

Northern opportunities: a strategic review of Canada's Arctic icebreaking services

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NORTHERN OPPORTUNITIES: A STRATEGIC REVIEW OF CANADA'S ARCTIC ICEBREAKING SERVICES

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ABSTRACT

Climate change presages increasingly ice-free waters in the Canadian Arctic and scope for a fundamental reconfiguration of Asia-Europe and Asia-US East Coast supply chain networks via the Northwest Passage and other Arctic routes. Retreating sea ice will continue to significantly impact the annual re-supply of goods to northern communities, the development of natural resource projects, cruise ship and adventure tourism activity, and the fishing industry. A review of the infrastructure required to support expectations of increased Arctic shipping and Panamax ships traversing the Canadian Arctic is imperative. Even today, the vast geography of the Arctic poses significant challenges in supplying support networks in remote locations. To support future developments, the capabilities of the Canadian Coast Guard (CCG) icebreaker fleet and the private sector will be crucial. While the private sector continues to build new icebreaking cargo ships with the aim of independent shipping operations in ice covered waters on a year round basis, the CCG fleet of Arctic icebreakers is old and in need of replacement. Canada's largest icebreaker, the Louis S. St-Laurent, was built in 1969 and is not scheduled to be replaced until 2017. Under the present allocation of CAD \$750M, the replacement icebreaker will not be capable of year round operations in the Canadian Arctic. In her 2007 Status Report, the Auditor General of Canada stated concerns pertaining to the CCG vessel replacement plan, formally referred to as Fleet Renewal Plan 2006 to 2030, in that it was outdated and unrealistic especially in light of planning to build ten vessels by 31 March 2011 when a minimum lead time of five years would be required to procure the vessels, of which no mention was made to Arctic icebreakers but rather to offshore fishery research and patrol vessels. To date there has been minimal academic debate relating to the need for, provision, ownership or management of Arctic icebreaking services required to open up a Northwest Passage. To rectify this, this paper will report on experts' perceptions of future marine activity in the Canadian

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Arctic and CCG services, principally Arctic icebreaking, in terms of their effectiveness and efficiency in the past, present, and future. It will also report on the identification and evaluation of possible private involvement in the delivery of CCG services, principally icebreaking, in the Arctic. The paper concludes by highlighting the requirements needed to ensure timely and uninterrupted marine transportation from vessels operating in these waters.

INTRODUCTION

For centuries explorers sought a route through the Arctic linking Europe and Asia. John Cabot proposed a Northwest Passage in 1490 and Roald Amundsen made the first ship transit in 1905 (Pharand, 1984, 38). Interest in the Arctic region, whether stemming from climate change or its abundance of natural resources, is high on the agenda of many nations. The annual extent of Arctic ice coverage is retreating at a notable rate and it is estimated that the Canadian Arctic will experience nearly ice-free summer seasons starting as early as 2050 but probably not before 2100 (Falkingham, 2004, A-5). However, things appear to be happening much faster in the Arctic and there is debate and uncertainty as to when the Arctic will actually experience ice-free summers. It could be as early as 2015 (Leahy, 2008). NASA data shows that Arctic perennial sea ice shrank abruptly by 14% between 2004 and 2005 (Hupp and Brown, 2006). It would be logical to think that less ice should increase the ease and mobility for ships currently working in Arctic regions and also for those ships that may be contemplating future activity. Milder sea ice conditions may present new merchant shipping opportunities by way of the shorter distances available to Europe-Asia and East Coast North America-Asia traffic. In terms of marine transportation, increased activity will probably result in new and increased business as a virtuous circle of business and economic activity appears to be moving northward (National-Research-Council, 2005, 3).

On a global scale, Arctic regions are rich in natural resources, holding about 25% of the world's undiscovered petroleum resources (Ahlbrandt and McCabe, 2002). On a local scale, Canada's Arctic regions are estimated to hold one third of its remaining recoverable natural gas and one quarter of the remaining recoverable light crude oil (Indian-and-Northern-Affairs-Canada, 2006, 7). Cruise ship activity is increasing and fishing fleets have already begun to follow the fish stocks that migrate northward as the ice edge retreats (National-Research-Council, 2005, 24). Any increase in activity will increase the necessity to respond to accidents and create a greater need for law enforcement in ice margin areas, which will increase the need for ice-capable ships in the Arctic (National-Research-Council, 2005, 25). After briefly reviewing relevant literature, this paper reports the methodology underpinning a quantitative survey of expert perceptions of the scope and priorities for developing CCG icebreaking services, and private ownership. Results are subjected to an exploratory factor analysis (EFA) which offers deeper insights and conclusions into the priorities for future ownership and development.

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LITERATURE REVIEW

Historically, Canada's ice breaking services have experienced numerous strategic changes. Self-governance, the beginning of independence from the United Kingdom, in the Dominion of Canada came about with the British North American Act of 1867 and with the 1867 Act came the authority for the icebreaking activities of the federal government (Canadian-Coast-Guard, 2001). Over the years, responsibility for icebreakers and icebreaking have been added and the responsibility has been transferred to different federal government departments with the most recent transfer being to the Minister of Fisheries and Ocean, via the Oceans Act, in 1997 (Canadian-Coast-Guard, 2001). Canada's history in its geographically vast Arctic includes the establishment during the 1920's of regular patrols during the short Arctic summer season, the opening of the port of Churchill during the 1930's, and the re-supply of the Distant Early Warning Line in 1957.

The history of icebreaking in Canada dates from 1842 when a commercially owned passenger steamer was designed and used for icebreaking in the Great Lakes. In 1855, government funded two vessels to tow sailing ships between the ice floes whilst they were engaged in salvage work and supplying lighthouses. They were operated by a private contractor in return for fees of service until 1859 when government took over their operation after the user pay concept failed (Canadian-Coast-Guard, 2001). More recently, a study conducted on behalf of the Department of Fisheries and Oceans Canada (DFO) and the Canadian Coast Guard (CCG), then a part of Transport Canada (TC), sought feasible ways to improve their efficiency in delivering services to the Canadian public. It concluded that the creation of a Crown Corporation was the alternative offering the largest potential savings, and most acceptable to the fleet management community (Consulting-and-Audit-Canada, 1994, 53). To date, this has not been enacted. The report also concluded that with respect to the option of privatising the ownership and operation of the fleet, which would take a long time to implement, it would first be necessary to establish a Crown corporation to operate the combined fleet.

By 2006 CCG was experiencing a funding gap of CAD \$55M, the fleet of vessels was deteriorating rapidly and becoming less reliable with frequent breakdowns and rising costs of operation and maintenance which contributed to overall funding pressures (Department-of-Fisheries-and-Oceans-Canada, 2006). Due to competing demands to replace other types of vessels, a 25-year fleet recapitalization plan to replace the ageing CCG fleet would not commence until 2017, ending in 2032. To design and build an icebreaker capable of operating efficiently in winter Arctic conditions would take a decade, and cost Canadian taxpayers over CAD \$1B. Based on a 2007 estimate that the useful life of an icebreaker is 30 years, when the planned icebreaker replacement schedule is enacted, it would be replacing vessels aged 40 to 48 years (Auditor-General, 2007). In 2006-7, the federal government announced spending of CAD \$750M on the CCG to replace 11 ageing vessels and add five new ones but with no specific reference to new icebreakers for Arctic operations. A consensus emerging from literature reviews and conversations with Arctic stakeholders indicates that icebreakers of greater size and horsepower than those in

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the current fleet will be required to assist exploitation of natural resources in the Canadian Arctic before 2027. Federal budget restraints in 1990 had ended an earlier federal government initiative to design and build a Polar 8 icebreaker, capable of year round navigation in the Canadian Arctic (Wilson, 1990).

The Arctic Ocean has been referred to as the earth's last frontier. The anticipated continued reduction in the Arctic Ocean sea ice could see this ocean being utilized as a viable option for marine transportation linking Europe and Asia. While there appears to be consensus that the Canadian Arctic ice is melting, the rate of ice melt and what this holds in store for the short and long term future is contentious (Birchall, 2006, iii). The annual extent of Arctic ice coverage is retreating at a notable rate and considering the predictions of Global Climate Models, it is estimated that the Canadian Arctic will experience nearly ice free summer seasons starting as early as 2050 but probably not before 2100 if the current warming trend continues (Falkingham, 2000, Flato and Boer, 2001, Falkingham, 2004). This timeframe is supported by scientists working with the Canadian Centre for Climate Modelling and Analysis who forecast that the Arctic will have ice-free summers by 2060 (Walsh and Timlin, 2003, 80). However, Serreze et al. (2007) make worthy mention that the results of climate model simulations are scattered and therefore contribute to the uncertainty regarding rates of Arctic ice loss through the 21st century. This uncertainty is bolstered by David Barber who estimates that the Arctic sea should experience ice free summers around 2015 (Séguin, 2008). With respect to marine transport and the setting up of schedules and shipping routes, an important phenomenon to note is that while there are observed increases in the total amount of accumulated open water throughout the Eastern and Western Canadian Arctic regions, there is still great annual variability in the actual ice conditions.

Prior empirical work to evaluate Northern opportunities to date has included a literature review and a scoping exercise consisting of three rounds of Delphi with 32 initial participants. It concluded that there is considerable uncertainty with respect to the future state of Arctic sea ice but there will undoubtedly be increased shipping activity. The CCG is currently not capable of dealing with the anticipated increase in future demand, and currently the Arctic suffers from a significant shortage of supporting infrastructure and services demanded of a global supply chain network. Subsequently, in-depth and semi-structured interviews with eight participants, inspired by the Delphi results, were conducted and analysed using inductive and deductive analysis adhering to the constant comparative method of grounded theory methodology in developing a substantive theory. Some of the hypotheses and relationships formulated suggest that: Canada's Arctic will be developed regardless of the presence and assistance of the CCG, Canada would benefit from regaining its expertise in designing and building icebreakers and becoming less dependent on other shipbuilding nations, and private involvement in the delivery of CCG services in the Arctic will result in less tax dollar spending. In an attempt to triangulate these research findings, the hypotheses and relationships formulated from inductive and deductive analysis were tested using a Likert style quantitative survey with 110 participants and analysed quantitatively.

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METHODOLOGY

Survey Design

Miles and Huberman (1994, 36) note that in the case of an applied, evaluation, or policy study the focus is tighter and the instrumentation is closely keyed to the variables of interest. Instrumentation should be a function of the conceptual focus, research questions, and sampling criteria. Prior grounded theory work and to a lesser extent a Delphi exercise had established various hypotheses and relationships between key concepts, so the main aim of the survey instrument was to test their incidence. Part A of a questionnaire sought to capture demographics, a respondent profile, and subject risk profiles. It also tested grounded theory findings dealing with contract durations and aimed to triangulate Delphi results dealing with the retreat of ice in the Northwest Passage. Further, 21 questions from Part B of the survey were analysed to report the attitude of respondents towards hypotheses and relationships arising from grounded theory work. These related to the private management and crewing of CCG icebreakers, private involvement in the design and construction of CCG icebreakers, and the leasing and chartering of privately owned icebreakers to the CCG. Finally, all questions from Part B of the survey were analysed on a multivariate basis to identify any undiscovered latent structure.

To triangulate the outcomes of the prior Delphi and grounded theory work, a Likert style survey was constructed to measure the attitudes of Arctic experts and stakeholders against these earlier results. Presser (1984, 95) defines a survey as any data gathering process in which the aggregates of human response, and not that of particular individuals, is of interest. Part A of the survey sought insights into the varying levels of business risk that survey participants were willing to accept. After inviting participants to define their initial risk profile, they were then offered three contracts representing three scenarios, each having different probabilities. They were asked to prioritize their selection of the three contracts. In subsequent questions, the contract conditions were altered slightly and participants were again asked to prioritize their selections. The answers were subjected to Hurwicz criterion, involving the processing of imprecise risk information in which a decision value is the weighted sum of its pessimistic and optimistic evaluation (Jaffray and Jeleva, 2007). This revealed the extent to which participants matched the risk profile they had chosen at the outset. The main focus of this paper is on Part B of the survey, comprised of 45 statements (S1...S45) founded on the hypotheses and relationships developed during the prior grounded theory research.

Sample design

Population, elements, population framework, sample and subjects are all terms associated with sampling. Sampling, according to Stephan and McCarthy (1965, 12), allows for a compromise between the time and financial pressures associated with a census, an extreme case of sampling. Non-probability sampling, deployed in this survey, avails of sample subjects that are rich in information and more appropriately

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suited to the research topic (Patton, 1990, 169). Numerous sampling techniques are available to a researcher. However, Lee (1993) warns that while the two main aims of sampling are representativeness and cost-effectiveness, neither may be easily attainable when researching sensitive or politically controversial topics. Unlike quantitative researchers utilizing large sample sizes in seeking statistical significance, one of the key features of qualitative sampling according to Miles and Huberman (1994, 27) is the careful selection and use of a small number of contextually nested people who are studied in-depth. In research dealing with political and or social issues that are not widely acknowledged, Lee (1993, 61) warns of the difficulties in trying to generate statistically adequate samples and that the subsequent use of non-probability sampling may result in the research not being taken seriously. In terms of the best sampling method or technique, Stephan and McCarthy (1965) suggest that there is no need to copy exactly the approach of others but rather it is more important to meet the particular needs of the researcher. This idea is supported by Patton (1990) who notes that the key to deciding on the unit of analysis for a study is ultimately influenced by the amount of authority that the researcher wishes to proclaim. Respondents were identified through the following means: literature review, attending Arctic related events such as conferences and seminars, individuals previously known to the researcher, colleagues, personal contacts, and Lloyd's Maritime Directory 2008. In this way, although a large sample size may be sought, Stephan and McCarthy (1965, 103) suggest that in some cases a small sample may be more representative than a large sample and the more information the sampler has about the population the more effective survey efforts should be. In the case of this research, with no sample or population frame available, non-probability sampling is appropriate (Saunders et al., 2007, 235), involving a relatively small number of experts and stakeholders in Arctic matters.

Statistical Issues

Veracious testing and analysis using more powerful parametric statistics is based on distributional assumptions about datasets. These assume variables with interval or ratio measurement scales (Foster, 2001, 7); normal distributions having zero skewness and kurtosis, a symmetrical distribution with the same mean and median, and a *Kolmogorov-Smirnov* Z test yielding a confidence level ≥ 0.05 (de Vaus, 2004). Foster (2001, 11) refers to such distributions as being perfect. Such precise parametric requirements were not apparent in most distributions in this survey. Notwithstanding this, Evans (2007, 60) notes that coefficients of skewness having an absolute value >0.5 and <1.0 are only moderately skewed and that coefficients $\leq +0.5$ and ≥ -0.5 indicate relative symmetry. For this survey, 64 percent of the distributions displayed skewness coefficients $\leq +0.5$ and ≥ -0.5 . De Vaus (2004, 76) suggests that a distribution skewness coefficient absolute value <1.0 is indicative of symmetry. *Kolmogorov-Smirnov* Z tests conducted on 27 variables (Tables 2, 3, 4 and 5) showed values ≥ 3.4 and ≤ 5.7 , with significance values of 0.00. In bolstering the use of parametric statistics with non-normal distributions, the central limit theorem allows for this in the case of large sample sizes $n > 100$, as in this survey ($n=110$,

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ibid). Neuman (2007, 149) associates the central limit theorem with random sampling, not deployed in this survey, and Foster (2001, 7) advocates the use of non-parametric tests when using an ordinal measurement scale.

Descriptive statistics offers measures to describe datasets and include frequency distributions and histograms, measures of central tendency, and measures of dispersion (Evans, 2007, 47). It allows for description and summary of the data or the relationships between variables in the data (Babbie et al., 2007, 270). Analysis of the 27 questions, noted earlier, to help fulfil a research objective to evaluate different models of privatization and the forms they might take, relies heavily on descriptive statistics. Inferential statistics allows for the generalization or drawing of conclusions from a sample to a wider population (Foster, 2001, 6). However, in order to make such statistical inferences, Saunders et al. (2007, 207) stress the need for probability sampling; non-probability sampling techniques were deployed in this survey.

Initially, tabulated survey results are presented for key topics in which means shown in Tables 2, 3, 4 and 5 represent 1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree. General comments on individual statements then precede an overall summary, including cross-tabulations, before further comparison and the results of EFA are presented.

Respondent profile

Given the diverse nature of the research, it was expected that respondents would display varying levels of expertise and stakeholder interest. With respect to survey non-response, Neuman (2007, 186) warns of sampling bias and problems with generalizing results that can be introduced when high proportions of a particular group, or strata, of the sample subjects do not respond. Research dealing with political issues may be seen by some groups as sensitive or threatening and consequently they may decline to participate (Lee, 1993). As experienced in the earlier Delphi exercise, CCG personnel were instructed by Fleet Directorate not to participate in this survey. Willimack et al. (2002, 215) note that with respect to business type surveys, university researchers tend to experience higher non-response rates than do government agencies and Saunders et al. (2007, 213) state the need to report survey response rates. The total response rate (TRR) for this survey was 34.05 percent while the active response rate (ARR) was 39.71 percent.

TRR = total number of responses / (total number in sample – ineligible)

In this survey: TRR = 110 / (406 – 83) = 34.05%

ARR = total number of responses / ((total number in sample – (ineligible + unreachable))

In this survey: ARR = 110 / ((406 – (83 + 46)) = 39.71%

The respondent profile (Table 1) spans nine groups, but some analyses using the Statistical Package for the Social Sciences (SPSS) present either four prime classes, namely academia, business, government, and mariner; or two prime classes, namely mariner or non-mariner.

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Table 1 Survey Respondent Profile

Profile	Percentage of total
Age	
20-30	10.0
31-40	11.8
41-50	32.7
Over 50	45.5
Gender	
Male	96.4
Place of Residence	
Western Canada	17.3
Central Canada	18.3
Eastern Canada	50.9
Northern Canada	3.6
Other	9.9
Years dealing with Arctic Matters	
<6	37.9
6-10	9.8
11-15	6.8
16-20	15.5
>20	30.0
Working in a Private or Public Organization	
Private	55.0
Background	
Academia	8.2
Business	26.4
Government	8.2
Mariner	10.0
Mariner & Academia	13.6
Mariner & Business	18.2
Mariner & Business & ex Canadian Coast Guard	3.6
Mariner & Government & Canadian Coast Guard	5.4
Other Combinations	6.4

Some respondents did not express an opinion on some statements offered in Tables 2, 3, 4 and 5. This may reflect difficulties in judging some of the issues and ideas presented, which is predictable given the broad scope of statements and the diverse sample. On Part B of the questionnaire, counts ranged from n=92 to the maximum possible n=110 for the statements presented here. Interestingly, S21 and S22 recorded both the most responses and the strongest level of agreement.

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ANALYSIS AND RESULTS

Survey Findings

Attitudes to governance and military developments in Canada

Table 2 reports general attitudes towards Canada's military and civilian roles in the Arctic, CCG terms of reference, Canadian Arctic expertise, involving local residents in Arctic development, and private involvement in delivering CCG services. Apparently, means for S1a and S1b indicate an overall negative desire to combine Canada's military and civilian roles in the Arctic, and for these roles to be managed by a newly created maritime organization. However, cross-tabs between mariner and non-mariner prime classes reveal that relatively, the greater percentage of disagreement came from the non-mariner class, particularly the under-represented government prime class (n=15). Whereas most academic, business, and mariner respondents agreed that private involvement in the delivery of CCG services in the Arctic is expected to result in less tax dollar spending (S27) most government respondents disagreed. Similarly, majorities in all non-government groups agreed that Canadians in general would not object to privatizing icebreaking services in the North only (S30) but cross-tabs revealed widespread agreement in government groups. Contrary to other groups, the vast majority of the government class shuns private involvement.

Table 2 Respondent attitudes to governance and military developments in Canada

Survey statement	n	Agree (%)	Mean
S1a Canada's military and civilian roles in the Arctic should be combined.	102	42.2	2.30
S1b Canada's military and civilian roles in the Arctic should be managed by a newly created maritime organization.	98	34.7	2.15
S2 Separating CCG Hardware from CCG Services will aid in setting clearer terms of reference for the CCG.	93	43.0	2.26
S11 Canada's Arctic would develop sooner if greater I/B capability were available on a year round basis.	108	74.1	2.97
S21 Canada needs to enhance its Arctic expertise.	110	96.4	3.57
S22 The local residents of Arctic regions need to be significantly involved in future Arctic developments.	109	95.4	3.39
S27 Private involvement in the delivery of CCG services in the Arctic will result in less tax dollar spending.	100	67.0	2.76
S30 The Canadian public in general will object to only privatizing icebreaking services in the north and not in the south.	92	44.6	2.49

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Overall, most respondents disagreed that separating CCG Hardware and Services would assist in setting clearer terms of reference for it (S2). The high number of strongly disagree responses, and current joint operation of hardware and services may suggest that defining clearer terms of reference for the CCG has nothing to do with private involvement and that a closer focus on the role of the organization may need to come from government. The greatest percentage of disagreement again came from the government class.

Almost all respondents expressed a very strong belief that Canada needs to enhance its Arctic expertise (S21). In terms of expediting Canadian Arctic development via greater icebreaking capability on a year round basis (S11), the mean reveals respondents overall strongly in favour, and even more strongly that future Arctic developments need to significantly involve local residents of Arctic regions. Only a couple of mariners and one non-mariner disagreed.

In summary, these results indicate that most respondents felt that Canada should continue to keep its military and civilian roles separate in the Arctic. Canada also needs to avail of its local Arctic residents whilst enhancing its Arctic expertise, and there is significant support for private involvement in the delivery of CCG services in the Arctic. It could be suggested that, if Arctic icebreaking services were to be privatized, this might lead to a greater presence of private shipping activity. This in itself would result in the enhancing of Arctic expertise over time and it could be supplemented by availing of the knowledge and experience of local residents given the current issues surrounding the shortages of qualified maritime human resources.

Attitudes to private management and icebreaker crewing

General attitudes towards private management and private crewing of CCG icebreakers (Table 3) reveal that respondents were quite strongly in favour of the notion that private ship management companies operating in the Arctic would be more cost efficient than government (S23a). Of the 13 dissenters, 6 came from the government class. With respect to Canadian taxpayers benefiting from having a fleet of icebreakers built competitively in Canada, to be managed by competitive private firms (S45), respondents were less supportive. This marginally positive attitude contrasts with stronger positive attitudes towards designing and building icebreakers in Europe or the Far East (in S37, S34, S38a, S38b, and S40), which might imply that taxpayers will benefit from competition. Views of the government class, who largely disagreed with S45, differed from other groups.

Respondents overall marginally felt that private companies would be more risk averse than government when operating in the Arctic (S23b). The issue of whether a private ship management company operating in the Arctic would risk its assets during the dangerous situations which may often arise is recurrent in this research. Given a mean of 2.62 and only 7 respondents who disagreed strongly and 14 who agreed strongly, the issue of risk aversion on the part of private interest is probably not a major deterrent towards private involvement in the delivery of CCG services in the Arctic. Cross-tabs revealed relatively more agreement with S23b amongst academic and mariner classes than business and government classes. In any event, it would

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be prudent for private service contracts to address the issue of dealing with higher than normal risk situations.

Table 3 Respondent attitudes to private management and crewing of CCG icebreakers

Survey statement	n	Agree (%)	Mean
S23a Private ship management companies operating in the Arctic would be more cost efficient than government.	102	87.3	3.15
S23b Private ship management companies operating in the Arctic would be more risk averse than government.	102	54.9	2.62
S24 Private firms are able to manage CCG I/Bs more efficiently than the CCG through Public Works & Treasury Board.	95	65.3	2.82
S25 Private management of the CCG fleet will resolve critical manning issues.	98	45.9	2.46
S42 Canada's Arctic development would best be accomplished by having a private local company to manage and crew I/Bs that are built outside of Canada and leased to the CCG for year round operations in the Arctic.	100	49.0	2.49
S45 Canadian taxpayers would benefit from having a fleet of competitively built, in Canada, Polar Class I/Bs that will be managed by competitive private firms.	99	64.6	2.75

On S24, respondents generally felt that private firms would be able to manage CCG icebreakers more efficiently than the CCG through the Public Works and Treasury Board. Cross-tabs again revealed general agreement by all classes except the government class, but a limited response (n=95) implies that some participants found S24 difficult to evaluate. This is not surprising since some participants have probably never had any dealings with the Public Works and the Treasury Board. Notwithstanding this, respondents in all classes excepting government felt that private management of the CCG fleet would not resolve critical manning issues (S25). The government group disagreed. CCG employees belong to large and influential unions and unless the CCG fleet is crewed privately the critical manning issues may not be resolved. Conceivably, private management will not worsen an already critical situation.

Although marginal, respondents overall disagreed that Canada's Arctic development would best be accomplished by having a private local company to manage and crew icebreakers built outside of Canada that would be leased to the CCG for year round operations in the Arctic (S42). However, in light of the positive attitudes with respect to increased icebreaker capabilities on a year round basis (S11), the perceived efficiency of private companies (S23a, S23b, S24), and the shipbuilding capabilities of foreign countries (S38a, S38b) the negative attitude in S42 may be connected with the leasing of the icebreakers to the CCG. Cross-tabs revealed general disagreement amongst academic and government classes and agreement by business and mariner classes.

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In summary, these results indicate that while a private ship management firm may be more reluctant than government in deploying a ship into a high risk situation, the same firm would be more efficient at managing, and possibly crewing, CCG or privately owned icebreakers.

Attitudes to icebreaker design and construction

Table 4 reports general attitudes towards icebreaker design and construction. Overall, respondents felt strongly that experienced shipyards in Europe and the Far East were able to build an icebreaker faster and with greater efficiency and effectiveness than Canadian shipyards (S37, S38a, S38b). Respondents felt that private firms were able to procure icebreakers more efficiently and effectively than the CCG through Public Works (S36). Further CCG would be better off using a proven icebreaker design than having a new design created in Canada (S34).

Table 4 Respondent attitudes towards icebreaker design and construction

Survey statement	n	Agree (%)	Mean
S34 It would be more efficient for the CCG to use a proven I/B design than to have a new I/B designed in Canada.	104	74.0	2.90
S36 Private firms are able to design & build I/Bs more efficiently and effectively than the CCG through Public Works.	100	91.0	3.30
S37 Canadian shipyards are unable to build a I/B as quickly as other experienced shipyards in Europe and the Far East.	100	83.0	3.13
S38a Other countries are able to build an I/B more effectively than Canada.	100	71.0	2.90
S38b Other countries are able to build an I/B more efficiently than Canada.	101	87.1	3.15
S40 Unless Canada decides to build a substantial fleet of Polar Class I/Bs, it will cost less to have them designed and built in European or Far East yards.	98	90.8	3.18
S43 The CCG would benefit from the acquisition of I/Bs designed and built by European or Far East yards, to manage themselves.	102	59.8	2.64

S40 reveals strong agreement that unless Canada decides to invest in and build a substantial fleet of Polar Class icebreakers, thereby allowing for the flattening of learning curves and exploiting possible economies of scale and scope, taxpayers would benefit by having icebreakers built in foreign yards. Overall agreement with S38a, stating that other countries are able to build an icebreaker more effectively than Canada, may imply perceptions that Canada is more inept at building icebreakers than designing them. The mean for S43 indicates that overall, respondents were only slightly in favour of the CCG acquiring icebreakers from foreign shipyards to manage themselves. However, higher mean scores on other

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statements dealing with the acquisition of I/Bs designed and built competitively outside of Canada, may imply that the CCG would be unable to extract the same gains as private industry in availing of shipyards outside of Canada. This may imply a perceived lack of negotiating skills required in dealing directly with the shipbuilding industry within the CCG, which currently procures only through public works.

These results indicate that with respect to the interests of expediting Arctic development and spending less Canadian tax dollars, I/Bs should be procured by private firms availing of proven vessel designs and European or Far East shipyards. Cross-tabs for all statements in Table 4 reveal similar attitudes in all classes.

Attitudes to leasing and chartering icebreakers

Concerning general attitudes towards the leasing and chartering of icebreakers (Table 5), the mean responses for S26a, S26b, and S39 indicate general agreement that Canada would increase its presence, and its taxpayers would benefit from private Canadian ownership of a fleet of multifunctional ice class vessels to be used by the CCG, Canadian Military, and oil companies operating in the Arctic. Cross-tabs reveal general disagreement only in the government class.

Table 5 Respondent attitudes to leasing and chartering icebreakers

Survey statement	n	Agree (%)	Mean
S26a Private Canadian ownership of a fleet of vessels used by CCG, Canadian Military, and oil companies in the Arctic will increase Canadian presence.	105	63.8	2.72
S26b Private Canadian ownership of a fleet of vessels used by CCG, Canadian Military, and oil companies in the Arctic will not jeopardise Canada's sovereignty.	102	67.6	2.78
S28 Chartering out of private I/Bs to the Canadian Government will necessitate long term time charters.	100	89.0	3.16
S39 Canadian taxpayers would benefit from the CCG and the military committing to charter a fleet of newly constructed and privately owned multi-functional ice class vessels that have the modular capability to meet their particular interest and will be time shared with oil companies operating in the Arctic.	98	69.4	2.85
S41 In the absence of increased funding for CCG, Canada's maritime requirements would be better served by setting up a Maritime Administration office which would be responsible for the development of CCG and DFO programmes and would avail of the existing CCG fleet, the leasing of private hardware and/or the contracting out of services.	93	64.5	2.67
S44 Without its own fleet of Polar Class I/Bs the CCG will need to engage in a long term time charter for I/B services in the Arctic.	100	85.0	3.00

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A hypothesis emerging from earlier grounded theory work posited that the Canadian Government would need to engage in long term contracts with the private sector when chartering icebreaker services in the Arctic. Responses to S28 and S44 which supported this view were not apparent in responses to Part A. Instead, given the uncertainty of future ice conditions, some respondents appeared to reject longer duration contracts as being unresponsive to environmental conditions. Cross-tabs for S28 revealed no disagreement in the government class, but a little in other groups, and on S44 no disagreement in the mariner class. Although respondents overall favoured the creation of a new maritime office or organization to deal with Canada's maritime requirements (S41) cross-tabs revealed widespread disagreement in the government class, but not in other classes.

In summary, these results indicate that Canada's presence and sovereignty in the Arctic could be bolstered by the CCG, military, and oil companies availing of a privately owned fleet of multi-functional icebreakers on a long term contractual basis. While this idea is somewhat contrary to the negative attitudes exhibited in S1a and S1b, which suggest that Canada's military and civilian roles in the Arctic should be combined and managed by a newly created maritime organization, it is commensurate with a new maritime office to deal with Canada's maritime requirements. This idea was supported by respondents, in S41.

Comparative View of Private Involvement

To gain further insight and clearer understanding of the opinions expressed by the prime classes with respect to the possible forms of private involvement in Arctic icebreaking services, the central tendency of response distributions for the 27 statements was compared using non-parametric statistics, and triangulated with earlier findings. Four-group comparisons of academic, business, government, and mariner prime classes were compared using the Chi-square and Kruskal Wallis tests. Mariner and non-mariner prime classes were compared using a Mann-Whitney test. Chi-square tests were used to test whether the frequency distributions of the prime classes were independent of each other with a null hypothesis that the same proportion of individuals would choose to agree or disagree regardless of which prime class the individual belonged to. The Kruskal Wallis test was used to compare medians of academic, business, government, and mariner prime classes with a null hypothesis of no significant differences. Alpha values for two-tailed Mann-Whitney comparisons of mariner and non-mariner prime classes were set at the 95% confidence level (Table 6).

To further explore the survey results and identify any relationships between survey statements, other than those founded on grounded theory and identified in Tables 2, 3, 4 and 5, the *Spearman rho* test, most often associated with ordinal data, was used to ascertain if there were correlations only, between variables. These correlations assist triangulation by identifying if the statements grouped in Tables 2, 3, 4 and 5 are appropriately positioned but do not imply causation (Foster, 2001, 205). Following bivariate comparisons, participant risk profiles of risk taker, risk neutral, and risk averse were added to the analysis to identify if certain risk types held

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different opinions with regards to the survey statements. With respect to participant risk profiles, weak negative correlations at the 95 percent level, -0.215 (S34) and -0.203 (S37) were noted. Table 7 shows other correlations significant at the 95 percent level.

Table 6 Comparison of central tendency of subgroup responses

Statement	Chi-square	Test for independence	Mariner: non-mariner
S1b	0.014	0.015	
S2	0.015	0.016	
S23b	0.015	0.016	0.002
S24	0.018	0.019	
S25			0.048
S26a			0.038
S26b	0.015	0.016	
S27	0.001	0.001	0.038
S30	0.043	0.045	
S39	0.009	0.01	0.034
S41	0	0	0.003
S42	0.005	0.005	0.008
S45	0.006	0.006	0.019

Exploratory Factor Analysis

Analysis had reduced 45 general statements to 27 grouped into four general topics, grounded in earlier Delphi and grounded theory work. To probe further and attempt to triangulate earlier findings, factor analysis (FA) and principal component analysis (PCA) of these statements was undertaken to gain insights into holistic perceptions of issues which respondents regarded as important in furthering private involvement in the delivery of icebreaking services in the Canadian Arctic.

Tabachnick and Fidell (2001, 25) inform of empirical and theoretical approaches in trying to identify underlying latent structure in a set of variables; PCA being the empirical approach while FA and structural equation modelling belong to the theoretical approach. Both approaches involve statistical techniques aimed at reducing complex sets of correlation matrices by determining which correlated variables belong to homogenous subsets that are largely independent of each other (Kim and Mueller, 1978, Kline, 1994, Cudeck, 2000, Foster, 2001, Tabachnick and Fidell, 2001, Stevens, 2009). FA may take the form of either exploratory or confirmatory, with exploratory being the most common (Foster, 2001, 232). Warner (2008, 753) informs that FA consists of a group of related analytic methods including PCA, and Stevens (2009, 345) informs that PCA is a form of EFA. However, Cudeck (2000, 274) stresses that PCA is often incorrectly used as a kind of FA and warns that some statistical packages used PCA as their default method of FA. This research deploys EFA and PCA. Kline (1994) informs that one aim of EFA is to

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explore a topic and to try and discover the latent constructs or dimensions that were previously unknown. It also aims to explain the correlation matrix in as few factors or components as possible and to ascertain which variables are deemed most important by those participating in a survey (Foster, 2001, 232).

Table 7 Significant *Spearman rho* correlations between statements in Tables 2, 3, 4, and 5

Statement	With, <i>rho</i>	With, <i>rho</i>	With, <i>rho</i>	With, <i>rho</i>	With, <i>rho</i>
Table 2					
S1b	S1a, 0.47				
S2	S1a, 0.33	S1b, 0.53			
S11	S1a, 0.31	S1b, 0.30			
S21	S11, 0.33				
S22	S21, 0.27				
S27	S1b, 0.41	S2, 0.34			
S30	S27, -0.30				
Table 3					
S23b	S23a, 0.27				
S24	S23a, 0.54				
S25	S23a, 0.33	S23b, 0.21	S24, 0.61		
S42	S23a, 0.25	S24, 0.50	S25, 0.32		
S45	S24, 0.36	S25, 0.37			
Table 4					
S36	S34, 0.24				
S37	S34, 0.21	S36, 0.23			
S38a	S34, 0.34	S36, 0.29	S37, 0.73		
S38b	S34, 0.22	S36, 0.45	S37, 0.80	S38a, 0.72	
S40	S34, 0.27	S36, 0.27	S37, 0.60	S38a, 0.61	S38b, 0.57
S43	S34, 0.36	S37, 0.26	S38a, 0.35	S38b, 0.26	S40, 0.48
Table 5					
S26b	S26a, 0.65				
S39	S26a, 0.51	S26b, 0.58			
S41	S26a, 0.38	S26b, 0.37	S39, 0.41		
S44	S26a, 0.36	S26b, 0.30	S43, 0.30	S39, 0.31	S41, 0.40

Various rules are offered regarding the suitability of sample size and whether factors or components are reliable (Yates, 1987, Foster, 2001, Child, 2006, Stevens, 2009). In consideration of the advise provided by Stevens (2009, 333), sample size and factor reliability for this survey are deemed appropriate. In determining sample adequacy, the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test, and the Anti-image matrices were run and analyzed. The initial and final KMO and Bartlett's Tests are shown in Table 8. KMO values <0.50 are unacceptable and should be removed from further analysis (Kaiser, 1974, 35, Child, 2006, 55). Thirteen variables identified along the diagonal of the anti-image correlation matrix with KMO values <0.5 were removed from subsequent work. The analysis involved 110 participants, 40 of 53 initial variables, and eight components.

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Table 8 KMO and Bartlett's Test

KMO and Bartlett's Test	Initial	Final
Kaiser-Meyer-Olkin measure of sampling adequacy	0.599	0.758
Bartlett's Test of Sphericity / Approximate Chi-square	3049.863	2309.510
Degrees of freedom	1378.000	780.000
Significance	0.000	0.000

Stevens (2009, 328) identifies four methods used in determining the number of components to extract or retain: eigenvalues >1 , scree test, statistical significance test, and retain only enough factors or components to account for 70 percent of the total variance. He goes on to highlight several studies supporting the accuracy of the scree test and that in some cases the scree test and the Kaiser eigenvalues will yield the same results in terms of true factors. Child (2006, 58) informs of methods used in helping to determine the appropriate number of factors to extract but notes that eigenvalues >1 and the scree test are the most common. Johnson and Wichern (2007, 445) inform that the scree plot is a useful aid in helping determine the appropriate number of factors to extract and that the user needs to look for a bend in the elbow of the plot to determine the actual number to use. The scree plot is somewhat subjective but can even be used when conditions are not ideal such as low sample and communality values (Tabachnick and Fidell, 2001, 621). For this research the scree plot proved better in terms of acquiring simple structure. The scree plot resulted in the extraction of eight components. In dealing with a participant's missing data, analysis was conducted using pairwise exclusion, resulting in varying sample sizes for some variables, of cases (Child, 2006, 68).

While PCA and FA are substantially different, they do often yield similar results in terms of the PCA weights obtained in analysis and the estimated regression coefficients in FA (Cudeck, 2000, 275, Child, 2006, 48, Stevens, 2009, 325). While Stevens (2009, 343-344) notes that FA and PCA are different, with factors estimated in FA but not in PCA and communalities <1 are used in the main diagonal of the correlation matrix in FA but not in PCA, he highlights several cases where the choice of analysis does little to affect the final outcome. However, he does note that outcomes can differ in cases with <20 variables. Child (2006, 58) provides advise on using PCA to prepare for FA. He goes on to explain that the results of PCA should be compared with other FA, such as Principal Axis Factoring (PAF) and Maximum Likelihood (ML), to see which method, when rotated, provides simple structure. Yates (1987, 3) informs that rotation is a transformation phase aimed at bringing about simple structure in which the variables are assigned to the factors. For this research, PCA, PAF, ML, and Image Factoring (IF) were conducted and subjected to both orthogonal and oblique factor rotation. The combination of analysis and rotation providing the best in terms of simple structure was PCA with orthogonal varimax rotation. In the rotated component matrix (Table 9) component titles reflect the content of the highest loading survey statements including Privatization (Pri), Resources (Res), Politics (Pol), Shipbuilding (Ship), Development (Dev), Special

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Table 9 Rotated Factor Matrix

Statement	Components							
No.	Pri	Res	Pol	Ship	Dev	SOA	Adm	Ser
S27	0.787							
S24	0.785							
S26a	0.758							
S26b	0.707							
S23a	0.683							
S25	0.658							
S39	0.652							
S42	0.614							
S32		0.767						
S33		0.766						
S20	0.335	0.725						
S31		0.585						
S45	0.427	0.502						
S15c	0.315	0.488	0.458				0.348	
S44	0.305	0.382			0.367			
S13			0.8					
S14			0.799					
S15a			0.76					
S15b	0.314	0.361	0.555		-0.325		0.315	
S19	0.301		0.459					
S21			0.417					
S38b				0.835				
S38a				0.826				
S37				0.817				
S40				0.747				
S36	0.454			0.483				
S9					0.777			
S10					0.761			
S11					0.739			
S12b					0.492			
S4a						0.858		
S5						0.795		
S4b						0.721		
S1b							0.748	
S1a							0.682	
S41	0.361	0.396					0.44	
S2	0.373					0.346	0.425	
S18								0.721
S17								0.541
S3						0.381	0.357	-0.526

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Operating Agency (SOA), Administration (Adm), and Services (Ser). Appendix 1 shows the rotated factor matrix with the survey statements included.

CONCLUSION

The selection of questionnaire statements and descriptive statistical analysis have identified that Canada needs to pay more attention to Arctic development. Also, there is significant potential for the private sector to be involved in this development with respect to the management and crewing of CCG icebreakers, the design and construction of icebreakers for the CCG, and the leasing and/or chartering of icebreakers to the Canadian government or other interested groups involved in Arctic operations. While there was a positive attitude toward longer term leasing and/or chartering contracts, some respondents did not favour longer term contracts which would be inflexible with respect to the changing and uncertain future ice conditions. The small sample of government employees reflects instructions from employers not to participate in the survey. The limited number of ex-employees who did respond were often more critical of private involvement.

Principal Component Analysis helped to triangulate the results of non-parametric analysis via highlighting the numerous potential benefits that could possibly be achieved from increased private involvement in developing the Canadian Arctic and that the current and future availability, and appropriate use, of resources will be paramount to such development. It also identified that political and administrative challenges are hindering Arctic development and the level of services that the CCG is capable of providing as a Special Operating Agency. Further, given the status quo, the taxpayers of Canada would benefit from the construction of new, and much needed, icebreaking capacity outside of Canada. Finally, there was uncertainty, with respect to future ice conditions in the Northwest Passage. This uncertainty corroborates findings from the Delphi exercise. A focus for future research would be centred on the need to explore further and develop the principal components identified. Further research involving more of Canada's Arctic stakeholders is required to canvas the in-depth opinions of local experts relating to various models which may underpin the ownership, organisation and management of relevant infrastructure. This research will require more government involvement at all levels and may well be supported by a quantitative survey, to triangulate the findings, and assess the extent of support for new initiatives.

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No.	Loading	Components with Statements
Privatization		
S27	0.787	Private involvement in the delivery of CCG services in the Arctic will result in less tax dollar spending.
S24	0.785	Private firms are able to manage CCG I/Bs more efficiently than the CCG through Public Works & Treasury Board.
S26a	0.758	Private Canadian ownership of a fleet of vessels used by CCG/Canadian Military/oil companies in the Arctic will increase Canadian presence.
S26b	0.707	Private Canadian ownership of a fleet of vessels used by CCG/Canadian Military/oil companies in the Arctic will not jeopardise Canada's sovereignty.
S23a	0.683	Private ship management companies operating in the Arctic would be more cost efficient than government.
S25	0.658	Private management of the CCG fleet will resolve critical manning issues.
S39	0.652	Canadian taxpayers would benefit from the CCG and the military committing to charter a fleet of newly constructed and privately owned multi-functional ice class vessels that have the modular capability to meet their particular interest and will be time shared with oil companies operating in the Arctic.
S42	0.614	Canada's Arctic development would best be accomplished by having a private local company to manage and crew I/Bs that are built outside of Canada and leased to the CCG for year round operations in the Arctic.
Resources		
S32	0.767	Canada needs to be at the forefront of icebreaking technology.
S33	0.766	Canada would benefit from regaining its expertise in designing and building I/Bs and becoming less dependent on other shipbuilding nations.
S20	0.725	Due to Canada's geographical expanse and ensuing political bureaucracy the CCG fleet is grossly inefficient and underutilized.
S31	0.585	Canada is capable of building ice strengthened supply vessels.
S45	0.502	Canadian taxpayers would benefit from having a fleet of competitively built, in Canada, Polar Class I/Bs, managed by competitive private firms.
S15c	0.488	Limited attention from Federal MPs has resulted in the CCG's poor operation.
S44	0.382	Without its own fleet of Polar Class I/Bs the CCG will need to engage in a long term time charter for I/B services in the Arctic.
Politics		
S13	0.800	Canada's low public interest in marine matters has contributed to the low public profile of the CCG.
S14	0.799	The low public profile of the CCG results in very limited attention being given to it by Federal Members of Parliament.
S15a	0.760	Limited attention from Federal MPs has resulted in the CCG's low funding.
S15b	0.555	Limited attention from Federal MPs has resulted in the CCG's poor management.
S19	0.459	Political intervention impedes the CCG from achieving more commercial-like efficiencies.
S21	0.417	Canada needs to enhance its Arctic expertise.

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Shipbuilding

- S38b 0.835 Other countries are able to build an I/B more efficiently than Canada.
- S38a 0.826 Other countries are able to build an I/B more effectively than Canada.
- S37 0.817 Canadian shipyards are unable to build a I/B as quickly as other experienced shipyards in Europe and the Far East.
- S40 0.747 Unless Canada decides to build a substantial fleet of Polar Class I/Bs it will cost less to have them designed and built in Europe/Far East yards.
- S36 0.483 Private firms are able to design & build I/Bs more efficiently and effectively than the CCG through Public Works.

Development

- S9 0.777 I/B support will be necessary for the development of the Arctic region.
- S10 0.761 Political will and I/B support will be necessary to expedite future development of the Arctic region.
- S11 0.739 Canada's Arctic would develop sooner if greater I/B capability were available on a year round basis.
- S12b 0.492 Canada's Arctic sovereignty claim and environmental stewardship would be bolstered if CCG I/Bs were stationed in the Arctic year round.

Special Operating Agency (SOA)

- S4a 0.858 Separating the CCG from the Department of Fisheries & Oceans (DFO) will strengthen its Special Operating Agency (SOA) status.
- S5 0.795 As a SOA, outside of DFO, the CCG would have more flexibility to operate more efficiently and effectively in the Arctic.
- S4b 0.721 Separating the CCG from the Department of Fisheries & Oceans (DFO) will help reduce crewing cost.

Administration

- S1b 0.748 Canada's military and civilian roles in the Arctic should be should be managed by a newly created maritime organization.
- S1a 0.682 Canada's military and civilian roles in the Arctic should be combined.
In the absence of increased funding for the CCG, Canada's maritime requirements would be better served by setting up a Maritime Administration office which would be responsible for the development of CCG and DFO programmes and would avail of the existing CCG fleet, the leasing of private hardware and/or the contracting out of services.
- S41 0.440
- S2 0.425 Separating Canadian Coast Guard (CCG) Hardware from CCG Services will aid in setting clearer terms of reference for the CCG.

Services

- S18 0.721 Increased political demands on the CCG have resulted in the CCG neglecting private sector service requests.
- S17 0.541 New southern security and science matters are shifting the workload of the CCG away from icebreaking in the Arctic.
- S3 -0.526 A single national organizational approach would reduce CCG crewing costs.

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