

Boat Launch and Recovery – A Key Enabling Technology For Flexible Warships

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ABSTRACT

The ability to launch and recover both manned and unmanned boats is a common feature of many future warship concepts; many also feature flexible mission bays to allow a range of vehicles to be stowed and deployed. This reflects the expectation that unmanned vehicles may offer the key to greater flexibility and effect from an individual surface vessel, mitigating the reducing numbers available to many navies. However, the transition from concept to operational capability will require the development of existing launch, recovery, stowage and movement systems; they will be required to interface with a range of different vehicles rather than be designed for one specific boat, the operational envelope will need to be maximised and issues regarding safe operation will have to be addressed. This paper seeks to review the progress made and identify the issues to be addressed in the immediate future if the concepts are to be fully released. It addresses the difficulty of incorporating operable and affordable systems from a ship designer's perspective and takes a view on how future ship / boat interfaces may develop.

BACKGROUND

The trend toward greater offboard capabilities

It has become a noticeable trend in warship design to allow for the carriage of greater numbers of offboard vehicles and boats. This appears to be the result of a combination of the well documented shifting operational focus (particularly western navies) from blue water, cold war to global policing together with a maturing of unmanned vehicles for use on the next generation of vessels. With current operations having a focus on constabulary type missions, the size of boats to be carried are increasing beyond commercial Fast Rescue Craft (FRC). Currently 7.5m RHIB (e.g. the RN Pacific 24) are common with aspirations for 11m or even 14m RHIB's in the future. Also, the number of boats is increasing e.g. two or even four boats can be used in a given operation, whilst still requiring at least one ship's boat to remain available with the host ship to support helicopter operations and Man Over Board (MOB).

With Unmanned Underwater Vehicles (UUV) now entering service for MCM reconnaissance operations there is an aspiration to deploy these from a range of surface vessels and Unmanned Surface Vehicle (USV) technologies are also developing for both MCM and surveillance missions. These vehicles vary greatly in size, shape and speed, which adds further complication to launch and recovery requirements if an extensive range of vehicles are to be operated.

Hence, the traditional port / starboard davit arrangement for two dedicated ship boats will no longer be suitable for many of the next generation of warship designs. Many designs now seek to incorporate a "mission bay" where a range of vehicles, boats and support equipment can be stored and deployed. Alongside this, the need to launch and recover this

range of assets in high sea states to maximise the envelope of operations is complicated by the need to handle these with a minimum of deck hands whilst achieving high safety standards. As some assets are likely to be unmanned, the launch and particularly recovery is further complicated.

Commercial Comparisons

Davits, stern ramps and unmanned vehicle launch and recovery systems are all currently utilised in commercial vessels. There are many similarities between naval boat davits and commercial FRC / MOB davits, although it is noted that naval systems have to be designed for more frequent use and potentially larger, heavier boats. Stern ramps are used in paramilitary and particularly coast guard vessels due to the fast response time. Some offshore vessels also utilise stern ramps particularly for workboats.

Of particular interest to navies are the offshore support vessels designed to operate Remotely Operated Vehicles (ROV), because of the parallel with naval vessels designed to conduct MCM utilising UUV's. As with ships boats, there are a variety of equipments used in launch and recovery of ROV's in the offshore environment, including cranes, A frames, telescopic davits and moonpools. Fitted with heave compensation, these systems are capable of operation to upper Sea State 6 (Ref. 1). Another interesting solution is the containerised launch and recovery system for UUV's used in underwater surveying, which allows the use of ships of opportunity rather than operating dedicated vessels.



Figure 1 ROV LARS system (left, image courtesy of Cargotec) and UUV in containerised LARS (right, image courtesy of Kongsberg)

LAUNCH AND RECOVERY TECHNOLOGIES FOR WARSHIPS

For the purposes of illustrating the relative merits, some analysis has been conducted. This analysis is part of ongoing work and at this stage should be taken as more illustrative than definitive in terms of performance numbers. The seakeeping analysis was performed on a 90m length concept (BMT Venator) representing a small multirole naval platform (refer to Ref. 2).

Davits and Cranes

The current generation of davits are typically designed for fast rescue or man overboard duties as required by SOLAS; for naval ships the davits are also designed for more regular use as the rescue craft are often also the ships boats.

Typically installed port and starboard on naval vessels to allow flexibility in the side on which to deploy, there are a variety of types available but typical types used in naval vessels include:

- Slewing davits, with a pedestal forward of the boat cradle and the arm stowed over, swinging in a horizontal plane to deploy / recover the boat;
- C type frames, with integrated boat stowage, where the arm swings in a vertical plane;
- Telescopic deck head mounted davits, used where the boats are stowed in bays.

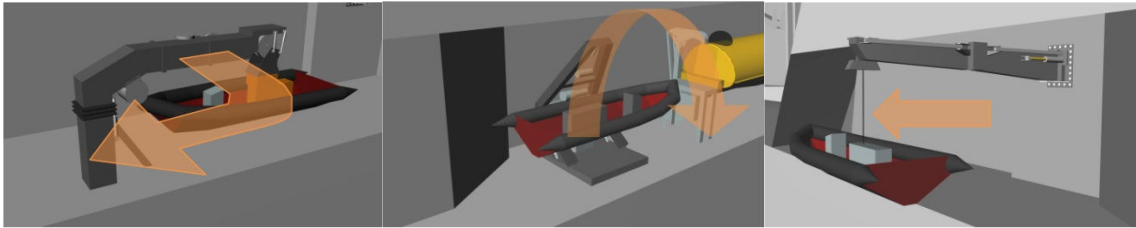


Figure 2 Types of davit – Slewing, C frame, Telescopic

The appropriate type of davit will depend on the arrangement to be adopted and space available (C type davits have a smaller footprint than slewing, but a slewing arm has a lower profile for example). In most applications the davit is associated with a single cradle and boat.

SOLAS requires fast rescue craft to be stowed “in a state of continuous readiness in not more than 5 min” and makes further reference to requirements within the LSA Code (Ref 6). Although no specific sea state requirements are defined for davits on commercial vessels, this latter document includes the following requirements for rescue craft launching appliances:

- “Shall be fitted with a device to dampen the forces due to interaction with the waves when the fast rescue craft is launched or recovered”;
- “The winch shall be fitted with high-speed tensioning device which prevents the wire from going slack in all sea state conditions...”;
- “Lowering speed for a fast rescue craft with its full complement of persons and equipment shall not exceed 1m/s”;
- “A fast rescue boat launching appliance shall be capable of hoisting the fast rescue boat with 6 persons and its full complement of equipment at a speed not less than 0.8m/s.”

For a naval vessel, the launch and recovery sea state limit of ships boats is often driven by the need to use them for fast rescue craft and specifically helicopter guard duties, hence the boats need to be recovered in sea states equivalent and often beyond the operating limits of the helicopter. A compensated davit may be expected to perform in Sea State 6, which is adequate for this purpose. The factors governing safe operation of the davit in high sea states include:

- Pendulum effects causing the boat to collide with the recovering vessel;
- Hoisting speed, too slow and there is a risk of snatching or the boat overturning if caught by a wave; too fast and the acceleration is not safe for the crew in the boat;
- The effect of ship motions on personnel on deck and resultant safety for the deck crew.

The davits are typically single point lift with heave compensation incorporated to control the distance between the boat and the sea surface as the boat is lowered / raised. However, it is also necessary to control the boat to prevent adverse swinging and, therefore, normal operations will involve a bow line being used to constrain the swinging motion of the boat as it is lifted or lowered. This is manually held at the deck of the recovering vessel, typically by deck crew a little distance from the davit location to provide sufficient length and angle in the line to control the boat. Depending on the sea state, this can require a

number of deck crew to control the davit and hold the lines and the ability of the deck crew to safely execute the operation can often become the limiting factor, with operations becoming interrupted, taking longer to perform or ultimately becoming unsafe altogether.

To investigate the pendulum effect, a tool has been developed which provides a simple model of a weight on a line. The model does not include passive or active compensation but it allows the line to be shortened or lengthened to reflect deployment or recovery. The motions of the vessel are modelled using data generated from a seakeeping programme and these are used to excite the pendulum by moving the point at which the line is “held”. Figure 3 illustrates how the diameter of the pendulum swing varies with height above the water surface as a simulation is conducted lifting a weight (for various ship headings in Sea States 5 and 6). The load being lifted is 2.2 tonnes (i.e. a typical RHIB) and the motions represent a davit at approximately midships on a 90m vessel. Additionally, lines representing the horizontal distance of the hull from the vertical origin of the pendulum are illustrated, taking into account the movement of the hull due to roll. These two motions, the hull and the pendulum, are coupled as the movement of the hull provides the excitation to the pendulum as shown in the sketch. Where the pendulum diameter (“A”) exceeds the horizontal distance to the hull (“B”) then this would represent the potential for the swinging boat to “impact” the ship’s side (i.e. where the lines cross, and noting that the distances account the width of the RHIB as 1.5 metres).

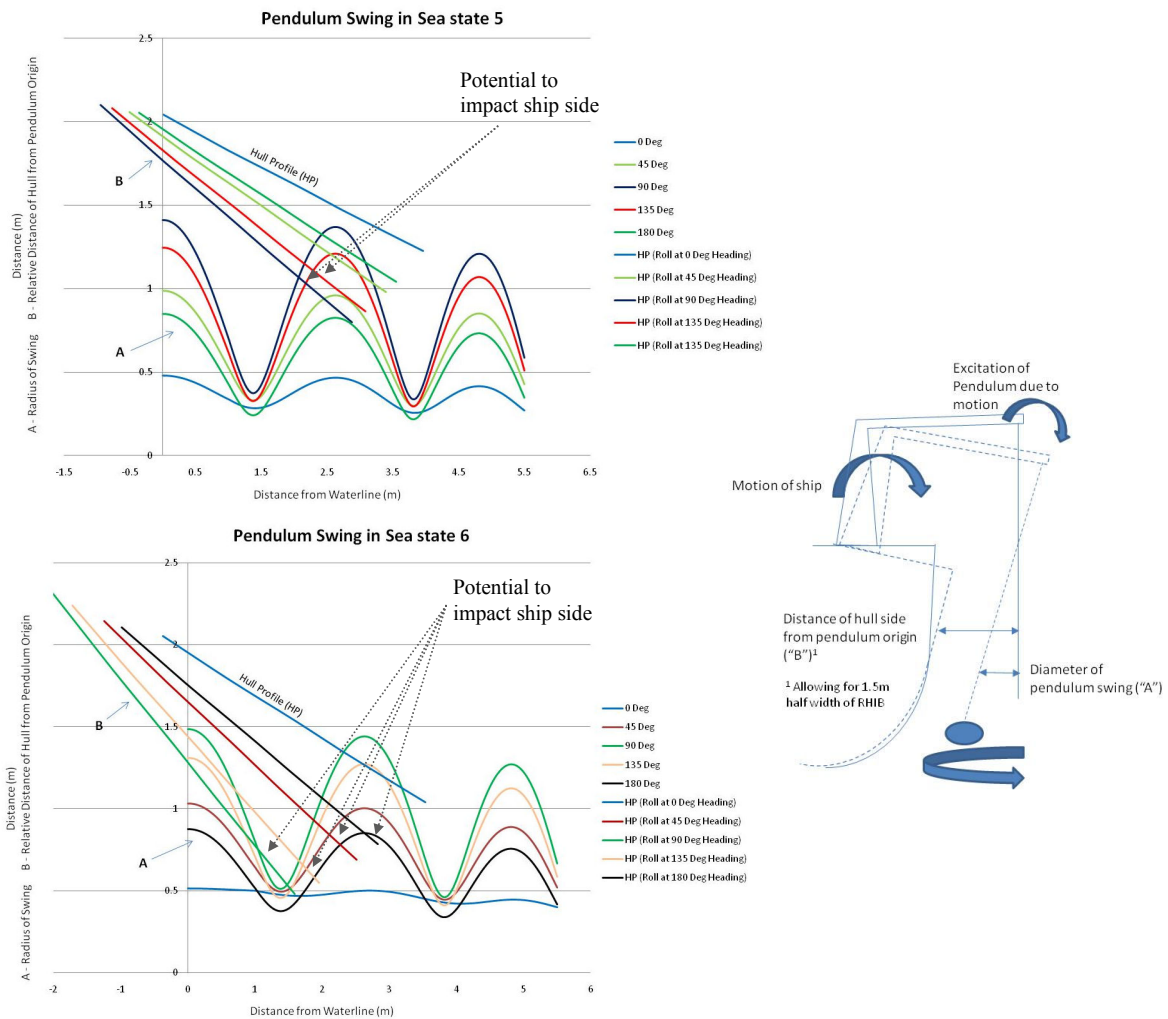


Figure 3 Pendulum diameter variation with height above water surface and ship heading (for a 90m vessel lifting a 2.2 tonne load; bow heading is 180 deg)

These curves illustrate:

- The maximum pendulum diameter occurs as expected for beam headings;
- The least diameter occurs in stern seas;
- For bow headings (as it is more common to recover in headings around the bow as better vessel directional control is possible), the pendulum diameter is greater than stern seas but still provides adequate hull clearance in Sea State 5 and has limited contact in Sea State 6.

As previously indicated, the LSA Code provides both minimum and maximum speeds for the hoisting of fast rescue craft. In most cases, the LSA Code requirement for FRC appliances on Ro-Ro vessels that hoist speed should exceed 0.8m/s should be sufficient for a warship in Sea State 6, although if sea states are required in excess of commercial norms then it should be checked that the boat can be hoisted sufficiently fast to remain clear of the profile of the wave surface.

The analysis also considered the impact of ship motions on personnel. The limits applied were: roll < 4 deg RMS, pitch < 1.25deg RMS, lateral and vertical accelerations < 0.1g. This analysis indicated potential limitations from Sea State 5 for the 90m length vessel considered, and demonstrates that depending on the size of the vessel these may become the limiting factor rather than the lifting appliances.

Stern Ramps

The incorporation of stern ramps in combatant designs became common practise a few years ago and a number of examples exist, most notably the USCG National Security Cutter which also incorporates a gantry overhead to lift RHIB's into the ramp and more recently the DCNS Gowind OPV L'Adroit.

Stern ramps have a variety of geometric configurations and these are explained to good effect in Reference 3 which reported a survey of different arrangements in service. A ramp:

- Will have an angle to the horizontal typically 7 to 12 degrees – a higher ramp aids self launching under gravity but can be harder to incorporate due to the height required;
- The ramp may be shaped to the boat hull or use rails and rubbing strips or rollers to provide protection to the boat and ramp whilst offering a suitable amount of friction;
- The end of the ramp (typically at the transom) will be sufficiently below the design waterline such that the boat will contact the ramp (“ground”) at a point beyond the end. The end of the ramp is the sill and the sill depth is the depth of water above the sill to the design water line.

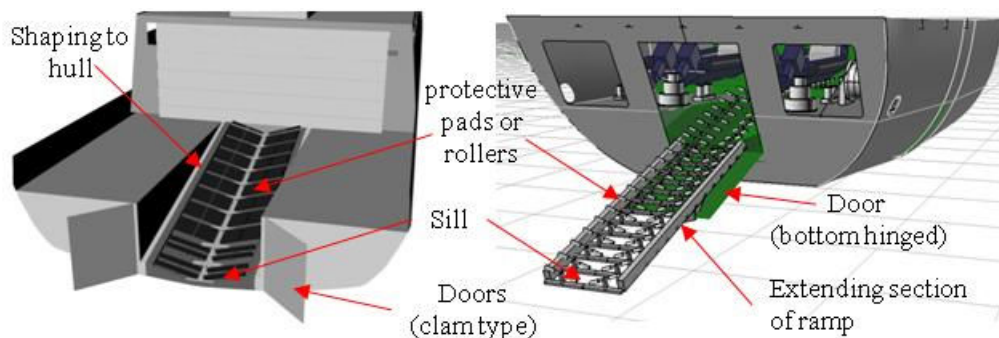


Figure 4 Typical Stern Ramp Geometry (internal left, extending right)

A principle advantage to the stern ramp is the rapid launch and recovery times possible and the reduced deck crew required for operations. From Reference 3 typical launch times that can be achieved are 10 seconds or less and if gravity launched then minimal manpower is required. It is recognised that there are some variations in the methods and procedures used but generally the following applies. To launch, the boat is normally partially lowered but held on a quick release hook such that the propulsors are submerged and the engines can be started (to prevent overload of the engines). The hook is released and the boat will self launch under gravity provided the ramp angle is sufficiently steep. Recovery times are typically 10 - 20 seconds and involve the boats coxswain lining up behind the vessel, then at the appropriate moment driving the boat partially up the ramp under its own momentum. The hook is then passed to the boat to capture it and attached to pull it fully up the ramp and secure it. There may also be doors to close the ramp to the sea. For both launch and recovery, there is no manual handling of the boat by line, other than capture or release by a quick release system. The latter system is an area for development as more automated and safer systems are sought.

The primary limitation in using a stern ramp is the sill water depth. In order to prevent damage to the embarking boat, it should contact the ramp beyond the end such that the boat is “grounded” on the shallow ramp angle. To achieve this, the sill depth must exceed the draught of the embarking boat as it crosses the sill (Figure 5).

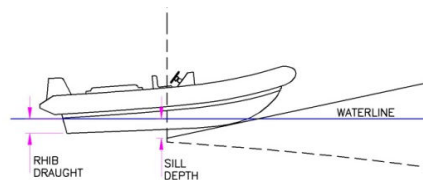


Figure 5 Sill Water Depth

Firstly, as a static geometric problem, the size and therefore draught of the embarking boat defines the sill depth required below the design waterline; the greater the sill depth that can be achieved, the larger draught boat that can be embarked. However, as the depth of the sill increases, this requires a greater transom immersion for the host vessel. This has adverse effects on the performance of the hullform and constrains the allowable propeller diameter.

Secondly, as the dynamic effect of waves is included, the profile of the wave surface combined with the pitching of the host vessel will cause the sill depth to change and the sill may even become exposed. Hence, for a given sea state there is a (reasonably cyclic) period of time during which the ramp is not available as there is insufficient clearance over the sill for the draught of the boat. As the boat is recovered typically under its own power by the coxswain selecting the right moment to drive into the ramp, there is a required window of time defined by the reaction time of the coxswain, time for the boat to accelerate on to the ramp, the actual time to recover on to the ramp plus suitable margins. The availability of the stern ramp becomes a factor of comparing the required window of time to recover against the predicted window for which the sill depth is sufficient in a given sea state (Reference 4 offers much further detail).

An initial analysis conducted on a 90m length concept vessel indicates that the ramp has good availability in Sea State 3 conditions (Figure 6). The ramp availability is illustrated in Figure 6 for a speed of 6 knots for the host vessel, and Figure 7 illustrates that this does not appear to be a significant factor as little difference is observed for 4, 6 and 8 knots

speeds. A minimum and preferable time window has been selected based on interpretations of References 3 and 4, although this would be subject to further consideration and testing. For Sea States 4 and 5, the availability window has reduced and becomes less than preferred and in bow headings is close to minimal. Compared to Reference 1, which indicates similar results for smaller vessels, this shows that the availability of the stern ramp is not (significantly) scalable with vessel size. In fact, as the host vessel increases in size its pitch motion becomes increasingly different to the recovering boat (the latter will tend to follow the wave profile, whilst a larger warship will be close or exceed the wave length and hence the stern motions will become out of phase with the waves).

One aspect that does appear to affect the availability is that as sea state increases, the associated wave period is also assumed to increase resulting in the sill remaining immersed for a longer period. This results in the plots for Sea State 4 and 5 in Figure 6 being much closer than that for Sea State 3. However, whilst the results for Sea State 4 and 5 have similar availability times, the larger amplitude of the waves in Sea State 5 will result in a faster change in the water depth and the wave travelling further up the ramp. In Figure 7 it can also be observed that the plot is shifted aft, an effect of the increased wave encounter frequency for bow headings due to the forward speed of the vessel. These results are clearly sensitive to the environment modelled and the behaviour of the ship, neither of which has been explored in detail here.

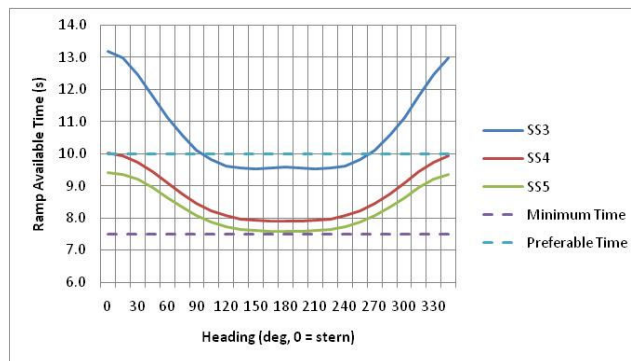


Figure 6 Stern Ramp Availability (90m concept design)

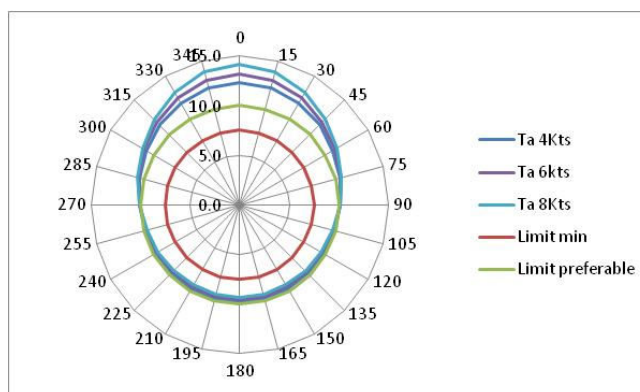


Figure 7 Ramp Availability Time (s) versus heading (degs) and ship speed (kts)

A further complication is the embarkation of unmanned vehicles. If stern ramp recovery is achieved by the coxswain selecting the correct moment to embark based on judgement of the sill depth variation, then doing so remotely will be more challenging. A more autonomous approach using motion prediction combined with accurate relative position systems would offer a solution without the human in the loop judgement. However, such

systems require analysis of the highly complex interactions of two different vessels on the sea surface ideally in Sea State 4 and beyond. Such systems will require significant research and testing and are currently beyond the Technology Readiness Level (TRL) to be suitable for the vessels currently being developed.

In the case of UUV recovery, as these vehicles are slow in comparison to a RHIB (circa. 4 kts typically), the recovering vessel will either need to stop or proceed at very low speed and would hence suffer from poor controllability. This can in part be overcome if a drogue system is used. In this case the UUV is captured by a drogue which is deployed and towed behind the recovering vessel. Once captured by the drogue, the UUV can be recovered at higher speed by winch rather than under its own propulsion. Whilst the UUV still has to catch the drogue, this can be achieved by paying out the drogue cable to reduce the relative speed of the drogue, whilst allowing the ship to proceed at a suitable speed.

Mission Bay Areas

In order to fully realise the potential of offboard vehicles, manned or unmanned, the host vessel needs to carry a number of vehicles, potentially different types and to be able to select and launch / recover the appropriate one without significant material handling.

Without entering the operational requirements domain in any detail, it can be considered that a future reconfigurable combatant could require:

- Two or four mission boats to conduct constabulary tasks or USV's for MCM;
- At least one ship's boat to allow helicopter operations to continue when mission boats are deployed;
- Two large UUV's to conduct underwater reconnaissance;
- Potentially tens of single shot type UUV's for MCM disposal.

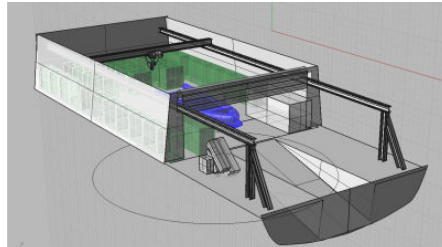


Figure 8 Mission Bay Arrangement (Reference 2)

The sensible conclusion is that a “garage” or mission bay area is required in which to store, configure and maintain all these vehicles in a protected environment (Figure 8 illustrates an example arrangement). However, with RHIB's now expected in the range 8 to 14 metres for some roles, the mission bay has to be of significant size and have a required height of approximately 6 metres or 2 deck heights to both stow and move items. The method of movement of vehicles from stowage to deployment and back also needs to be considered. The ability to handle vehicles and boats needs to match the aspiration for operating limits, e.g. at least Sea State 4 but ideally 5.

In Reference 2 a range of options were considered and in summary:

- Gantries are the most flexible and could move loads throughout the garage area; however, they may require greater deck head clearance and as the load is subject to pendulum forces, higher sea states will be more challenging;

- Using rollers or tracks on and in the deck offers the potential for safer movement in higher sea states, but are less flexible as the handling routes are defined and will incur a maintenance burden;
- Skidding also offers greater control in higher sea states, but obviously will require management of the surfaces due to wear;
- A combination – for example rollers transversely to move large items like boats, combined with a small gantry for lighter items such as UUV's.

A significant issue for the ship designer is the incorporation of a large mission area into the design. The structural integration into the main strength planes of the ship, the self supportability of the enclosing structure of a potentially large open area and also fore and aft access all need to be considered. Figure 9 illustrates the potential problems to be considered, where the garage in this case is two decks high and results in a structural arrangement where the fore and aft deck integration cannot be easily achieved and careful consideration is required around the discontinuities.

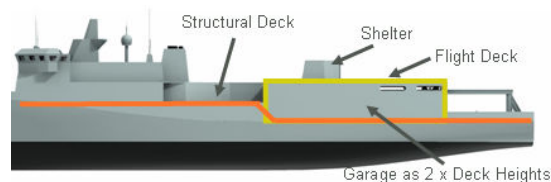


Figure 9 Garage and Flight Deck details

POTENTIAL SHIP SOLUTIONS

Initial concepts for host type vessels, such as in the USN LCS classes or as illustrated in the BMT Venator concept in Figure 10, utilised a stern ramp and mission bay. However, as described the stern ramp operability does not scale with size and the resulting sea state limits are below the aspirations. The further complications of recovering unmanned vehicles make the choice of a stern ramp much less attractive.

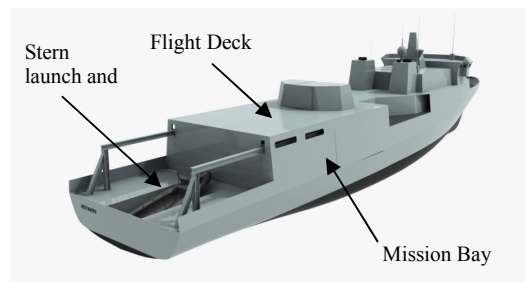


Figure 10 Concept With stern Ramp and Aft Garage

An alternative is to adopt a midships mission area utilising davit launching to either side. In the illustration in Figure 11, the mission bay area is located further forward in the same concept in order to utilise davit or crane systems amidships. As a result, the flight deck is now aft and lower from the original concept. However, the mission bay area is now in the prime midships region of the ship, requiring accommodation and operational spaces in the superstructure to be pushed forward. Access between the forward superstructure and aft of the mission bay is also difficult to arrange. This solution would have similarities to those adopted in the offshore industry where ROV and research ships adopt a similar arrangement. However, it is notable that these ship tend to have larger superstructures to accommodate the living areas of the ship forward of the working deck and as a result they are larger beamed and heavier displacement than warships and OPV's of similar length.

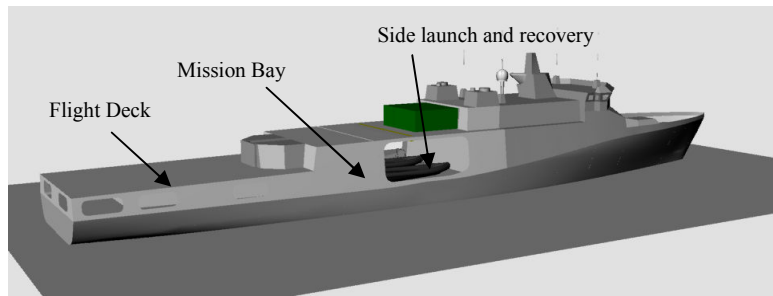


Figure 11 Concept with davits and midships garage

A further alternative is a mix of launch and recovery solutions, as proposed in the “Securitor” solution (Figure 12, Ref. 5). Here, the boats or vehicles are carried in side openings and launched and recovered via davits. However, the design also featured a small “dock” (although a stern ramp is equally applicable) allowing one boat or vehicle to be ready for more rapid deployment. The key reasoning in this concept was the expectation that boats or unmanned vehicles may be expected to spend much more time deployed as endurance is improved. Hence, once carried into theatre the host vessel becomes more of a support vessel. In many instances, more modest sea states would prevail and a floodable dock would allow refuelling, crew transfer and some maintenance operations to be conducted without lifting the vehicle out of the water.

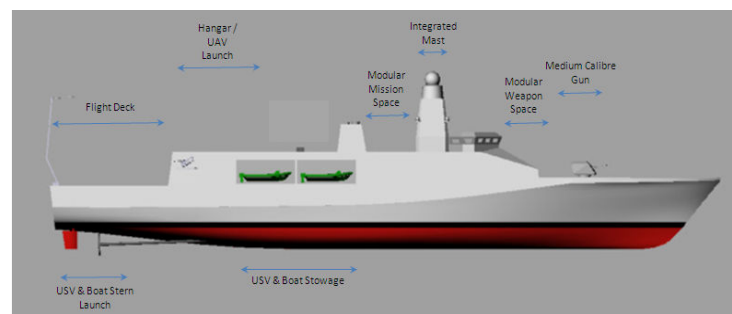


Figure 12 Concept with both stern ramp and davits

CONCLUSIONS

The inclusion of a stern ramp has advantages in terms of deployment and recovery speeds, but ultimately a stern ramp lacks availability in the higher sea states in which a davit is still capable of operation. The stern ramp availability is driven by sill depth and pitch motions, whilst a davit needs to consider a range of constraints associated with the environment, including pendulum effects, hoisting speed and the safety of deck crew.

Hence, a vessel designed to operate in benign to moderate sea conditions and requiring rapid boat response times may be appropriate for a stern ramp, as illustrated by their use mainly in coast guard and smaller patrol vessels. A vessel operating in higher sea states such as offshore environments, including conducting MCM and environmental assessment may select davit arrangements, accepting the increase in handling procedures to gain a greater environmental envelope. A flexible, multi-role naval vessel is therefore likely to err towards the later, because of its greater flexibility and sea state envelope. A mixed solution may offer a compromise between these but suffers from the need to find space for both systems and requires training to cover several deployment methods, although the rapid response would be beneficial when operating in constabulary missions and may be an advantage to consider. In this case, the stern ramp is the secondary method of deployment and the mission space would be located midships with the davit system(s).

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