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Trends and Technologies Applicable to Ship Delivery Projects in Canada

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By

Simon Timms

Trends and Technologies Applicable to Ship Delivery Projects in Canada

Abstract / Summary

The paper addresses the observed trends and new technologies/developments applicable to major ship delivery projects for the future in Canada. It identifies some of the trends and technologies that have been included elsewhere in the world and can be expected to be required for future major ship delivery projects in Canada. In addition trends and technologies from ongoing major non-marine capital projects will migrate where applicable to future major ship delivery projects. Evolving environmental requirements add additional requirements which will drive the adoption of new technologies which will impact the engineering, procurement, construction and maintenance/operation of future major ship delivery projects in Canada. This will impact evolving policies for future major ship delivery projects in Canada and will need be considered as plans evolve and hopefully projects start to get implemented.

Introduction

Recently much has been said about the need to ramp up Canada's marine and ship construction/erection industry from a period of inactivity in preparation for the growth in Government ship demand for both the Navy and Coast Guard plus other users.

Since the last major programs of the 1980s and 1990s in the Canadian shipbuilding industry, with the building of CPF and MCDV for the Navy and last significant Coast Guard build, much has happened in the world wide shipbuilding industry and related industries that can provide technology. This is especially true for significant ships of notionally a lightship displacement greater than 600 tons. This paper attempts to address these developments and how they will impact the ramp up.

The recent CADSI report of a year ago started this and is commended. But it must be recognized that for new construction the report was based on the last major activity in Canada such as the CPF project of the 1980s to 1990s, as a function of the way the report was structured and its mandate. Since then trends have occurred around the world which will impact the ramp up and to-date do not appear to have been considered, but do need be considered if value for money is to be provided to the Canadian taxpayer.

The impetus for this has recently been confirmed with government announcement of a new strategy on 3 June 2010. This is welcomed, but it is only a start. There now needs be a speedy application of sound technical and business principles as the strategy is fleshed out and the necessary corrections are made to some of the details. This paper hopefully contributes to this process.

Applicable Economic Environment

As we move forward beyond 2010 we must consider the economic environment in the world and Canada.

Oil has risen over the last decade to over 120 dollars per barrel fallen to 30 dollars a barrel and now sits at greater than 70 dollars and rising, as shown by the futures market. If such an environment had of existed in the early 1980s the decision by the government/Navy to reject consideration of any form of waste heat recovery when approached by the CPF designers might have been different. Points then made such as oil at 35 to 40 dollars per barrel being temporarily high and not being able to accept additional complexity to reduce pollution beyond known regulation would probably not be now made.

The world is concerned about carbon emissions, global warming, and discharges by the world's marine fleet including Government of Canada vessels. This is demonstrated by the world reaction to the massive oil discharge into the Gulf of Mexico. It is no longer politically acceptable for new Government vessels from countries such as Canada to claim exemption from world pollution requirements. Owners including governments are willing to spend dollars on pollution control systems that are reliable such that there is low risk of legal action or political embarrassment. This economic acceptance has led to regulations such as IMO III emissions, ballast water treatment, efficient collection and treatment systems etc being implemented.

Commodity prices in North America have fallen and then risen to the point where those that are heavily driven by raw material costs (e.g. copper and copper alloy tube/ steel pie and tube) have almost returned to levels of two years ago and those that involve a significant manufacturing element (e.g. plastic pipe and fittings/ industrial metal valves) have already passed those of two years ago. The majority of forecasting agencies are predicting the recent rises will continue. Thus there is a return to the era of issues of resulting pricing increases impacting government ship affordability when the budget is set in fixed dollars as seen two years ago. The opportunity to take advantage of reduction in prices has past especially when the time for government to get contracts in place is factored in.

With the recent economic downturn and trends in the Far East, there has been an increasing use of the established Far East countries such as Korea and new entrant countries such as Brazil to build ships of sophistication e.g. offshore supply vessels. The construction of less sophisticated ships e.g. bulk cargo ships, has started to occur in lower labour rate, less traditional shipbuilding far east countries e.g. Vietnam and China. Within Europe there has been a trend to have the less complex portions of the ship built in lower labour rate countries within the enlarged European Economic Union e.g. Romania and Poland. This is not confined to commercial or low-end ships as proven by the Netherlands with the Johan de Witt and new JSS with the construction of the less complex bow and stern sections in Romania or the bulbous bow section for the Queen

Mary 2 being built in Poland and then being shipped to France. Any loss in industrial benefits being more than offset by these countries need for high technology products in other economic sectors.

Country/Geographic area	Average burdened rate for shipyard/ erection facility industrial worker per hour
Less developed Far East	$5
China	$8
Eastern Europe	$16
Developed Far East	$23
North America	$55
Europe	$60
Note rates used are an average of at least five facilities in all cases and reflect one definition of what should be included in the burdened rate, but will vary from project to project and data should only be used for comparative purposes.	

As can be seen from the above and labour rate comparison, Canadian ship erection facilities will not be commercially cost competitive. Thus the Government or owner must have other reasons or policies for ship erection work to be done in Canada. As a result for planning purposes no commercial work for vessels bigger than 600 tons light ship can be expected in Canadian shipyards other than a small amount of opportunistic activity or owner mandated activity – this small amount will easily be taken up with natural flexibility. Canadians trades will not accept work for $10 per hour and are better employed in high technology higher value added workplaces with a better environment. This points to a need to adjust the build in Canada shipbuilding policy to be less encompassing with respect steel structure and not ignore the other parts of the marine value chain such as design and systems. By allowing some low value steel structure elements to be built offshore it will encourage offset arrangements to occur for high value added elements where Canada wishes to take its economy and if proper encouragement occurs achieve a significant multiplier effect. This will improve value to the Canadian taxpayer and make the right areas of the economy more competitive.

With the economic environment changing as a result of the information age and cross border data highways there have been significant changes in other engineering sectors and these are migrating to the marine industry. For example the ability to do computer software design and support it around the world, including with coding/production facilities and call centers in India, has migrated to the ship design world with multiple design offices around the world being able to work on a ship design connected by a data highway and only the project engineering of top level engineering control being held locally (e.g. T-AKE where major elements of detailed design were done in Maine, Quebec, Romania and Spain with control from California). The Canadian ship design community needs embrace this concept and develop practices to manage this process plus use this upcoming ramp up to develop niches that can be exported on non Canadian projects.

The globalisation of trade and technologies has meant that one technology is used in many areas to be economically cost effective and increase volumes. This has been and will continue to be true in Canada’s marine industry as proven by the use of; gas turbines in the 70s and beyond (from the aircraft industry), data highways (SHINPADS /SHINMACS) in the 80s and beyond (from the electronics industry), plastic piping in the 90s (from the petrochemical industry) and this century the above mentioned dispersed design offices as examples.

In order to take advantage of these trends future Canadian government ship designs will need use international standards focused on functional requirements tailored to the Canadian specifics rather than Canadian proscriptive specifications. For example if the proscriptive Canadian control specifications from the DDH 280 had of been demanded for the CPF there would have been no IMCS using data busses and a world leading Canadian industry would not have been created. The need for change in this area is illustrated by based on a sample of three ship designs ongoing today in Canada for the government (Navy and Coast Guard) the number of proscriptive customer requirements is a factor of four times greater than that of comparable foreign projects. This directly increases both in implementation and in service costs. It limits the use of COTS and in some cases creates obsolete equipment the moment it is delivered.

Trends in New Build Process

The use of modular pre-outfit started in Canada with the CPF has increased around the world especially for ships that cannot be built as a whole and lifted e.g. 500 tons at lift and 600 tons lightship once additional items are added. This allows economies of scale to prevail, reduced wasted hours due to access constraints and advantages to be taken of better computer systems discussed previously.

In this regard, the unit of measure for this aspect and metric for decisions on ship construction/erection should be light ship tonnage. It makes no significant difference to the ship construction process and economics whether a fuel tank is full at the deep departure condition or used as a stripping tank and filled as other tanks are used/emptied. Similarly whether a store room is empty or full makes no difference. What makes a difference is the amount of structure, piping systems, cabling and outfit and whether these are in the pre outfitted modules (or complete ship if small enough to be lifted) as measured by the light ship weight. Thus it is suggested the metric used in determining breakpoints in any Canadian ship construction / marine industry strategy should be light ship tonnage or equivalent.

Coupled with the use of modular pre-outfit, more and more modules, skids, and sub assemblies are being built outside the yard or ship erection facility. Facilities are using the same cost effective efficient techniques being used for other industries to increase economies of scale and take advantage of intrinsic economic advantages e.g. lower labour rates, cheaper power, etc. This is illustrated in the below trend and graphic for Canadian naval vessels but equally applicable for Coast Guard and other government vessels;-

- In the 50s and 60s – building the DDEs - the steam boilers and many other elements of the propulsion train were built in the yard by specialist boilermakers a trade that no longer exists in shipyards.
- In the 70s – building the DDH 280s – the GT engines came from outside the yard built at aircraft engine facilities, but the main machinery raft was built in the yard, and auxiliaries were individually assembled in the yard.
- In the mid 80s to mid 90s – building the CPFs - the engines and rafts came from outside the yard at specialist facilities building the equipment for other industries as well, but auxiliaries were individually fitted in the shipyard.
- Today on ships such as Type 45, T-AKE, LCS, F125, FREMM etc, complete tested skids with auxiliaries and engines are delivered to the yard.

As a result of this, outside Canada ship erection facilities target 70% pre outfit of modules prior to placing on the slip or in the dock for large first of class ships of greater than 600 tons light ship and 80% for follow on ships. The average rule developed by the Rand Corporation is that what takes 1 hour while the module is being built in the module assembly area will take 3 hours on slip or in the dock when the module is partially open and 8 hours if the task is done on the assembled vessel while afloat. This especially applies to electronic systems where products such as modular masts completely pre outfitted are being introduced.

All of the above has reduced the value added as a percentage of the ship cost being spent in the yard/erection facility. For the type 45 destroyers in production in the UK, it has been quoted that less than 15% of the ship cost is spent in the erection facility in labour and minor materials directly purchased by the yard. Modern erection facilities in Europe are quoting a value of less than 25% for less sophisticated Offshore Supply Vessels without specialist equipment. This represents a significant movement from the 30 to 45% quoted in the CADSI report based on CPF/MCDV and technology of the 1980s and 1990s.

Further dispersion is occurring from the final erection facility with on many projects a large number of modules being built at different yards and shipped large distances. For example for the Australian Warfare destroyer (AWD) 70% of the modules will be built at a different facility than the erection facility. For the new United Kingdom aircraft carrier (CVF) no modules will be built at the erection facility in Rosyth, Scotland. Similar principles apply to ongoing builds in Germany, Italy and France.

All of the above has been made possible with the advances in computer technology and systems. Modules in the pre-outfitted form can be expected to match and no longer is "green" material added to be later removed to get a match. In summary, computer data bases are moving the work away from the slipway or dock bottom to the offices plus factories around the country and in some cases offshore.

This trend has increased the importance of managing the supply chain to the erection facility, ensuring correct configuration control and project engineering, scheduling the various facilities activities and overall project planning. This is similar to that which has occurred on other big Engineer, Procure and Construct (EPC) projects such as building power stations, refineries, airports and other similar projects. As a result, techniques associated with having a prime contractor focused on the overall ship delivery have been adopted especially for large projects of approximately greater than 200 million dollars where there is a high complexity due to design or small numbers. This is foreseen to be the case for all new Canadian vessels over 600 tons light ship. The prime may be the same commercial entity as was the case on the CPF, but even in these cases it operates as a separate unit in a separate facility such that the erection facility can focus on the erection activities and the prime focuses on the overall ship delivery project leaving each facility to worry about its detail; or a totally separate commercial entity as was the case on MCDV. Due to the increasing importance of integration across distributed facilities, the later appears to be growing especially where small numbers of ships and first of class builds are involved as identified by the LCS project, AWD, CVF, F125, FREM etc.

Importing non Traditional Marine Technology

Given the recent inactivity in the Canadian shipbuilding sector for large government projects, as the ramp up occurs it can be expected technologies developed over the last 20 years from other Canadian industries will be adopted as well as those from abroad.

One candidate industry to supply this technology will be the oil industry both onshore and offshore. Areas such as those developed to supply prepackaged skids and modules fully wired and plumbed will be at the fore. Prime contractors as identified previously will be looking for suppliers to do this such that total project implementation costs (supplier plus shipyard costs) are reduced. The impact of tight ships on overall project costs is now better understood especially when input from industries such as the oil industry is considered. A look at the density of equipment on the CPF and comparing it with the FREMM, Type 45, and F125 clearly illustrates the point where primes have reduced the overall project cost by having a bigger ship and reducing congestion.

The co-generation power industry will also supply technology especially with the move to diesel electric plant. The facilities developed to build the equipment for this industry can expect to be involved in building systems for the ships.

As is now done for oil and power facilities purpose built pipe manufacturing facilities supplying many industries can expect to be used for all or a significant percentage of piping manufacture rather than having it all done in the yard. This is facilitated by the use of increased computer technology in the detailed design and the resulting ease of transmission of data between facilities. A similar principle will apply to pre-lagged HVAC ducting using practices from the construction industry. This has recently been proven in a large US yard which no longer makes any pipes or ducting within its facility and with the computer technology used has increased the quality plus on time delivery to the module pre-outfitting stations.

Using technology from the heavy truck industry and other heavy industries, increased use of pre-assembled cabling looms and cables can be expected for new construction. With technology such as DITMACO or equivalent, increased quality over that previously seen in shipyards in the last century can be expected.

All of the above will significantly impact labour relations and management practices but will be a condition of the ramp up occurring. It will also contribute to changing the skill mix required in the erection facility and further contribute to a reduction in value added at the final erection facility.

In addition from several industries there will be an introduction of an increased emphasis on the total systems to achieve the overall customer requirements. This can be seen on recent ships from Europe where government ships are as well appearing with slab sides that are easier to produce rather than looking right to traditionalists. E.G. if a hull has a 1% increase in resistance to make it cheaper to build and allows a 3% increase in propulsion efficiency due to better intake and exhaust arrangements then it will be done as was done on a recent European patrol vessel.

Segmentation– New Build versus Repair & Overhaul– Type of Construction

A. With the trends described earlier there has been a separation of the requirements for the facilities and staff involved in new construction/ship erection compared with repair including major refits such as Halifax Class Modernisation (HCM).

The erection element of new construction requires-

- Pre outfit with as big as possible modules with plenty of space around the modules in covered module assembly shops to facilitate pre outfit.
- Space for lifting gear, turning gear and large cranes/movers for modules.
- Space to park modules to provide necessary flexibility.
- Large paint and blast facilities preferably for completed modules as part of PO-1.
- Slips or floating platforms that are lowered infrequently but occupied for a significant period of time.
- High flow rate of steel with facilities such as panel lines that handle wide plate.
- A lower skilled work force as little diagnostics are required and work such as welding, installation of piping and cabling is set up for ease with many repetitive tasks.
- Can be located well away from operation bases as final delivery fuel is small fraction of cost.
- Significant capital to labour ratio.

On the contrary the major repair and refit facilities require-

- Limited amount of wharf space for berthing and floating dock or dry-dock that can be quickly operated repetitively.
- Sophisticated pipe shop such that one off repairs and cleaning can be accomplished.
- Sophisticated electrical shop such that one off repairs and calibrations can be achieved.
- Limited one off small size plate and paint requirements frequently required to be portable to the ship alongside.
- Flexible skilled work force to perform diagnostics in many cases, work in constrained workspaces on high variety of tasks, e.g. much welding will be in less than optimal conditions.
- Should be located as close to operational bases as practical such that crew and fuel costs are reduced.
- Low capital to labour ratio, but access to significant skilled labour is key.

The difference in requirements is well illustrated by the fact that even in Western Europe where land is expensive the smallest significant government endorsed erection facility is significantly larger than any facility in Canada presently doing repair and overall work. In addition because of the location needs these Canadian facilities cannot expand as they are located in urban areas where all surrounding land is at a premium.

As a result of the difference in working practices and philosophy used to plan and estimate tasks when costs for the same tasks in the ship erection process are compared it has been proven that a significant difference exists. The yard used to doing repair and overall/refit tasks as the bulk of its work will estimate a cost over 50% on average more with some tasks being three times as much. This can be explained by the fact the mindset in planning and estimating does not allow for practices such as turning the deck upside down so that down hand welds occur and cables can be laid in, also difficulties of access are assumed and not designed out.

Thus while both facilities form part of the marine sector; for reasons of technology used, skills of the work force needed, location requirements, providing best value to the customer for ship construction/erection they can be considered different segments of the market. Where allocation is being considered, to provide value to taxpayer those yards doing repair/overall work should not be eligible to be allocated large ship construction work and vice versa.

B. Within the new construction segment there is a point at which the advantages of module pre outfit are not significant and it is possible to build the vessel as a complete unit and then launch or crane in as a cost effective process. The exact size at which this transition occurs will vary dependant on the facilities available and the processes used. Based on a review of practices available in Canada allowing for the weather and available infrastructure it is suggested that this break point is approximately 600 tons of light ship.

With the processes used for smaller vessels the differences between repair and construction activities are reduced. This especially applies where modular building is not used. There is a reduced need to handle big modules, large plates, and have space for flexibility. In addition the economies of scale from outsourcing become less and in some cases the additional cost of running outsourcing may not be offset. Thus from a technical and business standpoint repair facilities could be considered in the same segment as the small vessel construction activities where labour resources were available.

C. On the basis that distribution across regions is required amongst the large ship (> 600 ton light ship) erection facilities then segmentation into equal portions such that each yard can be viable is necessary. This should logically be done on the basis of technology and skills required such that applicable centers of excellence are established. It being understood that little help in this area from purely commercial work can be expected as explained previously.

Segmentation within the large ship construction segment on the basis of technology and complexity would lead to one facility focusing on complex ships and another focusing on less complex ships. Complex ships would include warships where the combat system forms a large percentage of the value added and there is a high cable density; in addition it would include specialist scientific vessels which have radiated noise requirements, high laboratory and cabling requirements/value added and thus significantly vary from ships built to pure commercial standards.

Less complex ships would include vessels that were built to a commercial classification society with little tailoring. It would include patrol vessels such as coast guard vessels and icebreakers for which the electronics form a lower percentage of the value chain plus patrol vessels operated by the Navy in a constabulary/low threat environment (sometimes called non combatants by naval operators) where the combat/C3 system forms less than 10% of the value added and to reduce cost commercial classification society rules are used.

Such a segmentation or allocation would create one centre of excellence for vessels with high cable density, complexity and systems integration and another where the focus was on efficiently producing to commercial classification society requirements. The exact division point would be set to balance the work and ensure each allocated facility was viable and could justify the necessary investment.

Pollution Control Needs

One significant increasing area that will impact all segments (large ship construction, small ship construction and repair/overhaul) is pollution control and minimization. This is especially true in Canada with the impacts of global warming and resulting increasing traffic in the ecologically sensitive arctic waters.

Such a trend in Canadian government vessels is not new. For example when designed, the CPF was the most advanced warship in NATO with respect to minimizing polluting emissions. It was the only NATO warship delivered in the 1980s that could treat effluent continuously to meet inshore requirements, including the upcoming St Lawrence river requirements eventually introduced at the turn of the century. This trend was continued in the MCDV, which had pollution control features not seen in other country inshore patrol vessels, Naval or Coast Guard. This illustrates the continuing trend of Canadian government vessels being designed to not just meet the regulations of the day, but planned and expected regulations, even though they could be grand fathered to just meet the current regulations.

There is thus a challenge and opportunity for ship designers and suppliers to the upcoming ramp up of Canadian government vessel new construction. The customer is willing to pay for these advanced systems because the Canadian public expects this and the requirements of the waters where the ships will operate. This impacts the costs of the ships and percentage spent on pollution control systems. For example based on current requirements for AOPS more dollars will be spent on the collection, control, monitoring and treatment systems associated with pollution control than will be spent on the external hull and core structure.

A trend that will probably be adopted from the cruise and other commercial shipping industry is the use of total energy balances, carbon emission assessment and polluting emissions for the complete vessel. In this manner dollars are best spent to bring overall total emissions down.

In addition, industry and operators will be looking for techniques to achieve two objectives with one action. For example with growing fuel costs there will be pressure to simultaneously reduce the size of the engines by better total ship efficiency which results in lower capital costs and less emissions including carbon dioxide. For this reason added impetus can be expected to look at evolving techniques that both improve the hull efficiency and efficiency of the propulsion system. Where trades need to be made between the two, prime contractors will be expected to address the total ship impact as a system, not just the marine engineering or the naval architecture impact in isolation.

Pollution control is impacting all areas of ship design and construction including those not previously considered such as coatings on the hull, materials used internally, microscopic organisms that are not harmful but different, and off-board acoustic pollution. Given the above identified points techniques used on future Canadian government vessels can be expected to lead the way in these areas.

Pollution control will not just impact the ships it will also impact the facilities used to build and support them. Airborne emissions requirements for shipyards are starting to directly impact operations in manners not previously seen. Groundwater contamination or potential contamination is impacting operations. Additional facilities are needed to deal with what if scenarios or potential accidents. Pollution releases are frequently the way the public hears about mishaps and assesses the performance of the industry.

Way ahead

An analysis of the new building requirements expressed in the CADSI report and reaffirmed last week in the National Shipbuilding Procurement Strategy (NSPS) development release, coupled with the developments identified in this paper, shows a need for two large ship erection facilities in Canada. This assumes a balance between the two such that they are both viable and they have sufficient size to bring the necessary economies of scale. It addresses the need for some regional distribution with facilities that of the size accepted by the public as typical for large but not monopolistic ship construction/erection facilities.

By limiting the large ship construction facilities to two, other facilities can be used for repair and overhaul such that facilities are developed and recapitalised in an optimal manner to suit the segmentation and role. This results in a further regional distribution of the industry and location where the user requires it. It ensures that optimal economic and technical principles apply given the other constraints.

Based on the analysis, smaller ship construction can occur at facilities performing repair and overhaul with acceptable economic metrics. Analysis shows a need for three or four facilities capable of performing major vessel repair/overhaul/refit work of major federal vessels if that is their specialty and this would increase if these facilities also built small vessels.

The majority of foreseen provincially regulated vessels are covered by the small vessel category and the other few larger vessels can easily be addressed by the built in slack in the system.

As we move forward in the ramp up, there needs be full and open dialogue from all in the marine industry because with the changes in the value chain the shipyards have become an erection facility. This is still vital to the success of the marine industry but it is not the major or dominant element. In short, 15 to 25% should not drive the 85 to 75% it should be the other way around. With the creation of several major contributors all of which are important the need to integrate the elements is becoming more dominant and this applies to not just project implementation but how the industry influences change.

During the ramp up there will need be an adoption of new technology from abroad and other industries. This will require flexibility by all in the industry; suppliers, shipyards, integrators and labour force. The pace of change will continue and new technologies will continue to be required by the Canadian Marine industry as the ramp up occurs. For example when module construction was adopted for the CPF change did not stop, there was continual improvement with larger and larger modules being produced.

There will need be an acceptance that the need for pollution control systems is here to stay and will grow both in quality of performance and areas addressed.

Conclusion

The planned ramp up in the marine industry of Canada to meet the federal government need for new ships presents many challenges and opportunities for all parties. The recognition by the government in the need to develop a strategy is welcome, but much work remains in the implementation and as the proverb says "the devil is in the detail".

In developing the detail, economic trends and new technologies must be allowed for, including changes in the value chain and resulting changes in processes for managing ship delivery projects. The new technologies and economics directly effect the segmentation with the ship construction and repair sector of the marine industry and the planned allocation with relevant constraints must reflect this. E.G. segmentation and allocation of large ship construction to different facilities from those allocated large federal ship repair/refit overhaul; balancing splits such that economically viable clear centres of excellence are created; setting optimal break between large and small to reflect technologies employed.

New technologies such as the information age and increasing use of computers are impacting the marine industry and need be reflected in the implementation of the strategy. Pollution control requirements are here to stay and will increasingly impact the marine industry in Canada.

Government must be open to input from industry on these new technologies and their impact on the strategy they are developing/implementing, as at the end of the day it is industry that must do the job. Where required government must amend its strategy and regulatory regime (e.g. minor changes to the build in Canada policy) to allow the Canadian marine industry to deliver the ships and economic benefits to the country in an optimal manner.

It is hoped that this paper has assisted in the starting of development of the details of the strategy such that Canada's marine industry can start to grow again on a continuous basis without future boom and bust cycles.