Minor Warship Roles - How technology is leading to a new vessel type

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ABSTRACT

Minor warships are a category of naval vessel covering a range of roles, including Mine Counter Measures (MCM), offshore patrol and survey. These vessels may be deployed in a war role, within threat environments, but are often small and of a specialized nature. To date, the roles have generally been achieved through the design of specialized vessels for each role with little commonality. This is particularly true of the MCM vessel, a highly optimized platform due to the demanding and specific nature of its role.

Previous attempts to provide a common platform to meet these varying roles have met with mixed results. The emergence of new technologies, particularly the expected widespread use of off-board, unmanned systems offers new potential for a single common platform to be reconfigurable across these roles; the role optimization becomes focused on the off-board systems and not the mother platform.

This paper discusses the work conducted into a concept for a multi-role small surface combatant focused on the roles of MCM, maritime security, hydrographic and environmental assessment and patrol. The objective of this work was to identify how much commonality can be achieved in the platform, the art of the possible in terms of a small, globally deployable warship and the advantages and disadvantages of navies adopting the multi-role approach. Key aspects investigated include: the type of hullform adopted, comparing monohull and multi-hull performances to achieve global deployment requirements, issues of modularity, arrangement of multi-missions spaces, and deployment of unmanned vehicles to perform some missions.

BACKGROUND

Changing MCM Technology

Today many navies operate the classic Glass Reinforced Plastic (GRP) hulled mine hunter vessel. Designed to operate within or close to the minefield, these vessels are built of single skin GRP, have noise and vibration isolated main machinery and other fixtures, fittings and equipment constructed of non-metallic materials, all optimised so as not to compromise the signature of the vessel.

Mine hunting is conducted using the combination of hull mounted and towed mine sensors such as the RN Sonar 2153 and Remotely Operated Vehicles for identification, inspection and disposal. The latter are often deployed using cranes and require the vessel to operate within the immediate suspected minefield area.
The future of MCM is being rapidly changed by the introduction of Unmanned Vehicles, both Unmanned Underwater Vehicles (UUV) such as the HUGIN (Figure 1) and REMUS ranges and Unmanned Surface Vehicles (USV) such as the UK’s Flexible Agile Sweeping Technology (FAST) demonstrator. Already on trial successfully in a number of navies, the introduction of unmanned vehicles is seen as a key enabler to “remove the man from the minefield”. A result of this strategy will be the reduced need to manage the mothership’s signatures and hence negate the use of GRP or non-magnetic steels and noise / vibration reduction measures. What this will mean in practise is that MCM systems may be deployed from a variety of navy platforms rather than needing dedicated MCM vessel’s with very low signature characteristics, as in the case of the US Littoral Combatant Ship. In theory this will allow the MCM capability to be fielded with the combat force and without additional vessels.

However, there is a drawback to exclusively deploying from surface combatants; whilst conducting MCM operations the combatant is likely to be restricted in its ability to conduct other operations and the required volume for MCM systems will be at a premium alongside other mission equipments. Therefore, another concept that may be introduced alongside the deployment of MCM systems from surface combatants is the development of the “Auxiliary Surface Combatant (ASC)”. Simplistically, these vessels may be considered the replacement for the legacy MCM vessels, but the introduction of the new technologies offers the chance to make these vessels more flexible in mission profile, whilst still retaining the concept of a single role vessel aimed at low cost. The concept therefore is a very simple platform, using off-board and modular systems to conduct MCM, route survey or surveillance activities.

Figure 1 Hugin UUV in containerised Launch and Recovery System (left) and on board a MCM Vessel (right) (images courtesy of and © Kongsberg)

Wider Capabilities

The MCM vessel has often been utilised as a patrol ship to supplement its utility; examples include RN Hunt Class vessels which have been used for fishery protection and some were modified as dedicated patrol platforms, whilst the Canadian MCDV class already seeks to address utility through modular systems.

The roles for the ASC are those that represent a poor utilisation for a costly surface combatant such as a frigate, or would detract from them conducting their primary mission. In this sense, the ASC becomes a “second rate” combatant, capable of supporting the fleet world-wide but conducting either single role or low threat tasks to reduce the burden on the surface combatant fleet. For the RN, they would represent a return to a type of vessel prevalent before the NATO navies became optimised for the cold war.
Typically, these roles would include:
- Mine Counter Measures;
- Mine Counter Measures Tasking and Support;
- Survey and Rapid Environmental Assessment (REA);
- Coastal and Offshore Patrol;
- Maritime Security Operations (MSO) including Counter Interdiction, persistent surveillance and presence;
- Training.

In comparison to existing MCM and OPV types, in particular the Canadian MCDV which seems to bear a resemblance to the proposed concept, there are some key enablers required for the ASC not provided in these existing vessels:
- To provide the global reach required, the ASC needs both range and seaworthiness;
- Speed has to be sufficient to deploy with a task group and to conduct operations ahead of that group;
- Armament has to be sufficient for self-defence and to offer limited and modular offensive capability.

Mission Context

The ASC will be required to transit globally both as a dispersed unit and as part of a task group. As such, it will require an appropriate level of seaworthiness, cruise speed and range. Specifically, it will be required to conduct ocean transit with minimal risk of damage or diversion, be capable of deploying at equivalent speed to the task group without unreasonable demands on replenishment and to be able to transit at moderate speed over long distances (e.g. UK to Caribbean) without support.

However, as the ASC roles are principally littoral in nature, it would not be required to conduct missions in an open ocean environment. Hence, mission based performance requirements (sprint speed, deployment of off-board systems and helicopters, use of weapons) would be limited to offshore / littoral environments, e.g. Sea State 4 to 5.

ASC ENABLERS

Modularity

As an affordable and therefore relatively small combatant type, the ASC would rely on modularity to offer design utility. Each ASC would operate as a single role unit; the range of roles would be achieved by tailored equipments fits. Advantages to the use of modular systems versus batching are:
- The ability to flex the mix of role vessels;
- Simplification of technology up grading and potentially spiral development of equipments fits;
- The porting of equipment between platforms during non-operational periods to reduce the required number of expensive systems.
There are already a number of modular systems available; however, it is important to define what “type” of modularity is required. One possible description is four levels of modularity:

- Construction modularity
- Configuration modularity (e.g. MEKO®-class ships)
- Mission modularity (e.g. StanFlex series of vessels)
- Battle (network) modularity

A rapid re-role requirement is not envisioned for the ASC (refer to Mission Crews below), and hence modularity will primarily be concerned with bounding mission systems and interfaces, configuration control of both mission packages and platforms but as separate entities and in providing suitable routes for exchange but within a controlled environment, e.g. an up keep period in a home base or similar facility. Hence, it relates to “Configuration” modularity, perhaps with a touch of “Mission” modularity for some roles.

A key factor for the ASC is likely to be the deployment of off-board sensors, most probably using UAV’s / UUV’s / USV’s. Both the mine warfare and survey roles are likely to be performed using one or a combination of types of vehicle and the ability to deploy either modular vehicles or re-role by changing vehicles is an interesting prospect. To achieve this, the ASC needs to achieve flexibility in:

- Deployment and recovery of off-board systems;
- System control;
- System maintenance;
- Possible system reconfiguration if the vehicle is modular itself.

**Mission Crews**

The concept of a mission crew, individuals who embark with specific mission equipment in addition to a basic “float / move” complement, has been proposed for future modular concepts. However, there are significant drawbacks to such a concept:

- Time for mission crew to work up on new vessel;
- Familiarity with specific equipment on ship (can often be subtly different to that on which training is undertaken);
- How to maintain skills in mission crews not required at sea (“mission skills fade”).

This is a key reason why ASC vessels may preferably be configured to specific roles for long periods, rather than re-role on a regular basis. Hence, whilst there would be a common core complement that is the same for all variants, the role specific personnel can be integrated within the complement given that the vessel is not expected to re-role outside of normal crew rotations. However, it is noted that some roles will involve non-complement staff (e.g. fleet protection troops, marines, MCM support etc.) and some missions will require surge accommodation.

**Aviation**

Provision for a helicopter is a key feature for the MSO role but is not essential for other roles. Whilst provision should be made for limited embarkation of a suitable helicopter (e.g. Lynx), this space may also be more flexible. Hence, it could be used for other equipments when operating in a role that does not require an organic helicopter. It is noted that facilities to land a helicopter may be advantageous for MCM and survey although as a
minimum a VERTREP capability is required. Additionally, facilities should also be provided for surveillance UAV’s.

Survivability and Threat Environment

Depending on the role and mission, the ASC could be conducting operations within:

- A benign environment, e.g. training, civil hydrographics;
- A low threat environment against lightly armed opponents (small arms, small calibre weapons, small missiles or rockets), e.g. maritime security, surveillance and patrol operations;
- A high threat environment, e.g. when conducting MCM or REA in theatre for a medium or large scale campaign.

Against the threats, the ASC survivability should reflect the environment and its relative value, e.g. in low threat conditions it is likely to be a dispersed unit and therefore should be capable of continued operation with degraded or limited degradation of capability. In high threat environments it may be accepted that the vessel is either not likely to be a primary target or can be accepted as having no residual capability after a significant event.

Hydrodynamics

The required hydrodynamic performance is driven by the need to offer a very high degree of seaworthiness to achieve global deployability, balanced against resistance optimisation in order to achieve the maximum speed and a manageable fuel load for the required range.

Suggested requirements include:

- Maximum speed 25kts (track and stop suspect vessels);
- Cruise speed 18kts (for Task Group operations);
- Range 5000nm@18kts (Task Group operations), 7000nm@12kts (dispersed unit);
- Sustain transit in Sea State 6, operational in Sea State 4 / 5.

Other factors will include consideration of draught given the focus towards littoral missions and achievement of a satisfactory stability standard. The hull design should seek to achieve the required speed, range, draught and stability requirements whilst maximising the seaworthiness.

BASELINE SOLUTION - “VENATOR” CONCEPT

Having developed a basic set of requirements, BMT Defences Services together with BMT SeaTech and BMT Nigel Gee, began the process of developing a concept design with the aims of:

- Assessing the practicalities of a small, reconfigurable minor warship;
- Assessing the size required for the various payloads;
- Assessing the seaworthiness issues and potential size for global reach.

The principal characteristics and arrangement of design are indicated in Figure 2; a key driver behind the initial choice of size was a change in the damage stability rules of the UK MOD standard (Reference 1) that occurs at a length of 92metres, changing from a 2 compartment standard to a damage length 15% of the waterline. The arrangement was developed around the mission working area aft which features the following:
• A stern ramp for launch and recovery of RIB / USV’s of up to 11 metres length;
• Facilities for a containerised UUV launch and recovery system for MCM reconnaissance or survey UUV’s;
• A large garage opening on to the quarter deck for the stowage of mission equipment;
• A flight deck suitable for a small helicopter (e.g. Lynx) over the garage top;
• A telescopic Hangar.

![Figure 2 Baseline Design Arrangement and Characteristics](image)

Various configurations of Hangar, vehicle launching and recovery and flight deck were considered, however the selected length quickly suggests that the selected arrangement offers the optimum solution.

The adoption of a garage for stowage of mission equipment offers a more protected environment when the vessel is in transit although the required height to both stow and move items results in a garage of approximately 6 metres or 2 deck heights. Hence, the flight deck is placed higher than would conventionally be adopted and attention is required into how the garage / flight deck is incorporated into the primary structure of the vessel.

![Figure 3 Garage and Flight Deck details](image)

MODULAR SYSTEMS

A variety of modular payload and mission system standards have evolved, mostly bespoke to specific navies. However, increasingly there is a trend for the military to use existing packing standards as this eases integration with the wider transport infrastructure. The most widely used standard is the 20 foot container. It is also not necessary to force all items into the same dimensioned packages and an early decision was that the large unmanned vehicles should have bespoke stowage (e.g. large RIB based USV’s and the large reconnaissance UUV’s).

ISO Containers

Most modularity concepts discussed to date focus on the use of ISO containers. There are clear benefits to these containers:
• Established in the wider transport infrastructure;
• Already widely utilised by the military;
• Durable containers offering excellent protection against weather and damage;
• High volume;
• They can be used as enclosed offices and workshops.

However, when considered in the context of the ASC, there are also some disadvantages to containers:
• Voluminous and can lead to poor packing densities;
• Difficult to move without significant material handling equipment;
• Unversatile- fixed, large sizes could mean even small containers such as quadcons are too large for this application;
• Very difficult to manoeuvre in confined spaces;
• Excessive height is needed to lift one container over the other.

The above disadvantages are particularly applicable to the ASC because:
• The garage is a confined space with a small footprint;
• Significant height restrictions due to the flight deck and associated structure above the garage;
• It would be beneficial to be able to move equipment when underway;
• Versatility is a critical requirement in storage solution;

**Sub-Intermodal Packing**

When the wider range of commercial and military transport packaging is considered, beyond the 20ft, then “sub intermodal” packaging appears a very attractive solution. Here, units smaller than the standard container are considered but they retain compatibility to be stowed within 20ft containers for transport when required. The solution discussed here is typical and represents an in-service example.

The Mobile Shelter Systems Storage and Transport Frames (STF) are essentially caged storage racks built to be compatible with all commonly used means of transport. They are built in several sizes and are designed to permit quick loading and unloading of cargo from standard ISO containers, quadcons, tricons and other pallets.

*Figure 4 Storage and Transport Frame developed by MSS (images courtesy of and © Mobile shelter Systems)*

These racks provide all the advantages of the ISO container and dispel several of the disadvantages:
• Equipment can still be transported using ISO containers;
• Containers can be unloaded at dockside and the racks loaded onto the ship;
- Racks are much smaller and lighter and therefore more versatile both in mobility (forklifts can lift and move racks) and in storage into a small space (such as a garage).

The size selected for the VENATOR concept is a 2 tonne unit, which offers the potential for integration within the military supply change (RAS, VERTREP) and it is stackable within the two deck high garage, offering an even greater stowage capacity on the vessel.

**Controlled Environment Solution**

It is also necessary to provide reconfigurable “internal” space for MCM support spaces, unmanned vehicle control and planning / briefing / training. Whilst containers may be used within the garage space, limited internal area, water and weather-tightness, soundproofing, electricity, lighting and climate control are just some of the factors that would need to be addressed.

A preferable solution could be to incorporate a controlled, internal space that may be easily adapted. This is incorporated in the design within the superstructure. By placing the space immediately forward of the garage, direct access from the garage may be arranged for ease of re-role.

**Re-Role of Equipment**

Significant loading and unloading is required during re-role and some of the key assumptions developed regarding re-role are:
- Rapid re-role is not perceived as a requirement;
- Re-role will take place in a facility geared towards the task (i.e. mooring alongside with craneage and trained workforce available);
- Modular concept to facilitate an easy integration of equipments.

As has been discussed, a garage opening aft to a stern ramp and a flight deck above is a natural configuration for this size and type of vessel. However, if the flight deck is entirely above the garage a crane cannot lift equipment or stores directly into the garage.

Potential solutions to embarkation / disembarkation of equipment from the garage include:
- A “landing area” allowing craneage to “land” equipment onto the working deck and to utilise a secondary lifting system to move the items in their prescribed location within the garage;
- Introduce a lift between the flight deck and garage. Hence a crane lowers onto the lift, the lift can retract and a secondary lifting system locates items to their prescribed location within the garage;
- A retracting or opening flight deck which will allow access by a crane directly into the garage.

The second and third suggestions are costly, voluminous and introduce complexity to the vessel. The first solution is inexpensive and simple provided an effective secondary lifting system can be utilised within the garage. Hence, the baseline design includes an open quarterdeck area aft of the garage.
Onboard Material Handling

The onboard material handling is required for internal movement during re-role, movement of the unmanned vehicles and RIB’s to the points of deployment / recovery and general logistics re-supply. Various solutions have been considered as described in the following paragraphs.

Forklift

A forklift truck could be used during re-role to locate items inside the garage and offers a robust and practical solution. A forklift could be lowered onto the open transom area by crane and work in tandem with the crane to load and unload equipment. Once the task is complete the crane could unload the forklift.

Sled on Track

A track system could be laid into the deck with longitudinal and transverse freedom of movement. A sled can then move on the track through winches and pulleys. This system would require the stern ramp to accommodate the cradle and the RIB’s / USV’s would be deployed from the cradle on to the ramp. The sled system has the advantage of safer operation in higher sea-states. However, the sled system introduces complexity in use and a lack of versatility as sleds may have to be bespoke for a wide range of equipments. Arranging access throughout the garage could also pose a problem.

Gantry system

A gantry provides superior ease of use and versatility. However, a weight suspended on a gantry would swing as the ship responds to wave action and this is an area that requires further analysis and consideration against the user requirements and the actual conditions under which vehicles and equipment will be moved.

It has been discussed how equipment would be lifted on to the open quarterdeck for embarkation during re-role and the stern ramp is also external, hence material handling is required external to the garage. Two potential solutions are available:

- Run the rails of the gantry outside the garage and aft to the transom, e.g. so the gantry can lower RIB’s onto the ramp;
- Install a second lifting method such as a davit to bridge the gap between the gantry and the ramp.

![Figure 5 Internal / External Gantry System](image)
The second option is convenient because the davit allows a second deployment method for vehicles. However, when utilising the ramp deployment becomes a more complex and timely 3-stage process (gantry + davit + ramp). If the gantry rails can be run externally to the transom this would introduce simplicity and good versatility. The gantry could also aid in re-role by moving equipment from the external landing area to inside the garage.

GLOBAL DEPLOYMENT

The impact of global deployability has been considered through a parametric investigation of the baseline monohull and comparison to a SWATH solution. Nine parametric forms have been assessed for seakeeping, powering and stability performance based on variations in length (90m, 100m and 110m) and length / beam proportions (variously L/B from 6 to 8). As would be expected, the results show that the choice of hull characteristics allows the designer to optimise towards specific performance targets, but no one hull offers the best performance at all aspects. Hence, the selection of a hull is directly linked to a full understanding of the user’s requirements and the correct balance between of the relative performance of the hull in order to maximise its operating envelope.

Overall, it is concluded from this initial analysis that a 90m will not offer true global deployability, particularly if transiting with larger surface combatants (utilising Reference 2). A vessel approaching 110m has been shown to be more preferable and not necessarily significantly more expensive, due to potentially reduced powering requirements compared to a 90metre vessel (provided the mission payload is unchanged of course).

A short investigation into a SWATH alternative suggests that whilst this would offer far superior seaworthiness, speeds in excess of 20knots would make this form unattractive due to high resistance. Hence, from a hydrodynamic stand point, a monohull best meets the requirements set.

SUMMARY

With Project VENATOR BMT has sought to understand the operational context, design drivers and potential solution space for a globally deployable, single role but reconfigurable vessel to replace a range of minor warship types. The presented concept offers a glimpse of the types of vessel and has also identified the key design drivers to be considered by future operators:

- What is the required speed?
- What is the true definition of “globally deployable” within the concept of operations?
- What are the principal drivers in the choice of a modular systems, speed of reconfiguration, ease of configuration or minimal ship impact?

Above all, the study has highlighted that seaworthiness and complexity of incorporating such a large and diverse payload make the platform design and its requirement specification the challenge for this concept.

REFERENCES

1 Defence Standard 02-109 Stability Standards for Surface Vessels
2 STANAG 4154 Common Procedures for Seakeeping in the Ship Design Process