and marker positions and dynamic data reflecting the marker's environment (e.g., currents and climatic conditions). These aids can be located on shore, such as in a lighthouse, or on water, platforms, or buoys.

e. Search and rescue;

f. Accident investigation.

How AIS works

75. AIS transponders automatically broadcast information, such as their position, speed, and navigational status, at regular intervals via a VHF transmitter built into the transponder. The information originates from the ship's navigational sensors, typically its global navigation satellite system (GNSS) receiver and gyrocompass. Other information, such as the vessel name and VHF call sign, is programmed when installing the equipment and is also transmitted regularly. The signals are received by AIS transponders fitted on other ships or on land based systems.

76. The AIS transceiver operates using self-organised time-division multiple-access (SOTDMA). SOTDMA requires a transceiver to maintain a constantly updated slot map in its memory such that it has prior knowledge of slots which are available for it to transmit. SOTDMA transceivers will then pre-announce their transmission, effectively reserving their transmit slot. SOTDMA transmissions are therefore prioritised within the AIS system. This is achieved through 2 receivers in continuous operation. Default transmit rate is every few seconds.

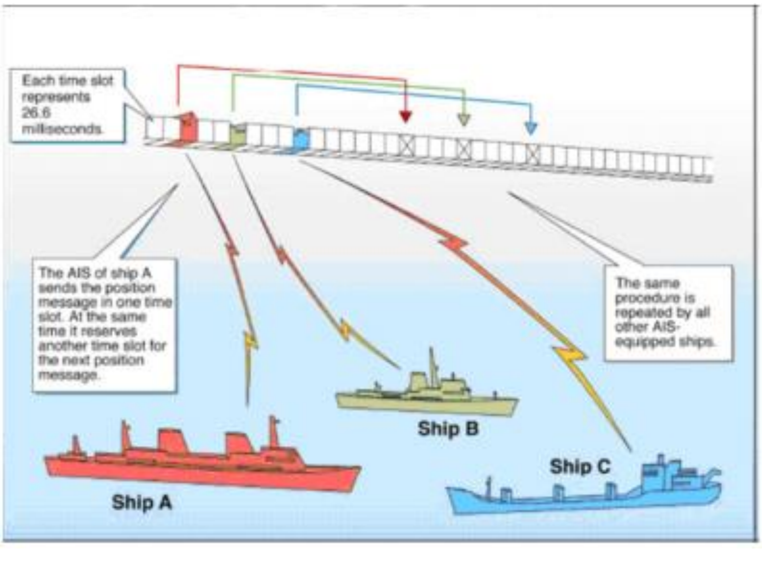


Figure 2-11: AIS SOTDMA Overview

77. Each AIS transponder consists of one VHF transmitter, two VHF TDMA receivers, one VHF Digital Selective Calling (DSC) receiver, and links to shipboard display and sensor systems via standard marine electronic communications (such as NMEA 0183, also known as IEC 61162). Timing is vital to the proper synchronization and slot mapping. Therefore, every unit is required to have an internal time base, synchronized to a global navigation satellite system. FFGs have an AIS specific GPS (located next to the AIS VHF antenna Fwd STBD side of GDP) for time base synchronisation which may also be used for position information, however, position is typically provided by the primary external receiver (DAGR on FFGs).

78. An AIS transponder normally works in an autonomous and continuous mode, regardless of whether it is operating in the open seas or coastal or inland areas. AIS transponders use two different frequencies, VHF maritime channels 87B (161.975 MHz) and 88B (162.025 MHz), and use 9.6 kbit/s Gaussian minimum shift keying (GMSK) modulation over 25 or 12.5 kHz channels using the High-level Data Link Control (HDLC) packet protocol. Although only one radio channel is necessary, each station transmits and receives over two radio channels to avoid interference problems, and to allow channels to be shifted without communications loss from other ships. The system provides for automatic contention resolution between itself and other stations, and communications integrity is maintained even in overload situations.

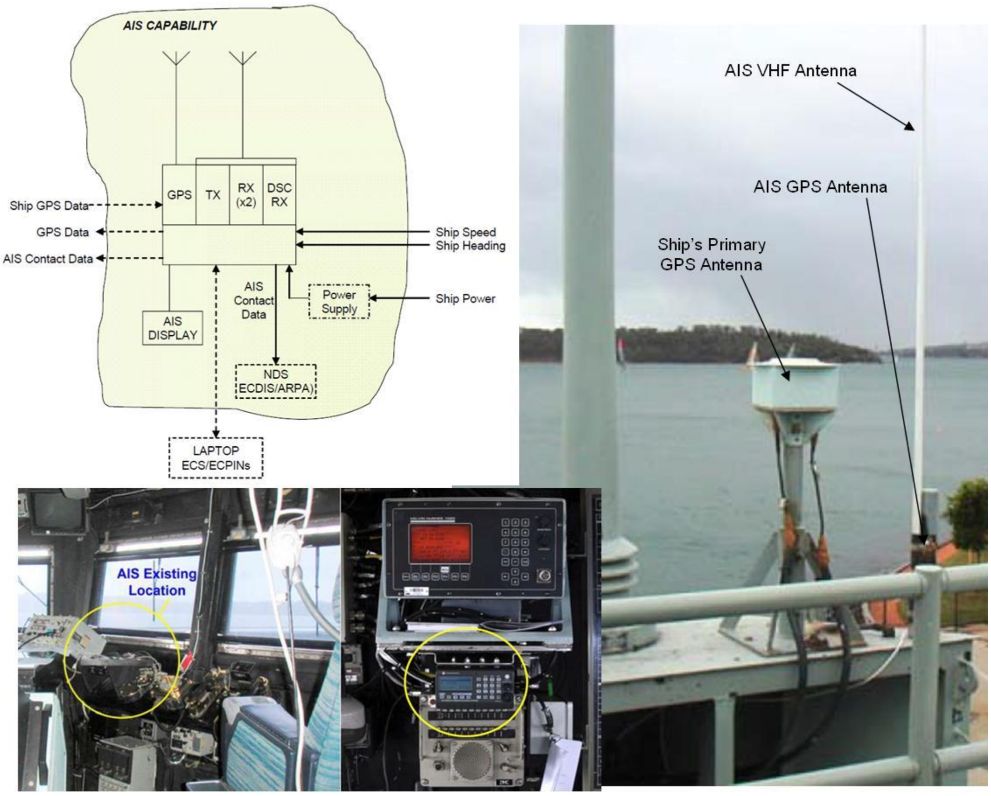


Figure 2-12: FFG AIS Fit

79. In order to make the most efficient use of the bandwidth available, vessels that are anchored or moving slowly transmit less frequently than those that are moving faster or are manoeuvring. The update rate ranges from 3 minutes for anchored or moored vessels, to 2 seconds for fast moving or manoeuvring vessels.

80. The system coverage range is similar to other VHF applications. The range of any VHF radio is determined by multiple factors including the height and quality of the transmitting antenna and the height and quality of the receiving antenna. Its propagation is generally more flexable than that of radar, due to the longer wavelength, so it is possible to reach around bends and behind islands if the land masses are not too high. The look-ahead distance at sea is nominally 20 Nmi (37 km). With the help of repeater stations, the coverage can be improved considerably.

81. The system is backward compatible with digital selective calling systems, allowing shore-based GMDSS systems to inexpensively establish AIS operating channels and identify and track AIS-equipped vessels.

82. An AIS transceiver sends the following data every 2 to 10 seconds depending on a vessel's speed while underway, and every 3 minutes while a vessel is at anchor:

a. The vessel's Maritime Mobile Service Identity (MMSI) – a unique nine digit identification number.

b. Navigation status – "at anchor", "under way using engine(s)", "not under command", etc.

c. Rate of turn – right or left, from 0 to 720 degrees per minute

d. Speed over ground – 0.1-knot (0.19 km/h) resolution from 0 to 102 knots (189 km/h)

e. Positional accuracy:

f. Longitude – to 0.0001 minutes

g. Latitude – to 0.0001 minutes

h. Course over ground – relative to true north to 0.1°

i. True heading – 0 to 359 degrees (for example from a gyro compass)

j. True bearing at own position. 0 to 359 degrees

k. UTC Seconds – The seconds field of the UTC time when these data were generated. A complete timestamp is not present.

83. In addition, the following data is broadcast every 6 minutes:

a. IMO ship identification number – a seven digit number that remains unchanged upon transfer of the ship's registration to another country

b. Radio call sign – international radio call sign, up to seven characters, assigned to the vessel by its country of registry

c. Name – 20 characters to represent the name of the vessel

d. Type of ship/cargo

e. Dimensions of ship – to nearest meter

f. Location of positioning system's (e.g., GPS) antenna on board the vessel - in meters aft of bow and meters port of starboard

g. Type of positioning system – such as GPS, DGPS or LORAN-C.

h. Draught of ship – 0.1 meter to 25.5 meters

i. Destination – max. 20 characters

j. ETA (estimated time of arrival) at destination – UTC month/date hour:minute

k. optional : high precision time request, a vessel can request other vessels provide a high precision UTC time and datestamp.

84. AIS data can be easily 'spoofed'. False data can be entered, and companies at trade fares openly advertise AIS units with the capability to offset ownship AIS position.

Kelvin Hughes Colour Tactical Displays (CTD)

References:

a. KH 5010 Issue 2, Jan 1995 - Supplemental Information for Colour Tactical Displays supplied to the RAN for Frigates & Destroyers

b. KH 1108 - CTD manual

General

85. The CTD system consists of three Kelvin Hughes Colour Tactical Displays (CTDs) linked by a network that has the following features:

a. Designed to operate with the capability to have tracks generated on one CTD displayed on all other CTDs.

b. Target data is available on any networked CTD.

86. CTDs are fitted to the FFG's in the following locations:

CTD	Location
1	Operations Room
2	Bridge (FWD)
3	Bridge (AFT)

Table 4: CTD Location

87. 'Control Interface Unit's interface the CTD Processors to the RSDS via the RADDS to Synchro decoders and their associated Bearing Cut Out switches (BCO).

Inputs

88. The CTDs receive the following inputs:

a. GPS

b. Gyro Heading

c. EM LOG Speed

d. 115V 60Hz 1 power

e. Selectable radar picture (not AN/SPS-49 'raw' due to limited inputs)

f. IFF (ops room only)

g. Network Data from other CTD's

h. NDS ARPA

89. Outputs:

a. Navigational picture

b. Radar & Video Select

c. Network Data to other CTDs

Capability Summary

90. The following is a summary of CTD capabilities:

a. Full colour raster scan display in portrait mode

b. Can track up to 50 targets automatically or 20 manually

c. Displays navigation lines / parallel index lines - scaled to range in use

d. Comprehensive mapping capability with a 200 map/20 navplan memory

e. Alpha numeric labelling of tracks and maps

f. Ability to draw sectors and sector screens

g. Helicopter landing path graphics

h. Command aids, Blind Arcs, Datums, Furtherest on Circles, and Dogboxes

i. ESM Bearing Lines

j. Operator error prompts

k. Sim Mode allows for in harbour training and testing

l. Automatic system fault status failure warning, loss of Sync/Video etc

m. Limited BITE capability, such as Video Level Bar Graph

n. Can perform Trial Manoeuvres

Limitations Summary

91. The following are a summary of the CTD limitations:

a. ARPA cannot process radar video from MK92 CAS due to the fast antenna scan rate of 60 rpm

b. ARPA cannot process radar video from SPS-49 when the antenna scan rate is at 6 rpm (too slow).

c. CTD will not process every PRT from SPS-55 due to PRF Limiter circuitry. Depending on range scale selected, CTD may only process 1 PRT then miss up to 4 PRTs while Scan Conversion takes place (polar to Cartesian co-ordinate conversion).

Control Interface Units - Bridge Displays

92. The Control Interface Units interface the bridge displays to the cabling from the radar distribution switchboard. Bearing data and true bearing indication is fed to the control interface unit from the RSDS via a Bearing Cut Out (BCO) Switch.

93. Video, master trigger (sync) and azimuth data are passed through the control interface unit unaltered. True bearing indication is converted to a suitable format for the CTD processor via opto-isolators. The control interface unit receives radar and video select signals from the CTD, and converts these to the correct selection signals for the switchboard. The control interface units for the bridge units are mounted adjacent to the CTD pedestal assembly, with power being derived from the CTD processor power supply.

CTD Processor & Display

94. The CTD processor is responsible for driving the display, performing all auto track functions, and interfacing network data to the networked displays. The display Human Machine Interface is via a menu system, with entries being made via softkeys.

95. All tracks generated at a display, whether manual or automatic, are transmitted over the network and are available for display at any of the networked displays. The operator may select the CTDs from which to display tracks via menu action. Filters to limit the display of networked tracks are also available.

96. The CTD is capable of displaying velocity vectors, track labels, and track history dots, as well as identifying tracks as friendly/hostile/neutral/unknown and air/surface/sub-surface. Facilities are also available to store and retrieve Nav plans and maps. A maximum of 200 maps can be stored in the system at one time although a serial interface to a notebook computer can be used to store and retrieve more maps offline.

97. Communications between displays is implemented over a co-axial cable using ARCNET protocols.

Parameter Distribution Systems

98. In order to send the various types of information from navigation sensors to all the equipment that needs that information, various distribution and conversion equipment is employed.

Main Internal Communications (IC) Switchboard

Reference

a. ABR 6821

99. The Main IC SWBD is located in the IC & Gyro compartment. It provides power distribution to various units of the navigation and weapon control systems. In addition, the switchboard also provides Action Cut Out (ACO) switching for own-ship functions and intersion communications and alarm circuits.

100. The Main IC SWBD comprises two main sections:

a. Section A (distribution section);

b. and Section B (ACO Section).

Height:	70.75 inches
Depth:	26 inches
Width:	43 inches
Weight:	810 pounds
Power Dissipation:	75 watts

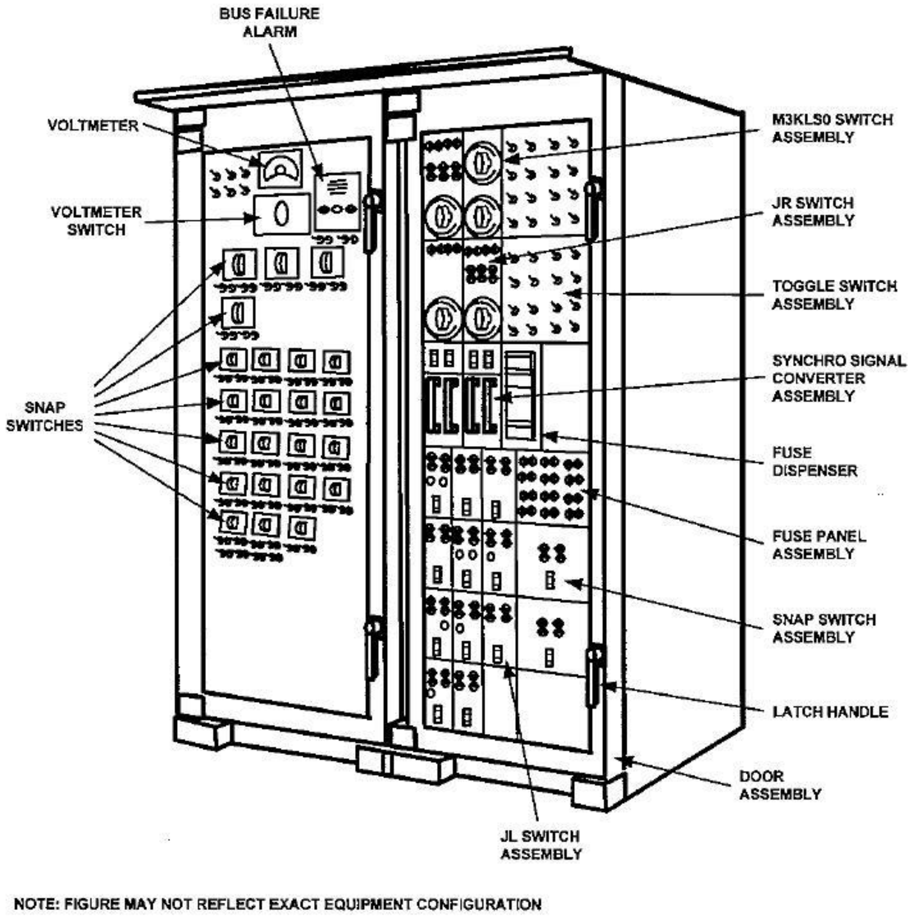


Figure 2-13: Main IC SWBD

Functions

Power Distribution (Section A)

101. Section A (Distribution Unit) receives:

a. 115V 60 Hz 3ϕ power from power panel 2-91-4, fed from a bank of three 450/120V 60Hz transformers.

b. 115V 400 Hz 3ϕ power from power panel 2-91-2, fed from a bank of three 450/120V 400Hz transformers.

102. This power is distributed to the metering circuits, bus failure alarm circuits, and appropriate distribution switches.

Synchro Switching

103. Section B (ACO Section) provides synchro data routing, synchro signal amplification, and ACO switching. The switches route synchro and status signals through the switchboard during normal operation, and can interrupt or redirect signal flow as required for test and maintenance.

104. Synchro signals from the WSN-7B Gyro, EM-Log, and WS&D anemometers are initially switched through the Main IC Swbd before either going direct to indicators and equipment or undergoing SSA amplification and further switching via the Combat System IC SWBD.

105. Gyro data is distributed via the ‘Normal’ and ‘Critical’ busses. The critical bus supplies the Ship Control Console (SCC) on the bridge, and the gyro repeat in aft steering. The normal bus is provided to the CS IC SWBD for distribution. This can be seen in the parameter distribution diagrams at the end of this chpater.

Internal Communications Switching

106. Panel 203 of Section B provides switching control of ships Internal Communications.

Alarm Circuits (MC)

107. Panel 206 of Section B provides switching control of ships Alarm Circuits. Alarm signals (circuit MC) provide various control stations with the capability of actuating chemical attack, collision, general and flight crash alarms.

Bus failure Alarm

108. The Bus Failure Alarm Assembly provides visual indication upon loss of either 60Hz or 400Hz power. A battery operated alarm gives an audible signal when power is lost.

109. The purpose of the Gyro Alarm system is to both alert watch keeping stations (Bridge, RICER, DCC, and OOD Stations) of a problem and also to alert equipment that relies on the signals of error conditions. For instance SPS-49 is alerted of a problem with either Gyro, or SSA #5 or #6 (Pitch & Roll) because ship's heading information is required to convert relative antenna bearing to true antenna bearing and Pitch & Roll information is required for antenna stabilisation.

Combat System IC (CSIC) Switchboard

Reference

a. ABR 6822

110. The CS IC switchboard consists of two cabinets, A & B, located in the forward end of the RICER to the starboard side of the Combat System Switchboard (CSSB)

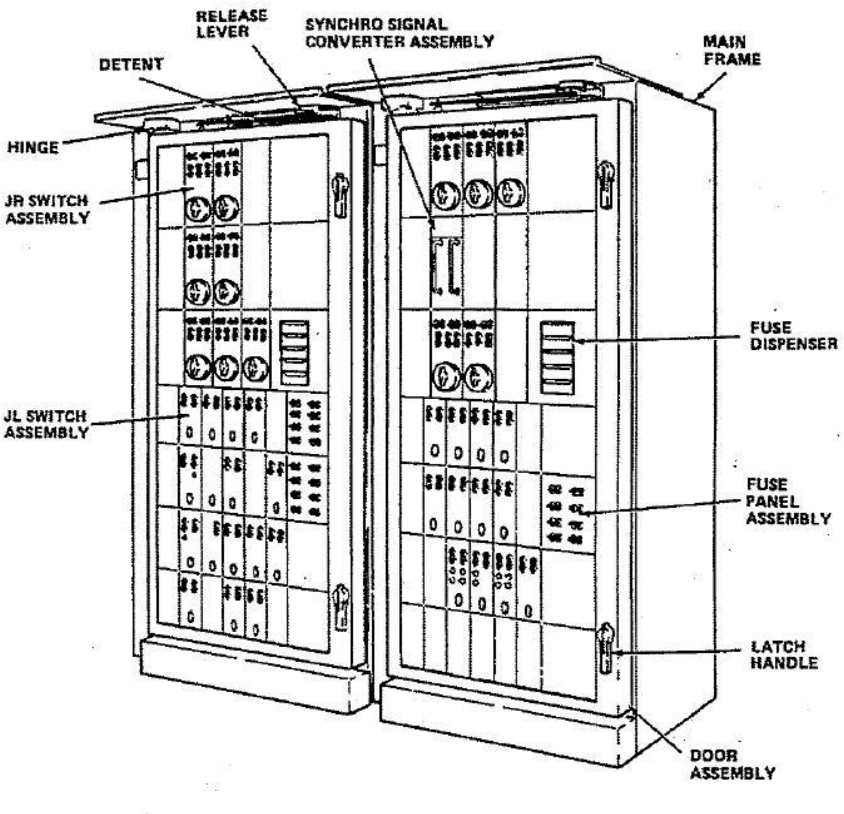
(a) Height: 70.75 inches (179.5 cm)

(b) Depth: 26 inches (66 cm)

(c) Width: 64 inches (162.5 cm)

(d) Weight: 900 pounds (408 kg)

(e) Heat Dissipation: 150 watts



Note: Figure may not reflect exact configuration

Figure 2-14: CS IC SWBD

111. The CS IC Switchboard provides interface switching for synchro signals from the Gyrocompass 'Normal' Bus, Wind speed & direction System, and Underwater Log System to various units of the navigation and weapons control systems.

112. The CS IC Switchboard provides:

a. Equipment Selection

b. Equipment Isolation

c. Fuse Protection

d. Synchro Signal Amplification

Servo Synchro Amplifiers Types E & F

Reference: SN305-AB-MMA-010

General

113. Synchro Signal Amplifiers (SSA) are used to amplify, and in some case convert from relative to true (resolve), signals that are in synchro format. SSAs can produce outputs in 60Hz and/or 400Hz as required. Six Type F, non-resolving, SSAs are used to amplify AN/WSN-7 Gyro information for use throughout the Combat System. Two Type E resolving SSAs are used to convert AN/SPS-49 and AN/SPS-55 antenna train information from relative to true bearing format.

114. The SSAs are all located in the RICER. The table below lists the purpose of each of the SSAs:

Type F SSAs		
No	**Purpose**	**Outputs**
1	Receive 400Hz Cqo (heading) from WSN-7	400Hz Cqo as Control Bus No1
2	Receive 400Hz Cqo (heading) from WSN-7	400Hz Cqo as Control Bus No2
3	Receive 400Hz Cqo (heading) from WSN-7	60Hz Cqo as Torque Bus No1
4	Receive 400Hz Cqo (heading) from WSN-7	60Hz Cqo as Torque Bus No2
5	Receive 400Hz Zdo (roll) from WSN-7	400Hz & 60Hz Zdo Roll Bus
6	Receive 400Hz Eio (pitch) from WSN-7	400Hz & 60Hz Eio Pitch Bus
Type E SSAs		
No	**Purpose**	**Outputs**
1	Receive 60Hz θs (relative bearing) from SPS-55	60Hz θ's (true bearing) – SPS-55
2	Receive 60Hz θs (relative bearing) from SPS-49	60Hz θ's (true bearing) – SPS-49

Table 5: SSA Type E & F – Purposes & Outputs

Operation

115. Each of the SSAs is similar in operation and appearance. The front panel includes:

a. fusing,

b. lamps indicating that excitation power is available and that the output is following the input within approximately 2.5 ,

c. alarm on/off switch, and

d. roll, pitch or heading dial window (as appropriate).

116. The SSA will output an alarm signal if the output fails to follow the input within tolerance or if one of the excitation supplies is lost. The alarm can be switched off with the front panel switch.

Signal Data Converter (SDC) CV-2953A

Reference: NAVSEA 0967-LP-581-9010 & 9020

General

117. The Signal Data Converter provides Analogue to Digital conversion input facilities for the ADS servers and AN/UYK-43 Computer.

System Inputs

118. The CV-2953A receives the following inputs from the ship:

a. Power (both power inputs are essential for operation)

i. 115V 60 Hz 1ϕ primary power, and

ii. 115V 400 Hz 3ϕ primary power.

b. Radar North Crossing pulses from the RADDS PDT decoder (Enclosure #7) associated with the following radars:

i. SPS-49,

ii. SPS-55, and

iii. Mk 92 CAS.

c. Own Ship's Parameters from the WSN-7 gyro, EM log, and anemometers:

i. Heading (Cqo),

ii. Pitch (Eio),

iii. Roll (Zdo),

iv. Speed (Dmho),

v. Wind Speed (Wha), and

vi. Wind Direction (Bwda).

System Outputs

119. Converted digital signal outputs for the above Radar North Crossings and Own Ship Parameters are provided to the ADS servers on NTDS Slow channels, and can be switched via the CSSB to provide the AN/UYK-43.

Description

120. The CV-2953A is designed to be able to interface with two computers on a time share basis and therefore has two computer channels, designated A and B. Operationally, these are connected to each of the ADS Servers (interface 105), however they can be switched to provide each IOC of the AN/UYK-43 (interface 160) when the Mk92 system is in 'Local' mode. For a visual representation of this interface switching, see the CSSB Cabinet B diagram in this manual, or ABR 6509 Section 10 Figure 1-1.

Operation

121. The ADACS or WCP program requests conversions of particular parameters by sending the SDC a request for a conversion on the "channel" to which that parameter is input in the form of an Output Data word. On completion of the conversion, the SDC responds with an Input Data word to ADACS/WCP.

122. For Digital Data Indicator (DDI) channels with data such as North Crossings, presence of the signal results in the SDC raising an interrupt to the ADS Server / UYK-43 computer alerting it of the signal presence.

Conversion Capabilities

123. The CV-2953A is capable of the following conversion types:

a. Analogue (synchro) voltages to digital word (used operationally for ship's parameters).

b. Digital word to analogue synchro voltages (not used operationally, only for End-Around testing).

c. Demand Digital (not used operationally).

d. Demand Digital Interrupt (used operationally for radar North Crossings).

e. Ready Digital (not used operationally, only for End-Around testing).

f. Logical Input (not used operationally)

g. Logical Output (not used operationally).

Testing

124. Virtually all testing of the CV-2953A is End-Around. This may be either via the computer driven POFA, or "locally" using the front panel of the CV-2953A. In either case, a digital word is input to the CV-2953, which then converts it to the corresponding analog value. This analog value is then sent, via internal end-around busses, to the corresponding circuitry for the inverse conversion where it is converted back to a digital word. This is then compared with the original one.

125. Analysis of CV-2953A faults is by signal chasing, using the circuit diagrams, CRO, and logic probe; usually during "local" operation. Faults (usually) cannot be analysed whilst the unit is operational. A detailed knowledge of the theory of CV-2953A operation is necessary for successful fault finding.

Parameter Distribution Diagrams

126. There are two parameter distribution diagrams on the following pages.

127. The first diagram depicts the following gyro distribution information:

a. Digital Data from AN/WSN-7 to computers

b. Synchro data from either WSN-7 or the Mk27 via the:

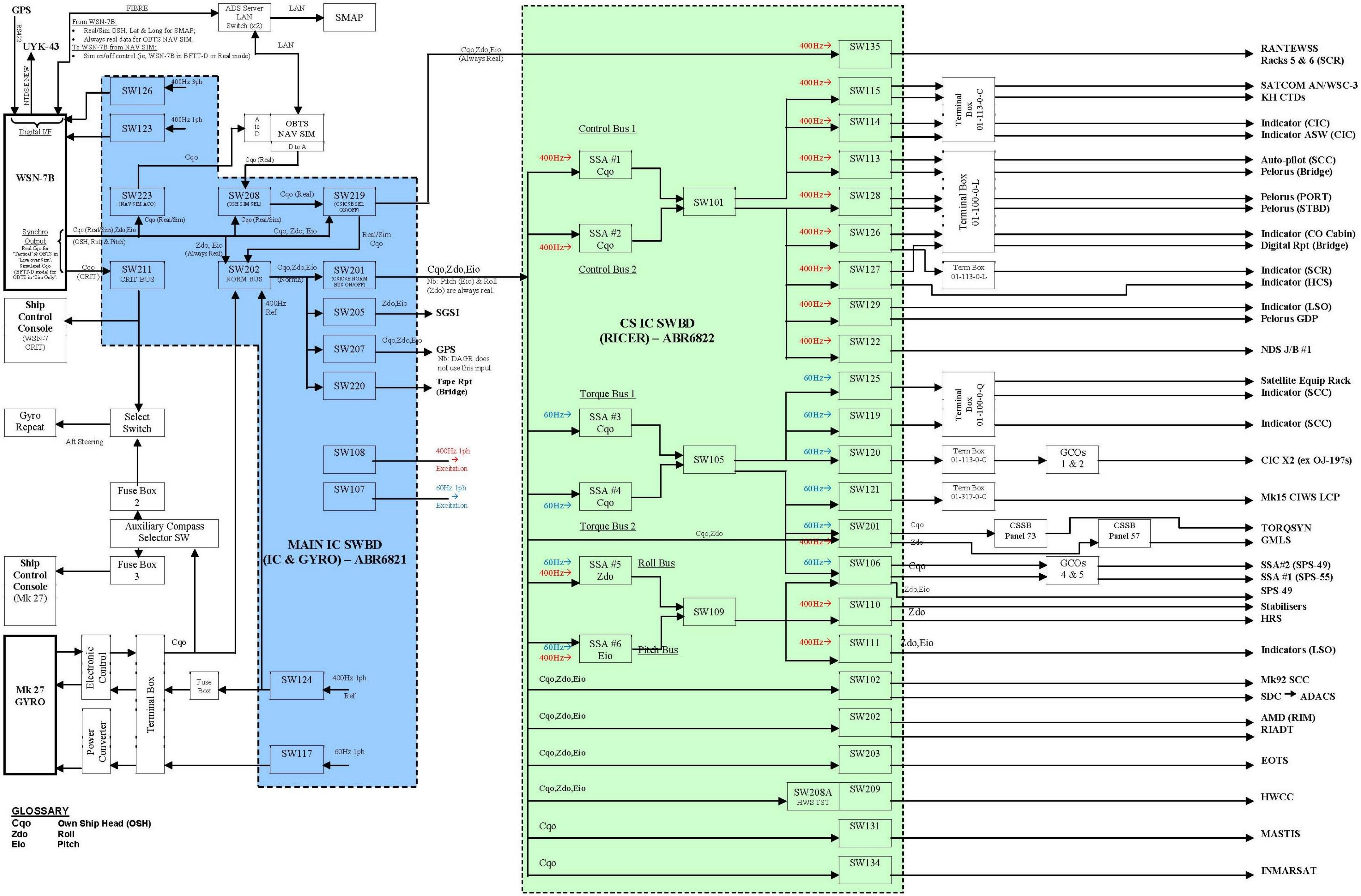
i. Main IC SWBD

1). Critical Bus

2). Normal Bus

ii. Normal Bus distribution and Amplification via the CS IC SWBD & SSAs.

128. The second diagram depicts synchro EM LOG and Anemometer distribution through the Main IC SWBD and the CS IC SWBD.



GLOSSARY

Cqo	Own Ship Head (OSH)
Zdo	Roll
Eio	Pitch

Figure 2-15: FFG Gyro Parameter Distribution

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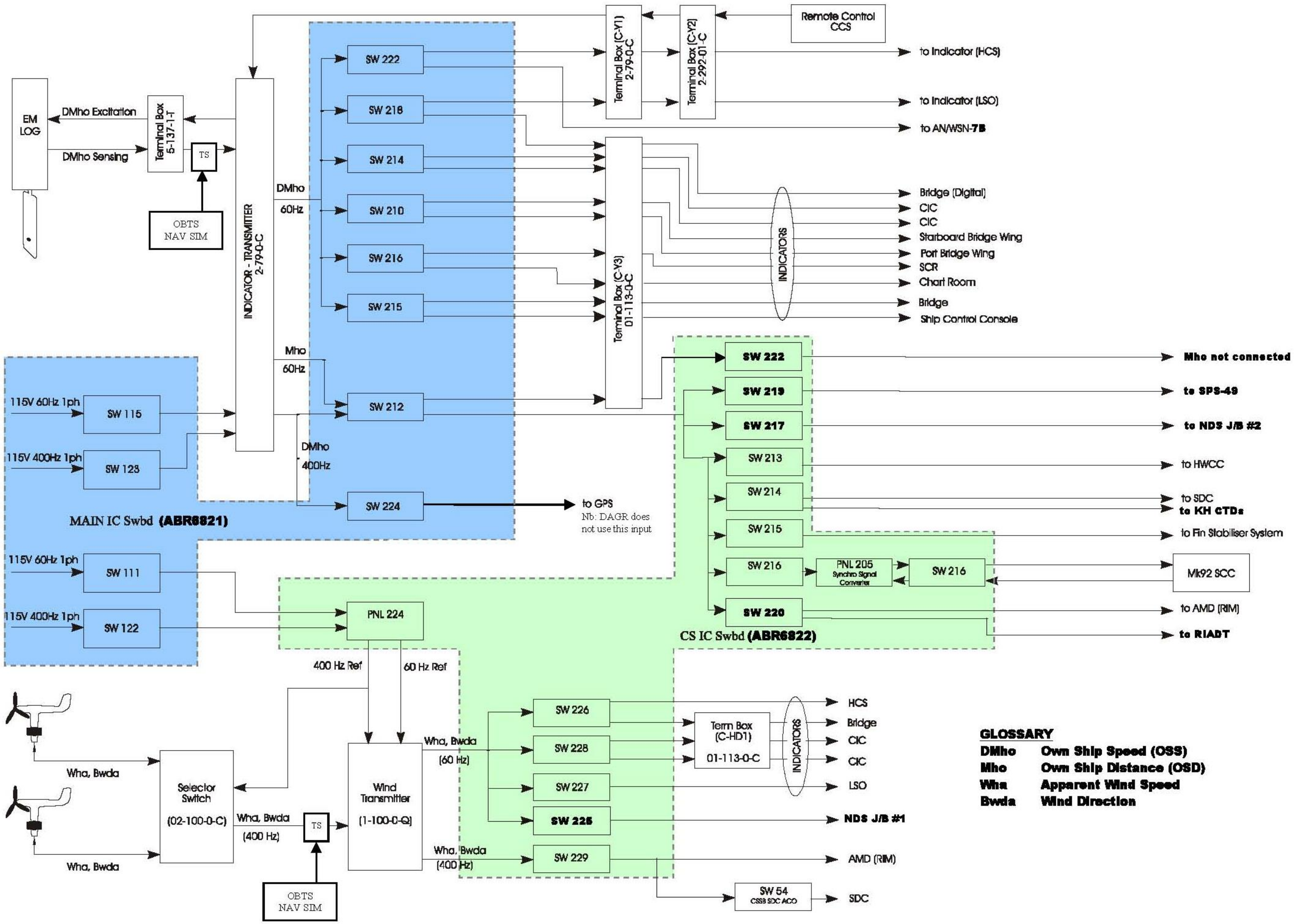

Figure 2-16: EM-LOG & Wind Parameter Distribution

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Chapter 3. External Communications Systems

Overview

1. The external communications system onboard RAN vessels is essential to provide to command:
    a. Real Time Communications with:
        i. Ship to Ship
        ii. Ship to Shore
        iii. Ship to Aircraft
    b. A medium in which to transfer tactical information:
        i. LINK 11;
        ii. LINK 16
    c. The ability of email / internet access;
        i. DRN/DSN Access
        ii. Personnel Management
        iii. Morale through access to “Quality Of Life” services
2. FFG shipborne communications systems are broken down into 2 parts:
    a. Terrestrial Communications Systems
        i. Voice
        ii. Data
        iii. Link
    b. Satellite Communication Systems
        i. Voice
        ii. Data

3. Terrestrial systems are conventional radio systems where the RF signal does not leave Earth’s atmosphere. These systems operate in the UHF, VHF and HF frequency spectrums.

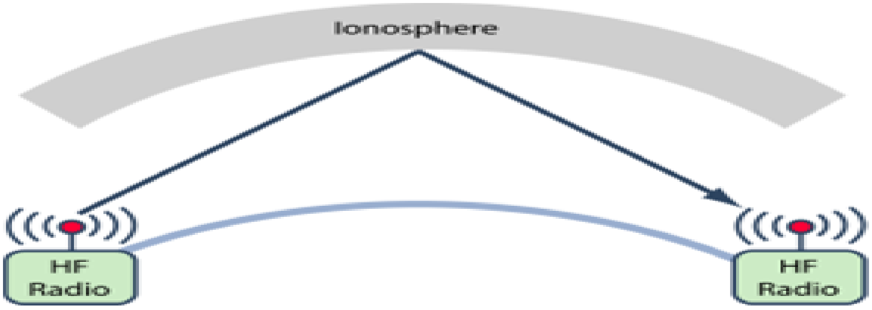

Figure 3-1: HF Radio Wave propagation

4. The satellite communication systems operate in UHF, Super High Frequencies (SHF) and Extremely High Frequencies (EHF).

5. A generic external communication system is outlined below:

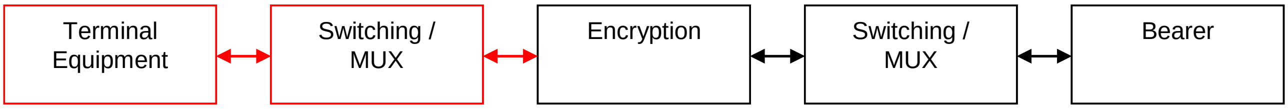

Figure 3-2: Generic External Communication System

6. The generic terms used to describe the external communications system are defined as follows:

Terminal Equipment

7. Terminal equipment generates information to be shared and/or uses information that has been received from external sources. The most basic example is a person who generates information via voice and listens to the returned voice signal.

8. Terminal Equipment on the FFG includes:

a. Voice (via VCS-945C);

b. LS-474 speakers;

c. CDLMS (LINK-11 & LINK-16)

d. Helo Data Link (HDL)

e. Message handling System (MHS)

Switching & Multiplexing

9. Not all external communications systems undergo switching and multiplexing, but many do.

10. Switching is basically providing a path for the information to get between the bearer to the correct equipment to interpret and use that information. Generally a switching system will connect many bearers with many terminal systems.

11. Multiplexing (MUX) is taking a number of information streams that will use the same bearer, and interlacing them together in a pre-determined way so many terminal systems can ‘simultaneously’ use a single bearer. Both the sender and receiver of multiplexed information need to share the protocol for the multiplexing in order to de-multiplex the information legibly at the receiver’s end.

12. Switching system on the FFG include:

a. SB-863/SRT (Transmitter Switchboards)

b. SB-2727/SRR (Receiver switchboards)

c. ACX-5A (Secure Voice Switch)

d. ACX-51 (Secure Data Switch)

e. VCS-945C (Remote secure Voice Switches)

f. Various patch panels

g. MTWAN Common Router Network (CRN)

13. Multiplexors employed on the FFG include:

a. AN/USQ-122 HDRCE (High Data Rate Communications Equipment);

b. MTWAN Common Router Network (CRN)

Cryptographic Equipment

14. Classified information is referred to as ‘**Red**’. Equipment that processes or transports red information is often physically coloured red.

15. ‘**Black**’ information does not pose a security threat through inadvertent disclosure.

16. All bearers are considered black, so red information must be encrypted before being supplied to a bearer for transmission. Cryptographic equipment encodes and decodes information such that it is unintelligible should an unintended recipient manage to receive/intercept a bearer transmission.

17. The Red Rack is used to house equipment where classified information is processed in plain language. Red rack equipment and cabling is specially shielded and uses filtered power supplies to eliminate the risk of coupling classified information into other lines which might result in inadvertent disclosure of the information.

18. The **Black Rack** is used to house equipment where information being processed/transferred has either been secured by cryptographic equipment, or is not classified and will be transmitted in plain language.

19. Cryptographic equipment on the FFG includes:

a. KY-58 (VHF/UHF voice encryption)

b. ANDVT (HF/UHF voice encryption)

c. KG-84C (HF/UHF Data)

d. KWR-46 (HF Data Receive only)

e. KG-40 (LINK-11 data encryption)

f. JTIDS (LINK-16 data encryption)

g. TACLANE (IP data encryption)

Bearers

20. A 'Bearer' is a system that allows transmission of information signals between units / network interfaces. A bearer transmits the signal through a medium. The medium may be solid such as copper or optical fibre, or it may be through the air within a specific frequency range. Most bearers on the FFG are through the air since the FFG is not a fixed platform.

21. Radio Frequency (RF) bearers generally have the following generic structure:

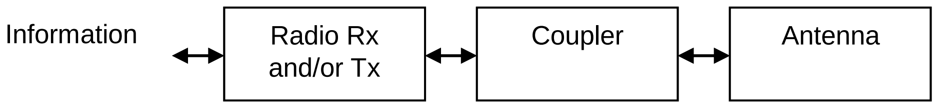

Figure 3-3: Generic Legacy Bearer Components

22. The **Radio Transmitter** converts voice and/or data into an oscillating Radio Frequency electric current. The **Radio Receiver** does the opposite and amplifies the received signal.

23. An **Antenna Coupler** is a device used to match the impedance of a transmitter or receiver to an antenna to provide maximum power transfer. This can be achieved by adjusting the electrical length of the antenna. Some couplers also allow multiple radios to connect to an antenna.

24. A transmitting **Antenna** radiates the energy from the RF current as electromagnetic radio waves. A receiving antenna intercepts some of the power of an electromagnetic wave to produce a tiny voltage. This signal is amplified by the radio receiver. Any antenna in the path of that electromagnetic wave could potentially intercept the signal, which is why bearers are considered 'black'.

25. Bearers can be described as either **'Strategic'** or **'Tactical'**. As a general (Naval) rule of thumb, strategic bearers provide communication between ship and shore establishments (ie to strategic command), whereas tactical bearers are generally ship-to-ship and are usually non-satellite Line Of Sight (LOS). The bearers on the FFG include:

a. Satellite/Strategic Bearers:

i. ASTIS-MCE (MASTIS);

ii. INMARSAT;

iii. Fleet Broad Band Sailor 500;

iv. MILSATCOM UHF:

1). DAMA; and

2). Non-DAMA.

v. Mini-M.

b. LOS and non-satellite (generally tactical) bearers:

i. High Frequency (HF). 3MHz – 30 MHz. Although HF can provide ship to shore communication far beyond the LOS, it is increasingly becoming labelled a tactical bearer, probably due to the low data rates compared with current satellite based strategic bearers. Information relayed via HF bearers includes:

1). Radio Automatic Teletype (RATT);

2). HF IP;

3). VOICE; and

4). LINK11.

ii. Very high Frequency (VHF). 30MHz – 300MHz. Information relayed via VHF bearers includes:

1). Voice, including the Global Maritime Distress Safety System (GMDSS); and

2). Next G.

iii. Ultra High Frequency (UHF). 300MHz – 3GHz. Information relayed via UHF bearers include:

1). RATT;

2). VOICE;

3). LINK11 & 16;

4). Subnet Relay (SNR); and

c. When units are alongside a fleet base they are provided additional strategic bearers including:

i. PSTN;

ii. NINSHORE Fibre Optic; and

iii. NINSHORE Wireless.

FFG External Communications System Diagrams

26. The two diagrams over the page (fold out) depict:

a. the FFG External Communication Systems including MTWAN components;

b. FFG Antenna Locations.

27. More detailed explanations of these systems are provided later in this chapter.

28. In support of the FFG Antenna Locations diagram, below is a brief description of numbered External Comms Antennas.

AntennaNº	Description
1-1	Twin whip assembly 1-1 comprises two 35ft whip antennas AS-2537A. The assembly is used to receive over a frequency range of 2-30 MHz but can be used as a radiating element after modification of the associated tuner. Six interconnected copper strips laminated inside the fibreglass casing of each whip serve as the electrical elements. A corona shield is integral to the top section of each antenna. Twin whip assembly 1-1 can be coupled to enable LF signal reception.
1-3 1-4	Two 5ft horizontal whip antennas AS-1857, P/O the SRA-43 Antenna Group, receive over a frequency range of 2-8 MHz. A 10 gauge half-hard beryllium copper rod, supported within the fibreglass enclosure of each whip, is the conducting element. An RF Tuner TN-438 is mounted with each whip.
2-1	The Lightweight Broadband HF Communications Antenna (LWCA) or 'HF fan' consists of two vertical fan structures constructed of bronze wire rope. The two fan structures are fed in parallel and form a single antenna. LWCA can be use for both HF transmission (2-6 MHz) and reception (2-30 MHz).
2-2 2-3 2-4 2-5	Four 35ft whip antennas AS-2537A, identical in construction to those that form 1-1, enables HF transmit operations over the 2-30 MHz frequency range. In order to clear safe firing zones for both the Mk 75 Gun and Mk 15 CIWS, the antennas can be lowered outboard to an orientation approximately 5° below horizontal[1].
3-1 3-3 3-4	Three transmit/receive antennas AS-1735 'BBQ plates' provide omnidirectional, vertically polarised azimuth coverage over the UHF frequency range of 225-400 MHz. Each antenna consists of four centre-fed planar arrays.
3-6	NT-66095(mod) IMMB VHF dipole antenna dedicated to the bridge ICOM-120 transceiver.
3-7 3-8 3-9	Three HX-101 VHF RAVEN Antennas
5-1A 5-1B	Two azimuth stabilised transmit/receive antennas, AS-3018A, part of the OE-82C antenna group, each with an associated RF Amplifier, are used with Fleet SATCOM systems. Antenna Control C-9597A receives a *Cqo* input to enable azimuth stabilisation.

Table 6: External Communications Antenna Numbering

1 Note that the lowering/raising operation is manual, and requires full man-aloft safety procedures including RADHAZ and safety harnesses.

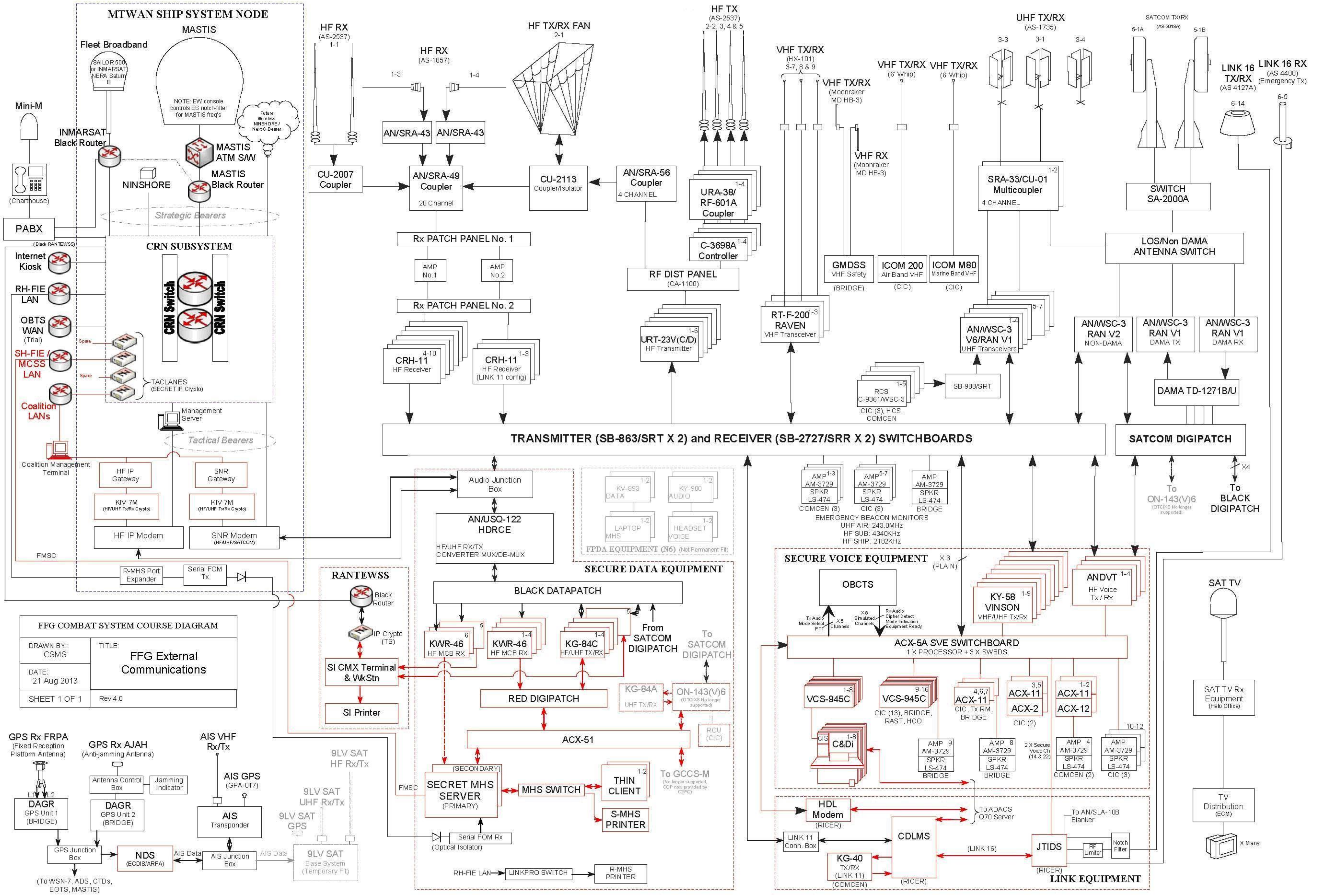

Figure 3-4: FFG External Communications System

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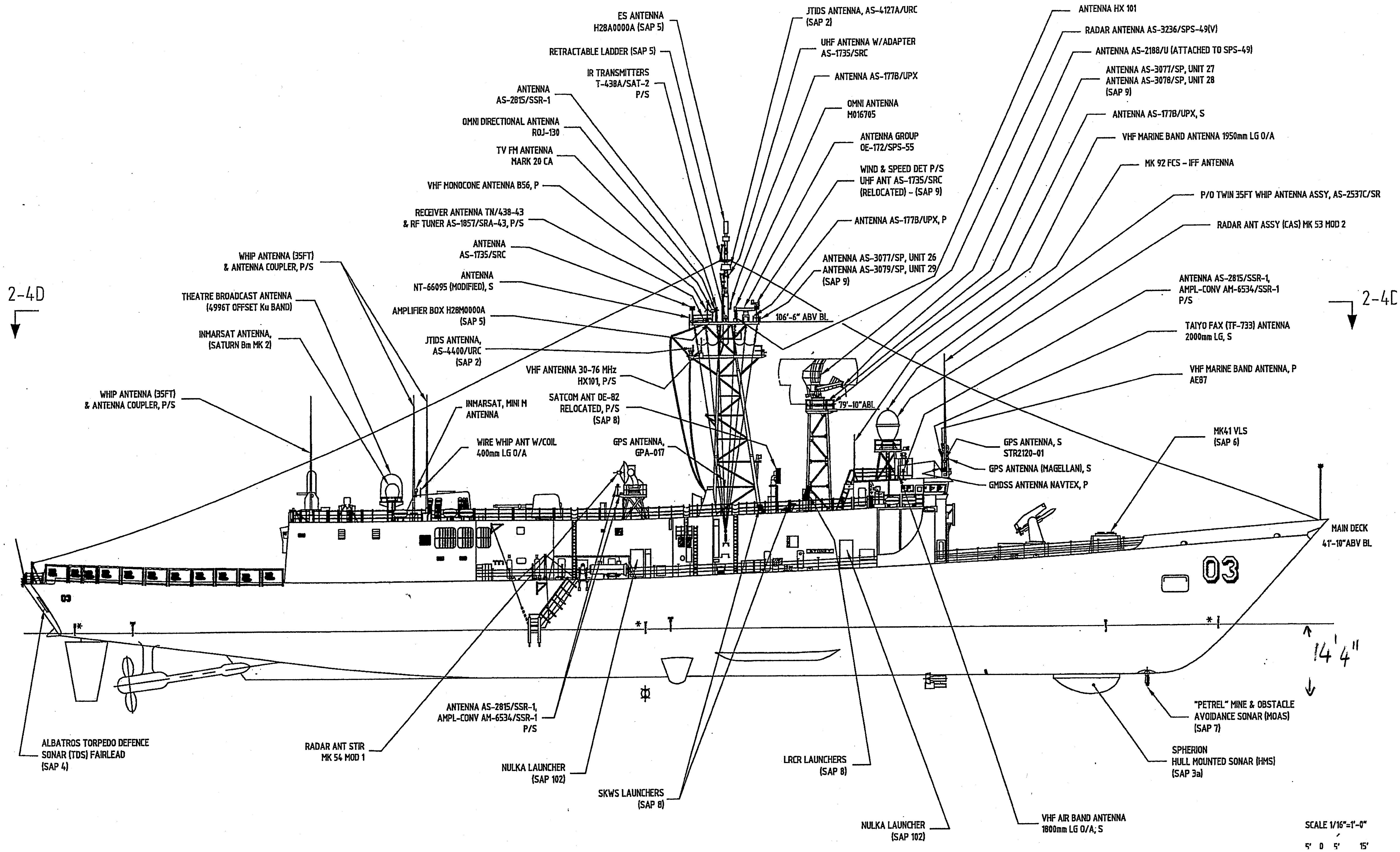

Figure 3-5: FFG Antenna Locations

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Tactical Bearers

29. Tactical bearers are generally LOS ship-to-ship communications. These include VHF & UHF, although HF is increasingly becoming recognised as a tactical bearer as high speed satellite systems make HF the poor-cousin of strategic bearers.

30. The Sub Net Relay (SNR) and HF IP are tactical bearers, but are described later in the MTWAN section of this chapter.

UHF

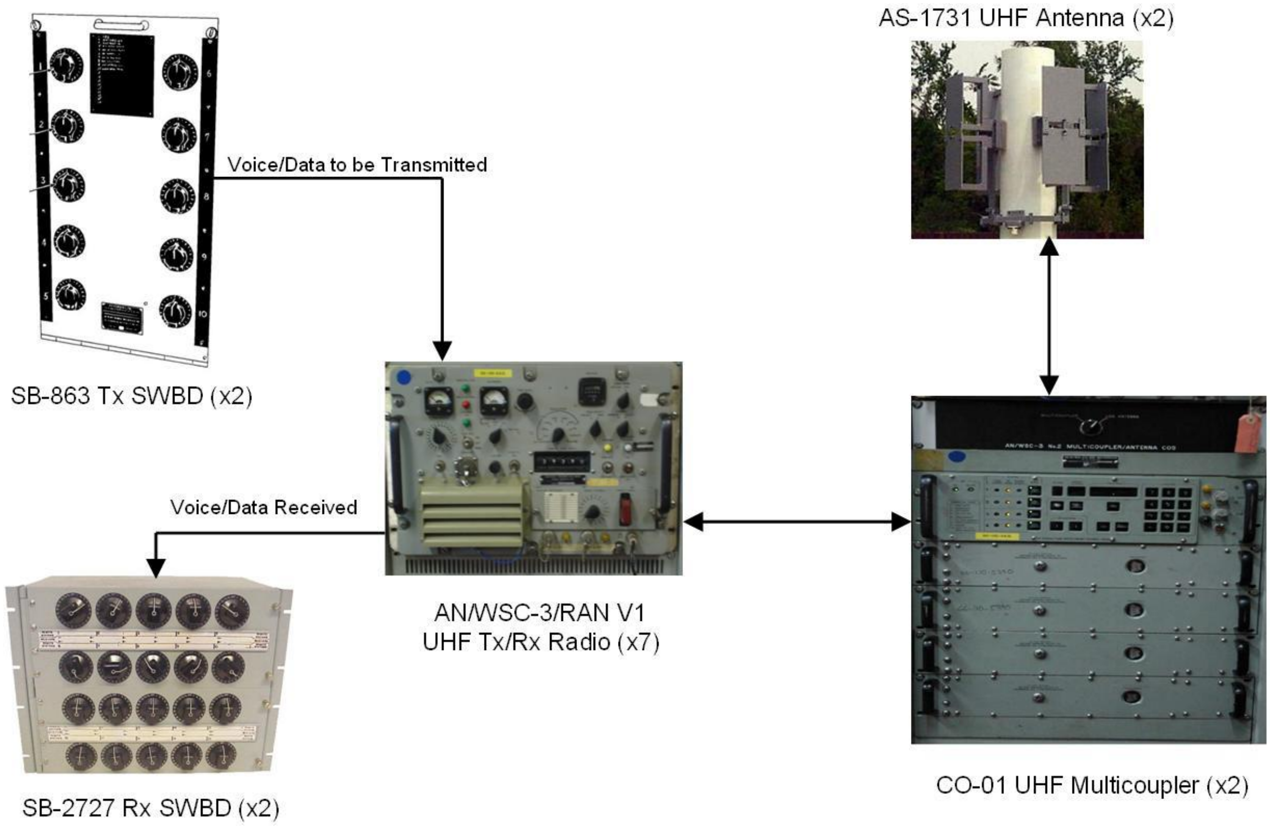

Figure 3-6:UHF LOS Tactical Bearer

AN/WSC-3 UHF Radio

31. The AN/WSC-3 (RAN V2) is used throughout the fleet in either the Satellite Communications System or for LOS Data or Voice Communications. There are ten WSC-3s in an FFG COMCEN, two are reserved for use for MILSATCOM DAMA, and one for non-DAMA MILSATCOM.

32. The WSC-3 operates in the UHF Band, frequencies are able to be set in 25 KHz steps. The WSC-3 interfaces with a Multicoupler system with each Multicoupler capable of storing 20 Pre Programmable channels.

33. The AN/WSC3 is utilised for the following:

a. DAMA (Demand Assigned Multiple Access)

b. Non-DAMA (single channel satellite access utilising differing uplink/downlink frequencies with one WSC3)

c. LOS (Line Of Sight) UHF operations

34. The capabilities of the WSC-3 are as follows:

a. Frequency range. 225Mhz – 399.975 MHz

b. Power output. 0 to 100w (Max only when used in FM Mode)

35. Modes of Emission:

a. AMBB - (Amplitude Modulation Baseband). Normal mode for LOS operation (with ships/rotary wing aircraft i.e. helicopters)

b. AMDP - (Amplitude Modulation Diphase). Normal mode for LOS operation (with fast moving aircraft i.e. FA18)

c. FM – Frequency Modulation. Used to Listen to Data in PSK Mode, used to receive Link 11, Allows the operator to hear and audibly monitor the receive transmission for DAMA

d. PSK – (Phase Shift Keying). Used when receiving Data that is being modulated by Phase Shift Keying. Also allows different Baud Rate selection

e. External Modem. EXT MODEM Allows the transmit WSC3 to be driven from an external source. (i.e. TD1271).

UHF Multicoupler & Antenna

36. Two CU-01 digital multicouplers (AN/SRA-33 on FFG03) couple RF between two AS-1735 “BBQ Plate” antennas (3-3) and (3-4) and the seven LOS (non MILSATCOM) WSC-3 transceivers. There is a third AS-1735 antenna (3-1) which is spare, or can be connected directly to a single WSC-3.

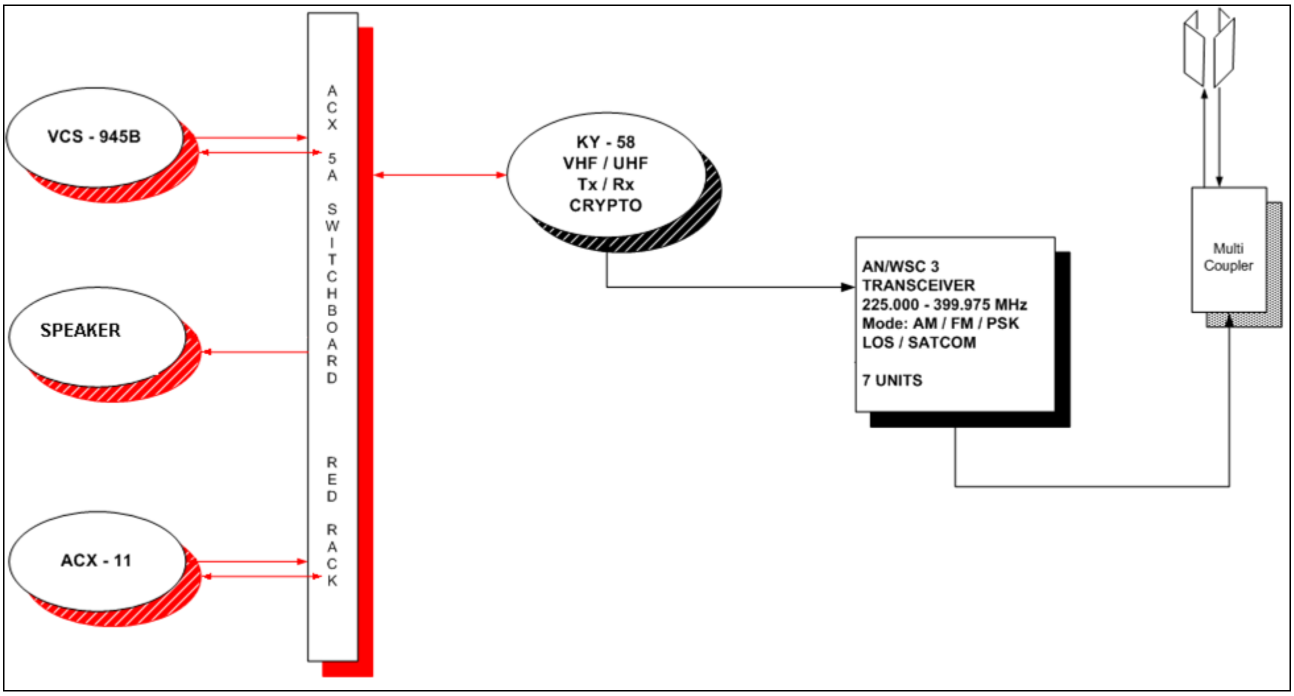

Figure 3-7: UHF Voice Signal Path

VHF

37. FFG VHF tactical bearers include:

a. There are three RT-F200 'RAVEN' VHF transceivers (30-75MHz). Each RT-F200 is coupled to its own dedicated HX-101 6' Whip Antenna, labelled 3-7 through 3-9. Two of these antennas (3-7 & 3-8) are located on the main mast 96ft 'T' platform, and 3-9 is on the 106ft 'H' Platform. Each RT-F200 has an ACX-88 interface unit to the Transmit and Receive switchboards.

b. Global Maritime Distress & Safety System (GMDSS), is a stand alone SOLAS requirement which allows VHF Digital Selective Calling (DSC);

i. The GMDSS uses two Moonraker MD HB-3 antennas. Exact locations vary on FFGs, some are on the GDP, some are on the main mast.

c. ICOM 200 VHF Air band radio (118-136.975MHz Tx/Rx);

i. The dedicated antenna location varies between FFGs, but is usually at the aft end of the GDP.

d. ICOM IC-M80 VHF Marine band radio (156-157.5MHz Tx, 156-163MHz Rx) has been replaced on most FFGs by GMDSS.

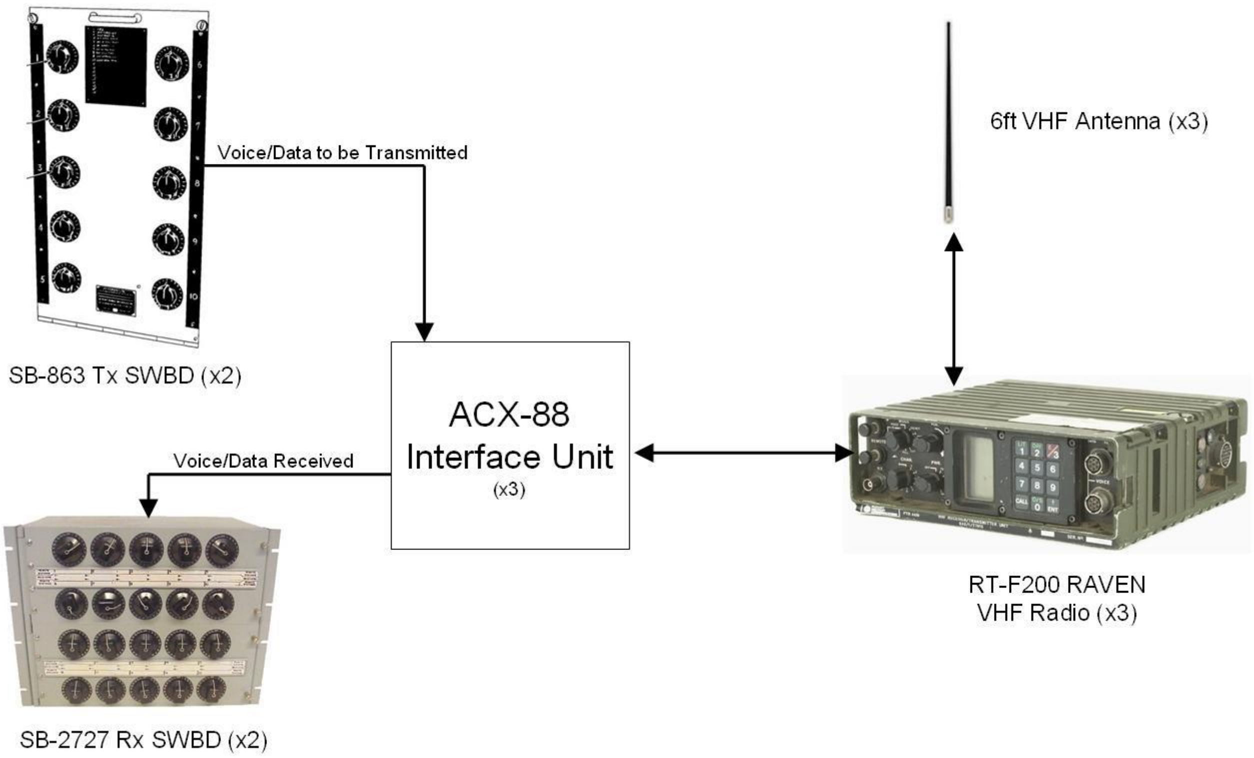

Figure 3-8:VHF Raven Tactical Bearer

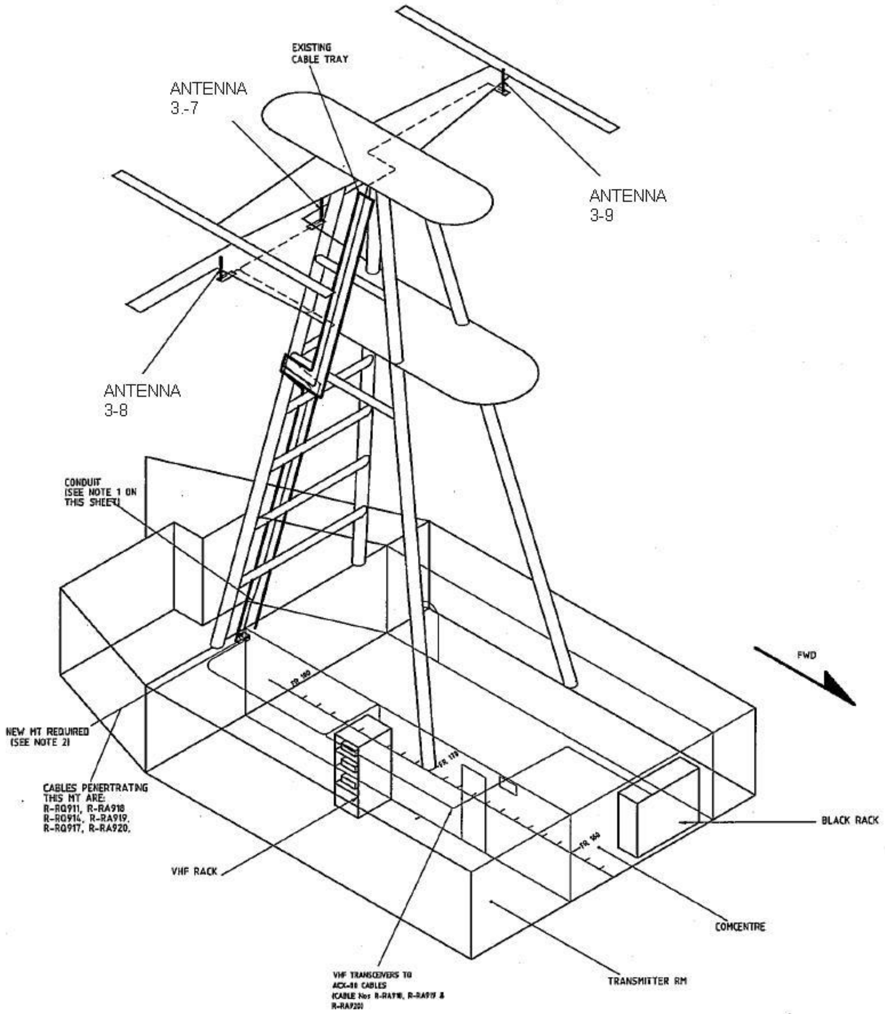

Figure 3-9: VHF RAVEN Antenna Position

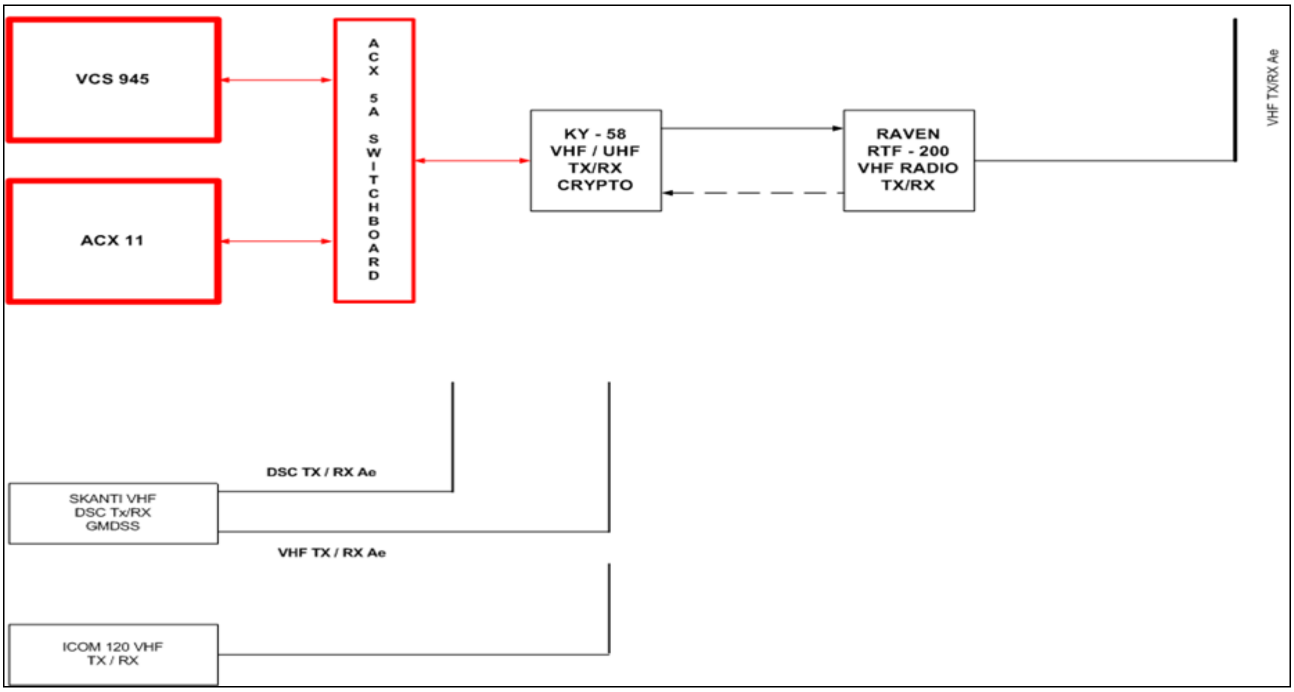

Figure 3-10: VHF Voice Signal Path

Strategic Bearers

38. Strategic bearers are generally BLOS ship-to-shore (strategic command) communications. These consist mainly of satellite systems, but technically include HF comms.

HF

39. Although HF can provide ship to shore communication beyond the LOS, it is increasingly becoming labelled a tactical bearer, probably due to the low data rates compared with other strategic bearers.

HF Receive

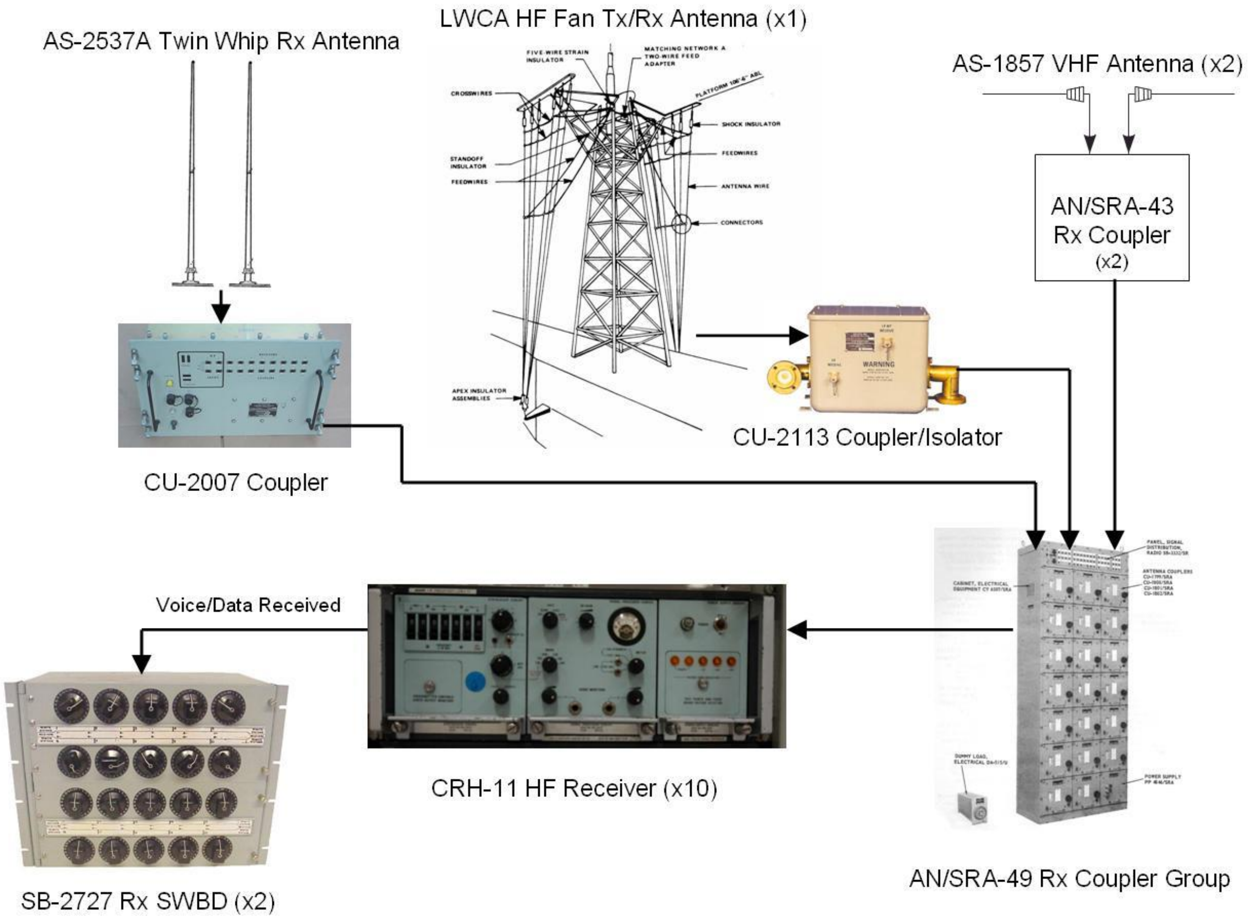

Figure 3-11: HF Receive Bearers

40. There are multiple HF receive antenna options:

a. RF received from Twin whip assembly (1-1) is distributed by Multicoupler CU-2007 to the AN/SRA-49 Multicoupler;

b. RF received from the LWCA (HF Fan) (2-1) is distributed by Coupler-Isolator CU-2113 to the AN/SRA-49 Coupler.

c. RF received from the Horizontal Whips (1-3 & 1-4) is distributed by Coupler AN/SRA-43 to the AN/SRA-49 Coupler.

41. The SRA-49 Multicoupler distributes the inputs from the CU-2007, CU-2113 and AN/SRA-43 couplers to the Antenna Patch Panel. The Antenna Patch Panel can accept up to ten inputs from the SRA-49. The received RF can then be patched through the Receiver Patch Panel to one of ten CRH-11 receivers.

42. The CRH-11 is a HF General Purpose Receiver using the 2-29.999 MHz band. The receiver may be used for the reception of ISB/SSB/AM/CW/FSK/DATA/Fax and High-Speed Data signals

43. The FFG COMCEN has ten CRH-11 receivers, three of which are configured for LINK-11 use.

HF Transmit

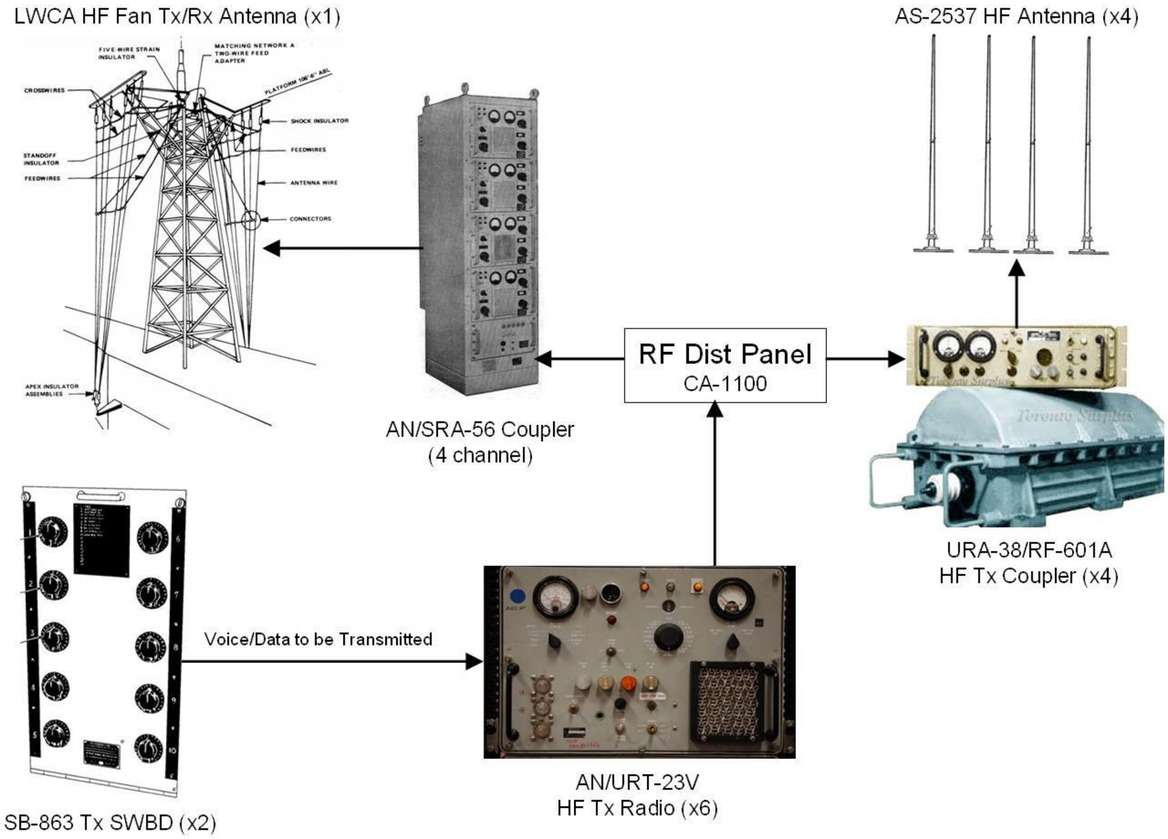

Figure 3-12: HF Transmit Bearers

44. A CA-1100 RF distribution panel interfaces the URT-23V transmitters with the;

a. SRA-56 Multicoupler,

b. URA-38 Antenna Group (No 1, 2, 3 & 4),

c. DA-242A Dummy Load

45. The SRA-56 Multicoupler accepts up to four RF inputs and combines them into a single RF output which is routed to the LWCA (2-1) via the CU-2113 Coupler-Isolator.

46. Four URA-38A Coupler Groups provide tuned RF outputs to respective HF transmit whip antennas (2-2), (2-3), (2-4) and (2-5).

47. The AN/URT23V is a high frequency transmitter using the 2-30MHz band (restricted to 2-6MHz if using the LWCA (HF fan antenna). The URT-23 is capable of transmission of HF Voice and data communications from fleet units via tactical communications and information exchange systems. The 23V has the capability to operate with power outputs up to 1KW, we are however limited by occupational RADHAZ levels to restrict the maximum power output of the 23V to 150 Watts except in exceptional circumstances.

48. The FFG has six AN/URT-23Vs in the COMCEN.

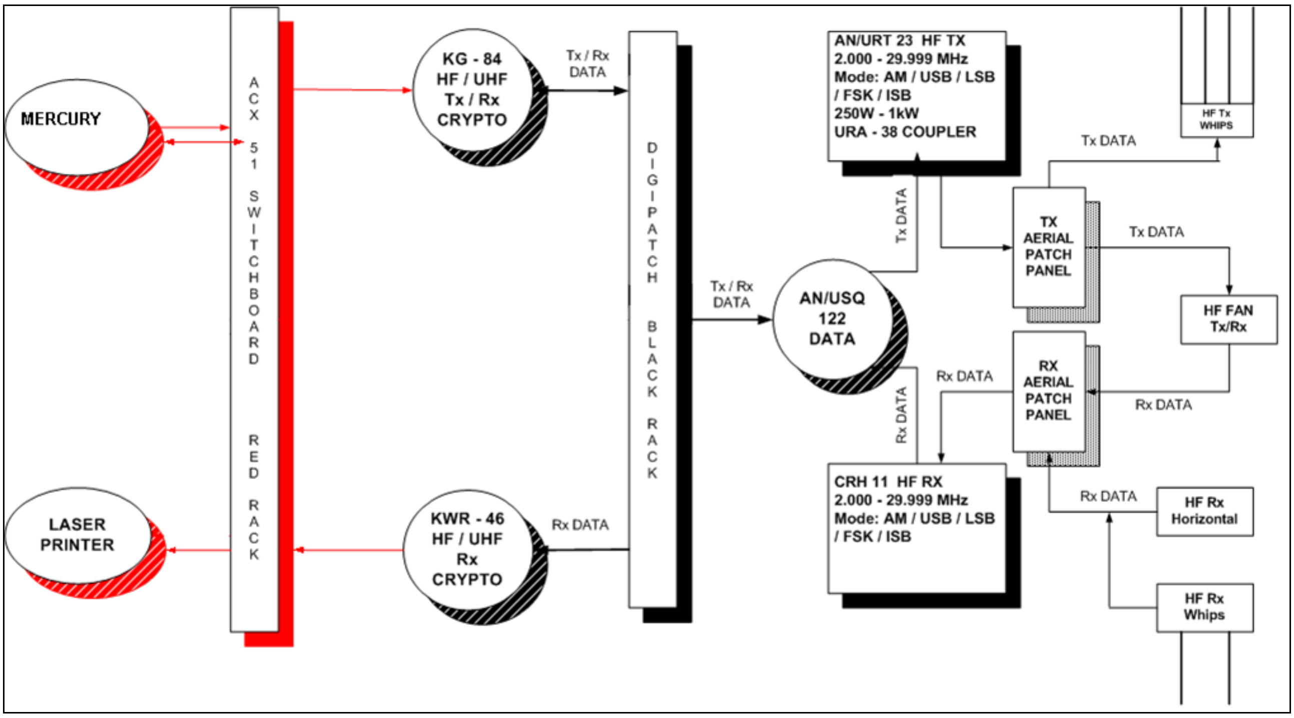

Figure 3-13: HF Data Signal Flow

UHF MILSATCOM

49. Two AS-3018A antennas provide an azimuth stabilised Satellite transmit/receive capability. These antennas form part of the OE-82C/WSC-3 Antenna Group, the other units being Switching Unit (SA-2000), Bandpass Amplifier-Filter (AM-6691) and Antenna Control (C-9597).

50. Up to four SATCOM channels can be routed to and from Antenna Group OE-82C through a system comprising an Antenna Switch, UHF Demand Assignment Multiple Access (DAMA) Subsystem, SATCOM DIGIPATCH and DIGIPATCH #1/#2 (Black). Two designated transmit and receive WSC-3 (LOS) transceivers are utilised.

51. Information can also be Tx/Rx via a single (non-DAMA) WSC-3 for ship-to-shore or ship-to-ship (BLOS).

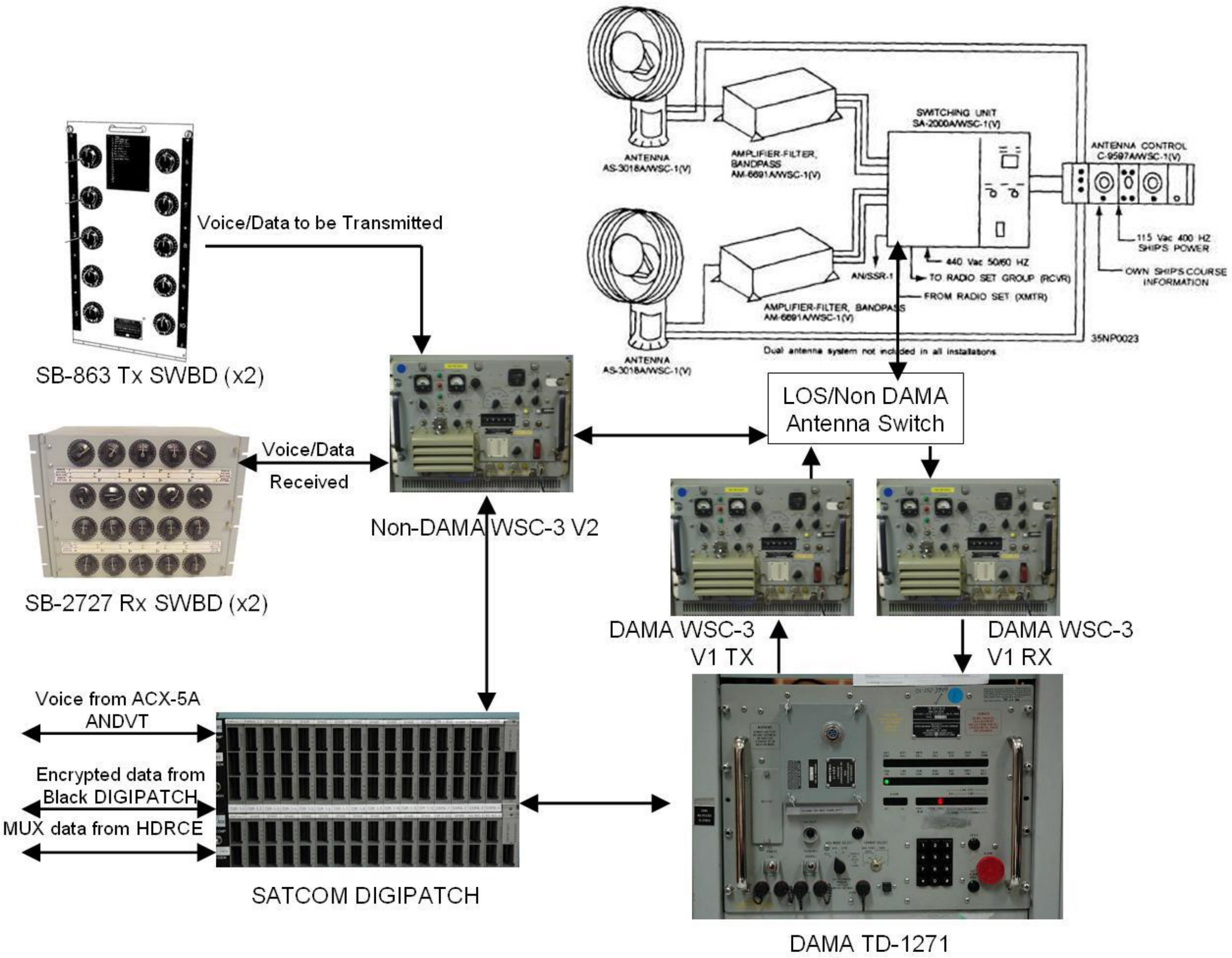

Figure 3-14: MILSATCOM DAMA / Non-DAMA Bearers

ASTIS (Advanced Satellites Terrestrial Infrastructure System)

52. The Advanced Satellites Terrestrial Infrastructure System (ASTIS) is part of Joint Project 2008. Parts of this project that are relevant to the RAN consists of:

a. Maritime ASTIS (MASTIS) on FFGs & FFHs (with plans to include on DDGs & LHDs);

b. Primary Injection Facility (PIF), to support both Maritime and Land Terminals;

c. Broadcast Capability (Software); and

d. Defence Strategic Network Interface (DSNI).

MASTIS

Reference: ABR 6557

53. The MASTIS terminal is a dual simultaneous X and Ka-band antenna capable of high data rate beyond line of sight duplex and simplex communications. The terminal consists of a 1.75m antenna (EADS Scot Design) and two racks of below deck equipment.

Figure 3-15: MASTIS Antenna

54. The below deck equipment provides the interfaces and ability to support a wide range of connectivity to various ship services such as networks, video, voice and data to meet operations and evolving ship capabilities. BDE includes:

a. Two racks in the Helicopter Control Office (HCO) that house:

i. Power Supply & Distribution;

ii. Antenna Control;

iii. X-band and L-band Converters;

iv. Satellite Modems;

v. RF Distribution;

vi. Asynchronous Transfer Mode (ATM) switch; and

vii. Network switching.

b. Equipment in the Red & Black racks in the COMCEN including:

i. Signal Entry panels;

ii. Fibre Optic transceiver assemblies;

iii. Cryptographic equipment

iv. Routing & Computer Terminal equipment to interface to the MTWAN CRN for distribution to various LANs/terminal equipment within various security enclaves.

55. The following diagram details the major MASTIS functional equipment, note however that this diagram was created before the interface to the MTWAN CRN was developed and therefore some of the interfaces to LANs etc on the right of the diagram now interface to the CRN.

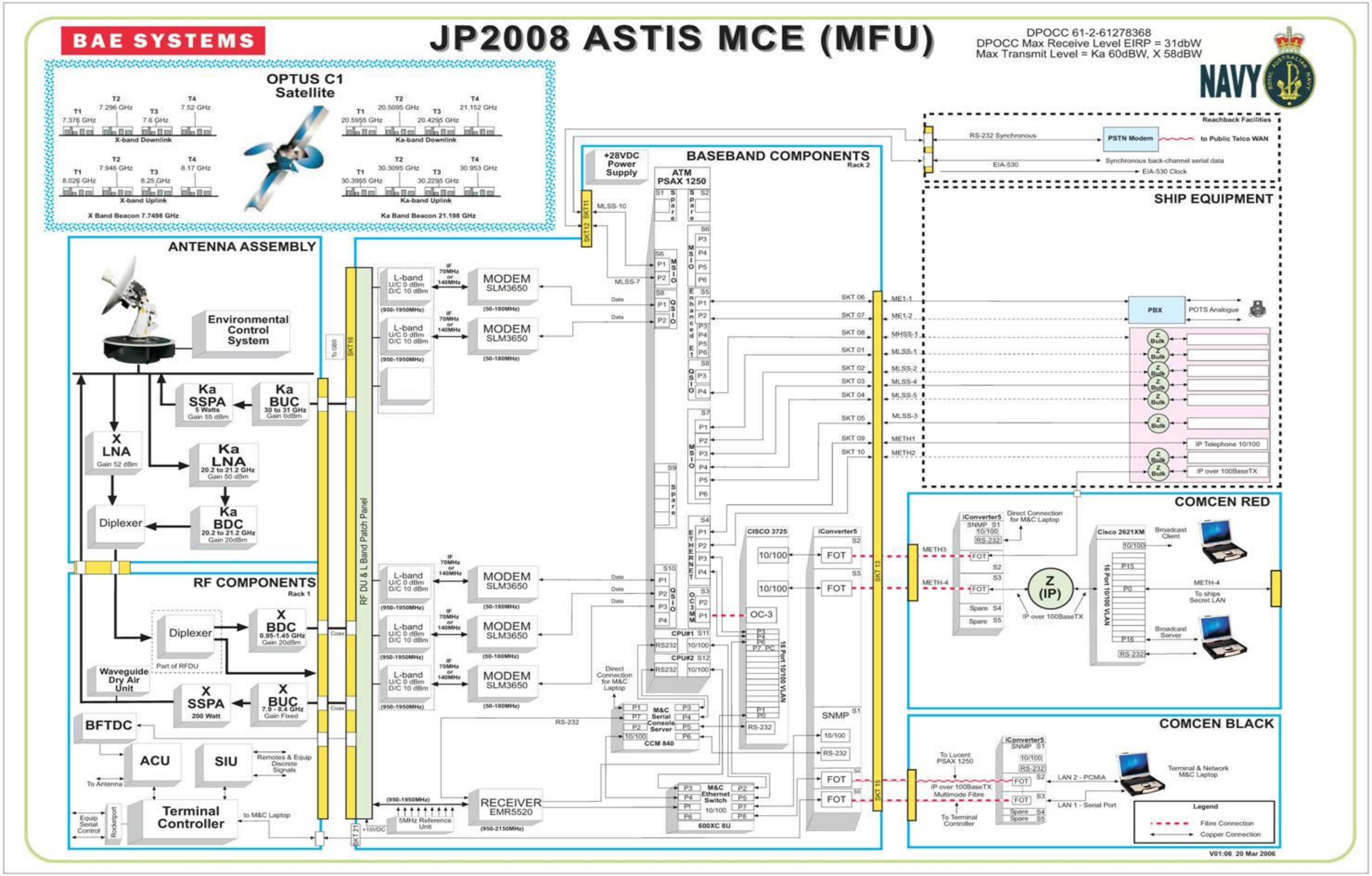

Figure 3-16: MASTIS Functional Diagram

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Primary Injection Facility (PIF)

56. The ASTIS Primary Injection Facility (PIF) functions as an Anchor station for the termination of bi-directional Command and Control (C2) links between ASTIS terminals and the Defence Strategic Network. Furthermore, it carries out information assembly gateways where data is aggregated and structured into streams for broadcast to ASTIS terminals.

57. The ASTIS PIF is located within the Defence National Operations Centre (DNOC) in Canberra and is contractor supported and manned. This facility does not manage the data being transmitted, this role is under the operational control of DEFCAMSAUS. The diagram below depicts the PIF Mission System Boundaries and provides a context diagram of the PIF and its relationship to other defence services. While the PIF forms a small part of the Defence Network Support Agencies (DNSA) Defence Payload & Operations Communications Centre (DPOCC) facility, the PIF is able to take or provide feeds from the DRN, DSN and the DVN and extend these services to Deployed ASTIS Terminals.

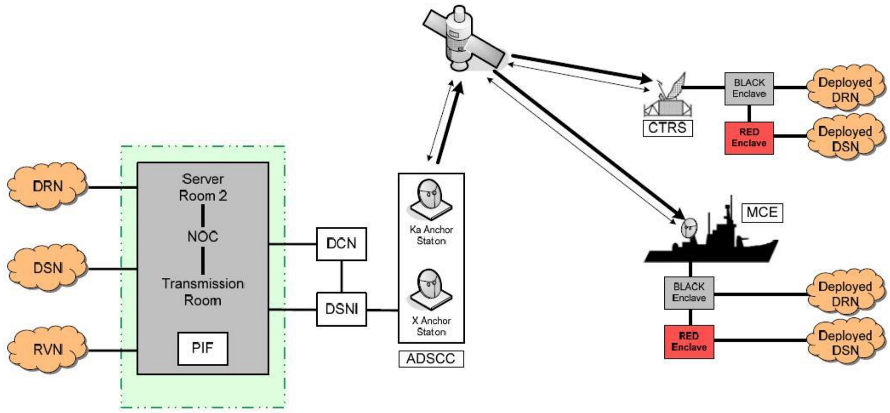

Figure 3-17: PIF Mission System

58. The application based structure of the PIF is represented in the context diagram below:

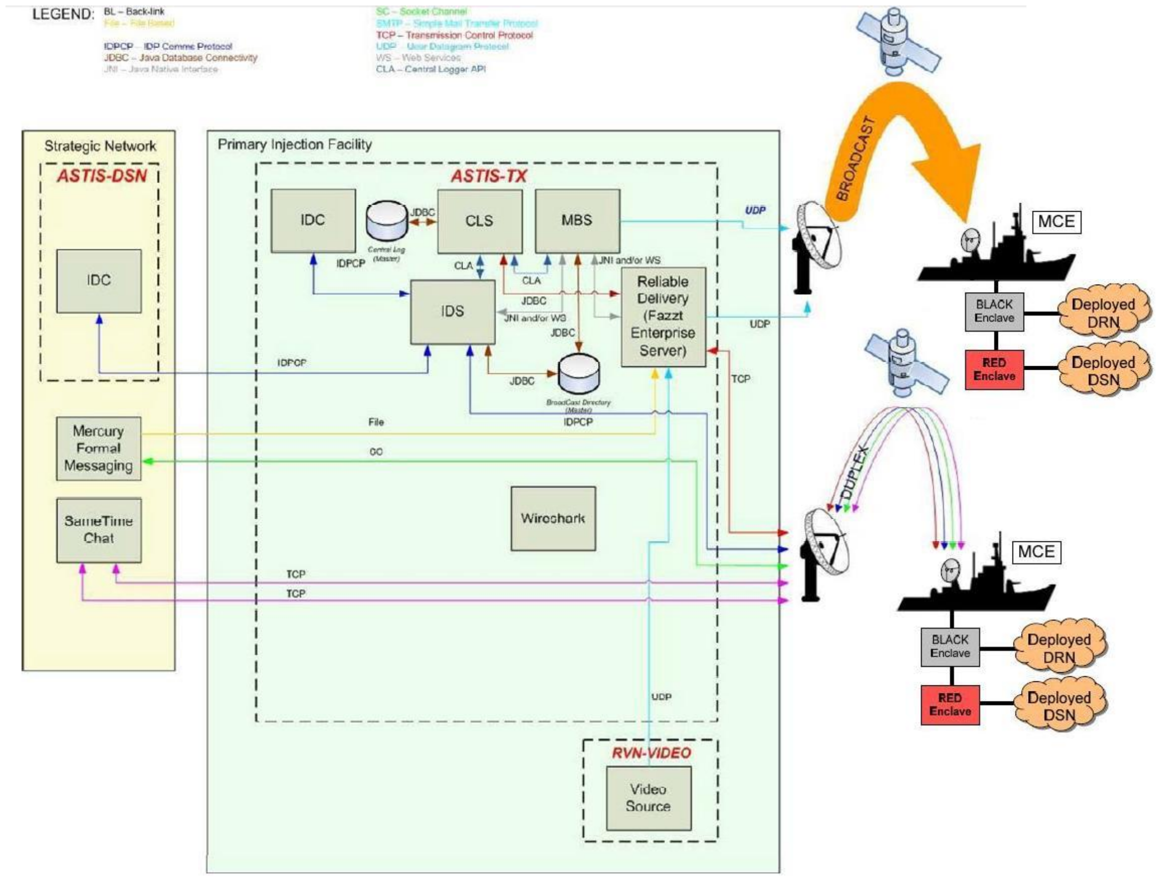

Figure 3-18: PIF Application Based Context Diagram

SAILOR 500 Fleet Broadband

Reference: ABR 6841 – SCMP-M Operator and Technical Manual

59. The Sailor 500 Fleet Broadband is the primary bearer for the SCMP-M, operating on the STRATOS Broadband Global Area Network (BGAN) through the INMARSAT 1-4 satellite constellation. In Australian littoral waters the Sailor 500 is supported by the Next G which accesses the Telstra 3G Universal Mobile Telecommunications System (UMTS). Next G is High Speed Packet Access (HSPA) capable, providing reliable high data rates, up to 14 Mbps in the downlink and 5.8 Mbps in the uplink. For the SCMP-M configuration the RAN operating profile limits data rates to around 2 Mbps.

60. The above deck equipments consist of:

a. a Sailor 500(B) 'L' band stabilised antenna with internal GPS; and

b. a Next G 850 MHz whip antenna and associated modem in a protective casing.

61. The below deck equipments consist of:

a. the Sailor 500 terminal and handset;

b. the Monitoring and Control system;

c. interface to the MTWAN CRN;

d. RADHAZ control unit; and

e. power supply consisting of:

i. a 28V DC power supply;

ii. an Uninterruptible Power Supply; and

iii. power distribution.

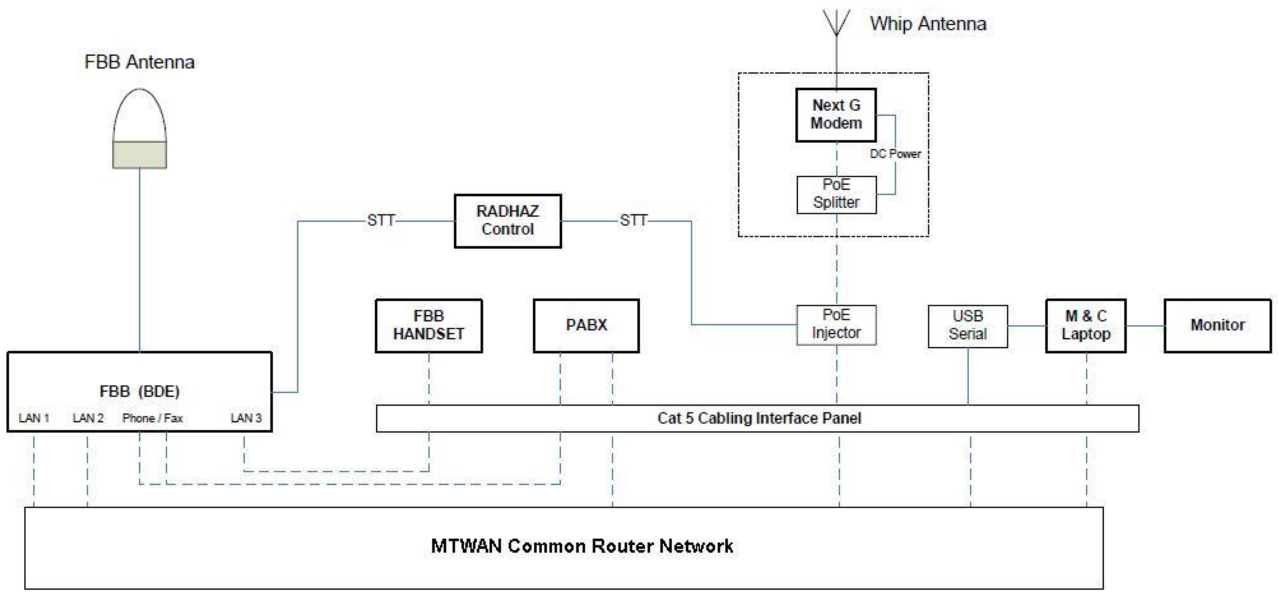

Figure 3-19: SAILOR 500 System Block Diagram

62. The BGAN maritime mechanical tracking antenna is installed on a pedestal, protected by a fibreglass radome.

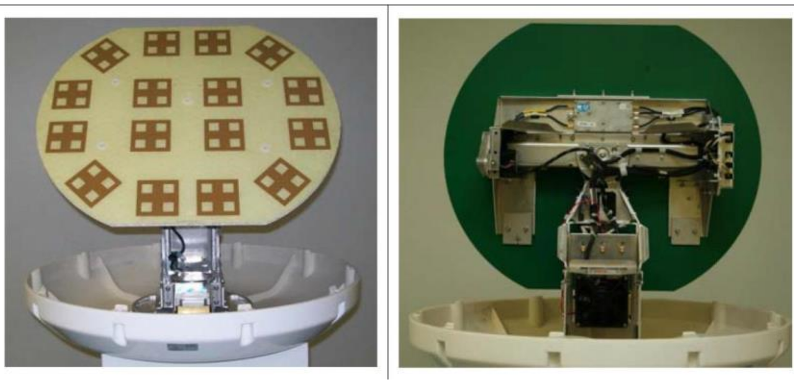

Figure 3-20: SAILOR 500 FBB Antenna

63. The physical and environmental characteristics of the antenna are set out below:

Parameter	Characteristic
Weight of antenna assembly plus radome	19 kg
Diameter at radome base	630 mm
Height of radome and base	655 mm
Operational temperature range	-25o to + 55 o C
Operating humidity	100% condensing
Wind	Up to 200 km/h
Spray	Spray proof
Maximum ship motions for continuous operation	Roll 30 o with period 4 sec Pitch 15 o with period 3 sec Yaw 10 o with period 5 sec

Table 7: SAILOR 500 Antenna Characteristics

64. A single coaxial cable connects the terminal and antenna. The cable connects to the antenna via a rotary joint in the antenna base that permits unrestricted rotation of the antenna. The cable transfers the following signals:

a. RF receive in the frequency band 1525.0 - 1559.0 MHz;

b. RF transmit in the frequency band 1626.5 - 1660.5 MHz;

c. monitoring and control signals; and

d. 28 V DC power to the antenna which has an operational output of 56 W.

65. A RADHAZ control module provides the following functionality:

a. a Safe To Transmit (STT) key for each bearer that will prevent any antenna radiation;

b. a Safe To Rotate (STR) key for the Sailor 500 Fleet Broadband System that removes all power to the system; and

c. EMCON Control which is provided through the STT function.

66. The STT capability enables transmission to be disabled in the event of specific evolutions such as helicopter operations or fuelling. For the Sailor 500 this can be accomplished without the need to power down and then reboot the system. It also enables a maintainer to trouble shoot with power on the system, without any radiation hazard. The STR capability enables the maintainer to keep the key on his/her person and conduct maintenance without any risk of below deck personnel powering up the system.

INMARSAT

67. The Nera Saturn Bm Marine Inmarsat B terminal provides voice, data and fax services to and from the ship to other ship and shore stations. The Inmarsat B terminal has a connection to the PABX, which allows satellite voice communications from administrator specified telephones around the ship. The International Maritime Satellite (INMARSAT) system consists of a number of satellites in geostationary orbit above the Earth. These satellites receive communications from INMARSAT fitted vehicles and retransmit to satellite ground stations, which in turn connect to the terrestrial telephone system. The satellite ground stations transmit communications from the terrestrial telephone system to the satellites, which retransmit to the INMARSAT fitted vehicle.

68. The Inmarsat B terminal is located in the COMCEN with a remote distress unit located on the Bridge. It has a transmit frequency range of 1626.5–1646.5 MHz and receive frequency range of 1530–1559 MHz.

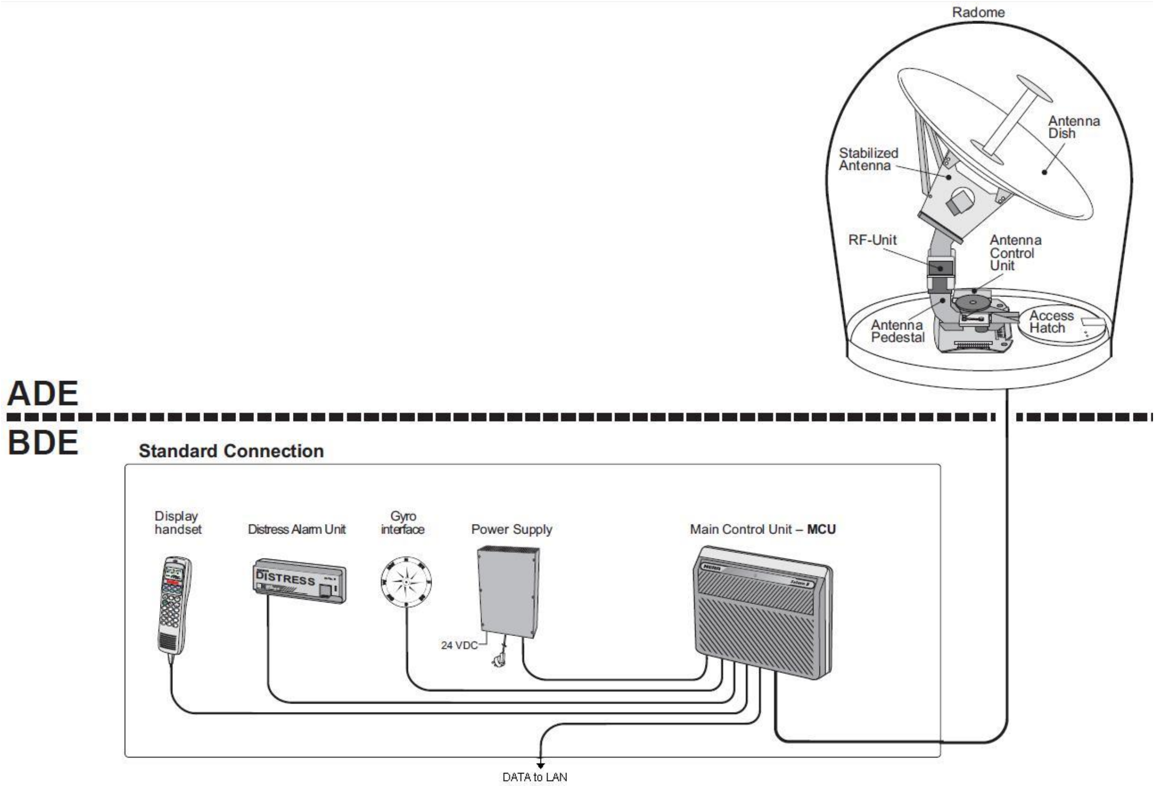

Figure 3-21: INMARSAT NERA Saturn B System

NINSHORE

69. When alongside Australian fleet bases, ships can connect to fibre optic Navy Information Network Shore (NINSHORE) cables which provides broadband strategic bearer access to the MTWAN.

Wireless/3G NINSHORE

70. A wireless/3G version of NINSHORE is currently being developed.

Cryptographic Equipment

KY-58

71. The KY-58 is a member of the VINSON family. The VINSON family consists of wideband secure voice (WBSV) units developed to provide line of sight half-duplex voice and data encryption. The KY-58 provides security for UHF & VHF half-duplex PTT combat net radios.

72. The KY-58 is certified to pass data up to TOP SECRET and accepts keys from the family of Common Fill devices.

73. There are nine KY-58s in an FFG COMCEN.

Figure 3-22: KY-58 Voice Crypto

KYV-5 (ANDVT)

74. The ANDVT (Advanced Narrowband Digital Voice Terminal) is the standard HF/Satellite voice encryption equipment used by the ADF. There are four ANDVTs in an FFG COMCEN.

Figure 3-23: ANDVT Voice Crypto

KG-84C

75. The KG-84 is a general, high capacity key generator used to encrypt and decrypt teletypewriter and digital data in both tactical and shore environments. There are five KG-84Cs in an FFG COMCEN.

Figure 3-24: KG-84C Data Crypto

KWR-46

76. The KW-46 simplex cryptosystem was introduced in order to provide communications security (COMSEC) for naval broadcasts.

77. The KWR-46 is a "low level" device that performs on-line decryption of digital messages, records, and data traffic received over the broadcast system at data rates from 50 to 9,600 bits per second in asynchronous, stepped or synchronous modes.

78. The KWR-46 is used for over-the-air transfer (OTAT) of keying material to support other cryptographic equipment in use. The KWR-46 is primarily used in the reception of all Fleet Broadcasts irrespective of data rate.

79. The KWR-46 is used on ships; the KWT-46 (transmit crypto) is located in shore units.

80. Un-keyed KWR-46 equipment is classified CONFIDENTIAL. Keyed KWR-46 equipment assumes the classification level equal to that of the keying material but not less than confidential.

81. Electronic key fill of the KWR-46 will only be accomplished through the utilization of the Key Tape Reader KOI-18 AN/CYZ-10.

Figure 3-25: KWR-46 RX only Data Crypto

TACLANE

82. A TACLANE (Tactical FASTLANE, or Tactical Local Area Network Encryption), is a network encryption device developed by the National Security Agency (NSA) to provide network communications security on IP and ATM networks for individual users or enclaves of users at the same security level.

83. TACLANEs are used to overlay Secure Virtual Networks (such as MCSS and Coalition networks) on top of existing public and/or private network structures (such as MTWAN).

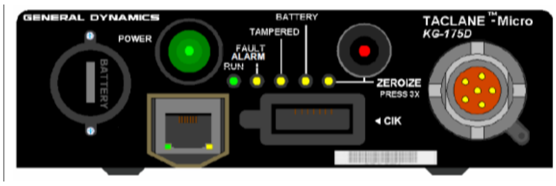

Figure 3-26: TACLANE IP & ATM Crypto

KIV-7

84. There is currently a project to replace the KG-84 cryptos with the smaller KIV-7. The KIV-7 family of embeddable KG-84 communications security (COMSEC) modules are lightweight, compact, commercial off-the-shelf (COTS) cryptographic devices that provide protection for digital and voice communications. The KIV-7 provides security protection through TOP SECRET, depending on the classification of the fill key. There are currently four models in the KIV-7 family:

a. KIV-7 Speeds up to 512 kbit/s

b. KIV-7 HS Speeds up to T-1 (1.54 Mbit/s)

c. KIV-7HSB Speeds up to 2.048 Mbit/s

d. KIV-7M Speeds up to 50 Mbit/s and supports the High Assurance Internet Protocol Interoperability Specification (HAIPIS)

85. The KIV-7 cryptographic device was designed as a miniaturized KG-84A/C and intended to be completely interoperable with KG-84A/Cs.

86. The KIV-7 has storage for up to 10 traffic encryption keys, which simplifies multi-net communications. A removable cryptographic ignition key (CIK) prevents unauthorized access and protects all internally stored keys. The KIV-7 fill interface is compatible with AN/CYZ-10 Data Transfer Device and KYK-13, KYX-15, KOI-18 common fill devices.

87. When unkeyed or when the CIK is removed; and not collocated, the KIV-7 is handled as an UNCLASSIFIED controlled cryptographic item (CCI). When the KIV-7 is keyed, it is handled at the classification level of the highest level of stored key.

Figure 3-27: KIV-7 Cryptographic device

Switching Systems

88. Prior to the installation of IP switching systems and high speed satellite bearers, various 'legacy' switchboards and multiplexors were used to connect radio transmitters to legacy bearers (HF, VHF, UHF, MILSATCOM).

Legacy Transmitter/Receiver switching

Black Receive Patch Panel

89. The SB-2727/SRR Black Receive Patch Panel is used to manually patch Radio Communications Equipment to Cryptographic Equipment and Modems. The FFG has two SB-2727s. Each piece of Communications equipment has an associated dial with 24 switch positions. Each individual piece of equipment has been hard wired to these switch positions.

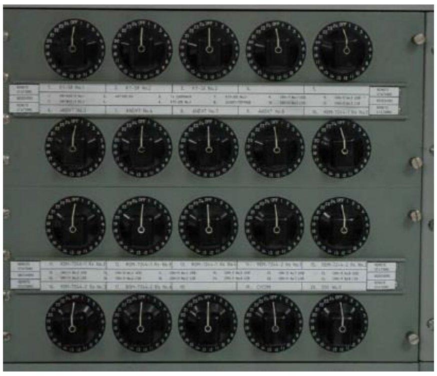

Figure 3-28: SB-2727/SRR Black Receive Patch Panel

90. The tally plate and name plate are used to select the appropriate dial for the communications equipment, the dials then manually turned to the corresponding number associated with the required equipment.

Black Transmit Patch Panel

91. The SB-863/SRT Black Transmit Patch Panel is used to manually patch Cryptographic Equipment and Modems to Radio Communications Transmitters/Transceivers. The FFG has two SB-863s. Each piece of Communications equipment has an associated dial with 24 switch positions. Each individual piece of equipment has been hard wired to these switch positions.

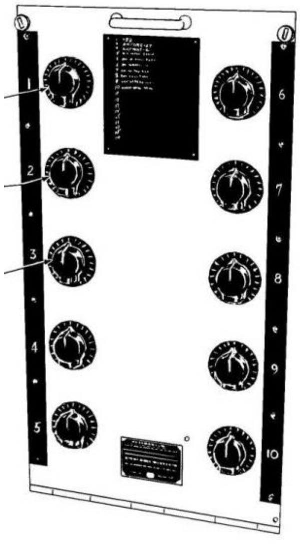

Figure 3-29: SB-863/SRT Black Transmit Patch Panel

Legacy Voice Switching

ACX-5A Red Voice Switchboard

92. The ACX-5A Switchboard is a a 19-inch rack mounted microprocessor controlled switchboard that, by local or remote selection, provides covered (Encrypted Speech) and uncovered (Plain Speech) voice circuit switching between remote units (VCS-945C, ACX-11 and Amplifier/Speakers) and cryptographic or radio equipment.

Figure 3-30: ACX-5A Red Voice Switchboard

93. ACX-5A Processor Unit controls the Channel Cards in the ACX-5A Switchboard associated with each remote unit and equipment. A supervisory control facility enables:

a. connection of remotes to equipment,

b. inhibition and disconnection of remotes and equipment,

c. equipment assignment, and

d. 'pre-set' configuration locking.

94. There are three ACX-5A Switchboards and one Processor Unit allowing a maximum of 30 remote units and 24 equipment units. In the event of ACX-5A processor failure, 'bypass cards', comprised of two PCB's connected by a 20-way ribbon cable, replace the required equipment and remote card of the ACX-5A switchboard to provide a dedicated connection.

VCS-945 Remote Voice Switch

95. The Remote Speech Processor Versatile Control System (VCS)-945 allows both covered (Encrypted Speech) and uncovered (Plain Speech) circuits to be operated from a single remote headset.

96. At a C&Di console or position fitted with internal communications facilities, the VCS-945C also provides hands-free (internal) communications on the selected circuit via the Hughes Console Interface. Internal communications audio is provided to the left ear of the headset.

Figure 3-31: VCS-945 Remote Speech Processor

97. There are a total of sixteen VCS-945s on an FFG:

a. Thirteen are in the Ops Room

i. eight of these are positioned at the eight C&Di consoles;

b. One on the bridge;

c. One in the Helo Control Office; and

d. One in RAST.

ACX-11

98. Much like the VCS-945, the ACX-11 allows for covered (Encrypted Speech) and uncovered (Plain Speech) circuits to be operated from a single handset. However, this handset is not compatible with the internal intercom of the VCS-945.

Figure 3-32: ACX-11 Remote Speech Processor

99. There are a total of seven ACX-11s on the FFG:

a. One in the Ops Room;

b. One on the Bridge (paired to a loud speaker)

c. One in the Transmitter Room

d. An additional two in the Ops Room paired with ACX-2 Channel Selectors; and

e. Two in the COMCEN paired with ACX-12 remote volume controls, and loud speakers.

ACX-2

100. Channel Selector ACX-2 enables remote channel selection for ACX-11 sets. The ACX-2 does not possess audio circuitry. An integrated ACX-11/ACX-2 station provides all facilities available at VCS-945C stations except internal communications.

ACX-12

101. Telephone Extension ACX-12 enables remote volume control when the VCS-945C or ACX-11 is not local to the operator's position.

Legacy Data Switching

ACX-51 Red Data Switch

102. The ACX-51 (RED) teletype switchboard functions to switch digital data between processors and peripherals. Previously it switched OTCIXS data to provide GCCS-M capability, however now on the FFG it simply switches the MHS servers to cryptographic equipment.

Figure 3-33: ACX-51 Red Data Switch

103. It can be considered as a 48 48 digital patch between 24 processor ports (each with an input and output channel), and 48 peripheral ports consisting of 24 input and 24 output channels. In the event of complete ACX-51 failure, 'null modems' can be fitted to hard patch MHS equipment directly to cryptographic equipment.

AN/USQ-122A – HF/UHF Data Converter and Multiplexer

104. The USQ-122A High Data Rate Communications Equipment (HDRCE) was introduced to provide Fleet Units with High Speed Data and multi-channel (TDM) capability. It is capable of handling High Speed Fleet Broadcast messages via either HF or UHF DAMA bearers.

Figure 3-34: AN/USQ-122 HDRCE

105. Four HF Modems provide error correction capabilities using interleaving de-interleaving; FSK coding decoding, and modulation, demodulation of synchronous, asynchronous data for transmit and receive of HF radio circuits.

106. It provides Full duplex, Half duplex, and simplex transmit and receive of digital data rates up to 2400 bauds coded and 4800 bauds uncoded.

107. The TDM is configurable and provides for full- duplex, simplex and dual-simplex transmission and reception of digital data. The TDM transmit has the capability to multiplex a max of 12 user configured channels into an aggregate data stream. The TDM receive does the opposite and de-multiplexes a max of 12 user configured channels.

TD1271 – UHF DAMA MULTIPLEXER

108. Demand Assigned Multiple Access (DAMA) was developed to multiplex several sub-systems or users on one satellite channel.

Figure 3-35: TD-1271 UHF DAMA Multiplexer

109. The TD-1271/U Multiplexer is a UHF DAMA sub-system, it was developed to provide adequate capacity for the Navy and other Defence users. The multiplexing factor can be increased by patching the TD-1271 with the USQ-122A.

110. TD-1271/U Multiplexer includes a modem integral to the transceiver. Equipment input or output data rate with DAMA equipment can be 75, 300, 600, 1,200, 2,400, 4,800, or 16,000 bits per second (bps).

111. The DAMA transmission rate on the satellite link (referred to as “burst rate”) can be 2,400, 9,600, 19,200, or 32,000 symbols per second.

Electronic Information Exchange (EIE)

Reference: RANCP 3(C) – Australian Fleet Communications Instructions

112. The Electronic Information Exchange (EIE) refers to information that is exchanged using Internet Protocol (IP). The EIE consists of specific IP capable bearers and Information Systems (FIE) as follows.

EIE Bearers

113. EIE bearers are IP capable strategic bearers. On the FFG these include:

a. Maritime Advance SATCOM Terrestrial Infrastructure System (MASTIS);

b. Fleet Broadband (FBB) Sailor 500 or International Maritime Satellite (INMARSAT);

c. Navy Information Network Shore (NINSHORE) – alongside only; and

d. NINSHORE Wireless 3G – alongside only.

Fleet Information Environment (FIE)

114. The FIE represents the extension of the Defence Information Environment (DIE) into the maritime tactical environment. The FIE comprises of the designated at-sea IT networks and systems in the UNCLASSIFIED, RESTRICTED and SECRET security domains, and includes hardware, software, middle-ware, communications and security in the development, test, and production environments for those applications that directly support the fleet's core mission.

115. The FIE includes the following physical networks and Communities of Interest (COI):

a. Unclassified Internet Kiosk;

b. Restricted High – Fleet Information Environment (RH-FIE), which is an extension of the Defence Restricted Network (DRN). Services provided include:

i. Email;

ii. Web access;

c. Maritime Command Support System (MCSS) / SH-FIE, which is an extension of the Defence Secret Network (DSN). Services provided include:

i. Same Time Chat (STC);

ii. Common Operating Procedure (COP) - via Command & Control for the Personal Computer (C2PC);

iii. Email;

iv. Web access;

d. Fleet Mercury Socket Channel (FMSC), which provides Mercury Signal traffic;

e. Coalition networks, which are various alliances between countries, or COI, for specific missions/operations which may be long or short term. Some Coalition networks/services include:

i. Persistent Chat (P-Chat),

ii. COP (as for Equipment Fit/Exercise requirements),

iii. CENTRIXS (Combined Enterprise Regional Information Exchange System)

1). GCTF (Global Counter-Terrorism Forces) - Information sharing tool for 'Operation Enduring Freedom'. Primary system used by Coalition Naval Forces CENTCOM;

2). CNFC (CENTCOM Naval Forces Component) - CNFC is a Virtual Private Network within CENTRIXS-GCTF;

3). CMFP (Combined Maritime Forces Pacific) - Information sharing tool between pacific navies including US / AUS / JAP / SING / IND / KOR to support antiterrorism, antipiracy, and humanitarian assistance and disaster relief operations. Also used extensively to support RIMPAC;

4). CFE (CENTRIXS Four Eyes) – Standing planning network for AUS / CAN / UK / US, including facilitating Air Ops;

5). MCFI (Multinational Coalition Forces-Iraq) - Information sharing tool for 'Operation Iraqi Freedom'.

iv. FPDA (Five Power Defence Agreement) – UK / AUS / NZ / Malaysia / Singapore

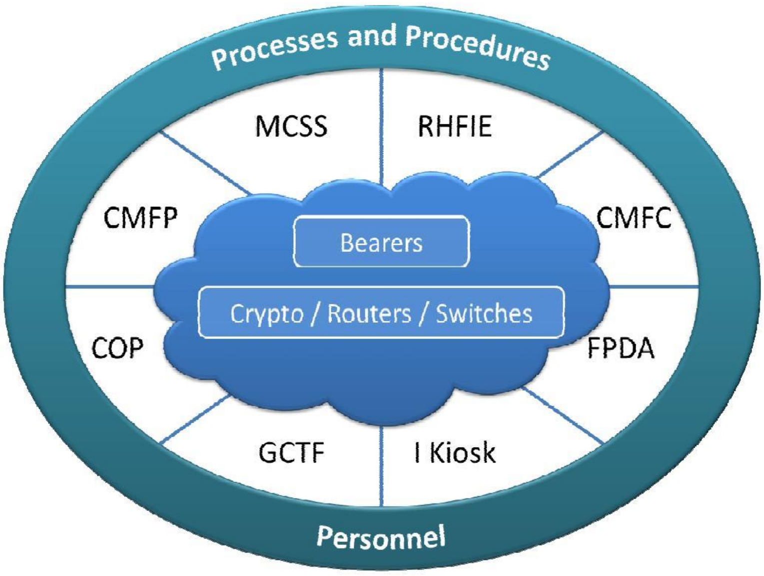

Figure 3-36: FIE Operational View

116. From a technical view, the FIE can be viewed as comprising the layers two through seven of the model depicted in the Figure below. This view highlights the common services and user applications within each FIE enclave.

Figure 3-37: FIE Technical View

117. The following systems do not form not part of the FIE:

a. TS networks (DSD is the sole authority for these systems);

b. The combat system or equipment related to the combat system;

c. Training and simulation systems other than those dedicated as FIE systems; and

d. Process-control or monitoring systems such as air conditioning, Private Automated Branch Exchange (PABX), power supplies or machinery control.

Defence Formal Messaging System

118. Mercury is a PC based Message Handling System (MHS) for signal traffic, similar to its predecessor, Poseidon that replaced the even earlier SMART system. Formal messaging using UHF MILSATCOM / HF broadcast equipment, is the standard method of traffic delivery to a Fleet unit at sea. Transfer via Fleet Mercury Socket Channel (FMSC) is only to be used if the unit does not have Satellite Communication (SATCOM) or HF capabilities. All fleet units maintain two fully functional General Service (GENSER) messaging circuit paths in order for the unit to sail, remain at sea, or assume four hours or less Notice for Sea (NFS).

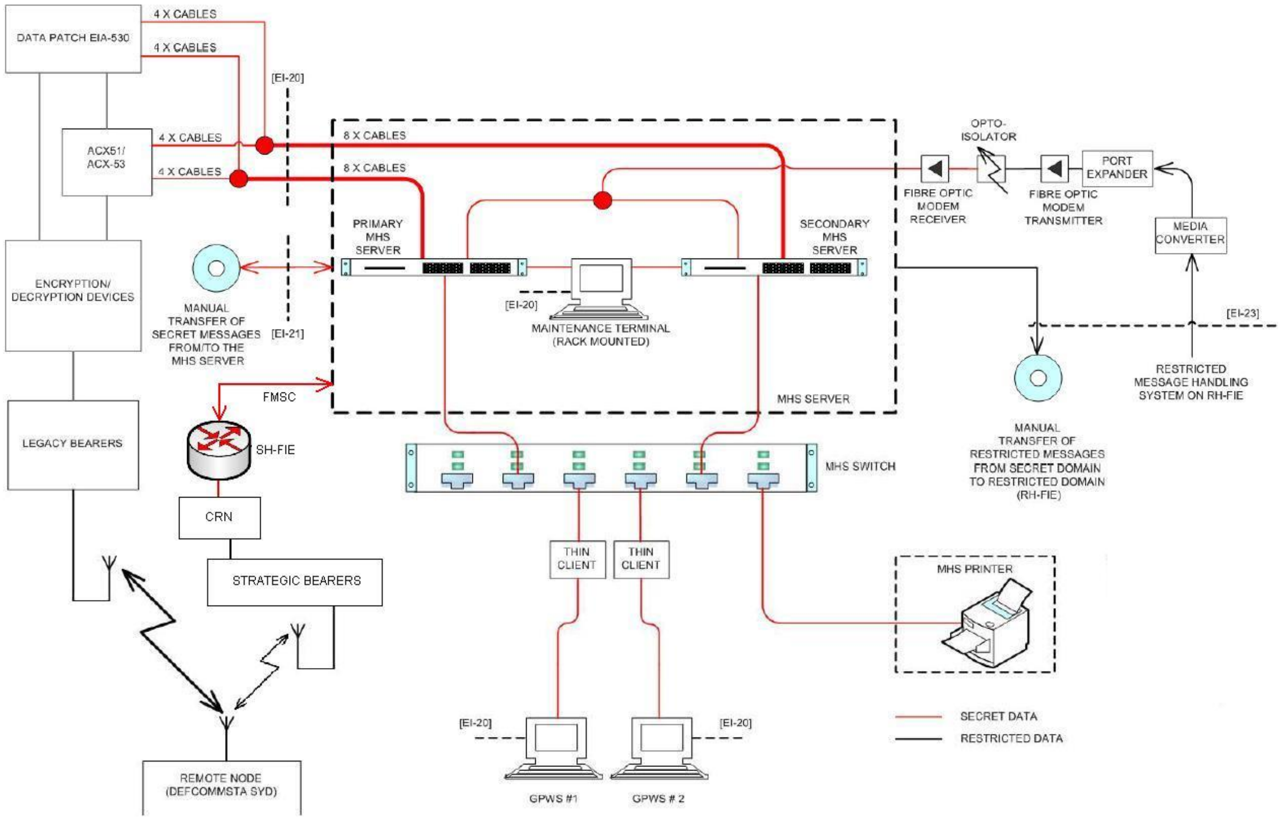

Figure 3-38: MHS Configuration

119. Messages sent/received via legacy bearers (UHF tactical data, UHF MILSATCOM & HF data) utilise the ‘teletype system’. The teletype system is equipped to handle transmission or reception of Frequency Shift Keyed (FSK) signals.

a. Transmit

i. Mercury Messages prepared on the MHS are switched by the ACX-51.

ii. the ACX 51 directs the messages to KG 84C Security Equipment Sets for encryption.

iii. USQ-122 accepts data from up to four of the KG-84C via a black DIGIPATCH for multiplexing and conversion to FSK audio signals.

iv. FSK audio signals are which are forwarded via SB-863 Transmitter Switchboard to UHF MILSATCOM, Tactical LOS UHF, or URT-23C (HF) radio sets.

b. Receive

i. Single Channel HF or UHF RATT signals are routed through SB-2727 Receiver Switchboard to the USQ-122 for conversion of FSK audio to teletype pulse trains.

ii. HF or DAMA Multi Channel Broadcast tones are routed through SB-2727 Receiver Switchboard to USQ-122 for de-multiplexing.

iii. KWR-46 or KG-84C Security Equipment Sets receive pulse train data from the USQ-122, and forward decrypted data to Mercury MHS via the ACX-51 Switchboard.

Fleet Mercury Socket Channel

120. FMSC is an IP connection between MCSS / SH-FIE to Mercury services at DEFCOMMSTA SYDNEY or PERTH. This permits the transmission and receipt of military messages via an IP bearer. Fleet policy for units to use FMSC as follows (IAW AUSFLTOPS Signal R 080715Z AUG 08)

a. Alongside: FMSC is authorised at all times subject to an IP comms path being available and this path meeting all security requirements.

b. At sea: MILSATCOM and/or HF is to remain the method of passing military messages. In instances where both of these communications mediums are unavailable, fleet units are to raise a COMSPOT. The COMSPOT is to request DEFCAMSAUS approval to pass military messages via FMSC if this is deemed the preferred option/solution by the fleet unit. Upon restoration of MILSATCOM and/or HF capability, the unit is to shift from FMSC to the available bearer.

c. The use of FMSC is to take precedence over Data Transfer Facility (DTF). Also, the use of same time chat to pass military messages is not condoned and is only to be considered as an option in exceptional circumstances with a strong operational imperative.

121. While the technological advances made with DTF and FMSC provide a much enhanced capability, the requirement to retain the skills to utilise HF / MILSATCOM is essential.

Same Time Chat (STC)

122. STC is a planning and coordination tool. Chat is not authorised as a means of ordering tactical manoeuvres or authorising fire missions; for these types of tasking military messaging or voice communications are to be used.

123. STC is available on MCSS, SH-FIE and all Coalition Information Environment (CIE) enclaves. P-Chat is available only on CIE enclaves.

Command & Control Systems

Command and Control for the Personal Computer (C2PC)

124. C2PC facilitates the creation and visualisation of the Common Operating Picture (COP) in a Microsoft Windows environment. C2PC normally operates in a hierarchical network configuration, with many C2PC clients linked to a single Internet Connection Sharing (ICS) server via the C2PC Gateway process. This configuration enables visualisation of the COP, as well as access to track management functions and related decision and planning aids.

125. C2PC provides an open architecture using Microsoft technologies to integrate with desktop applications such as Microsoft Word and PowerPoint. This allows familiar Microsoft menus and functions to be used, for example: C2PC maps can be quickly cut and pasted into briefings and reports. This is the standard COP programme available on MCSS, DSN and Coalition COIs.

Event by Event (EBE) Broadcast

126. EBE Broadcast provided a shore to ship communications route for Event by Event GENSER intelligence messages. This service, when generated, was compiled by DEFCOMMSTA SYDNEY and provided over HF or UHF Satellite bearers at speeds of 75bds – 2400bds depending on the end users requirements. The EBE Broadcast provides OTH real time positioning reports and on request can be tailored to the end users requirements. This RMP is also employed by MFU as the first alternate when unable to copy the OTCIXS network.

127. Due to the slow baud rate of transmission of the EBE Broadcast, this facility is currently in abeyance, and available only on request.

EIE Defect Management

128. Due to the increasing reliance on EIE services as primary command and control paths, there exists a requirement for both operational authorities and administrative chains of command to have visibility of a unit's EIE capabilities and status. Fault finding an interruption to service may be a 'network setup' or hardware issue, each having different support and reporting arrangements.

COMSPOT

129. When a unit requires the assistance of DEFCAMSAUS or relevant supporting agency for the rectification of a significant disruption or loss to a CIS service or advising of difficulties, the requesting unit is to submit a COMSPOT report to DEFCAMSAUS.

130. A COMSPOT for an EIE Disruption is to be raised on all network disruptions, or degradation of services. The relevant service provider or interface site is to be the action addressee for all EIE related COMSPOTs with DEFCAMSAUS, DMC4EW, and DEFCOMMSTA Sydney as information addressees. HQJOC or MAROPS is to be included as required dependant on unit tasking and force assignment. COMSPOTs are to indicate whether a Fleet Support Centre (FSC) incident has been logged or not.

URDEF

131. The Urgent Defect (URDEF) system, which is more familiar to the WE department than COMSPOTs, is utilised in conjunction with communications reporting for EIE problems. The CIS and Weapons Electrical Engineering (WEE) departments must work collaboratively to report and resolve defects relating to CIS services. Accordingly, interruptions to services, wherever the platform's ability to undertake its mission is impacted should result in URDEF action (by the WE Department) following COMSPOT reporting (by the CIS Department). For all CIS equipment URDEFs, DEFCAMSAUS is also to be added as an information addressee.

Reporting Time Line

132. CIS manager reports & URDEFs from fleet units are to provide adequate appraisal of the situation to effect resolution. The guideline depicted in the figure below (from RANCP 3(C)) is provided for Managers to ensure the relevant information has been provided and reported within the time line indicated.

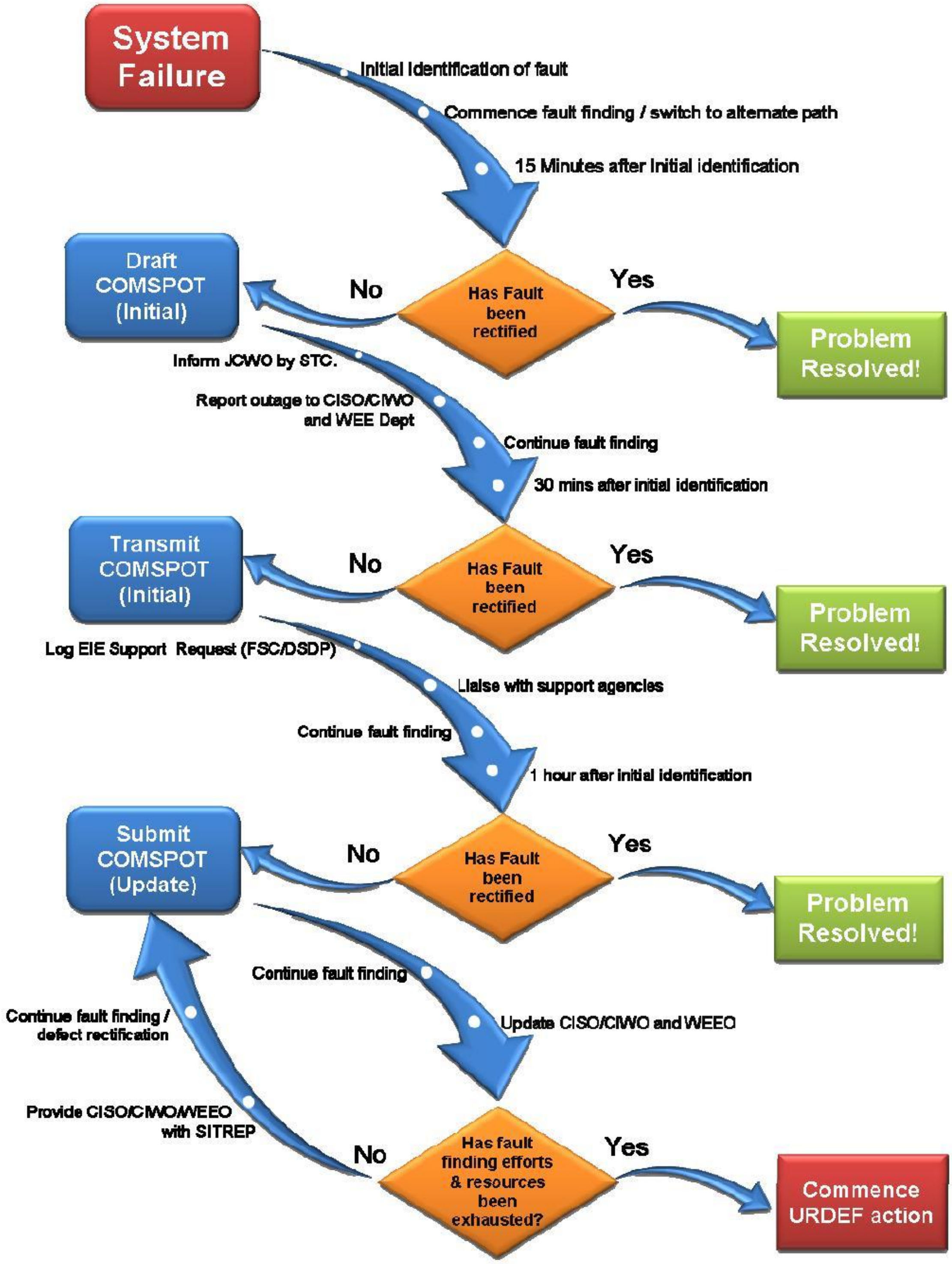

Figure 3-39: COMSPOT / URDEF Reporting Timeline

Maritime Tactical Wide Area Network (MTWAN)

133. The MTWAN provides a networked computing environment capable of supporting seamless information exchanges among fleet units, joint and coalition forces. MTWAN enhances the IP networking capability of fleet units by moving from a hub-spoke architecture, which completely relies on SATCOM, to a meshed architecture, which makes efficient use of available bandwidth and increase network availability.

134. The MTWAN delivers the following:

a. Reducing reliance on satellite communications;

b. Self-configuring networks and reduced operator intervention;

c. Maximised use of available bandwidth; and

d. Increasing network availability through multiple data paths.

135. MTWAN is used interchangeably in a coalition and national environment:

a. MTWAN supports both coalition and national networks;

b. MTWAN provides for multiple networks of varying security levels across multiple communications bearers; and

c. LOS Bearers in this context are HF, VHF and UHF bearers that do not require shore infrastructure.

136. One of the objectives of MTWAN is the affordability to reduce reliance on satellite communications resource in a maritime tactical environment. This is essential so that disadvantaged ships without high data rate satellite communications capability can still have access to their information exchange requirements via fleet units that have this capability via LOS or Beyond Line of Sight (BLOS) bearers.

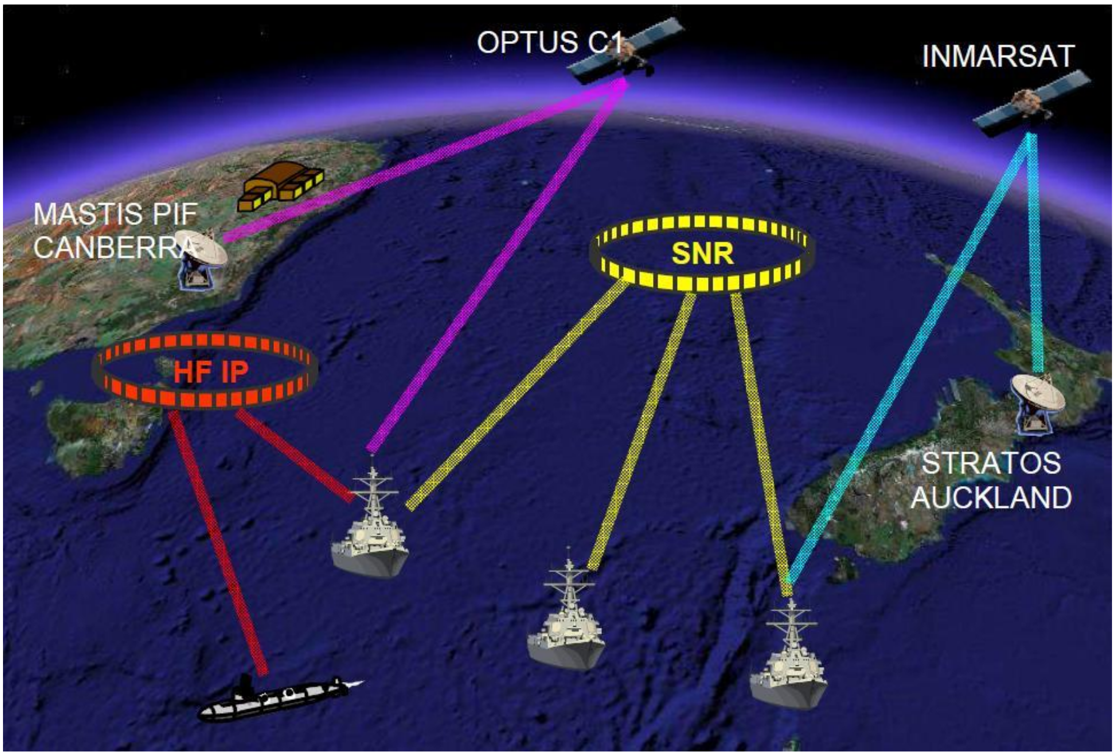

Figure 3-40: MTWAN Concept

137. The MTWAN communications architecture is made up of the following components:

a. Fleet Information Environment (FIE) Services; and

b. Communications Services.

FIE Services

138. Security enclaves include coalition and national networks and are categorised as follows:

   a. National Unclassified;

   b. National Restricted;

   c. National Secret; and

   d. Coalition (Secret).

139. User Applications are categorised as follows:

   a. Web Services (Intranet & Internet);

   b. Instant Messaging (Chat Services);

   c. Email Services;

   d. Database Replication;

   e. COP (i.e. C2PC);

   f. Enterprise Applications (i.e. PMKeys, AMPS and Navy-specific Applications); and

   g. VoIP.

140. The Fleet Support Centre, located in DEFCOMMSTA Sydney is responsible for the management of the FIE which includes MCSS, MTWAN and Network Monitoring and Management (NM&M).

Communications Services

141. The MTWAN Communications Services consists of the following bearers:

   a. Satellite Bearers:

      i. SAILOR 500 FBB or INMARSAT; and

      ii. MASTIS.

   b. LOS Bearers:

      i. UHF SNR (Subnet Relay);

      ii. HFIP (HF Internet Protocol); and

      iii. LOS HDR (High Data Rate) Capability.

   c. Dockside Bearers:

      i. PSTN;

      ii. NINSHORE Fibre Optic; and

      iii. NINSHORE Wireless.

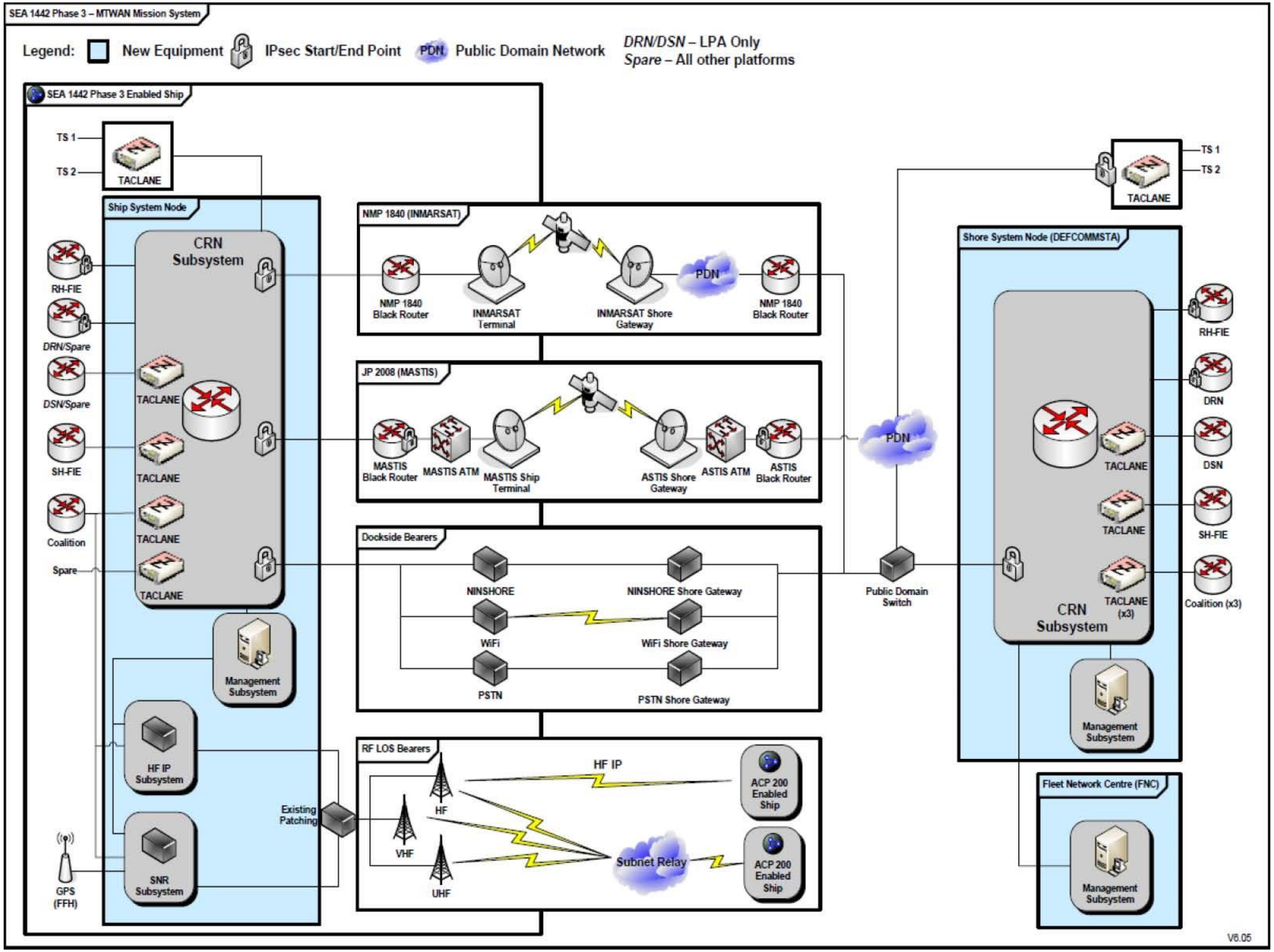

Figure 3-41: MTWAN Mission System

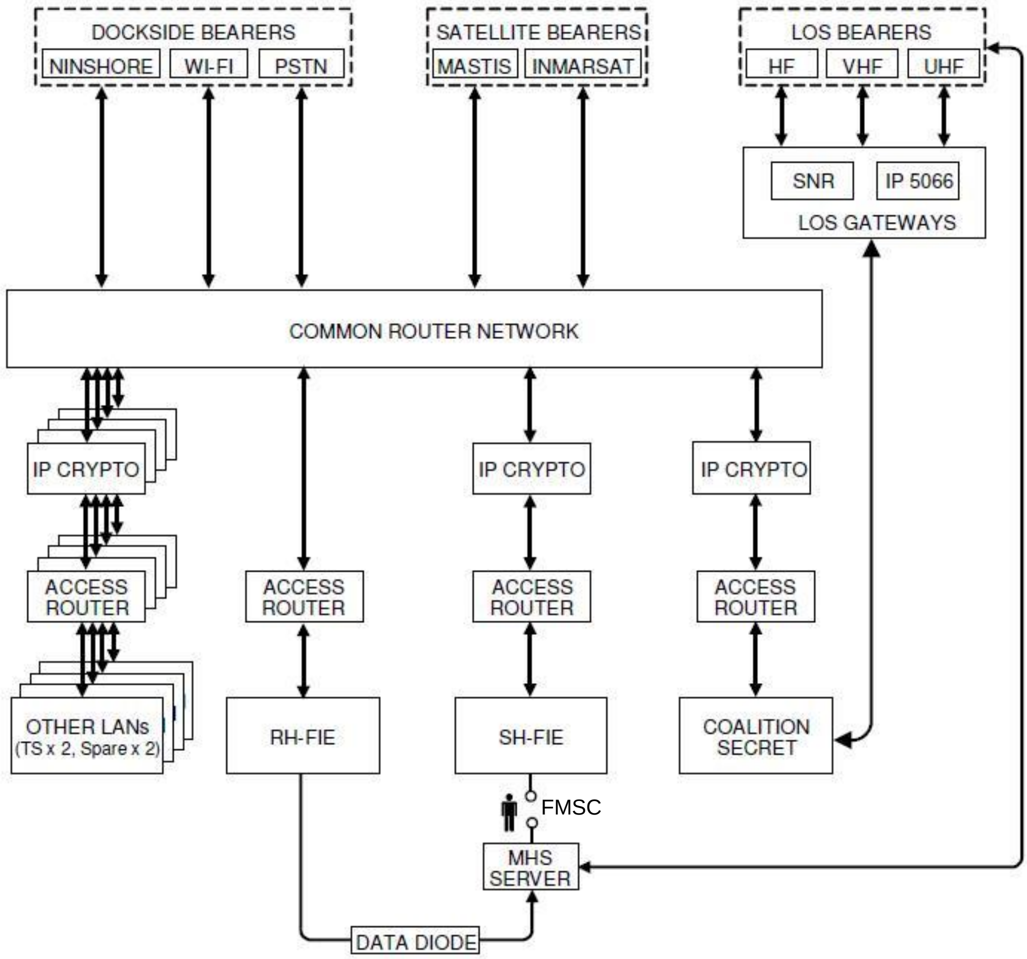

Figure 3-42: Simplified MTWAN MFU Node

Common Router Network (CRN) Subsystem

142. The core of the MTWANs design is a robust and reliable Common Router Network (CRN) providing a converged IP network for the Wide Area Network (WAN) interconnections for all FIE services and security domains within the maritime battle space information environment. The CRN enables efficient use of multiple bearers of dissimilar transmission characteristics and provides an IP switching and routing fabric for the interconnection of LANs, including those on shore and onboard fleet units, whilst providing interoperability with allied and coalition forces. Unclassified voice will also be supported through the Common Router. HF-IP and SNR subsystems guidance will be promulgated once the SEA-1442 project has reached the appropriate level of project maturity.

143. The selection (on-off) on the Integrated Management Environment (IME) management workstation controlling the FIE and CIE systems and bearers is to be managed in accordance with the relevant Jupiter state. Users are to be cognisant that this function can not be used to satisfy RADHAZ requirements.

Subnet Relay (SNR)

144. SNR provides self-configuring, multi-node, multi-hop, ship-to-ship networking over shipboard tactical UHF radios at data rates up to 64kbps. SNR uses relay nodes to extend the coverage of UHF radios beyond LOS.

145. The SNR will improve information exchanges between ships operating in the same AOR, reduce the ships' reliance on SATCOM, support ships that are non-SATCOM capable, and enable the efficient use of communications assets by allowing a single frequency to be shared among a number of ships. When the network topology changes due to ships movements, the SNR will enable IP traffic to be delivered to its final destination without user intervention

146. An SNR net can be formed over HF, VHF, and UHF LOS bearers although more commonly on UHF LOS bearers due to higher data rate although limiting the range between two Ship Nodes. Under the interim MTWAN solution, SNR will be operated over UHF LOS Bearer. Features of SNR include:

a. Self-configuring. SNR allows Ship Node to join a pre-configured network when within UHF LOS distance;

b. Multi-node. Allow maritime platforms to form a SNR network with up to 16 members; and

c. Multi-hop. Allow IP data packets to be relayed between multiple Ship Nodes to reach its destination Node. This technology can be used to overcome distance limitations with up to a maximum of five hops.

147. Under the interim MTWAN solution, SNR will only be used for CNFC. Primary user Applications in CNFC include e-mail, STT, P-chat web-services and file transfers using FTP (File Transfer Protocol). In the future SNR will be used to support the Coalition environments including CFE and GCTF.

148. A single SNR hop via UHF Bearer can achieve up to a nominal distance of 20 NM. SNR can support up to five hops which can increase the range of data exchange however, this is largely dependent on geographical dispersion of Ship Nodes.

149. The SNR waveform is capable of data services only with data rate ranging between 32kbps to 64kbps depending on radio performance. SNR can theoretically operate at a data rate of 76.8kbps.

150. The SNR Communications Service is comprised of the following components:

a. SCRN (Self-Configuring Relay Network) Module. Gateway for CNFC router to access UHF LOS bearer;

b. Cryptographic Equipment. KIV-7HSB or KG-84A can be used for link encryption;

c. SNR MODEM. Modulates and demodulates encrypted serial data to 25kHz waveform and vice versa; and

d. UHF Radios. Tactical ship-board UHF radios supporting 25kHz waveform.

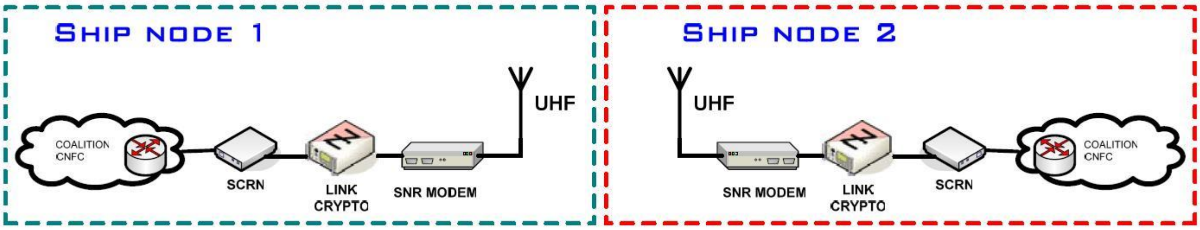

Figure 3-43: Subnet Relay Link

High Frequency Internet Protocol (HFIP)

151. HFIP is based on STANAG 5066, supporting multi-node IP networking over a HF data communications system at data rates up to 9.6kbps for single sideband and up to 19.2kbps for two independent sidebands.

152. The HFIP will be used to carry Coalition traffic including CFE and GCTF. HFIP is mainly used to support e-mail and text-chat such as P-Chat.

153. The system is intended for use with surface wave paths which provided extended-LOS coverage of up to 200 NM at sea. Ships can join and leave a HFIP net at any time.

154. The HFIP waveform is capable of data services only with data rate ranging between 9.8 kbps to 19.2 kbps depending on mode of operation on the MODEM, atmospheric condition and radio performance.

155. The HFIP Communications Service is comprised of the following components:

a. HFIP Server. Gateway for CNFC router to access HF LOS bearer;

b. Cryptographic Equipment. KG-84C or KIV-7HSB to encrypt serial data;

c. HF MODEM. To achieve a data rate of up to 19.2kbps, the MODEM needs to comply with MIL-STD-118-110B Appendix F waveform for ISB operation; and

d. HF Radio. Existing ship-board HF radios.

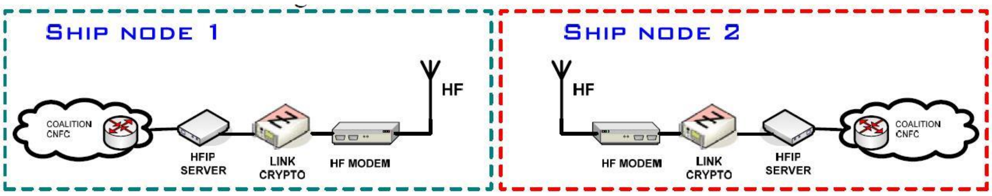

Figure 3-44: HFIP Link

SCMP-M (Specialist Communications Modernisation Program – Maritime)

Reference: ABR 6841 – SCMP-M Operator and Technical Manual

156. The Specialist Communications Modernisation Program – Maritime (SCMP-M) is the integrated satellite and terrestrial wireless data communications system designed to provide a common architecture for all surface RAN Major Fleet Units and Minor War Vessels. The system provides broadband WAN connectivity and simultaneous access to data and voice services across multiple security enclaves.

157. The figure below sets out the functional configuration of the SCMP-M for MASTIS fitted Major Fleet Units.

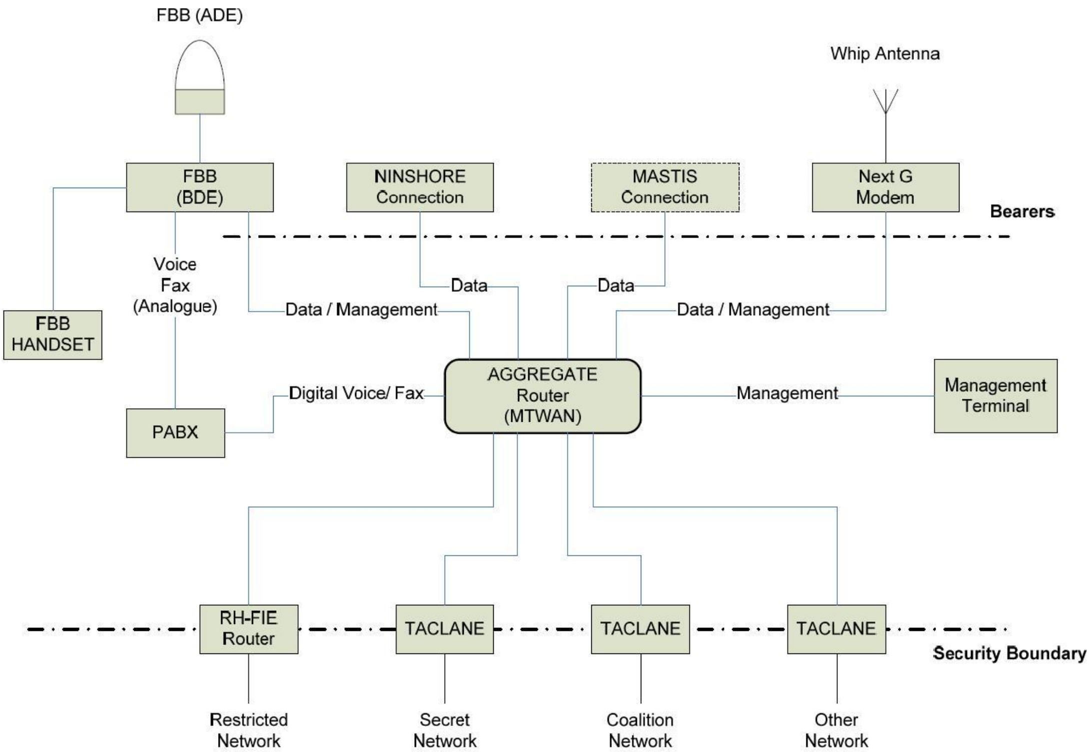

Figure 3-45: SCMP-M Functional Configuration

158. The primary bearer for the SCMP-M is the Sailor 500 Fleet Broadband which is a compact commercial satellite communications system that operates on the STRATOS Broadband Global Area Network (BGAN) through the 'INMARSAT I-4' satellite constellation. This consists of 3 geostationary satellites which provide overlapping footprints, guaranteeing coverage over most oceanic areas with the exception of the very high latitudes. The footprints of the three satellites are illustrated below (as of Jan 2010).

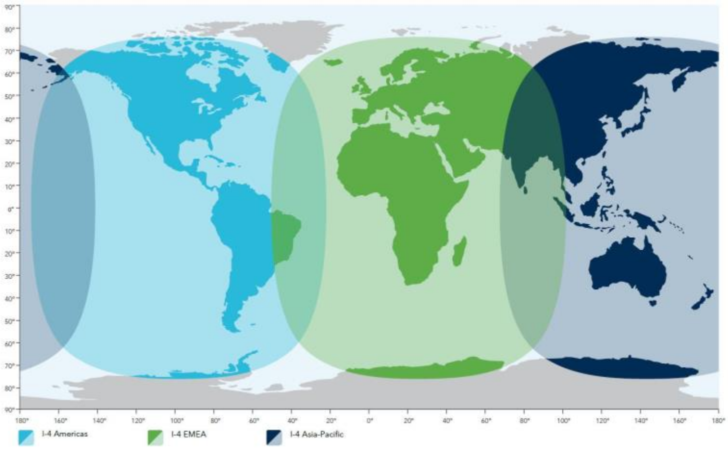

Figure 3-46: INMARSAT I-4 Coverage

159. In Australian littoral waters the Sailor 500 is supported by the Next G which accesses the Telstra 3G Universal Mobile Telecommunications System (UMTS). Next G is High Speed Packet Access (HSPA) capable, providing reliable high data rates, up to 14 Mbps in the downlink and 5.8 Mbps in the uplink. For the SCMP-M configuration the RAN operating profile limits data rates to around 2 Mbps.

160. SCMP-M will also manage the NINSHORE connection as an additional bearer thereby providing for the simultaneous access for all attached security enclaves whist alongside at Australian based home ports.

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Chapter 4. Internal Communications Systems

1. The FFG Internal Voice Communication system is comprised of:

   a. Several Multi-Channel (MC) amplified voice systems,

   b. a sound powered telephone system,

   c. an Interphone system, and

   d. Private Automatic Branch Exchange (PABX).

Amplified Voice Systems

2. Multi-channel (MC) systems transmit orders and information between stations within the ship, by means of direct, amplified voice communications. There are two types of MC equipment—one type is used in intercommunication (intercom) systems; the other type is used in shipboard announcing systems.

3. Shipboard **announcing** systems (also called central amplifier systems), are designed to broadcast orders or information to a large number of stations simultaneously. In each of these systems, a central amplifier is used, hence, the system affords only one-way communication. Circuits include:

   a. 1MC (Amplification provided by the Main IC SWBD);

   b. 5MC (Amplifier outside HCO);

   c. 6MC (Amplification provided by the Main IC SWBD);

   d. 10MC (Amplifier on the Bridge);

   e. 29MC (Amplifier in SCR); and

   f. 91 MC (Amplifier in Mk 92 Equipment Room)

4. Intercommunication (**intercom**) systems allow two-way transmission of orders and information between stations (in the same space or in different spaces). Each intercom unit contains its own amplifier. The Intercommunication Sets used are generally the LS-519A “Squawk Box”.

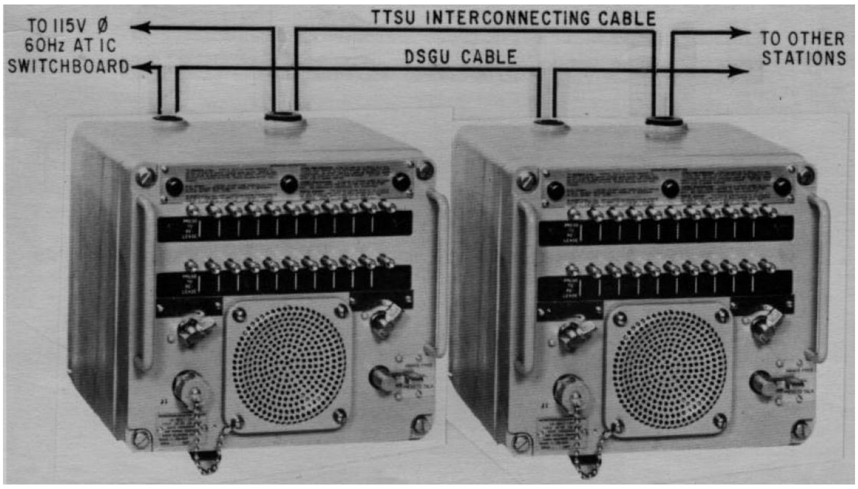

Figure 4-1: LS-519A “Squawk Box”

5. MC “intercom” Circuits include:

   a. 21MC;

   b. 26MC and

   c. 32MC.

MC Circuit Descriptions

6. **Circuit 1MC -** General Announcing. This circuit provides means for voice transmission from various microphone control stations to all areas within the ship, and to all topside areas.

7. **Circuit 6MC** – Inter-ship Announcing. This circuit provides means for transmitting orders and information to nearby ships, landing craft or to shore. It operates through a 'bull horn' speaker located near the base of the main mast.

8. The 1MC and 6MC amplifier group is located in IC & Gyro (2-79-0-C) and consists of two 500 W amplifiers (one for each circuit), a control cabinet, two alarm signal generators and switching equipment.

9. Microphone control stations are located as follows:

   a. Bridge

   b. Ship Control Operator (Ship Control Console)

   c. OOD (Ship Control Console)

   d. OOD Station (Breeze Way)

   e. OOD Station (Flight Deck)

   f. Operations Room

   g. Damage Control Central (DCC)

   h. Common Office Complex (COC)

10. The Bridge microphone control station has priority over all other stations. Transmission over 6MC is controlled only from the Bridge microphone control station by a 6MC Group selector switch.

11. **Circuit 5MC** - Flight Deck Announcing. This circuit provides means for transmission of Flight Deck orders between the Helicopter Control Station and the Flight Deck/Hangars. The Amplifier is located outside the Helo Control Office (HCO).

12. **Circuit 10MC** - Bridge Announcing. This circuit provides means for two-way transmission of ship control orders and information between the Bridge, Operations Room, CO's Cabin, 03 Level and the Bridge Wings. Power for the Amplifier is taken from a 115V, 60Hz single phase lighting panel located on the bridge.

13. **Circuit 21MC -** Captain's Command Announcing. This circuit provides means for two-way transmission of ship control orders and information between the following areas:

   a. Bridge

   b. Captain's Chair

   c. Ship Control Console

   d. Chart Table

   e. Operations Room

   f. Communications Centre

   g. Steering Gear Room

   h. Helicopter Control Station

   i. Sonar Control Room

   j. RAST Control Station

   k. Central Control Station

   l. Sheltered Admin Station (Flagdeck)

14. Communication is via LS-519A Intercommunication Sets (Squawk Box).

15. **Circuit 26MC** - Machinery Control Announcing. This circuit provides means for two-way transmission of orders between machinery operating stations. Communication is via LS-519A Inter-communication Sets (Squawk Box).

16. **Circuit 29MC** - Sonar Control & Information Announcing. This circuit provides a means for transmission of orders and information between the Sonar Control Room and the Bridge and Operations Room (PWO position). Communication is via a microphone system, with the amplifier located in the SCR.

17. **Circuit 32MC** - Weapons Control Announcing. This circuit provides means for two-way transmission of orders and information between Weapons Stations. Communication is via LS-518A Inter-communication Sets (Squawk Box) located as follows:

a. Operations Room (AWO)

b. Mk 92 Equipment Room

c. Gun Magazine

d. STIR Equipment Room

e. GMLS Control Room

f. RICER

g. CIWS Local Control

18. **Circuit 91MC** - Visual Signalling Announcing. This circuit provides means for transmission of orders and information between:

a. Bridge and Bridge Wings

b. Operations Room

c. Flagdeck

19. The amplifier for this system is located in the Mk 92 Equipment Room.

Alarm Circuits

20. Provision is also made to transmit distinctive Collision, Chemical Attack, General and Flight Crash alarms over the 1MC circuit. These alarms have a priority precedence in the order listed i.e. Collision alarm will override the General alarm etc. The table below lists the locations from where alarms can be activated.

	Collision	**Chemical**	**General**	**Flight Crash**
Pilot House	X	X	X	X
OOD Stations	X	X	X	
HCS				X
LSO				X

Table 8: MC Alarm Activation Points

Sound Powered Telephone System

21. As the name implies, the sound powered telephone requires no external power source to operate. The sound waves of the speaker's voice provide the energy necessary for the reproduction of the voice at the remote location. The system is designed to be able to handle 10 headsets on a single circuit without audio degradation.

22. There are two types of sound-powered telephone systems:

a. The primary battle telephone system circuits JA to JZ (table 9) include all circuits used for the main channels of communications in controlling the weapons control, engineering, damage control, and maneuvering.

b. The auxiliary battle telephone system circuits XJA to XJZ-includes circuits duplicating certain primary battle telephone circuits as alternates in case of damage.

23. The functional groups of sound powered telephone systems are as follows:

a. Ship Control

b. Engineers & Damage Control

c. Armaments Control

d. Miscellaneous

24. Of importance to Combat System operations and casualty control are the following systems:

a.	JA	Captain's Command
b.	1JG	Helicopter Control
c.	JL	Lookout
d.	1JS	Operations Room Information
e.	22JS	Surface & Air Radar
f.	61JS	Sonar Information
g.	81JS	Electronic Warfare Information
h.	2JZ	Damage & Stability Control
i.	2JP	Battery Control
j.	6JP	Torpedo Control
k.	X6J	Electronic Service
l.	X43J	Weapons System Service

Sound Powered Communications and the C&Di Console

25. Sound powered communication is available in the left ear-phone of the VCS 945C (external comms) headset. The selection of the circuit is made at the left-phone select switch on the Communications Intercommunications Station (CIS) of the C&Di. Volume control for the left phone is exercised at the VCS 945C.

26. A Hughes Console Interface (HCI) is fitted to each console and provides the necessary link between the VCS 945C and the C&Di. Operation on the sound powered circuit is reliant upon power being available to the VCS 945C and HCI. In the event of power loss to these elements, an emergency sound power jack is provided at the C&Di and the barrel switch associated with the console. Connection to the C&Di input will enable sound powered communications on circuit 1JS. A special handset, designed for emergency sound powered communication, must be used.

27. Internal (sound powered) communications is aided by a voice activated keying system provided by the VCS 945C. The press to talk switch is only used for external communications.

28. Associated with the SP5 left-phone select switch position on most consoles is a barrel switch that enables the proprietary selection by the operator of that circuit.

29. At positions not supplied with the VCS 945C and HCI fit, an Intercom Station LS-537A can be used to provide sound powered communications. In the event of power loss at the LS-537A, an emergency sound power jack is provided that will enable sound powered communications on circuit 1JS. A special handset, designed for emergency sound powered communication, must be used.

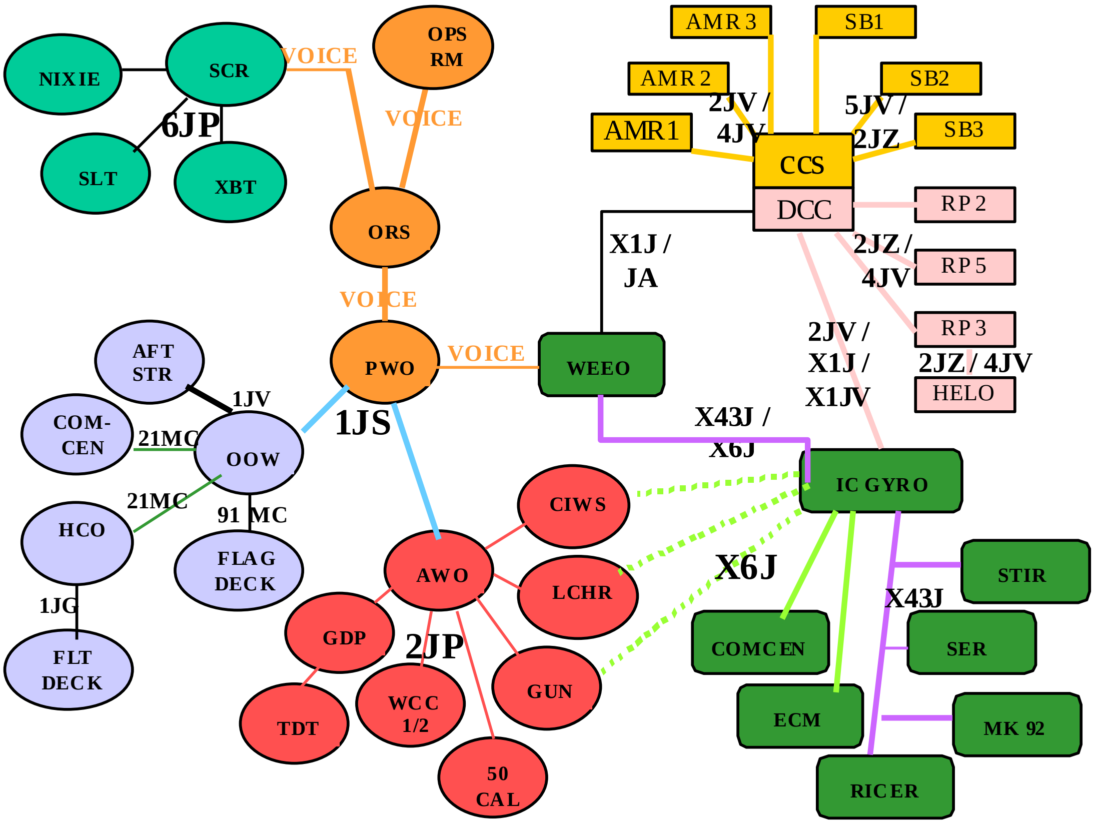

Figure 4-2: Sound Powered Telephone System Diagram

Circuit	Title	String/Switchbox Type	Switchbox Location
	Primary Circuits		
JA	Captains Command	String	
1JG	Helicopter Control	String	
20JG	Telebrief Helicopter Comms	String	
JL	Lookouts	Swbx	
2JP	Battery Control	Swbx	CIC
4JP	Mini-Typhoon Control	String	
6JP	Torpedo Control	Swbx	CIC
10JP	VLS Control	String	
1JS	CIC Information	Swbx	CIC
22JS	Surface and Air Search Radar	String	
61JS	Sonar Information	String	
81JS	Electronic Warfare Information	String	
1JV	Manoeuvering and Docking	Swbx	Bridge
2JV	Engineers Engine Control	Swbx	DCC
4JV	Engineers Fuelling and Stability	Swbx	
5JV	Engineers Electrical Information	Swbx	
JW	Ship Control/Bearing Takers	String	
JX	Radio and Signals Information	Swbx	
2JZ	Damage Control	Swbx	
	Auxiliary Circuits		
X1J	Ships Administration	Swbx	
X1JV	Auxiliary Manouevering and Docking	Swbx	IC/GYRO
X4J	Degaussing Control	String	
X6J	Electronic Control	String	
X23J	Pallet Elevator	String	
X28J	Dumbwaiter	String	
X40J	Casualty Communication	String	
X43J	Weapons System Service	String	
X52J	Sewer System Service	String	

Table 9: Sound Powered Circuit Listing

String/Switchbox Circuits

30. String circuits are wired such that all headsets/handsets are directly in parallel. Switchbox circuits are connected via switchboxes (switchboards) that allow individual outlets to be disconnected. The switchboxes are located in the area that has operational control over the circuit. This allows for damaged circuits that are loading down the rest of the circuit to be disconnected at the switchbox.

X40J - Casualty Communication

31. This string circuit provides emergency communication facilities at vital below deck stations for rigging communication lines between these vital stations after a casualty has occurred.

32. Architecture: Permanently installed vertical riser cables are installed between single telephone jackbox assemblies (P & S) in the vital below deck stations and corresponding four-gang telephone jackbox assemblies (P & S) on the first weather deck above each station. The jack outlets in each four-gang jackbox assembly are connected in parallel.

33. Locations of below deck stations are as follows:

a. APU Machinery Room

b. IC & Gyro Room

c. Electronics Shop

d. AMR 1

e. AMR 2

f. AMR 3

g. Engine Room

h. 400 Hz Frequency Changer Room

i. Central Control Station

j. Steering Gear Room

k. AC Machinery Room

34. Casualty Communications Implementation: Each Repair Station is equipped with four patching cables, each consisting of 200-foot lengths of cable fitted with a plug on each end and stowed on a reel, eight double gang jackboxes, and two sound powered headsets. Should normal sound powered telephone services be disrupted the patching cables, portable jackboxes, headsets and permanently installed jackboxes and risers can be utilised to connect X40J over a wide variety of routes.

Interphone System

35. The interphone system provides point to point communications between two or more selected operators via LS-537 communications panels. LS-537 panels are located:

a. above the Weapons Control Consoles (WCC);

b. above the Command Desk in the Operations Room;

c. on the bridge;

d. Helo Control Room, and

e. Launcher Control Room.

Figure 4-3: LS-537 Interphone

36. The interphone system also provides point to point call up (buzzing) between C&Di CIS and LS-537's. The most common use for this buzzing capability is for the Surface Operator to 'buzz' the bridge, letting the OOW know to join SO on sound powered circuit 22JS for a contact report.

PABX

37. All FFGs have been fitted with PABX telephone systems. This greatly enhances administrative communication throughout the ship with telephones installed in most compartments. The system is connected to shore lines when alongside and normally allows authorised access to INMARSAT and other fitted mobile telephone systems. Sound powered telephone is still the primary means of Damage Control communications. MASTIS has been integrated into the PABX to provide external phone access at sea.

38. The PABX has a battery backup that will allow it to run for a short time after loss of power.

Figure 4-4: PABX

Chapter 5. Combat System Switchboard (CSSB)

References:

- ABR 6823 COMBAT SYSTEM SWITCHBOARD MK 60 MOD 7
- ABR 6832 COMPUTER SWITCHING CONTROL PANEL MK 328 MOD 38

General

1. The CSSB Mk 60 Mod 7 functions to provide the following Combat System services;

   a. AC power distribution,

   b. Synchro Reference distribution,

   c. DC power generation and distribution,

   d. Combat Data System Analog & Digital interface switching, and

   e. Weapon Direction Analog & Digital interface switching.

2. The CSSB is located in the forward section of the RICER (1-100-0-Q) and comprises two major sections:

   a. Rear Section

   b. Front Section

Rear Section

3. The Rear section consists of three inter-connected cabinets, numbered 1 through 3. The Rear Section functions to connect the Front Section to the cables from equipment of the Sensor, Command & Decision, Support, Fire Control and Effector elements.

Front Section

4. Composite units include three cabinets, designated A through C.

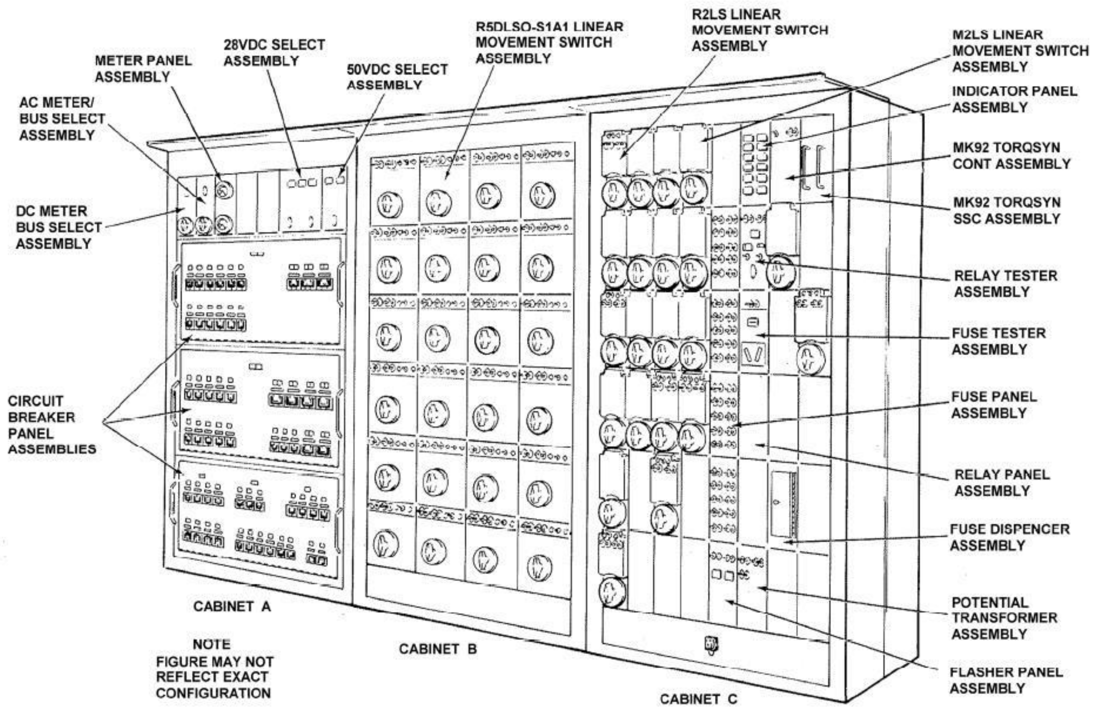

Figure 5-1: CSSB (front View)

Cabinet A

5. Cabinet A functions to:

   a. control and distribute 115V 60 Hz and 400 Hz supplies;

   b. generate and distribute 25, 28 and 50 VDC supplies;

   c. Provide Earth Checking.

115 V 400 Hz	115 V 60 Hz	28 V DC	50 V DC
GMLS REF provides Synchro Ref for GMLS, Mk 92, HWCC, IC SWBD, Harpoon EAT and WTIs	*FUSE IND* provides supply voltages for CSSB Relay Tester and Fuse Tester	*Mk 92* provides logic power to Mk 92, Channel Selector, CSIC SWBD and TORQSYN Control	*CWI No.1* provides logic power to the CAS CWI Transmitter
Mk 75 REF provides synchro ref to Mk75 Gun	*Mk 92 TORQSYN* provides power to TORQSYN to generate True Bearing Indicator	*HARPOON* provides logic power to HWCC and Harpoon Fire Warning switch	*CWI No.2* provides logic power to the STIR CWI Transmitter
SM-1 REF provides missile roll synchro ref to GMLS and Mk 92 via 115V:26V transformer	MSL FIRE WARNING provides power to Flasher Panel for Missile Fire Warning Annunciators	*GMLS* provides logic power to GMLS	
HARPOON provides 3-phase primary power to HWCC	R5DLS	CSCP	
GMLS Launcher Simulator	CSCP Execute	*TDT* provides logic power to TDT Switching Unit and EOTS	
Mk 92 TORQSYN provides antenna bearing synchro ref to TORQSYN	R2LS EXCITATION provides power to motorised Cabinet C switches 36, 38, 51, 52 and 57	Lightweight Torpedo System	
CIWS TORQSYN	*RECTIFIER* provides power to DC rectifiers	*RELAY TESTER* provides power to Cabinet C Relay Tester	
MK92 CAS Simulator	Weapon Train Indicator Illumination	DLS Control	
76MM Gun Simulator	CIWS TORQSYN	*DUD/EMERG FIRING* provides logic power to Alternate/Dud/Emergency Firing Order circuit in Mk 92 FCS	
	Lightweight Torpedo System	GMLS Launcher Simulator	
	Potential Transformer	*NORMAL FIRING* provides logic power to Normal Firing Order circuit in Mk 92 FCS	
		76MM Gun Simulator	

Table 10: Cabinet A Power Distribution

Cabinet B

6. Cabinet B functions to provide digital inter-computer and peripheral reconfiguration facilities for the ADS Servers and UYK-43 computer digital interfaces.

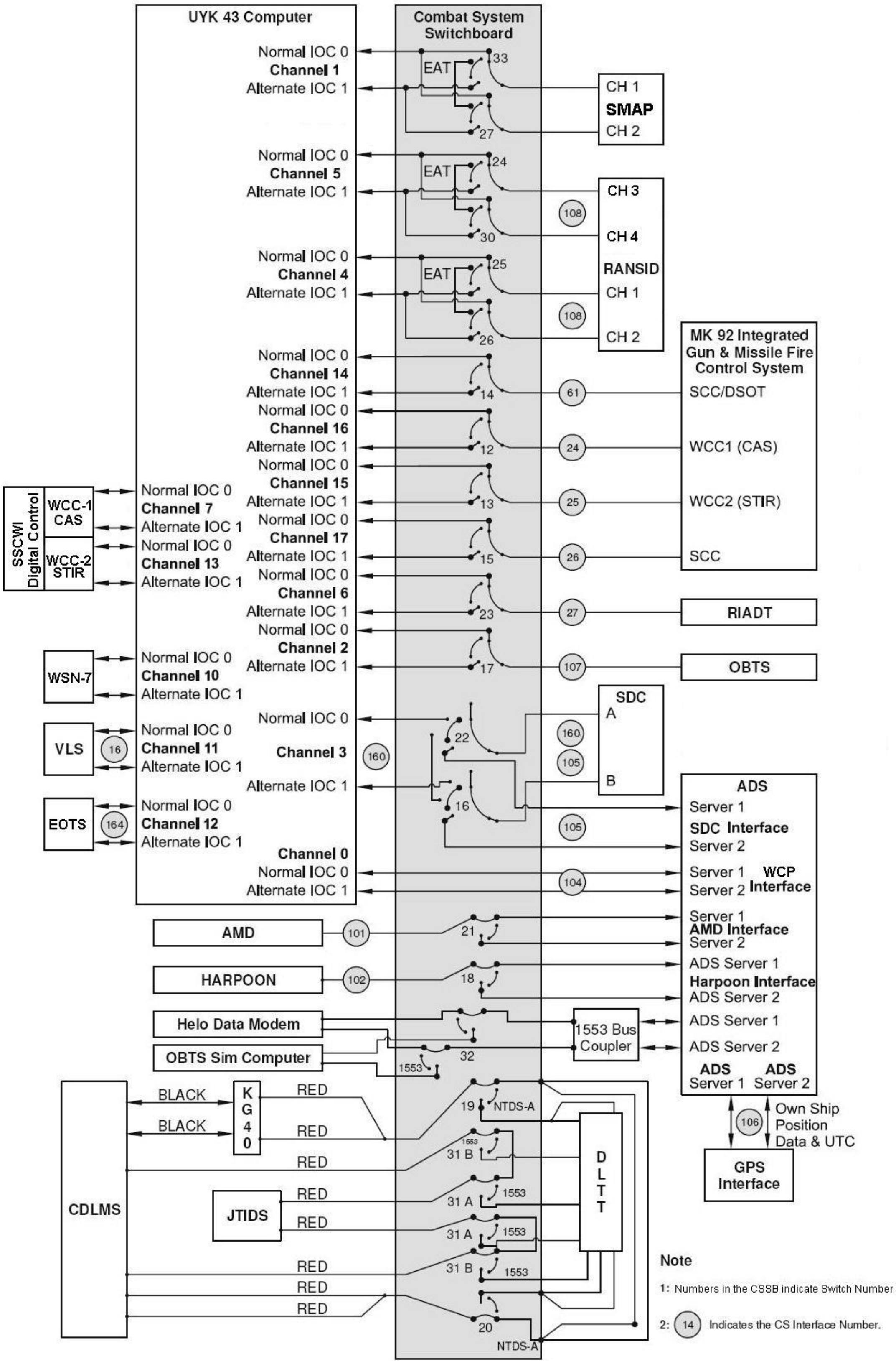

Figure 5-2: Cabinet B Switching Options

7. Due to the complexity of the switching requirements between the various sub systems within the combat system, motorised switches called Digital Linear movement Switches (DLS) are used to reconfigure the Cabinet B interfaces.

Cabinet C

8. Cabinet C functions to provide analog switching of the combat system interfaces including:

a. Provide manual and automatic GMLS connection and switching facilities for Mk 92 and Harpoon Fire Control Systems.

b. Launcher Sim on/off switch

c. Gun Sim on/off switch

d. Provide manual and automatic Mk 75 Gun and TDT connection and switching facilities for the Mk 92 Fire Control System.

e. Provide manual Weapon Train Indicator connection facilities for the Mk 75 Gun and GMLS.

f. House the Mk 92 TORQSYN.

g. Provide missile fire warning enunciator excitation.

h. DC supply protection (fusing) for certain Weapon Control element equipment.

9. Four Cabinet C switches are motorised and may be controlled remotely via DC logic signals generated by external devices. For example, Switches 36 and 38, both labelled LS ASSIGN, may be switched from the MK 92 position to the HARPOON position and vice-versa under the control of WCP. Similarly, Switch 51, TDT SELECT, may be controlled from the remote TDT Switching Unit in the Operations Room. All manual switches (ie. not motorised) are also simple ON/OFF switches and are referred to as Action Cut-Out (ACO) switches.

10. The following Diagram depicts the Mk92 TORQSYN interface through Cabinet C (Refer to ABR6823 Vol1 for a functional description):

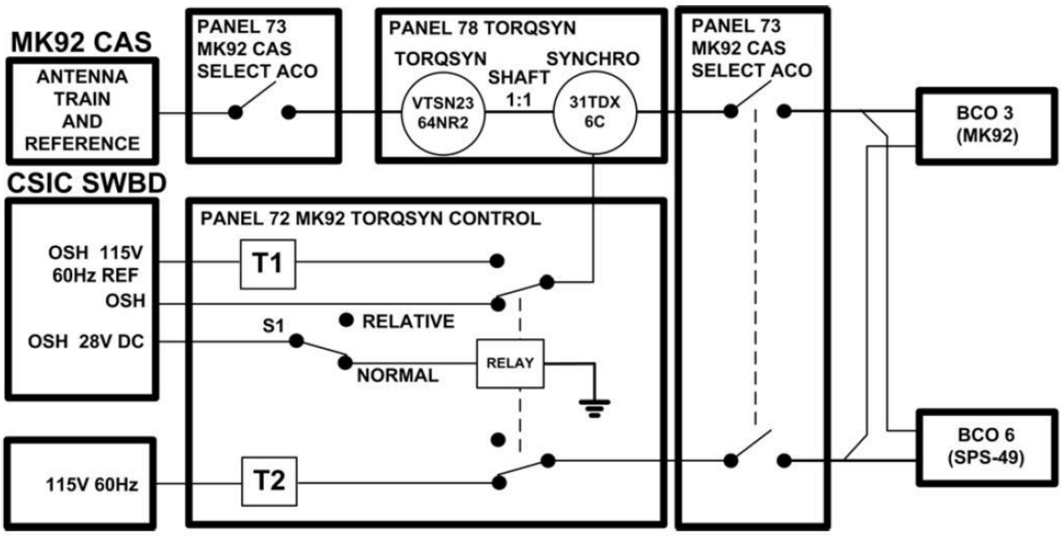

Figure 5-3: CSSB Cabinet C – Mk92 Torqsyn Switching

11. The following diagram depicts the Gun And Launcher interfaces through Cabinet C:

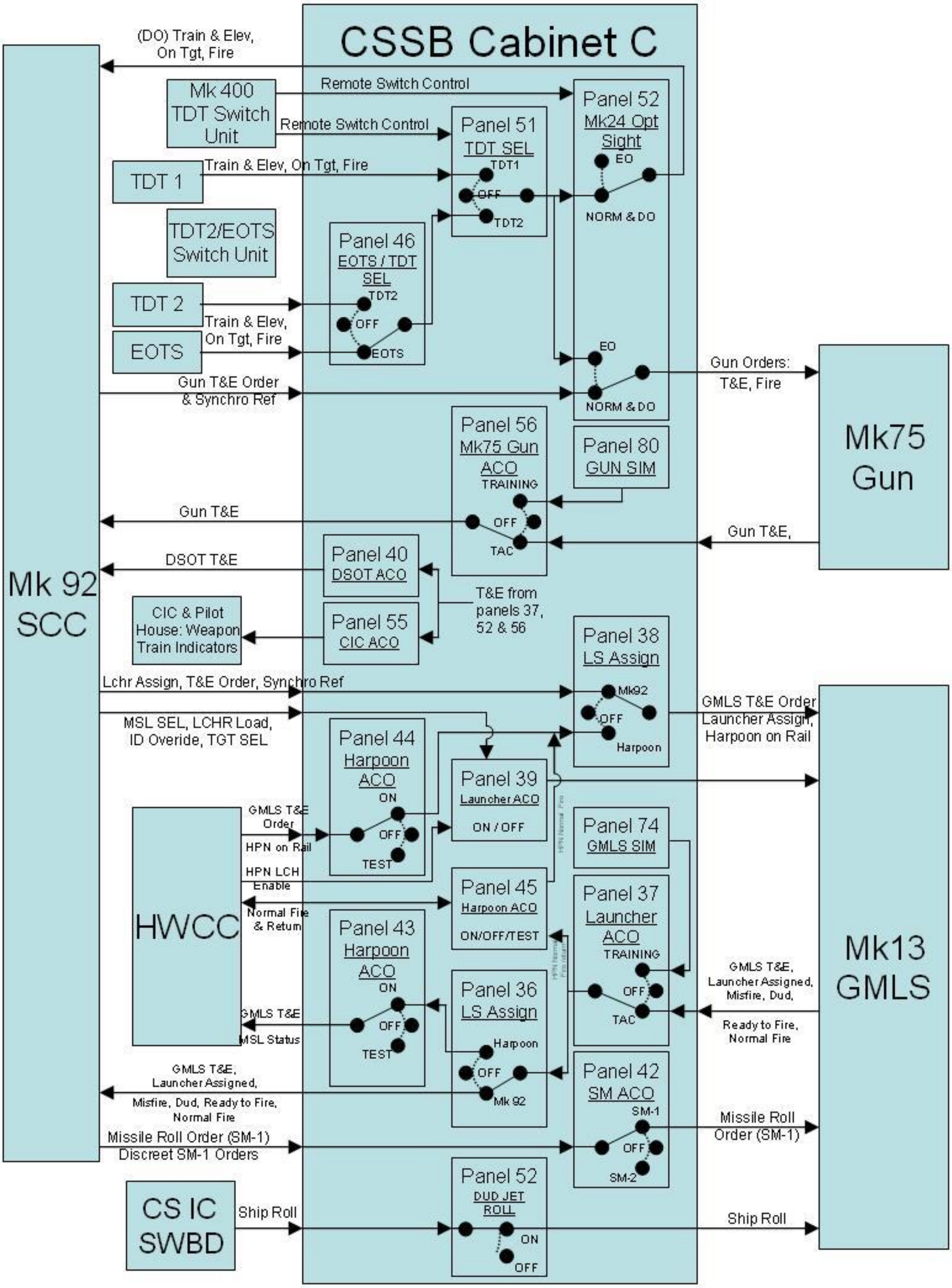

Figure 5-4: CSSB Cabinet C – Gun & GMLS Switching

12. The following diagram depicts the CIWS TORQSYN interface through Cabinet C – Note however that CIWS is not interfaced with the ADS, so this interface is not used.

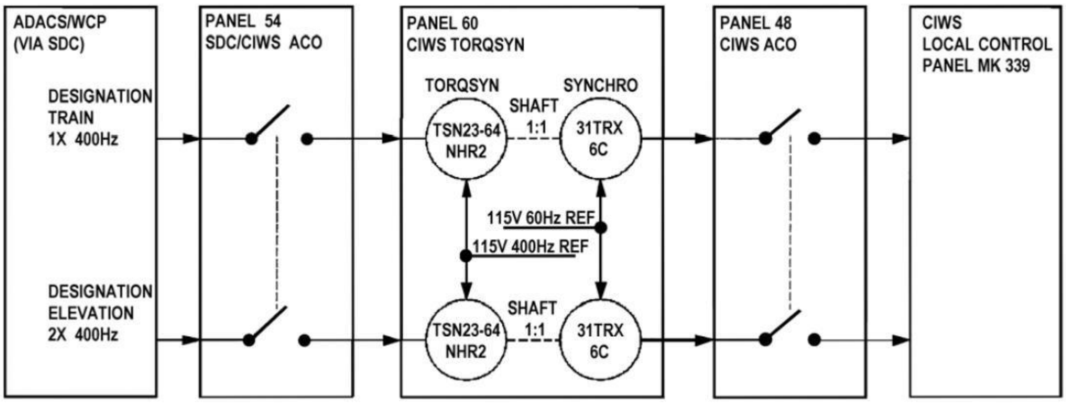

Figure 5-5: CSSB Cabinet C – CIWS Torqsyn Switching

13. Cabinet C switches are tabulated below:

Panel	Label	Major signals switched	Purpose
36*[2]	Launcher Assign	Discreet Signals: • Launcher Assigned, • Misfire, • Dud, • Ready to Fire, • Normal Fire. Synchro: • GMLS Train • GMLS Elevation • Synchro Ref	Assign GMLS to Mk92 or HWCC. Control originated by Mk92.
37	Launcher ACO	Same as Panel 36	Choose GMLS to be in Tactical (Mk92 or HWCC), Training (Sim), or Isolate (off).
38*	Launcher Assign	Synchro: Train & Elevation Order Discreet: Launcher Assign, Harpoon on Rail	Assign GMLS to Mk92 or HWCC. Control originated by Mk92.
39	Launcher ACO	Missile Load Orders & Missile Orders	Isolate GMLS from Mk92
40	DSOT ACO	Train & Elevation Repeats (Synchro)	Isolate Launcher and Gun repeatbacks from Mk92
42	SM1 ACO	SM1 Missile Orders	Isolate SM1 Missile Orders from GMLS. – Note that SM-1 is no longer in FFG inventory.
43	Harpoon ACO	Missile Status signals, Launcher Position	Isolate Harpoon missile from HWCC
44	Harpoon ACO	Train & Elevation Orders and Repeatbacks (Synchro) Harpoon on Rail (Discrete)	Isolate HWCC from GMLS
45	Harpoon ACO	Ready to Fire, Normal Fire, Misfire (Discretes)	Isolate HWCC from GMLS
46	EOTS/TDT2 Select	EOTS/TDT2 Train & Elevation (Synchro) On Target & Fire (Discrete)	Select either EOTS or TDT2 for DO/EO modes

[2] * indicates remote power driven switch.

Panel	Label	Major signals switched	Purpose
48	CIWS ACO	Nil	Fitted for integration of CIWS to ADACS interface.
49	Spare		
50	Chan Select ACO	LS Assign FC1/2	Isolates the Channel Selector from Mk92 – Note, the Channel Selector is for selecting CWI channel for SM-1 only. SM-1 is no longer in the FFG inventory.
51*	TDT Select	TDT Train & Elevation (Synchro) On Target & Fire (Discrete)	Selects TDT 1 or 2 for DO/EO modes in conjunction with panel 52. Control originated by TDT control panel.
52*	Mk24 Optical Sight	TDT Train & Elevation (Synchro) On Target & Fire (Discrete) Gun Train & Elevation Order (Synchro) Fire Order (Discrete)	Selects EO or DO/Normal modes for gun control. Control originated by TDT control panel.
54	CIWS	Nil	Fitted for integration of CIWS to ADACS interface.
55	CIC ACO	Gun & Launcher Train (Synchro)	WTI isolation
56	Mk75 Gun ACO	Gun Train & Elevation Repeatbacks (Synchro)	isolate Gun position repeatbacks
57*	Dud Jet Roll	Ship's Roll (Synchro)	Pass ship's Roll to GMLS during Remote Dud-Jet operations. Control originated by Mk92.
60	CIWS TORQSYN	Nil	Fitted for integration of CIWS to ADACS interface.
73	Mk92 Torqsyn ACO	Ship's Head, Mk92 Antenna Train (Synchro)	Isolate Mk92 Torqsyn
74	LAUNCHER SIM	Simulated launcher and Missile status.	Isolates launcher and provides simulated data for training.
80	GUN SIM	Simulated gun status	Isolates gun and provides simulated data for training.

Table 11: Cabinet C Switching Options

Computer Switching Control Panel (CSCP) as

14. The CSCP is located above the HARPOON Weapon Control Console (HWCC) in the Radar Identification Friend or Foe Communications Equipment Room (RICER) (1-100-0-Q).

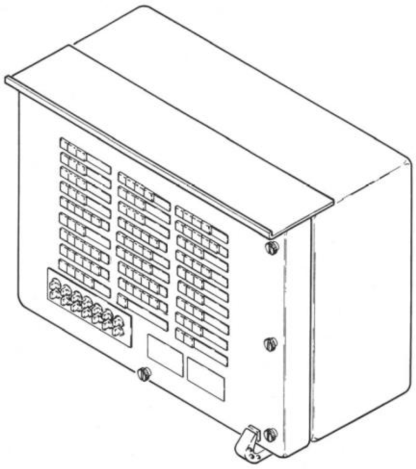

Figure 5-6: Computer Switching Control Panel

15. The MK 328 MOD 38 CSCP provides remote control of the five position Digital Linear Slide (R5DLSO-S1A1) switches and the five position Low Level Slide switches (R5LLSO-1C) in the MK 60 MOD 7 Combat System Switchboard (CSSB) Cabinet "B". The CSCP provides individual R5DLSO-S1A1 and R5LLSO-1C position control and actual position status, also preselected group control and actual position status. The CSCP also provides external system interface configuration control to CSSB Cabinet "C" and the MAIN INTERNAL COMMUNICATION (MIC) Switchboard Panel 208.

16. The CSCP provides the capability to remotely control and provide positive switch position indication by three methods:

a. Individual Switch Control – In this method the R5DLS or R5LLS switch and the switch position must be individually selected. The End-Around Test (EAT) position cannot be remotely selected from the CSCP. The R5DLS or R5LLS switch must have the REMOTE/MANUAL TOGGLE SWITCH placed in manual and the EAT can manually be positioned;

b. Group Switching Control – This method provides remote control of a group of 10 switches by activation of the U43 IOC-0 or U43 IOC-1 of the UYK-43 CONFIGURATION CONTROL Push-Button Indicators (PBI);

c. Pre-Configured Switch Control – This method is fixed and cannot by altered without internal wiring changes. Selected switches change switch position automatically upon the activation of the On-board Training System.

SWITCH PANEL NUMBER	SWITCH PANEL DESCRIPTION	CONFIGURATION			
		U43 IOC-0		U43 IOC-1	
12	ASSIGN WCC 1	S/DS1	16	S/DS2	16
13	ASSIGN WCC 2	S/DS19	15	S/DS20	15
14	ASSIGN SCC SSCP	S/DS37	14	S/DS38	14
15	ASSIGN SCC WCCU	S/DS55	17	S/DS56	17
16*	ASSIGN SDC CHAN B	S/DS76	3	S/DS75	3
17	ASSIGN STIR SIM	S/DS91	2	S/DS92	2
22*	ASSIGN SDC CHAN A	S/DS63	3	S/DS64	3
23	ASSIGN RIADT	S/DS133	6	S/DS134	6
34	SPARE (ASSIGN ASSTASS)	S/DS139	Spare	S/DS140	Spare
35	ASSIGN GPS	S/DS115	7	S/DS116	7

Figure 5-7: CSCP UYK-43 Switching Configuration

* denotes that the switch panel is internally interlocked to prevent BOTH switches to be switched simultaneously onto the same computer.

SWITCH PANEL NUMBER	SWITCH PANEL DESCRIPTION	CONFIGURATION	
		TACTICAL	TRAINING
19	ASSIGN KG-40	S/DS13	S/DS15
20	ASSIGN CMDLS	S/DS31	S/DS33
31A	ASSIGN JTIDS	S/DS49	S/DS51
31B	ASSIGN CMDLS	S/DS67	S/DS69
32	HELO DATA SELECT	S/DS85	S/DS87
37*	LAUNCHER ACO	Tactical	Training
56*	MK 75 GUN ACO	Tactical	Training
73*	MK 93 CAS SELECT	CAS STIM	CAS TRAINING
208**	OSH SIM	OSH 1X 36X	OSH 1X 36X SIM

Figure 5-8: CSCP Training Switching Configuration

* denotes that the switch panel is located in the CSSB Cabinet 'C'.

** denotes that the switch panel is located in the Main IC Switchboard.

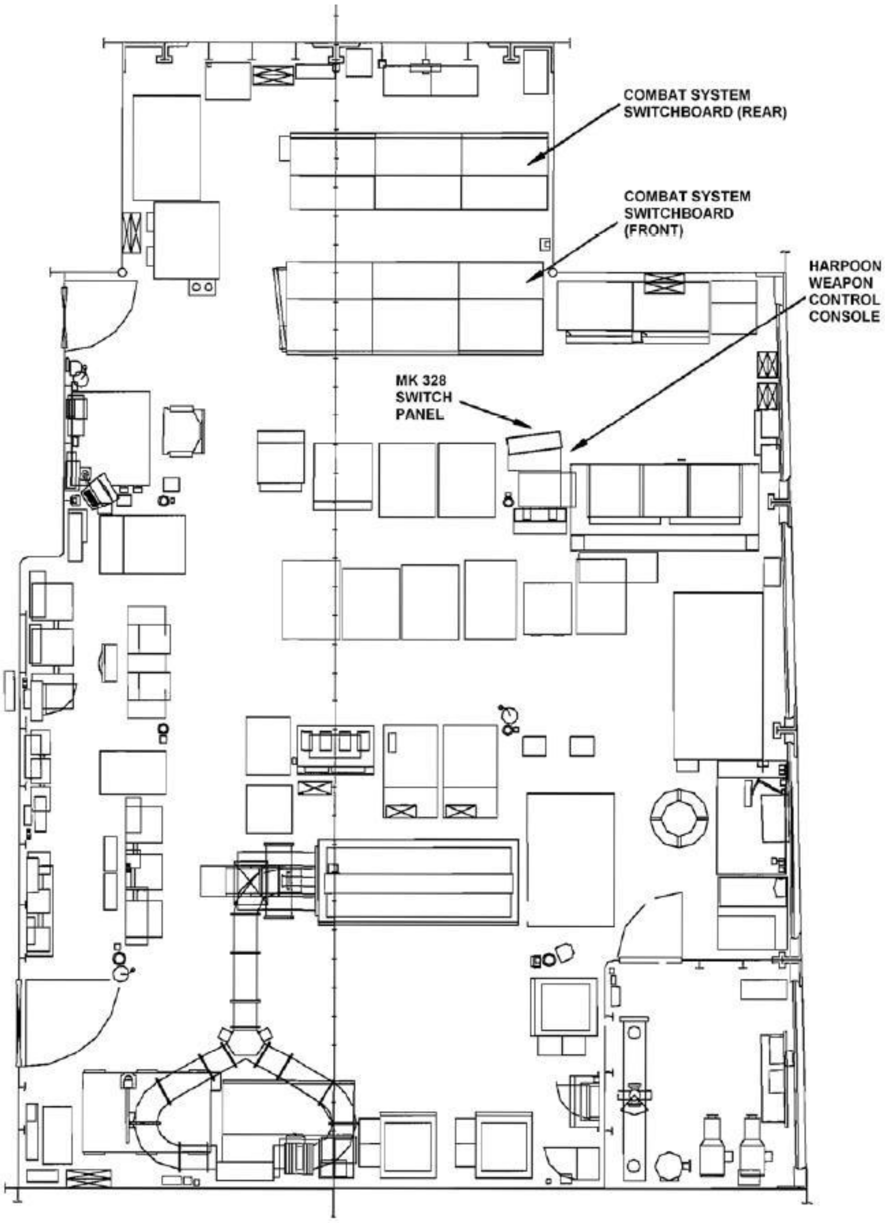

Figure 5-9: CSSB Locations within the RICER (1-100-0-Q) Compartment

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Chapter 6. FFG On-Board Training System (OBTS)

References:

- ABR 6498 Vol. 1 Onboard Training System (OBTS) Operator Manual
- ABR 6498 Vol. 2 Onboard Training System (OBTS) Maintenance Manual

Overview

1. The OBTS provides real time training for multiple personnel, under realistic conditions, in the use of combat systems. Training capability is provided for the MK-13 GMLS, MK-41VLS, the MK-75 Gun, Long Range Chaff and Decoy Systems, NULKA, MK-15 CIWS, ES Surveillance Systems, LINK 11/16 and voice communications. Simultaneous AAW, ASuW, EW and ASW capabilities are provided by the OBTS.

2. Through a combination of hardware, software and an Ethernet LAN, consoles, stimulators and sensors are linked to provide a single comprehensive integrated training system.

3. The OBTS stimulation/simulation environment comprises three major elements as shown below; the tactical environment, the natural environment and the own-ship sensor and effector systems. These components combine to engage the own-ship with simulated air, surface and sub-surface targets that are able to move and deploy weapons and decoys to provide realistic battle training.

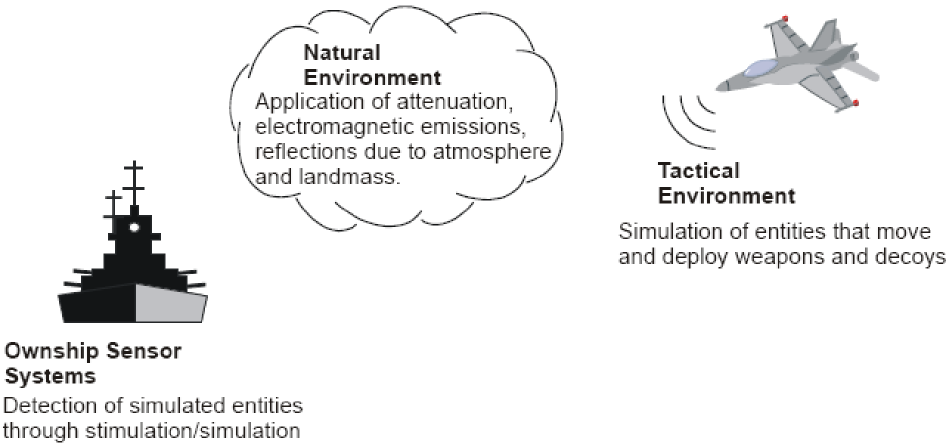

Figure 6-1: OBTS Major Elements

4. The tactical environment defines the behaviour of entities that can be detected by the own-ship sensor systems. These entities have the capability to move through the environment, according to a preplanned flight path, to launch weapons and decoys. Additionally, they have the ability to provide jamming transmissions that can be detected by own-ship sensors. Included in the tactical environment is the simulation of fighters, bombers, surface ships and submarines. Munitions and decoys after launch are also included.

5. The tactical environment has no knowledge of the characteristics of the own-ship sensor systems, that are being simulated, or the condition of the natural environment that lies between an entity and the simulated own-ship systems. Information about the tactical environment is transmitted over the **Synthetic Theatre of War (STOW)** LAN using data packets. These packets may also be received from a WAN, transmitted by other ships or land based sites equipped with OBTS. The tactical environment is controlled by one or more game controllers.

6. The natural environment defines the effects on emissions received by the own-ship sensor systems that are caused by atmosphere, land and water. These effects include landmass masking and attenuation due to range and weather. To provide these effects, the natural environment simulator monitors the position of the entity, in relation to the stimulated sensors, and the state of the natural environment that lies between the entity's position and that of the sensor being stimulated. Information about the natural environment is transmitted over the STOW LAN using data packets. These packets may also be received from a WAN, transmitted by other ships participating in the exercise. The natural environment is controlled by one or more Game Controllers.

7. The own-ship sensor systems provide target, landmass, environmental and jamming contacts, as specified by the tactical and natural environments, to the radar terminal. The own-ship sensor systems are either stimulated by the injection of signals that appear as real targets or simulated to provide targets where the sensor is not directly interfaced.

8. The major hardware components of the OBTS comprise computers, stimulators, simulators and a LAN to link the system together. The following paragraphs describe each of the major components. Figure 29-1 shows a simplified interface block diagram of the system.

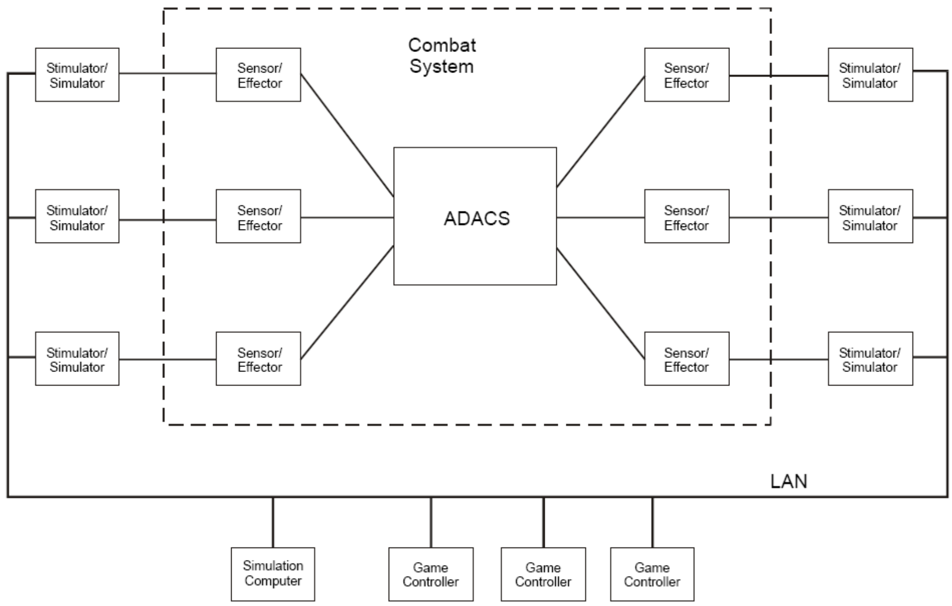

Figure 6-2: OBTS Simplified Generic Interface Block Diagram

9. **Simulation Computer** – The Sim computer provides the central control for all the processor elements used in the OBTS System. The Sim computer provides the following functions during a training exercise:

a. scenario Control;

b. scenario control messages between the ADACS and the OBTS;

c. interface with game controller;

d. entity simulation;

e. environment simulation;

f. interface via the WAN to other units in multi-ship exercises;

g. simulated data link messages to the combat and control processor;

h. weapon effector and sensor stimulation and simulation for entities that are not interfaced with the OBTS; and

i. filtering of all Distributed Interactive Simulation (DIS) information from outside sources to those applicable for the own-ship training environment simulated within the OBTS/.

10. **The Game Controller** – is a commercial laptop or desktop Personal Computers (PC) with software installed to perform the central scenario control functions for the training exercise. The primary functions of the Game Controller are to:

a. set up the exercise;

b. prepare the scenario;

c. observe and control the exercise;

d. perform role playing for equipment not interfaced to the OBTS/;

e. initiate and control debriefing;

f. initiate and display on-line fault monitoring; and

g. provide daily system testing information.

11. **Launcher Sim** – This simulator emulates the MK-13 Launcher so that it appears to the combat systems operator that there is an active launcher loaded with an SM-1 or Harpoon missile. The OBTS/ models motion and status and sends the required signals to the missile launch data processor and the missile launcher control console so that they operate as they would when using operational hardware. At the land based sites the MK-13 GMLS is software simulated.

12. **Gun Sim** – This simulator emulates the MK-75 Gun so that it appears to the combat operator that an active gun is connected and functioning. The OBTS/ models motion and status and sends the required signals to make the gun appear to be operating as it would when using operational hardware.

13. **Nav Sim** – The Navigation Simulator in the OBTS models the heading and speed of the own-ship and the wind speed and direction. Pitch and roll simulation is not required as the ship's systems receive live pitch and roll data always. Live pitch and roll information is available to the ship's equipment at all times.

14. The speeds and headings modelled by OBTS are injected into the combat system, through a training switch to the Interior Communication (IC) switchboard.

15. **Mk92 Weapons Sim** – This unit provides a computing and hardware interface for simulation of the MK-75 Gun, MK-13 GMLS, MK-41 VLS, SM-1 Missile, Evolved Seasparrow Missile (ESSM) and Harpoon Missile.

16. **CAS Search / SPS-55 / SPS-49A Stimulators** – Stimulator units provide stimulation of actual radars. These units comprise a common hardware module into which sensor unique hardware personality modules for each radar type are installed. These modules are configured to stimulate each of the specific radar types including, where applicable, IFF.

17. To assist in the provision of a realistic training exercise the host processors within the stimulator/simulator system generate landmass, weather, sea state, targets, chaff and Electronic Counter Measure (ECM) effects.

18. Communications between the stimulator/simulator host processors and the controlling OBTS computer system is achieved via several LANs. These networks are the STOW LAN, the radar LAN, the ADACS LAN, PETREL (MOAS) LAN and the Emulator Panel LAN. The STOW LAN is the main LAN used to control and coordinate the stimulators, simulators, sensors and effectors during an OBTS/LBSS exercise.

Trainer States and Modes

19. The OBTS provides the capability to conduct simultaneous, interactive training exercises that have a high level of realism. Training may be conducted in full Sim Only or Live Over Sim.

20. The training modes of the OBTS are **Idle**, **Game**, **Debrief**, **Scenario Preparation**, **MapGen** and **Diagnostics**. Each of these modes is detailed in the following paragraphs.

21. **Idle mode** – is the first mode entered after power is applied to the system. During this initial transition, the software runs a start up diagnostic. This establishes the status of the system and includes a test of all safety critical interfaces. Idle mode is a safe mode of operation.

22. **Game mode** – supports all game play functions including game control, game monitoring and game modification. Game mode is entered from idle mode by a request from an operator at the master game controller. Before the game mode can be entered, a permission to train signal must be established. Once in game mode the instructor sets up the initial operating condition by specifying whether the game will function as Sim Only or as Live Over Sim. This is the Initialisation State of Game Mode.

23. Once initialisation is complete the Freeze State is entered in which all trainer functions are suspended, all simulated entities are spatially frozen, the scenario and simulation models are paused and the time stops updating. This state remains until the instructor starts the game by entering the Run State.

24. In Run State, all operations and functions are available for the game to continue. The instructor can switch between Freeze and Run States at any time until the game enters the Termination State.

25. When the Termination State is entered, the game is ended. The instructor can enter the Termination State with or without a scenario debrief. If debrief mode is selected the game controller and the simulation computer go to debrief mode and all other parts of the system go to idle mode. If no debrief is selected all systems return to idle mode.

26. **Debrief mode** – is entered from game mode as described previously or from idle mode. The debriefing session can operate in either synchronous or asynchronous conditions. The synchronous condition can only be entered from game mode and is used to perform a coordinated debrief with the combat system. The synchronous condition uses both the game controller and the simulation computer for the debriefing. With the asynchronous condition, only the game controller is used.

27. **Scenario preparation mode** – is entered from idle mode and is used for creating or editing a scenario, previewing a scenario and executing a validation of a scenario. The three states of the scenario preparation mode are Scenario Generation, Scenario Preview and Scenario Validation. Only the Game Controller can enter scenario preparation mode and the game controller can enter scenario preparation mode while other systems are operating in game mode.

28. **MapGen mode** – is entered from idle mode and is used to generate landmass maps from CDROM source files that are used for simulation modelling and game controller displays. Only the game controller can enter MapGen mode. The game controller can enter MapGen mode while other systems are operating in game mode.

29. **Diagnostic mode** – is used to remotely control the diagnostic test for each of the computer systems. Diagnostic mode is entered from idle mode and automatically returns to idle mode after the tests are completed.

Operating States and Modes

30. Within the OBTS, a mode is a major operating condition of the system that is mutually exclusive of other modes within each computer in the system. A state is an operating condition within a mode that directs the processing of that mode. The states and modes fit into the distributed architecture of the training system.

31. In the OBTS there are two Game Controller Personal Computer (PC) positions and one laptop computer for controlling and monitoring functions, one Sim computer that executes the scenario and many simulation/stimulation systems for processing functions related to the ship's systems. The states and modes allow the various computer systems to be simultaneously in different modes.

32. The OBTS can be operated in either Sim Only mode or in Live Over Sim mode:

a. ***Sim Only Mode***. In Sim Only mode, all radar tracks are simulated/stimulated by the OBTS, as are ownship navigation data. The exercise can be carried out independent of the ownship's actual heading or speed. <u>*For navigational safety, Sim Only Mode is only to be used while the ship is alongside.*</u>

b. ***Live Over Sim Mode***. Live Over Sim mode provides live radar tracks along with simulated/stimulated tracks on radar displays. In this mode the ownship navigation data is also live and any changes to heading or speed required by the exercise must actually be carried out.

33. On entering game mode, the Game Controller sets the operating mode to either Sim Only or Live Over Sim. Once the operating mode is set it applies for the full instance of the game, it cannot be altered while the game is in progress.

34. The OBTS allows a ship to train in stand alone mode or integrated with other ships, joint platforms or other designated allies, in a common synthetic environment, over a WAN. Combat system operators may be trained individually or as a team.

35. The OBTS allows for simultaneous Realtime/Offline operation. This means that multiple game controllers can be connected to the STOW LAN at the same time. For example, one game controller can be in game mode, controlling and monitoring an exercise in progress, while the another game controller is simultaneously preparing another scenario.

36. The manning requirements of the system are quite flexible and depend largely on the training exercise to be undertaken. Training can be conducted for a battle group of two or more ships, an individual ship or for an individual combat system operator. The normal operational manning requirements of the ship must also be taken into account when determining the manning requirements for a particular exercise.

37. The positions that may need to be role played by Local Game Controllers, depending on the level and type of training being undertaken, are as follows:

a. MK-15 Close-in Weapons System (CIWS) Service Crew;

b. MK-15 CIWS Remote Control Panel Operator;

c. Long Range Chaff Round (LRCR) Service Crew;

d. LRCR Panel Operator;

e. MK-158 Firing Panel Operator;

f. MK-36 Launcher Crew;

g. MK-75 Gun Service Crew;

h. Helmsman;

i. Helicopter Crew; and

j. Combat Air Patrol (CAP) Pilot.

38. The manning requirements for the system depend on the level of training being undertaken and the complexity of the exercise.

39. Shipboard weapons are switched off-line during training and stimulator/simulator units, such as the Launcher Sim, provide realistic feedback to the weapons control processor. Training switches installed between the weapons control processor and the shipboard systems, transfer control signals from the weapon systems to the OBTS. Effectors not interfaced as part of the shipboard configuration are brought into the simulation scenario by means of software activation by the OBTS game controller. Safety for effector systems is assured by training switches.

System Safety

40. The issue of weapons safety is extremely important in simulations involving the use of actual weapons consoles. Consideration must be given to preventing unintended actuation of weapons or weapons platforms, while providing realistic simulation. This includes the ability to quickly and safely switch between live and simulated modes with fail safe feedback to the Sim controller as to whether the system is in live or simulated mode.

41. Safety in the system design and operating procedures are aimed at protecting equipment, personnel and the public. Safety in the OBTS falls into three general areas:

a. safety designed into the system;

b. safety included in operating procedures; and

c. safety warnings in the documentation and software.

42. Design safety is achieved by the incorporation of training switches fitted to critical items. These switches ensure that all sensors and effectors are in training mode before an exercise can be commenced and for the duration of a training exercise.

43. Training switches are fitted to shipboard equipment that does not have a specific training function built in. Before an exercise can commence, all training switches must be in the training mode to allow the correct signals to be sent to the Sim computer.

44. The selected approach for ensuring weapon safety relies on a Permission to Train Unit (PTTU) that is responsible for gathering all information relating to trainer safety and providing a safety critical interface to the Sim Computer.

45. Information relating to trainer safety includes the status of training switches that manually switch between simulated and live weapon systems. The training switches are monitored by the PTTU during all phases of trainer operation to ensure that the switches are in a safe position for training. The OBTS is not allowed to enter training mode and must immediately exit training mode whenever switches are not in the safe position.

46. The use of manual switches maintains human control over the combat system mode, even when the training system is offline or a malfunction occurs. The diagram below details the training switches used to support weapons safety. Each weapon/simulator pair is connected to a manually actuated training switch. The switches have two positions, Training and Normal. When set to Normal, the weapon’s control panel will be connected to the combat system. When set to Training, the weapon’s control panel will be connected to the associated Effector simulator.

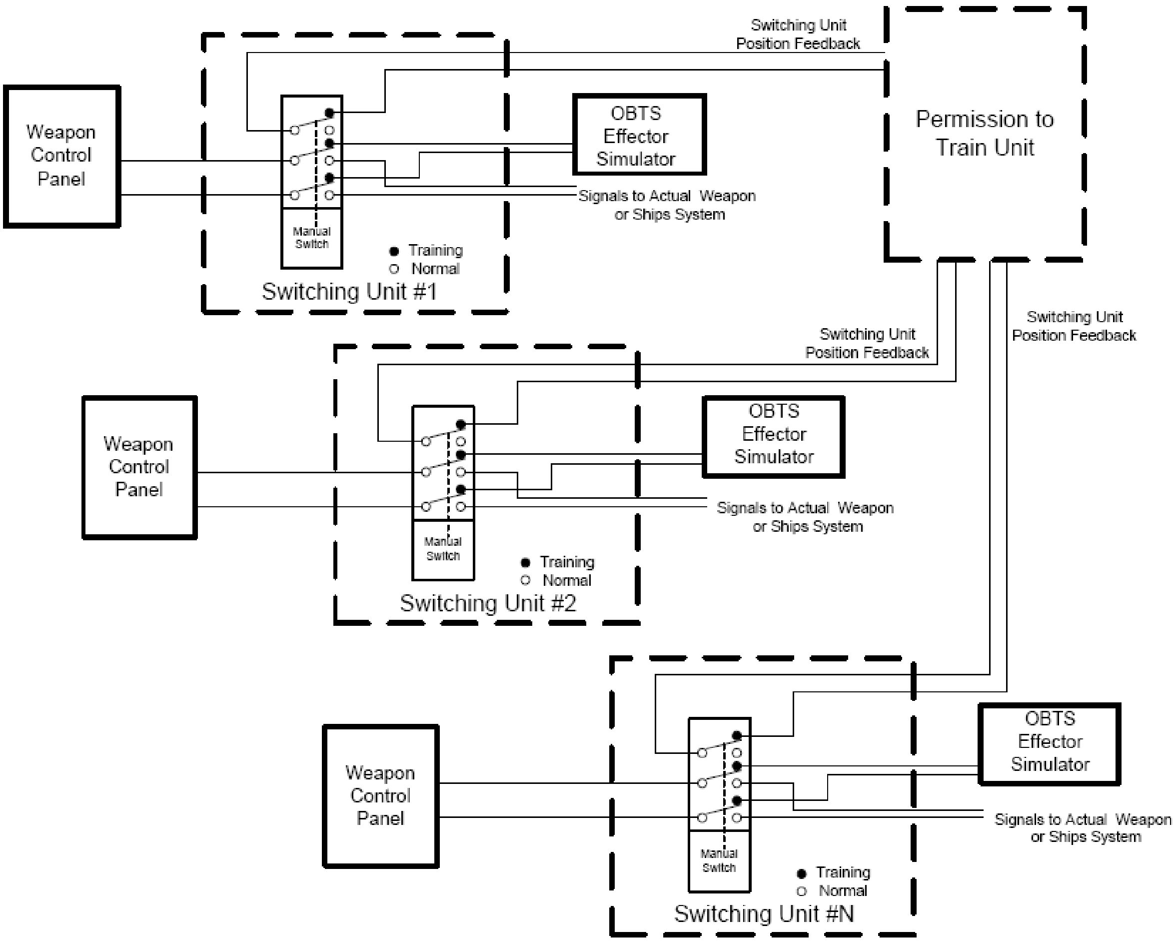

Figure 6-3: OBTS Effector Training Switches

47. It is important to note that the state of each training switch is monitored at all times and returned to the PTTU where it is continuously monitored to ensure that the effectors remain disconnected during simulation. A safety critical interface to the Sim Computer provides the information required to switch between training and tactical mode.

Permission to Train

48. A safe status condition of the training switches is a necessary input to the PTTU for it to send a ‘Permission to Train’ signal to the Sim Computer. Additionally, positive indications of the safe status of other effectors not interfaced by the OBTS must be present at the PTTU. The PTTU will not send a Permission to Train signal to the Sim Computer unless safe status indications are present from all training switches and effectors.

49. Ship’s procedures are used to ensure that the training switches are set to Normal when normal weapon system operation is desired.

50. In addition to the PTTU, other unsafe conditions can cause the Sim Computer to terminate the exercise and remove stimulation signals from the Combat System. If communication is lost between the ADACS and the Sim Computer or between the OBTS and the WCP, the Sim Computer will immediately terminate the training exercise and remove stimulation signals from the Combat System. This is to ensure that no stimulators can continue to inject simulated data into the combat system without knowing the combat system’s status. For this same reason any stimulator/simulator that can not communicate with the Sim Computer within a prescribed timeout period will terminate its stimulation/simulation and return to an idle mode.

51. Transition from training to normal operation can be performed quickly by terminating the exercise from the Game Controller. Full training capability will be restored when Permission To Train has been granted again from the PTTU.

52. During the running of a training exercise, the system may find a fault present that causes the permission to train signal to be removed. If a fault occurs, a safety alert message is sent to the game controller and is displayed on the screen. A distinguishable audible alarm signal is also generated.

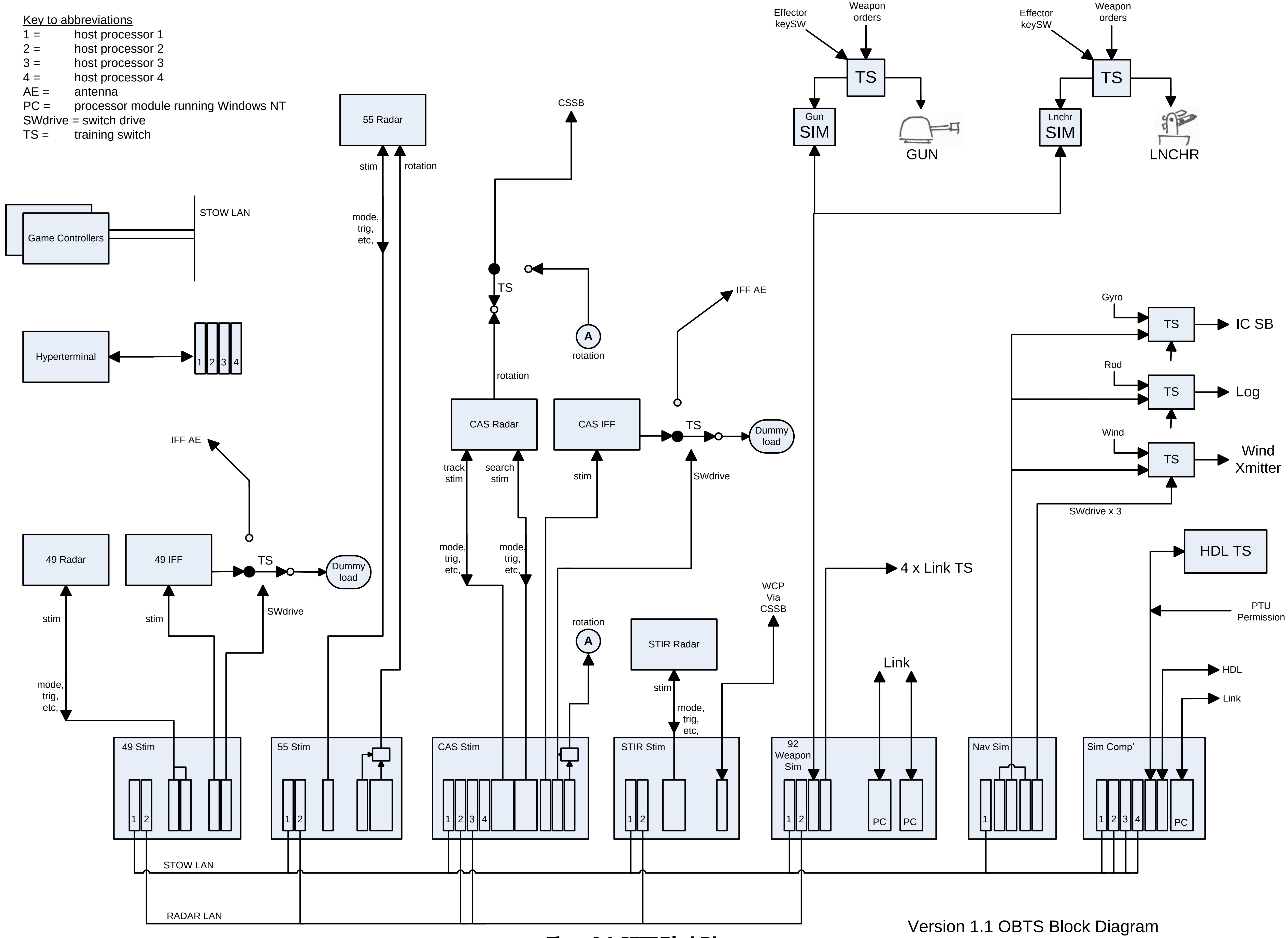

Figure 6-4: OBTS Block Diagram

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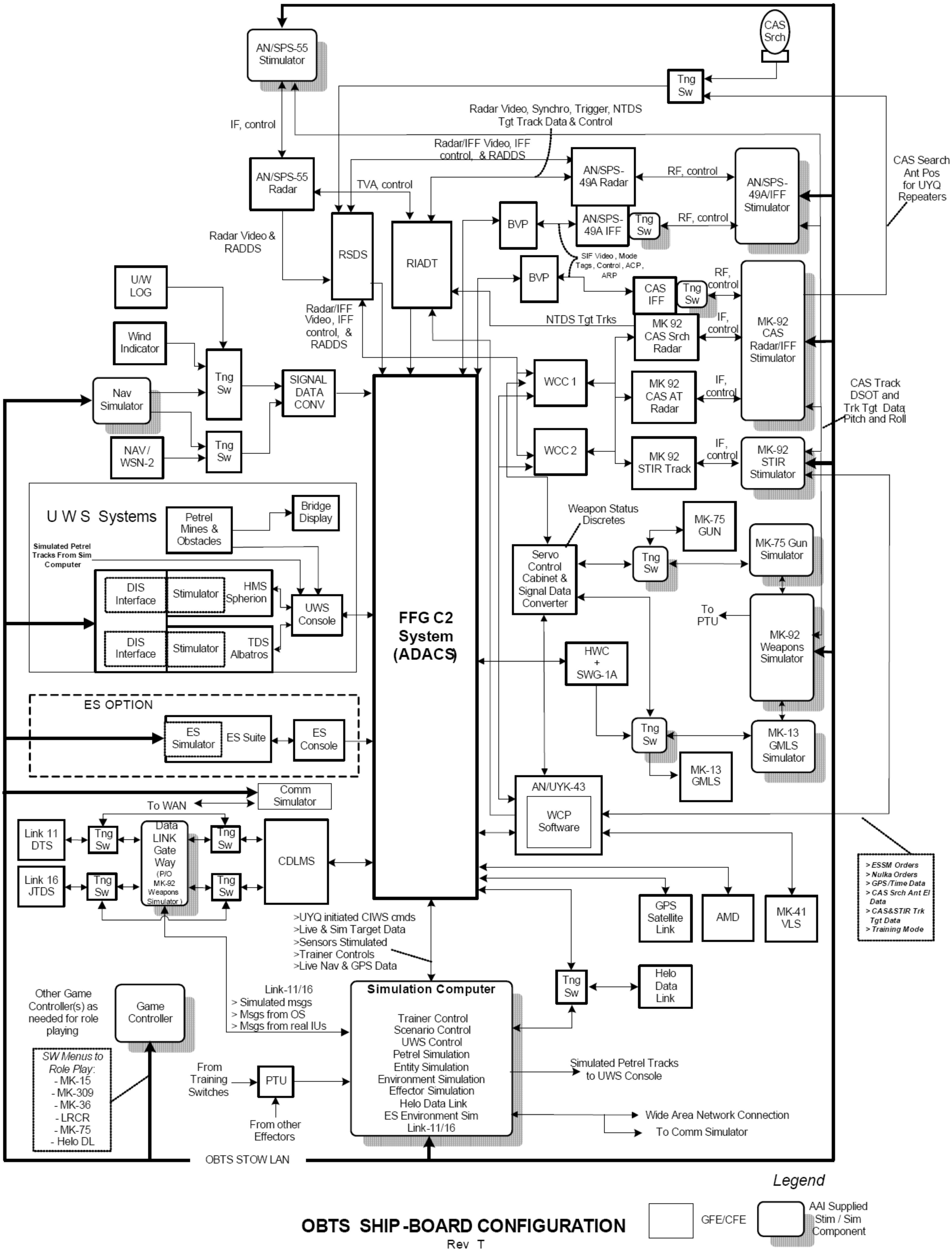

Figure 6-5: OBTS Shipboard Configuration

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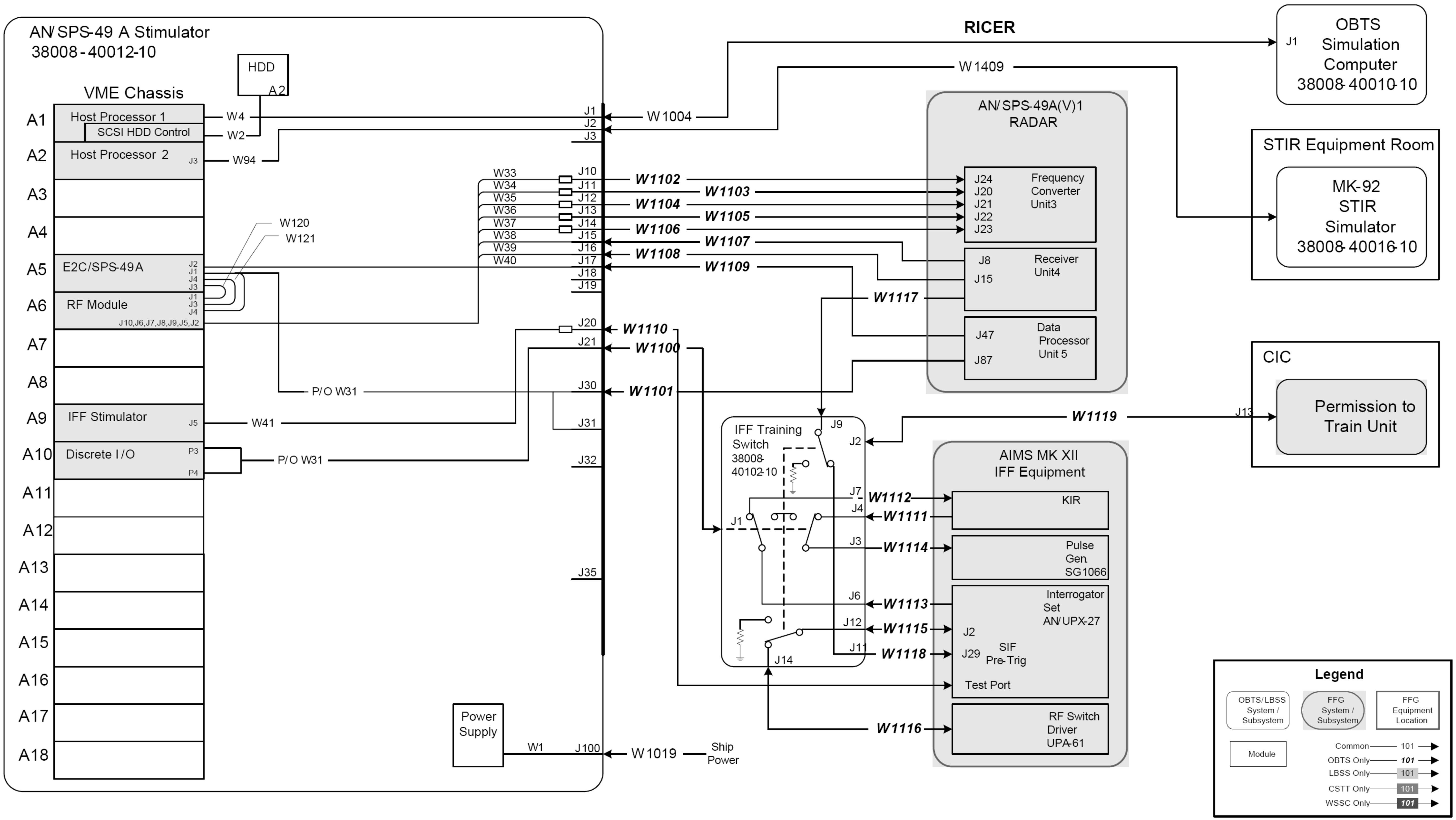

Figure 6-6: AN/SPS-49 Simulator Interconnection Diagram

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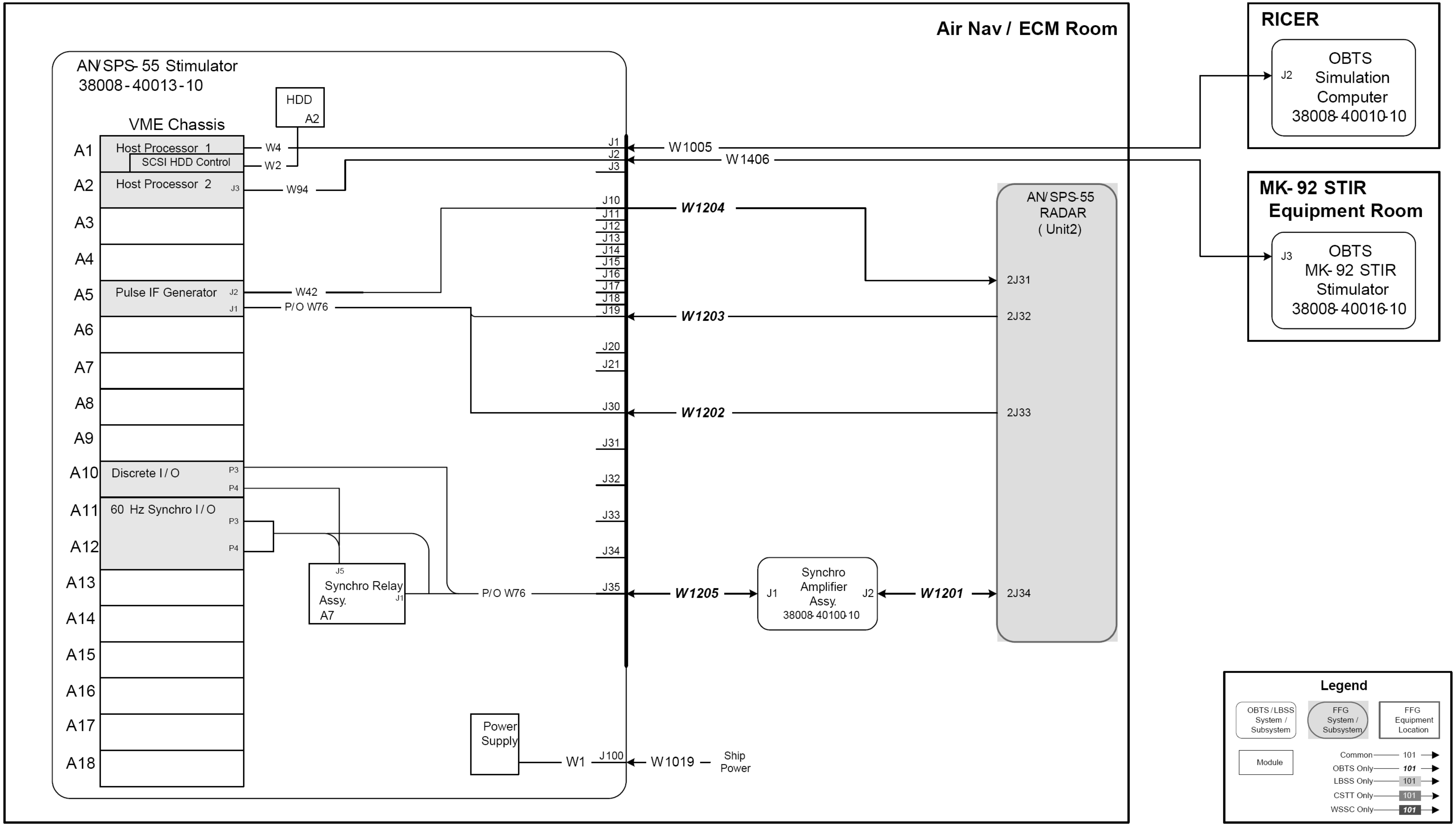

Figure 6-7: AN/SPS-55 Simulator Interconnection Diagram

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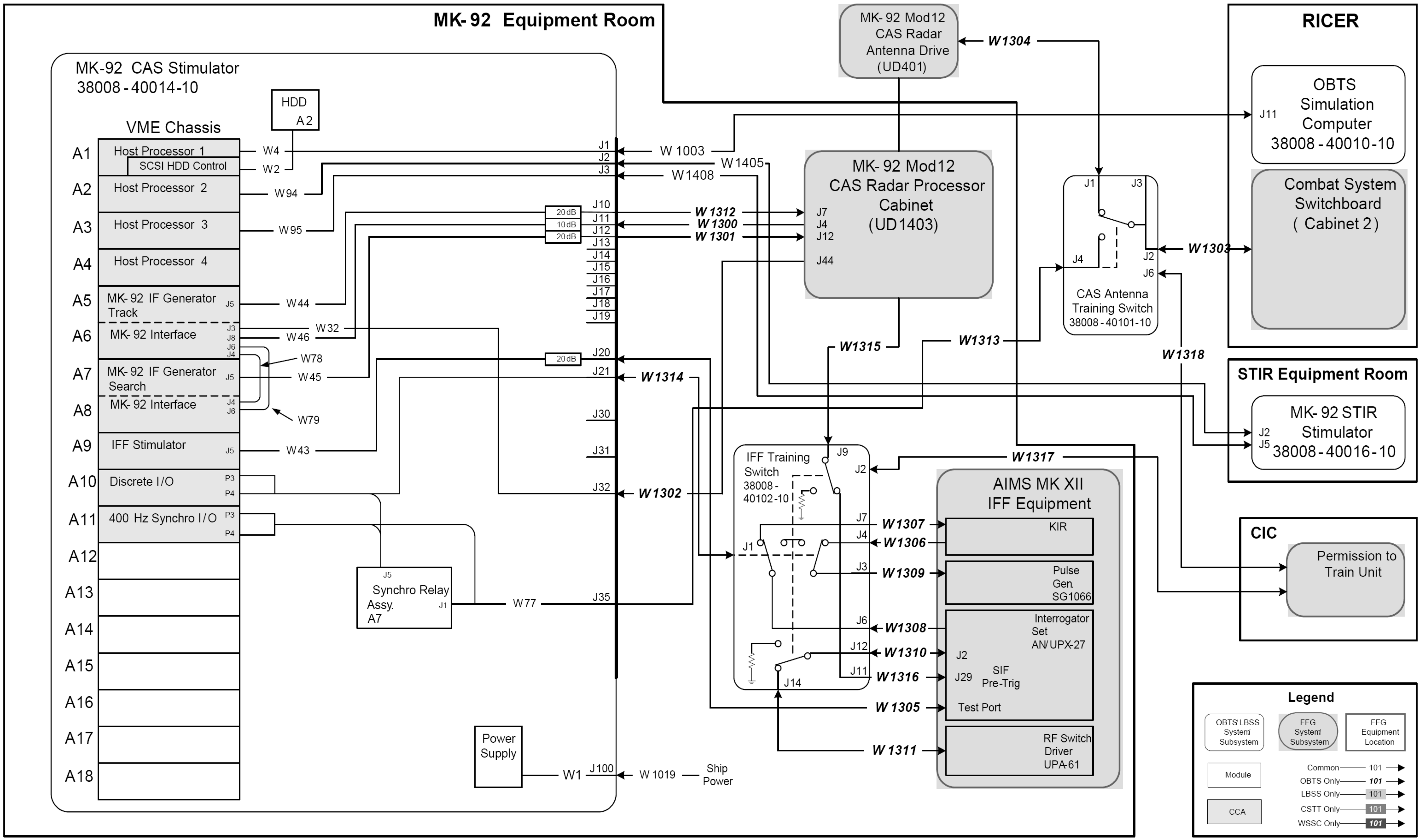

Figure 6-8: CAS Simulator Interconnection Diagram

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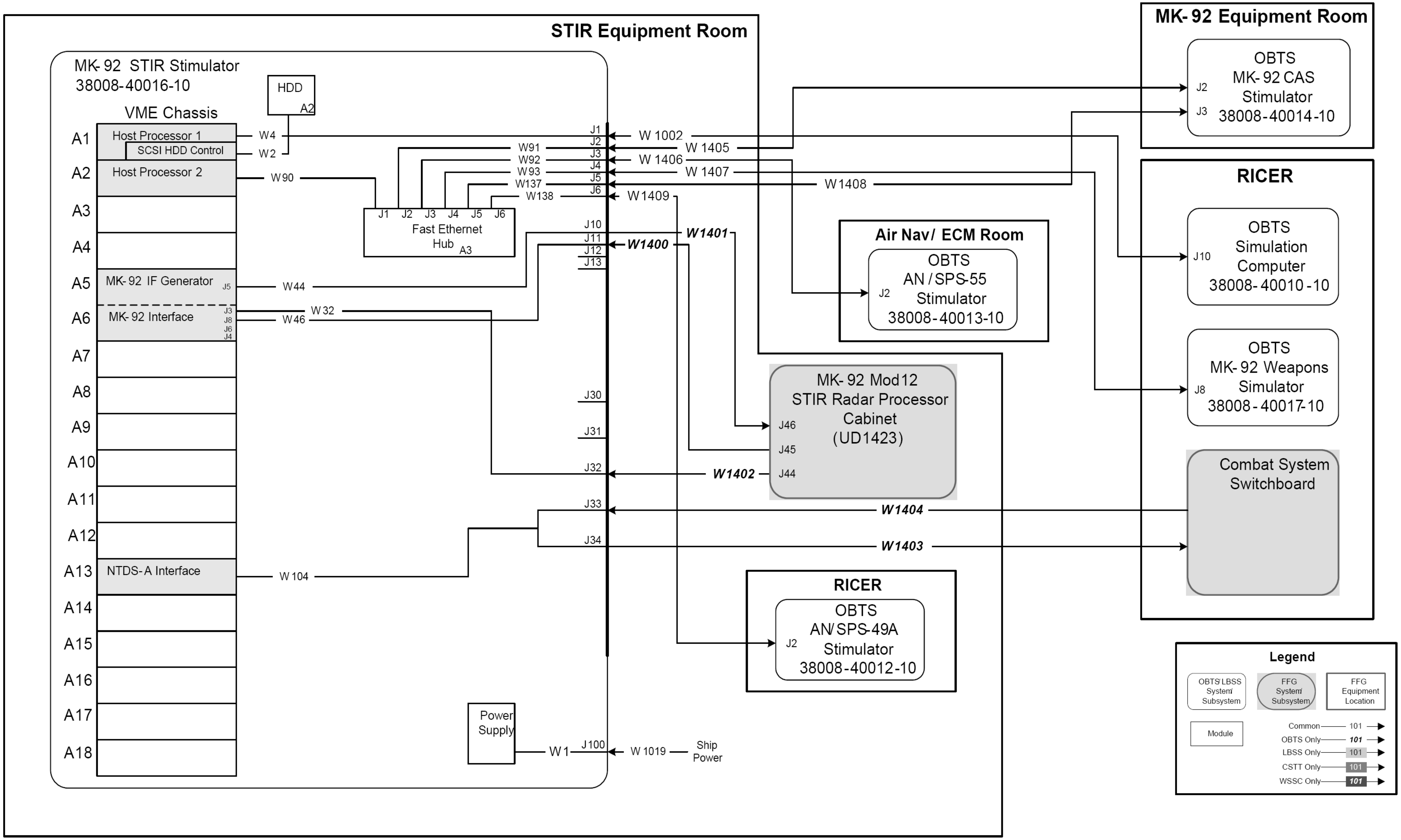

Figure 6-9: MK92 STIR Simulator Interconnection Diagram

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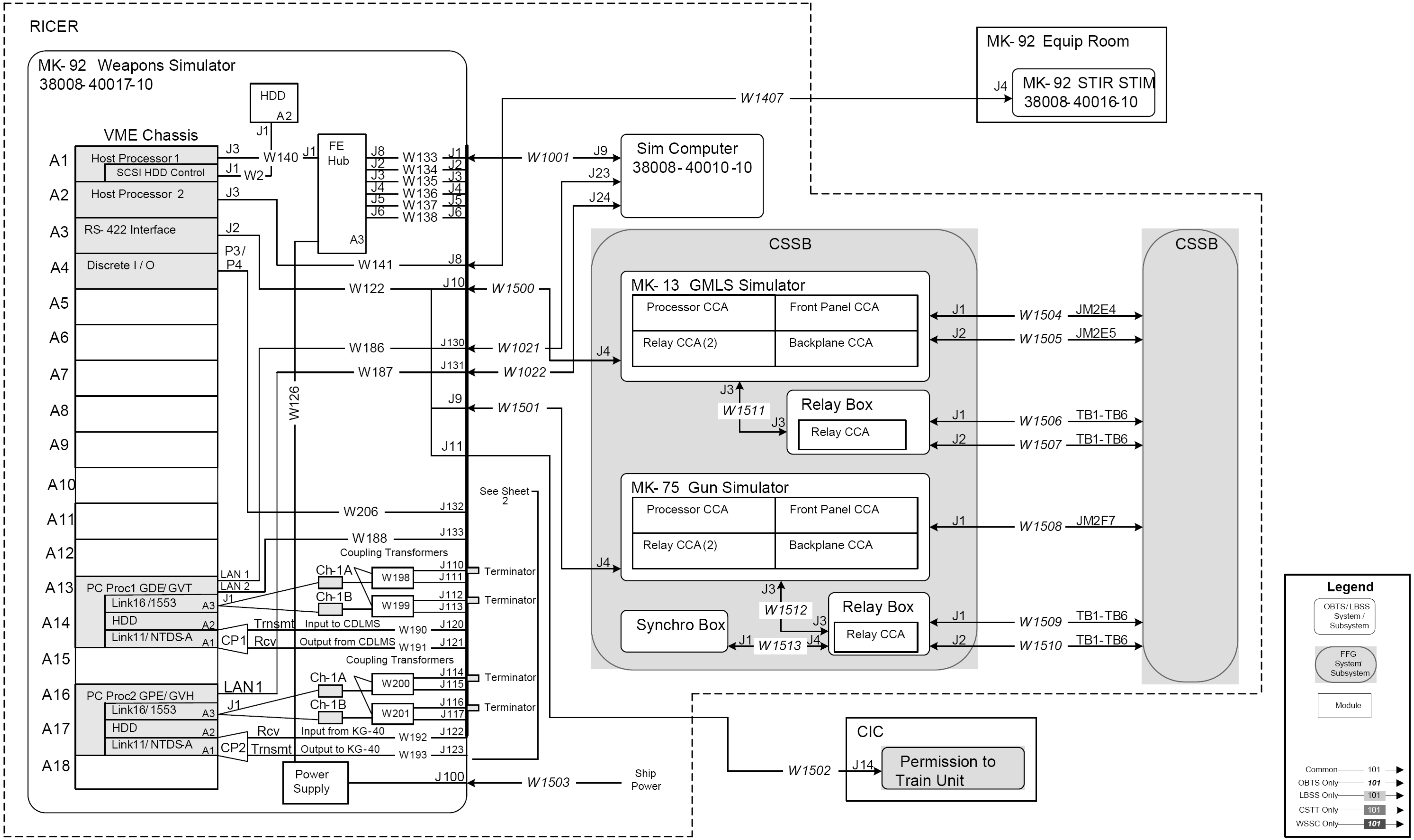

Figure 6-10: MK92 Weapons Simulator Interconnection Diagram – Sheet 1 of 2

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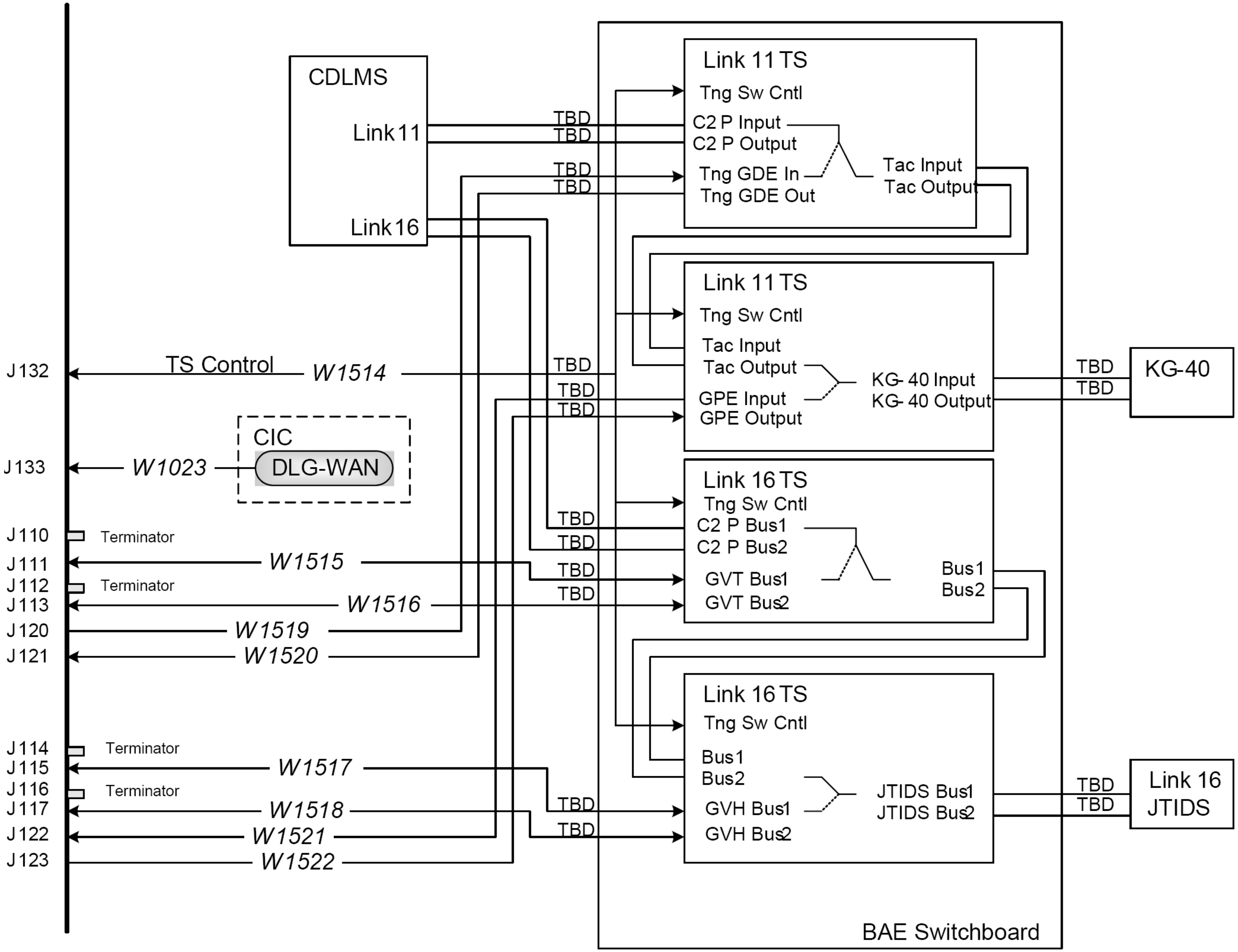

Figure 6-11: MK92 Weapons Simulator Interconnection Diagram – Sheet 2 of 2

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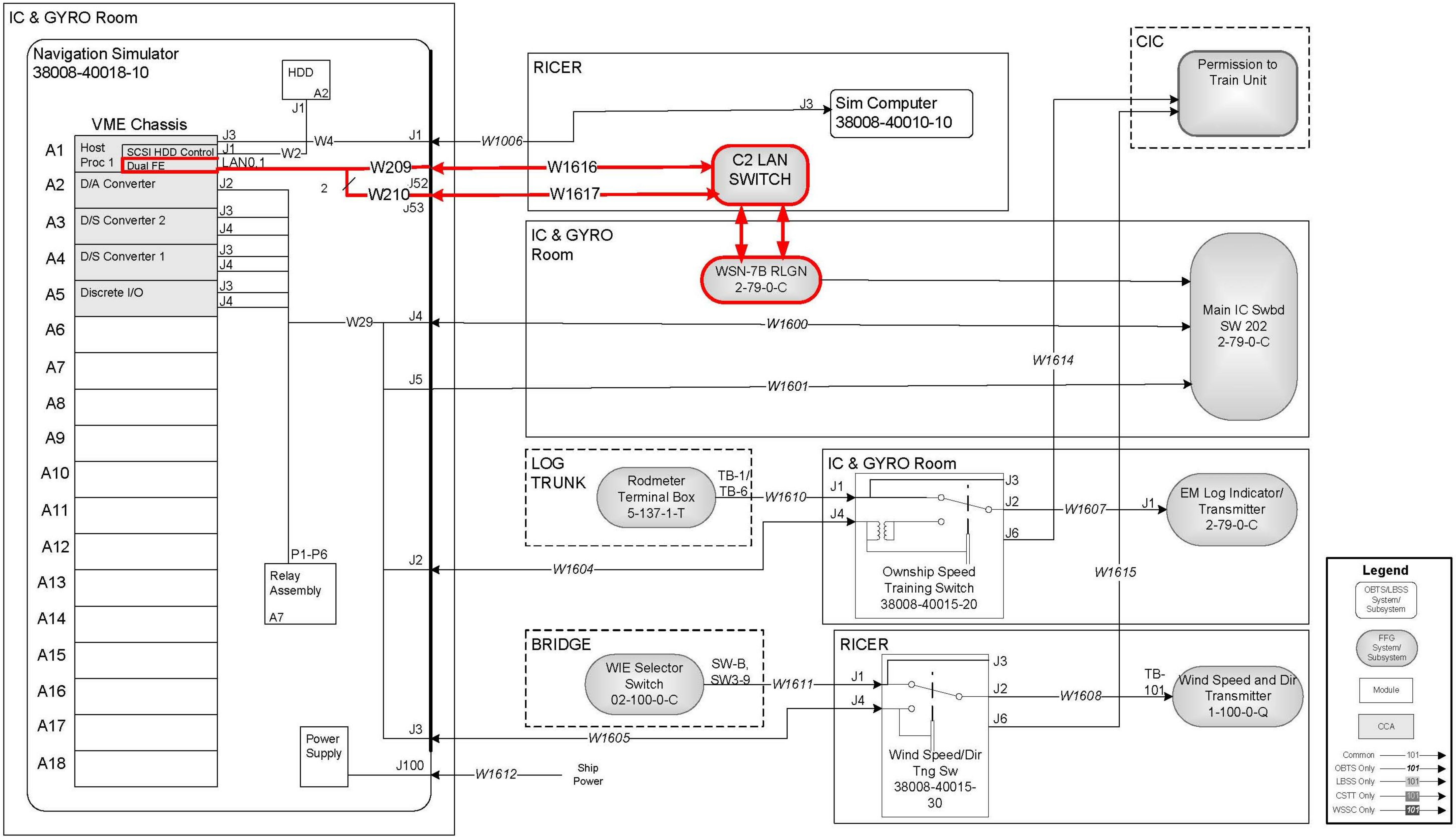

Figure 6-12: Navigation Simulator Interconnection Diagram

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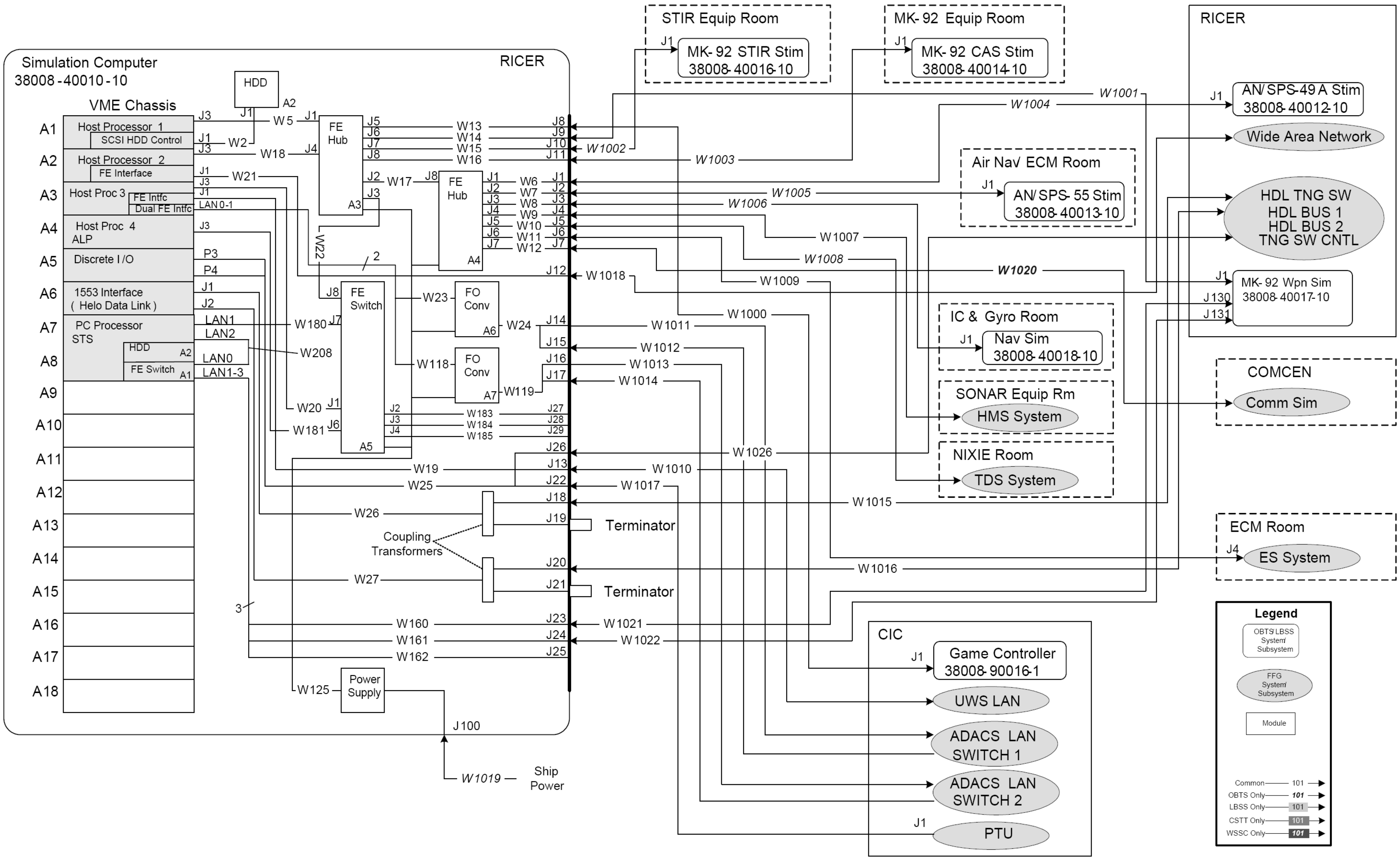

Figure 6-13: Sim Computer Interconnection Diagram

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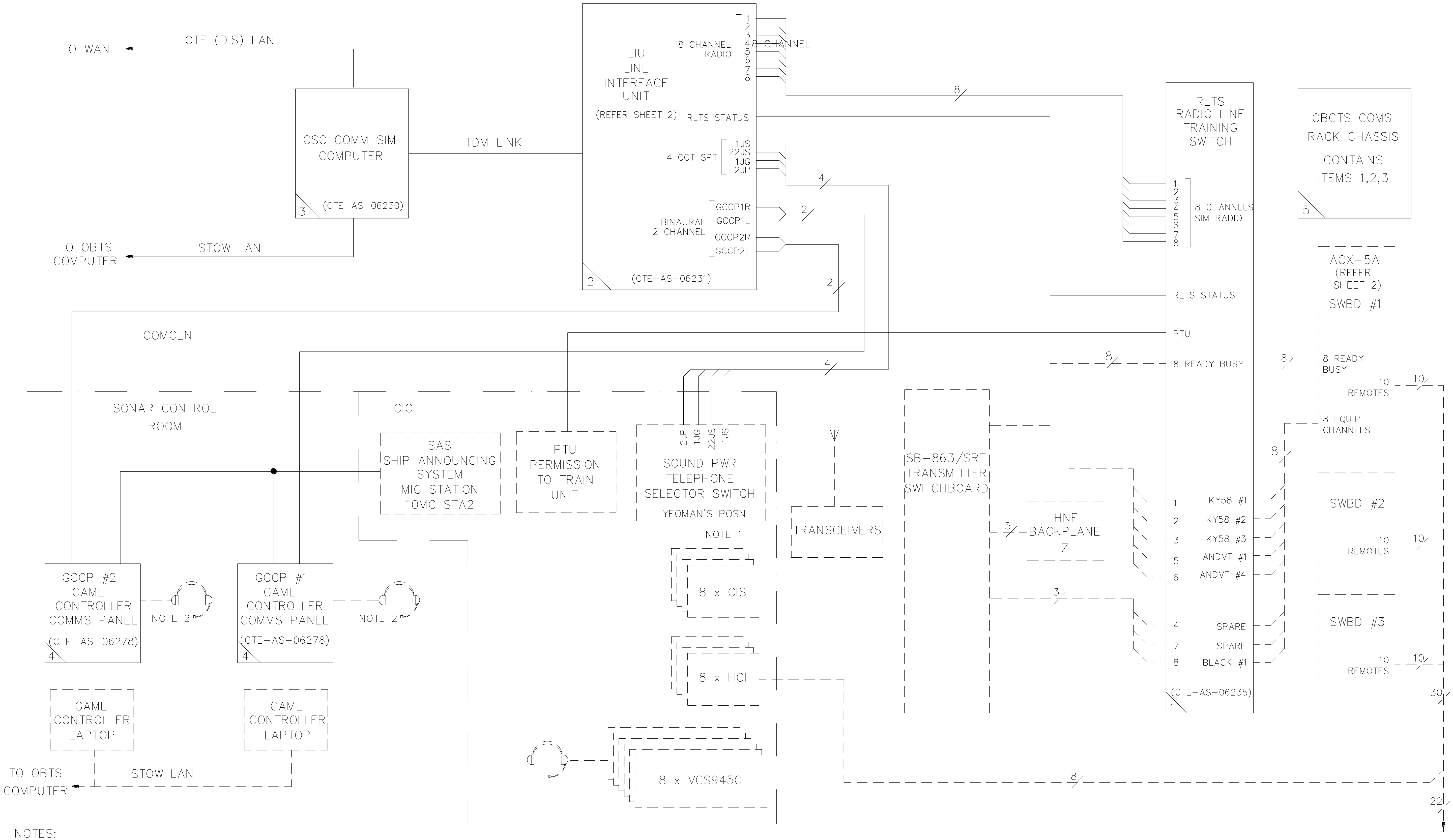

NOTES:

1. EQUIPMENT AND CABLE SHOWN DOTTED – – – – IS SHIP FITTED OR PART OF ANOTHER SUB SYSTEM.
2. HEADSETS AND CONNECTORS ARE CFE SHOWN FOR INFORMATION ONLY. CONNECTOR MS3476W-14-19P OR EQUIVALENT.

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Figure 6-14: Onboard Communications Training System Block Diagram

Chapter 7. Platform Systems

Reference: A: ABR 6509 FFG Combat System Manual - Section 3

Introduction

1. This chapter provides an overview of the ADELAIDE Class FFG platform subsystems that directly support the Combat System. The platform subsystems provide humidity control, temperature control and pneumatic and electrical power distribution. The following subsystems and equipment comprise the platform support subsystems:

   a. Dry Air and Nitrogen,

      i. Central Dry Air System (low pressure air system),

      ii. Electronic Dry Air System,

      iii. High Pressure Dry Air System, and

      iv. High Pressure Nitrogen System.

   b. Liquid Cooling;

      i. Underwater Sonar (UWS) cooling water system,

      ii. High Pressure (HP) electronic cooling water system,

      iii. Low Pressure (LP) electronic cooling water system, and

      iv. AN/SPS-49A(V)1 (SPS-49A) radar cooling water system,

   c. Ship Power and Distribution,

   d. Air Conditioning and Heating,

   e. Magazine Safety Systems, and

   f. Prairie Masker/Fin Stabiliser air distribution.

2. The diagram over the page depicts the physical location of the major platform systems that support the Combat System.

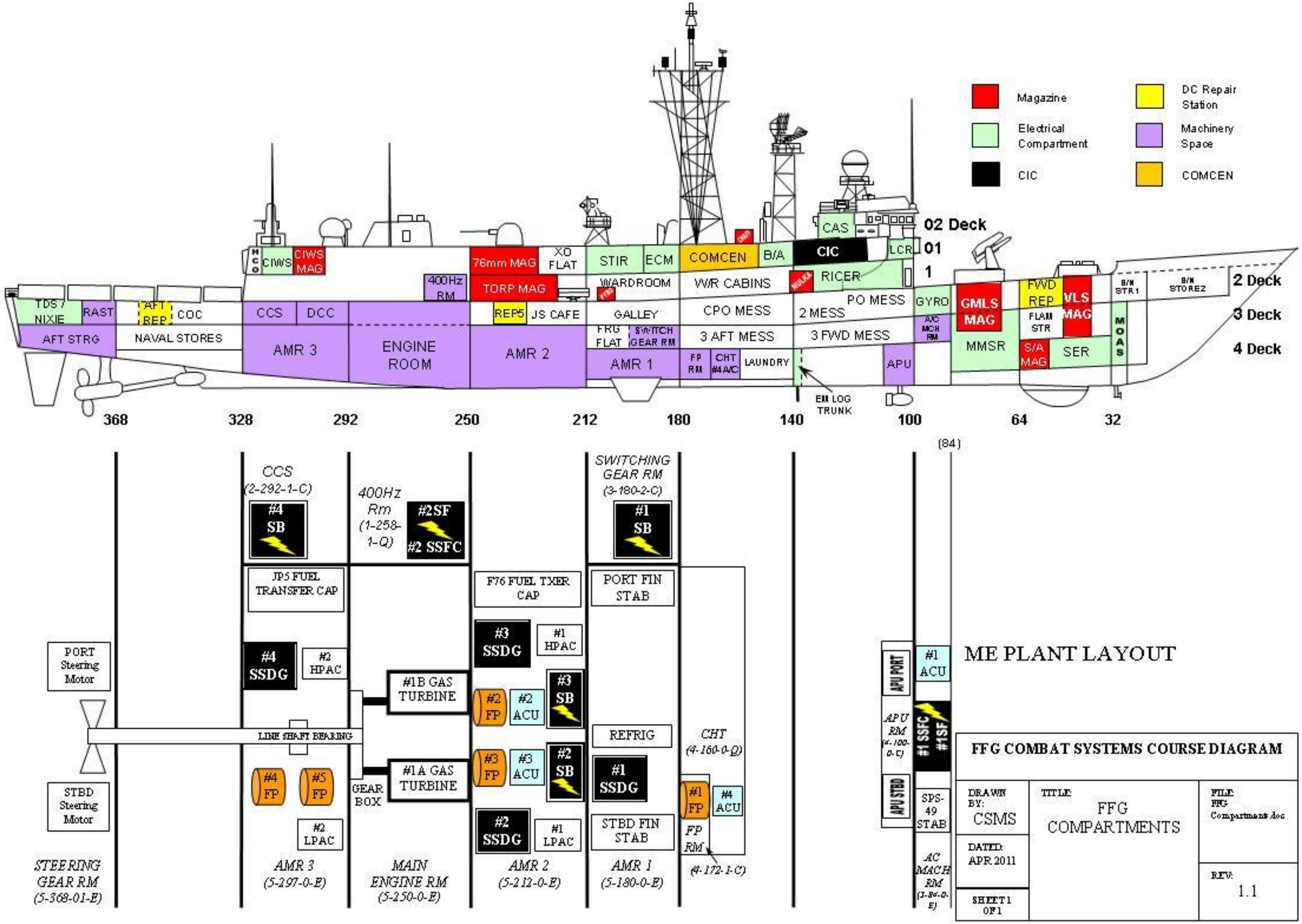

Figure 7-1: FFG Platform Systems Locations

Ship's Dry Air

High Pressure Dry Air System

3. Two High Pressure Air Compressors (**HPAC**'s), one each in Auxiliary Machinery Room's (AMR) 2 & 3, produce high pressure dry air at 3000 PSIG.

4. The following combat system elements are directly fed from this source (see Reference A. Fig 7-6.1);

a. SVTT Charging Stations

b. GMLS Strikedown Reducing Station

c. GMLS Water Injection Compression Tank Charging Station

d. HELO Services

Central Dry Air System (Low Pressure)

5. Two Low Pressure Air Compressors (**LPAC**'s), one each in AMR's 2 & 3, produce dry, oil-free air at 125 PSIG. Both LPAC's feed VITAL and NON-VITAL Low Pressure Air services; the HPAC system provides an emergency back-up in the case of failure of both LPAC's. The NON-VITAL system Automatic Cut-out's are located in AMR 3 and the Engine Room, and operate when pressure drops below 85 PSIG at 200 SCFM.

Non-Vital LP Air

6. **NON-VITAL** Low Pressure air supplies are fed to the following Combat System elements (Ref A Fig 7-6.2):

a. SPS-49 Auxiliary Dehydrator (Unit 10)

b. Torpedo Magazine Hoist

c. Sonar Cooling System Compression Tank

d. Sonar Dome Pressurisation Station

e. Electronic Cooling System Compression Tank (Bowling Alley)

f. A/C Chilled Water Compression Tanks

Electronic Dry Air (Vital LP Air)

7. 'Electronic Dry Air' services are a **VITAL** supply (Ref A Fig 7-6.3). Electronic Dry Air is supplied via 2 dehydrators, one each in of AMR's 2 and 3, providing air at 85-125 PSIG with filtration limits set at .08μ and a Dew Point of -40°F at 80 PSIG.

8. The following combat system elements receive supplies of Electronic Dry Air:

a. Mk92:

i. CAS DOME

ii. STIR Receiver Enclosure

iii. Waveguides:

1). CAS Waveguides are supplied via two Air Control Panels, each of which is fed with EDA at 0.54 SCFM. Five WG's are pressurised in the CAS system;

a. TRACK, TRACK LO, CWI

b. SEARCH Transmit

c. SEARCH Receive

d. DSOT SEARCH

e. DSOT TRACK

2). STIR Waveguides are supplied via two (2) Air Control Panels, each of which is fed with EDA at .09 SCFM. Three (3) WG's are pressurised in the STIR system;

a. TRACK

b. TRACK LO

c. DSOT, CWI

b. SPS-49:

i. Control Indicator (Unit 11) at 5 SCFM. Unit 11 has other inputs from:

1). Unit 10 (Auxiliary Dehydrator)

2). Emergency Nitrogen

a. If the Dew Point of the EDA rises above -40ºF, Unit 10 is automatically selected as the supply. If the Dew Point of the EDA from Unit 10 rises above -20ºF, dry air is shut-off.

ii. Unit 11 feeds:

1). Waveguide

2). Unit 22 - W/G Switch

3). Unit 17 - RF Reflection Isolator

4). Unit 18 - Directional Coupler

5). Unit 21 - Directional Coupler

6). Unit 19 - Circulator

c. SPS-55

i. There has been an 'RAN Modification' to supply the SPS-55 waveguide from a parasitic feed off the old SLQ-32 Air Control Panel.

Nitrogen

9. Because an Air/Oil mixture is EXPLOSIVE (the Diesel Effect), nitrogen is used extensively to pressurise accumulators.

10. Apart from the emergency EDA supply available at CAS, STIR and SPS-49, Nitrogen is used in;

a. GMLS

i. Eight bottles in the MMSR service the GMLS accumulators as well as the DUD-Jettison mechanism.

b. Mk75 Gun.

i. Two bottles in the magazine supply the Gun accumulators and recuperator.

Water Cooling

General

11. Combat System elements that rely upon cooling water services include:

  a. C&Di Consoles

  b. Mk92 FCS Radars

  c. CWI

  d. AN/SPS-49A

  e. UWS

  f. Mk 75 Gun (Barrel Cooling)

  g. CIWS

12. All of the above mentioned systems, with the exception of the Gun, employ a primary coolant to cool the secondary (active) coolant that circulates around the equipment being cooled. In ALL cases the secondary coolant is distilled water.

TDS/Mk 92 Low pressure loop

13. This system uses distilled water cooled by chilled water supplied by the ship's A/C plant.

14. The TDS cooling equipment comprises 2 Circulation (CIRC) Pumps and 2 Heat Exchangers (with attendant demineralisers, filters, control valves, balancing valves and header tanks).

15. Under normal conditions one set is active, the other being on Standby.

16. The equipment is located in the Electronic Cooling Equipment Room (Bowling Alley 01-151-0-Q).

17. The chilled water supply is maintained at 50ºF from the A/C plant.

18. The distilled water is in a closed loop and is maintained at 70±5ºF. It should never exceed 76ºF at the supply.

19. This system serves to cool:

  a. C&Di Consoles

  b. AN/UYK-43

  c. STIR

    i. Radar Cabinet

    ii. Dummy Load

  d. CAS

    i. Radar Cabinet

    ii. Dummy Load

TDS/Mk 92 High pressure loop

20. The HP Electronic Cooling Water System is a two loop system (primary and secondary) that uses the ship's chilled water circulating system in the primary loop to cool demineralised water in the secondary loop. The system incorporates two circulating pumps and two heat exchangers. One of each of theses is used as the operational unit and the other is used as a standby unit. Other major items in the system are a demineraliser, a compression tank, a flow meter, regulating valves, a temperature indicator and control orifice plates to control the flows and pressure sensors.

21. Critical components serviced by the high pressure loop include

  a. CAS SSCWI

b. STIR SSCWI

c. CAS Diplexer Iso-Circulator

d. STIR Diplexer Iso-Circulator

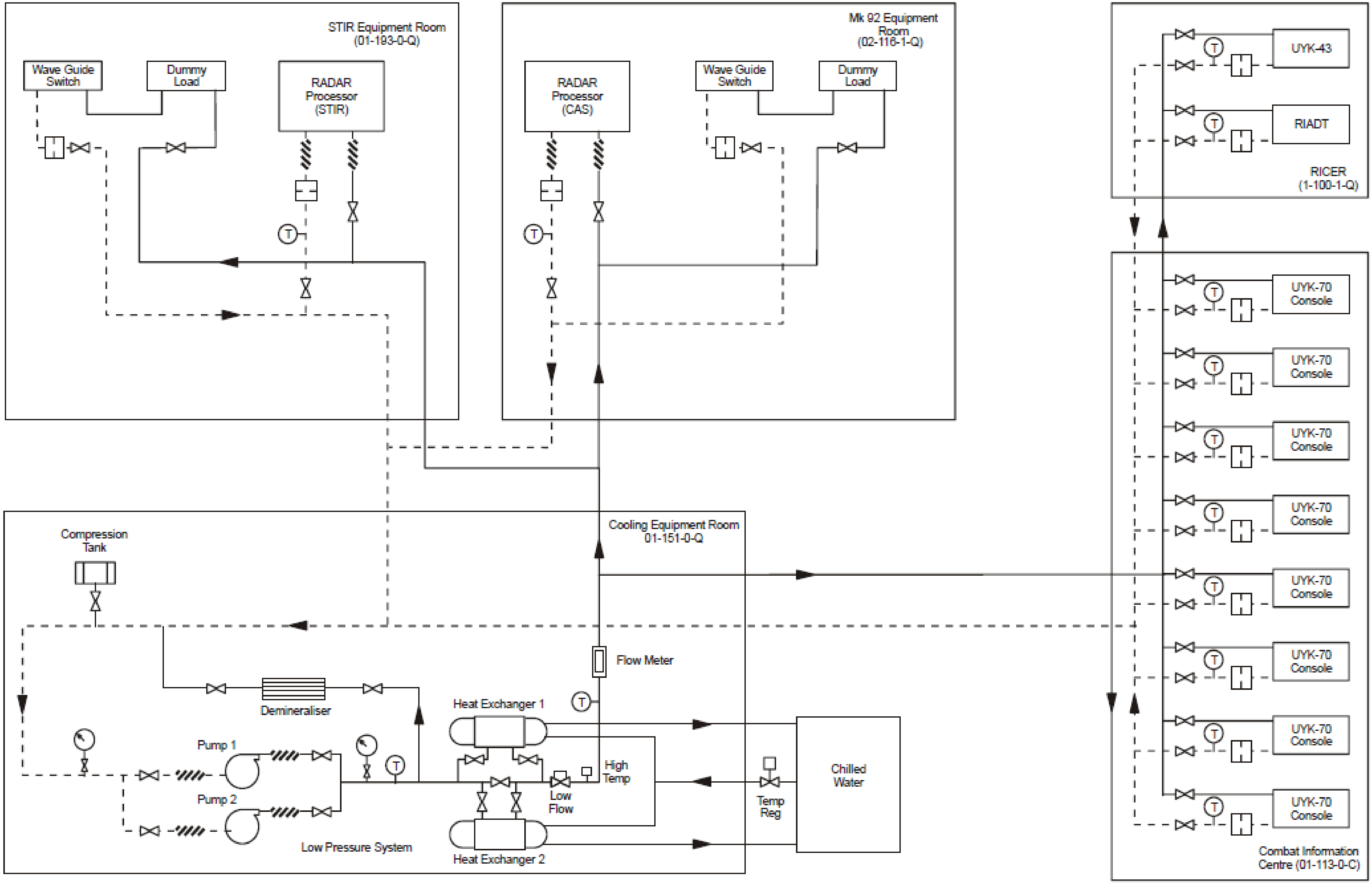

Figure 7-2: Mk92 Low Pressure Cooling Loop

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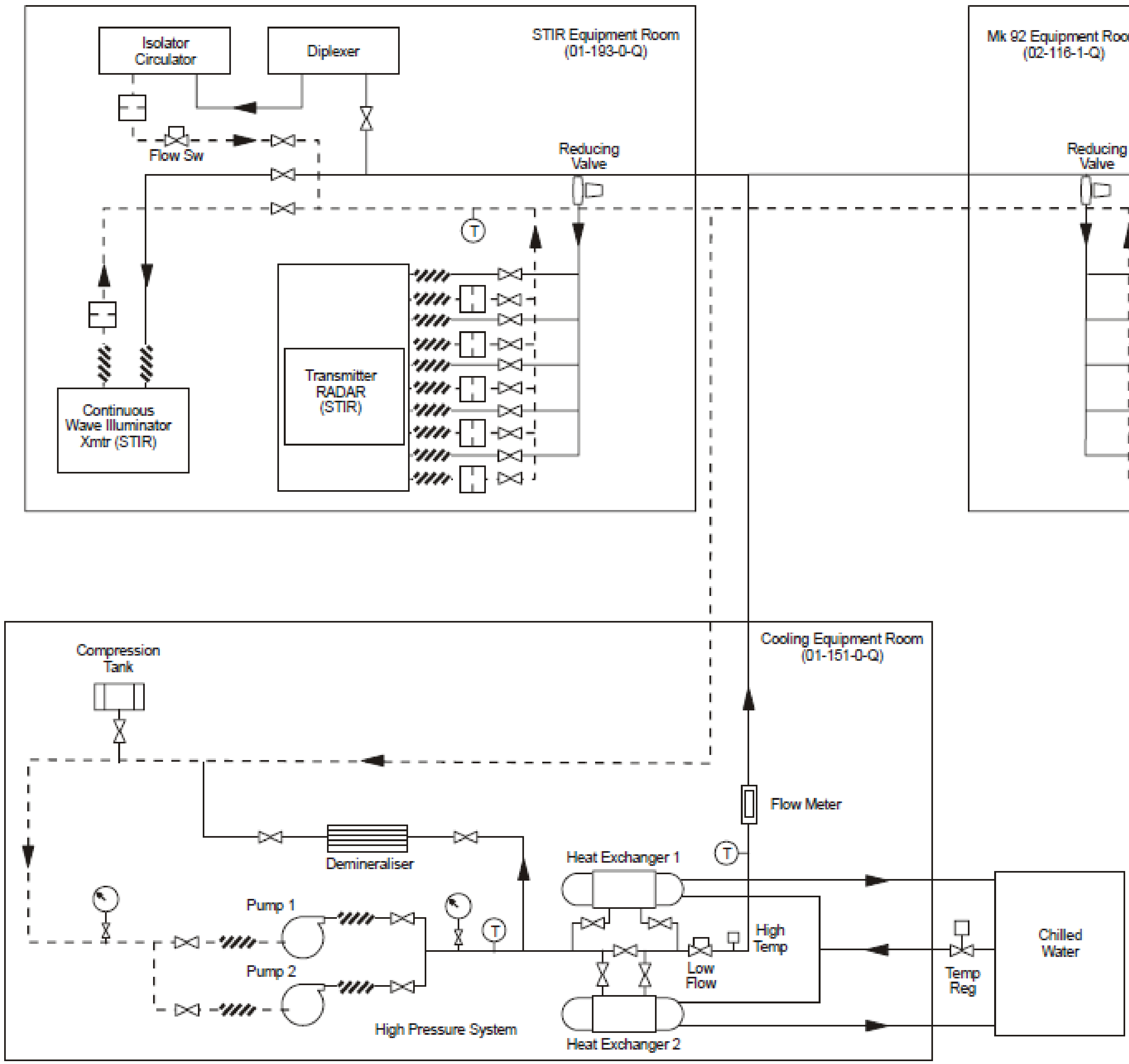

Figure 7-3: Mk92 High Pressure Cooling Loop

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AN/SPS-49A Water Cooling

22. This system uses distilled water cooled by salt water that is provided by the ships firemain.

23. The equipment that comprises the system includes 2 CIRC Pumps and 2 Heat Exchangers (with attendant demineralisers, filters, control valves, balancing valves and header tanks).

24. Under normal conditions one set is active, the other being on Standby.

25. The equipment is located in the SPS-49 Cooling Equipment Room (1-132-1-Q).

26. Distilled water is in a closed loop and is maintained at 97ºF.

27. High temperature alarms are activated if the distilled water exceeds 110ºF.

28. The areas cooled by this supply include:

    a. Klystron
    b. LPF
    c. HVPS
    d. Transmitter Heat Exchanger
    e. Dummy Load
    f. Isolator
    g. Circulator
    h. Transmitter Solenoid

UWS Water Cooling

29. The UWS Cooling Water System is a single loop system that takes cooling water from the ship's air conditioning chilled water circulating system and supplies it directly to the electronics cabinet cooling units. The used chilled water is then fed back into the chilled water circulating system for re-chilling.

30. The UWS components that are supplied with liquid cooling are:

    a. the Torpedo Defence Sonar (TDS) electronics cabinet,
    b. the Hull Mounted Sonar (HMS) electronics cabinet, and
    c. the Mine and Obstacle Avoidance Sonar (MOAS) electronics cabinet.

CIWS Water Cooling

31. The cooling for the Close-in Weapon System (CIWS) equipment is provided by the ships chilled water cooling system. As a casualty option, CIWS can cooled by salt water that is provided by the ships firemain.

76mm Gun Barrel Cooling

32. This systems uses salt water to cool the gun barrel, with a fresh water flush to be used on completion of the exercise. The fresh water flush is provided by a 150 gallon reservoir located on 01 Deck gantry, forward of the Helo Office.

33. The gun flush injection pump supplies the fresh water via the Water Control Panel. The salt water is regulated to the Water Control Panel at 100 PSI. The flushing water is discharged from an orifice at the end of the barrel (not a closed loop system).

Power Generation and Distribution

Reference: ABR 6509 Section 3 Chapter 4.

Ship's Service 60 Hz Power:

34. The ship service of 60 Hz generating plant consists of four diesel generators and four ship service switchboards divided into A and B sections.

35. Each Ship Service Diesel Generator (SSDG) produces 450V 60 Hz, 3ϕ power and is rated at 1000 kW (1600 A deliverable).

36. The power generated be each SSDG is fed via the A sections (Bus Ties labelled 1SA thru 4SA) to the B Sections of associated Ship Service Switchboards (labelled 1SB thru 4SB).

37. The SSDG's and Distribution Switchboards are located as shown in the table below:

Item	Location	Item	Location
1SSDG	AMR No.1 (5-180-0-E)	1SB	Ship Service SW GEAR Room (3-180-2-C)
2SSDG	AMR No.2 (5-212-0-E)	2SB	AMR No.2 (5-212-0-E)
3SSDG	AMR No.2 (5-212-0-E)	3SB	AMR No.2 (5-212-0-E) (Shore Power Connection)
4SSDG	AMR No.3 (5-292-0-E)	4SB	Central Control Station (2-292-01-C)

Table 12: Ship Service Diesel Generators and Switchboards

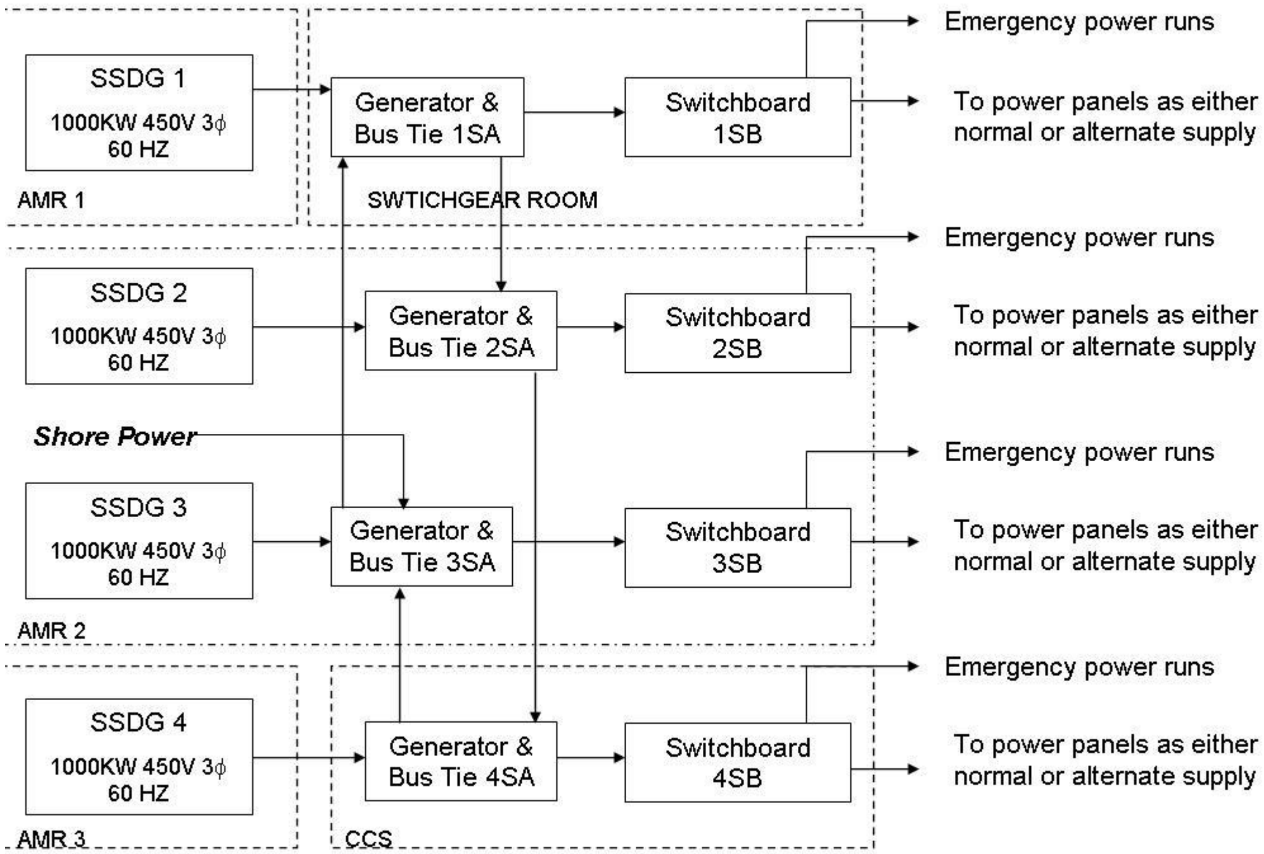

Figure 7-4: Ship Service Diesel Generators, Bus Ties & Switchboards

38. From the Bus Tie Sections of each switchboard the power generation plant can be operated in either of the following modes:

a. Parallel Mode.

i. In parallel (normal) mode, all Bus Tie circuit breakers between the switchboards are closed to permit power from the on-line diesel generators to be distributed from all four switchboards.

ii. Should an SSDG fail, the standby generator will be automatically started and paralleled with the on-line generator(s).

iii. Should the load exceed the available generator capacity, all non-vital loads will be automatically dropped (shed).

b. Split-Plant Mode.

i. In split-plant (emergency) mode, the diesel generators supply power to their respective switchboards with the Bus Tie circuit breakers between the switchboards open.

ii. Should a diesel generator fail, power to equipment fed from that switchboard will be available via alternate feeders (MBT / ABT) from another switchboard.

iii. Should the load exceed the capacity of any generator, all non-vital loads on all switchboards will be automatically dropped.

iv. Invocation of Split-plant mode should be restricted to:

1). emergency conditions such as an inoperative switchboard, or

2). if the ship is on shore power (via Bus Tie 3SA) and an SSDG (not 3) needs to be flashed up to supply equipment with a high load (such as the gun). Shore power may not be able to support this, so the plant would be split between shore power and the online SSDG(s).

39. The 450V feeders originating at the Ship Service Switchboards are categorised into VITAL and NON-VITAL supplies; Normal and Alternate lines are coupled from the Distribution Sections to:

a. four Manual Bus Transfer points (MBT),

b. two Power Panels, and

c. one Automatic Bus Transfer point (ABT).

Special Frequency (400Hz) Generation and Distribution

40. Two Solid State Static Frequency Converters (SSFC's) convert ship service 440V 60 Hz, 3ϕ supply to 440V 400 Hz, 3ϕ power.

41. Each SSFC has a rated output power of 187.5 kVA and provides output frequency regulation at 400 Hz ± 0.5% under all load conditions.

42. SSFC-1 is configured to supply Ship Service Switchboard 1SF and SSFC-2 is configured to supply Ship Service Switchboard 2SF. The SSFCs can be switched to supply 1SF and 2SF in parallel or each SSFC can supply both 1SF and 2SF as required.

43. The SSFC's and Distribution Switchboards are located as shown below:

Item	Location
1SSFC	A/C Machinery Room (3-84-0-E)
2SSFC	400Hz Equipment Room (1-258-1-Q)
1SF SWBD	A/C Machinery Room (3-84-0-E)
2SF SWBD	400Hz Equipment Room (1-258-1-Q)

Table 13: SSFC and Switchboard Locations

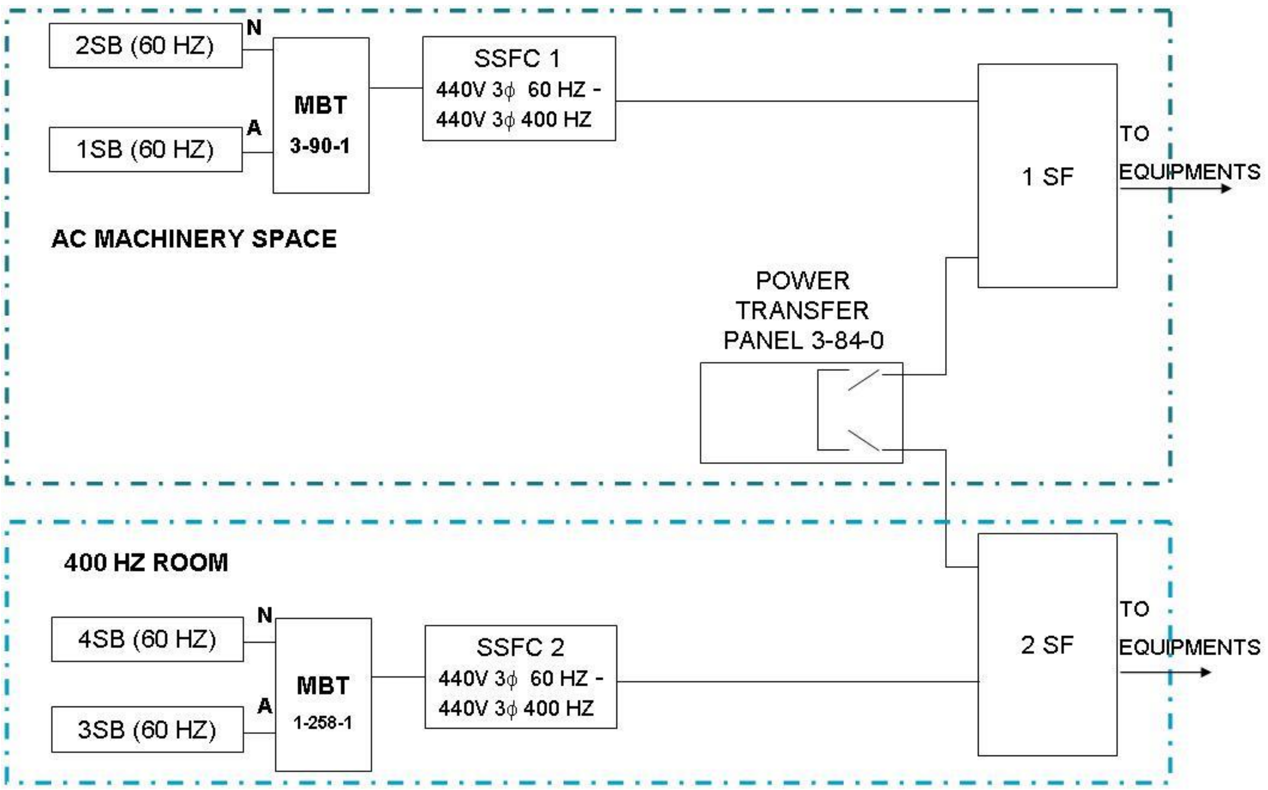

Figure 7-5: SSFCs feeding Special Frequency Switchboards

44. Power for each SSFC is provided on the VITAL Bus via a Normal and Alternate feeder through an associated Manual Bus Transfer (MBT) point.

45. Normal and Alternate lines are coupled from the Distribution Sections of 1SF and 2SF to various bus transfer points associated with Combat System equipment.

Power Distribution

46. The Distribution Diagrams that follow summarise the Distribution of 60Hz & 400Hz power.

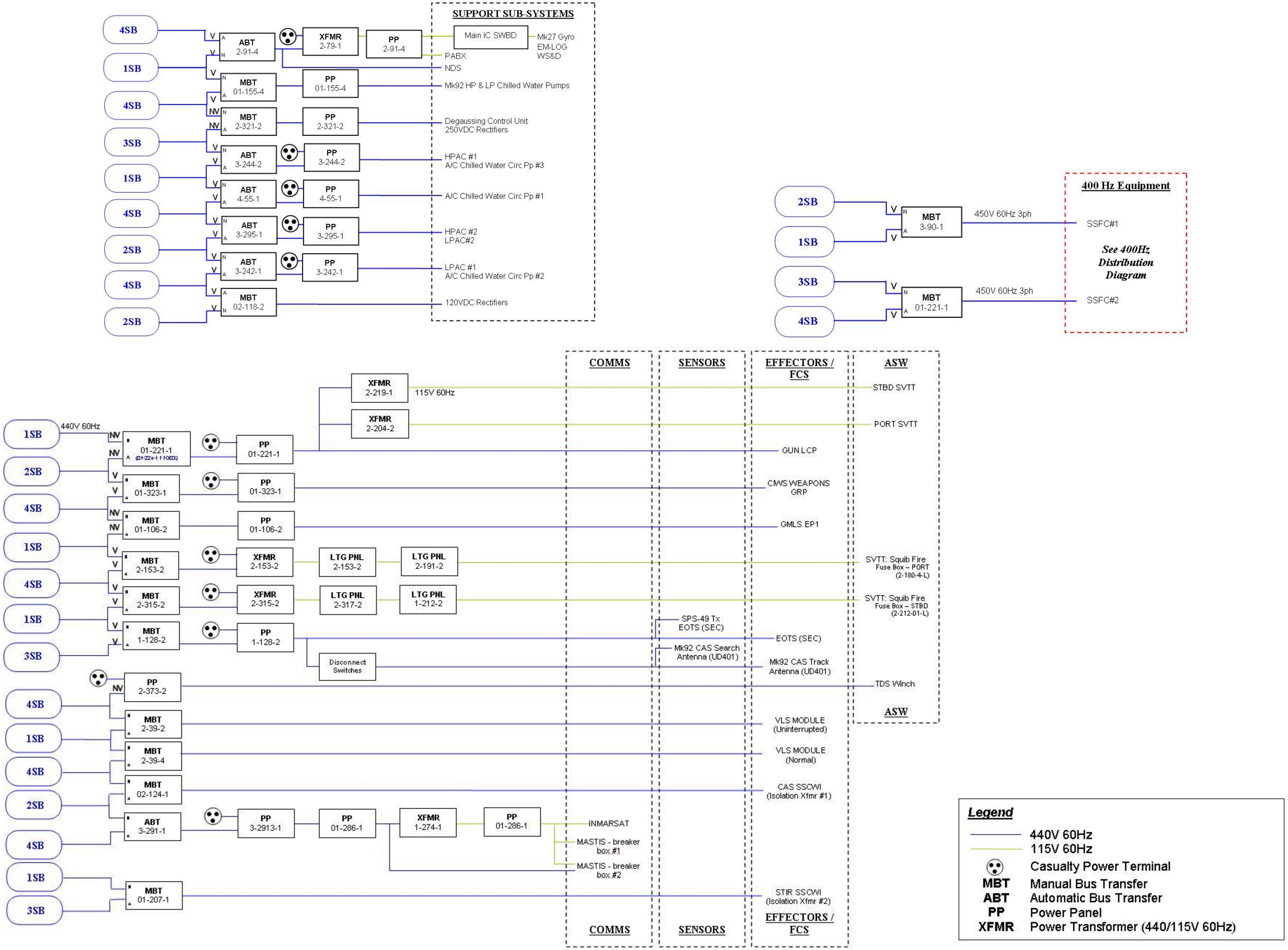

Figure 7-6: 60Hz Distribution Sheet 1 of 2

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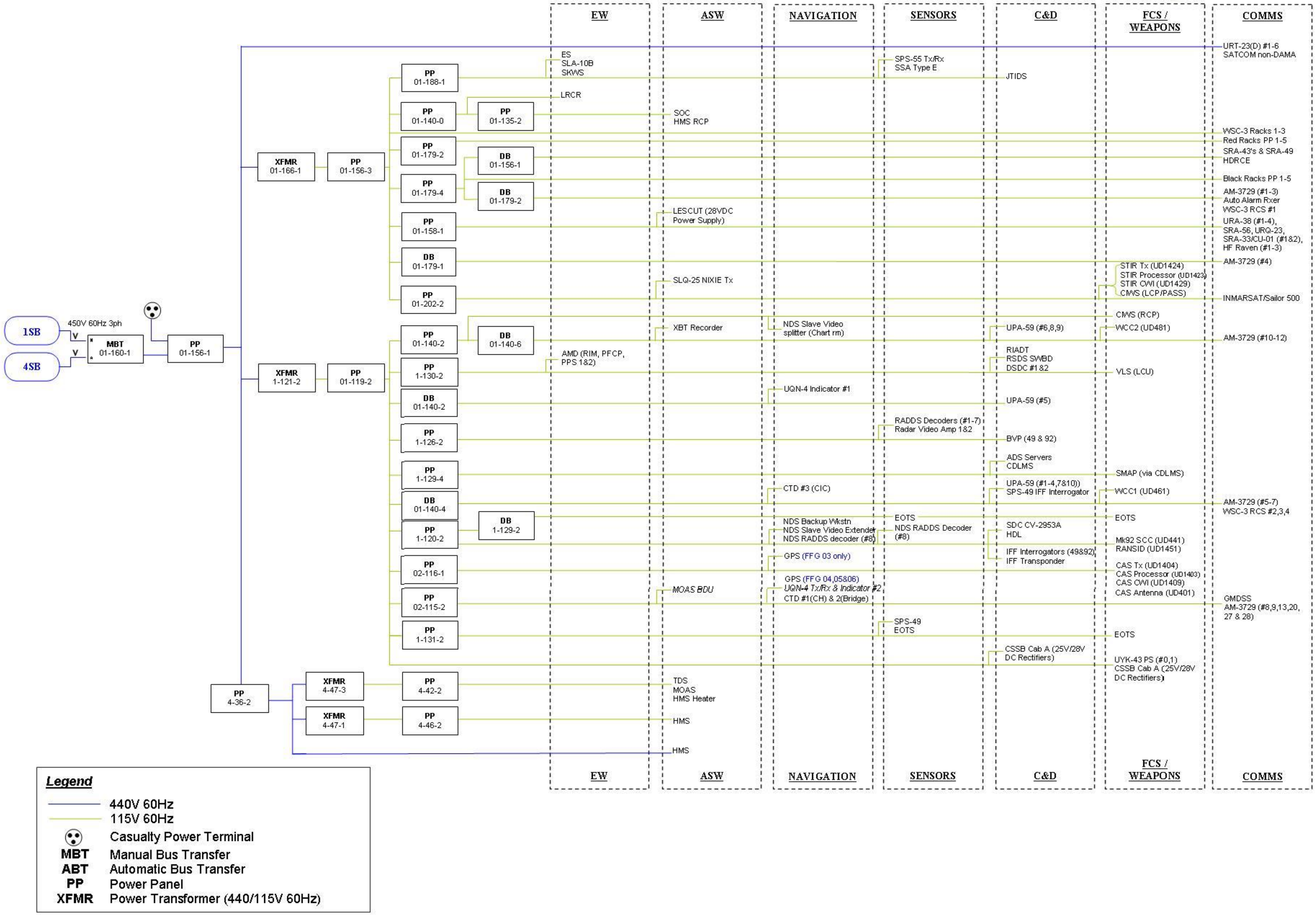

Figure 7-7: 60 Hz Distribution Sheet 2 of 2

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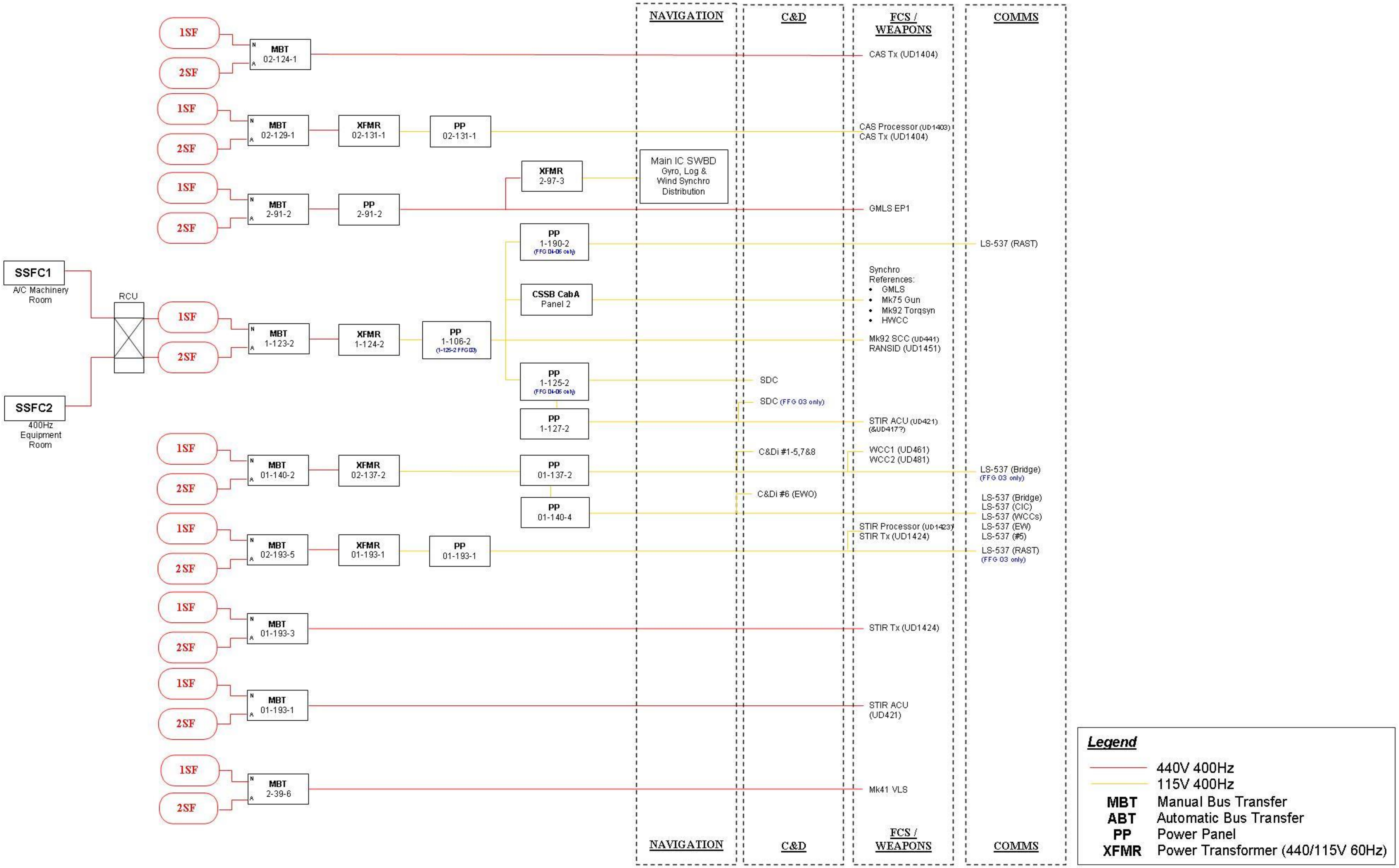

Figure 7-8: 400Hz Distribution

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Air Conditioning / Heating & Chilled Water

References: ABR6509 Section 3 Chapter 6

47. The air conditioning system provides the controlled environment required by the Combat System compartments and equipment. One or more fan rooms service each combat system compartment, located adjacent to or near the compartment. The associated fan rooms contain (in addition to the fans, heating, cooling and ventilation equipment) all the associated plumbing, ducting and controllers necessary to maintain the required temperature, humidity and airflow.

PERFORMANCE PARAMETERS

48. Information about the air conditioning and heating system is provided in the following table:

Parameter	Description
Capacity	Three units 80 ton each One unit 45 ton (#4 in CHT compartment) Total 285 ton. Note: 1 ton = 3.52 kW
Conditioned Temperature Range	85 ºF (29 ºC) maximum 75 ºF (24 ºC) nominal 65 ºF (18 ºC) minimum
Relative humidity	55%
Chilled Water High Temp Alarm	45ºF (7ºC)
Chilled Water Low Temp Alarm	35ºF (1.5ºC)
Refrigerant	R134a

Table 14: A/C Parameters

PHYSICAL DESCRIPTION

49. A total of four air conditioning plants are installed; three 80 ton units and one 45 ton unit.

50. The chilled water system consists of three closed loops. The system comprises circulation pumps, compression tanks and controls such as valves and venturi meters and sensors such as high and low temperature alarms and low tank level alarms. The temperature and level alarms are displayed at the auxiliary control panel.

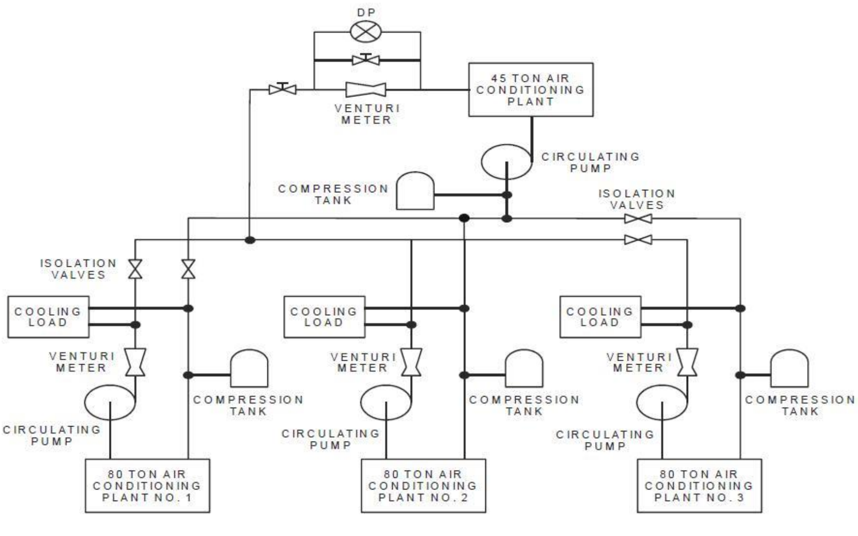

Figure 7-9: A/C System

51. Depending on the time of year, ship geographic location and the demands of the compartment, the heating and cooling coils operate to condition the air to the required compartment temperature and humidity. The cooling coil operates to condense excess moisture out of the air to maintain the relative humidity while the heating coils are used to return the air to the set temperature.

52. Controlled temperature and humidity in the various combat system compartments is usually maintained at 85 °F (29 °C) maximum and 65 °F (18 °C) minimum dependent on outside temperatures. The relative humidity is maintained at approximately 55% maximum.

FFG MAGAZINE SAFETY SYSTEMS

Ref: ABR 6509 Sec 3 Ch 7

GMLS MAGAZINE

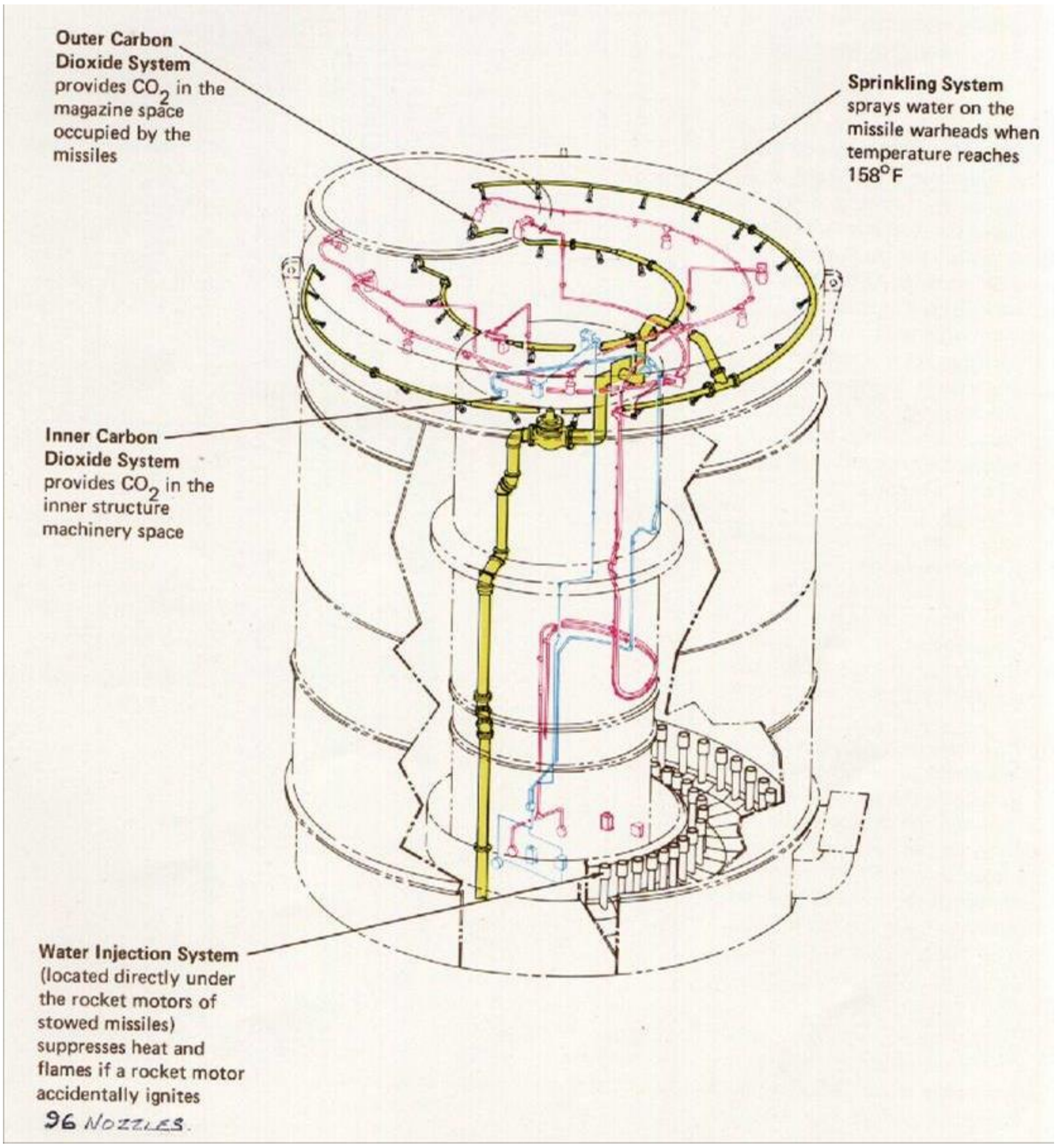

Figure 7-7-10: GMLS Fire Suppression Systems

Carbon Dioxide Drench.

53. Two independent CO_2 systems are fitted to service the Ready Service Ring (missile storage area) and the inner structure (machinery area).

54. The Ready Service Ring (RSR) system comprises:

a. Four 50-pound capacity cylinders, located in the Missile Magazine Service Room (4-64-0-Q).

b. Two Control Heads mounted on the Discharge Heads fitted to two of these cylinders.

c. Two Discharge Heads fitted to the remaining two cylinders.

d. Six Discharge Nozzles, located around the deckhead of the RSR structure.

e. Four Heat Sensing Devices, located on cross-members on the deckhead of the RSR structure.

55. The Inner Structure system comprises:

a. Two 50-pound capacity cylinders, located in the Missile Magazine Service Room (4-64-0-Q).

b. One Control Head mounted on the Discharge Head fitted to one cylinder.

c. One Discharge Head fitted to the remaining cylinder.

d. Two Discharge Nozzles, located around the deckhead of the inner structure.

e. Two Heat Sensing Devices, located on the deckhead of the inner structure.

Water Injection System (Wet).

56. In the event of a rocket motor ignition within the magazine, water is injected into the motor of the missile through one of 96 injectors located below the blow-in plates at the RSR base. Up to three injectors can be supplied simultaneously.

57. The system is charged to the injectors with fresh water at 200 PSI, supplied by a 75 gallon Missile Injection Compression Tank pressurised by ship's HP air (via valve 4-66-4). An alarm alerts ship's staff to a low pressure condition in the Compression Tank.

58. Upon activation, fresh water is provided to the injector until the Compression Tank supply falls below 70 PSI, at which time salt water from the ship's firemain supply at 70 PSI is ported to the injector by Control Valve (4-70-1). The maximum flow rate of salt water in the injection system is 450 GPM.

DRY type Sprinkler System.

59. This system provides water sprinkler facilities within the RSR, and comprises:

a. Forty sprinkler heads located around the deckhead of the RSR.

b. Six Heat Sensing Devices (HSD); seven located on cross-members on the deckhead of the RSR and one located in the exhaust plenum in the RSR base.

60. Designed to activate at 174°F

Operation

Carbon Dioxide Drench.

61. RSR and inner structure system operation may be independent:.

a. Automatically activated by the HSD when:

i. the fusible link melts (at 160°F), or

ii. a rapid pressure build-up is detected.

b. **Manually activated** at the CO_2 bottles fitted with Control Heads. The supply of gas will continue until cylinder exhaustion.

c. **Manually de-activated** by resetting the activated Control Head(s).

d. **Gas flow can be inhibited** at the manual shut-off valves (one for each system) located below the inner structure lower entry hatch.

e. A Gas flow indicator provides activation alert.

Water Injection System:

62. **Automatically activated** as a result of:

a. Missile motor ignition rupturing the plenum blow-in plate. This exposes the Injection Detector Nozzle Assembly to the exhaust.

b. Burn through of the Nozzle Assembly Valve Retainer. this enables the shear wire to break, permitting the flow of water from the nozzle.

63. **Manually de-activated** and **re-activated** at the Solenoid Valve (4-70-1) or at the Valve Control located in the Missile Launcher Control Room (01-100-2-C).

Sprinkler System:

64. **Automatically activated** by the HSD when:

a. the fusible link melts (at 165°F), or

b. a rapid pressure build-up is detected.

65. **Manually activated** by either:

a. positioning the Sprinkler Control Valve, located in the Missile Magazine Service Room (4-64-0-Q) to OPEN, or

b. by positioning the remote Sprinkler Control Valve, located in Passage 2-64-0-L, to OPEN position.

66. **Manually de-activated** by either:

a. positioning the Sprinkler Control Valve, located in the Missile Magazine Service Room (4-64-0-Q) to CLOSE, or

b. by positioning the remote Sprinkler Control Valve, located in Passage 2-64-0-L, to CLOSE position.

VLS MAGAZINE

67. The Vertical Launching System (VLS) cooling comprises a deluge system and a sprinkler system.

68. The deluge system is a pressurised water system that sprays cooling water inside all four subcells of a canister, if that canister has an overtemperature condition of more than 88 °C (190 °F). If a subcell overtemperature condition occurs, all four subcells are deluged simultaneously. Actuation of the deluge control valve releases water from the deluge system into the canister subcells.

69. The VLS sprinkler system extinguishes fires in the launcher by spraying water into the launcher area. The sprinkler system is controlled by heat sensing devices located at various points within the launcher area.

Deluge System

70. The water injection or deluge system function is to spray water over the missile warhead(s) in response to a restrained firing or canister over temperature condition. The deluge system is a wet system with pressurised water constantly available to the deluge valve at each launcher cell. The system is charged with fresh water to minimise corrosion and maintenance.

71. The water injection or deluge system is a pressurised water system that sprays cooling water inside all four subcells of a canister, if the canister has an over temperature condition of more than 190°F (88 °C).

72. If a subcell over temperature condition occurs, all four subcells are deluged simultaneously. Actuation of the deluge control valve will release water from the deluge system into the canister subcells.

73. The deluge water is turned off after 90 to 110 seconds by an automatic signal from the Launch Sequencer (LS), provided the overtemperature condition no longer exists. Deluge can also be turned off by the DELUGE – NORMAL/RESET switch on the status panel which controls the two-way deluge manual control valve.

74. Deluge water is supplied to each canister through the deluge control assembly. The deluge control assembly includes a deluge valve manual override mounted on each deluge control assembly in each cell. The manual override can be used to manually select a cell to be deluged. In addition, a quick-disconnect valve is located above and upstream from each deluge control assembly. The quick-disconnect valve can be used to isolate the cell from the deluge system water supply during maintenance (e.g., deluge control assembly replacement).

75. During a deluge event, if the fresh water charge is expended the deluge operation is completed using seawater from the ship's firemain.

Sprinkler System

76. The sprinkler system extinguishes fires in the launcher by releasing water from the ship firemain water supply to the sprinkler heads located above the upper and lower walkways in the launcher areas. The launcher sprinkler system is a dry system. During condition ZEBRA when all 5 fire pumps are operating and the firemain is split into two systems, the VLS sprinkler system concurrently draws from both sides of the firemain ring main.

77. If the canister deluge system is taken offline, the sprinkler system becomes the primary firefighting component. The sprinkler system consists of eight sprinkler heads, four heat sensing devices and control valves.

78. The launcher system is maintained in the automatic mode at all times. The exception to this requirement is when maintenance is being performed on the sprinkler system.

GUN MAGAZINE

79. The 76mm gun is fitted with a **Dry** type Sprinkler System. Thirteen sprinkler heads and eight Heat Sensing Devices are co-located on the deckhead of the magazine. Upon activation, sprinklers are supplied with salt water from either the starboard or port section of the ship's firemain at the:

a. 'Gun Flat' Passage (01-212-0-L), with emergency firemain connection provided at (01-222-1), at maximum flow rate of 565 GPM; or

b. Helicopter Shop (1-253-2-Q), at maximum flow rate of 537 GPM.

Operation

80. Starboard section (Gun Flat Passage) supply can be:

a. Automatically activated by HSD when:

i. the fusible link melts (at 160°F), or

ii. when a rapid pressure increase is detected.

b. Manually activated by either:

i. positioning the Sprinkler Control Valve, located in Passage (01-212-0-L) at 01-229-1, to OPEN position; or

ii. positioning the remote Sprinkler Control Valve (2-291-5), located in Passage (2-250-0-L), to OPEN position.

c. Manually de-activated by either:

i. positioning the Sprinkler Control Valve, located in Passage (01-212-0-L) at 01-229-1, to CLOSE position; or

ii. positioning the remote Sprinkler Control Valve (2-291-5), located in Passage (2-250-0-L), to CLOSE position.

81. Port section (Helicopter Shop) supply can be:

a. Manually activated by either:

i. turning the Gun Magazine solenoid valve, located on the forward bulkhead of the Port Helicopter Hanger (1-278-2-Q), in a clockwise direction; or

ii. actuating the Gun Magazine solenoid valve control switch on the Magazine Sprinkler Control Panel in DCC (2-292-01-C).

b. Manually de-activated by either:

i. turning the Gun Magazine solenoid valve, located on the forward bulkhead of the Port Helicopter Hanger (1-278-2-Q), in a counter-clockwise direction; or

ii. repositioning the Gun Magazine solenoid valve control switch on the Magazine Sprinkler Control Panel in DCC (2-292-01-C).

TORPEDO MAGAZINE

82. The Torpedo magazine is fitted with a Wet type Sprinkler System, with eight sprinkler heads and four Heat Sensing Devices (HSDs) co-located on the deckhead of the magazine. Fresh water, from a gravity accumulator tank located in passage (01-212-0-L), is provided to the sprinkler heads. Upon activation, sprinklers are supplied with salt water from either the starboard or port section of the ship's firemain at:

a. Main Passage (1-212-0-L), at maximum flow rate of 429 GPM; or

b. Helicopter Shop (1-253-2-Q), at maximum flow rate of 439 GPM.

Operation

83. Starboard section (Main Passage) supply can be:

a. Automatically activated by HSD when:

i. the fusible link melts (at 160°F), or

ii. when a rapid pressure increase is detected.

b. Manually activated by either:

i. positioning the Sprinkler Control Valve, located in Passage (1-212-0-L) at 1-235-1, to OPEN position; or

ii. positioning the remote Sprinkler Control Valve (2-291-3), located in Passage (2-250-0-L), to OPEN position.

c. Manually de-activated by either:

i. positioning the Sprinkler Control Valve, located in Passage (1-212-0-L) at 1-235-1, to CLOSE position; or

ii. positioning the remote Sprinkler Control Valve (2-291-3), located in Passage (2-250-0-L), to CLOSE position.

84. Port section (Helicopter Shop) supply can be:

a. Manually activated by either:

i. turning the Torpedo Magazine solenoid valve, located on the forward bulkhead of the Port Helicopter Hanger (1-278-2-Q), in a clockwise direction; or

ii. actuating the Torpedo Magazine solenoid valve control switch on the Magazine Sprinkler Control Panel in DCC (2-292-01-C).

b. Manually de-activated by either:

i. turning the Torpedo Magazine solenoid valve, located on the forward bulkhead of the Port Helicopter Hanger (1-278-2-Q), in a counter-clockwise direction; or

ii. repositioning the Torpedo Magazine solenoid valve control switch on the Magazine Sprinkler Control Panel in DCC (2-292-01-C).

CIWS MAGAZINE

85. The CIWS magazine is fitted with a Dry type Sprinkler System. Two sprinkler heads and two Heat Sensing Devices are co-located on the deckhead of the magazine. Upon activation, sprinklers are supplied with salt water from either the starboard or port section of the ship's firemain at the:

a. Passage (1-212-0-L), at maximum flow rate of 66 GPM, or

b. Passage (01-296-1-T) at maximum flow rate of 66 GPM.

Operation

86. Port Section, Passage (01-296-1-T) supply can be:

a. Automatically activated by HSD when:

i. the fusible link melts (at 160°F), or

ii. when a rapid pressure increase is detected.

b. Manually activated by either:

i. positioning the Sprinkler Control Valve, located in Passage (01-296-1-T) at 01-301-1, to OPEN position; or

ii. positioning the remote Sprinkler Control Valve (2-291-1), located in Passage (2-250-0-L), to OPEN position.

c. Manually de-activated by either:

i. positioning the Sprinkler Control Valve, located in Passage (01-296-1-T) at 01-301-1, to CLOSE position; or

ii. positioning the remote Sprinkler Control Valve (2-291-1), located in Passage (2-250-0-L), to CLOSE position.

87. Starboard section, Passage (1-212-0-L) supply can be:

a. Manually activated by either:

i. turning the CIWS Magazine solenoid valve, located on the starboard bulkhead of Passage (1-212-0-L) at 1-296-1, in a clockwise direction; or

ii. actuating the CIWS Magazine solenoid valve control switch on the Magazine Sprinkler Control Panel in DCC (2-292-01-C).

b. Manually de-activated by either:

i. turning the CIWS Magazine solenoid valve, located on the starboard bulkhead of Passage (1-212-0-L) at 1-296-1, in a counter-clockwise direction; or

ii. repositioning the CIWS Magazine solenoid valve control switch on the Magazine Sprinkler Control Panel in DCC (2-292-01-C).

SMALL ARMS MAGAZINE

88. The small arms magazine is fitted with a Dry type Sprinkler System. Three sprinkler heads and two Heat Sensing Devices are co-located on the deckhead of the magazine. Upon activation, sprinklers are supplied with salt water from firemain at Passage (4-48-2-L) at maximum flow rate of 78 GPM.

Operation

89. Supply can be:

a. Automatically activated by HSD when:

i. the fusible link melts (at 160°F), or

ii. when a rapid pressure increase is detected.

b. Manually activated by either:

i. positioning the Local Sprinkler Control Valve (4-56-2), located in Passage (4-48-2-L), to OPEN position; or

ii. positioning the Remote Sprinkler Control Valve (2-52-2), located in Passage (2-40-2-L), to OPEN position.

c. Manually de-activated by either:

i. positioning the Local Sprinkler Control Valve, (4-56-2), located in Passage (4-48-2-L) , to CLOSE position; or

ii. positioning the Remote Sprinkler Control Valve (2-52-2), located in Passage (2-40-2-L), to CLOSE position.

PRAIRIE MASKER / FIN STABILISER AIR

References: ABR6509 Section 3 Chapter 10

90. The Prairie Masker/Fin Stabiliser Air Distribution System provides temperature controlled air for the prairie air system for the propeller, the stabiliser fins and the masker air system.

91. The Propeller Air Injection Equipment (Prairie) air system supplies compressed air that is discharged along the leading edge of each propeller blade to reduce the hydrodynamic noise originating from the propeller. The Multiple Air Screen Keel Emitter (Masker) air system supplies compressed air that is discharged through emitter belts around the underwater girth of the ship. The masker air forms an air bubble screen about the hull to reduce transmission of machinery noise to surrounding waters. The fin stabiliser air system discharges compressed air along the fin stabiliser to reduce the hydrodynamic noise originating from the fin stabiliser. Air is supplied to the Prairie Masker/Fin Stabiliser Air Distribution System by the propulsion gas turbine air system.

Chapter 8. Organic Craft

S-70B-2 Seahawk Helicopter

References: ABR 6511 Sec 1 Ch 12

ABR 6509 Sec 3 Ch 8

General

1. Although organic aircraft are not specifically included as part of the ship's combat system, they are a vital asset that integrates closely with the onboard systems and command procedures. The FFG is able to deploy several helicopter types, and provide a certified flight deck for numerous other helo types, however the S-70B-2 Seahawk helicopter was purpose built for the RAN's FFGs, therefore only this aircraft has been considered for this learners guide.

Figure 8-1: RAN S-70B-2 Seahawk Helicopter

2. Up to two S-70B-2 Seahawk helicopters can be deployed from the FFG, one accommodated in each hanger. A relatively large helicopter, the S-70B-2's rotors and tail assembly must be folded to allow it to be stowed within the hangers.

FFG Support Systems

3. Support systems on the FFG for the aircraft include:

   a. The Recovery Assist Secure and Traverse (RAST) system is used to assist flight deck crew in manoeuvring the aircraft into position, and moving it in and out of the hanger. The RAST is maintained by the ME department.

   b. The Horizon Reference System (HRS) is a 10-foot lighted bar which is gyro-stabilized to provide the pilot with an artificial horizon. The HRS is mounted on the aft end of 02 deck and is maintained by the ME department.

   c. The Stabilised Glide Scope Indicator (SGSI) is an optical viewing system used to indicate to a pilot the aircraft approach angle to the ship. The colour of the light indicates to the pilot whether they are above (green), below (red), or on (amber) the proper glide slope. The FFG SGSI is located on 02 deck aft, on the port side of CIWS. The SGSI will be replaced with a stabilised system that provides symbology to the pilot, and is Night Vision Goggle (NVG) friendly. The SGSI is maintained by the WE Department CSO4 section.

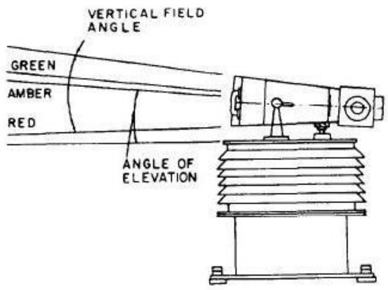

Figure 8-2: Stabilised Glide Scope Indicator

d. Visual Landing Aids (VLA) include all Helicopter deck area markings, clearances, lighting, equipment and accessories that assist in Helicopter operations. These operations include, take off, landing, VERTREP/hover and Helicopter in-flight refuelling. VLAs are maintained by the ME department.

e. The Helicopter Telebrief is a Sound Powered Telephone System (20JG) which facilitates telephone communications between the CIC, pilot house, Helicopter control station, RAST control station, Helicopter No.1 and 2 hangar and the Helicopter whilst it is manned on the flight deck. Communication to the helicopter is established through, via an externally mounted audio jack. The sound powered system is maintained by the We Department CSO4 section.

Primary Roles

4. The primary roles of the S-70B-2 Seahawk helicopter are USW and SW, with secondary roles including personnel transfer (PAX Transfer), replenishment (VERTREP), and search and rescue (SAR).

Aircrew

5. The S-70B-2 has a standard crew of 3 personnel: a pilot, a tactical observer (TACCO), and a sensor operator (SENSO).

Pilot

6. The pilot is the aircraft Captain, ultimately responsible for the safety of the aircraft and its crew, no matter the military rank. The pilot flies the aircraft from the right hand cockpit seat.

TACCO

7. The TACCO sits in the left hand cockpit seat and acts as Mission Commander, as well as a visual observer and being able to operate the Tactical Data System (TDS). The TDS controls helo data link (HDL), communications, forward looking infra-red (FLIR), electronic support (ES) system, and radar.

SENSO

8. Located in the rear compartment of the aircraft, the SENSO operates the acoustic sensors via a TDS console. The SENSO loads, deploys, and monitors sonobuoys, as well as operating the magnetic anomaly detector (MAD) sensor. HDL, communications, ES, FLIR, and radar can also be controlled and monitored by the SENSO. During VERTREP and SAR missions, the SENSO will normally operate the winch mechanism when needed. The SENSO also fires the door-mounted machine gun.

Operating Capabilities

Weight

9. Maximum all up weight of the aircraft is 21,884 lbs. Up to 6,000 lbs load can be carried externally, with the winch able to hoist 600 lbs.

Speed

10. The maximum speed is approximately 180 knots (air speed), however this can only be achieved with a relatively low weight. When laden, the aircraft speed is reduced to approximately 150 knots maximum. Cruising speed is generally 120 knots, with a preferred loiter speed at 80 knots.

Endurance

11. Endurance at 120 knots, with three crew but no extra weapons, is approximately 3.5 hours. External auxiliary fuel tanks can extend the endurance by about an hour per tank, however these are not normally used from ships due to the risk of damage through hard landings. All up weight and the environment are two factors that will greatly affect the aircraft's endurance. As a rough guide, the helicopter can be on task for approximately 2.5 hours at 80 nm.

Tactical Data System

12. The TDS integrates various avionics and sensors via two display generator units (DGUs) for centralised control and display on the tactical display units (TDUs). Multi-functional keysets (MFKs) provide the human-machine interface (HMI). TDS provides all the functionality of a small C2 system, incorporating sensor control and display, navigation, fire control and track management functions.

Helo Data Link

13. Integrated with TDS, the HDL transfers track data and messages between the helicopter TDS and the controlling FFG's ADS. Using one of the UHF radios, HDL transmissions are limited in range to approximately 60 nm. Messages can be encoded via the KY-58 cryptographic equipment, however this limits the data transfer rate and may reduce the effective range. HDL transmits or receives the following message types:

a. track data (initial reports and updates),

b. sonobuoy positions,

c. weapon orders,

d. special points,

e. status,

f. narrative (Barracuda codes or free text),

g. drop track orders, and

h. environmental data (transmit only).

Communications

14. VHF/UHF and HF communications are available, either in cypher mode or in plain. VHF and UHF are provided by two AN/ARC-182 transceivers, while the HF is provided by a single AN/ARC-174 transceiver. HDL utilises one of the ARC-182's.

Sensors

Visual

15. Visual searches are conducted by the crew as a primary method of identification and battle damage assessment, as well as during silent or reduced EMCON. Night vision goggles (NVGs) can be used to supplement visual detection in the dark.

Forward Looking Infra-Red (FLIR)

16. AN/AAQ-27(3FOV) FLIR is fitted to the S-70B-2 to provide detection and identification at long range when at higher altitudes. This version of AAQ-27 has three fields of view (3FOV), which allows the aircraft to fly and navigate at low levels, or for the primary long range detection and identification functions.

Radar

17. The THORN/EMI Super Searcher radar provides 360° coverage to approximately 60 nm for a frigate sized vessel, or 10 nm for a submarine's search periscope. Super Searcher has a frequency range of 9 to 9.5 GHz, in either fixed or agile frequency mode. Automatic detection and tracking is conducted within the radar, with a capacity of 32 auto and 31 manual tracks (a 32nd manual track is the helo itself).

18. An IFF transponder is included, with the aircraft able to transmit replies for Modes 1, 2, 3/A, 4, and C. Mode 2 cannot be changed in flight.

Electronic Warfare

19. The electronic support (ES) system is an AES 210. It reports intercepts between 0.5 to 18 GHz directly into TDS.

20. An AN/AAR-54 Missile Approach Warning System (MAWS) passively detects the UV energy produced by missiles. It tracks multiple sources and rapidly classifies contacts as:

a. lethal missile,

b. non-lethal missile, or

c. clutter.

21. The countermeasure dispensing system is the ALE-47.

Acoustic

22. Acoustic sensors are the active and passive sonobuoys. The AN/UYS-503 acoustic processor can receive and process data from up to eight sonobuoys simultaneously, covering a frequency range from 0 to 3200 Hz. The helicopter has stowage capacity for up to 30 'A' size buoys made up from the following types:

a. AN/SSQ-36 Bathythermograph,

b. AN/SSQ-53 Directional Frequency Analysis and Recording (DIFAR),

c. AN/SSQ-62 Directional Command Activated Sonobuoy System (DICASS), and

d. AN/SSQ-801 Barra.

23. The SSQ-36 bathythermograph sonobuoy records thermal data to a depth of either 1000 ft, 2000 ft, or 2635 ft, depending on the buoy variant.

24. DIFAR buoys are passive only. There are several SSQ-53 variants in production, with each progressively gaining more functionality. The 'D' version is the standard version in use with numerous countries. The 'E' version incorporates 4 selectable depths, auto gain control (AGC), a shallow omni¬directional hydrophone, and Command Function, allowing settings such as depth to be altered after deployment. The 'F' version further adds a calibrated omni-directional hydrophone co-located with the DIFAR sensor. Each have a variable time of life; sinking on completion.

25. DICASS has active and passive capability. The SSQ-62 operates on one of four available frequencies at source levels exceeding 200 dB. A command function allows the buoy's settings such as depth, frequency, transmit on/off, and operating time to be changed after deployment. As with the SSQ-53, the DICASS buoy sinks once the time of life has expired.

26. The SSQ-801 Barra buoy is broadband directional, with narrowband analysis capability. An operating depth of either 21.5 metres, or 121.5 metres is selected prior to deployment. The acoustic array consists of five antennas with five hydrophones per antenna.

Magnetic Anomaly Detector

27. The magnetic anomaly detector (MAD) on the S-70B-2 is an AN/ASQ-504 Integrated MAD System (IMADS). It detects variance or anomalies in the earth's magnetic field, to a maximum range of approximately 2,800 ft. Primarily used for classification and localisation of contacts detected by other sensors, the IMADS may suffer high false alarm rates and reduced performance due to its location within the aircraft tail boom assembly.

Weapons

28. Weapons include:

    a. Air Launched Mk46 Torpedo

    b. Door Mounted .50Cal Machine Gun

    c. Door Mounted 5.56mm Machine Gun

Sea Boats

29. Currently the majority of Sea Boats are rigid hull inflatable boats (RHIBs) and are in service with the Surface Combatant community. They are used to conduct a wide range of tasks. In the current context the term 'RHIB' is used generically and it is recognised existing boats are not of a single manufacture and their characteristics may vary slightly such as length and means of propulsion. However, they are generally known as RHIBs.

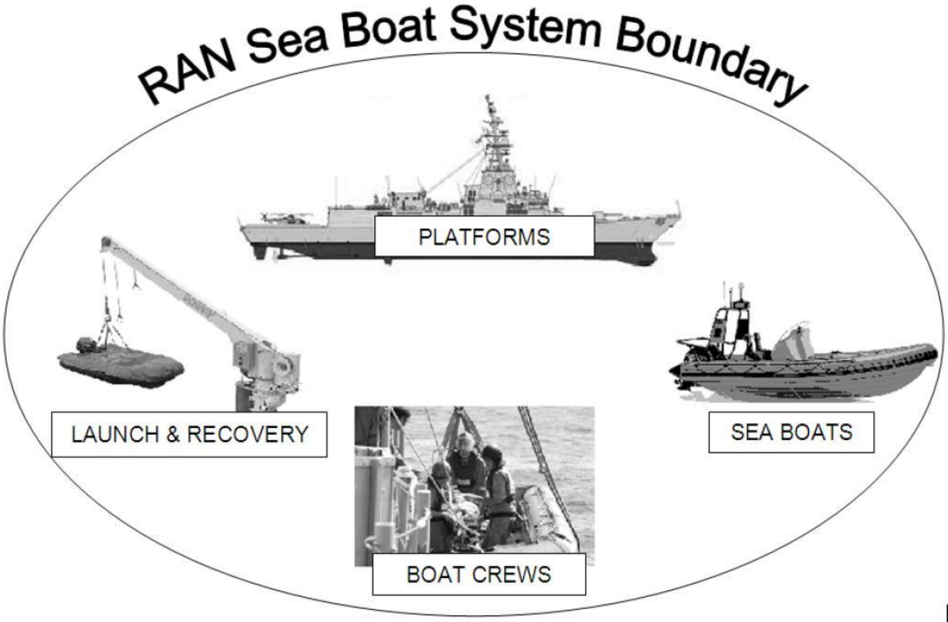

Figure 8-3: RAN Sea Boat Systems

30. A critical tool to protect Australia's maritime sovereignty in the offshore domain is the capacity to board vessels entering Australia's maritime sovereignty and exclusive economic our zones as defined by the United Nations Convention on Law of the Sea. Further, there exists a right by warships to board a vessel on the high seas to confirm its nationality. The operations to achieve this are often best conducted by small craft (RAN Sea Boats) transferring boarding parties.

31. Sea Boats ensure the FFG is capable of operations in a range of seas states to perform:

a. Rescue of personnel;

b. Boarding operations;

c. Insertion operations; and

d. Small craft support.

32. All FFGs maintain at least one 7.2m Jet RHIB as a Sea Boat at all times whenever the ship is at sea. This boat must be available to be launched at any time at very short notice.

33. The minimum mission needs for Sea Boat is when used for man overboard recovery (exercise or actual). The boat must be launched as quickly as possible, achieve engine start first time, and be able to reach full speed almost immediately so that the quickest possible recovery of the man in the water is achieved.

34. The most demanding mission needs is when the boat is used to convey a boarding party (6 personnel making 8 in total) plus their equipment (which is expected to be of approximately 900-1200kg) for extended boarding operations. These operations may be conducted over the horizon from the ship and may last several hours. The Boat must be able to sustain high speed when fully laden (as appropriate to the safe conduct of the boat in the prevailing conditions), and have sufficient endurance to transit to a remote operating area, remain on station for a determined period at loiter speeds and return to the ship. Littoral and underway Force Protection operations also place significant demands on the operational capability of Ships boats.

Chapter 9. Combat System Alignment

References:

A.	SW225-B6-CSA-010	Total Combat System Alignment for FFG-7 Class
B.	SW225-AO-MMA-010	Theory of Combat System Alignment
C.	NAEC 91-7949	Ship's Glide Slope Indicator Certification Test Procedures
D.	AFGOs (AFTP 1) Ch 312	Weapons Electrical Engineering
E.	ABR 6509 Sect 7 Ch 2	Combat System Manual
F.	Ship's Book	

1. The aim of Combat System Alignment is to maximise the fighting efficiency of the ship's combat system by ensuring all elements of the combat system are aligned to the same coordinate system. When this is achieved within specified tolerances:

   a. All sensor and weapon elements will refer to a given point in space by the same co-ordinates.

   b. Designation and acquisition times are minimised.

   c. Weapon accuracy is maximised.

Total Combat System Alignment Concept

2. During total Combat System Alignment all equipment of the combat system are correctly positioned with respect to each other and levelled to their reference planes (within specified tolerances).

3. Combat System Alignment consists of alignments within sub-systems and between sub-systems.

4. Equipment is initially installed by precision methods in a newly constructed ship, taking into account stress caused by operational loading, and adjusted for accurate alignment when the ship is waterborne and loaded to 80%. Alignment procedures undertaken thereafter will include checks and small adjustments to ensure the alignment of systems remains in tolerance.

Methodology

5. There are 8 major steps in completing a Combat System Alignment. Most of these steps are completed during ship construction and are not repeated unless the ship undergoes major modifications and/or receives major damage.

   a. Establishment of Reference Planes.

   b. Establishment of Reference Marks.

   c. Establishment of Parallelism.

   d. Performance of FC radar RF-optical alignment.

   e. Establishment of Train and Elevation Zero.

   f. Performance of Train and Elevation Space Alignment (star) Checks.

   g. Establishment of Benchmark and Tram Reference Readings.

   h. Performance of Transmission Checks.

6. These steps require that the sub-systems be internally aligned prior to commencing the CSA.

Establishment of Reference Planes

7. The Ship's Base Plane is the plane extending horizontally along the keel. The Master Level Block (MLB) is representative of the ship's base plane and is located, aligned and machined during ship construction. In the case of the FFG-7 it is positioned on the centreline under the deck plates in the AMR 1 where it will experience minimal angular deflection.

8. The MLB serves as the foundation machine and roller path inclination reference during the initial Combat System Alignment. It need not be used for post-construction alignment unless the ship is subjected to major damage or major modifications.

9. The Mk 75 gun roller path plane is designated as the Weapon Control Reference Plane (WCRP) and is machined during construction. The WCRP serves as the in-service levelling reference for all combat system elements.

10. The Centreline Reference Plane (CRP) is established during ship construction. It takes in the ship's centreline and is perpendicular to the ship's base plane. This plane is the reference used to establish train zero alignment of all combat system elements.

Establishment of Reference Marks

11. Centreline marks, off-set centreline marks and equipment bench marks are established during construction.

12. When the ship centreline and offset centreline are established, reference marks are installed. Each element with an alignment telescope is provided a bench mark.

Establishment of Parallelism

13. The Roller Path Planes (RPP) of all rotating combat system equipment must be parallel ie. inter-equipment parallelism must be verified. The degree of parallelism required is based on design and manufacturing criteria, the operational environment and the requirements of the various equipment operating modes.

14. The steps involved in achieving parallelism are:

a. **foundation machining** pertains to the physical process required to attain a specified degree of parallelism and may involve milling or welding pre-machined surfaces in-situ. Foundation Machining is accomplished with the ship afloat and loaded to simulate the full load and the strains of major concentrated loads for a period greater than 48 hrs prior to commencement of work. Minimal temperature changes are also required.

b. **inclination verification** consists of the measurement of tilt between two RPP's. The difference between the two planes is expressed as the angle of inclination between the planes and the bearing at which the inclination occurs.

c. **inter-equipment levelling** is achieved by adjusting support legs (CAS), levelling rings (STIR), shims (SPS-49, SPS-55, TDTs, SKWS) or by software adjustment.

Performance of FC Radar RF-Optical Alignment.

15. The purpose of FC radar RF-Optical alignment (collimation) is to ensure that the RF and optical boresights are coaxial. When the radar is tracking, the RF axis is the reference used for target location and prediction. During horizon, space and bench mark checks, the optical axis is the radar position reference axis.

16. Once the optical-to-RF alignment of STIR is established, the in-line telescope is secured. Later alignment of STIR is RF-to-optical.

17. If RF-Optical alignment is suspect, it should be checked prior to alignment checks that use optical axes.

Establishment of Train and Elevation Zero

18. Train and elevation zero alignment is done to ensure that all combat system equipment will point to the same point in space when directed.

19. Train Zero is defined as that angle at which the optical axis is parallel to the centreline of the ship. Elevation Zero is that angle at which the optical axis is parallel to the RPP.

20. There are two methods of completing this alignment;

a. Using alignment or boresight telescopes. Equipment that uses alignment telescopes include CAS, STIR and SPS-49. The Gun and GMLS utilise boresight telescopes. Each element is physically positioned to train and elevation zero using surveying techniques and the train and zeroing the elevation dials and synchros.

b. Equipment not compatible with telescopes or boresights are aligned by matching indicator marks to deck scribe marks/plates or by installing a stow pin and zeroing the train and elevation dials and synchros.

Performance of Train and Elevation Space Alignment

21. Train and elevation alignment between reference and non-reference elements of the combat system can be checked by comparing the optical axes of both elements when sighted on a distant object (eg. a star).

22. Objects of range greater than 20 nm minimise the effects of parallax and elevation less than 30° minimise the effects of train errors from Roller Path Inclination. At least two targets on opposite sides of the ship are required.

23. If corrective action is taken after the distant object check, a new set of tram or benchmark readings must be recorded.

24. Although theoretically sound, practical experience suggests that Star Checks are ineffective in FFG Combat System alignment. For example, if the accuracy achieved during a star check is +/- 5', and the Mk 75 Gun alignment tolerance is +/- 3', then one can only say that the test result is inconclusive. Therefore Star Checks are not conducted on FFGs.

Establishment of Benchmark and Tram Reference Readings

25. Reference readings are provided to allow an easy means of checking the train and elevation alignment of equipment.

26. Trams and benchmarks are provided to facilitate checking the position of an element after it has been trained and elevated to some definite position.

27. Minor misalignment, due to vibration, wear or maintenance, can be relatively easily identified by pointing the element to a pre-defined position and comparing the train and elevation readings with those recorded in the smooth log.

Performance of Transmission Checks

28. There are two methods by which this routine activity can be accomplished:

a. Use Mk 92 "snap" to check dynamic transmissions; and

b. Complete a distant object check and then check synchros.

Parallax Compensation

29. The compensation for parallax in the FCS is calculated using the vertical and horizontal displacements between CAS, STIR, Gun and the GMLS.

30. These displacements are stored within the WCP software and are calculated from the ship's Centre Of Movement (COM).

Misalignment Isolation

31. Once it has been determined that a misalignment exists, it must be decided which sub-system and, subsequently, which equipment contains the misalignment.

32. A TOP-DOWN alignment fault isolation procedure is employed. The procedure consists of six steps:

a. Determine that an error exists that may be alignment related.

b. Determine which sub-system (and mode) is under suspicion.

c. Perform an applicable alignment verification test.

d. If an Out-Of-Tolerance condition exists, isolate the faulty equipment.

e. Align the faulty equipment.[1]

f. Perform an applicable alignment verification test.

33. Alignment is considered to be corrective maintenance and should be conducted only when test results indicate that an alignment problem exists. Therefore, the alignment test(s) must include functional or operational checks of alignable quantities.

Weapon System Accuracy Trials

34. There are 4 test phases designed to assess the overall accuracy of the ships Combat System:

a. Phase 1 dockside equipment, subsystem and interface checks

b. Phase 2 dummy weapon firing (GMTR)

c. Phase 3 underway sensor accuracy checks

d. Phase 4 underway dynamic system level tests (weapon firing)

Combat System Smooth Log

35. The function of the Combat System Smooth Log is to provide a detailed history and reference of each alignable element of the combat system.

36. There should be a Smooth Log for the following systems:

a. Fire Control

b. ASW

c.Sensors

d. Countermeasures

e. Support

37. Each should contain the following information:

a. alignment methods, dates and readings,

b. collimation dates and results,

c. plots of roller path,

d. cutout cams and zones,

e. benchmark and/or tram readings,

f. calibration checks and settings,

g. 'Double Echo' checks and resultant settings,

h. power out, MDS and noise figure readings,

i. Firing reports and results,

j. Self Noise test results.

38. Smooth Logs are normally held by the WEEO and maintained by the DWEEO.

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[1] Of fundamental importance is alignment auditability. Record all settings prior to any adjustment to ensure the combat system can be returned to a known state. Make one adjustment at a time, recording the new settings, then verify the alignment of the system. If the alignment problem has not been solved, or is worse, return to the original settings before touching anything else.

Operational Alignment Verification - TCT

39. Tracking Comparison Tests are an automated, integrated means of verifying intersystem alignment that is for the combat system. RIADT can perform the TCT and report index errors. These index errors can be re-input as software corrections for slight hardware misalignments.

40. The purpose of the Tracking Comparison Test (TCT) is to provide a means of verifying the relative alignment of ships sensors (Reference NAVSEA 0967-LP-015-0271).

In Service Alignment Checks

General

41. Tracking and firing exercises are the practical test of a combat system's performance. Tracking exercises must be conducted to assist in assessing system performance before proceeding to the firing exercises. Observation of system performance during tracking exercises will give an indication of dynamic pointing accuracy consisting of tracking performance, system static alignment, and weapons servo system responses. This is why WE personnel must be present during all tracking serials. Alignment in particular, can be monitored during tracking exercises by the following:

a. TV DAC System - Gun bore camera observations may indicate a consistent error in elevation and/or bearing which may be alignment related. Also, the director mounted camera may show a consistent alignment error due to the misalignment of the optical and RF axis, indicating that a collimation is required. To ensure the validity of TV DAC observations, it is imperative that the camera is aligned accurately IAW ABR 1043 and TV DAC Handbook.

b. TCT - The Tracking Comparison Test is used for at sea alignment checking when the ship's sensors are in their normal operational state. These tests compare the position of a target as reported by two sensors to ADACS/WCP. The TCT samples positional information and prepares an analysis based on operator selections. Test results are displayed dynamically at an C&DI whilst the test is being performed, and can be printed out on the DEAC in tabular form after each run. The C&DI provides for test monitoring only, whereas the printout allows for the mean and standard deviation of the measurement errors to be analysed. After analysis the printouts are included in the Smooth Log. Note that the TCT provides a comparison between two elements and is not a measurement of absolute alignment to an alignment reference such as the WCRP nor ship's centreline, therefore, the alignment error allowed can be double the individual element tolerance.

In Service Fault Isolation

42. Alignment is only one aspect contributing to the overall performance to specification of a weapon system. Other factors which might affect weapon system performance and give similar indications of poor performance include:

a. operator performance;

b. acquisition and tracking performance (not related to alignment);

c. ballistics and prediction; and

d. ship parameter inputs.

43. Errors in these areas must be considered and investigated before alignment is considered suspect and any alignment adjustments made. Corrective alignment action should not be taken on the results of one tracking or firing serial. Results of previous exercises should be compared and any differences attempted to be resolved. The static alignment of a system varies only very slowly unless settings have been moved or equipment associated with alignment is defective. A ship may take until the next major combat system alignment to recover from a poorly, hastily conducted or ill-considered alignment. If you need help - **ASK.**

Procedure

44. Alignment is considered to be corrective maintenance and should be conducted only when the test results indicate that an alignment problem actually exists. It must be stressed that more than one test is to be conducted to confirm that misalignment actually exists. These tests must include functional or operational checks of alignment quantities for the system(s) believed to be deficient.

45. The general procedures for alignment fault isolation are as follows:

a. Determine that an error that may be alignment related exists.

b. Determine which system or subsystem mode is under suspicion.

c. Perform transmission checks between the equipment of the suspect system or subsystem.

d. If an out of tolerance condition exists, isolate the faulty equipment, system, or subsystem.

e. Using procedures detailed in Reference A, correct the alignment of the faulty equipment, system, or subsystem.

f. Verify that the error (fault) has been corrected.

g. Record the results in the alignment section of the Smooth Log after any alignment check or adjustment.

Determine That an Error Exists

46. An alignment problem may be detected during:

a. routine planned maintenance;

b. selected Sea Acceptance Tests (SATs)/ Ship's Qualification Trials (SQTs);

c. prefiring checks; or

d. abnormal operation during routine serials.

47. Regardless of the method used to detect the apparent problem, it must be determined initially if the suspect alignment is within or outside the specified tolerance. If the alignment is outside the specified tolerance, an alignment problem exists and the faulty equipment must be isolated.

Routine Planned Maintenance

48. PMS plays an important role in determining the necessity for combat system alignment. The PMS provides the ship with a simple and standard means of planning, scheduling and performing a variety of related tests and checks. The following are alignment related PMS:

a. TCT - Already discussed

b. Star Checks - not conducted on FFGs.

c. Horizon Checks - A Horizon check can be used to determine whether the horizontal plane of the gyros (WSN-7 and CAS internal stabilisation) are parallel to the Roller Path Plane of the gun (the WCRP). The check uses the borescope camera in the gun and ballistic calculations are removed. The gun is assigned to an NGS target on the horizon in gun align mode. The horizon position with respect to the boresight is plotted as a function of relative bearing. This plot will provide the amount of tilt and the tilt angle between the WCRP and gyro. Although not intended as a check of dynamic stabilisation, a feel for this can be achieved by observing the dynamics of the horizon in the boresight: it should not oscillate with ship motion, but change only slowly with bearing. Horizon checks should be performed in low sea states.

d. Radar Collimation Checks - These tests are performed on the FC directors' antenna using the collimation tower in the dockyard (GID berth West Dock Wall, or FBW Parkes Wharf). The tower has a pair of targets for the STIR director. One is an optical target used for sighting the associated alignment telescope. The other is an RF target used to determine where the boresight of the RF beam lies. These targets are offset by the same amount as the boresight telescope is from the RF axis of the director. In general terms the director is trained so that the optical Line of Sight (LOS) and the radar beam sweep over their respective targets. The RF signal strength is measured and the personnel in the Collimation tower and on the ship determine if the maximum RF signal strength occurs when the telescope is sighted on the optical target. The process is conducted individually for train and elevation. The results of the collimation are analysed and, if necessary, the position of the RF feed and reflector is adjusted with respect to the optical LOS of the reflector. All adjustments are recorded in the Smooth Log.

e. Tram Bar and Benchmark Checks - Reference readings are provided to allow an easy means of checking the train and elevation alignment of equipment. Minor misalignment, due to vibration, wear or maintenance, can be relatively easily identified by pointing the element to a pre-defined position and comparing the train and elevation readings with those previously recorded in the smooth log (after coming out of refit). Primary Bench Marks for the RAN FFG are as follows:

i.	STIR director	-	main stack
ii.	GMLS Mk 13 Mod 4	-	bow
iii.	Mk75 Gun	-	No. 1 Diesel Exhaust
iv.	CIWS (barrels)	-	flightdeck aft
v.	SPS-49	-	bow
vi.	SPS-55	-	bow
vii.	TDTs	-	bow
viii.	CAS Antenna	-	bow
ix.	Centreline Pelorus	-	bridge (portside)
x.	Port/Stbd Pelorus	-	bow

Pre Firing Checks

49. Benchmarks are checked as part of routine pre-firing checks. These checks may indicate a possible misalignment error and are therefore another check of combat system alignment. They are conducted on directors and weapons. Reference to these checks can be found in ABR 1043 - RAN Firing manual.

Normal Operations

50. A number of activities conducted as part of a ship's normal program build confidence in the relative alignment of combat system elements, or alternatively provide indications of alignment problems. These include:

a. DSOTs

b. Tracking serials, including acquisition times from ADACS and IDDs

c. Firing Serials

DSOTs

51. DSOTs are intrasystem tests and exercise most aspects of the system under test. If passed, DSOTs give the operators a degree of confidence that the system is functioning correctly. RF targets are injected into the Mk92 radars just after (Rx point of view) the feed horns and comparators and the performance of each radar is assessed against the known target parameters. The DSOT checks most aspects of the system, but does not asses performance against a live target. Live tracking performance can only be subjectively assessed during tracking serials.

Inter-Director Designations

52. Inter director designations pass fire control positional information from one fire control system to another. The positional information is expected to be far more accurate that that provided from the search radars. The receiving FCS sets itself for height reliable operation. Therefore acquisition times via an IDD (FC1 to FC2 or vice versa) should be significantly less than from the search radars.

Determine The Faulty System

53. Once it has been established that a misalignment actually exists, it must be determined which system, and subsequently which equipment, has the misalignment. The most effective way of determining which system is causing the problem is to compare the positional quantities developed by at least three systems. The TCT is very useful here, especially when tested against the gun system.

54. When comparing two systems, at least two search radar systems and two FCs should be used, as it is possible that a false indication could be caused by faulty ship parameters. The search radars and FCs are fed from different SSAs which can be useful in isolating faulty systems.

Determining the Problem with the System

55. The main steps involved in determining the problem with a system are:

a. Check system is in the correct configuration;

b. Perform data transmission checks between the system and other systems;

c. Isolate the fault in the transmission path

d. Perform internal data transmission checks;

e. Check mechanical alignment;

f. Check electrical alignment.

Configuration

56. Incorrect values entered into a computer (ballistics etc), incorrect set-up of a sub-system or other actions performed incorrectly could appear as a misalignment when no such error exists. For example, a search radar may be in relative bearing instead of true.

Transmission Checks between Systems

57. These checks are conducted to ensure data is exchanged between systems without being corrupted. A data transmission check is not an alignment check by itself. It is an alignment fault isolation procedure.

Mechanical Alignment Checks

58. These are conducted to confirm the physical positioning of rotating structures. These alignment checks are:

a. benchmark checks

b. tram bar checks; and

c. checks with a moveable structure pinned in a stow position.

59. Benchmark and tram bar checks provide mechanical position indicator readings (such as dials for the directors and gun mount) which are checked against the reference readings established by the dockyard during the Combat System Alignment. The readings are entered in the alignment section of the Smooth Log. If benchmark readings are in error, the mechanical alignment must be corrected. When the mechanical alignment has been corrected, the electrical alignment should be checked by training, and elevating where appropriate, the structure to zero degrees train and elevation and electrically zeroing the electrical position information. The electrical zero of the antenna synchro is checked and adjusted as required. If the mechanical alignment is adjusted and the subsequent verification checks indicate a misalignment, the ship's structure may be distorted. The dockyard should then be consulted.

Verify that the Problem Has Been Fixed

60. After an out of tolerance condition is determined, corrective action is taken to rectify the out of tolerance condition. The alignment correction is verified by again performing the initial test from which the out of tolerance condition was diagnosed. If the misalignment has been corrected, the results of the test should be entered in the ship's Smooth Log. If the misalignment condition still exists, the same fault isolation procedure should be conducted. If the alignment condition persists, the dockyard should be consulted as the ship's structure may be distorted, a benchmark may be moved or damaged, or there may be some other condition that is beyond the capability of ship's staff to rectify.

EQUIPMENT	Construction tolerance[1]		Operational tolerance[2]	
	Train[3]	Elevation[4]	Train	Elevation
Master Level Block	±5'	NA	NA	NA
Search Radar Subsystem				
SPS-49	±30'	NA	±30'[5]	NA
SPS-55	±30'	NA	±30'[5]	NA
EW Subsystem				
L/M/H band antenna	TBA'	NA	NA	NA
VLB antenna	TBA'	NA	NA	NA
SKWS/LRCR launchers	TBA'	NA	NA	NA
Close-In Weapons System				
CIWS	±20'	NA	NA	NA
Underwater Weapon System				
UWS/MOAS	±5'	NA	NA	NA
SVTT Mk32	±60'	NA	NA	NA
Gun-Missile Subsystem				
CAS	±2'	±2'	±2'[6]	±2'
STIR	±2'	±1'	±2'[6 7 8]	±2'[6 7 8]
GMLS	±5'	±3'	±6'[6 7]	±5'[6 7]
Gun	±2'	±2'	±2'[7 8]	±2'[7 8]
TDT Mk 24	±30'	±30'	±30'	±30'
Support Systems				
WSN-7	±2'	NA	±2'[6 9 10]	NA
Mk27 Gyro	±2'	NA	NA	NA
Pelorus Stands	±30'	NA	±30'	NA
Wind Detectors	±60'	NA	NA	NA
SGSI	±60'	NA	NA	NA

Table 15: Train and Elevation Construction and Operational Alignment Tolerances

1 Conducted by support activities only (dockyard).
2 Operational tolerances apply to various shipboard alignment procedures including benchmark readings etc.
3 Referenced to Centreline Reference Plane.
4 Referenced to Roller Path Plane.
5 Referenced to CAS.
6 Referenced to the Mk 75 gun mount.
7 Limit for benchmarks is ±5'.
8 Limit for benchmarks is ±3'.
9 Limit for roll and pitch is ±2' operational, and ±1' optical alignment.
10 Applies to operational Cqo and optical alignment azimuth.

EQUIPMENT	Foundation Machining		Operational RPP Inclination	
	Tolerance	Reference	Tolerance	Reference
Master Level Block	±0.5’	SCBP	NA	NA
Gun Mount Mk 75 (WCRP)	±3’	MLB	NA	NA
Search Radar Subsystem				
SPS-49	±10’[1]	MLB	±10’[2]	WCRP
SPS-55	±20’	MLB	±20’[2]	WCRP
Close-In Weapons System				
CWIS	±20’	WCRP	NA	NA
EW Subsystem				
L/M/H band antenna	TBA’	NA	NA	NA
VLB antenna	TBA’	NA	NA	NA
SKWS/LRCR launchers	TBA’	NA	NA	NA
Gun-Missile Subsystem				
CAS	±20’	MLB	±2’	WCRP
STIR	±5’	MLB	±2’	WCRP
GMLS	±3’	MLB	±12’	WCRP
TDT Mk 24	±20’	MLB	±30’	WCRP
Underwater Weapon System				
UWS/MOAS	±10’	MLB	±10’[2]	NA
SVTT Mk32	±30’	MLB	NA	NA
Support Systems				
WSN-7	±20’	MLB	±1’[3]	WCRP
Pelorus stand	±20’	MLB	NA	NA

Table 16: Foundation Machining/Roller Path Inclination Tolerances

1 Machined flatness total indication runout must not exceed 0.0005”
2 Applicable to initial installation only.
3 Applies to levelling stations during optical alignment

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