Sovereignty, Security and Prosperity

− Government Ships −

Designed, Built and Supported by Canadian Industry

The Report of the
CADSI Marine Industries Working Group

May 2009

Cover: HMCS St. Johns, Canadian Patrol Frigate

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CADSI Marine Industries Working Group

Opportunity and Challenges

The Government of Canada has announced plans to build approximately 55 Navy and Coast Guard ships over the next 30 years to meet its maritime security requirements. These ship acquisitions, along with associated In-Service Support spending, have the potential to generate $50B in Canadian industrial opportunities over this period, support 10,000 jobs annually in communities across Canada, sustain a domestic Canadian supply chain of many hundreds of companies, and deliver world-class vessels.

This report of the CADSI Marine Industries Working Group:

- defines Canada's Marine Industries;
- assesses their capability and capacity to meet the government's needs;
- identifies the economic benefits to be derived;
- identifies issues that must be resolved; and
- makes recommendations for moving forward.

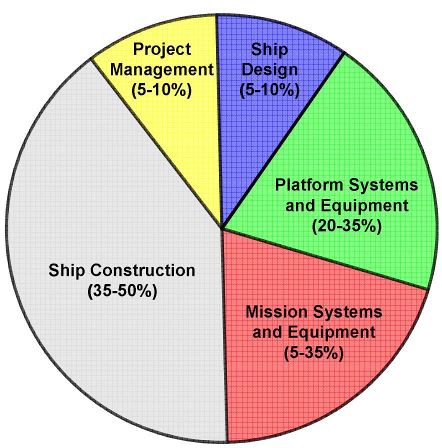
The Nature of Government Fleets

Government ship procurements are different from those carried out for the air and land elements of a nation's armed forces. Ships tend to be purpose-designed and are much fewer in number compared to air and land vehicles. Like Canada, most leading industrial nations design and build their own warships as a matter of national security and to benefit from the associated valuable economic activity.

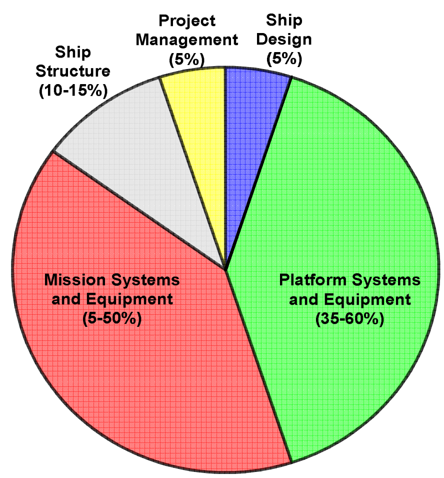
Modern ships represent a high degree of integration and leading edge technologies. Advanced industrial nations design their own naval ships to meet specific operational needs and industrial strategy objectives. Canada's requirements need to be met in ways that best support our sovereignty requirements and reflect the distinctive needs of our maritime and northern environments. Since the early 1950s all major ships for Canadian government service have been designed, built and supported by Canada's Marine Industries.

Defining Canada's Marine Industries

Canada's Marine Industries are broader than the ship construction that occurs in shipyards. They include project management, ship design, and systems integration and equipment supply involving many hundreds of Canadian companies, most of them Small and Medium Enterprises. Systems and equipment are generally categorized as either platform (e.g. propulsion, electrical and hotel services) or mission specific (e.g. command and control, sensors, guns, missiles, helicopter operations, underwater systems). The involvement of these sectors varies with the type of ship and from the Design and Build Phase to that of In-Service Support, as shown below.



Work Effort − Design & Build



Work Effort − In-Service Support

Findings

1. Canada's Marine Industries Can Design and Build Canada's Government Ships

The last major government ship acquisitions occurred during the 1980s through to the late 1990s. These procurements, in particular the 12-ship Canadian Patrol Frigate (CPF) Project, launched several Canadian systems integrators and equipment suppliers into the international marketplace where they have thrived and are ready and able to respond to today's ship projects. Likewise, these projects required shipyards to advance their quality assurance and project management capabilities, which enabled many of them to capture equally challenging work in the off-shore oil and gas sector. While ship construction in Canada has declined in recent years, this alternative market has enabled these companies to survive and be available for new ship projects. However, Canada's shipyards are in a precarious situation when it comes to government ship construction. The industry can do the work, but it faces several challenges, mostly related to onerous contract terms and conditions, and boom-and-bust government procurement. Capital improvements and human resource investments will have to be made as part of a new build program.

The size of the Canadian ship design sector has also diminished since the last round of government ship projects. This sector is in high demand around the world and some Canadian ship designers have managed to participate in that market place. However, Canadian designers have not been active on major government ship design work for over a decade.

In general, the readiness and capabilities of Canada's Marine Industries in most areas are superior to their relative state in the early 1980s when the last major government fleet renewal began; some sectors, most notably system integrators and equipment suppliers, are well ahead of where they were then. However to implement these projects the industry as a whole will face a ramp-up challenge similar to that of the last major build programs. As it was then, the largest challenge will be for the shipyards to assemble and train a workforce. It was successfully accomplished then and should be achievable again. Canada's Marine Industries are anxious to participate in the forthcoming government rebuild program. If this is done properly, not only will the ships be designed and built in Canada, thus benefiting the designers, integrators and shipyards, but also hundreds of Small and Medium Enterprise companies will benefit from being involved in the supply chain throughout the ships' service lives. Moreover the investment will be made in Canada and in Canadians

2. Canada's Marine Industries Are Competitive

Canada's Marine Industries are often accused of being non-competitive in the international marketplace. From a shipyard perspective, this is the case when measured against commercial shipyards in Asia; however, these yards generally are not producing sophisticated government ships. A more valid yardstick for these special service ships is to compare Canadian competitiveness with that of similar industrialized nations such as our NATO allies. A Department of National Defence study of the Canadian Patrol Frigates (CPFs) compared favourably with more than half a dozen frigates of other western allies. The CPFs were comparable in cost and of equal or better capability than those other ships; this was in part due to the length of the production run, where benefit was gained from repetitious work, the so-called learning curve.

The biggest competitiveness challenge confronts the shipyards, because their productivity is linked to trained and experienced workers engaged in steady and repetitious work, thereby benefiting from the learning curve. Once they are up and running, Canada's shipyards can be internationally competitive, when measured against comparable projects. Canada's system integrators and equipment suppliers have demonstrated their competitiveness by their continuing international sales, even in the absence of current ship projects in Canada. These capabilities and their competitiveness are a direct result of past government decisions to design and build Canada's government fleets in Canada and over time to nurture and increase Canadian industrial capabilities and responsibilities.

3. Economic Benefits for Canada

As currently structured, departmental plans are to acquire up to 55 of the largest ships for the Canadian Navy and Canadian Coast Guard representing a $30B design and build opportunity for Canada's Marine Industries over the next 30 years, and at least another $20B in providing In-Service Support for the government's current and future fleets. CADSI estimates that this work will employ an annual average of 10,000 Canadians across Canada over the next 30 years.

Government ship projects are good for the Canadian economy. Direct Canadian content is high due to the ability to source and conduct most of the work here in Canada. The design and build of government ships typically achieves 70% direct Canadian content; the remaining 30% consists of certain equipment such as propulsion engines, gearing, propellers, some sensors, and weapons (guns, missiles and torpedoes) that are not produced in Canada. When Industrial Regional Benefits are applied to the procurement, these purchases are offset by an equivalent amount of Canadian products or services. The direct Canadian content of In-Service Support work is equally high, if not higher.

4. Canada's Marine Industries – a Strategic Resource

Through the Canadian Patrol Frigate Project, the Government of the day established four major industrial objectives:

- to establish a Canadian capability to manage major warship projects including design and electronic subsystem integration;
- to have at least two major electronic subsystems integrated by Canadian-controlled firms;
- to build the 12 ships in Canada; and
- to maximize, as much as practicable, the Canadian content in the Project.

All these objectives were met or exceeded. The design and integration capabilities have largely remained and are ready and available in Canada today. Since then the various participating companies have evolved due to normal market influences, but much of the skills and capabilities are extant in the workforce today, as are advanced generations of many of the systems developed for that project. In addition, other companies have been attracted to the Canadian marketplace, thereby providing a healthy competitive environment.

CADSI believes that the next round of major ship projects should take these objectives one step further and establish a more robust government ship acquisition and In-Service Support capability in Canada, as several of our allies have done with their industries. Such a strategy could streamline acquisition and provide long-term stability, benefiting both Government and industry. Recently, the Ministry of Defence in the United Kingdom implemented such a strategy for the design, build and support of its warships. As part of a Canadian strategy, CADSI believes that, in addition to the government's policy for ships to be constructed in Canada, the following high-value responsibilities should be carried out in Canada by Canadian companies:

- prime contractor;
- project management;
- platform and mission systems integration;
- the management and control of ship design; and
- In-Service Support.

Such a strategy would also maximize the use of Canadian material, components and equipment, thereby contributing to Canadian economic benefit, and easing the cost and enhancing the availability and assurance of In-Service Support.

Canada is the only G8 nation that has taken a *laissez-faire* approach to the acquisition and the sustainment of government fleets. This approach has led to reduced high technology marine-related research and development and jobs. Canada is essentially at a tipping point − either move forward and renew and sustain Canada's government fleets indigenously, or transfer wealth, technology and jobs to other nations.

5. Government Procurement Processes

In its November 2008 Speech from the Throne, the Government acknowledged the need to reform its procurement processes, in particular those related to defence procurement. The failures of the solicitations for two recent projects − the Navy's Joint Support Ship (JSS) and the Coast Guard's Mid-Shore Patrol Vessel (MSPV) − have underlined issues related to the government's approach towards ship procurements. These issues include:

- the need for real and effective industry/Government dialogue;
- the need to reconcile budget, schedule and requirements;
- the need to rebalance risk; and,
- the need to establish a new relationship with Canada's shipyards.

For the government's ship projects to proceed successfully, these issues must be resolved in direct and open consultation with industry.

Principal Recommendations

CADSI offers the following principal recommendations to enable the Government to succeed in its plans to renew its Navy and Coast Guard fleets:

That Government continue its policy of building its ships in Canada.

That Government lay out a predictable long-term, integrated fleet renewal plan with adequate and stable funding to support it.

That Government and the Canadian shipbuilding industry jointly develop a long-term strategy governing how the shipyards will continue to contribute to government ship projects.

That Government establish a Marine Industrial Strategy that maximizes the direct participation of Canadian Marine Industries in the design, build, and support of government ships by requiring that, in addition to ship construction, the following critical functions be carried out in Canada by Canadian companies:

- Prime Contractor,
- Project Management,
- Platform and Mission System Integration,
- Management and control of Ship Design; and
- In-Service Support.

That Government undertake procurement reform that begins with a more flexible and realistic approach, in combination with industry, to reconciling trade-off decisions before locking budget, schedule, and requirements into an RFP.

That Government optimize the balance of risk between industry and Government in fixed-price or capped profit projects to maximize best procured value and to minimize overall cost and risk to Government.

That Government review and use the tools it currently has to support the nurturing and development of strategic capabilities, technologies and products in naval and marine systems and other products that can be applied to ship acquisitions and to other defence and security procurements. These tools include the following:

- Industrial and Regional Benefits to promote investment by using multipliers, carry-over credits and other features to nurture a wide spectrum of Canadian naval and marine contractors;
- The Strategic Aerospace and Defence Initiative; and
- Research and development in government and private sector labs focused on relevant technologies.

CADSI believes that now is the time for Canada to seize the economic and strategic opportunities of the government's multi-billion dollar, 30-year plan to renew its Navy and Coast Guard fleets and support them throughout their service lives. Together, the Canadian Government and Canadian industry can achieve great things:

- **meeting the need for new ships;**
- **supporting 10,000 lasting, high-value jobs;**
- **creating leading technologies for Canada and for export markets; and,**
- **providing economic benefits across the country.**

CCGS Martha Black and HMCS Fredericton

Canada's Marine Industries

1.0 The Challenge

To meet its maritime security requirements, the Government of Canada has announced plans to build approximately 55 Navy and Coast Guard ships over the next 30 years. These ship acquisitions, along with associated In-Service Support spending, have the potential to generate $50B in Canadian industrial opportunities over this period, support 10,000 jobs annually in communities across Canada, sustain a domestic Canadian supply chain of many hundreds of companies, and deliver world-class vessels.

Since the Second World War, government ships have been designed, built and maintained **by Canada's Marine Industries**, consisting of prime contractors, project managers, ship designers, platform and mission systems integrators, shipbuilders and In-Service Support providers. The failures of two recent government ship solicitations − the Joint Support Ship (JSS) for the Canadian Navy and the Mid-Shore Patrol Vessel (MSPV) for the Canadian Coast Guard − have led some observers, incorrectly, to question Canada's Marine Industries' ability to meet the government's needs. As this report indicates, Canada's Marine Industries have the ability to design and build the government's ships, but in doing so both Government and industry face significant challenges.

This report, produced by a CADSI-sponsored Working Group of 37 knowledgeable industry representatives, targets the following objectives:

- defining Canada's Marine Industries;
- assessing their capability and capacity to meet the government's needs;
- identifying their economic and strategic importance to the nation;
- identifying issues that must be resolved and
- making recommendations for moving forward.[1]

[1] This report addresses the needs of the Government for specialized ships performing defence and security missions (Navy and Coast Guard), ships which can be characterized as representing medium-to-high technical complexity. The report focuses on ships greater than 1,000 tonnes. High-complexity vessels are considered to be front line combatants of the Navy; all other government ships are considered medium-complexity.

2.0 Context

2.1 Canada's Marine Industries

Marine Industries design and build ships, and support them throughout their service lives. The term 'Marine Industries' encompasses more than the ship construction associated with shipyards. They also include ship design; the design and integration of the multitude of systems that comprise a modern ship; and, the overall management and implementation of these complex undertakings.

Ships can be viewed as a system of systems that represents a high degree of integration and leading edge technology. They are one of the most complex challenges an industrial team can undertake. Ships have all the services of a modern city. Whether a warship, oceanographic research vessel, icebreaker, or navigational buoy tender, they must be able to reliably perform their assigned mission; and, they must be able to float, move and survive in extreme conditions, which is the role of so-called "platform" systems. Depending on their mission, some classes of ships must be able to remain at sea, unsupported in any way, for weeks or even months at a time.

Figure 1 shows the major industrial activities involved in the Design and Build phase of a medium-to-high complexity ship. The percentages show the proportional division of work effort typically required over a range of ship types. While ship construction is the dominant sector, at least half of the design and build of a ship involves overall project management, ship design, and systems integration and supply of equipment. These sectors are described in more detail in **Section 4** of this report.

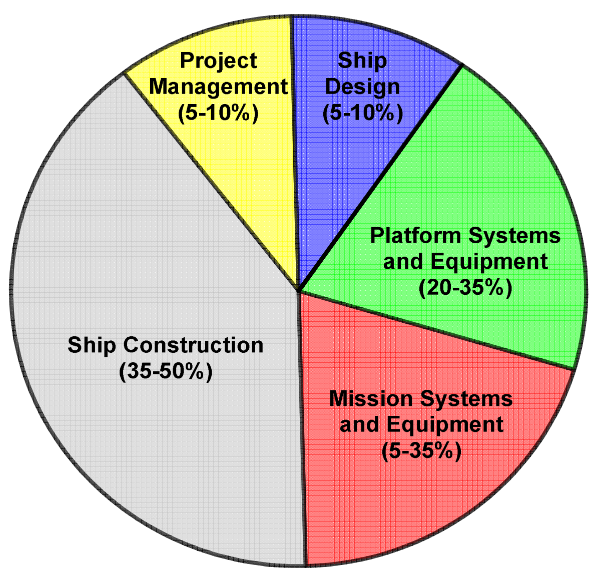


Figure 1 - Major Activities involved in the Design and Build of Medium-to-High Complexity Ships

During service lives that can exceed 40 years, ships require periodic maintenance to prevent and correct defects and to preserve structural integrity of the hull. Industry does most of this In-Service Support (ISS) work. The division of work for ISS differs significantly from that of the acquisition phase. ISS is largely focused on maintaining and upgrading the ship's platform and mission systems and repairing and replacing related equipment and components. **Figure 2** shows the typical range of work split for the government's medium-to-high complexity ships. As with the Design and Build phase, the major difference is between platform and mission systems, where the percentage of the former is higher with Coast Guard ships that have relatively few mission systems. The reverse is the case with the complex mission systems of the Navy's warships.

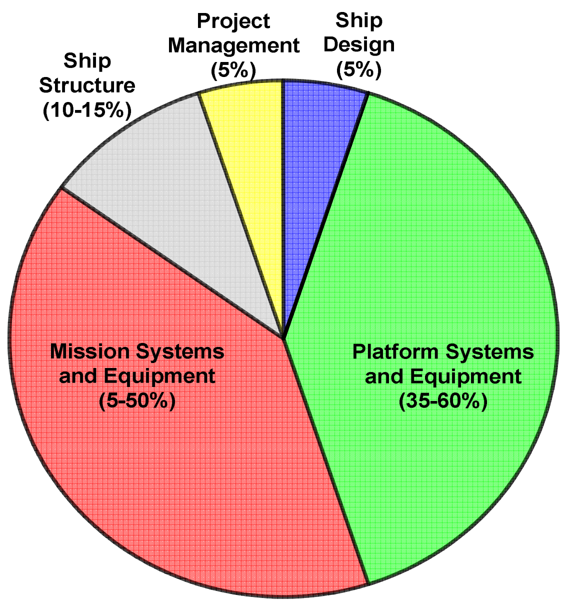


Figure 2 - Activities involved in the In-Service Support of Medium-to-High Complexity Ships

2.2 Canada – a Maritime Nation

Canada is surrounded on three sides by oceans: the Pacific; Atlantic; and, the increasingly accessible Arctic. As physical barriers, they help to secure our shores. Environmentally, they shape the very existence of our citizens – from the impact they have on our climate to the renewable and non-renewable resources contained in and under them. And, as great highways, they facilitate Canadian economic activity and trade, and our engagement in international affairs. Combined, these realities have moulded Canada itself and the culture, economy, and way of life of its citizens. Our future ability to successfully promote and exploit Canada's national interests in each of these maritime regions, and to maximize the economic benefits to Canadians and our economy, rests on Canada's ability to patrol and control these regions with its government fleets. This national objective can be achieved only by sustaining viable and vibrant Canadian Marine Industries able to produce and support these government fleets.

2.3 The Opportunity

The Canadian Navy operates a fleet of 29 surface ships of 1,000 tonnes or greater, with an average age of 18 years. Some vessels, such as the two Replenishment ships, are 40 years old, while the three Tribal Class destroyers are approaching that age.

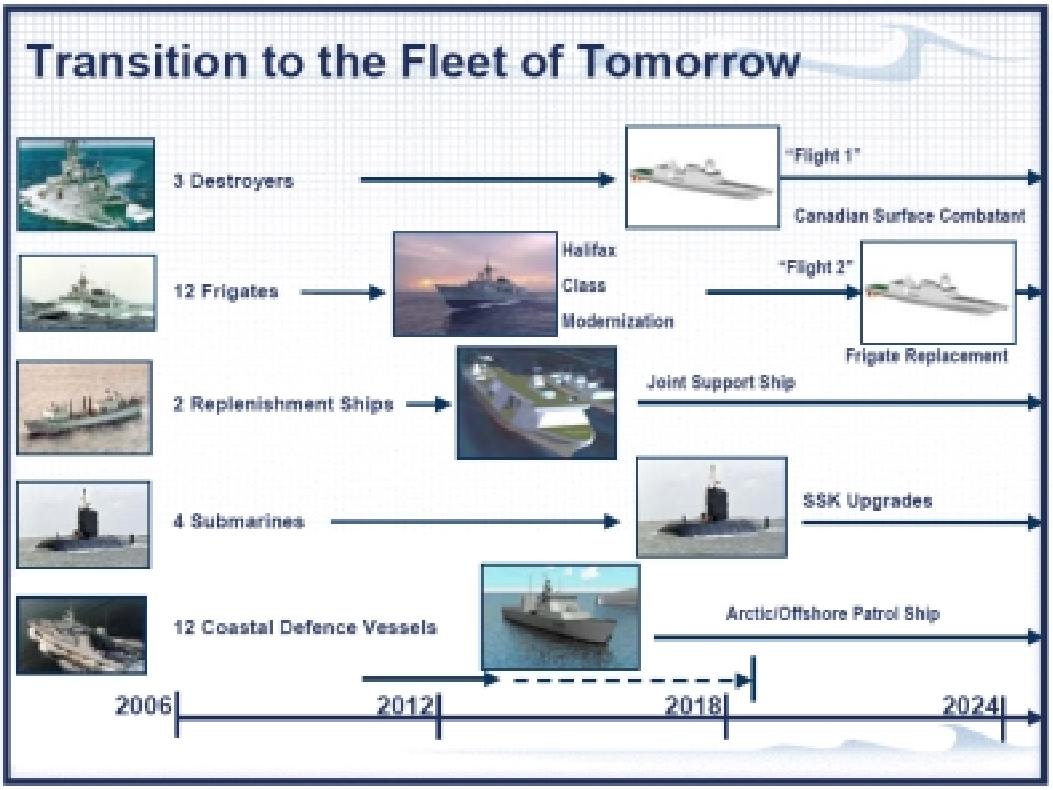


Figure 3 - Canadian Navy's Transition to the Fleet of Tomorrow (Graphic, Courtesy of Department of National Defence)

The Coast Guard operates a fleet of 28 ships above 1,000 tonnes, with an average age of 28 years.[2] Five of the vessels are 40 years or older and are beyond their useful economic lives. The Coast Guard's fleet of 28 larger ships comprises a mix of more than 18 different ship configurations, presenting significant logistical support challenges. The plan for the new fleet is to have one configuration per ship class, with all ships of a class built to the same design, in the same shipyard, to benefit from construction productivity improvements (the 'learning curve') and through-life support economies.

[2] Note that both the Navy and Coast Guard operate fleets of smaller vessels below 500 tonnes − the Navy 45, the Coast Guard 86.

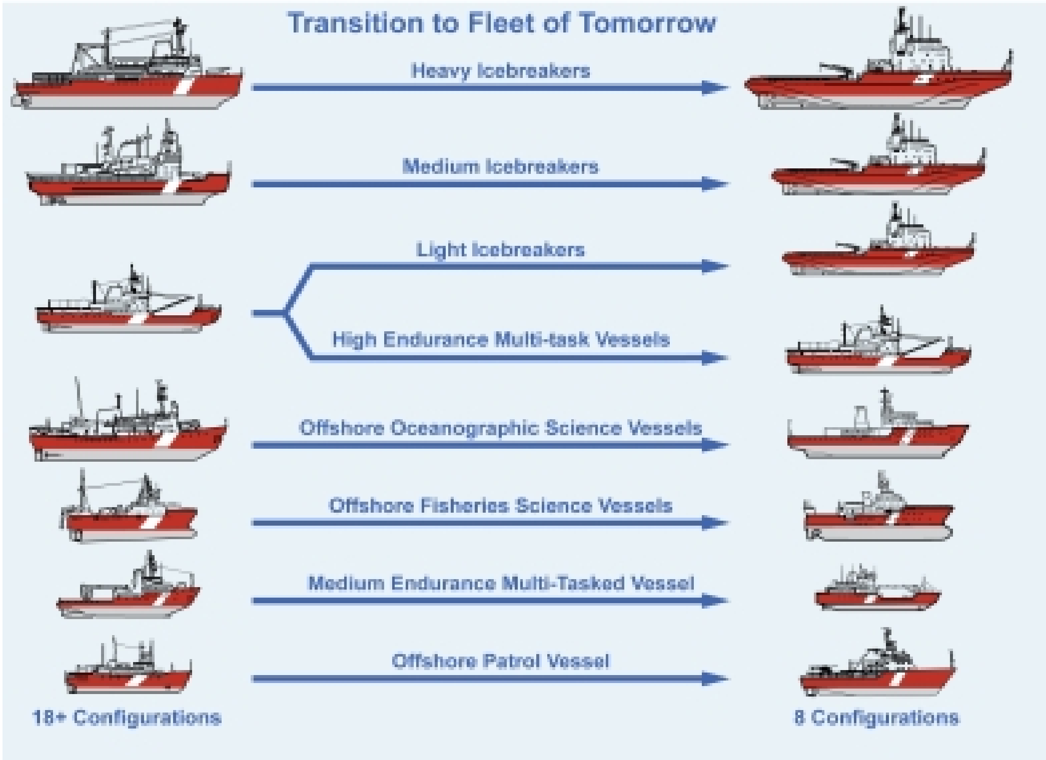


Figure 4. Canadian Coast Guard's Transition to the Fleet of Tomorrow (Graphic, Courtesy of General Dynamics Canada)

Canada urgently needs to build the ships that will serve the nation for the first half of the 21st century. Government's ability to manage and industry's ability to deliver these important assets depends on an orderly plan for fleet renewal.

Figure 5 shows the government ship projects understood to be contained in current departmental plans. This list is limited to vessels of approximately 1,000 tons or larger, which are considered to be of medium-to-high complexity and which represent the vast majority of ship-related capital expenditures. The Navy's projects and funding levels have all been identified in Departmental plans or announcements. So far the Government has announced $1.4B for 17 of the Coast Guard's planned vessel replacements. The total budget figure of $38B represents planned or forecast total project costs, not all of which will translate into contract costs. It is assumed that at least 80% of these project costs should result in contracts, which would represent, at minimum, a contracting opportunity of approximately $30B for Canada's Marine Industries.

Ship Class	# of Ships	Budget
Department of National Defence		
Halifax Class Modernization (FELEX and CSI)	(12)	2.2B
Joint Support Ship	3	2.1B
Arctic Offshore Patrol Ship	6-8	2.9B
Canadian Surface Combatant, Flight 1	3	26.B
Canadian Surface Combatant, Flight 2	12	
Total (new ships)	24-26	$33B
Canadian Coast Guard		
Polar Icebreakers	2	
Medium Icebreakers	4	
High Endurance Multitasked Vessels	3	
Medium Endurance Multitasked Vessels	8	
Off-shore Oceanographic Science Vessels	2	
Off-shore Fisheries Science Vessel	3	
Off-shore Patrol Vessels	7	
Total	29	$5B **(Est)**

Figure 5. Forecast of Major Government Ship Acquisition Projects over the next 20-30 Years

In addition to fleet renewal, both the Navy and Coast Guard fund refits, modifications, and equipment repair and overhaul on an annual basis. The Navy's average annual repair and overhaul budget is $620M (about $500M of which is estimated to be spent in Canada), while that of the Coast Guard is $80M. The January 2009 federal budget committed a further $175M to the Coast Guard over the next two years for vessel life extensions and the acquisition of small vessels and craft.

Combining the projected capital plans and the annual maintenance budgets of both departments reveals an average annual expenditure of just under $1.6B over the next 30 years. This is a significant opportunity for Canada's Marine Industries.

Designing, building and supporting Canadian ships in Canada creates high-value, long-lasting jobs in communities all across the country. As well, past government ship projects created certain Canadian capabilities that continue to participate in world markets for their products.

As the 2008 Federal Budget said of the Canada First Defence Strategy:

"A stable, predictable, and long-term investment program will create new, significant, and long-term opportunities. Canadian industry will have the opportunity to position itself as high-tech leaders, invest proactively in research, and develop technologies that can be used at home and exported to foreign markets."

Canada's Marine Industries have done exactly that in the recent past. They are ready to repeat that success.

2.4 The Rationale for Marine Industries in Canada

For decades, Canadian Governments have made the strategic decision to maintain an indigenous Marine Industry to design, build, and support its government ships. That policy, without being explicitly stated, has produced and supported very capable and impressive ships for the Canadian Navy and Coast Guard since the 1950s.

Critics of this approach point out that none of the Canadian Air Force's major aircraft fleets are built in this country, and question why Canadian Naval and Coast Guard fleets must be built here. The answer lies in the fundamental differences in the aerospace and marine marketplaces. Because of the high cost of designing, building and certifying an aircraft, for practical and economic reasons on a global basis there tend to be relatively few aircraft designs, with much larger production runs of each than those of ships. For the same reasons there are far fewer aircraft companies, led by the global giants Boeing and Airbus. Canada has one remaining aircraft producer, Bombardier. This means that the bulk of Canada's aircraft needs, of necessity, must come from abroad.

Ships, on the other hand, do not face the high cost of airworthiness certification, but must meet less-costly seaworthiness standards specific to their operating environments, such as stability considerations in severe icing conditions and helicopter operating requirements. Ships tend to be designed to meet their customers' specific requirements, largely because it is operationally important and, given the nature of the industry, cost-effective to do so. The result is that, worldwide, there are many hundreds of ship designs and shipbuilders, with relatively small production runs of each ship type, as compared to aircraft. These marketplace realities have resulted in Canada and other leading industrial nations designing and building ships for their domestic needs, in particular those related to defence and security. This is a global reality and it makes sense.

Historically, ships in Canadian government service are required to remain operationally effective for more than 40 years. They are tailored to meet requirements that are made unique by the combination of missions to be performed, the operating environment, and the In-Service Support needs. They are also procured in limited numbers which necessitates that they be carefully designed and optimized if the operational needs are to be met through their long service life in a cost-effective manner. This is true for most customers around the world. Generally there is no “off-the-shelf” solution that can be bought from elsewhere in the world that can replace the need for using a customized design, unless the customer is ready to be constrained by someone else’s prior requirements, accept sub-optimal operational performance, and forego the economic benefits from using in-country designers, integrators and suppliers. The use of in-country resources also ensures more reliable and cost-effective support of the ships throughout their service lives.

Canada’s Marine Industries are able to design, build and support the country’s marine fleet requirements, as do the respective industries of other leading industrial nations. Given the vast size and economic importance of Canada’s maritime regions, it makes strategic sense to have this capability in-country. This activity also provides domestic employment and opportunities for Canadian Marine Industries to participate in the global marketplace at the system or product level, as several have done with good success. Therefore, it makes good economic and national security sense for Canada to possess a vibrant Marine Industries sector.

CCGS Amundsen, Medium Icebreaker

3.0 Canada’s Marine Industries Contributions to Date

Since the 1950s Canada has designed and built the vast majority of its own government ships. Only a handful of Navy or Coast Guard surface ships have come from off-shore and these were invariably older vessels that were converted in Canada for their use. Over the decades these new ship projects have created an extensive industrial capability within Canada that has survived, despite the cyclical nature of the demand. The brief history of this evolutionary experience follows.

3.1 Canadian Navy

During the 1950s and 1960s the Canadian Navy produced a fleet of 20 destroyer escorts (frigates in today’s parlance) to a unique Canadian hull design. Many of the systems were based on British Royal Navy designs but manufactured and subsequently improved by Canadian industrial production. Canadian developments − such as pressurized interiors and exterior wash-down systems (for nuclear fallout) and the adaptation of medium-sized helicopters to relatively small, unstable flight decks of ships − were to earn Canada international recognition and markets.

In the late 1960s the Canadian Navy procured three Replenishment vessels, built to a commercial design and standards. At the same time the Navy embarked on the design and build of four DDH-280 IROQUOIS Class destroyers which were the first warships in the world to exclusively use gas turbines for propulsion. This Project was also in the forefront of designing and building systems to manipulate and display operational data in a ship’s operations centre. The DDH 280s were the first ships of their size to carry two helicopters.

The four IROQUOIS class ships and 20 earlier destroyer escorts were designed under Canadian Naval guidance and direction, with the Government acting as prime contractor, and were constructed in seven different shipyards on Canada’s east and west coasts and along the Quebec shores of the St Lawrence River.

In the 1980s, Canada’s next class of frigate was procured under a different strategy: industry responded to a set of naval requirements and, following a funded competitive project-definition phase, one Canadian-led industrial team was awarded a contract for the design and build of six Canadian Patrol Frigates (CPFs). Later, this contract was amended to procure a total of 12 ships at $6.2B.

The CPF Project had the industrial benefit objective of establishing a Canadian capability to manage major warship projects, including design and electronic subsystem integration. At the outset, it was apparent that Canadian capabilities were insufficient for the task. Despite that, the prime contractor, Saint John Shipbuilding Limited (now known as Irving Shipbuilding Inc.) achieved these capabilities through the life of the Project with investment, hiring, training, technology transfer and hard work. The company managed the entire Project and built nine of the ships at its shipyard in Saint John, New

Brunswick, along with Paramax Electronics, Montreal, the electronic systems integrator, a creation of Sperry of the U.S. Despite concerted post-CPF marketing efforts, and in the absence of any timely follow-on government shipbuilding projects, Irving Shipbuilding eventually had to shut down its Saint John facility and the country lost its most modern and capable shipyard. Fortunately, Paramax survived and eventually became part of Lockheed Martin Canada. The CPF Project spawned several successful Canadian designed systems that went on to reap international sales. Some of the more notable of these are described at Appendix A.

During the same timeframe, through the Tribal Update and Modernization Project (TRUMP), the four IROQUOIS class vessels were entirely refitted by Davie Shipyards and Litton Systems Canada (in charge of the electronics systems integration) to upgrade the destroyers with modern computerized technology and weaponry enabling them to continue as the Navy's command ships.

The Navy validated the success of the CPF procurement strategy by using a similar approach for the design and build of its next class of ship − the Maritime Coastal Defence Vessel (MCDV) − a fleet of 12 ships to be operated by Canada's Naval Reserve. The MCDV Project introduced three significantly new conditions: the design was to use commercial standards, the ships were to be built to classification society[3] rules, and the ship's operational capabilities were to fit within a fixed budget − a design-to-cost exercise. In 1992, following a competitive funded-definition phase, SNC-Lavalin was awarded a $650M fixed-price contract for the design and build of the 12 vessels. The Government contemplated building the MCDVs in up to four shipyards but lessons from the CPF Project showed the considerable cost benefit from continuous production in one shipyard, where productivity improvements could be realized from one ship to the next. Therefore, all 12 MCDVs were built by Halifax Shipyards (today part of Irving Shipbuilding) where the learning curve established over the production run enabled the Project to deliver maximum capability within the project budget.

3.2 Canadian Coast Guard

Canada's Marine Industries also served the fleets of the Canadian Coast Guard and Fisheries and Oceans throughout their existence. The current Coast Guard fleet consists of 114 vessels, 28 of which are over 1,000 gross tons and are considered medium complexity. All of these larger vessels are 20 years or older. The last batch of CCG new construction was ordered by the Government at the same time as the CPF contract award in July 1983 − a program for 18 ships spread over nine shipyards:

- six 3,800 ton, High-endurance Multi-tasked Vessels: two at MIL, Tracy/Sorel (lead yard); two at Versatile Pacific Inc., Vancouver; and one each at Collingwood and Halifax Dartmouth Industries;
- one 6,800 ton, Medium Icebreaker at Versatile Pacific Inc., Vancouver;

[3] (A classification society is a non-governmental body that develops and publishes marine industry construction standards, e.g. Lloyds.)

- two Medium-endurance Multi-tasked Vessels: one each at Ferguson Industries, Pictou and Vito Steel Boat and Barge, Vancouver;
- two Offshore Patrol Vessels: at West Coast Manley Shipyards, Vancouver;
- one Offshore Oceanographic Science Vessel at Bel-Air Shipyards, Vancouver; and
- six Type 800 buoy tenders built at Breton Industries in Port Hawkesbury, Nova Scotia.

CCG had designs ready for each of these ship classes and the 18 vessels were all delivered by the end of 1987 − an impressive accomplishment. Of the nine shipyards used to build these vessels, only Halifax Dartmouth Industries Limited (now part of Irving Shipbuilding Inc.), remains in business today.

3.3 Shipyard Rationalization

The boom-and-bust history of government fleet procurement is clearly demonstrated by the fact that no ship projects have been implemented since the delivery of the last MCDV in 1998, other than the recently-awarded (2009) HALIFAX Class Modernization contract. In fact, the majority of Canada's shipyards have not received any government orders for new construction since the 1980s, with the last major CCG program. As a result, in the late 1980s and early 1990s, several yards either shut down or converted their business to more generalized industrial pursuits as part of an industry-led, government-supported shipyard rationalization program. The most modern and capable shipyard in Canada at the end of the CPF Project in 1996 − the Saint John facility of Irving Shipbuilding Inc. − was included in these shutdowns. As part of the same shipyard rationalization thrust, the major shipbuilding capacities along the St. Lawrence River were concentrated at the Davie shipyard, which is still in operation today.

HMCS Athabaskan, Tribal Class destroyer

4.0 Canada's Marine Industries Today

Successful ship procurement projects require the following capabilities:

- Project Management (Prime Contractor);
- Ship Design;
- Platform Systems;
- Mission Systems;
- Ship Construction; and
- In-Service Support.

The following sections describe the current capabilities and capacity of each of these sectors and identify recommendations to enable Canada's Marine Industries to meet future requirements.

4.1 Prime Contractor Capabilities and Capacity Today

A prime contractor assumes responsibility for the successful delivery of a complex ship project, relying on effective project management and overall project integration skills to organize numerous key contributors within a highly interdependent schedule. Owners, in this case the Government, must either undertake these roles themselves or contract for them.

After delivery of Canada's IROQUOIS Class destroyers in the early 1970s, the Government moved away from acting as its own prime contractor and systems integrator. Among the reasons for this change was government's recognition that it was not especially adept at avoiding preferred solutions or "requirements creep", both significant cost-drivers. At the same time, it appeared that industry could be more effective at finding and delivering more cost-effective solutions to meet the government's operational requirements, while being held contractually accountable for delivering what was specified in terms of operational performance within the allocated budget. This latter concept has been validated, but only when Government provides industry with the true flexibility to do so by avoiding prescriptive technical (preferred) solutions and by allocating budgets sufficient to provide for the technical and budget risk associated with specific projects.

The CPF Project showed that Canadian industry could manage and integrate the design, engineering, procurement, construction, test, trials and delivery of highly complex Canadian government ships. At that time, the idea that a Canadian prime could successfully deliver project management and systems integration was new and challenging[4]. The Government of the day recognized the challenge to industry and established an appropriate budget and a target/ceiling price contract structure with agreed risk sharing. Canadian industry proved it could accept contractual risk and deliver the required level of performance.

[4] In fact, the idea of employing a prime contractor with this responsibility for naval design and construction was unique in the world at the time. Canada led the way to what is today a more widely accepted practice.

The prime contractor, Saint John Shipbuilding Ltd. (now Irving Shipbuilding Inc.), submitted a proposal accepting a concept of “Total Systems Responsibility” for a myriad of requirements within the context of a target/ceiling contract structure. It set up a successful team to perform the project management, ship design, systems integration and equipment supply, construction, trials and delivery. At the time, the Canadian Patrol Frigate Project was the most complex project ever undertaken in Canada and it may still be. The CPF was a superb success. Canadian industry rose to the challenge and delivered one of the most technically-complex and capable warships of its day. Industry also delivered an industrial and regional benefits program to Canada in excess of 100% of the value of the contract including the development of several Canadian systems and products, many of which were also applied to the Tribal Update and Modernization Project (TRUMP), and which became successful in the international marketplace.

The CPF was followed by the Maritime Coastal Defence Vessel (MCDV) Project which, albeit a smaller and simpler ship, was also very successfully delivered through its prime contractor, SNC-Lavalin. The most recent naval example of a prime contractor-led team is the contract to Lockheed Martin Canada for the highly complex modernization of the CPF’s combat system.

To perform effectively as a prime contractor for a government ship acquisition project, a company must have significant financial depth and have, or have access to, a wide range and depth of commercial and managerial capability. It must have proven, broad, project management experience in complex projects and demonstrated capability and processes in a wide range of areas. (See **Figure 6.).**

• Risk Management	• Design & Engineering Management
• Scheduling	• Integrated Logistics Support Management
• Cost schedule control	• Sub Contract Management
• Procurement	• IRB Management

Figure 6 - Key Elements of Project Management involved in Ship Projects

Several companies operating in Canada have the current industrial and financial capacities, skill sets and processes to undertake the prime contractor/project management of complex ship design and build projects, either with in-house capacity or through reach-back to a corporate partner or parent. **Figure 7** lists the prime-contractor companies that were qualified by the Government for the recent JSS and HALIFAX Class Combat System Integration competitions and those, shown under medium complexity, which qualified for the CCG Mid-Shore Patrol Vessel Project.

Company	Complexity	
	High	Medium
General Dynamics Canada	√	
Irving Shipbuilding Inc	√	√
Lockheed Martin Canada	√	
MacDonald Dettwiler & Associates (MDA)	√	
The SNC-Lavalin Group	√	
Thyssen Krupp Marine Systems Canada	√	
Upper Lakes Group Inc		√
Washington Marine Group		√
Peter Kiewit		√

Figure 7 - Canadian Companies with Demonstrated Capability of Acting as Prime Contractor for Medium and High Complexity Government Ship Projects

This list is merely representative, since there are several other international marine companies with either Canadian facilities or interests that could compete as primes in the Canadian market. These companies have demonstrated their abilities to act as primes in large shipbuilding programs. With reach-back, they bring their companies' strengths, delivering modern and competitive solutions while growing the Canadian marine industry. Such companies would include Raytheon, Thales, Finmeccanica, BAE, DCNS, and others.

Canadian industry has demonstrated that it is capable of delivering the prime contractor/project management capability with experienced personnel for the design, integration and delivery of complex government ship projects. However, there are several serious issues involved with government contracting in general, and ship projects in particular, that challenge industry's ability to perform this role in an optimum manner. These are explored in **Section 6** of this report.

Recommendation:

That Government maximize Canadian Marine Industries direct participation in designing, building and supporting its ships by requiring that the role of Prime Contractor be carried out in Canada by Canadian companies.

4.2 Ship Design Capabilities and Capacity Today

As noted, Canada has not procured government ships since the early 1990s. The result today is that, while certain elements remain of the design capability that produced the last round of new construction, the capacity required for new projects for these specific ship types has been much diminished. Expertise in the design of many types of government vessels can only be sustained with continuous programs, through continued engineering support to existing vessels and through diversification into overseas markets.

In large measure the ship design industry was in a similar situation at the beginning of the CPF Project in the late 1970s. Industry was able to ramp up and produce world-class results, but not without substantial investment in personnel, facilities, technology transfer and training.

Ship design encompasses a wide range of activities associated with different stages of the acquisition process:

- Concept Exploration,
- Feasibility Studies,
- Functional Design,
- Detailed Design and
- In-Service Support.

Each stage requires different skills and, up to the In-Service stage, a progressively increasing number of resources. Current capability and capacity in Canada varies significantly among these different design stages.

Several companies active in ship design today have capabilities in Canada. Each tends to specialize in certain types of ships, not all of which are directly relevant to government vessels. Some only provide certain services related to aspects of ship design.

The companies listed in **Figure 8** are active in the defence and security sector or can provide specialist services relevant to ship design work in this sector. The assessments in the table are intended to reflect the current capabilities of each company within Canada. Several of the entities listed have parents/affiliates in other countries that can provide a more extensive range of expertise, as highlighted in the 'notes' column of the table. Several smaller design companies across Canada could become more interested in defence and security work if more projects were undertaken in the future; these entities represent a potential pool for recruitment, for subcontracting by lead design organizations, and for the provision of shipyard support.

Two organizations not listed in **Figure 8** are DND and CCG themselves. In many countries, the government retains in-house design capabilities for at least the Concept Exploration and Feasibility Design phases. DND performed these functions in-house until the end of the DDH 280 program in the early 1970s, but has since contracted the work externally. There is some evidence that both DND and CCG are now seeing the need to rebuild some level of in-house design capability, at least for Concept Exploration. In many countries ship design is conducted within the shipyard or prime contractor organizations. However, with the exception of the JD Irving Group, which includes Irving

Shipbuilding and Fleetway Inc., no Canadian shipyard or prime contractor has any significant level of design capability.

In addition to the companies listed in **Figure 8**, there are other design-capable companies with significant interest in the Canadian defence and security market as demonstrated by participation in recent project competitions and by the establishment of some level of Canadian presence. These are listed in **Figure 9.**

Company	Vessel Categories	Concept Exploration	Feasibility Studies	Functional Design	Detailed Design	ISS	Notes
BMT Fleet Technology	Auxiliary, combatant, ice breaker	Yes	Certain ship types	Certain ship types	Yes	Yes	Extended org with significant capabilities, mixed commercial and naval/CCG orientation
Fleetway	Auxiliary, combatant	Limited	Certain ship types	Certain ship types	Yes	Yes	Naval/CCG orientation
STX	OPV, OSV auxiliary, icebreaker	Yes	Certain ship types	Certain ship types	Yes	Yes	Commercial/coast guard patrol vessel orientation. Part of very large company with primarily commercial focus
Robert Allan	Smaller auxiliaries, patrol Vessels, icebreakers	Limited	Certain ship types	Certain ship types	Yes	Yes	Commercial but some patrol vessels

Figure 8 - Ship Design Companies with Significant Capabilities in Canada

Company	Canadian Presence	Corporate Capability
Alion Science and Technology	Representative	Design of warship and support vessel types for USN and patrol vessels for US Coast Guard, plus export market.
BAE (BVT)	Office mainly supporting non-marine programs; residual support to submarines	Design and build of all warship and patrol vessel types; predominant UK focus but significant export market.
TKMS	Representative	Design and build of all warship and patrol vessel types; predominant German focus but very significant export market

Figure 9 - International Ship Design Companies with Representation in Canada

Another list could be compiled of companies that offer support services to aspects of the design process. This ranges from classification societies and their own affiliates through to niche organizations with specialized capabilities. In Canada there is a fairly broad spectrum of these: examples are Oceanic for tank testing and other forms of performance verification, and companies such as Genoa and Highwater which specialize in developing detailed/production engineering packages for shipyards (using ShipConstructor software, developed by another Canadian company).

Canadian design organizations have been able to support government clients in the early-stage design activities (Concept Exploration and Feasibility Designs) of the recent government projects. In turn, Canadian shipyards and prime contractors have been able to assemble teams drawing on both Canadian and foreign design capabilities to respond to the resulting requests for proposals. As with the CPF Project in the early 1980s, in most of these recent projects the process has involved knowledge and technology transfer into Canada, as it has been necessary to search out current experience with the types of vessels and systems involved. There has been some recruitment from overseas into the Canadian community, and this would have to grow as and when projects move into full implementation.

Canada has a limited supply of designers from internal sources, notably Memorial University and some programs at the University of British Columbia and the University of Victoria. New graduates from any of these programs require time to gain experience. There is a general shortage of naval design skills worldwide, which is a cause of publicly expressed concern to the US Department of Defense and UK Ministry of Defence, among others. Canadian immigration policies, plus the security requirements applied to a number of recent procurements, diminish an already limited pool of talent.

Companies attempt to address these problems with technology. Both JSS bid teams had people in four countries on three continents working together on their bids using collaboration technologies and information-sharing environments to communicate when face-to-face meetings were not required or not possible.

The Canadian Government's broad application of conflict-of-interest provisions often prevents the available design capacity in Canada from fully participating in ship procurement projects. Specifically, the involvement of a contractor in direct support of the Government for Concept Exploration or Feasibility Design stage work, when combined with a role in structuring the management of a project, prevents them having any role in the subsequent Design and Build or In-Service Support contracts. By its nature, most design support work does not need to be covered by a conflict-of-interest provision as its conduct does not confer any advantage. If there is any doubt, the resulting work can be made readily available to all potential bidders. When there is a real potential for conflict-of-interest associated with management work, then that work should be split out from the design component as it could be performed by companies outside the ship-design community.

The limited availability of design capability in Canada could soon become a major bottleneck for project implementation. This is most likely to happen if several major projects move forward simultaneously, thereby spiking the demand for design services to support proposal development. There will also be a problem if current constraints on the use of design talent are maintained or strengthened. Changes to the current practice would help distribute this already thin expertise more broadly for government ship projects.

Ship design is an essential capability for Canada's Marine Industries to support government ship acquisition projects. Recognizing that it will not always be possible to completely support all phases of the design cycle with Canadian designers, emphasis should be placed on ensuring a Canadian capability for Concept Exploration, Feasibility Studies, Functional Design and In-Service Support. Detailed Design, which involves the largest volume of work, can be augmented by offshore providers.

Recommendations:

That Government require that design services for Concept Exploration, Feasibility Studies, Functional Design and In-Service Support be done by Canadian companies in Canada, to retain and nurture an important strategic capability.

That procurement policy conflict-of-interest rules regarding ship design activity during project definition be tempered so that the limited design capability in Canada can participate effectively throughout the life of a procurement project.

4.3 Platform Systems Capabilities and Capacity Today

As shown in **Section 2.1, Figure 1,** platform systems comprise from 20-35% of the overall cost of a medium-to-high complexity ship. These systems are essential for a ship to carry out its fundamental functions of being able to float, move and survive, while providing the services required by the mission systems and for support of the crew, for many weeks or months. Most equipment used in shipboard platform systems is also used in similar industrial applications in other market sectors like power stations, oil refineries, chemical plants, buildings and other moving vehicles such as trains. Care must be taken to choose materials that can withstand the harsh marine environment (sea water, temperature variations, humidity and motion), but otherwise these products generally are designed for wide industrial application in a global marketplace.

The scope of platform systems is often described as being from the "bridge to propeller" and includes the following systems:

- Propulsion (engines, gearing, shafting, propellers and steering system);
- Electrical power generation and distribution; (generators, switchboards, panels and wiring);
- Heating, ventilation and air conditioning (HVAC);

- Auxiliary Systems: fuel, sea water, fire fighting and flooding, fresh water making and distribution, compressed air, hydraulics, sanitary and environmental;
- Integrated Platform Management System (IPMS) that manages and controls many if not most/all of these systems and their related auxiliary services;
- Ancillary systems such as liquid/load control system, winches; and
- Hotel services, dining, and medical facilities, etc.

The scope of platform systems is relatively consistent for all types of ships: these functions are required by most ship designs in one form or another. However, the capabilities and requirements of these systems are uniquely sized and configured to the particular characteristics of each ship design, and their design and material selection can have a significant impact on In-Service Support costs.

Most larger and more complex equipment such as engines, generators, compressors and gearing is sourced offshore; there simply is not a Canadian market of sufficient size to support the design and production of this equipment in Canada. Most of the less complex equipment and system components can be manufactured or sourced in Canada where economies of scale make sense. In some cases the need for Industrial Benefits, as an element of the procurement strategy, can drive Canadian sourcing where it might not otherwise occur.

For some of the more complex ship projects, a platform systems integrator − sometimes referred to as either a Single Source Vendor (SSV) or Platform/Propulsion Systems Integrator (PSI)) − may be engaged as part of the project’s contactor team. The SSV assumes total responsibility for assigned platform system elements: systems engineering, design, development, manufacturing, supply, integration, test and trials, and services and support. This may be driven by the customer’s need for a fully-supported technical solution involving complex Integrated Logistics Support (ILS) products that often are not provided by typical commercial equipment suppliers.

For the DDH 280 IROQUOIS Class Project, United Aircraft of Canada Ltd was the propulsion system SSV responsible for the entire propulsion train and its control system. For the CPF Project, Saint John Shipbuilding performed this role as the prime contractor, with CAE (now L-3 MAPPS) playing a key role as the Integrated Platform Management System (IPMS) provider. Given the vital role that the IPMS performs in the day-to-day operation of the ship, the Navy usually requires a shore-based test bed be provided or maintained in Canada by the supplier to ensure through-life support of this critical system.

Large power system companies that can assume the role of an SSV are DRS Technologies, Rolls Royce, L-3 MAPPS, Siemens, Converteam and Kongsberg. None of these companies have an organic capability in Canada that has executed the SSV role for a ship project in Canada, but all have corporate reach-back capability that could enable such work to migrate to Canada for specific projects (note that L3-MAPPS is a Canadian company).

Ongoing In-Service Support requirements could see this capability remain in Canada and be available for follow-on projects.

In summary, platform systems comprise a wide range of general industrial equipment, much of which can be sourced in Canada. Most of the larger, more complex equipment must be sourced offshore; there simply is not the market for it in Canada and breaking into the export market is probably unrealistic. Industrial benefit requirements sometimes lead to components being sourced to a variety of Canadian manufacturers under licensing arrangements. Given its operational importance, it is essential that the platform system integrator of government ships be resident in Canada and be able to provide In-Service Support for the life of the system.

Recommendation:

That platform system integration of government ships be carried out and supported in Canada, for operational reasons and assured In-Service Support.

4.4 Mission Systems Capabilities and Capacity Today

Ship projects with onboard mission systems of medium-to-high complexity invariably require specialist integrators. The mission system on the majority of Coast Guard vessels and on minor naval vessels is typically of low-to-medium complexity; whereas the mission systems associated with naval warships are of medium-to-high complexity. In Canadian warships, the mission systems can account for up to 35% of total project cost.

Throughout its modern history, the mission systems onboard the Navy's ships have been integrated in Canada by Canadian-based companies:

- Paramax (now Lockheed Martin Canada) − high complexity HALIFAX Class frigates, as part of the Canadian Patrol Frigate (CPF) Project;
- Litton (now a part of L3 Electronic Systems) – high complexity mid-life modernization of the IROQUOIS Class destroyers, as part of the Tribal Update and Modernization Project (TRUMP);
- Thomson-CSF (now Thales Canada) and Macdonald Dettwiler & Associates (MDA) – medium complexity Kingston Class MCDVs , as part of the Maritime Coastal Defence Vessel Project; and
- Unisys Government Systems (now Lockheed Martin Canada) – medium complexity mid-life modernization of CFAV Quest.

With the exception of TRUMP, where Litton was initially the prime contractor, each of these mission system integrators was a Tier 1 subcontractor to the respective prime contractor.

The components of a mission system are selected based upon the mission requirements of each specific ship. Some components, such as radar and radios, are required by all ships; but most others are specifically selected to accomplish the unique mission of each ship or ship class. The most complex mission systems are those associated with a modern warship. In the case of the Canadian Navy's frigates and destroyers these would typically include the following:

- **Above-water sensors:** radar (surface and air coverage and navigation), infra-red and optical surveillance systems;
- **Underwater sensors:** sonar, towed arrays;
- **External communications:** radios, satellite communications, data links;
- **Interior communications:** telephones, Local Area Network;
- **Electronic support measures:** detecting and classifying electromagnetic radiations;
- **Electronic countermeasures:** decoying or defeating incoming missiles;
- **Weapons:** guns, missiles, torpedoes and associated launch and control systems;
- **Command and Control System:** a fully integrated system that compiles an operational picture from the ship's sensors, evaluates threats and assigns weaponry, and enables an operational team to operate and defend the ship from distributed multifunctional work stations; and
- **Helicopter handling and control systems:** landing systems, radar control, communications.

Mission systems consist of a wide range of diverse and highly-specialized products. Although several companies have many products that are designed for various marine mission systems, it is unlikely that any one company would have the most cost-effective components for all elements of a particular ship mission system. Therefore, it is common practice for mission systems to be provided by a team of suppliers, headed by a mission systems integrator. There is a strong presence in Canada of companies capable of leading the design and build of complex ship missions systems. In addition, this basic skill set can be applied to similar systems in Army and Air Force projects.

As with platform systems, some of the more complex equipment must be procured from foreign suppliers because there is no existing Canadian source and it is unlikely that it would ever be practical to create a domestic capability for this unique equipment. Where it is necessary to procure equipment from foreign suppliers, the requirement for direct industrial benefits can result in significant Canadian participation in build-to-print or assembly, test and trials and the In-Service Support of mission system equipment and components.

While western navies are quite adept and very experienced in operating together, each navy has its own internal protocols and operating procedures, often imposed by concerns for national security. These procedures become an integral part of the ship's command and control system and are part of the implementation of the mission system design. These operational requirements make it important, if not imperative, for the mission system integrator of a warship design to be Canadian-based and conversant with the way that the Canadian Navy operates its ships.

Over the past 25 years Canada has produced several capable mission system suppliers and integrators. **Figure 10** lists companies whose Canadian-based, mission system integration capabilities have served Canada's naval fleet requirements. All but MDA are international companies with significant indigenous capability and reach-back capability to a parent corporation. However, a key aspect of their value to Canada is their knowledge and understanding of Canadian naval operations and procedures.

Company	Demonstrated Canadian Capabilities – Marine Mission System Integration	Corporate Reach Back
Lockheed Martin Canada	Combat System Integration, Command and Control System Integration,, Electronic Warfare Systems (ESM and ECM) Integration	Yes
General Dynamics Canada	Sonar system integration	Yes
MDA	Mine-hunting and route survey systems	Not Applicable (Canadian company)
Raytheon Canada	Radar system integration	Yes
Thales Canada	Command and Control System Integration, Communication system integration	Yes
DRS Technologies	EO/IR Systems, Interior Communication Systems	Yes

Figure 10 - Demonstrated Mission System Integration Capability in Ship Applications

In addition, a substantial number of Canadian companies have developed products and/or capabilities, or been involved for many years as the Canadian In-Service Support provider for products that are included within the mission systems on board government ships. A number of the more prominent companies and their products that are in-service in Canadian ships are identified in **Figure 11**. Many of these companies have been able to compete in the global marketplace because of their success in providing mission system components for Canadian government ship projects.

In summary, there is a strong cadre of mission system integration expertise and marine mission-system product suppliers resident in Canada. This expertise and these products are available for the acquisition and In-Service Support of Canadian government ships. Given its operational importance, and for national security reasons, it is essential that the mission system integrator for naval ships be resident in Canada and able to provide In-Service Support for the life of the system.

Recommendation:

That mission system integration of naval ships, including development and support of the command and control system, be carried out in Canada, for reasons of national security and assured In-Service Support.

Company	Best Known For	Other Marine Products / Capabilities
C-Tech	Underwater acoustics	
General Dynamics	Sonars – Passive and Active	Acoustic processors, multi-function consoles
Hepburn Engineering	Replenishment at Sea equipment	
IBM	Data Links	Computer systems
Indal Technologies	Helicopter Haul-down system	Hanger doors, RAST, tow handling equipment; Stabilized Horizon Reference
Knudsen Engineering	Echo Sounders	
L-3 Wescam	EO/IR sensors	L-3 Mapps – Integrated Bridge System
Lockheed Martin	Integrated Processing and Display System	EW and ECM systems; Sonars; Trainers
MDA	Trainers	Remote Minehunting System
OSI Geospatial	Electronic Chart Systems	SHINNADS, Warship AIS, Asset Control and Tracking (ACT), Integrated Bridge Systems, Common Operating Picture software
Raytheon Canada	Radar integration	In-Service Support for Phalanx gun systems
Rheinmetall Canada	EO, decoys	Medium calibre gun systems, trainers
Rutter Technologies	Radar Processors for Ice Detection	Voyage Data Recorder, Electronic Chart
Thales Canada	Radars	EO/IR, In-Service Support for: sonars, periscopes, radars, radios
Ultra	Sonobuoys and Sonar components	
Valcom	Whip antennas	
W.R.Davis Engineering	Exhaust Gas Infra Red Suppression Systems	Shaft grounding
Xwave	Electronic Warfare software	Trainers

Figure 11 - Some Prominent Companies in Canada with Marine Mission System Products

4.5 Ship Construction Capabilities and Capacity Today

The state of Canada's ship construction sector is to a very large extent the result of government programmatic and policy decisions over the last three decades. The ship construction sector has also diminished over the past 20 years due to industry-led, government-supported rationalization, but the physical capacity still exists today to support the government's ship construction needs.

There is no question that the workforces and infrastructure are reduced and that there is a lack of current experience in constructing government-service ships. However, the last round of government building in the 1990s enhanced shipyard infrastructure and brought the industry to new standards of quality assurance and program management capabilities which have allowed some of the shipyards to participate in equally challenging work in the off-shore oil and gas sector. As well, some yards have retained certain skill levels through the on-going In-Service Support of the government's ships. That said, capital improvements and human resource investments will have to be made as part of a new build program, but this will not occur until projects evolve into firm contracts. The industry responded in the past when the Government called for new ship classes to be built − the DDH 280 destroyers in the late 1960s and the CPF in the early 1980s. Industry answered the call then and it will answer again.

Over the years, there has been considerable debate about the competitiveness of Canadian ship construction in the global marketplace. Asian nations have about 85% of the world shipbuilding business, because of lower wage rates, technological investments that have streamlined production, and integrated supply chains. U.S. and European yards have high productivity as well, due to the regular flow of work, and investments over time in facilities and human resources. However their wage rates make them less competitive globally. On the face of it, going off-shore for our government ships might seem like an attractive option. However, that would deny the participation of Canadian designers, integrators and suppliers and increase the cost of In-Service Support through reliance on foreign suppliers. In addition, it is extremely unlikely any off-shore company would bid to the government's onerous project requirements and contract terms and conditions for ship procurement. A broader view must be taken of the true costs of producing and supporting government ships in Canada.

The competitiveness of Canadian government ship projects must be considered in comparison to nations with similar work standards and wage rates, building similar classes of ships. An analysis by DND's Chief of Review Services entitled "The Canadian Patrol Frigate − Cost and Capability Comparison" compared the CPF with a number of similar frigates produced by other western nations. In such an analysis it is important to consider the same cost elements and to account for the relative operational capabilities. The results showed that the CPF sailaway cost (the cost of adding one additional ship to a production run) was within 3 – 8% of six similar ships. In the capability comparison, the CPF was clearly equal or greater in most categories. A relevant factor in this comparison was the benefit of the productivity learning curve that came from producing 9 of the 12 CPFs in one shipyard. This analysis suggests that Canada can get good value when designing and building its government ships in-country. This condition can best be reached by having a long-term program of steady ship production, thereby enabling continuous improvement and productivity gains to be realized from learning experiences.

Following the shipyard rationalization of the late 1980s and the closure of the Irving yard in Saint John NB in the early 2000s, there remains only a small core of Canadian shipyards potentially capable of building medium-to-high complexity government ships. To various degrees, each of these yards would need to invest in capital improvements and staff up to train new workers and management teams to undertake a new round of government ship projects, in particular for high-complexity ship projects. The shipyards that most likely could compete for government ship projects today are, from west to east:

- Washington Marine Group in Vancouver and Victoria BC
- Upper Lakes Marine and Industrial's yard in St. Catharines, ON
- Davie Yards Inc., in Levis PQ
- Irving Shipbuilding Inc.'s Halifax Shipyard, in Halifax NS
- Kiewit Offshore Services, in, Marystown NL

Shipyards in Canada are in a precarious situation when it comes to government ship construction. The industry can do the work, but it faces several challenges, mostly related to onerous contract terms and conditions and the government's boom-and-bust procurement practices. As this report confirms, the government's "Build in Canada" policy has been good for Canadian businesses and the economy, not only for the shipyards but also for the other major participants − ship designers, systems integrators and material and equipment suppliers. However, none of these benefits would flow without the Canadian yards that build the ships. The shipyards are the most important link in the chain. Their issues concern us all.

For larger ship projects, Government requires industry to offer complete financial protection and assume catastrophic financial risk. These risks must either apply directly to the shipyards if they are the prime, or be borne by the prime and then flowed down to the shipyards if they are in a subcontract relationship. In reality, this requirement is a major limiting factor in a shipyard's ability to bid, and eventually sign, a contract. This is a serious impediment to advancing the government's plans for its ship renewals. It needs to be resolved.

Canada is the only G8 nation that has taken a *laissez-faire* approach to the acquisition and the sustainment of government fleets. This approach has led to reduced high technology marine-related research and development and jobs. Canada is essentially at a tipping point − either move forward and renew and sustain Canada's government fleets indigenously, or transfer wealth, technology and jobs to other nations.

This report contends that indigenous ship design and construction is a strategic asset, and the Government needs to establish a framework to ensure its survival so it can serve the nation in the decades to come. Canada's shipyards are an essential part of such a framework. If Government wants stable, lasting, high-value employment, stronger communities, ships suited to Canada's needs, and the independence to protect our sovereignty and security, it must commit to a core, long-term sustainable ship construction industry. In adopting such a new approach, the Government will need to consult with the industry to determine how best to reach the desired outcome.

Recommendations:

That Government continue its policy of building its ships in Canada.

That Government lay out a predictable long-term, integrated fleet renewal plan with adequate and stable funding to support it.

That Government and the Canadian shipbuilding industry jointly develop a long-term strategy governing how the shipyards will continue to contribute to government ship projects.

4.6 In-Service Support Capabilities and Capacity Today

The principal marine ISS capabilities required to support Navy and Coast Guard vessels have existed in Canada for many decades. This capability has three primary components:

- the government-owned-and-operated Naval Dockyards and CCG facilities;
- an industrial base of commercial repair companies that provide maintenance and logistics services as and when required to the wider marine industry (both commercial and government fleets); and
- Fleet-specific long-term arrangements, such as the following:
  - Combat Systems Engineering Support Contract for HALIFAX and IROQUOIS classes (Lockheed Martin Canada);
  - HALIFAX / IROQUOIS Class ISS Contract, for engineering and data services (Fleetway Inc.);
  - Minor Warship and Auxiliary Vessels ISS Contract for the management and delivery of maintenance and repair work for the MCDVs, Orca Class training vessels and 23 auxiliary vessels (SNC-Lavalin Defence Programs Inc.); and the
  - ISS Contract for the VICTORIA Class Submarines (Canadian Submarine Management Group).

Setting aside the government-owned repair facilities and commercial shipyards used for periodic dockings (usually performed on a five-year basis), a significant portion of industrial marine ISS capability serving government fleets is spread among a diverse group of hundreds of Small and Medium Enterprise companies performing small repair jobs. Companies that serve both Naval and Coast Guard fleets are typically located in the vessels' home ports, or in the case of Coast Guard vessels, in their five operational regions −

Newfoundland and Labrador, the Maritimes, Québec, Central & Arctic, and Pacific. They are mobile and provide most of their services onboard the vessel wherever it may be located. These service providers survive by having a much larger commercial industrial client base, including commercial marine clients.

The Navy's MCDV fleet saw the beginning of a prime contractor approach to providing ISS for the management and delivery of maintenance and repair to some of the Navy's ships. The ISS contractor plans and coordinates the support activities with those of the Navy, subcontracts for its implementation (tapping into the existing marine and related industry) and oversees safety, environmental, and quality requirements on the waterfront. The ISS contractor also maintains all of the MCDV logistics support and technical data and documentation. ISS contracts usually are linked to guaranteed service levels of ship availability. As an indication of the importance of this activity to DND, both the JSS and AOPS projects plan to have the Design and Build contractor team also carry out the ISS work.

There are several companies in Canada that could perform the ISS prime contractor role. Shipyards are typically not involved in ISS, other than for periodic dockings. An ISS Prime Contractor need not provide any maintenance or repair work itself; it is possible for all of this to be subcontracted, as is the case with the MCDV, leaving the prime to concentrate on providing the specialized services such as engineering/inspection, logistics, technical data management and quality management.

The few capability gaps that exist in Canadian industry are associated with the maintenance of specialized systems typically only found on a military vessel, or third-line repair and overhaul by non-Canadian original equipment manufacturers (OEMs) for specialized systems. The OEM repair industry expertise for most specialized equipment (e.g. communications and propulsion equipment, and weapon systems) is usually found within the NATO countries in Western Europe or the USA, and for major repairs the equipment is either sent to the factory or factory representatives are sent to the ship for the overhauls. In some cases, these OEMs establish relationships with Canadian service providers. These specialized skills gaps do not adversely affect overall ISS capability delivery.

Current new Naval and Coast Guard projects emphasize commercial off-the-shelf equipment wherever possible, with some ship classes like JSS and AOPS being designed and maintained to a commercial classification, which Canadian Marine Industries have the experience to support.

In summary, In-Service Support is a growing area of work for Canadian industry, at least as it pertains to overall management of significant segments of the work by contractors. DND policy is that this shall generally be the norm for new projects, as shown by JSS and AOPS. Canadian industry is quite capable of taking on this important work and it is good for the retention of key capabilities in Canada.

Recommendation:

That Government continue its practice of implementing long-term In-Service Support contracts for existing and new fleets.

4.7 Overall Assessment of Canadian Marine Industries Readiness

Overall, the readiness and capabilities of Canada's Marine Industries are considered to be superior to their condition in the 1980s, before the Government last undertook a group of major ship acquisition projects. The status of individual sectors are different today, but the overall readiness is generally superior. Specifically, the six main sectors in Canada examined in the report are assessed as follows:

Project Management & Prime Contractor	Canadian industry is far more knowledgeable, experienced and able to assume this role today than it was in 1980.
Ship Design:	The Canadian design sector is less visible today than it was in the early 1980s and lacks recent experience in the design of high-complexity modern warships. It also finds itself in a role of assisting the government project teams in project definition, thereby limiting its participation on bidding teams downstream.
Platform Systems	There is greater capability today due to the residual CPF industrial experience and advances made by Canadian industry with IPMS technology. As well, several international companies have shown interest in importing this capability in pursuit of new ship projects.
Mission Systems	There clearly is significantly greater capability and capacity today with the existence and experience of a number of veteran CPF companies, augmented by increased presence in Canada of several other systems companies having developed proven mission systems for Canada or other markets.
Ship Construction	There is less capacity today due to rationalization of the shipyards resulting in fewer yards and skilled tradespersons. However, the last round of government ship projects required shipyards to enhance their infrastructure and improve quality assurance and project management capabilities which, in the interim, have been applied to the equally-stringent requirements of the off-shore oil and gas sector. As with the CPF Project, this sector has the greatest hill to climb to take on this new wave of government ship projects. There are several serious issues including risk allocation that

	must be resolved before the shipyards will be able to meet the government's need for ship construction.
In-Service Support	Industry is much better situated to provide this service today.

The two naval ship projects that face industry today − the Joint Support Ship and the Arctic/Offshore Patrol Ship − are not as technically complex as the Canadian Patrol Frigate. Thus the "ramp up" challenge to industry should not be as demanding as it was in the 1980s, but it still will be significant. Shipyards face the greatest challenges. The complexity of the Navy's replacement destroyers will be comparable to the challenge the CPF faced. All other foreseeable Canadian government ship requirements, mainly those forecast for the CCG, are likely to be of medium complexity and, therefore, manageable.

5.0 The Strategic and Economic Impact of Canada’s Marine Industries

5.1 The Economic Analysis

This report attempts to predict the economic impact that should come from the government’s plans to renew its Navy and Coast Guard fleets. The expected volume of work is based on the current plans, as reflected in **Section 2.3**, **Figure 5,** totaling an estimated $38B over the next 30 years. These cost estimates are either contained in departmental plans or representative of assumed anticipated values. Assuming that the industrial benefits are in the order of 80% of project budget (the assumed contract values), they have the potential of producing more than $30B of benefits, or an average of $1B per year over a period of 30 years. It is assumed that Navy projects will require 100% IRBs. Given the naturally high Canadian industrial capability in this sector, achievement of 70% direct and 30% indirect should be realized, based upon past projects. In addition, based on current experience, it is forecast that Navy and Coast Guard In-Service Support will amount to a further $600M of Canadian activity annually, resulting in a total projected, average, annual benefit to the economy of $1.6B.

To estimate the likely employment from this level of activity, data was extracted from a report entitled **Economic Contribution of the Oceans Sector in British Columbia**, prepared by GSGislason & Associates Ltd., for the Canada/British Columbia Oceans Coordinating Committee, consisting of six federal and provincial ministries. This report contained detailed data from 2002 to 2005 and covered all the industries of concern to CADSI’s study, principally those in ‘ship and boat building’, and ‘ocean technologies’. The BC report allowed us to determine a ratio between dollar expenditures and employment in terms of Full-Time Equivalents (FTEs) in these specific sectors (5580 FTEs from $933M). Using this ratio, the projected $1.6B annual average expenditures of government ship activity should yield approximately 10,000 jobs or FTEs.

Exclusively relying on direct effects underestimates the economic impact of this work. It is also important to take into account industry-specific indirect and induced effects which can only be calculated using input-output tables and a macro-economic model. “Indirect effects” are defined as the impacts one economic sector can have on others through its demands on those sectors’ goods and services as inputs for its own production processes. “Induced effects” recognize that an existing industry contributes to the economy by providing employment and thus impacting consumption. Hence, the absence of an industry should lead to job loss and lower GDP. As noted above, exact determination of these factors requires extensive analysis and modeling. Industry Canada traditionally uses a rather conservative “multiplier effect” (in the range of 1.5:1) to credit this additional economic stimulus. Other jurisdictions apply factors from 1.5:1 up to 5:1. Applying a multiplier effect of only 1.5:1 would bring the total annual economic impact of this work on government fleets to roughly $2.4B and 15,000 jobs.

In addition, the government's fleet requirements over the decades have resulted in several significant technological developments that have permitted a number of Canadian companies to establish leading-edge product lines and export sales. Some of these more notable "success stories" are listed at **Appendix A**, covering the following technologies:

- Helicopter Handling Systems
- Sonar Systems
- Shipboard Integrated Processing and Display System
- Shipboard Integrated Interior Communication System
- Ship Onboard Passive (Infra Red) Surveillance and Detection
- Active Phased Array Radar
- Shipboard Integrated Machinery Control System
- Modeling and Simulation of Naval Propulsion Systems and Machinery Control
- Stealth Technology
- Electronic Chart Display and Information Systems
- Simulation and Training Systems, and
- Ship Design

These are only some of the more notable developments by Canadian industry that have resulted directly from Canadian government ship projects and the developments leading up to these ship projects. It is estimated that these export sales represent an annual average of over $150M. Without the ship projects, the developments would not have occurred, nor would the resulting export sales and ongoing employment. Canadian ship projects clearly have the potential to contribute to the technological and economic development of Canadian industries and help to make them internationally competitive

5.2 A Canadian Marine Industrial Strategy

Through the Canadian Patrol Frigate Project, the Government of the day established four major industrial objectives:

- to establish a Canadian capability to manage major warship projects including design and electronic subsystem integration;
- to have at least two major electronic subsystems integrated by Canadian-controlled firms;
- to build the 12 ships in Canada; and
- to maximize, as much as practicable, the Canadian content in the Project.

All these objectives were met or exceeded and the resulting design and integration capabilities largely have remained and are ready and available in Canada today. Since then, the various participating companies have evolved due to normal market influences, but most of the skills and capabilities are still extant in the workforce today, as are advanced generations of systems developed for that project. In addition, other companies have been attracted to the Canadian marketplace, thereby providing a healthy competitive environment.

CADSI believes that the next round of major ship projects should take these objectives one step further and establish a more robust and dedicated government-ship acquisition and In-Service Support capability in Canada, as several of our allies have done with their industries. Such a strategy could streamline acquisition and provide for long-term stability to the benefit of both Government and the industry. Recently, the Ministry of Defence in the United Kingdom implemented such a strategy for the design, build, and support of its warships. As part of a Canadian strategy, CADSI believes that, in addition to the government's policy for ships to be constructed in Canada, the following high-value responsibilities should be carried out in Canada by Canadian companies:

- prime contractor;
- project management;
- platform and mission systems integration;
- the management and control of ship design; and
- In-Service Support.

Such a strategy would also maximize use of Canadian material, components and equipment, further contributing to Canadian economic growth, and lowering the cost of In-Service Support.

In addition, CADSI suggests that the Government target its Industrial and Regional Benefits program to nurture and develop industrial marine technologies in Canada, because the systems and services they provide will be required by the Navy and Coast Guard during the 30-year build program and subsequent ISS phases of the new fleets. Many capabilities applicable for marine procurements are equally relevant for future land and aerospace projects and represent knowledge-based jobs for Canadians and export opportunities. Five of the nine technologies on Industry Canada's Strategic Aerospace and Defence Technologies List have marine applications: Mission Systems; Communication and Control; Propulsion and Power Management; Sensors; and, Simulation, Training and Synthetic Environment. Under the Strategic Aerospace and Defence Initiative (SADI), the Government grants up to $225M annually to aerospace and defence companies in repayable loans for research and development on advanced technologies. In addition, Industry Canada could promote investment in marine applications into these identified technologies through the use of multipliers and banking credits. As well, the Government could encourage research and development in government and private sector labs focused on relevant technologies, such as improving the environmental footprint of Canada's fleets.

In summary, Marine Industries are important contributors to the sovereignty and security of Canada's maritime regions. CADSI estimates that their involvement in government ship projects over the next 30 years should contribute up to $1.6B and 10,000 jobs per year to the economy in terms of direct benefits, and a further $800M and 5,000 jobs due to the economic multiplier effect. In addition, these industries provide further value to the country in terms of their strategic capability and their regional economic impact.

Recommendations:

That Government establish a Marine Industrial Strategy that maximizes the direct participation of Canadian Marine Industries in the design, build, and support of government ships by requiring that, in addition to ship construction, the following critical functions be carried out in Canada by Canadian companies:

- **Prime Contractor,**
- **Project Management,**
- **Platform and Mission System Integration,**
- **Management and control of Ship Design; and**
- **In-Service Support**

That Government use existing tools to nurture and develop strategic capabilities and technologies, such as naval and marine electronics and other products that can be applied to ship acquisitions and to other defence and security procurements. These tools include the following:

- **Industrial and Regional Benefits to promote investment by using multipliers, carry-over credits and other features to nurture a wide spectrum of Canadian naval and marine contractors;**
- **The Strategic Aerospace and Defence Initiative; and**
- **Research and development in government and private sector labs focused on relevant technologies.**

HMCSs Protecteur and St. Johns during At Sea Replenishment

6.0 Challenges Facing Canadian Government Procurement

In the 15-year period between the previous round of ship projects and those now scheduled, the Government has significantly reduced its own capacity to manage government ship projects. The failures of the JSS and MSPV solicitations have, with other factors, drawn attention to that missing capacity. Other issues inhibit the ability of the Government and industry to define and implement these projects effectively. These issues are explored in this section.

6.1 The Need for Real and Effective Industry/Government Dialogue

One of the biggest problems in government ship procurement is the lack of dialogue between Government and industry during a solicitation request. The dialogue that does occur within the context of specific projects is so constrained as to be incapable of articulating, discussing, or resolving the major issues on which Government and industry need to have a common understanding. The inability to conduct meaningful dialogue during the JSS Project Definition competition was one of the major reasons for the failure of the solicitation. CADSI recognizes that Government must conduct procurements with transparency and probity and constrain communications while a specific RFP is open. However the rules should not be so constrained as to effectively preclude timely and meaningful dialogue.

The Halifax Class Modernization (HCM) Project, and more recently the Arctic/Offshore Patrol Ship (AOPS) Project represent significant first steps in the government's commitment to open more meaningful dialogue with industry. The Government invited industry to participate in a series of project-specific working groups, and these sessions have been well attended.

However, procurement issues are significantly broader than RFPs for specific projects. Missing from any dialogue is a broader discussion about the Marine Industry and shipbuilding in general. Discussion could include, among others, the following issues:

- the cyclical nature of ship procurement − is this best for Canada and industry?
- what are ship project cost drivers?
- what is the appetite of Canadian industry for high-risk low-margin ship projects?
- how can the total cost of fleet ownership be reduced, from the earliest stages of an acquisition project?
- how can the shipbuilding industry be incentivized to represent and promote Canada's interests over the long term – beyond just contract to contract – to remain competitive and viable?
- how can Government maintain a competitive pool of potential prime contractors and subcontractors that operate in many fields (not just shipbuilding) in upcoming projects?

These issues are important to Canada's national interests and they are not being discussed at any Government-industry level.

Recommendations:

That Government broaden the communication channels during acquisition projects in a manner that does not compromise procurement transparency and probity.

That Government work with industry to develop a long-term Canadian Marine Industrial Strategy that meets the need for government fleets and industrial and regional benefits.

6.2 Reconciling Budget, Schedule, and Requirements

In Canadian government-ship projects, the Government sets the budget, schedule, and requirements, and only then involves industry in a definition or bidding process in which these factors are non-negotiable. Dictating budget, schedule, and requirements requires a highly intimate understanding of several interdependent factors. This is a complex relationship that normally can only be fully understood after a detailed project definition phase. Yet, for the JSS Project the Government set budget, schedule and requirements in advance of the competitive project definition phase. In the end, there was insufficient latitude for the competitors to make the trade-offs necessary to fit within these constraints. Likewise, the bid solicitations for the MSPV Project had locked in these constraints in a manner that precluded compliant bids.

A significant factor in managing these parameters is the government's current practice of establishing project budgets in Budget Year (BY) dollars. This approach − apparently an outcome of the government's new process of accrual accounting/budgeting − is a departure from the long-established practice where project budgets were set in "fixed year" dollars (for example 2004 dollars) and then inflated year by year until the project had been properly defined by the receipt of industry bids against known requirements. Under the fixed-year dollar approach, industry deals with a budget with known purchasing power, protected from the influence of inflation, work schedule and project slippage. Once the bid is accepted, the contract price is adjusted to allow for inflation (both past and anticipated) and the now-defined work schedule and known project start date. For ship projects, with typical durations of 15 to 20 years from initiation to final delivery, the deleterious impact of setting initial budgets in BY dollars is momentous, in the order of 20-25% over the project life. If Government hopes to successfully implement projects which involve elements of design, development and build over lengthy periods of time (i.e. not "off-the-shelf" procurements), the BY approach must be re-evaluated.

Recommendation:

That Government undertake procurement reform that begins with a more flexible and realistic approach, in combination with industry, to reconciling trade-off decisions before locking budget, schedule, and requirements into an RFP.

6.3 Rebalancing Project Risk

Recent government procurements have assigned significant and increasing risk to industry, in particular catastrophic risk. As well, "Total Systems Responsibility" has been interpreted by Government to mean that industry is effectively responsible for all project and performance risk. However, in practice, Government maintains a significant degree of product and schedule control, increasing contractor risk. At the same time, Government has capped profits. All of this forces companies to re-evaluate the risk/reward balance. Industry does not have the same tools as Government to deal with this, except to factor in significant risk premiums at the expense of operational capability. It is also clear that the current risk/reward (risk/profit) formula is badly skewed to excessive risk, with margins far smaller than similar commercial marine work. Canadian ship projects are becoming so risky that companies have refused to step forward as prime contractors, or have withdrawn from such opportunities, as recently witnessed on the Halifax Class Combat System Integration solicitation.

In the end, the Government remains obligated to provide capable fleets to conduct government missions. No amount of contractor insurance, guarantees, or cash will obviate the government's commitment to that obligation. A regime that assigns unmanageable risk to contractors will adversely impact the degree of operational capability and could have a significant impact on the contractor's approach to the work, to the detriment of the end product. A more balanced approach to assignment of risk will benefit everyone.

Recommendation:

That Government optimize the balance of risk between industry and Government in fixed-price or capped profit projects to maximize best procured value and to minimize overall cost and risk to Government.

6.4 Summary

Several significant issues are hindering Government and Canada's Marine Industries from implementing the planned renewal of the government Naval and Coast Guard fleets. This results from changing government project budgeting practices, detrimental risk assignment, and overall, inadequate dialogue. These issues remain to be addressed. CADSI would be pleased to assist the Government in resolving these issues in any way possible.

7.0 Summary and Recommendations

Canada's Marine Industries and the ships they build and support are key strategic assets. The opening of the Arctic to international marine transportation and the resource and sovereignty issues this raises mean the government's marine fleets are more important than ever.

The Government is about to begin another cycle of ship procurement. This work can and should be done in Canada. A number of issues − both on the side of Government and industry − affect the nation's ability to respond in an effective manner. These issues can and must be resolved.

7.1 Summary of Recommendations

That Government continue its policy of building its ships in Canada.

That Government lay out a predictable long-term, integrated fleet renewal plan with adequate and stable funding to support it.

That Government and the Canadian shipbuilding industry jointly develop a long-term strategy governing how the shipyards will continue to contribute to government ship projects.

That Government establish a Marine Industrial Strategy that maximizes the direct participation of Canadian Marine Industries in the design, build, and support of government ships by requiring that, in addition to ship construction, the following critical functions be carried out in Canada by Canadian companies:

- Prime Contractor;
- Project Management;
- Platform and Mission System Integration;
- Management and control of Ship Design; and
- In-Service Support.

That Government use existing tools to nurture and develop strategic capabilities and technologies, such as naval and marine electronics and other products that can be applied to ship acquisitions and to other defence and security procurements; these tools include the following:

- Industrial and Regional Benefits to promote investment by using multipliers, carry-over credits and other features to nurture a wide spectrum of Canadian naval and marine contractors;
- The Strategic Aerospace and Defence Initiative; and
- Research and development in government and private sector labs focused on relevant technologies.

That Government undertake procurement reform that begins with a more flexible and realistic approach, in combination with industry, to reconciling trade-off decisions before locking budget, schedule, and requirements into an RFP.

That Government optimize the balance of risk between industry and Government in fixed-price or capped profit projects to maximize best procured value and to minimize overall cost and risk to Government.

That Government maximize Canadian Marine Industries direct participation in designing, building and supporting its ships by requiring that the role of Prime Contractor be carried out in Canada by Canadian companies.

That Government require that design services for Concept Exploration, Feasibility Studies, Functional Design and In-Service Support be done by Canadian companies in Canada, to retain and nurture an important strategic capability.

That procurement policy conflict-of-interest rules regarding ship design activity during project definition be tempered so that the limited design capability in Canada can participate effectively throughout the life of a procurement project.

That platform system integration of government ships be carried out and supported in Canada for operational reasons and assured In-Service Support.

That mission system integration of naval ships, including development and support of the command and control system, be carried out in Canada for reasons of national security and assured In-Service Support.

That Government continue its practice of implementing long-term In-Service Support contracts for existing and new fleets.

That Government broaden the communication channels during acquisition projects in a manner that does not compromise procurement transparency and probity.

That Government strike a dialogue with industry to develop a long-term Canadian Marine Industrial Strategy that meets the need for government fleets and industrial and regional benefits.

CCGS Terry Fox, Heav Icebreaker

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In addition, meetings were held with a number of government officials to obtain input and information. While this latter information was helpful in understanding the environment, the views and recommendations contained herein are those of CADSI only.

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List of Abbreviations and Acronyms

ACCS	Airborne Command and Control System
ACT	Asset Control and Tracking
AIS	Automatic Information System
AOPS	Arctic/Offshore Patrol Ship
AOR	Auxiliary Oiler Replenishment
APAR	Active Phased Array Radar
ASIST	Aircraft Ship, Integrate Secure and Traverse System
CADRE	Command Air Defence REplacement Project
CANTASS	Canadian Towed Array System
CCG	Canadian Coast Guard
CFAV	Canadian Forces Auxiliary Vessel
COTS	Commercial Off-The-Shelf
CPF	Canadian Patrol Frigate
CSC	Canadian Surface Combatant
CSI	Combat Systems Integrator
DAF	Dominion Aluminum Fabricators
DCIEM	Directorate Civil Institute and Environmental Medicine
DDH	Helicopter Destroyer
DFO	Department of Fisheries and Oceans
DIPP	Defence Industry Productivity Program
DND	Department of National Defence
DRDC	Defence Research and Development Canada
ECDIS	Electronic Chart Display and Information System
ECPINS	Electronic Chart and Precision Integrated Navigation System
ELFE	Extremely Low Frequency Electromagnetic
FELEX	Frigate Life Extension
FMS	US Foreign Military Sales
HCM	Halifax Class Modernization
HHRSD	Helicopter Hauldown and Rapid Securing Device
ILS	Integrated Logistics Support
IMCS	Integrated Machinery Control System
IPMS	Integrated Platform Management System
IRST	Infra Red Search and Track system

ISS	In-Service Support
JSS	Joint Support Ship
LR-IRST	Long-Range Infrared Search and Track Systems
MATCALS	Marine Air Traffic Control and Landing System
MCDV	Maritime Coastal Defence Vessel
MIO	Maritime Interdiction Operations
MPT	Maintenance Procedures Trainer
MSPV	Mid-Shore Patrol Vessel
MWAV	Minor Warships and Auxiliary Vessel
NAAWS	NATO Anti-Air Warfare System
NCOT	Naval Combat Operator Trainer
OOSV	Offshore Oceanographic Science Vessel
ORTT	Operations Room Team Trainer
PNS	Precise Navigation System
PSI	Platform System Integrator
PWGSC	Public Works and Government Services Canada
RAST	Recovery Assist Securing and Traversing system.
RMTS	Reconfigurable Maritime Training System
REMSEVS	Remote Secure Voice System
RNLN	Royal Netherlands Navy
SAC	Shipbuilding Association of Canada
SADI	Strategic Aerospace and Defence Initiative
SHINCOM	Ship’s Integrated Communications Systems
SHINMACS	Shipboard Integrated Machinery Control System
SHINNADS	SHip’s INtegrated Navigation And Display System
SHINPADS	Ship Integrated Processing and Display System
SSV	Single Source Vendor
SVS	Secure Voice System
TPC	Technology Partnerships Canada program
TRUMP	Tribal Update and Modernization Project
VDS	Variable Depth Sonar
VISSC	Victoria (Class Submarine) In-Service Support Contract
W-AIS	Warship Automatic Information System

Appendix A

Export Sales Generated by Participation in Canadian Ship Acquisition Projects

Over the decades government ship projects have created direct Canadian industrial participation of around 70 percent or higher. This work was centered on the shipyards in the form of direct labour, but it also applied to many hundreds of Canadian suppliers across the country. Most of these participants also supply commercial ships as well as broader industrial customers such as the oil and gas sector, chemical plants and power stations.

Significantly, several of these Canadian companies have sold products internationally because they participated in these government ship projects. This appendix highlights some of the more notable Canadian and export sale successes resulting from Canadian ship projects.

A-1 Helicopter Handling Systems

The longest standing Canadian success story may be the operation of helicopters from government ships. The Coast Guard was first to operate light weight helicopters from smaller ships, beginning with the ice breaker John Cabot in 1963. The ship's helicopter was stored in a telescopic hangar built by Dominion Aluminum Fabricators (DAF). This product became so successful that over the years DAF, later known as Indal Technologies, has produced hangars for 170 ships around the world. Hangar doors are another widely deployed product, with over 400 doors fitted on 200 ships, many of them for fixed rather than telescopic hangars.

In the mid 1960s the Canadian Navy's took this helicopter/ship relationship one step further by deploying medium weight Sea King anti-submarine helicopter to its relatively small 3,200 ton destroyer escorts. A key challenge was to develop a means of safely launching and recovering the helicopters in rough seas. The answer was to connect a wire to the helicopter hovering over the pitching deck and to haul it down and trap it in what became known as the Helicopter Hauldown and Rapid Securing Device (HHRSD), more commonly referred to as the "Bear Trap". As both the Canadian Navy and Indal's experience in shipboard helicopter operations grew, so did the evolution of HHRSD which through modification and redesign became the Recovery Assist Securing and Traversing (RAST) system.

With assistance from the Canadian Defence Industry Productivity Program (DIPP), the RAST system was upgraded and procured by the United States Navy which has become the largest user of these systems. Overall, 211 RAST systems have been sold to six countries and the system is still in production. As part of the HALIFAX Class Modernization Project, the RAST system is being upgraded to handle the new Maritime Helicopter.

The next generation Aircraft Ship, Integrated Secure and Traverse (ASIST) system was developed in the late 1980s and was first trialed in 1990 by the Canadian Navy onboard HMCS Ottawa. The ASIST system was also supported by DIPP funding and the follow-on Technology Partnerships Canada (TPC) program. Since the first sale to the Chilean Navy, 60 ASIST and its variant systems have been sold to eight navies worldwide. The ASIST sales recently include the USN DDG-1000 and USCG Deepwater programs.

With RAST and ASIST, Indal Technologies has approximately 75% of the world market for shipboard helicopter handling.

A-2 Sonar Systems

As a predominantly Anti-Submarine Warfare Navy, in the 1960s Canada began to develop sonars that could be towed behind ships and streamed to depths better suited to detect submarines. The Naval Research Establishment (now DRDC Atlantic) developed the concept of the Variable Depth Sonar (VDS), and worked with Canadian industry to produce streaming and handling systems that would permit their use in the rough conditions of the North Atlantic. These systems were sold to other navies as well. The next generation sonar, the AN/SQS 505 was conceived by the Canadian Navy and developed by Westinghouse (receiver and processing) and Edo, now C-Tech (transducer and transmitter). This sonar was installed in both hull mounted and variable depth configurations onboard the Tribal Class destroyers in the early 70s.

The latest generation of sonar development focused mainly on improvements to signal processing, led by DRDC (Atlantic) and engineered by Computing Devices Canada (now General Dynamics Canada). All of the sonar systems on the Canadian Patrol Frigates: the AN/SQS-510 medium frequency hull-mounted sonar, the Canadian Towed Array System (CANTASS) AN/SQR-501 processor, and the AN/UYS-503 Sonobuoy Processing system, were designed and produced by Computing Devices Canada. In each case, a research concept was converted into a rugged, robust military system through a successful collaboration between DRDC (Atlantic) and the contractor. These sonars have played a prominent role in the Canadian Navy − keeping Canada at the forefront of ASW on the world stage. In addition the IROQUOIS Class DDH also has the AN/SQS -510 and the AN/UYS-503.

Foreign sales of these systems include: eight AN/SQS-510s to Portugal and three to Belgium; over one hundred Sonobuoy Processing Systems to Sweden, Australia, United States, Japan, UK, and South Korea; and eleven Integrated Sonar Suites (HYDRA) to the Royal Swedish Navy. GDC was the prime contractor to the Royal Swedish Navy for the Integrated Sonar Suite, which for the VISBY class corvette consisted of a towed array sonar, hull mounted sonar, variable depth sonar, remotely operated vehicle sonars, sonobuoy processing systems, and ancillary sensors and capabilities.

General Dynamics Canada continues to invest internal R&D funds, developing up to date acoustic processing techniques, acoustic performance prediction models and decision aids − keeping ahead of the technology curve.

A-3 Ship Integrated Processing and Display System

Local Area Networks. The computer architecture incorporated within the Command and Control System of the Canadian Patrol Frigate and Tribal Update and Modernization Project is referred to as the Ship Integrated Processing and Display System (SHINPADS). SHINPADS, developed in Canada in the late 1970s, introduced multiple redundant digital data buses and distributed and reconfigurable computer networks to naval combat systems. Originally conceived by the Navy, SHINPADS was brought into production by Sperry (now Lockheed Martin Canada) during a time when the concept of Local Area Networks was virtually unknown in the commercial world. SHINPADS technology was exported even before it was used in a Canadian system. The US Airborne Command and Control System (ACCS) and the Marine Air Traffic Control and Landing System (MATCALS) were the first systems fielded with this revolutionary redundant and distributed computer architecture. This concept has since been adopted as the standard architecture for modern naval combat systems around the world.

Lockheed Martin Canada has continued to evolve the SHINPADS architecture and it is now fully based on Commercial Off-The-Shelf (COTS) technology that is suitable for the electronic, electro-magnetic and supportability demands inherent in the marine environment. In 2008, Lockheed Martin Canada's newest generation technology was selected for the modernization of the HALIFAX Class Command and Control System.

Ruggedized Computer Systems. The design, manufacture, repair and overhaul of computer systems suitable for a harsh marine environment was established in Canada as a contractual obligation within the acquisition contract for the CP-140 Aurora aircraft. LM Canada also has delivered mission system computers to the U.S. ACCS and MATCALS, the U.S. S-3 Viking aircraft, and for the Canadian Navy the HALIFAX and IROQUOIS class Shipboard Integrated Processing and Display System (SHINPADS), the Operations Room Team Trainer (ORTT), the Shipboard Integrated Communication System (SHINCOM), and the Remote Secure Voice System (REMSEVS).

Until the early 1990s, military processors were significantly more powerful than any in the commercial sector. As commercial processors began to outstrip their military equivalents, LMC evolved its mission system computer solutions to incorporate commercial processors. For example, the beam-steering computer currently in production for the European Active Phased Array Radar (APAR) system is primarily based on commercial components.

A-4 Ship Integrated Communications Systems

The Ship's Integrated Communications Systems (SHINCOM) heritage began with the Remote Secure Voice System which was developed by Leigh Instruments and installed throughout the Canadian Navy in the early 1980's. The original SHINCOM system was a collaborative development between DND and Leigh that began in the mid 1980s and resulted in SHINCOM being selected for the Canadian Patrol Frigates. Also in that time frame the USN acquired a SHINCOM system for installation on the USN aircraft carrier, USS George Washington (CVN 73). In the late 80s Leigh Instruments was purchased by Spar Aerospace which subsequently was acquired by DRS Technologies Canada Ltd (DRS TCL).

SHINCOM 2100. Through the 1990s DRS and DND collaborated on a SHINCOM II development program which moved the system's technology base to a more COTS, open systems architecture. The resulting product was the SHINCOM 2100 procured in the late 1990s for the TRUMPed IROQUOIS Class Destroyers, the AORs and DND's scientific research vessel Quest. The George Washington's system was replaced by SHINCOM 2100, and in the early 2000s the system was sold to the Venezuelan Navy for their Lupo Class Frigate's communications system upgrade.

In the early 2000s DRS and DND collaborated on a SHINCOM II Phase II development program in anticipation of the Halifax Class Mid-Life Upgrade. Also, in this time frame, the USN asked DRS to compete for the Secure Voice System (SVS) for AEGIS Destroyers DDG 103-112, which it won. As part of this program, DRS was able to develop a product from the SHINCOM II Phase II development system design. Additional systems were also procured for the USS Coronado (AGF), USS John F. Kennedy (CV-67) and USS Enterprise (CV-65). The USN variant of SHINCOM (AN/ON-658 SVS) is part of the AEGIS Combat System, which has resulted in sales to Japan, Korea and Australia through US Foreign Military Sales (FMS).

SHINCOM 3100. In the early 2000s, DRS invested in moving the SVS network interfaces from copper to fiber. The result was the SHINCOM 3100 system which was procured by the USN to support Atlantic and Pacific command centers and training facilities. As well, through the mid-2000s, the USN procured a variant of the SHINCOM 3100 system SVS-F, for their Wallops Island Ship Self Defence System Facility to test it for suitability for installation as part of the Combat System currently deployed in USN Carriers and other Large Decks (LPD, LHD, LHA, LSD).

In 2007, the USN selected the AN/ON-568 SVS to replace the aging SVS systems in the remainder of AEGIS Cruisers and Destroyers. The first seven, of up to 70 potential replacement systems were procured in 2007.

In 2007, DRS was awarded a contract to overhaul the Canadian Navy's HALIFAX Class Frigate's original SHINCOM system, replacing key components with SHINCOM 3100 technology. As well, SHINCOM 3100 technology has been selected to replace the Australian Navy's ANZAC Frigate's aging Secure Voice and Intercom Subsystem.

The evolving SHINCOM product line is a Government, Navy, and industry collaborative success story. A key to this success was having this Canadian system in service in the Canadian Navy, thereby enhancing credibility with international customers.

A-5 Shipboard Passive (Infra-Red) Surveillance and Detection

Canada became involved with shipborne infra-red surveillance and detection systems in 1975 with the evaluation of a test model inspired by DRDC (Valcartier) and produced by Spar Aerospace Canada onboard HMCS ALGONQUIN. Subsequently Canada collaborated with the US Navy in co-development of an Engineering Development Model of an infra-red surveillance and tracking system known as the AN/SAR-8 IRST. This joint program faltered in the late 1980s, after which Canada and the US decided to pursue separate programs.

In 1994 the Canadian and Dutch governments agreed to fund collaborative development of a "Sirius" Pre-Production Model (PPM) IRST system, collectively bringing together expertise gained from their previous experience: AN/SAR-8 (Canada) and IRSCAN (Netherlands). Successful trials supported the early decision of the Canadian Navy to order their Sirius systems together with the RNLN.

The Sirius IRST was jointly developed by DRS and Thales Naval Nederland. The system is designed to enhance a ship's self-defence capabilities by automatically detecting and tracking anti-ship missiles and aircraft. In addition it is capable of detecting and tracking low flying aircraft and small surface threats. It also provides high resolution video under day/night conditions, improving situational awareness to guard against unexpected threats such as hostile pirate activity. In April 2006 DRS TCL was awarded a contract for its part in the production of seventeen *Sirius* Long-Range Infrared Search and Track Systems (LR-IRST), thirteen for the Canadian Navy and four for the Royal Netherlands Navy (RNLN). These systems are part of the Halifax Class Modernization Program.

A-6 Active Phased Array Radar

In the early 1990s, Canada was a significant participant in the NATO Anti-Air Warfare System (NAAWS) study. The study generated a recommended combat system configuration that would best counter the threats that navy's would face when entering into the 21st century. A significant component of this configuration was the development of a Multi-Function Radar (MFR) and a long-range Infra Red Search and Track system (IRST). At the time, the Canadian Navy was developing the replacement ship for the IROQUOIS Class known as the Command Air Defence REplacement (CADRE) Project. In pursuing technologies that embraced the NAAWS concept, Canada entered into a tri-national memorandum of agreement with the Royal Netherlands Navy (RNLN) and the German Navy (GE) for the development of a multi-function radar, which became better known as APAR. The Prime for this activity was Thales Nederland, with a number of Canadian companies involved in critical product development of this revolutionary radar system. These companies included: Brecon Ridge (Nortel at the time), Lockheed Martin Canada, Stork Canada, Thales Canada, and CMC Electronics.

Unfortunately, the CADRE Project did not proceed to contract, but APAR was and still is a major success story in the international market. Now fielded on the Dutch Navy LCF frigates and the German Navy F124 Frigates, APAR has recently been selected for installation in the Denmark Navy. Canadian companies have reaped a return on the significant Canadian Navy investment of over 4:1, with other potential international sales in the works, clearly demonstrating the Canadian Marine Industry's abilities. APAR is a potential candidate system for the Canadian Surface Combatant (CSC) Flight 1 Project.

A-7 Ship Machinery Control Systems

In the early 1980s, the Navy and the Directorate Civil Institute and Environmental Medicine (DCIEM) – (now DRDC Toronto), in collaboration with CAE of Montreal (now L3 MAPPS) designed and developed a modern approach to monitor and control a ship's engineering plant through data bus technology, as opposed to the traditional point to point hard wired architecture. A contract followed to build a real-time demonstration system to validate the benefit of colour-graphics based consoles in conjunction with a distributed computerized control system for shipboard machinery control. This cutting edge naval technology, dubbed "Shipboard Integrated Machinery Control System" (SHINMACS) created a paradigm shift in shipboard controls that has, in many ways, shaped the evolution of today's modern ship platform management systems.

Canada was the first to showcase this platform management technology by applying this research and development to the Canadian Patrol Frigate and TRUMP Projects in a first generation application entitled Integrated Machinery Control System (IMCS). Similar systems were sold to the United States Navy in 1988 for a fleet of twelve Mine Hunters. Others followed for the Israeli, Australian and New Zealand Navies.

In the mid-1990s, CAE through its experience and technology improvements, created a new system entitled Integrated Platform Management System (IPMS). This resulted in more integration of the platform systems into the IPMS, thereby allowing reductions in manpower, footprint, weight, training and In-Service Support costs. A large part of the increased automation for the IPMS was the integration of the Battle Damage Control System. Many ships have separate systems for Damage Control and Platform Control. CAE was able to integrate the Damage Control picture into the IPMS, enabling all users to see the identical damage control picture in real time.

Benefiting from CAE's simulation heritage, L-3 MAPPS introduced the On-Board Team Training System as part of the IPMS. This includes high fidelity simulation models of the ship's platform machinery and systems as well as an advanced Instructor Facility that enables operator training of the ship's crew at sea. The same models are also used for Dynamic Analysis to validate control algorithms during IPMS design and testing. L-3 MAPPS has also delivered several land based training simulators to Navies around the world.

IPMS international contracts have followed and include various USN front line ships and numerous classes of ships in the navies of the Netherlands, Germany, Malaysia, Brunei, South Korea, United Arab Emirates, India and the United Kingdom. Recently, the Canadian Navy adopted IPMS technology for its newly delivered class of ORCA training vessels. IPMS technology ranges from small training/patrol ships such as ORCA to large aircraft carriers like the USN's CVN-77. This technology, which is widely applied to military ships, has also influenced the platform technology on commercial ships worldwide.

CAE sold this business to L-3 Communications Corporation in 2005 where it is now a major part of L-3's Marine and Power Systems Division.

As part of the Halifax Class Modernization (HCM) Program, the Canadian Navy is upgrading its IMCS to a latest state-of-the art IPMS.

SHINMACS, then IMCS, now IPMS has had a most successful global reach in terms of export sales and is a prime example of how a small investment by the Canadian Government can create and maintain hundreds of jobs for over 25 years. These developments also highlight to the international naval community that Canada is at the forefront of excellence in naval technology.

A-8 Modeling and Simulation of Naval Propulsion Systems and Machinery Control

One of the key components of the Integrated Machinery Control System (IMCS) implementation for the CPF was the development of an LM 2500 (GE Gas Turbine) Engine Controller. GasTOPS, a Canadian Company with expertise in marine gas turbines controls and dynamic simulation, was a key contributor to the successful development of this controller, the first digital implementation of the GE LM 2500 gas turbine control strategy. GasTOPS developed a high fidelity simulation model of the LM 2500 that accurately depicted gas turbine rotor dynamics, fuel control and combustion processes as well as a digitized version of the hydromechanical control algorithms for the engine. This highly specialized solution was successfully tested and implemented in the CPF's IMCS.

Throughout the 1990s, GasTOPS expanded its dynamic modeling and simulation capabilities to include all components of naval propulsion systems. It developed world-class simulation-based processes to assess and design control solutions for naval propulsion systems, and these processes have been used by international navies, ship propulsion system integrators, and marine control system equipment vendors. These solutions have been used for control and/or operator training for organizations such as the Canadian Navy, Royal Navy, Israeli Navy, US Navy, United States Coast Guard, and Canadian Coast Guard.

Keeping pace with the emergence of integrated electric propulsion as a viable solution to naval and marine propulsion, GasTOPS now includes simulation solutions for the assessment of both mechanical and electrical propulsion dynamics in its suite of simulation tools. Electrical propulsion systems in ships such as the United States Navy LHD 8 (presently undergoing sea trials) and the United States Coast Guard's Great Lakes Icebreaker (commissioned in 2006) have both been successfully implemented with the utilization of GasTOPS' propulsion plant simulations and propulsion dynamic assessments.

A-9 Stealth Technology

Naval ships conceal their presence by reducing signatures, including:

- infra-red emissions from engine exhaust gases; and
- an extremely low frequency electromagnetic (ELFE) underwater signal, which results from the alternating current flow between a ship's cathodic protection system and its propellers.

The former can be detected by infra-red sensors, a particular concern for those located in the guidance system of an in-coming missile; and the latter by underwater influence mines that can trigger their detonation.

In the early 1980s the Defence Research Establishment in Suffield Alberta began working on devices to dilute exhaust gas emissions and developed a configuration that became known, due to its shape, as the DRES ball. W.R. Davis Engineering won the contract to develop the DRES ball and eventually these Infrared Suppression Systems (IRSS) were installed in the two main gas turbine exhausts of the Canadian Patrol Frigates. A different configuration was applied to the TRUMP destroyers and both ships' diesel generators. Since then, DAVIS has become the world leader to such an extent that it has no competitor in the western world. Its products are installed on all programs that use IR suppression, which includes over 70 ships in over 20 different classes. As a result of becoming recognized experts in IR signature suppression, DAVIS expanded into the aircraft environment in 1990. It has supplied IR suppression for over 10 different types of aircraft and is operational on over 300 aircraft. The largest program is the supply of suppressors to the U.S. Army for the CH-47 (Chinook) helicopter.

Similarly, early developments led to the production of an Active Shaft Grounding System that virtually eliminates the ELFE signature by grounding the propeller shaft to the ship hull so that a constant anode to hull current is achieved through the shaft rotation. This product is unique and has no competitors. It has a more limited market, but is being fit to all new naval construction in the U.S. In addition it has been supplied to naval ships in Canada, Norway, the U.K., Australia and South Korea.

To complement its IR work, Davis developed the Naval Threat Countermeasures Systems software to model the infrared signature of a ship and its IR threats. This unique software has been adopted by both the USN and NATO. There are over 20 users as well as ongoing development contracts with some of those users.

A-10 Electronic Chart Display and Information System

Electronic charting was first developed as the Precise Navigation System (PNS) in Canada in the late 1970's to support accurate locating of offshore drilling platforms. The early system leveraged the navigation accuracies that could be achieved with satellite navigation and the efficiency of operations achieved by not having to manually plot the platform's position on a paper chart. This was largely an entrepreneurial venture, and also necessitated the development of a private capability to produce electronic chart products as national Hydrographic Service Offices were still producing paper charts only at the time.

The Canadian Navy acquired the original system and its second generation, Precise Integrated Navigation System - PINS 9000 in the mid-'80s to support the highly accurate navigation required for Mine Warfare and Route Survey operations. Throughout the 1980's, the system was continuously improved and, in the late '80's, PINS 9000 became the world's first electronic chart system to include radar image overlay through a development project with Transport Development Canada. In 1989 the Canadian Navy began a fleet-wide deployment of the third generation Electronic Chart and Precision Integrated Navigation System (ECPINS) known in the Navy as the SHip's INtegrated Navigation And Display System (SHINNADS).

The benefits of electronic charting and the data rich situational awareness environment provided by these systems were quickly appreciated and new capabilities added. In the mid-1990's the fourth generation ECPINS achieved International Maritime Organization certification as an Electronic Chart Display and Information System (ECDIS). Acknowledging the increased safety of shipping and operating efficiencies provided by electronic navigation systems, the commercial marine sector also took up the technology and ECPINS was supplied to Canada Steamship Lines and Teekay Shipping. Improvements in warship systems were confirmed when ECPINS achieved full compliancy to NATO Warship ECDIS (WECDIS) standards in 2004. Continuous improvement has resulted in ships fitted with ECPINS being able to operate in a "paperless" environment with the electronic navigation system fully replacing paper charts.

Today ECPINS is at sea in ten major navies, with the UK, Australian, New Zealand, Danish and Portuguese navies joining Canada in the fleet-wide deployment of the system. Of the 350 ships that carry ECPINS, over 200 use the capability provided to achieve paperless navigation. Continuous improvement is still underway. The ability to electronically interact with the ECPINS system and access and harness the information available within has created some "spin-off" capabilities. Work with the UK Royal Navy has produced a system called the Warship Automatic Information System (W-AIS). Based on ECPINS WECDIS capabilities and interfaced with various databases, the system enables the tactical exploitation of commercial Automatic Information System (AIS) and other information collected by the sensors integrated with ECPINS. W-AIS is deployed fleet-wide in the Royal Navy and has been very successfully employed in Maritime Interdiction Operations (MIO) in the Arabian Sea and the Persian Gulf. Further leveraging the ECPINS and AIS capability has produced a system called Asset Control and Tracking (ACT). ACT enables the sharing of data rich situational awareness information between ECPINS systems and small boats or other assets. The "mother" ECPINS can either be on the bridge of a ship or in an ashore operations facility and can control any number of "daughter" assets, limited mainly by the operators' ability. The ACT system has proven to greatly enhance the conduct of port and maritime security operations. It also has application in MIO, amphibious operations, search and rescue and any operations where positive control and continuous monitoring of small assets is required.

ECPINS, WAIS and ACT are produced by OSI Geospatial at the company's facilities in Vancouver, BC. OSI is a Canadian company and a world leader in the provision of warship navigation and unique operations support systems. The company has a long history of working with the Canadian Navy to develop and deploy advanced navigation systems and is now working with the Navy to provide ACT to support security operations.

A-11 Simulation and Training Systems

The arrival of the Canadian Patrol Frigate and its complex systems underlined the need for more effective and less costly training methods for both operator and maintenance procedures. Past practice used a complete set of ship's equipment in a shored-based training facility. In the early 1990s it was recognized that the evolution of personal computers and synthetic training environments had reached a level of maturity that could be practically exploited. Therefore, the Canadian Navy contracted with Canadian industry to develop synthetic trainer solutions that would allow personnel to be trained in a more efficient and cost-effective manner.

These contracts resulted in the delivery of three advanced training systems by Canadian industry:

- **Maintenance Procedures Trainer (MPT)** – This trainer allows technical personnel to learn to diagnose and repair mission systems and/or equipment using a synthetic computer model of the actual equipment hosted on a personal computer. The first solution was delivered in Nov 1994. Independent studies confirmed that training time can be reduced by 30% to 60% and that students trained in this environment perform better on the job. This trainer was designed and developed by Lockheed Martin Canada and is now in service in Canada, the US, the UK, South Korea, Japan and Norway.
- **Operations Room Team Trainer (ORTT)** – This trainer, also designed and developed by Lockheed Martin Canada, allows the Navy to assess the proficiency level and to train the HALIFAX Class Command Teams. The ORTT includes a sophisticated synthetic environment running on a COTS replica of the ship's

operations room equipment. This trainer was delivered in 2000 and is deemed to be a critical component of the Navy's training.

- **Naval Combat Operator Trainer (NCOT)** – This is a reconfigurable, PC based trainer that supports individual and sub-team training. This trainer, produced by MacDonald Dettwiler and Associates (MDA), emulates the systems and equipment and allows students to learn and practise everything that they need to do on the actual equipment. NCOT led MDA to develop the Reconfigurable Maritime Training System (RMTS), an exportable, modular training solution that can be readily adapted to suit specific requirements for naval training systems around the world. This has resulted in an export contract with the Royal Navy to train combat personnel on Type 42 and Type 45 destroyers, with the potential to expand the system for training and tactical practices on up to seven other ship classes. The Royal Navy has seized on the flexible nature of the system and is incorporating it into much broader training schemes that will generate additional sales. Other NATO navies are currently evaluating the technology for use to train their personnel.

A- 12 Ship Design

Canada's ship design and engineering capacity is relatively small but of high quality and has considerable engagement in the export market. Companies with an international reputation include BMT Fleet Technology, Robert Allan Limited, and STX Canada Marine Inc. Work on Canadian government projects has helped all these companies build and maintain their leading edge positions.

An illustrative example of this is STX Canada Marine Inc., (formerly Aker Yards Marine). Formed in 1983 to serve the North American market, STX Canada Marine (STXM) has grown steadily since that time and now offers naval architecture and marine engineering In the early 1980's the company designed two patrol vessels for the Canadian Coast Guard and Department of Fisheries and Oceans, the "Leonard J Cowley" and the "John P. Tully". From this experience the company became very successful in the design of Off-Shore Patrol Vessels ranging from 75 to 90 metres. Subsequent projects include the following:

- 75M vessel "Vigilant" designed and constructed in Chile for the Mauritius Coast Guard;
- Two 78M vessels, the "L.E. Roisin" and the "L.E. Niamh" for the Irish Naval Services constructed in the UK;
- Two 85M vessels, the "RNZNS "Wellington" and the RNZNS "Otago" for the Royal New Zealand Navy constructed in Williamstown, Australia; and
- Recently down selected as one of two bidders for the next generation of OPV for the Irish Naval Service.

Using its knowledge and expertise in the design of medium size complex vessels, STXM has also secured contracts for the design of a wide range of Offshore Vessels including Platform Supply Vessels; Anchor Handling Supply Vessels; Diving Support Vessels and Construction Support Vessels. The majority of these vessels have been constructed in the Gulf of Mexico.

In the last 15 years STX Canada Marine has also been involved in the majority of the US Government “commercial” ship programs for the Military Sealift Command (MSC); US Coast Guard; and the US Navy. This experience covers 280 metre new construction Sealift ships for MSC; conversion of a 200 metre Soviet Ro-RO vessel for MSC; and icebreakers for operation in the Great Lakes and Arctic/Antarctic for USCG.

BMT Fleet Technology (BMT FTL) is another success story with a slightly different focus. The company undertakes specialized ship design services for both DND and CCG, and is currently acting under contract to support the JSS, AOPS, and CCG’s OOSV Projects. In addition to design services BMT FTL has a long tradition of undertaking applied research and advanced engineering for the Canadian Government, and has been highly successful in obtaining international clients for both areas of its business based on its leading edge capabilities.

Some recent and current projects include the provision of welding engineering support to U.S. and European shipyards including Newport News and Fincantieri, for aircraft carriers and large cruise ships respectively. BMT FTL has worked with DRDC on the development of its hydrodynamic analysis tools, and markets DRDC software worldwide. This in turn has developed an advanced hydrodynamic analysis capability that has enabled BMT FTL to secure contracts for projects such as the Government of Singapore’s floating sports stadium and the new floating ferry terminal for Hong Kong’s airport. BMT has more conventional ship design projects under way in the Middle East, the US, the Caspian Sea, and South Africa.

A-13 Conclusion

These notable developments by Canadian industry resulted directly from their involvement in Canadian government ship projects and supporting research and development programs. Without these ship projects, these developments, the resulting export sales and ongoing employment would not have occurred.

Appendix B

Marine Industry Companies across Canada

This listing includes companies that either operate entirely in the marine sector or can contribute to the sector. It also includes defence electronics companies known to participate in government ship projects. The majority of these companies are Small and Medium Enterprises.

The listing does not include the many hundreds of additional Canadian suppliers providing components, material and other services to these companies.

NEWFOUNDLAND	
CHC Composites	Composites
DFB Group	Lifting appliances
East Coast Hydraulics	Hydraulics and deck machinery
Genoa Design International Ltd.	Ship design
Hi-Point Industries	General marine
ICAN Marine	Electronic charting systems, tracking, data management
IMP Marine	Safety equipment, wire ropes
Marine Industrial Lighting Systems	Lighting
Newdock	Ship repair
Peter Kiewit Sons Co.	Cow Head & Marystown Shipyards
Marine Industrial Lighting Systems	Marine lighting
Marport Canada Inc	Sonar
Northstar Networks Limited	Advanced sonar technology development
Ocean Consulting Corporation	Hydrodynamics, simulation
Rutter Technology	Marine data records, lights, radars
St. John's Dockyard Limited	Ship repair
Siemens Canada Ltd.	Electrical, mechanical repair and servicing
Stratos Global Corporation Ltd.	Electronic components, navigation, communications
Terra Nova Marine	Marine electrical design and manufacturing

NOVA SCOTIA	
Advanced Precision	Manufacture and assembly of precision components
Alscott Air Systems	Marine and offshore HVAC
'Atlantis Systems International'	Training systems
Bradeans	Tool and die, CNC
Canadian Maritime Engineering	Mechanical and welding
Composites Atlantic	Structural and non-structural composites
CTH Instruments Ltd.	Valves and calibrations
C-Vision	Electronics manufacturing
Detroit Diesel-Allison Canada, East	Diesel engines
DRS Pivotal Power	High reliability static power conversion equipment
East Coast Hydraulics & Machinery	Hydraulic machinery (shown as in Nfld)
Fleetway Inc.	Ship design
Hawboldt Industries (1989Corp.)	Hydraulic and deck machinery
Hydraulic Systems Ltd.	Hydraulics and deck machinery
Irving Shipbuilding Inc.	Halifax Shipyard
IMP Group	Engineering, maintenance, components
K&D Pratt Ltd.	Marine supplies
L3 Comms, Electronic Systems	Displays, repair and overhaul, logistics support
Lenkeek Vessel Engineering	Engineering services
Kongsberg Mesotech	Manoeuvering systems
Lunenburg Industrial Foundry & Eng'g	Shipyard and foundry
Marine Exhaust Solutions	Exhaust systems
Martec	Advanced engineering simulation technology
Macdonald Dettwiler & Associates	Naval In-service Support
Mil-Aero Electronics	Electronics design, integration, (cables, harnesses)
Seimac	Marine communication products, handheld devices
SNC-Lavalin Defence Programs Inc.	Naval In-Service Support
Ultra Electronics Maritime Systems	Advanced antisubmarine solutions (sonobuoys, sonars)
Wartsila Canada Ltd.	Diesel and propulsion

NEW BRUNSWICK	
Apex Industries Inc.	Machine shop, installation of armour
Bourque Industrial	Metal working, install armour
Caris Geomatics	Geomatics, mapping
CE3/Custom Electronics Integrators	Electronics design, manufacture
DEW Engineering	Ballistic protection
Eagle Specialty Machining/Number One Machining	Aboriginal machine shop
Guest Screw Machine Products	Screws and machined products
Irving Equipment	Cranes, rigging
Lexitech	Translation services
Malley Industries	Specialty vehicles, metal fabrication, armour, etc.
Red Hot Learning	Training, simulation, e-learning
Source Atlantic	Large motor operated valves
Tech-Atlantic, team of Innovatia, Brovada, and Mariner Partners	E-learning, technical publications, data integration

QUEBEC	
A. Crosbie	Large motor operated valves
Atlas Copco Compressors Canada	HP/LP air systems
Bronswerk Marine	HVAC marine
CMC Electronics	Communications and specialized electronics
Compare	HP/LP air systems
Crane Supply	Large motor operated valves
Davie Yards Inc.	Shipyard
EADS Defence and Security	Electronics integration
Exeltech	MRO
Fixair	Refrigeration and air conditioning
GOTAR	Solvents, chemical products
Henri Line	Machine shop
Hewitt (Caterpillar)	Diesels

QUEBEC	
International paints	Painting systems
Joiner Systems	Marine outfit products,
L3 MAPPS	Integrated platform management systems
Lockheed Martin Canada	Naval command and control systems
Marinvent Corporation	Aero R&D, software, simulation, flight test services, etc
Montreal Bronze and Foundry	Foundry
Montreal Valves	Valves
Navenco Marine	Small boats
Obzerv	Night vision technology
Plad Equipment	Pumps
Preston Phipps	Large motor operated valves
PyroGenesis	Plasma waste treatment systems
Pyrotronics Systems	Pyrotechnic, countermeasures, air, marine and land
Rheinmetall Canada	EO, decoys, gun systems
Robco	Fluid sealing products
Schneider Canada	Marine electrical, switchboards
SNC-Lavalin Defence Programs	Marine In-Service Support Management
Solacom Technologies	Critical communications, air and marine
Sonpar	Electrical switchboards, controls
Treuil de la Capitale Inc.	Winches
Tyco Simplex Grinnell	Fire suppression
Unified Alloys	Metallic piping
Verreault Navigation	Shipyard
Wainbee Ltd.	HP/LP air systems

ONTARIO	
Allied Marine & Industrial Inc.	Maintenance, repair, fabrication
Alion Science and Technology	Ship design
'Atlantis Systems International'	Training systems
Alscott Air Systems	Ventilation

ONTARIO	
Applanix Systems Ware	Integrated inertial/GPS technology
Belclawat Manufacturing	Doors and windows
Berg Chilling System	Refrigeration and heat transfer systems
BMT Fleet Technologies	Engineering services
Canadian Bearings Ltd.	Bearings
Canal Marine & Industrial Inc.	Marine Electrical and electronic systems
Cantwell Cullen and Co.	Large motor operated valves
Casebank Technologies	Diagnostic support systems
China-Steel	CNC machine shop
Cleeve Technology	Electrical and mechanical systems, cabling
CMC electronics	Communications and specialized electronics
Coverteam Canada	Propulsion system integration
C-Tech	Sonar equipment, manufacture
Cummins Eastern Canada	Diesel engines
Davis Engineering	Exhaust gas suppression systems
DRS Technologies	EO/IR and Interior Communication Systems
Fleetway Inc.	Ship design
Gallium	Graphic user interfaces
GasTOPS	Control systems, condition assessment
General Cable	Cables
General Dynamic Canada	Electronic systems integration
General Electric Canada	Motors
GT Machining	Metal work, trucks, loading system
Hammond Power Solutions	Power supply equipment
Hepburn Engineering	Lifting appliances
Hike Metal Products	Boat and small shipbuilding
Hobart Food Equipment Group	Galley equipment
Hypernetics	Electromagnetic components, avionics
Indal Technologies	Helicopter handling systems
Ingersoll Rand Canada	HP/LP Air Systems
ITT Industries	Pumps
Jastram Technologies	Large motor operated valves
Johnson Controls Ltd.	Refrigeration

ONTARIO	
Knudsen Engineering	Echo sounder systems
Lakehead Marine & Industrial Inc.	Dry-docks, repair, fabrication
Lockheed Martin Canada	Electronic systems integration
Mann Diesel Canada	Diesel engines
Metalcraft Marine Inc	custom boat design, manufacturing, refit
New era Tool and Die	Tools and Die equipment
Nutech Precision Metals	Titanium tubing
ODIM Spectrum Ltd.	Launch/recovery systems
Pyxis Innovation	Geospatial mapping
Raytheon Canada	Radar system, electro optics
Rhode and Schwarz Canada	Communications equipment
Rolled Alloys Canada Inc.	Metallic pipe
Schneider Canada Ltd.	Marine Electrical, switchboards
Seaway Marine & Industrial Inc.	Shipbuilding, dry-docks, repair, fabrication
Siemens Canada Marine	Electrical and propulsion systems
Silex Innovations Inc.	Exhaust systems
SKF Canada	Bearings
Thales Canada	Electronic systems integration
Thordon Bearings	Marine bearings
ThyssenKrupp Marine Systems Canada	Prime contracting, ship design
Timberland Equipment Ltd.	Winches and hoist, electrical components
Upper Lakes Marine & Industrial Inc.	Marine services, mechanical, electrical structural
Valcom	Fibreglass whip antennae, professional services
Weir Strachan and Henshaw Canada	Cargo handling systems
Xwave	Information, communications, technology

MANITOBA	
Acklands – Grainger Inc.	Marine supplies
Coldstream Products	Refrigeration
Filtex (a Waterite Company)	Marine supplies
Magellan Aerospace	Component manufacturing

Monarch Industries	Pumps, metal fabrication
Standard Aero	Engine servicing and R&O

SASKATCHEWAN	
Cleartech Industries	Marine supplies
Culligan	Water purification
Dumur Industries	Custom sheet metal, precision metal fabrication
SED Systems	Electronics, communications systems
SIL	Advanced sensor technology

ALBERTA	
Almac Machine Works	Machining, fabrication and servicing
BW Technologies	Instrumentation
Comco Pipe and Supply	Metallic pipe
Fairbanks Morse Engines	Diesel engines
Global Thermoelectric	Power systems, cathodic protection
Intergraph Canada Ltd.	Spatial information management software
Meridian Specialties	Large motor operated valves
Raytheon Canada Technical Services	Engineering, systems integration, Phalanx R&O
Reisley Machine	Machining
Solar Turbines Canada	Gas turbines, heat exchangers
Van Leeuwen Pipe & Tube	Metallic piping
VariSystems	Manufacturers custom cables

BRITISH COLUMBIA	
Analytic Systems Ware	Power conversion products
Allied Shipyards	Ship Repair
Airchime Manufacturing	Air Horns

BRITISH COLUMBIA	
Alaskan Copper and Brass Co.	Copper nickel piping and fittings
Albrite Lighting Ltd.	Lighting
Amstel Metal Products Ltd.	Joiner systems
Anchor Marine Electric Ltd.	Marine electrical
Armature Electric	Electric motor supply and repair
Arrolectric Power Systems	Electric Generators
A. R. Thompson Group	Large motor operated valves
BMT Fleet Technology	Ship design
Bosch Rexroth Canada Corp.	Hydraulics and deck equipment
Britmar Marine Ltd.	Lighting
Broadwater Industries	Marine Repairs
Burrard Ironworks	Winches
Canadian Maritime Engineering Ltd.	Mechanical and welding
Carmanah Technologies	Buoys, lighting, solar power systems
Cloverdale Paint Inc.	Painting systems
ComNav Marine	Autopilot Manufacture
Con-Space Communications	Communication Equipment
Cowichan Hydraulics	Hydraulics and deck machinery
Cullen Diesel Power Ltd/.	Diesels
Current Corp	Night navigator camera systems
Daniels Electronics	Radio Repeater Manufacturing
DBC Marine	Fire and Safety equipment
Detroit-Diesel Allison B.C.	Engine sales and Service
Finning Canada	Engine Sales and Service
Garibaldi Glass	Marine glass fabrication and glazing
Greggs Marine Interiors Ltd.	Marine interior systems
Hydroxyl Systems Inc	Wastewater Treatment
Inter-Con Marine	Marine Rigging and Ship Repair
International Submarine Engineering	Towed bodies and sonars
Jastram Engineering	Marine steering systems
Jenkins Marine	Shipyard
Jordair Compressors Inc.	HP/LP air compressors
Keypower	Bowthrusters & Stabilizers

BRITISH COLUMBIA	
Kobelt Manufacturing Co Ltd	Steering Controls
Kongsberg Mesotech Ltd.	Underwater acoustic products
LANTEC Winch and Gear	Winches and Gears
Les Hall Filter	Marine Filtration Systems
Manly Marine Closures	Doors and Window Supply
Marine Design Associates	Vessel Design
Macdonald Dettwiler & Associates	Electronic systems integration
Metal-Tech Industries Ltd	Fabricators and Hydraulics
Nanaimo Shipyards	Ship repair
NGrain	Interactive, 3D training
Osborne Propellers	Propellers
OSI	Electronic navigation systems
Point Hope Maritime Ltd.	Ship repair
Prime Mover Controls	Engine Controls
Pullmaster Winch Corp.	Manoeuvring systems
Quester Tangent	Data Acquisition Systems
Radio Holland Canada	Radar & Communications
Ramsay Group	Welding Fabrication
Reliance Foundry Ltd	Castings
Robert Allen Ltd	Ship design
Schneider Canada Ltd.	Marine electrical, switchboards
ShipConstructor Software	Computer Software
SNC-Lavalin Defence Programs Inc.	Naval In-Service Support
Spectrum Signal Processing Inc	Radio communications and intelligence
STX Europe	Ship design
United Engineering Ltd.	Mechanical and welding
Van Ingen International ltd	Piping Supply
Veco Canada	Consulting Engineers
Versatech Products	Pollution Control
West Coast Industrial Insulation Ltd.	Insulation
Washington Marine Group	VanShip, VanDock and VicShip, shipyards
Xwave	IT Solutions supply
Zodiac Hurricane Technologies Inc.	Small boats

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