Realistic Timeframes for Designing and Building Ships

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One of the most misunderstood issues surrounding any consideration of fleet renewal is how long it takes to design and build warships. Many Canadians complain that it takes too long. And from a public perspective, this seems to be the case but unfortunately these complaints reveal a lack of understanding of how challenging it can be to forecast fleet requirements and how complex the engineering task actually is. Moreover, the service life of a warship is typically 35 to 40 years in Canada. With a destroyer or frigate now costing in the range of $1 billion, we should expect the government to insist on a comprehensive consideration of the mission requirements and a full investigation of the range of technical solutions. Warships are a huge investment.

Now that Canada has adopted a national strategy for renewal of the navy and the coast guard, it is important to have realistic expectations on the time it takes to design and build ships. Why does it take so long? I will attempt to answer this question.

Building modern warships is a major national technological achievement. A warship is a complex entity, it is a system of systems, self-contained like a spaceship. In addition to their complexity, warships are designed and built in such small numbers that even the first ship must work right the first time. There is no room for error. The financial consequence of failure is very high, not to mention the risk to national security and reputation.

Canada has renewed its fleet three times since the end of World War II: the *St. Laurent*-class of ships which were destroyers built in the 1950s; the *Iroquois*-class of destroyers commissioned in the 1970s; and the Canadian Patrol Frigates built in the late 1980s/early 1990s. Other than these three occasions, national support for the defence shipbuilding sector enjoyed brief periods of high rhetoric, but little long-term government commitment. Canada's experience is that major warship projects take longer and cost more than originally conceived, but in the end the navy receives highly capable ships. Canada developed a good reputation with the Canadian Patrol Frigate (CFP) project, and the ships have received positive international recognition.

A Chief of Review Services Report on the CPF project in 1999 noted that the cost of the frigates was 10% above a notional free-market price but the class exceeded many of the performance characteristics of similar multi-purpose

*HMCS **Iroquois** (DDH-280), launched 28 November 1970, moored at New York Cruise Terminal in 2009.*

frigates. What is *not* made clear in the report is that it took 20 years to get the first CPF into the fleet, and the requirements and strategic context for the ship had changed by the end of the project. For example, the government originally envisioned a 24-ship project but it ended with 12 ships.[1] As well, the frigates were designed for the Cold War, but between the commissioning of the first ship in 1988 and the last ship in 1996, the Cold War had ended and the exact role of the ships was evolving.

As noted, the government has announced plans for the next renewal of the navy and coast guards fleets – the National Shipbuilding Procurement Strategy (NSPS). Nova Scotians celebrated in August 2011 when it was announced that Irving Shipbuilding in Halifax would be the supplier for combat vessels for the navy. The mood is more sombre today. When Prime Minister Stephen Harper announced the government's intention to build a fleet of vessels to patrol Canada's Arctic waters – the Arctic and Offshore Patrol Ship (AOPS) – in July 2007, a contract was supposed to be awarded in May 2009, with delivery of the first vessel set for 2013. An announcement was made in March 2013 that the design contract for the AOPS has been signed. The delivery of the first vessel is now planned for 2018 and it will be a while before any ship construction starts.

The AOPS project is following the pattern of history whereby political considerations set the direction and pace of progress in large defence projects. The magnitude of the investment weighs heavily on political decision-makers who introduce requirements for distribution of work and Canadian-content in the attempt to ensure that taxpayers receive the best value.

Ship design and build activities take long enough, so when delays occur the reaction is usually negative. But the discussion suffers from a lack of knowledge about the ship acquisition process. Ship acquisition is like a complicated dance among the politicians who set policy objectives, naval staff who determine the operational requirements, and the project team that develops the solution. Observers see delay but often do not appreciate the risk and the consequence of failure. The risk factor creates caution in the decision-making process.

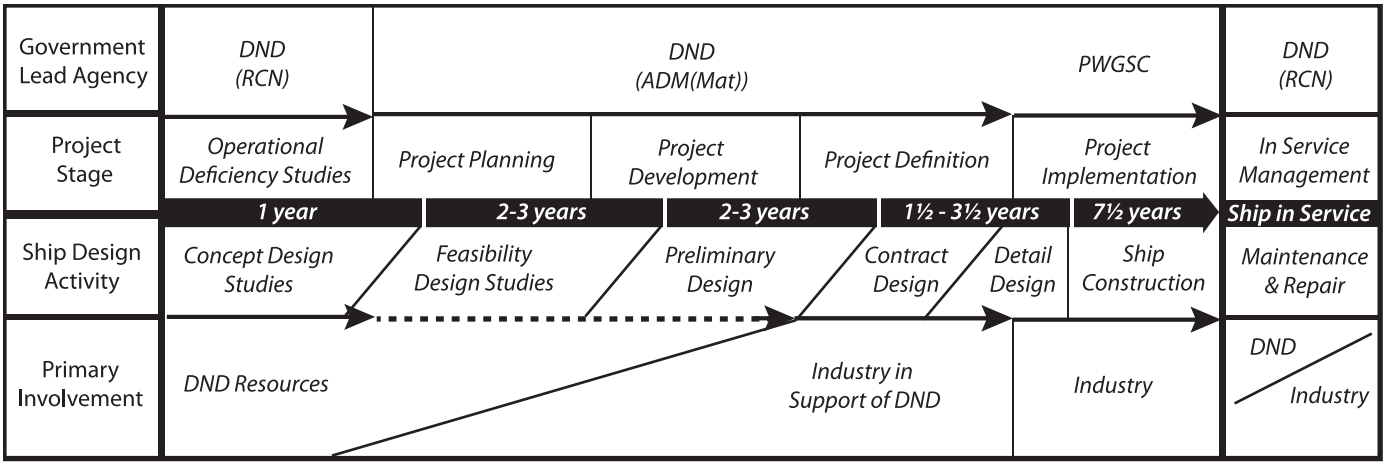
Part of the risk is the unique nature of the shipbuilding market in Canada. Acquiring ships is not like visiting a dealer and buying a car; there is no free market with ready-made solutions. Naval vessels have unique requirements and are built in such low numbers that every ship class is like a concept car. While military off-the-shelf designs are available for warships, they offer limited flexibility to respond to the particular requirements of a navy. For example, no existing design worldwide will meet the requirements of the AOPS, even if some latitude is introduced into the requirement. No country has Canada's unique mix of geography, climate and policy concerns. The desire for an optimal political solution is most often the source of delay. At least three government departments are involved in procurement: National Defence; Public Works and Government Services Canada; and Industry Canada. The dynamic that occurs between departments and in Cabinet makes comparison with other states' shipbuilding projects difficult. We can estimate the time to build a ship, but the political decision-making process is a bit more difficult to predict.

Unlike buying a car, the time it takes to buy a warship must include all design activities and well as construction. If you had to wait for your car to be designed and then built, car buying would also be a long process. It should be noted that it is not just Canada that experiences delays in shipbuilding – buying a warship never occurs quickly, no matter what state is doing it.

An appreciation of the ship design process is necessary to establish the minimum time required for warship acquisition. Figure 1 shows a generic timeline for warship acquisition based on ship design and build activity. The figure shows the entire process from the initial concept to a completed ship. Below each design activity is the organization, or organizations, that typically conduct them. It also shows project activity above the timeline and the corresponding Canadian government lead agency. This figure does not describe the actual procurement process, it just links a generic procurement process with ship design activities.

Ideas for new ships in Canada germinate within the navy when internal studies recognize a discrepancy between the navy's capability and what government policy says the navy is supposed to accomplish. Ideas are formed well in advance of any shipbuilding activity, so they always have an element of risk in terms of future threats and national priorities. Official recognition that Canada needs to consider building new ships kicks off the first set of studies for a project; these explore a future capability deficiency. For the CPF, this took two years. During these studies, the naval staff investigates the range of possible operational solutions. A small DND concept design team, which conducts design studies, works in close

Figure 1. Ship Acquisition Timeline



Credit: Maritime Engineering Journal

Canadian Patrol Frigate megamodule being lowered into place.

communication with the naval staff. In some cases, the naval staff may investigate one solution for more than one capability deficiency. A case in point is the Arctic and Offshore Patrol Ship which combines Arctic sovereignty support and offshore patrol in one ship.

Once the range of solutions that are possible to satisfy a capability is thoroughly investigated, the naval staff will have a concept design with rough costing information for more investigation. They will also have eliminated options due to cost, performance or other issues. Usually, insufficient resources are allocated to explore more than one design at once, so the concept design studies could take years. One year would be an absolute minimum and this would happen only in circumstances where there was considerable pressure to speed up the approval process and tolerance for higher cost risk.

The results of the concept design activity will lead to a submission at the departmental level to set up a capital project and transfer responsibility from a Project Director in the RCN to a Project Manager in the procurement organization under the Assistant Deputy Minister (Materiel) (ADM (Mat)). The transfer also marks the point at which financial resources shift from operations and maintenance to capital funds. The next steps are to confirm the options for further investigation, conduct planning studies, and begin to develop a Statement of Requirement and a System Requirements Document. These project documents are key building blocks for any acquisition.

Depending on the project, the ship design activity may either remain at the concept level as an extended options analysis is conducted or the design may proceed to feasibility designs investigating one or more preferred options in ever increasing detail. At this stage, designers might conduct design trade-off studies to explore the cost and capability relationship of possible solutions or confirm the technical feasibility of a solution. Studies may involve a detailed examination of a high-risk area of design, such as novel propulsion systems or new hull forms. Ship design is evolutionary, so often not all aspects of a design pose similar levels of risk.

The time spent in this stage depends on the number and depth of the studies. Simple modifications to an existing design may need relatively little exploration; novel or complicated designs may need considerable study. The purpose of feasibility design activities is not to design a ship but to ensure that technical and cost risks are acceptable and that the design concept is feasible. Designers could take two to three *years* to understand the range of feasible solutions. This period would be particularly long if a design incorporates new technology to meet the challenges of the future.

The Project Manager decides when the time is right to start a preliminary design. Now that the project team has a good idea of cost and a range of feasible design options, it should have defined the range of designs that offer a solution to the requirement. The purpose of a preliminary design is to improve the cost estimate and ship design details for one or two designs. Designers confirm all critical aspects of the design and all areas of higher technical risk in more detail. The goal is not only more design fidelity, but a more accurate estimate of the cost of the technical solution. The CPF project engaged industry for ship design activities at this point. If the requirement is clear and the design team is experienced, two to three years should be sufficient for this activity. The CPF project team took two years to complete this stage – the 'source qualification' stage.

At the end of the preliminary design stage, the ship project moves into the 'definition' stage, when specifications and requirements for a contract to design and build are assembled. Depending on the contracting strategy and the best avenue for technical and financial risk reduction, the design effort in this stage may proceed to a contract design or detail design level. Which option is selected here will depend on the contracting strategy and whether the contract is performance-based or prescriptive. Prescriptive contracts for building a ship require more design detail; either a contract design for specific aspects of the ship or a fully completed detail design. Performance-based contracts leave the solution to the prime contractor,

although the government must be confident that a satisfactory detail design is achievable. In any case, detailed design must be done.

For the CPF project 'definition' took 15 months and involved two separate design teams completing implementation proposals and offers for six ships. At the end of the 15-month period the government paid for two contract designs. Once the implementation contract with Saint John Shipbuilding was signed, an extensive effort was required to validate the design and develop the detail drawings and specification for construction. This effort took an additional two years. Depending on the complexity of the design, the contract and detail design activities could take up to four years.

Project implementation is the easiest stage to estimate because the details on ship build times and operational transfer to the navy are readily available. Figures 2 and 3 show the construction time for each ship in the CPF series – Figure 2 gives the exact dates, and Figure 3 compares the construction times. The CPF project used two shipyards: Saint John Shipbuilding (SJSL), the lead yard in Saint John, NB; and Marine Industries Limited (MIL) in Lauzon, Quebec. The time given in Figure 3 represents the duration from first cutting steel until the ship joins the fleet as an operational unit. The ships built at both yards experienced similar build times. It is clear that

Figure 2. Canadian Patrol Frigate Schedule

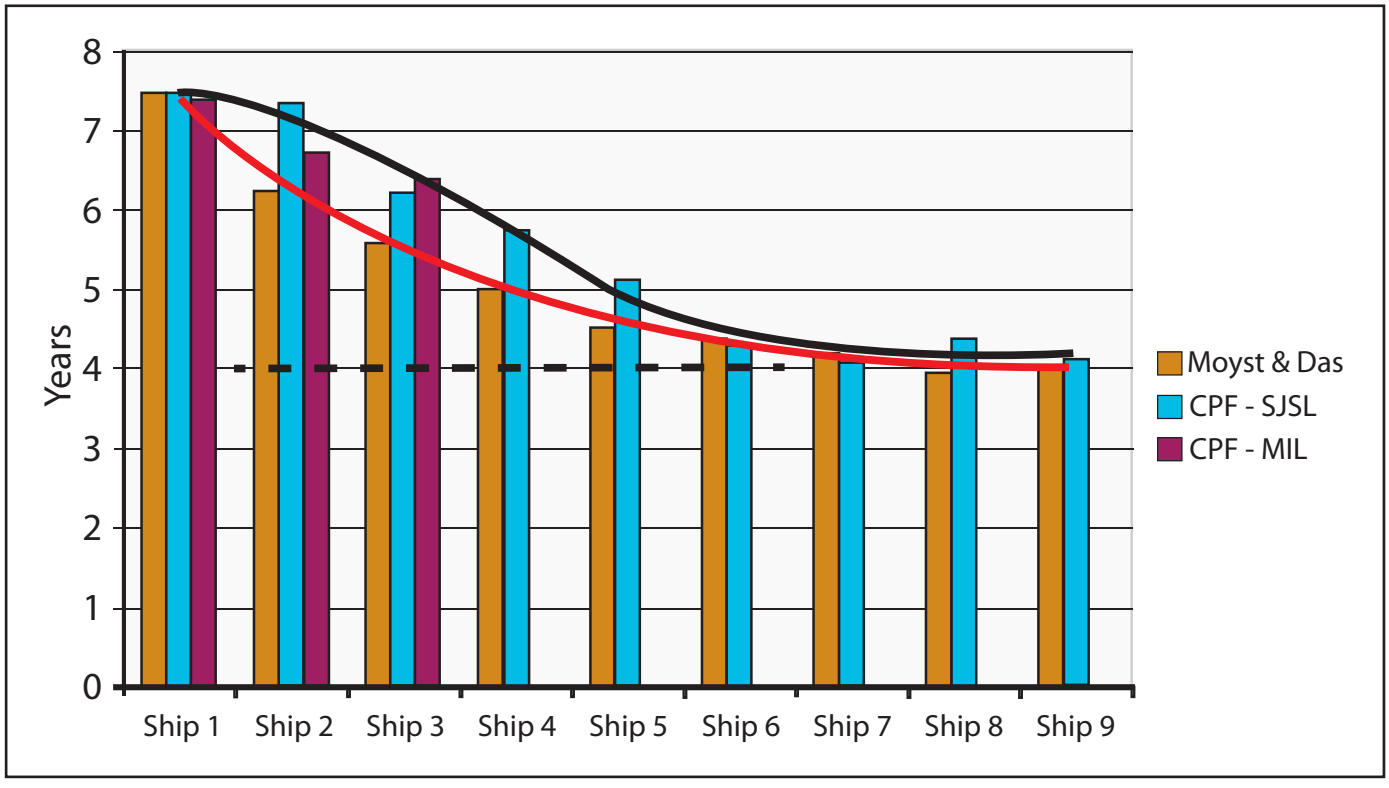
		START FAB	KEEL LAYING	FLOAT-UP OR LAUNCH (L)	START SEA TRIALS	DELIVERY
CPF-01 HALIFAX	S.	31-May-86	14-Mar-87	09-Jan-88	20-May-89	25-Oct-89
	A.	08-Jun-86	19-Mar-87	30-Apr-88	06-Aug-90	28-Jun-91
CPF-02 VANCOUVER	S.	14-Feb-87	06-Feb-88	10-Dec-88	12-May-90	24-Sep-90
	A.	06-Dec-86	19-May-88	03-Jul-89	10-Feb-92	11-Sep-92
CPF-03 VILLE DE QUÉBEC	S.	02-May-87	17-Oct-88	27-May-89	16-Jun-90	29-Jan-91
	A.	25-May-87	17-Jan-89	16-May-91(L)	10-Feb-92	11-Sep-92
CPF-04 TORONTO	S.	26-Sep-87	17-Dec-88	21-Oct-89	15-Dec-90	29-Apr-91
	A.	16-Jan-88	24-Apr-89	18-Dec-90	21-Sep-92	23-Dec-92
CPF-05 REGINA	S.	07-Nov-87	18-Jun-88	19-May-90	15-Jun-91	15-Oct-91
	A.	11-Aug-88	06-Oct-89	25-Oct-91 (91)	27-Nov-93	02-Mar-94
CPF-06 CALGARY	S.	06-Feb-88	18-Jun-88	24-Feb-90	11-Jan-92	29-Apr-92
	A.	21-Feb-89	15-Jun-91	26-Aug-92 (L)	19-Jun-94	30-Aug-94
CPF-07 MONTRÉAL	S.	06-Feb-88	18-Jun-88	24-Feb-90	11-Jan-92	29-Apr-92
	A.	14-Jan-89	08-Feb-91	26-Feb-92	20-Jun-93	27-Jul-93
CPF-08 FREDERICTON	S.	17-Mar-90	10-Nov-90	21-Mar-92	12-Jun-93	29-Sep-93
	A.	03-Jul-90	25-Apr-92	13-Mar-93	23-Jan-94	24-Feb-94
CPF-09 WINNIPEG	S.	15-Dec-90	24-Aug-91	19-Sep-92	12-Mar-94	29-Jun-94
	A.	02-Jul-91	19-Mar-93	11-Dec-93	06-Sep-94	11-Oct-94
CPF-10 CHARLOTTETOWN	S.	07-Dec-91	11-Jul-92	18-Sep-93	17-Dec-94	29-Mar-95
	A.	25-May-87	17-Jan-89	16-May-91	(27-Mar-95)	(28-Apr-95)
CPF-11 ST.JOHN'S	S.	26-Sep-92	22-Jul-93	11-Jun-94	16-Sep-95	29-Dec-95
	A.	26-Jul-92	24-Aug-94	(04-Jul-95)	(13-Nov-95)	(10-Dec-90)
CPF-12 OTTAWA	S.	05-Jun-93	29-Jul-94	18-Mar-95	15-Jun-96	29-Sep-96
	A.	31-May-93	(27-Apr-95)	(24-Dec-95)	(27-May-96)	(30-Jun-96)

NOTES:
S = CONTRACT SCHEDULED DATE (preOAA)
A = ACTUAL DATE
() = CURRENT TARGET DATES

*28 JUNE 91 was Provisional acceptance For CPF-01. Final Acceptance was 23 Dec 92.

Credit: Maritime Engineering Journal, No. 35 (June 1995), p.8.

Figure 3. Warship Construction Times



first of class ships take longer to build than the seventh and eighth ships in a series. Once a workforce is familiar with a design, construction times decrease significantly. Figure 3 compares these times against a hypothetical ship series that reduces the first of class construction time by a learning factor identified by Howard Moyst and Biman Das in their study of the cost and time factors involved in building ships.[2] The effect of learning is very important for predicting the time it will take to complete each ship in a series of ships, but it is the delivery of the first ship that really sets the public perception of the time it takes to build a ship, and that's more difficult to predict.

For the CPF project, both yards took 7½ years to deliver their first ship. If you investigate recent international projects you will find that six to seven years is typical for the first of class ships of destroyer or frigate projects of medium power navies.[3] There is no reason to anticipate a significantly faster time for the first ship in a future Canadian project. We know from past shipbuilding efforts that once production is established and the workforce understands a design, build times will decrease. Significant relearning is necessary each time a shipbuilding project starts after a long delay, unless some form of continuous shipbuilding exists.

When similar sized, but less complex, offshore patrol vessels are built to civilian standards construction times can be reduced appreciably. The first ship of the French *Floréal*-class, built around the same time as the CPF in the 1990s, took only two years to build. *Floréal* has no ice protection or cold weather capability, it is a lightly armed constabulary vessel with a simple command and control capability like the Arctic Offshore Patrol Ship (AOPS). In comparison, the FREMM, a cooperative French-Italian designed frigate comparable to the CPF, took seven years. This illustrates that the time of construction can vary significantly depending on the standards and sophistication of the ship. There is a huge difference between building a naval warship and a significantly less complex naval constabulary vessel. This provides an indicator that we should expect the shipyard to build the first AOPS in much less time than a CPF. However, while the time to build an AOPS should be less than a comparable warship, it will no doubt be longer than for the *Floréal*, which was built in a French yard with a full order book and up-to-date design and build experience. In theory, if construction of the AOPS starts in 2015, Irving Shipbuilding should be able to deliver the first ship by spring 2018.

If we add up the time estimates for the different activities in the ship design and build process, the minimum time to buy a ship – from official recognition of a capability deficiency to having a new ship in the fleet – will be at least 14 years for a warship and perhaps three to four years less for a commercial constabulary vessel like AOPS.

But even that number can be disputed because the biggest challenge is knowing when to start the clock. This is not a trivial question, nor is it as simple as it sounds. The naval staff is constantly considering and evaluating capability, so determining the point when a project begins is not always clear. Take the Joint Support Ship (JSS) as an example. The naval staff published an article on preliminary studies and concept investigations in 1994 on the Advanced Logistic Support Concept, a capability that eventually became the Joint Support Ship project.[4] In this case, concept studies were prolonged as the capability requirement was debated before the activity moved forward as a capital project. If we count the years from 1994 when the concept was first discussed, we already have almost 19 years, and the JSS is still far from joining the fleet. But is it accurate to start the clock in 1994, or should it have been started later when the concept had more chance of acceptance? This real life example exposes the complexity of even something as simple as when to start the clock on a project. It also illustrates the difference between an idealized project and reality, where political concerns affect the priorities of government.

Credit: Wikimedia Commons

***Carlo Bergamini**, the first Italian FREMM-class multi-purpose variant.*

Credit: Maritime Engineering Journal, (June 1995), p.8

*A **Kingston**-class Maritime Coastal Defence Vessel (MCDV) under construction in the mid-1990s at Irving Shipbuilding.*

The ship design timeline could be significantly shortened by a decision to buy an existing ship or build to a foreign design. However, such a decision would have significant implications for Canadian industry and for the navy. The advantage of saving time in acquisition must be compared against potential consequences both for the navy in terms of suitability and capability and for the government in terms of political considerations. The navy might have to compromise on Canadian requirements that a foreign design could not be affordably adapted to accommodate. As well, Canadian technical experts may not have the same level of design access for maintenance and repair activity, and service support from foreign suppliers may become impossible. And for the government, foreign design or construction means the loss of industrial benefits and employment. These consequences can be completely avoided by prudent planning for the real time scales involved in ship design.

Warship design takes time, no matter which country conducts it. A major challenge to an informed debate on naval fleet renewal is the lack of awareness about the timeframes involved in ship design and build. Moving from an idea to a material ship takes more than a decade, and once built ships can be in service for 40 years. It's no wonder the navy spends time trying to get the requirement right. A significant part of the challenge and the risk is projecting requirements half a century into the future. With so few warships built, there is no room to get the design wrong.

Up until now our discussion of the time to build ships has focused on ship design activity. But there are factors that may extend that time. A good example is the time required to obtain departmental project approvals, which must consider the wider context of expensive capital projects on the total defence budget. Another consideration is the political sensitivity of projects that are national in scope and affect regional employment and industry. The size of these projects generates considerable interest and the timelines involved offer a large window for political involvement in decision-making. And we must not forget that a change of government with different priorities, or a change in economic or strategic conditions, might take the project back a few steps. The maritime helicopter is a good example of government redefining a project even after contracts were signed.

An understanding of the time it takes to design and build warships helps to shape expectations. Ships are not designed and built in a day, and Canadians must understand that. However, Canada is capable of designing and building a warship in a reasonable time once the decision to proceed is taken. We did it with the Canadian Patrol Frigate and we can do it with future warships.

Notes

1. Department of National Defence, Chief of Review Services (CRS), "Canadian Patrol Frigate Cost and Capability Comparison," 26 March 1999, 7050-11-11, available at http://publications.gc.ca/collections/Collection/D2-127-1999E.pdf.
2. Howard Moyst and Biman Das. "Factors Affecting Ship Design and Construction Lead Time and Cost," *Journal of Ship Production*, Vol. 21, No. 3 (August 2005), pp. 186-194.
3. See Royal Institution of Naval Architect, Warship Technology and Naval-Technology website, available at www.naval-technology.com/projects/category/destroyers-and-frigates.
4. Commander S.E. King and Lieutenant-Commander P.J. Brinkhurst, "Afloat Logistic Support: The Future is *Now* for Multirole Support Vessels," *Maritime Engineering Journal*, June 1994, available at www.cntha.ca/images/Otherdocs/mej/mej-32.pdf.

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