TYPE 45 DESTROYER
PRESENT AND FUTURE CAPABILITY

BY

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Introduction

The Type 45 programme started in May 1999 following the UK's withdrawal from the tri-national HORIZON programme, when it became clear that the UK's requirements were significantly different from those of France and Italy. The UK MoD appointed GEC Marconi (soon to be part of BAE SYSTEMS) as Prime Contractor for Type 45, responsible for all aspects of design and procurement (except for the main AAW suite – PAAMS – which continues as a tri-national programme, albeit with national variants).

There are to be up to 12 ships of the Type 45 class and, following an initial design phase, the contract for the first 3 was awarded to BAE SYSTEMS in December 2000. Approval for a further 3 was announced recently and some of the equipment for ships 4-6 is already on order. The plan is to grow capability progressively through the class (subsequently retrofitting to earlier ships) allowing flexibility as requirements evolve over the next few years. This will keep costs down in the early stages (there is now only one nation's budget instead of three) and also help in achieving the very tight timescales planned for the first of class.

Type 45 requirements

The most obvious requirement is to replace the existing fleet of Type 42 destroyers now coming to the end of their service life. Designed 40 years ago for a different world, the Type 42s are not suited to today's new threats, nor to the flexible roles required of today's warships. Furthermore, they have now been in service a long time, and are becoming very difficult and expensive to maintain and support.

The RN's *Single Mission Statement for the Type 45* stresses versatility, joint operations, and ability to work in multi-threat environments, but the main specialist capability (as befits an AAW destroyer) is Air Warfare capability until 2040.

The Type 45 is designed to be highly capable against a very wide range of air threats. This includes all kinds of manned aircraft as well as unmanned aircraft and, most importantly, missiles. Missile threats may be subsonic or supersonic, high divers or sea-skimmers, with increasingly sophisticated manoeuvring capability. To counter these threats, the Type 45 needs not only superlative sensors, but also a highly agile missile. And, of course, the ship must be able to deal with a large number of these threats all at the same time!

One kind of missile threat not included in the list is a Ballistic Missile, and the BMD is not currently a stated requirement for Type 45. None the less, as mentioned later, the upgrade to BMD capability is a natural development of the Type 45.

The Scenario (FIG.1)

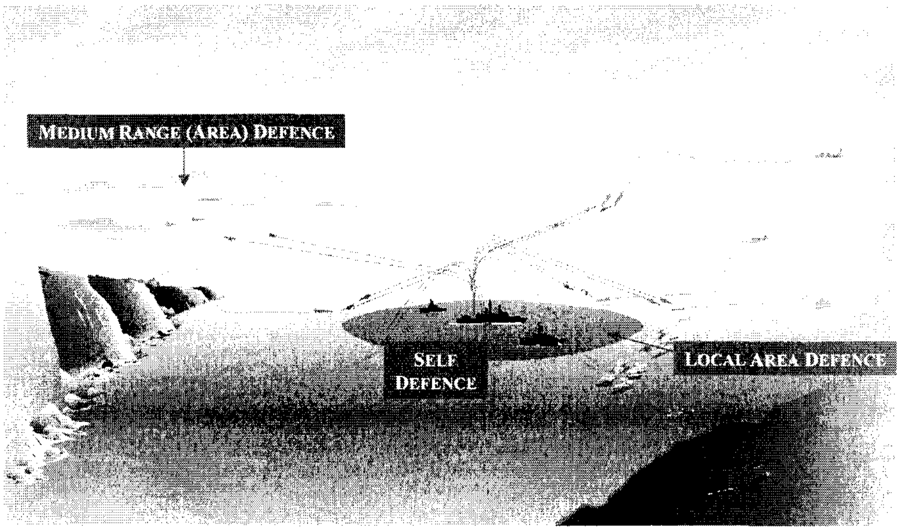

FIG.1 – AAW REQUIREMENT – THE SCENARIO

The AAW system is designed not just for self-defence, but crucially for the defence of mission critical assets such as a carrier, and other vessels in a force. The Type 45 can defend the local area as well as engaging medium range threats.

The scenario is typically a complex, multi-threat environment, often in littoral waters, with incoming missiles launched from land, aircraft, hostile ships, and even submarines. The attacks may be concerted, seeking to saturate defences, so the ship must be able to respond in several different ways (against several different attacks) at the same time.

The combination of very capable threats and very demanding Air Warfare scenarios needs an extremely capable AAW system. For the Type 45, this system is PAAMS.

PAAMS (FIG.2)

The main components of PAAMS are the:

- Radar.
- Missiles.
- Launcher.
- Command and Control (C^2) system.

The tri-national PAAMS programme, which provides the AAW system both for Type 45 and the French/Italian HORIZON ships, started its Development and Initial Production contract in August 1999, well before either of the ship contracts. The missiles (local-area ASTER 15 and longer range ASTER 30) and the (SYLVER) vertical launchers are common for all ships, but the radar is not. HORIZON will use the EMPAR radar – Type 45 will use SAMPSON, whose capabilities are more in line with the particularly demanding UK requirement.

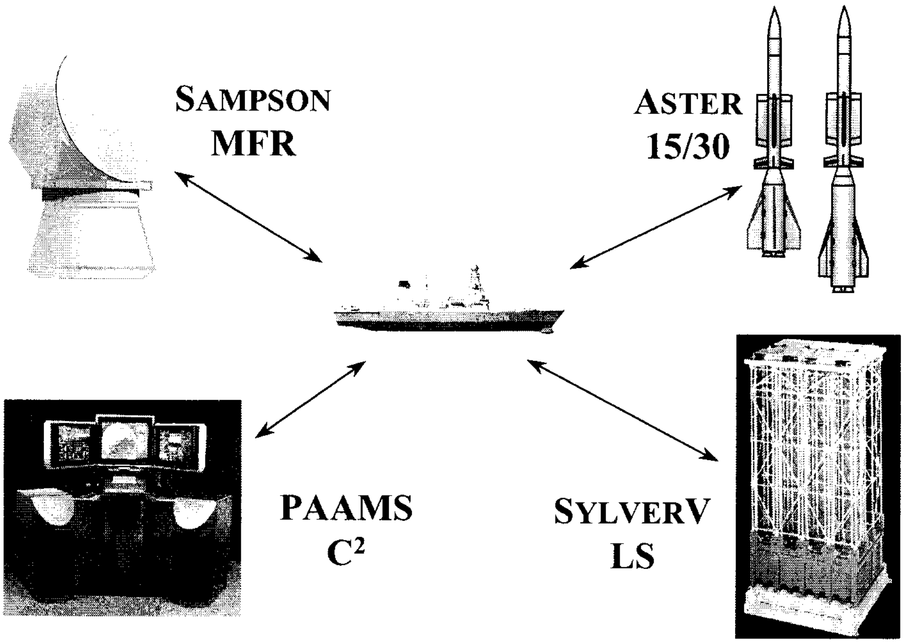

Fig.2 – AAW Solution – PAAMS

The fourth element (Command and Control (C^2)) consists of some common parts and some national variants. In the case of the Type 45, the PAAMS C^2 is closely integrated with the ship's Combat Management System (CMS) and takes advantage of the many sophisticated Tactical Picture Management features in the CMS. This high level of integration ensures that functions such as Threat Evaluation and Weapons Assignment (TEWA) (involving both individual Weapon TEWA and Platform TEWA) operate in a consistent and complementary manner.

SAMPSON MFR (FIG.3)

SAMPSON was developed using advanced technology from the UK's MESAR programme. The Gallium Arsenide elements making up the array faces generate the RF output and (importantly) do not need waveguides to transfer the power to the faces. This facilitates a rotating radar design, allowing 360 degree coverage with only a single face instead of four. (In practice, SAMPSON uses two faces back to back, rotating at 30 rpm, for additional power and capability). The absence of waveguides and the smaller number of faces needed gives the radar a high power-to-weight ratio compared to other phased-array radars, and enables it to be mounted very high, giving improved range and performance particularly against sea-skimmers. In practice, for the 7,350-tonne Type 45, the SAMPSON radar is mounted more than 30m above the waterline.

The radar uses electronically-steered pencil beams with very low sidelobes and can adapt each beam in a variety of ways appropriate to the track characteristics and effects of clutter. The software optimizes the radar's time and energy resources to match the changing environment.

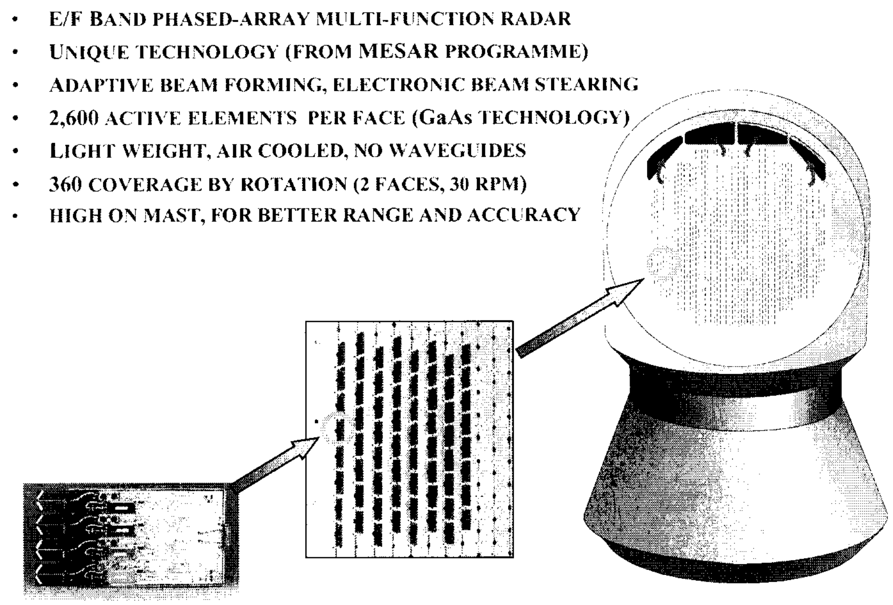

FIG.3 – SAMPSON MFR

Specific capabilities include:

- Search in 3-D at rates and dwell times appropriate to threat and background clutter.
- Wideband frequency agility maintains tracking performance in the presence of multi-path effects and makes jamming difficult.
- Special 'pseudo-random' search patterns complicate hostile ECM in that it is not possible to predict the next intercept.
- Rapid response to enable 'look back' to:
  - Reduce false alarm rates.
  - Resolve velocity and range ambiguities.
- Fast track update where required.
- High relative track accuracy for missile mid-course guidance.
- Additional functionality:
  - Special functions for track identification.
  - Kill assessment following engagement.
  - Cued search and track.
  - Command communications to own missiles in flight.

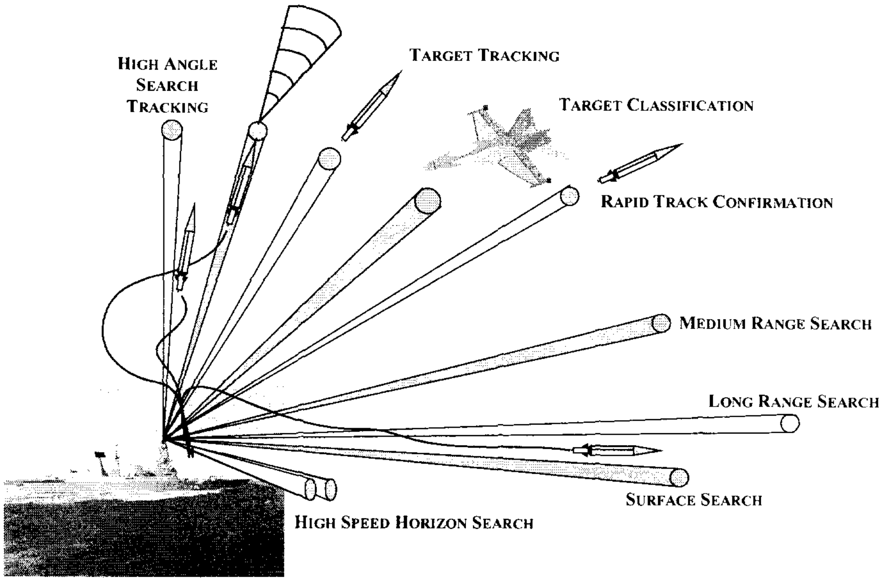

FIG.4 – SIMULTANEOUS FUNCTIONS

SAMPSON is a solid state radar with electronically steerable beams and (FIG.4) shows the major tasks which the radar is capable of carrying out simultaneously.

Aster Missile

There are two variants, (FIG.5) with a common dart and differing only in the booster – the larger booster giving a higher initial velocity and a longer range. Both boosters have directionally-controlled thrusters enabling the missile to turn over very quickly following launch, thus minimizing the time to get into the correct trajectory.

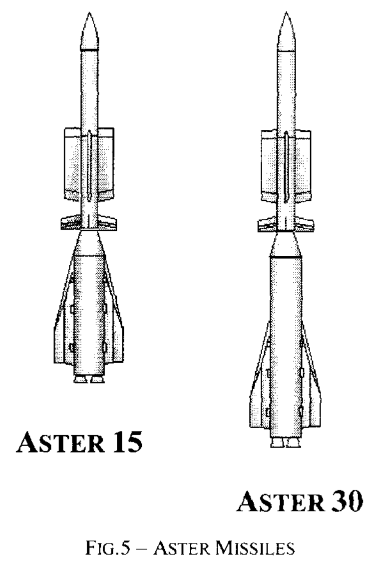

FIG.5 – ASTER MISSILES

The Dart (FIG.6) accepts mid-course guidance information from SAMPSON throughout its flight to ensure that it stays on course to the target. The final phase uses active homing (no additional illumination needed) during which ASTER recalculates its interception course at a very high rate and uses its impressive manouevrability to follow the target's manouevres.

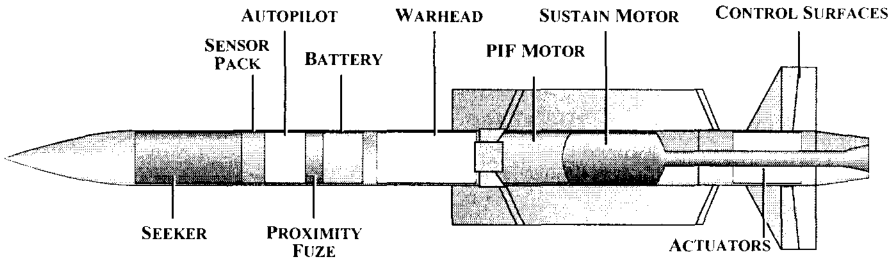

FIG.6 – THE STRUCTURE OF THE DART

ASTER's high manouevrability (whether in the midcourse phase or the homing phase) is achieved by the PIF (Pilotage en Force) and PAF (Pilotage Aerodynamique Fort) systems (FIG.7). Aerodynamic navigation (PAF) is facilitated by the large control surfaces, but the real innovation is PIF, a ring of thrusters which operate at right angles to the line of flight through the centre-of-gravity and can, almost literally, 'throw' the missile sideways at very high accelerations.

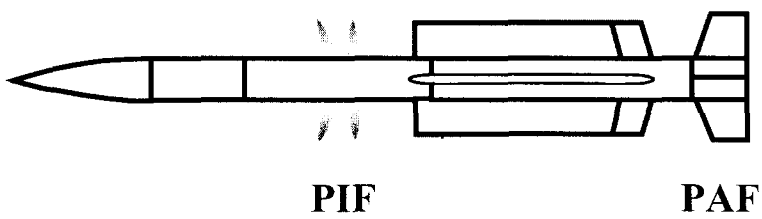

FIG.7 – ASTER PIF AND PAF SYSTEM

Type 45 Combat System

The Type 45 Combat System (FIG.8) compared with existing RN ships, represents a considerable capability upgrade across the board:

S1850M long-range 3D radar (LRR)

Provides aircraft control plus long-range detection for situational awareness and cueing to PAAMS.

RESM system

A high-spec development of UAT for the first 3 ships, (but with plans for even better capability later in the class) and the IFF (the new SIFF system under development for the fleet) provide additional surveillance and identification.

Electronic Warfare

Electronic warfare is supported by DLH (active and passive, including the new-development rounds) and by the DLF floating decoy.

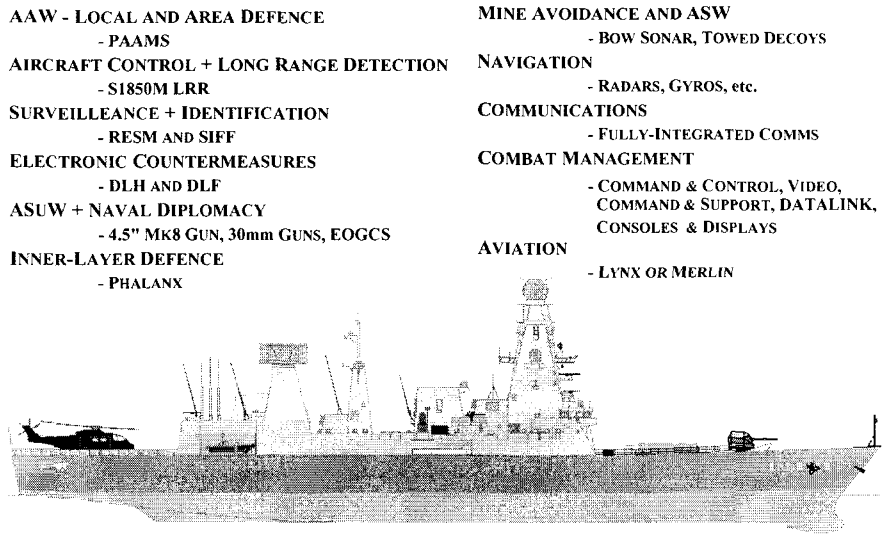

FIG.8 – TYPE 45 COMBAT SYSTEM

The Medium-Calibre Gun (MCG)

The MCG is the 4.5" Mark 8, but upgraded (Mod 1) for electric drive and a digital interface. The Electro-Optic Gun-fire Control System (EOGCS) is being extended to provide control not only of the MCG, but also remote control of two 30mm guns.

Phalanx 1B

Will provide inner-layer defence, and provide an upgrade path to SEA RAM in the future.

Mine and ASW

Mine avoidance, and torpedo and submarine detection is provided by a medium-frequency bow sonar, while torpedo defence will make use of the new-development SSTD system, initially only a towed decoy, but upgrading to launched decoys as the SSTD programme progresses.

Navigation

The navigation system provides high-quality attitude data to precision systems such as PAAMS and LRR, plus surface-search radars equipped with track extractors. Type 45 also has an Integrated Bridge, with a single coherent physical design of all equipment.

Fully-Integrated Communications System (FICS)

FICS provides flexible connectivity between internal and external systems and reduces the personnel required to manage the system (a dedicated communications office is not necessary). It makes use of software-programmable radio and can take advantage of new waveforms without needing new hardware.

The Combat Management System and Data Transfer System (CMS & DTS)

These represent the heart of the whole combat system. They not only look very different from existing systems (the new console design provides far better HCI and more flexibility of layout), but are specifically designed with growth and 'multi-function' flexibility in mind. The CMS consoles will provide all the HCI for PAAMS and LRR, and probably (to be confirmed) for Sonar and EOGCS. Also provided is the ability for other systems to use a 'window' of the CMS console, and an open programming interface for third-party software.

Aviation

The Type 45 has a very large flight deck and hangar (compared to existing ships) and can operate either a LYNX or the much-larger MERLIN helicopter

Key Requirements

The mission statement is not all about Combat System equipment – the capabilities demanded extend to all aspects of the warship design. The list of key requirements below cover not only capability but also cost, whole life as well as procurement, and time scale. This list is very onerous, and felt to be probably unachievable using traditional procurement methods.

Mission statement

The T45 will be a **versatile destroyer capable of contributing to world-wide maritime and joint operations in multi-threat environments**, providing a specialist Air Warfare capability until 2040.

Selected Key Requirements

Range	> 7,000 NM.
Accommodation	Much better than today's RN ships.
Special operations	Embarked Special Forces capability.
Availability	35% at sea, 35% available for sea.
Other '...ities'	As good or better than today's RN ships.
Support costs	Target £10m/year less than Type 42.
Procurement cost	Built to tight budgets.
Planned upgrades	Sized for specific growth through class
Unallocated margin	Substantial space/weight margin.
In-Service Date	Tight development timescale.

The 'SMART acquisition' model has been developed by the MoD to make the process of naval procurement 'cheaper, faster, better'. Its implementation for the Type 45 is based on three major foundation blocks:

- Appointment of a Prime Contractor as Warship Design Authority. The requirement placed on the Prime Contractor is expressed in terms of capability and not solutions, allowing him maximum freedom to come up with the best, most cost-effective design. The Prime Contractor has wide authority to bring in commercial best practice (instead of existing standards if appropriate). He selects and manages all the equipment suppliers, and takes a far larger ownership of the programme risks than previously.

- An excellent relationship between the DPA and PCO teams, founded on working closely together and supported by a Project Charter and a partnering-style contract through which both customer and supplier benefit from any good ideas adopted. This relationship extends in both directions – to the wider customer and stakeholder community, and to the equipment suppliers.
- A proven set of processes for cost-capability assessments and trade-offs, giving the customer (Capability Manager) the opportunity to prioritise his expenditure in the areas of most value. Based on a tool named EQUITY and formal 'Decision Conferencing' with all the MoD Stakeholders and Industry, the process provides a fast-track for making decisions on capability and equipment options.

Building the Ship

As important as the new way of managing the work is the new way of designing and building the warship and its systems.

Structure

Existing military standards for the structure of warships have grown up over many years, and many of the provisions have not been optimized for cost-effectiveness and time considerations. The Type 45 is being designed to the new Lloyds Naval Rules, which seek to achieve the same military objectives but through a more coherent set of rules derived from experience of advances in civil shipbuilding.

The objective is to save time and cost while not diluting the special requirements of a warship as opposed to a commercial ship. Lloyds approval includes Military notations for e.g.:

- Residual strength after damage.
- Internal blast resistance.
- Shock assessment.
- Fragmentation protection.
- Small arms protection.

The Type 45 structural 'scantling' drawings were submitted in May 2001, and are now approved by Lloyds Register.

Size

The well-known problem with many warship designs is that the ship is sized for a specific list of equipment and tasks, and cannot easily accommodate new equipment and new roles later on in its life. The Type 45 addresses this problem by designing the ship bigger (FIG.9) than needed for the initial equipment fit. Three levels of 'spare capacity' are built in:

- Accommodation is provided for 235, although the crew needed to operate the ship is only 187. The remaining space can support training needs, humanitarian roles, etc. There is also 'austerity' accommodation for Embarked Forces, which can also be used for other purposes as required.
- The ship is designed with space and weight provision for named future upgrades. Some of these are for upgrades likely to happen (e.g. more VLS cells, bigger Gun, EW extensions) while some others

(e.g. HARPOON) may never be implemented, the space and weight provision being available for other equipment not yet thought of.

- Finally, the ship is being designed with a substantial 'Navy Board Margin', the equivalent of several hundred tons in weight. Key compartments are being laid out with spare space to accommodate future equipment.

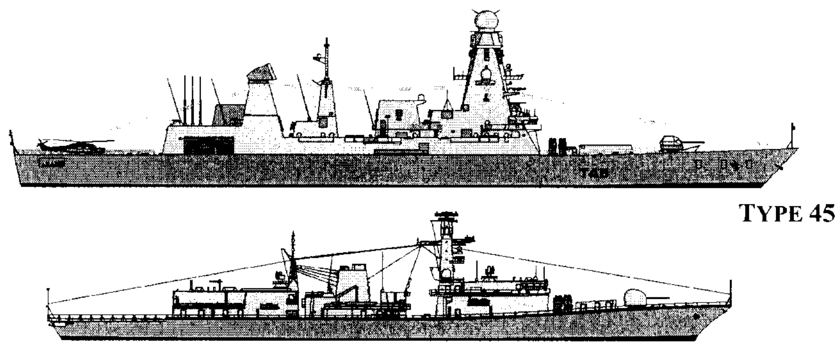

FIG.9 – SIZE COMPARISON T45 V T23

Power and Propulsion

The Power and Propulsion system (FIG.10) has been designed primarily with whole-life costs in mind. The power is provided by two 20+ MW gas turbines, backed up by two diesels. The normal, efficient, operating mode is for one of the gas turbines only to be in use, supplying power for both propellers and for all ship's systems and services. The propulsion system itself dispenses with gearboxes (often high-maintenance and a source of problems) using instead a 20MW electric motor on each shaft.

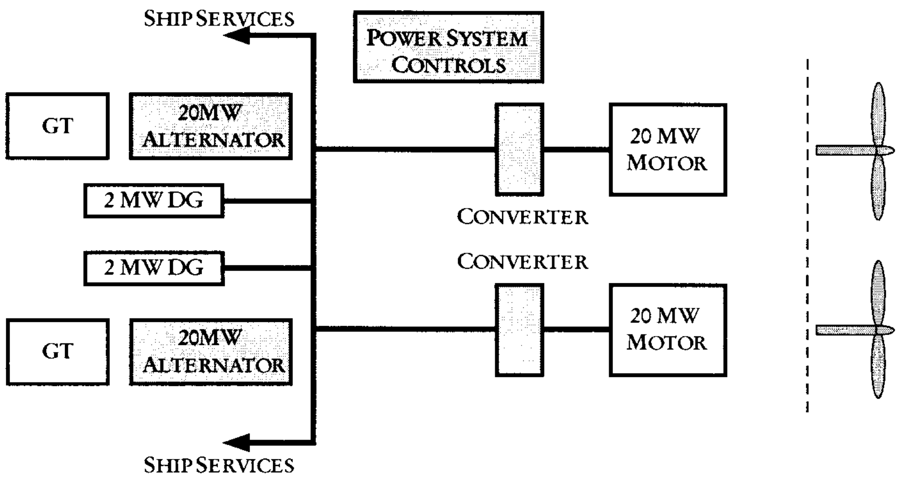

FIG.10 – POWER AND PROPULSION SYSTEM

Although the Type 45 is the first warship with electric propulsion, the concept is not new in the civil world. It is used, for example, on some cruise ships such as the *Millennium*, where the use of electricity allows the propellers to be mounted in external movable pods, giving full control of the direction of thrust. These civil systems can use conventional (synchronous) motors but these are very large and would not easily fit into Type 45 (which is much smaller than the *Millennium* but needs almost as much propulsive power). Instead, the Type 45 uses an Induction motor (FIG.11), needing a Pulse Waveform Modification (PWM) converter (FIG.12) to adapt the supply needed for its operation.

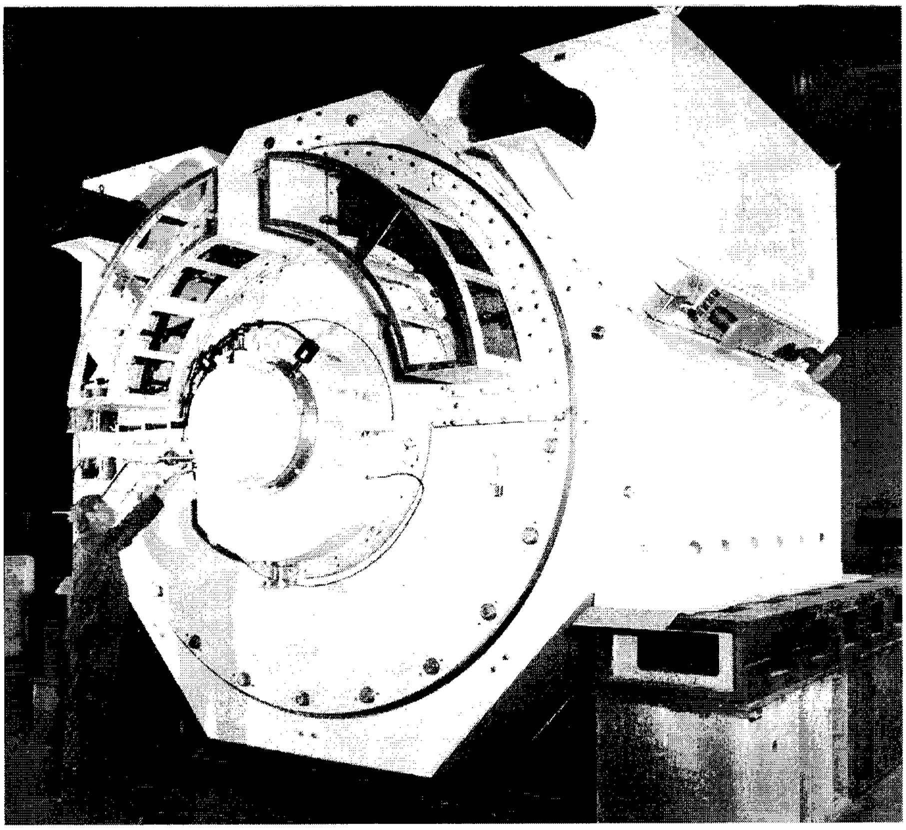

FIG.11 - 20MW ADVANCED INDUCTION MOTOR

Each of the motors weighs almost 90 tons. Alstom provides the motors and the other major electrical components.

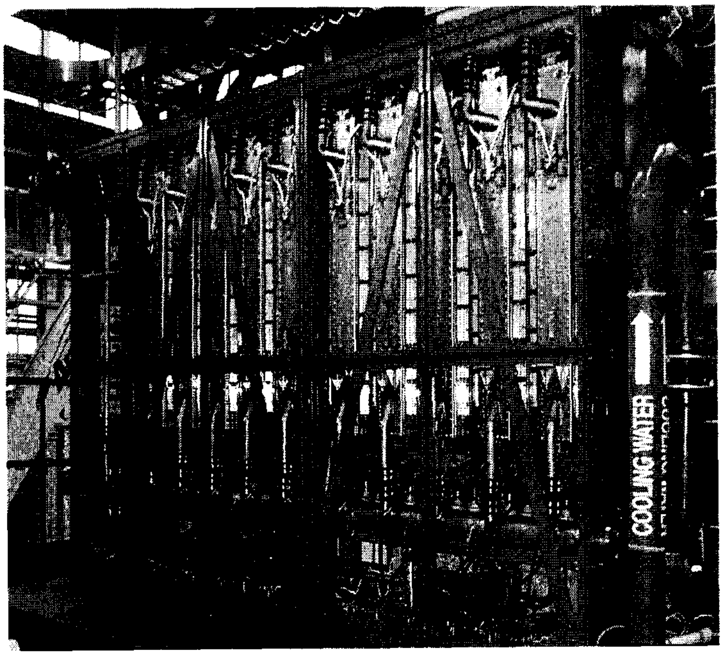

FIG.12 – PWM CONVERTER DRIVE

Accommodation (FIG.13)

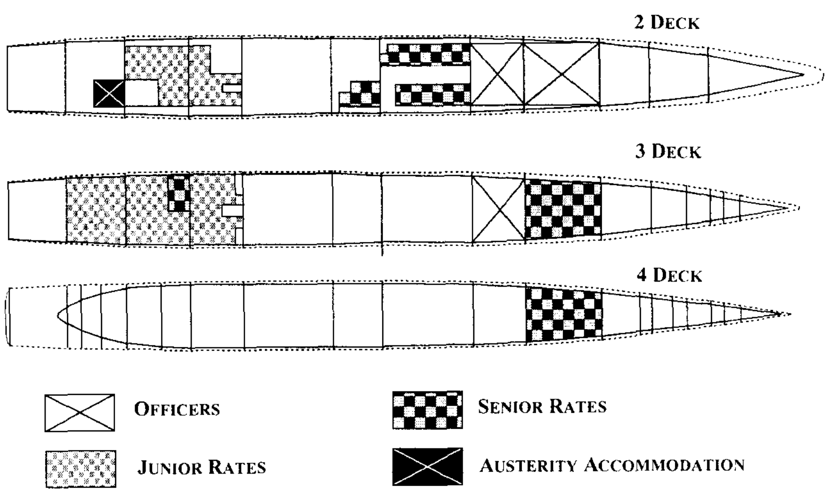

FIG.13 – INDICATIVE LAYOUT OF ACCOMMODATION

The accommodation on the Type 45 is sized for 235 crew – basic complement (187) + training (48). There is 39% more space per person than previous RN ships. Officers will be in single-berth cabins, Senior Rates in singles/doubles and Junior Rates in six-berth cabins. Common and recreation areas are also markedly improved, and there is a fully equipped Fitness Centre.

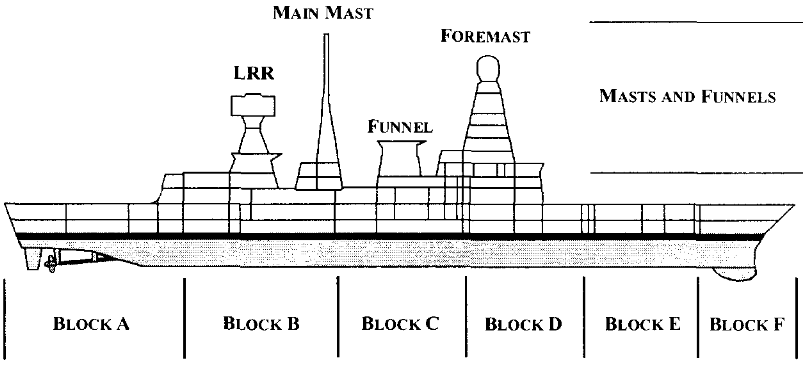

FIG.14 – TYPE 45 BLOCK BUILD STRATEGY

Traditional build methods, where the ship is built on the berth or slipway and most of the outfitting is done in the whole-ship environment, are costly and time-consuming. The Type 45 will use a block-build strategy (FIG.14) where each of the major blocks is built and outfitted in as close as possible to a 'factory' environment and then transported to the berth for final assembly. This approach lends itself to the use of techniques such as 'open sky' where equipment is placed in a space before that space itself has been completed. This is particularly valuable for major items such as engines and electrical motors, where providing following build would be impractical.

One key advantage of the block build strategy is that it enables the building work to be divided up amongst several locations and yards, thus making maximum use of existing resources. No one UK yard would be able (without substantial investment) to build all the ships in the class at the planned rate of one every 6-9 months.

The block build strategy is supported by a block design strategy. Provided the block interfaces can be defined and agreed in detail, the internal design of each block can proceed in parallel with and without reference to the other blocks.

The aim is a 'production line' for ships, analogous to that for high-volume items like cars. Obviously, that level of production line and automation will never be achieved for ships, but each step in that direction will save time and cost, and reduce re-work.

(FIG.15) illustrates the build sequence for a block. Again the same basic principles apply – as much of the work as possible is done on individual units (into which the block is subdivided) and only then is the whole block assembled.

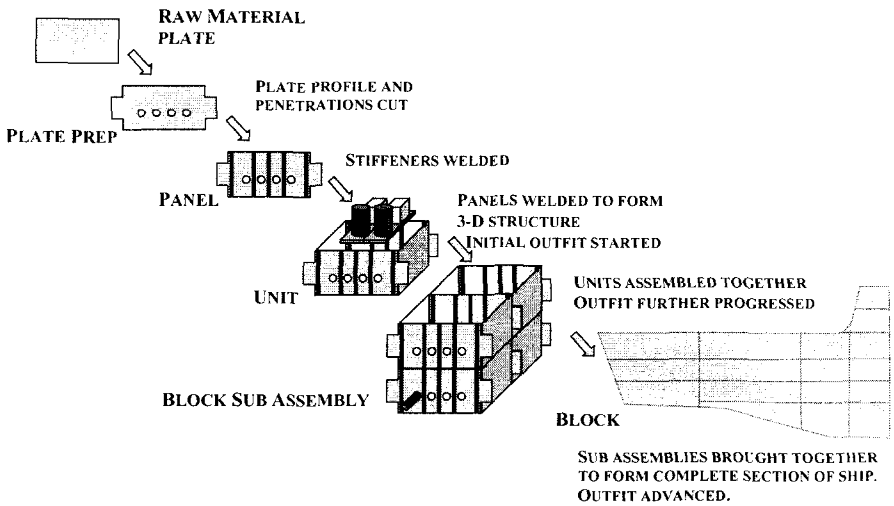

FIG.15 – CONSTRUCTING THE BLOCKS

The ship assembly sequence is shown in (FIG.16). Masts and funnels, which cannot fit under this roof of the Assembly Shed, are added following launch.

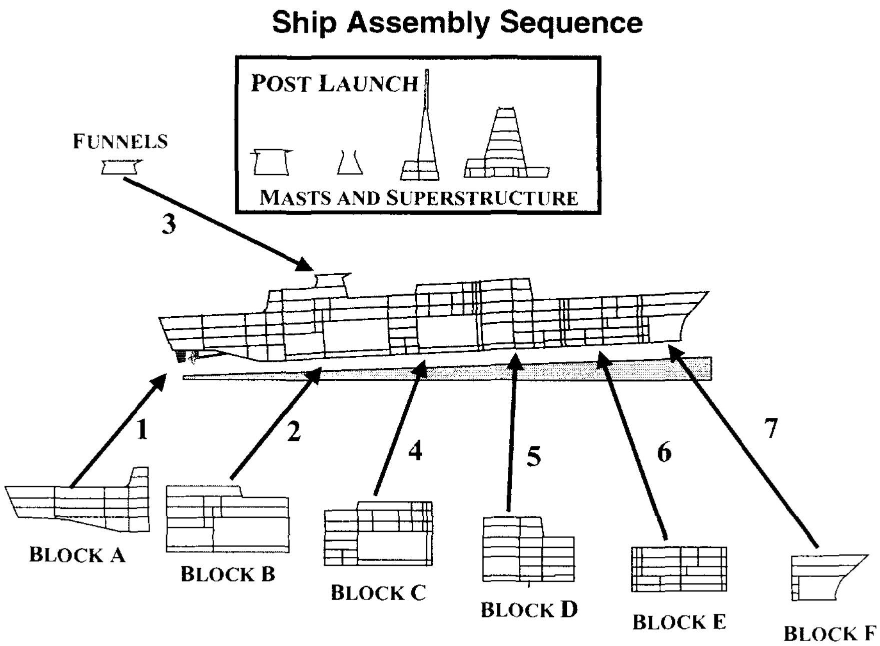

FIG.16 - SHIP ASSEMBLY SEQUENCE

One of the big benefits of the block build approach is that the work can be done at a number of locations. The Type 45 will be built at three locations – the BAE SYSTEMS yards on the Clyde and in Barrow, and the new Vosper Thorneycroft yard in Portsmouth (FIG.17). Completed blocks will be shipped by barge to the assembly yard (Scotstoun, Glasgow for the first-of-class, Barrow for all subsequent).

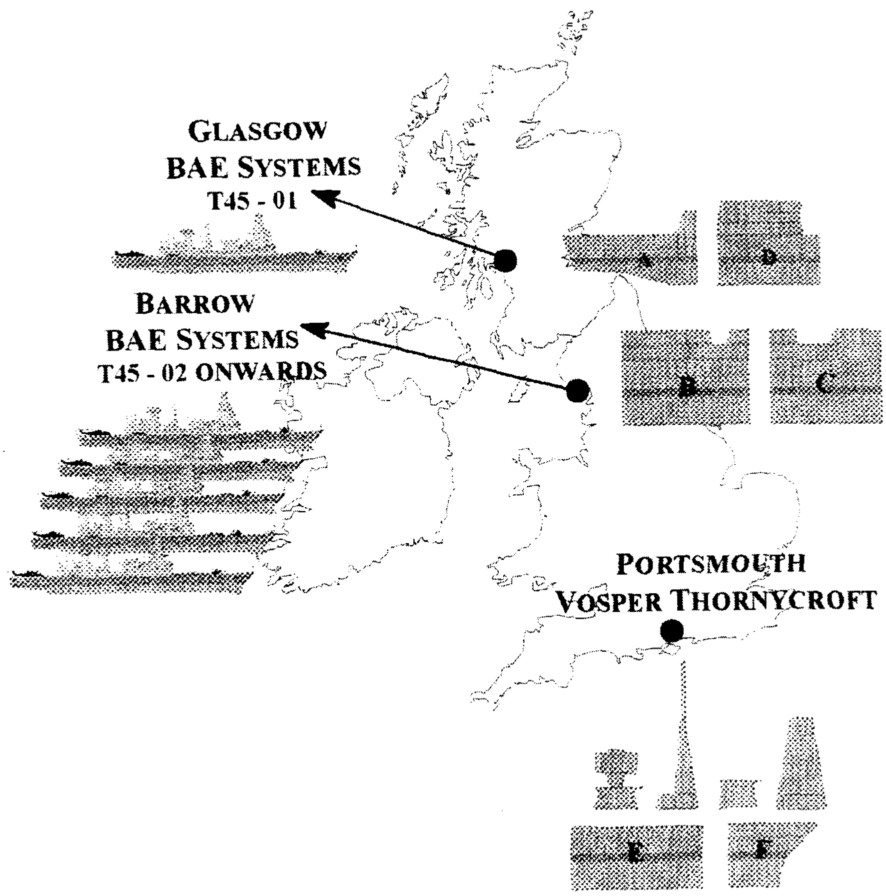

FIG.17 – MULTI-YARD BUILD STRATEGY

Each part of the steelwork and block build and outfit will be done by the same yard for all Type 45 ships in the class. This will allow each yard to develop a centre of excellence for its share of the work, thus driving down costs.

All the yards will provide design personnel to the PCO in Scotstoun during Stage 1 and 2 design. This will give each yard visibility of the overall design and assist in preparation for the Production Design and Build to be done by the yard. The yards are not in competition with each other for Type 45,which will facilitate open sharing of good, cost-saving ideas. The UK Government has approved this co-operative build model.

The future

Versatility is not just about having a range of capabilities and roles today, but also about being able to change easily those capabilities and roles in the future, as the requirements develop. Nowhere is this more important than in the area of joint operations, where the landscape is changing all the time. Not only is the technology of interoperability advancing (datalink, CEC, battlespace digitization) but so is the very nature of conflicts (NATO role, European forces, blue water vs. littoral, asynchronous threats). As the mission statement makes clear, Type 45's ability to fit in with these changing roles needs to be maintained for a very long time (until 2040).

The Type 45 design has several important features in support of the three different ways to provide upgrades in the future:

- The LAN-based overall Combat System architecture facilitates upgrade to existing equipment – changes to interfaces can generally be kept at the software level. In addition, the open, published programming interface inside the CMS facilitates easy addition of capability, including third-party additions.
- The specific allowances for additional equipment already built in to the Type 45 design, together with the substantial Navy Board Margins, support the introduction of capability through new equipment.
- The modular block design and build strategy support the ability to design platform variants at minimum cost.

Future capability

Possible in the Short Term

- Enhanced Communications, EW, and CMS – In class requirement.
- SSTD Launched Decoys In class requirement.
- Additional ASW (e.g. TLS) and ASuW (e.g. HARPOON).
- Land Attack Missile (16-cell Mk41 + TLAM).

Medium term possibilities

- Co-operative Engagement Capability (CEC).
- Confederated Training.
- Naval Fires (Larger Gun, ERGAM, Smart Munitions).
- PHALANX upgrade to SEA RAM.
- Integrated Technology Mast.

Longer term possibilities (probably Type 45 variants)

- BMD with SAMPSON + SM2 Blk4A (or future ASTER development).
- Sonar improvements (e.g. Sonar 2100).
- UAV launch and recovery.
- Flexible Helicopter capability (Special Forces, Land Attack, Transport).

The above list of possible future capabilities is indicative rather than exhaustive and, apart from the items marked as 'in class requirement', implies nothing about what the RN would like to add or the priorities that would apply. The three categories merely indicate the relative time scales in which the capabilities could reasonably be added to the Type 45.