Small But Able Frigate Fleets

By **Dr Nik Moss**

Nik Moss is the Strategy and Technical Director of the Naval Division at Thales. He says that future small but able frigate fleets demand greater flexibility of use to maximise cost effectiveness, and that combat systems' modularity has a role to play.

After the comparative stability of the Cold War, military strategy has moved into a more volatile environment with challenging and increasingly sophisticated asymmetric threats. Changing territorial powers and interests – fuelled by increasing competition for oil and other natural resources and climate change impacts – may aggravate these tensions in the coming decades. While the ongoing land campaigns in the Middle East have the limelight today, international maritime security remains a fundamental prerequisite of our global economy. Future naval forces will need to continue to evolve to counter unpredictable future threats at sea and to support land-based actions in the projected operating life of the Royal Navy's next frigate class.

The UK Strategic Defence Review (SDR) in 1997 enshrined the need for expeditionary warfare in the new world order and this has been pursued in the Royal Navy with the ongoing procurement of the amphibious and carrier task groups and their support vessels. Today the Type 23 frigates, conceived originally for Cold War anti-submarine warfare (ASW), are providing the mainstay of the task force escorts, outwith area air defence by the Type 42 and shortly the Type 45 destroyers. They are also fulfilling a range of general purpose patrol roles, sustaining the Royal Navy's global reach capabilities.

With both UK aircraft carrier and SSBN successor programmes looming large alongside completion of the Type 45 destroyer procurement, and the increasingly expensive land-based military operations, naval budgets for future frigates to replace Type 23 will be stretched. Addressing the capability gaps opened by the changed threat environment and sustaining the frigate fleet versatility will require new levels of Royal Navy warship affordability and flexibility of use. With the UK front-line frigate fleet numbers only half what they were at the time of the Falklands War, business as usual is not an option when it comes to designing the future surface combatant solutions. These have to maximise an affordable capability with a more modest fleet size. New technologies including greater use of electro-optics and exploitation of remote unmanned sensor systems for enhanced situational awareness, and robust management of the asymmetric threats in the littoral, will also impact future frigate solutions with new capabilities emerging to counter the changing threats.

Under the MoD Defence Acquisition Change Programme, the S2C2 Pathfinder Team has outlined a coherent programme for managing upgrades and life extension of the Type 23 alongside new warship procurement to achieve a natural evolution of the required escort and other frigate capabilities into the truly 'future' surface combatant (FSC) fleet solution for the Royal Navy [Pathfinder industry day[1], DEC AWE industry day[2]]. Not only is the FSC expected to deliver a wide range of roles from close consort protection, to precision land attack, to deployment of future autonomous surveillance systems, but it is also expected to cope with other, as yet uncertain, future maritime threats. It is also required to sustain the Royal Navy's area (force) ASW capability post Type 23, and provide command functions. Limited hull numbers and inevitable changes in future operational priorities and threats in the 30+ year life of the projected class demand increased flexibility of use. This will only be achieved by design. Flexibility of use can be facilitated in various ways, but modularity of combat systems' equipments is a potential enabler, which could reduce refit time for upgrades to counter changing threats, and facilitate a degree of re-roling in service.

Modularity

Work has been carried out in the UK research community at Dstl[3] on modular combat systems packages but this has yet to impact significantly on the future UK frigate design engineering thinking. In the early post-war years, the Royal Navy had a number of single-role warships (e.g. Types 14, 41 and 61), but in more recent times has evolved to a more multi-role frigate capability with the Type 22 and 23 frigates embracing elements of both ASW and surface warfare with, as a minimum, effective self-defence against all air threats.

Modularity can take a number of forms, and there are two well-known examples in naval service overseas today that illustrate different approaches:

- **The Danish Stanflex GRP Ships**. These have fully containerised weapon systems for escort, patrol, MCM and other duties. The containers can readily be inter-changed alongside without any special facilities, and a wide portfolio of containerised systems is maintained separately from the ships. They have provided a broader capability with a limited fleet size with modest investment and provide rapid re-roling in service.[4]
- **The Blohm and Voss MEKO Modular Design**. This has self-standing engineered weapon equipment modules which can be incorporated in different ship hulls designed for this purpose. Historically, this approach has maximised design re-use for different customers contributing to highly cost effective warship solutions on the international market[5]. However, upgrades with replacement modules and in-service re-roling have not been exploited to any great extent in the MEKO fleets.

In the US, the LCS programme plans to develop a largely containerised combat systems fit along broadly similar principles to the Stanflex concept. ThyssenKrupp Marine Systems are now extending their MEKO approach to include fully containerised weapon systems in their new design Littoral Warship[6]. Conversely, the new Danish Navy Absalom class will use Stanflex-type weapon system containers, but there is no plan to interchange them to re-role ships in-service[7].

Neither the MEKO-like engineered weapon systems modules, nor totally containerised combat systems equipments, fit readily into the UK procurement and operational context for the future surface combatant. Wholesale modularisation will inevitably incur additional procurement costs which will be more exposed in a small fleet, and ship space and weight constraints with a number of separate containerised systems may further limit achievable warship combat systems' payload. Further, the future surface combatant needs to evolve cost effectively alongside Type 23 upgrades with some commonality of equipments, and sustain high-end, naval warfare capabilities at long range, remotely from other assets.

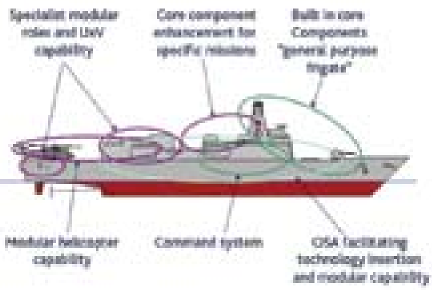

Figure 1: A modular warship [Thales]

Combat System Fits

These high-intensity and global-reach warfighting needs of the Royal Navy frigate fleet – which include not just the warship engineering, but critically the crew training and effectiveness, and the logistical and in-service support – might encourage a more pragmatic approach. An exploration of something that lies between the extremes of fully containerised systems and a traditional bespoke fit is worthy of closer scrutiny for FSC. It is also helpful to consider which combat system elements are expected to be subject to significant technology change and refresh in the warship's life, and to design the installations to best facilitate this process.

Conceptually we might consider three types of combat system fit for FSC:

- **A core combat systems capability**, which is designed as integral to all ships and is a universal part of the class capability solution. This would focus on physically large elements like the main vertical launch missile system with a large silo, a major gun system, the basic communications fit, and most importantly the command systems infrastructure. Primary sensors would also fall into this category, but may benefit from an integrated mast installation that facilitates ready upgrades with modular elements in the sensor systems.
- **Additional role-specific combat system elements**, which can be both accommodated readily in batch builds of the ships as required, and also enable role change in-service within maintenance periods of no more than a few weeks. Here the case for a MEKO-like logic might be beneficial using engineered 'modules' with allocated space, weight and services in the ship layout. These would focus on specific aspects of capability, e.g. ASW, littoral anti-surface warfare (AsuW) and anti-air warfare (AAW) with CIWS, new sensor and decoy systems for soft kill, and special fits for additional surveillance capabilities. Modular elements within the envisaged integrated mast assembly for primary sensors would also be engineered in a like manner to support ease of upgrade and technology insertion to counter changing threats.
- **Fully containerised systems for specific missions**, which can be fitted in a standard container and exchanged on deployed ships in a few hours either alongside or even by air or sea in sheltered waters. Examples here include remote vehicle systems for enhanced surveillance above, on and below water, remote mine countermeasure (MCM) systems, equipment required by EMF, and facilities for disaster relief, etc. Committing to 20ft ISO containers to provide ease of transport and handling worldwide is attractive, but will impact on ship design and space requirements. Some standardisation of on-board services interfaces to the containers would be important. The MoD Dstl studies provided a survey of these potential options.[3]

In practice there will be variations on these themes, but in combination all three of the above 'types of installation' could contribute to a cost-effective, holistic warship design for the FSC. Today we already have some modular systems like the ship's helicopter, which comes with an on-board support package. However, before considering the implications of a broader approach, it is important to gain some insight into whether such modularity might be expected to contribute to greater fleet flexibility, and hence effectiveness and affordability in the context of the FSC.

Operational Analysis

A first step has been taken in Thales with simple operational analysis (OA) models that simulate tasking of the fleet ships in the geographical space over prescribed time intervals, and determine the achieved utilisation of ships and separate combat system modules (which may be fitted away from home base). Using operational demand models aligned with current Royal Navy fleet-tasking policies and simulating future unplanned tasks arising from different levels of required future military intervention, the ship and combat system module utilisation achieved against the demands have been modelled stochastically over a five-year period.

The example tasking demand (Figure 2) shows how the nominal 25-ship fleet is stretched by unplanned (emergent) tasks on top of lower priority standing tasks, recognising standing tasks are abandoned to resource the required intervention actions, and available ships exclude those undergoing scheduled support activities, refits, work-ups etc. at base.

The current T23 and T42/T45 capability has been compared for nominal 50- and 25-ship fleets in Monte Carlo multiple simulations with statistically varying task demand of the same overall intensity, and also compared to a 25-ship T42/45 and FSC fleet where the FSC is assumed to have a significant modular combat system fit, allowing it to cover a wider range of tasks than would be possible with a bespoke fit. No one FSC ship can carry all the capability, but the modularity permits re-roling with prescribed combat system elements on deployments remote from home base.
In this simple simulation example, no constraints on crewing, or availability of the required modular combat system elements, have been imposed, but the ship allocation accounts for the base port activity constraints of maintenance, refits, work-up and training in the available fleet tasking model (Figure 3).

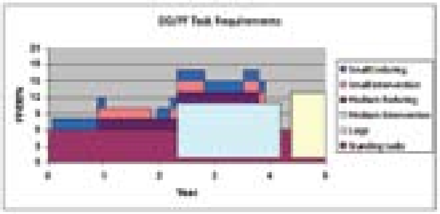

Figure 2: Example of surface combatant fleet tasking over five-year period [Thales]

Figure 3: Stochastic analysis of fleet effectiveness [Thales]

Capability Shortfall

The results identify capability shortfall in specific warfare areas (such as ASW) for the fleet make-up achieved in theatre. In the case of the bespoke fleet, the shortfall might reflect a lack of the right type of ship, in specific roles like area ASW, while other needs like ASuW and AAW close consort protection are met by the available ships. In the modelling assumptions made here, such shortfalls impact even the standing tasks to a degree because of other ship availability constraints arising from base port maintenance, refits, training and other non-operational activities.

The ability to carry out the synthesised task demand with warships at the required readiness levels is impacted naturally by fleet size. However, transit times to theatre are a significant constraint in the scenarios considered, and there is only a modest difference in the 50- and 25-ship fleets for the same assumed intensity of demand, which is sized for objectives appropriate to the smaller (bespoke) fleet. The modular 25-ship fleet, in contrast, has a much higher level of task delivery with some modular combat system elements changed out on ships remotely from home base. A separate benefit of the utilisation of modular elements is the reduced number of equipments needed to meet the total demand. This recognises that these combat system elements are not required on all ships, or while ships are out of service in maintenance periods and refits, or even *in extremis* in transit to theatre, although training and crew work-ups to achieve the required readiness will still have to be allowed for.

More needs to be done to demonstrate and bound potential cost benefits of this approach, including consideration of time and cost impacts on crew training and the need for extended work-ups to address crew and equipment changes on deployed ships, management (logistics and maintenance) of separate combat systems modules, as well as the impact on the ship design envelope and engineering and procurement cost consequences. This is worthy of serious analysis in the context of the whole life-cycle cost and fleet capability for the future surface combatant class that is expected to be operational in the Royal Navy to at least 2060.

Implications for Future Design

There are two important implications for a future surface combatant design if it is to facilitate such modular options. Combat system architectures need to make it easy for major additions and changes to combat systems equipments, providing near instant 'integration' within a more federated command systems approach. The modular approach has to cater for accurate ship sensor and weapon systems alignment, and cater for sensor systems with their own processing and track management systems to be added and changed out without recourse to time-consuming and costly integration activities. Evolving open systems architectures at different levels, and moving to a more distributed computing environment with 'data models' shared between suppliers so that separately supplied systems can be added readily on board without any major integration activity, will be an important enabler for this. The MOSA[8] multi-company team is exploring industrial consensus options with the MoD, which would facilitate such an approach.

From a platform engineering perspective, provision for modules has to be designed for, and requires some changes in the way ship layouts are optimised and the design and through-life growth margins are allocated. Margin policies in particular will need to change, perhaps trading off part of the through-life weight growth allowance against a greater variable load for containerised systems. Ship services and infrastructure have to be arranged to provide containerised systems with electrical power and combat systems data connections, cooling water or HVAC to maintain environmental needs, and fire management systems. Container handling and storage on board, and access to other facilities like cranes and remote-vehicle launch and recovery arrangements, will impact the ship layout aspects. At a fundamental level the greater variable load will have to be managed with regard to intact and damage stability characteristics of the platform, possibly requiring variable ballast provisions.

Conclusion

In summary, the future challenge for the Royal Navy's frigate fleet in way of flexibility and affordability in an uncertain and challenging world could benefit from increasing the modularity of combat systems fitted to the warships. Engineering studies and cost benefit analysis are needed to scope, inform and optimise the benefits at the warship concept level before the FSC solution is committed in the procurement programme. ■

NOTES

1 MoD DIS Pathfinder Industry Day hosted by DMA, London, 30 January 2007

2 DEC AWE Industry Day hosted by DMA, London, 22 June 2007

3 Dstl report (UK RESTRICTED) TR12552 V1.0, November 2004

4 *Modular Concept for Warships, Future Danish Naval Capabilities*, A. S. Pedersen, Naval Team Denmark, Future Surface Warships Conference, September 2003

5 *German Frigate for the Future MEKO D*, Wolfgang Bohlayer, Blohm & Voss, Future Surface Warships Conference, September 2003

6 The MEKO CSL Littoral Warship, Wolfgang Bohlayer, ThyssenKrupp Marine Systems, Future Surface Warships, September 2006

7 *Jane's Navy International*, February 2007

8 1st Maritime Combat Systems Conference, 6–7 June 2006