

M.Sc. Marine Engineering Ship Design Exercise 2001



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No.	Design	Students
5	FUTURE SURFACE WARSHIP (MONOHULL)	Lt M Boyes, RN, ME(M) Lt Cdr P Freire, Brazilian Navy, ME(E) Mr J Bryars, NA
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7	HIGH SPEED EXPORT CORVETTE (PENTAMARAN)	Lt S Day RN, ME(E) Mr L Ong, NA
8	BATTLEWORTHY RFA (MONOHULL)	Lt E Sharkey, RN, ME(E) Mr A Martin, NA

The Ship designs are a group effort with teams of between two and four students comprising of Naval Architects and Marine Engineers. The students are issued outline requirement of their ships early in the New Year, but they did not start working on their design full time until 20th March. The Marine Engineers had to submit their reports on 24th May 2001.

Dr A Greig

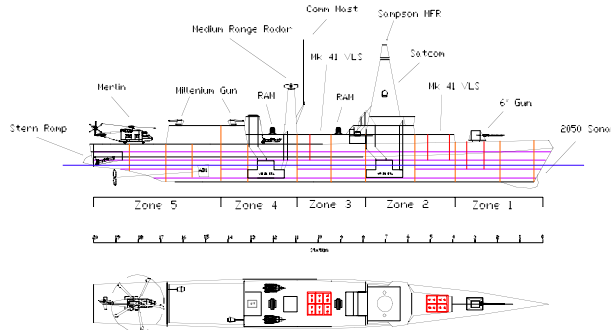
Dr R Bucknall

FUTURE SURFACE WARSHIP (MONOHULL) GROUP 5: 2001

Lt M Boyes, RN, MSc Marine Engineering (Mechanical Option)

Lt Cdr P Freire, Brazilian Navy, MSc Marine Engineering (Electrical Option)

Mr J Bryars, MSc Naval Architecture



Introduction

Following the break up of the Warsaw Pact, NATO has had to redefine the threat it faces and this was echoed in the Strategic Defence Review (SDR) which highlighted the need for a flexible rapid reaction force. It has also become increasingly clear that the requirement for a naval force capable of operating effectively in the littorals has become a driving factor for most future operations. The Future Surface Warship (FSW) is a ship that has been designed to meet the requirements of the SDR and is based on similar principles to the Future Surface Combatant project, scheduled to replace the Type 23 frigates.

Roles

Despite being the direct replacement for the Type 23 frigate, ASW operations will only be a supporting role for the FSW, its primary role being the support of amphibious operations and operation in littoral waters. To achieve these roles the FSW will be designed as a highly flexible 'swing role' monohull ship, able to operate both alone and as part of an amphibious task force protecting the capital ships. The Type 45 will provide the area air defence capability for these task groups, but it will lack a comprehensive ASW fit. The FSW will therefore be required to perform a screening role for submarines before proceeding into the littorals, ahead of the task group to complete the land strike role and neutralise defensive positions. To enable autonomous operation outside the umbrella of protection from other units, FSW will have to have a multi-role capability and an effective AAW point defence.

Threat

The FSW must be capable of countering the threat in both open ocean and within the littoral environment. The open ocean threat is well defined and the primary ASW screening will be conducted with ship-mounted sonar (passive and active) supported by helicopter dipping sonar. The threat within the littoral environment can change rapidly and come from a number of different areas. These include land-based aircraft, missiles and munitions; small fast attack craft with low calibre weapons and small missiles; and subsurface threats from submarines and mines. To operate effectively in such an environment besides the strike and multi layer self-defence capabilities, the vessel will be fitted with an advanced communications suite that allows constant contact and transfer of information between units in the task force. In addition, the vessel will have low signature levels to help evade detection and prosecution whilst remaining highly survivable in the event of any damage sustained.

Payload

The FSW is fitted with a varied payload which provides for deep strike land attack by vertical launch TLAM and a 6" gun, surface unit prosecution using vertical launch Harpoon and AAW self-defence by vertical launch Aster 15 missiles. Two RAM launchers and two millennium guns provide the CIWS coverage whilst magazine torpedoes and the ships helicopters are used to attack submarines. A multi-function radar is provided to detect and subsequently prosecute potential threats whilst standard countermeasures and decoys are fitted in the event of an attack.

Machinery

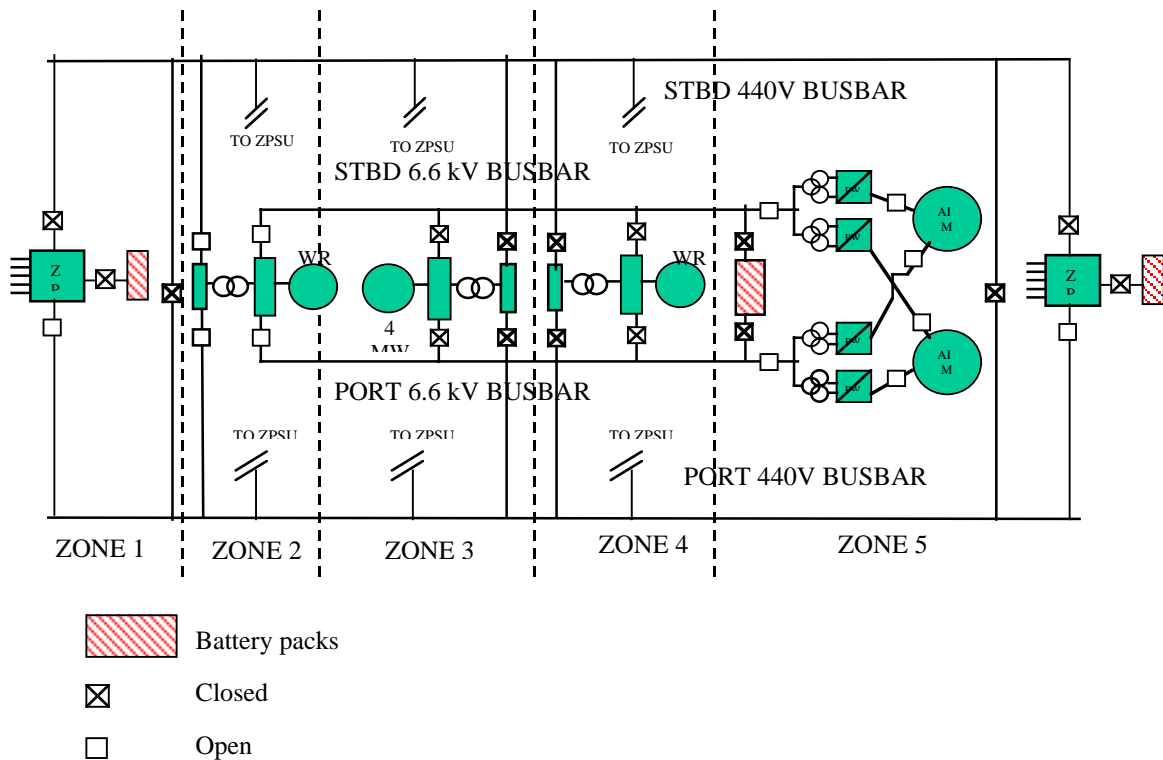
A fully Integrated Electrical Propulsion system is provided with only 3 gas turbine alternators supplying both the propulsion and service loads simultaneously. Single generator operation will be employed with a ride through capability provided by Zonal battery supplies in the event of a generator failure. Propulsion is achieved through 2 Advanced Induction Motors positioned on two shafts driving fixed pitch propellers.

Auxiliary systems include 2 high pressure and 2 low pressure air compressors, 6 chilled water plants, two reverse osmosis plants, 5 high pressure and 6 low pressure sea water pumps and integrated sewage treatment and garbage disposal plants.

Key Features

Principle Characteristics		Payload
Cost	£ 240 million	16 x MK 41 Launcher (TLAM/Harpoon)
Displacement (Deep / Light)	6780 / 6389 tonnes	16 x MK 41 Launcher (Aster 15)
LPP / LOA	155 / 160 meters	1 x 6 inch Gun
Beam (Extreme / Waterline)	17.8 / 16.9 meters	2 x RAM Launcher
Depth	12.5 meters	2 x Millennium MDG 35
Draught (mean)	5.4 meters	2 x Magazine Launch Torpedo System
Speed (Maximum / Cruise)	30 / 14 knots	1/1 x Helicopter (Merlin)
Endurance (Fuel)	7195 nm @ 14 knots	Whole Ship Integrated Management system
Endurance (Stores)	60 days	
In Service Date	2015	Propulsion
Design Hull Life	30 years	Integrated Full Electric Propulsion
Compliment (flight embarked)	94	2 x Rolls-Royce WR21 GTA (25 MW)
Accommodation	Up to 133	1 x Advanced Cycle GTA (4 MW)
		2 x Advanced Induction Motor (20 MW)
Propulsors		4 x IGBT based PWM Converters
2 x shafts		6.6 kV 60 Hz propulsion busbar
2 x Fixed Pitch Propellers		Battery Packs for ride through capability (30 min)

Electrical Propulsion System Configuration

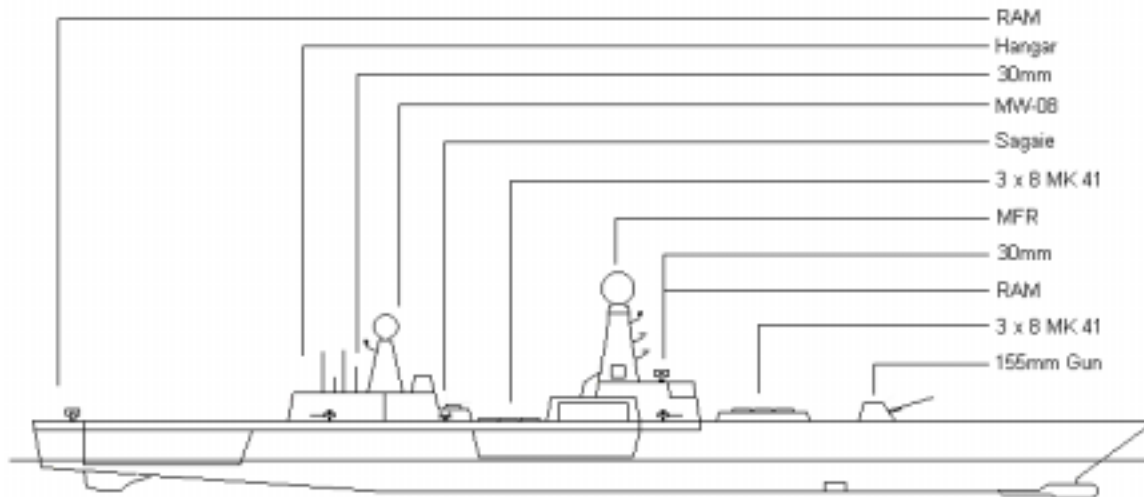


FUTURE SURFACE WARSHIP PENTAMARAN GROUP 6: 2001

Lt. Austin RN, MSc Marine Engineering (Electrical Option)

Mr G Mailer, MSc Naval Architecture

Mr R Pwling, MSc Naval Architecture



FSW (P) PRINCIPLE FEATURES

The Future Surface Warship (Pentamaran) FSW (P) has the following main roles:

- The projection of power ashore
 - Long range land attack and support to amphibious landings.
- Sea control
 - When operating alone or in a task group, with an emphasis on ASW in the littoral environment.
- Naval presence
 - Provide flexible response and naval presence in area.
- The FSW(P) must also be capable of landing a small force ashore

• Ship Characteristics:

- Maximum Speed: 35 knots
 - At power: 35 MW
- Maximum Range: 12000 Nm
 - At speed: 15 knots
 - At power: 6 Mw

• Ship Features:

- Deep displacement, beginning of life:	9129.8 tonnes
- Deep displacement, full fit:	9129.8 tonnes
- Overall length:	201m
- Length BP:	193m
- Main hull beam:	14.47m
- Main hull draught:	7.06m
- Main hull depth:	13.7m
- Length of side hulls:	38.6m
- Beam of side hulls:	3.365m
- Draught of side hulls:	0.7m
- Depth of side hulls:	7.84m
- Overall beam:	31.12m
- Wet-deck clearance:	6.135m
- Main hull Cp:	0.55
- Main hull Cm:	0.81

• **Machinery:**

➤ Main Propulsion Fit:

- Prime Movers: 2 x 28MW WR21 Recuperative Cycle Gas Turbine Alternators.

The alternators are 6 pole generators rated at 28MW, 60HZ, 6.6kV and supply both the propulsion and ship supply load in the IFEP architecture.

- High Voltage Distribution: This will be of a “parallel tree” architecture and rated at 6.6kV supplying propulsive power.

- Propulsion: 35MW of propulsive power required to drive the vessel at 35 knots will be achieved using 2 water jets; 2x 18MW units.

The water jets will be electrical driven by permanent magnet motors controlled via IGBT PWM Controllers from the 6.6kV distribution system.

➤ Auxiliary Power:

- The 440V electrical distribution system will derive power from the 6.6kV system via 2 transformers. The 440V system will be of a parallel tree configuration with 5 zonal divisions.

- Two Eurodyn GTA rated at 2.6 MW will provide harbour and emergency generation capability. They will be able to supply either the 440V or the 6.6kV distribution systems at any one time. The prime movers are distributed not more than one per zone.

- Ship Service maximum Activity Load 4 MW

• **Complement:**

➤ Accommodation:

- Ships' company: 111
- Flight: 40
- Embarked forces or specialists: 30
- Total: 181

ME Department

- 1 CCMEA
- 2 CPOMEA
- 4 PO
- 11 JR

• **Other Major Features:**

➤ Other significant features of the FSW(P) design include:

- Split VLS silos
- Ability to launch and recover two 16m Very Slender Vessels (VSV) for use by special forces. Or, ability to operate two Unmanned Underwater Vehicles (UUV)
- Waterjet propulsion systems
- Increased mast height due to pentamarian hullform
- Wet-deck clearance of 6.1 m

Cost - £M 300

In service Date 2015

HIGH SPEED EXPORT CORVETTE (PENTAMARAN) GROUP 7: 2001

Lt S Day RN, MSc Marine Engineering (Electrical Option)
Mr L Ong, MSc Naval Architecture



In designing a vessel to fulfil the roles of sea control, projection of power ashore and providing a naval presence the possibilities of the pentamaran design are fully explored. With tasking that stretches from the purely military capability of being able to detect and prosecute contacts in the air, on and below the surface, providing NGS to support an amphibious landing and the insertion and support of Special Forces, through the paramilitary role of policing and interdiction to the requirement to providing a limited worldwide role to further Government policy, the vessels breadth and scope of ability are wide. One of the key strengths of the pentamaran hullform in military vessels is the large upperdeck area relative to size. The ability to utilise this in support of aviation assets, beyond those typically associated with the corvette/OPV, provides a step change in the traditionally expected capabilities. Public and government resources have been used in some detail to determine the nature of the prospective market, the likely additional tasking and threat environments.

The vessel features a weapon and sensor suite to make a full account of itself in all spheres of warfare, within the context of the 'low' threat environment specified in the Statement of Requirement. An otherwise predominantly missile armament of SAM and SSM is complemented by the 76mm Otto Melara gun and the Phalanx CIWS. ESM and decoys are fitted to complete the array of capability.

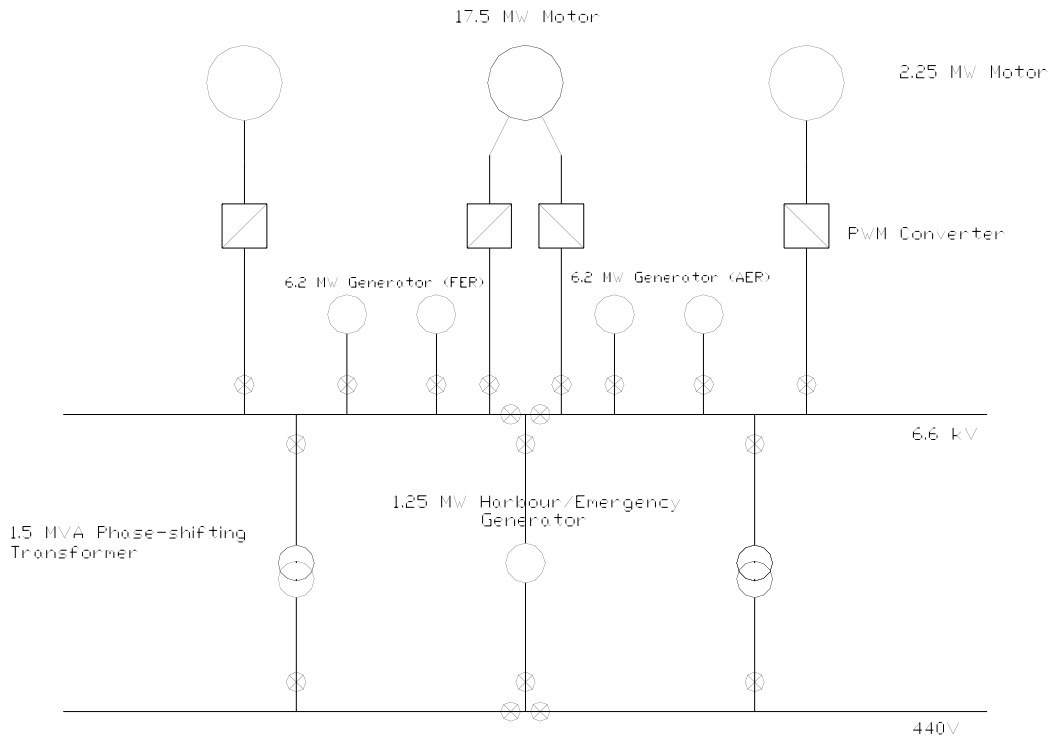
The vessel features an Integrated Full Electric Propulsion (IFEP) architecture to meet the combined propulsive and domestic electrical loading. This topology presents benefits in layout and flexibility of operation as well as a method to allow the more straightforward honing of propulsion machinery to individual customers' requirements. Optimised for diesel electric propulsion, using as a baseline MTU 1163 engines, the vessel's operating profile is centred around a 30-day patrol cycle with the cruise speed of 18 knots achievable using Single Generator Operation (SGO). Waterjets have been used as propulsors for the vessel to maximise power transmission within the bounds of the slender hullform. This system also reduces appendage drag on the hull increasing efficiency and resulting in an endurance of 3200 nautical miles.

Identified as a key design driver, the reduction of personnel to 50 has required the use of a wide range of automation systems. The integrated control system for propulsion and generation is centred on the bridge, with an engineering specialist on call on a watch basis. Trend analysis in support of an RCM policy is provided through a LAN-type network with workstations throughout the vessel.

Displacement	2360 tonnes
LOA	116.5m
Beam	21.6m
Endurance	3000 nautical miles
Complement	Engineering 15 Total 50
Cost	£106.5 M
In-service date	2010
Main prime movers	4 MTU 1183 20V TB 73 Diesel generator sets (6.2 MW) 1 MTU 12V 396 TB34 Harbour Generators (1205 kW)
Propulsors	2 Kawasaki KPJ-68A1 (1.9 MW) 1 Kawasaki KPJ 189A (15.5MW)
Electrical Transmission	4 Propulsion generators feeding 6.6kV 60Hz Propulsion Busbar. PWM Drive for 3 synchronous motors powering waterjets Domestic load at 440V transformed by phase-shifting transformer for harmonic attenuation

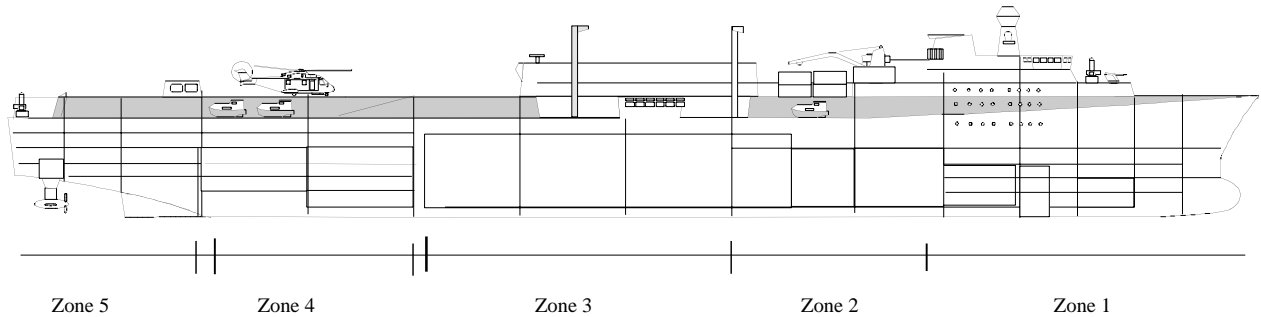
Command System	NAUTIS
Communications	1 ICS-3 Communication Suite 1 SCOT Satellite Communications
Sensors	1 Type 996 (3D) Air/Surface Search Radar 2 Type 1007 Navigation Radar 2 Type 911 Fire Control Radar
EW	1 Sea Archer Electro Optical Director 1 TSM 2633 Spherion Hull Mounted Sonar 1 UAF1 Cutlass ECM Intercept 1 Type 675 ECM Jammer 1 Type 1011 IFF Transponder
Weapons	2 Sea Gnat Decoy System 1 Oto Melera 76 mm Super Rapid Gun 2 Oerlikon 20 mm GAM 8 MM40 Exocet Block II 16 Cell BAe Seawolf VLS 1 Phalanx CIWS
Aircraft	2 Whitehead STWS Westland Super Lynx
Maximum Speed	32 knots
Power Requirement	Propulsion 18.95 MW Total Connected Load 3031.48 kW Action Utilised Load 1440 kW
Auxiliary Systems	Combined Ballasting/Firefighting/Machinery cooling HPSW system 4 142kW WTNZ Chilled Water Plants Rochem RO Plant Hamworthy Super Trident STP Integrated Control System

IFEP Architecture and Layout



BATTLEWORTHY RFA (MONOHULL) GROUP 8: 2001

Lt E Sharkey, RN, MSc Marine Engineering (Electrical Option)
Mr A Martin, MSc Naval Architecture



Introduction

It is envisaged that logistics will be brought in to the frontline in order to provide an effective support role for the next generation aircraft carrier (CVF). As the proposed airgroup for CVS will consume much greater quantities of ordnance and aviation fuel, sustaining a prolonged campaign will require a replenishment ship to operate in theatre for longer durations. The future RFA will be exposed to the same threats as warships, which are becoming increasingly stealthy, and therefore its design must incorporate the adequate battleworthy features to avoid compromising the task force and survive in hostile environments.

Roles

The Primary role of the Battleworthy RFA (BRFA) is to provide front-line logistical support to multi-national and national taskgroups engaged in a range of peace and wartime activities. The most demanding scenario is support of a 50 CAG task force on a 60-day mission. The BRFA will provide a 'one stop' facility capable of carrying a mixed cargo of ordnance, fuel and dry stores. It will also provide aviation support to RN warships and provide cargo transport in support of Joint Force Operations. The BRFA will also have the ability to conduct independent Naval Presence operations in low threat environments.

RAS features

The BRFA has a mixed cargo to provide a 'one stop' replenishment facility and minimise RAS time is afforded by 4 abeam transfer rigs. The ability to transfer stores efficiently is further enhanced by vertical replenishment afforded with a 3 spot flightdeck

Key Features

Principle Characteristics		Payload	
Cost	£258 million	AVCAT	14,000 tonnes
Displacement	47,500 tonnes	Dieso (F76)	8,000 tonnes
Length (LPP/LOA)	234 / 229m	Ordnance	1,250 tonnes
Beam(waterline/overall)	28.72 / 31m	Dry stores/spares	5250m ³
Draught (full load)	11.2m	Fresh water	100 tonnes
Speed (max/cruise)	22 / 15 knots	Garbage	11.5 tonnes
Endurance	60 days	Lub Oil	20 tonnes
In service date	2015	Garbage	11.5 tonnes
Design hull life	30 years	Grey water	250 tonnes
Complement (RFA)	118		
Complement (total)	230		
		Armament	
		2 x SEA RAM	
Propulsion		2 x Millenium with E/O sights	
Integrated Full Electric Propulsion		4 x mounts for 0.5cal MG or AGL	
4 x 12 MW Roll Royce SM1C Spey GTA		3 x Outfit DLH launchers	
2 x Kamewa-Alstom podded drive		Decoys (Mk 251, 216, 245, 'teluma')	
4 x IGBT PWM Converters			
6.6kV propulsion busbar			
1x 3MW pump jet			

Electrical Propulsion system configuration

