Type 31 Frigate: Complex Warship Design for a Dynamic Operational Environment

J Johnson, M Howard

Babcock International, Bristol, UK

Synopsis

A complex warship design active in the upcoming third of the 21st Century has to be adaptable to survive, both in an operational context and a competitive export market. The ability to cost-effectively reconfigure the capability of a warship to suit a dynamic operational need and changing threat environment will result in a platform that remains relevant throughout its entire life, and can be tailored for a number of different customers to be attractive to the widest base. However, while pursuing adaptability this complex warship must also balance modularity with the platform features commensurate to the threat environment in which it will employ these capabilities, such as survivability, signatures, damage control, damaged performance and recoverability.

The capacity to adapt to future roles was a core requirement of the Royal Navy for the Type 31 INSPIRATION Class Frigate, driven by rapidly developing technology and a dynamic global strategic context. Despite a common lineage the ARROWHEAD-140 product and the Royal Navy's Type 31 Frigate design have a different approach to adaptability to the Danish IVER HUITFELDT class. These differences, and the reasons behind them, will be outlined within this paper.

This paper will also explore the lessons identified within the Type 31 Frigate design & build contract to both deliver an adaptable warship for the Royal Navy and a successful export design, including:

- Requirements that enable a balanced design with the freedom to incorporate envelopes, features and margins to allow for capability growth or reorientation when in-service; with a design ownership solution employed during the programme configured to allow this necessary freedom;

- Managing the concurrency of requirements and future adaptable roles to deliver a feasible and safe complex warship that can still be certified by an independent Class society and ultimately be built to a reasonable cost;

- The design of platform features ranging from survivability, recoverability and signatures to certifiable structural design and margins that are the fundamental foundations underpinning an adaptable warship that still remains credible in the face of a changeable threat.

The Type 31 Frigate has passed through the design stages into production, with a number of export customers now also adopting this complex warship design for their future major naval platforms. This design is therefore a strong demonstration of how adaptability can credibly and cost-effectively be delivered within a Frigate, and will be explored within this paper.

Keywords: Type 31 Inspiration Class, Frigate, Procurement, Requirements, Adaptability, Arrowhead-140, Capability, Design Ownership.

Author's Biographies

J Johnson – A delegated Design Authority for the Type 31 Frigate, and the Transversals Engineering Manager. Responsible as Design Authority for the operability, complement and future adaptability solutions of the platform, alongside managing transversals engineering aspects including security, standards, noise & vibration, materials compliance, human factors, operating environment, Bridge / navigation solution and Design Authority detail design liaison. He was previously a Warfare Officer in the Royal Navy.

M Howard – ARROWHEAD-140 Technical Director responsible for the export of this proven design, which has been selected for both the Indonesia and Poland (Miecznik) programmes (at the time of writing). His previous role was the Type 31 Frigate Chief Engineer, 2017 to April 2022, which included Design Authority responsibility for the platform and gun systems. His tenure as T31 Chief Engineer included the Competitive, Basic, Functional and Detailed Design phases.

1. Introduction

A number of misconceptions have been reported in the public domain about the Type 31 Frigate. Ranging from confusion over how a credible capability can be afforded within the procurement price to disbelief that a complex warship can be designed and built in the timescales published. These misconceptions have emerged, in part, due to the procurement strategy adopted which differs greatly from that used to procure previous UK warships and other major defence equipment in other domains.

Compared to previous procurement programmes to deliver complex warships to the UK Royal Navy (RN), Type 31 has followed a rapid timeline. First announced to the public in the 2015 Strategic Defence & Security Review (SDSR) (HM Government, 2015), the 'General Purpose Frigate' (GPFF) as it was known at the time went into a phase of requirements compilation, supported by Requests for Information (RFI) from Industry. Those open-source RFI documents were swiftly overtaken by developments and subsequent internal documents that described the capability demand of the, now named, Type 31 Frigate, to create the final set of requirements. Figure 1 below outlines a high-level summary of the programme timeline from an Industry perspective. In late 2018 the Competitive Design Phase (CDP) commenced, culminating in contract award in late 2019 to Babcock as the 'prime' and Thales UK as the sub-contracted mission system integrator; two years later steel was cut on the first ship. Compressing the timeline of designing a complex warship to this extent has been a huge challenge for a relatively small team of around 100 engineers, however, despite a global pandemic, the schedule remains on track.

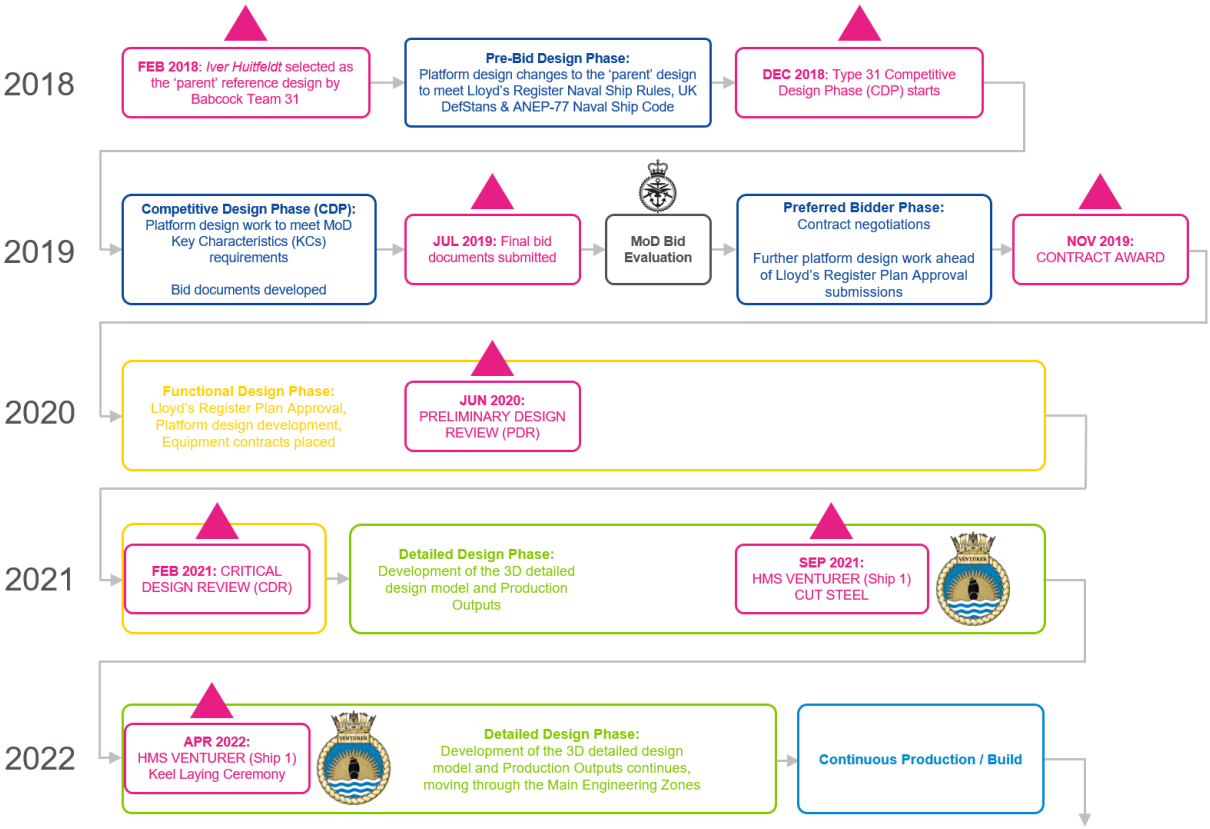

Figure 1 - High Level Summary of the Type 31 Frigate Design & Build Contract Timeline (to date)

The enablers behind this rapid timescale and low procurement cost are summarised in this paper, explaining how doing things differently compared to previous contracts in areas such as design ownership (Design Authority), procurement strategy, requirements and contracting method have facilitated the design and build of the Type 31 Frigate.

Figure 2 - Type 31 Frigate

2. Doing Things Differently

2.1 *Procurement Strategy – Shipbuilder's Perspective*

The procurement solution adopted by the UK Ministry of Defence (MoD) for the Type 31 Frigate differs greatly from previous warship procurement programmes. This different procurement solution has clouded the external view of the capability of the platform in particular, with those on the outside struggling to comprehend how a true Frigate can be delivered for the programme cost when compared to legacy and contemporary warships.

The refresh to the UK National Shipbuilding Strategy (National Shipbuilding Office, 2022) included the paragraph below.

> *'Type 31, the pathfinder project of the 2017 strategy, got to contract on schedule and for the headline price demanded, with the capability exceeding many expectations. The project is remarkable for the speed and innovation shown in its procurement, including valuing UK prosperity and adaptability for export.'*

The referenced document alludes to the speed and innovation within the procurement strategy adopted for the Type 31 Frigate. To help outline this difference in procurement solution to previous examples, and how it relates to capability, a simplified analogy is included below.

Procurement Analogy: Mobile Phones

Imagine that you want to buy new mobile phones (cell phones) for yourself and your immediate family, and you can decide between the two options to buy these phones outlined below:

a) You go directly to a phone manufacturer's head office and tell them that you want a new mobile phone to your bespoke and exact specification. During the design process you instruct that every design option from screen resolution to battery capacity to software features has to be presented to, and decided, by yourself. You make these decisions using a cost / capability trade-off process, where the benefits of each option are considered by your family against any increased cost and any potential delay in delivery. Every so often, while the design is underway, you may identify a new feature in the cost / capability trade process that you decide is essential in your new phone to suit a new need, and direct that these new features must be added as the benefit is assessed to be worth the impact. Finally, once this lengthy design

process is complete, you order two handsets of this bespoke phone design and unique manufacture parameters from the supplier.

b) You sit down with your immediate family and draw up a list of features that you want your new phones to have (camera features, screen size, operating system etc). Once complete you go to a mobile phone store or website and compare your list against the features of the products on offer in your price range, and select the phone that has the most functions from your list. You place a full order at the fixed advertised price for that product, walk away, and a week later all of the phones for your family are delivered. Once delivered you select and add accessories, such as a case, to suit the needs of each family member.

Whilst it seems a stretch from buying mobile phones to complex defence equipment procurement, the options above are analogous to existing programmes. Option A is similar to how complex equipment has been procured by the MoD in the past, with bespoke designs generated over significant periods of time and subjected to detailed cost / capability trades that form part of the decision making process. This flexible cost / capability trade process is intended to ensure the end result will meet the exact capability need identified at the time it is introduced to service, considering the length of time that may have elapsed since the programme was first started. However, the amount of money absorbed in contingency and risk funds within a programme such as this to allow for this level of change in requirements and the changing appraisal of decision-makers, notwithstanding the increased cost of changing equipment itself with associated costs in development, testing and production of this sub-system equipment, can increase the overall cost of a procurement programme significantly.

Option B is essentially an analogue for the Type 31 design and build contract. UK Defence Equipment & Support (DE&S), Navy Command Headquarters (NCHQ) and wider RN stakeholder groups drew up a list of requirements, known as the 'Key Characteristics' (KCs), incorporating features and capabilities that they wanted in the Type 31 Frigate. These KCs were then compared to the products on offer by the three competitors (BAE Systems, Babcock and Atlas Elektronik) in the CDP and assessed during the Evaluation Phase. The MoD selected their product at a fixed advertised price when the contract was signed in November 2019, with all five ships to be delivered by 2028. All design decisions in the product are made by the prime supplier or their mission system integrator as the Design Authority rather than DE&S / RN personnel. This has contributed to a far more stable process over the life of the programme, significantly reducing risk and contingency costs that are required, and is in part the reason why Type 31 has moved from contract award to construction in record time and at a record cost for a UK complex warship. However, as a fixed price contract the MoD has very limited flexibility to modify the design during the build phase; therefore the adaptability provision to subsequently add capability later is crucial, and is discussed in following sections of this paper.

Of course, Option B is only available where products exist that are adaptable enough to meet or nearly meet the customer's requirements, such as in the case of the Type 31 Frigate, or the customer is willing to accept alternative solutions or equivalence in standards to achieve the goal of the overall capability requirement. Some unique capability requirements may still necessitate an Option A style procurement, where the flexible cost / capability trades will facilitate the dynamic development of the solution to meet these bespoke needs.

This change in procurement solution for Type 31 also means a comparison of capability between warships based on overall programme cost is meaningless. Capability comparison using a method where the total open-source single figure cost is divided by tonnes displacement or length overall of the warship and then compared to other platforms is only relevant when all the constituent parts that make up that cost are known and are directly comparable, in order to accurately compare the actual capability delivery element of the cost itself.

It should be noted that the design and build contract currently underway, and discussed in this paper, is one element of the wider Type 31 Frigate programme. Programme delivery strategies are in place beyond this contract to mitigate the risks of introducing both cutting edge and new to service equipment, particularly from a pan-Defence Lines of Development (DLoD) perspective, and the MoD are developing the pre-In Service Date (ISD) sequence of activities such as hot weather trials and the capability insertion periods that form the overall Type 31 delivery programme.

This procurement process started in 2015 with the SDSR and open-source RFIs around a 'Light Frigate' and ended with Industry able to offer a credible >7,000 tonne General Purpose Frigate to meet the final capability need identified. This is the benefit of this change in procurement approach, for which the National Shipbuilding Strategy and the MoD should be applauded.

2.2 *Requirements*

The KCs were used to define the capability required of the platform by the end user (the RN) for the purposes of the CDP. These KCs were graded in accordance with safety criticality and priority. Certain KCs were assigned as 'Key Hazard Certification' and had to be achieved, in areas such as stability, structures, fire-fighting and magazine safety as examples. Others were 'Mandatory', in areas such as shock resilience, operation within a defined seawater temperature range and the storage of depth charges as examples. The remainder were graded between 'Key' and priorities 1, 2 and 3. These six grades were weighted within an evaluation tool; 'Key Hazard Certification' and 'Mandatory' requirements had to be achieved as a minimum, with the remaining 'Key' to level 3 requirements attracting higher marks depending on their priority level. This evidenced score achieved for the capability assessment generated by the evaluation tool was the majority component of the overall bid assessment, combined with evaluation of other aspects such as UK prosperity, export strategy and project management to select the winning bidder for the Type 31 design and build contract.

This mechanism ensured that the capabilities that the RN needed in the Type 31 Frigate were achieved. The bidders had complete discretion to make decisions within the design to meet these requirements, with no direction from the MoD to use any particular systems or equipment to achieve them. For example, the high level requirement of one KC stated:

'The whole-ship shall engage surface targets at range with small calibre guns.'

This came with (classified) subordinate definitions of what type of surface targets, at what range, and what qualified as a small calibre gun (SCG), however the bidders were left to decide which solution they would offer to meet the requirement. In the case of the weapons and sensors the MoD evaluation of the bidder's solution was also supported by independent capability modelling and analysis conducted by Dstl[2], using tools including the Ship Air Defence Model (SADM) amongst others. The best solutions offered would score higher marks in this impartial capability modelling assessment, which contributed considerably to winning the competition.

Due to the importance of achieving the highest overall capability modelling assessment score to the success of the bid, selection of these gun systems for Type 31 took over a year, and all options available on the market were considered. To guide this selection, separate performance modelling was conducted on these systems by the bidder themselves (Babcock Team 31), independent of the Original Equipment Manufacturers (OEMs), using provided source data including servo behaviour, reaction times, fragmentation patterns and accuracy of the various alternatives. The selected options (BAE Systems Bofors 57 Mk3 & 40 Mk4) were not the cheapest options available; however, against the multiple KCs set by the RN they were the options that provided the best combined performance against the full range of air and surface threats, proven by analysis and assessment.

The subsequent contract with the prime supplier to design and build Type 31 is not held against a User Requirements Document (URD) and System Requirements Document (SRD), as found in previous contracts, although the MoD employ these documents across the Type 31 programme. The KCs, and the levels of capability offered by the bidder to deliver the KCs, were entered into a 'Build Specification' document that describes the entire product instead. It is to this document that the contract is held and ultimately accepted. Using the same example area of SCGs, the Build Specification for this capability includes the following statement:

'Arrowhead 140 will provide 2 BAE Systems Bofors 40 Mk4 Naval Gun Systems as SCGs to engage [REDACTED], effective at a maximum range of [REDACTED].'

[2] Defence Science and Technology Laboratory (Dstl) provides the UK Ministry of Defence with science and technology expertise in support of defence outputs.

The solution designed against the various elements of the Build Specification is summarised in Figure 3 below. Other related aspects such as the weapon arcs, mission systems integration, deck-penetrating magazine support and reversionary control (amongst others) are described in other parts of the Build Specification, and overall combine to deliver the capability required by the original KCs as assessed by the Dstl capability modelling during bid evaluation.

Figure 3 - High Level (Unclassified) Summary of the Type 31 Gun System Solution to meet the MoD KCs and Build Specification

The prime supplier's responsibility within this fixed price contract is therefore to deliver the product as detailed in the fixed Build Specification. As described above the prime (Babcock), together with their mission system integrator (Thales UK), are the Design Authority for the platform (including gun systems) and mission systems scopes respectively. The Design Authority makes all design decisions and equipment selections to deliver this product in accordance with the Build Specification, from the layout of the Operations Room to the design of the chilled water system to the complement solution and associated Watch & Station Bill.

3. Design of an Adaptable Warship

Type 31, and the ARROWHEAD-140 product, are derived from the 'parent' Royal Danish Navy (RDN) IVER HUITFELDT Class of area air warfare Frigates; however, it is not a 'build to print' of the IVER HUITFELDT design. From the 'parent' class basis the entire Type 31 platform has been extensively redesigned to meet Lloyd's Register Naval Ship Rules versus the parent class Det Norske Veritas (DNV) rules. Type 31 is also now redesigned to meet NATO ANEP-77 Naval Ship Code and the stringent UK naval stability requirements as a key element amongst wider compliance with UK DefStan 02-900 General Naval Standard, amid a significant number of other UK naval standards.

The various rule sets and standards used worldwide to design ships deliver varying levels of capability into a warship, even amongst NATO navies. The RN's requirements have been honed by real-world and hard-won naval combat experience in the missile age; driving some of the most exacting standards to which a warship can be designed. The Type 31 Frigate now complies with these requirements and latest standards, materially increasing its performance over many overseas Frigate designs and the legacy 1980s-designed Type 23 General Purpose Frigate that it will replace in RN service. This has impacted a range of areas across the ship that include, but are not limited to:

- Increased compartmentalisation and watertight subdivision to meet naval damaged stability rules;

- System redundancies across the platform redesigned;
- Armour scheme, blast protection and shock resilience redesigned to meet UK standards;
- Recoverability features and equipment levels increased to align with current RN practice;
- Signature mitigation measures modified to account for wider changes in the platform;
- Introduction of IMO Tier III compliance, with Selective Catalytic Reduction (SCR) equipment added to Type 31 to manage exhaust emissions, as the IVER HUITFELDT class pre-dates these international environmental regulations.

Figure 4 - IVER HUITFELDT Class (top) & Type 31 Frigate (below)

Therefore Type 31 is a new complex warship platform design with substantial differences to features, layouts and systems that are found in the IVER HUITFELDT. This is shown in Figure 5; as the IVER HUITFELDT class was a fixed design point all aspects of this design were empirically known, ranging from stability and seakeeping performance to maximum speed and internal noise levels, as the class has been in service for a number of years. As the Type 31 platform was designed between Bristol and Rosyth (through functional and detailed design stages respectively) the engineers were able to 'take a fix' to plot a course from this known design point, to guide decisions and underlying calculations. As examples, the IVER HUITFELDT scantling plans, Piping & Instrumentation Diagrams (P&IDs), compartment arrangements and the 3D CAD model were all used as the start point in the development of the platform, modified by the Type 31 engineers to suit the alternative standards, regulations, capabilities and layouts required by the Build Specification. This mature inception significantly reduced the time, risk and cost of the Type 31 design and is another reason why Type 31 was able to move from contract award to cut steel in a record time for a complex warship.

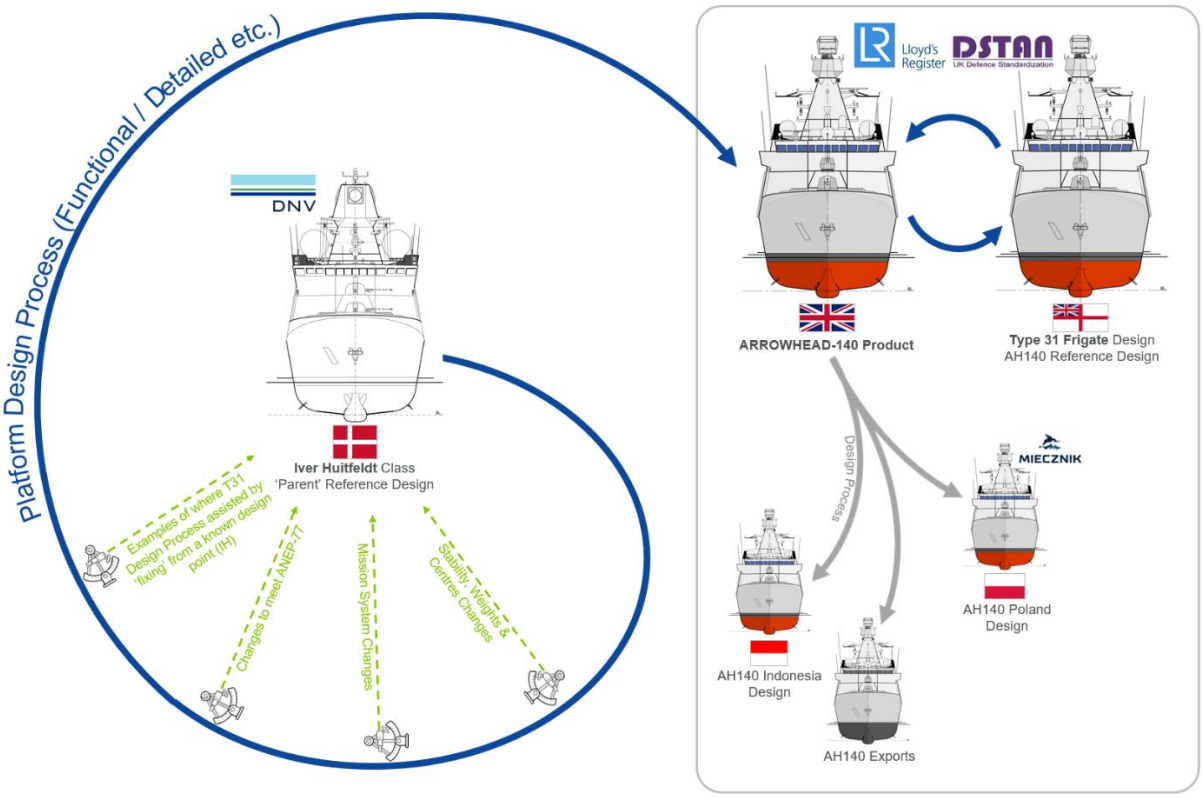

Figure 5 - ARROWHEAD-140 & Type 31 Frigate Design Relationship to the 'Parent' IVER HUITFELDT Class

The policy within the design team of only employing mature off the shelf systems and equipment is another area that results in high-end capability delivered for a lower cost in the Type 31 Frigate. The Combat Management System (CMS) TACTICOS is already in service in over 180 other naval platforms, and both the Integrated Platform Management System (IPMS) and Damage Surveillance and Control (DSAC) system fitted are the ones found in the QUEEN ELIZABETH Class aircraft carriers and Type 26 Global Combat Ships. The Integrated Bridge & Navigation System (IBNS) is the same as that fitted to the Type 45 Destroyers and Type 26 platforms, and a full communications suite is included as expected for a globally deployable warship, centred on an updated version of the communications equipment that is currently employed in the QUEEN ELIZABETH Class aircraft carriers, all as examples. From the ballast water treatment plant to the propulsion gearboxes to the galley equipment everything onboard is either Military Off The Shelf (MOTS) or Commercial Off The Shelf (COTS) products, removing the extremely costly requirement to develop and test bespoke and exquisite equipment with the associated risk and contingency costs involved.

3.1 *Future Adaptability*

The flexibility of the IVER HUITFELDT Class and the 'Stanflex' system is well documented (Lok, 2006), employing a common module size for different mission systems equipment such as Medium Calibre Guns (MCGs), Vertical Launch Silos (VLS) and Surface-Surface Guided Weapons (SSGW). In practice this has meant the RDN have been able to move equipment between classes quickly as one is decommissioned and the replacement is built. With the majority of the platforms within the Danish Navy Fleet adopting this Stanflex system there are obvious benefits from this solution. However, for another navy that would only have Stanflex on a single class amongst many other platforms the benefits are more constrained.

Type 31 adopts more of a spiral development approach to adaptability, opening up the ability to introduce a wide range of systems from different suppliers as required in the future. This spiral development, discussed by Johnson and Wakeling (2017), reduces the initial procurement cost of a platform by delivering the baseline platform with a fixed specification while providing the ability to add equipment through-life to suit the dynamic operational need and the rapid pace of technological development over time. The baseline platform for Type 31 retains the platform features ranging from survivability, recoverability and signatures to structural design, habitability and endurance, with the provision to add systems in the future intrinsically embedded throughout the design. This includes

additional processing capacity within the IPMS system, additional capacity in the electrical distribution cabinets alongside margins in chilled water, HVAC and network infrastructure systems to accommodate additional capabilities. A summary of the various roles that can be added to augment the baseline general purpose capabilities is included in Figure 6 below.

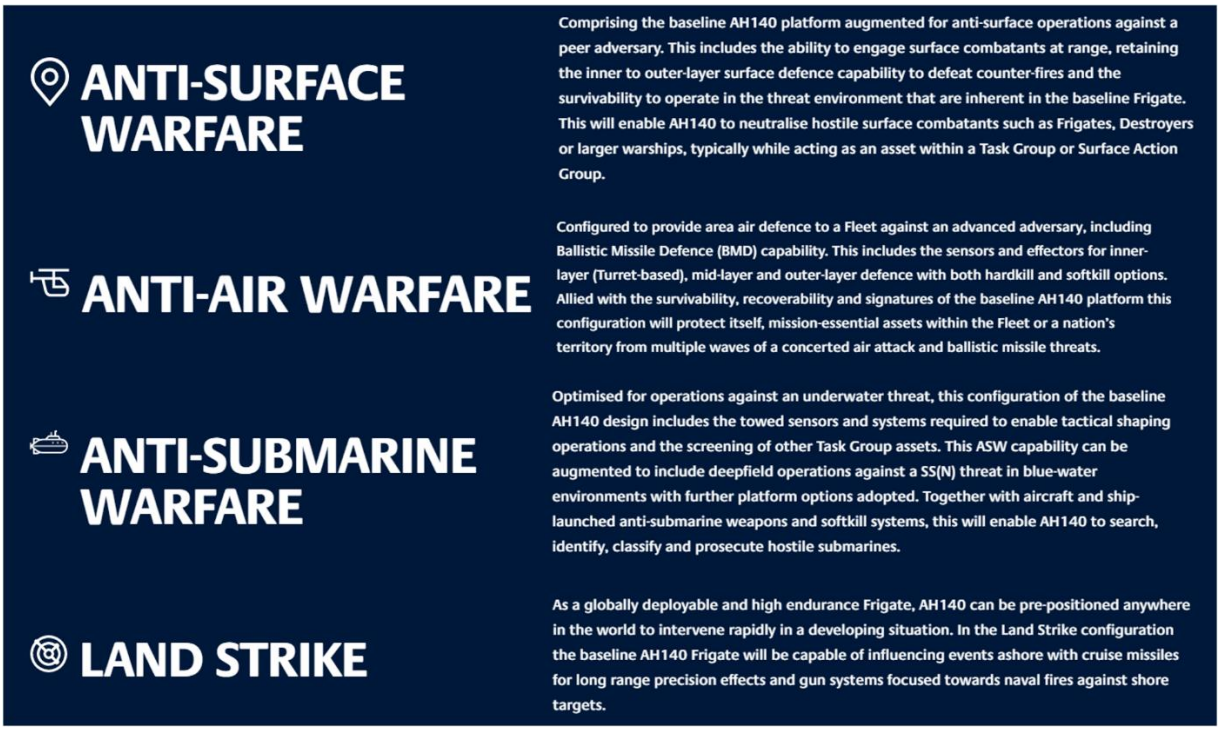

Figure 6 - Summary of Adaptable Roles

As two examples of the adaptable features within the platform; the foundation structural seats for four 8-Cell Mk41 Strike Length VLS modules are built in the baseline Type 31 Frigate to accept the fit of these Mk41 modules if required in the future, and electrical power generation systems in Type 31 create in excess of a megawatt of power margin solely assigned to be harnessed by future capabilities as technologies develop.

Type 31 is entirely designed in 3D modelling software, down to the level of individual domestic plug sockets within compartments. Production outputs are generated from this 3D model that drive the PEMA pulse line automated manufacture facilities that now lie at the heart of the upgraded shipyard in Rosyth, following major investment by Babcock in the modernisation of this site.

A key difference between a commercial ship and a warship, in the majority of cases, is the density of outfit within the platform. Compressing all of the equipment required for platform systems such as HVAC, electrical distribution and steering control alongside mission systems equipment with its below-decks processing cabinets into a comparatively small hull is a considerable challenge. This is compounded by the redundancy of these systems that a warship requires for survivability purposes and a ship designed to commercial standards that does not. This density has driven cost and schedule delay into programmes in the past due to physical re-work in the build phase of a programme to correct issues and mistakes. The 3D modelling undertaken in Type 31 de-risks this activity, with all equipment, furniture, pipe and cable runs placed, seated, routed and deconflicted in a virtual model before any physical build activity takes place. Reducing the contingency and risk costs associated with physical re-work during build, and increasing the pace of construction with automated panel lines, are advantages that have been exploited in the Type 31 design and build contract with this digital shipbuilding methodology.

This Type 31 3D model also contains the outfit equipment that would be required for alternative adaptable roles, such as the automated ammunition handling system required for a 5” (127mm) Medium Calibre Gun and alternative Medium Range Insertion Craft (MRIC) offboard assets, based on installation data provided by their respective OEMs. For example, the installation data for a CAPTAS towed array & variable depth sonar was

provided by Thales to support the integration of this equipment within the Type 31 design model. This de-risks the introduction of these capabilities in the future within the platform.

The comprehensive 3D model, incorporating the equipment to support the adaptable roles, is also intended to make the platform attractive to other potential export customers by simplifying the design process with their tailored capability requirements, whilst being able to rapidly produce production outputs that feed the panel lines and other digital build processes to meet challenging programme timescales. The Polish customer has already taken advantage of this ability to incorporate alternative equipment in the design and build programme for the MIECZNIK Frigate for example.

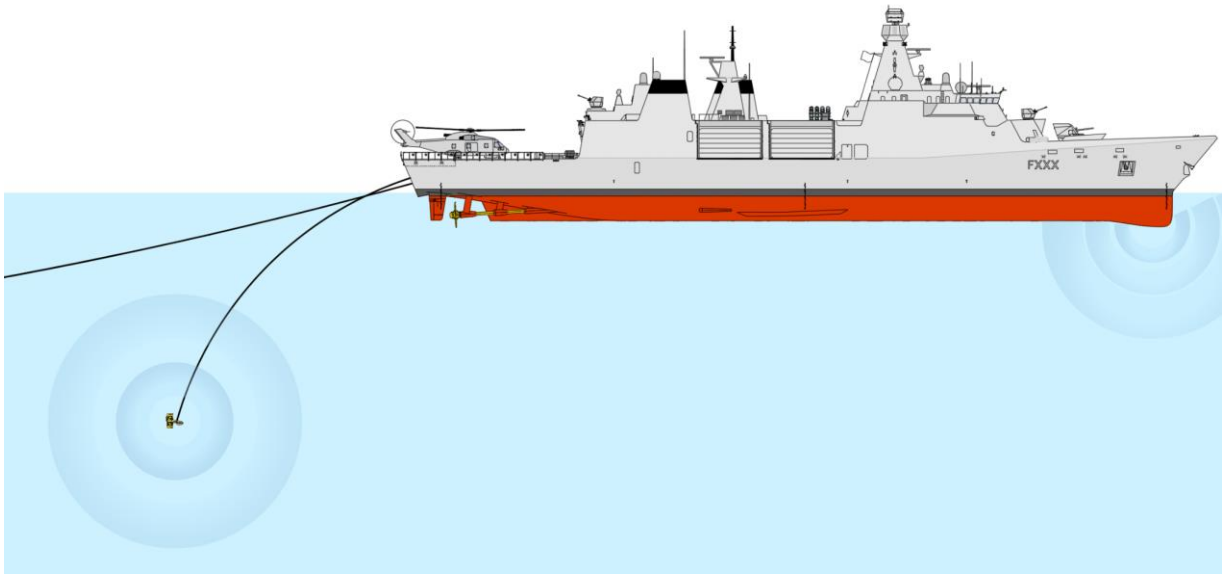

Figure 7 - Adaptability Role Example - ASW

3.2 *Concurrency – A Multi-Role Frigate*

Concerted effort was expended during the design of the Type 31 Frigate on the concurrency of these future capabilities and roles within the platform. Multiple roles, balanced with the requirements of the baseline platform such as stability, accommodation provision and endurance, are deconflicted so they can be fitted at the same time. This provides the option for the end users to create a true multi-role Frigate with the latest technologies available, while reducing the risk, cost and schedule delay in the initial ship build contract by decoupling the delivery of this additional capability from the baseline platform and its associated trials and commissioning.

This differs from other examples of complex warship procurement where the total capability demand is specified within the initial design & build contract, and expected to be built, commissioned, tested and delivered at the same time. While this means the total capability that the platform will provide is fixed and known from the initial contract, there are disadvantages. A complex warship generated from first principles (i.e. without a ‘parent’ reference design) can take a significant amount of time to design, with capabilities, systems and equipment that the platform is designed around fundamentally ‘locked in’ from an early stage. This can potentially mean that by the time the platform actually enters service that equipment or system may be approaching obsolescence, or the strategic & tactical situation that the platform will enter service into has changed and the platform struggles to adapt. Introducing a mission bay is one method to mitigate this particular risk of capability obsolescence, providing space with services such as power, data and communications that can be used to host the latest modular equipment against the latest operating environment and threat; Type 31 includes a mission bay for this purpose. By also adopting more of a spiral development approach, and ensuring the enablers for future adaptability are intrinsically incorporated throughout the design before it is built, the decision of what additional capabilities, systems and equipment will be fitted to Type 31 can be made considerably later in the programme to take advantage of the latest technologies and with full view of the latest strategic situation.

As such, it is important to note that at the time of writing (May 2022) the capability that has been identified so far in open source material only comprises some of the systems included within the initial design & build contract, which is not the total capability of the Type 31 Frigate that will be delivered into RN service on the ISD. The adaptable provisions designed within the platform will support the full capability that the RN will employ; a package of capability upgrades are planned to be installed in the Type 31 Frigates once the platforms are delivered by the shipbuilder, prior to ISD with the RN, as part of the overall MoD delivery programme.

4. Conclusion

When HMS NORFOLK, the first Type 23 Frigate of the DUKE Class, was commissioned into RN service in 1990 it did not have a Combat Management System (CMS) fitted. Nor did the following six ships of the class, with HMS WESTMINSTER (ship 8) the first to be delivered with the DNA-1 combat system. The capabilities of the Type 23 Frigates grew over the years of service from this starting position to become the valued workhorses of the RN today; so too will the capabilities of the Type 31 Frigate. There are differences in the approach; Type 31 does not start from the same position as the Type 23 did with core platform capabilities, and will instead be delivered with a highly capable mission system that includes the latest variant of the TACTICOS CMS and the first 4D (3D + full Doppler) Dual-Axis, Multi-Beam, Active Electronically Scanned Array (AESA) Radar to be fitted to a RN Frigate. This mission system introduces the latest automation of processes such as picture compilation and rapid assignment of fully integrated weapons to the RN. Also unlike the Type 23 this ability to grow capability in-service is facilitated in the Type 31 platform by deliberately designing and building the ship around the installation of additional equipment and capabilities in the future to simplify and de-risk the process.

An adaptable ship does not necessarily always mean employing mission modules that are transferred between platforms. The spiral development of a warship that has been introduced to a fixed specification, price and timeline reduces the 'front-end' cost of a programme, while also including the features, margins and capacities to accept the low risk introduction of additional capabilities in the future. This also makes the platform more attractive on the export market. However, it is essential that the platform features such as survivability, habitability, recoverability, structures and stability of the baseline vessel are designed to accommodate this future capability. 3D detail modelling enables the integration of this adaptability, and system design from IPMS to Chilled Water to the HVAC system has to facilitate the future integration of equipment without incurring considerable costs of redesign.

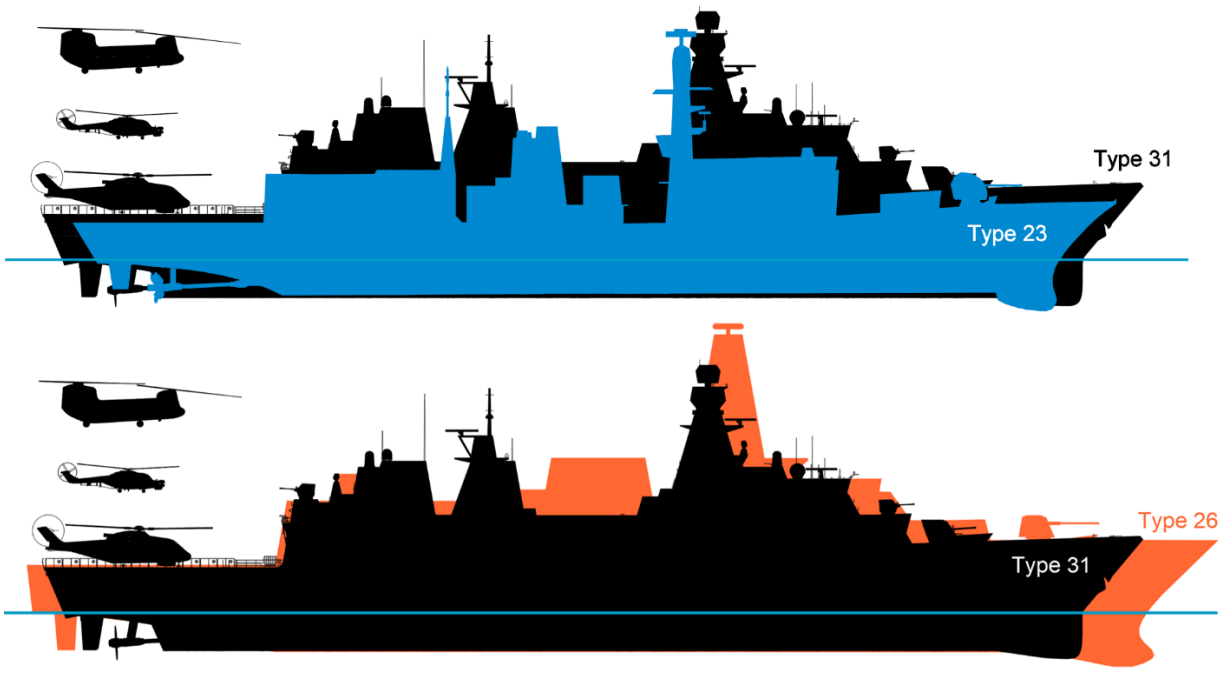

Figure 8 - Type 31 Frigate Size Comparison

Throughout this paper example areas where costs have been reduced or removed from the Type 31 design and build contract have been identified, particularly where they differ from the processes adopted in previous procurement examples. None of these cost reductions relate to the military capability of this warship. Incentivised by the MoD KC requirements and their evaluation method, including independent capability performance modelling, the capability of the platform itself was preserved, literally at all costs, in order to win the competition.

A key difference from previous major warship procurement programmes is the formal assignment of the supplier as the Design Authority, rather than the customer. This stable method of procuring a product to a fixed price and by a fixed date reduces the wider associated programme costs such as risk, contingency, equipment development, performance trials, commissioning and change management considerably. It is in these wider areas where the cost has been removed from the Type 31 Frigate when compared to legacy examples.

The Type 31 programme has led the way for a new style of procurement under the UK's National Shipbuilding Strategy, breaking new ground in strategy, requirements, contractual arrangements, design ownership and delivery of complex platforms. This procurement strategy has subsequently been used in the UK Fleet Solid Support (FSS) programme, albeit in a slightly altered form to reflect the type of ship required, and will guide the procurement of future RN warships such as the Type 32 and Type 83 platforms.

5. Acknowledgements

It has taken a monumental effort by a dedicated team from the MoD, RN and Industry to get to the position that the Type 31 Frigate programme is in today, which has been described briefly in this paper. The early work within the UK MoD to push a new style of major equipment procurement through the various approvals to become a multi-million pound programme, and following this through with the generation of the requirements and new competition evaluation techniques was a trail blazing effort by those MoD and RN personnel involved. Once on contract the pace has been relentless, with a relatively small group of committed engineers performing minor miracles on a regular basis to hit each of the design milestones to get this complex warship to a position where cut steel could be achieved on schedule, against the background of a global pandemic. So much has been achieved in a short space of time; there is still a long way to go, but as the aphorism goes, those who say it cannot be done should not interrupt the people doing it.

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