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Evaluating Exposure Time until Recovery by Location

Technical Report

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EXECUTIVE SUMMARY

This report summarizes the proceedings and findings of the project "Evaluation of Exposure Time until Recovery by Location," which was funded by Transport Canada. The study involved the investigation of potential exposure times at eight locations dispersed throughout northern Canada. Exposure time, as defined in this report, relates to the total time from which an alert notification of an emergency event is sent, to when a rescue is affected. The primary goal of this study was to identify and assess key factors that influence the exposure time by quantifying the effect where possible.

In order to evaluate exposure time and the numerous factors that can influence this time, a two-part study was conducted. This approach allowed us to obtain experienced based quantitative and qualitative information relating to the potential exposure times and related factor effects. The first component of the study involved the development of a two-part survey which was distributed to experts in the area of marine-based SAR resources as well as air-based SAR resources. The first part of the survey was a questionnaire which prompted responses relating to the effect of key factors at the different locations considered. The second part of the survey, termed as the factor ranking sheet, listed the key factors that had been identified through a literature review and requested that they be ranked in terms of their potential to increase exposure time.

The second part of the study involved hosting a workshop to present the consolidated results of the exposure time survey, the details of the methodology that was applied to the consolidated results in order to determine the range in exposure time at each location and finally, the resulting exposure time range values. The workshop was attended by representatives of JRCC Trenton and JRCC Halifax as well as other representatives with experience in marine or air based northern operations. The workshop allowed for refinement of the survey-based exposure time ranges based on an open discussion of the factors considered as well as identification of other factors that were not captured through the survey.

The workshop findings were applied to the survey-based exposure time ranges which resulted in the final survey plus workshop based exposure time range values. These range values are applicable to the conditions under which they were investigated and are subject to change if the actual conditions are vastly different. One such condition relates to the time of year for which the exposure time ranges were defined. The marine-based exposure times may differ greatly for different periods of the year since the strategic positioning of CCG vessels can change dramatically. The conditions and assumptions surrounding the defined exposure time ranges should be considered when contemplating the exposure times indicated.

The final exposure times indicated that the minimum of the low-range exposure time values was 13 hours and this related to locations 6 and 8. The maximum of the low-range exposure time values was 27 hours which occurred at location 1, the most northerly of the locations considered. Another interesting point is that when considering marine resources only, the maximum low-range exposure time jumps to 48 hours and occurs at location 1. Survival in the harsh environmental conditions of northern Canada even at the minimum predicted exposure times would be challenging. Efforts to ensure that operations in these locations are equipped with adequate emergency and survival equipment is essential to help prevent loss of life, given the exposure times that can be expected in these areas. This could be supported by strengthening policy and regulation relating to operational requirements and Life Saving Appliance testing conditions. This partial solution could be complemented by the more costly alternative of enhancing Canada's search and rescue capabilities in the north.

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LIST OF ABBREVIATIONS

ACIA	Arctic Climate Impact Assessment
AIS	Automatic Identification System
AMSA	Arctic Marine Shipping Assessment
AOPS	Arctic Offshore Patrol Ships
CASARA	Civil Air Search and Rescue Association
CCG	Canadian Coast Guard
CCGA	Canadian Coast Guard Auxiliary
CF	Canadian Forces
CIS	Canadian Ice Services
CSC	Canadian Surface Combatant
CWEA	Canadian Wind Energy Atlas
DND	Department of National Defense
EPIRB	Emergency Position Indicating Radio Beacons
FRC	Fast Rescue Craft
FWSAR	Fixed Wing Search and Rescue
GEO	Geostationary Earth Orbit
GMDSS	Global Maritime Distress and Safety System
HF	High Frequency
HF/DSC	High Frequency Digital Selective Calling
ILD	Instrument Landing System
IMO	International Maritime Organization
JRCC	Joint Rescue Coordination Centers
JSS	Joint Support Ship
LEO	Low Earth Orbit
LSA	Life Saving Appliances
MF	Medium Frequency
MRSC	Maritime Rescue Sub-Center
NDB	Non-Directional Beacon
NSPS	National Ship Building Procurement Strategy
NSS	National SAR Secretariat
POB	Persons on Board
RCAF	Royal Canadian Air Force
SAR	Search and Rescue
SMMS	Search and Rescue Mission Management System
SOLAS	Safety of Life at Sea
TEMPSC	Totally Enclosed Motor Propelled Survival Craft

1 INTRODUCTION

Climate change in the Canadian north is leading to an evolution in available marine transportation paths due to varying ice conditions. In recent years global warming has led to the reduction in sea ice levels which allows for travel in remote areas of northern Canada that were inoperable in the past due to extreme ice conditions. Also, less severe ice conditions are leading to an increase in the type of vessel capable of transiting through the north. Hence, not only is climate change leading to increased activity in the Canadian north, but it is also leading to operations in new remote locations as well as operations with new vessel types. Thus, climate change is causing an increased potential for an unexplored marine emergency scenario to occur within the remote areas of northern Canada.

Search and rescue operations in response to a marine emergency within Canada are managed by the federal government through three Joint Rescue Coordination Centers (JRCC's) and one Maritime Rescue Sub-Center (MRSC). The lead agency for federal search and rescue is the Department of National Defense (DND). DND provide primary air resources to response and Air Force personnel in the JRCC's. The Canadian Coast Guard provides the marine component of the search and rescue system and provides primary marine resources and personnel for the JRCC's. Incidents occurring in Canadian oceans or within the federal waters of the Great Lakes and St. Lawrence River system are considered federal SAR incidents and are managed by the JRCCs. Additional information pertaining to the coordination and organization of SAR operations in Canada can be found in the National SAR Manual (DFO, 2000). Marine SAR operations are undertaken by a number of different resources including SAR vessels, helicopters, fixed wing aircraft as well as vessels and aircraft of opportunity. A vessel or aircraft of opportunity denotes a vessel or aircraft whose primary function is not SAR activities but which could be tasked with assisting in SAR activities.

This project involves an evaluation of the potential exposure times resulting from a marine emergency scenario occurring in the Canadian north. The Canadian north is defined here as locations within Canadian boundaries and above 60 degrees northern latitude. Exposure time in this context is defined as the time from when an emergency alert is sent out to the time that rescue is completed. The evaluation of exposure time is complex and requires the consideration of a number of factors that have the potential to affect the exposure time relevant to a given scenario. A key factor affecting exposure time may be location which is a primary investigation in this study. The exposure time for a marine incident occurring at a location within the high Canadian north may be much greater than the exposure time for the same incident occurring at lower northern latitude due to large distances from search and rescue assets and vessels of opportunity as well as inaccessibility caused by severe environmental conditions.

Currently available Life Saving Appliances (LSA), such as survival suits and life rafts, may not be designed to withstand the possible lengthy exposure times due to a marine emergency occurring in northern Canada. Thus, an evaluation of exposure times for different locations across the vast Canadian north will provide data that will be useful in not only gauging potential exposure time, but also assessing levels of preparedness, developing relevant regulations, and setting a baseline for the design of LSA adequate for use in such harsh, remote regions.

2 APPROACH

The approach taken to evaluate the exposure time resulting from a marine emergency occurring at locations across northern Canada is described below.

Development of exposure timeline
A timeline, representing the different phases that make up overall exposure time is formulated and described. Development and description of the exposure timeline will allow a clear understanding of what exposure time means in this context and influence consistency in terms of how exposure time is evaluated.

Canadian response resources
A review of Canadian SAR response resources was conducted and is presented in brief. This includes Canadian Forces air resources and Canadian Coast Guard marine resources. Secondary air resources offered by the Civil Air Search and Rescue Association (CASARA) and secondary marine resources offered by the Canadian Coast Guard Auxiliary are also identified.

Determination of key factors
A literature review of occurrence reports pertaining to northern emergencies along with discussions with search and rescue experts will help identify key factors that affect the duration of exposure time resulting from a marine accident in northern Canada. A qualitative review of these factors will be completed to identify how they affect exposure time and if they have the potential to restrict any phase of the exposure timeline.

Selection of locations
General locations across northern Canada to consider in the evaluation of exposure time were selected based on a number of key factors. All locations are above 60^{o} latitude and within Canadian jurisdiction. Current and future northern Canadian shipping trends was a primary factor in that locations were selected that fall along routes that are currently travelled and those that could open up due to climate change. The quantity of locations considered was limited to the number that could be thoroughly examined in the selected evaluation scheme which includes a survey and follow-up work shop.

Development of emergency scenario
An emergency scenario was defined to allow for a comprehensive evaluation of exposure time at each of the locations selected for consideration. The scenario details were limited in an attempt to find generalized results that could be applied to a number of potential emergency scenarios. The scenario details were included as a component of the survey package and hence, considered in the survey responses.

Survey development and review
A survey was developed with the aim to gauge expert opinion on the effect that key factors have on exposure time relevant to each of the defined locations. The consolidated survey results were analyzed for each location to provide an indication of the expected range in exposure times.

Workshop for subject matter experts
A workshop was designed to obtain feedback and confirmation regarding the consolidated survey results and elicit expert opinion on factor ranking. Another goal of the workshop was to determine if experts could agree on map zones or limits where the exposure time can be differentiated.

Data analysis

The data arising from the survey and workshop was compiled and reviewed to gauge the range in potential exposure time relevant to each considered location. Survey and workshop results were used to develop a ranking scheme which is used to prioritize the exposure time factors considered in this study. Factor ranking is conducted for each location to gauge if and how the prioritization of factors, in terms of their significance in effecting exposure time, varies from one northern Canadian location to another.

Development of exposure time map

The range in exposure time, resulting from survey and workshop output, were summarized for each location considered. The results are displayed on a geographical map to provide a visual of the disparity in potential exposure times at different locations throughout the Canadian north.

Consideration of future developments

A qualitative investigation was conducted to assess the effects that future Canadian Government Arctic infrastructure projects could have on exposure times in northern Canada.

Conclusions and recommendations

Conclusions regarding the identified exposure times and factor affects across northern Canada are presented. Recommendations for further work that would complement the results of this project are provided.

3 TIMELINE OF EXPOSURE

The process by which exposure time was defined is given in Figure 1. The first phase, entitled *Initial Communications*, involves the duration of time between the initial alert call and the rescue resource departure. This phase includes the time it takes to select rescue resources and collect the required personnel. The second phase, entitled *Travel to Location*, is the duration of time from which a resource departs its original location to when it reaches the incident location. The travel time may vary largely for different response resources that could be used, such as a helicopter or a vessel. The third phase, entitled *Search Period*, involves the duration of time between arriving at the desired location and locating the personnel in distress. The duration of this phase could fluctuate depending on the emergency scenario details, for example if the ship has been abandoned and personnel are in survival craft the search time will likely be longer than if all personnel are still on the ship. The fourth and final phase, *Rescue Activities*, involves the duration of time between locating personnel and successfully performing rescue operations to get all personnel on board a rescue resource. Again, the duration of this phase may change depending on the location of the personnel, whether still aboard the vessel in distress, in a lifeboat, or in the water.

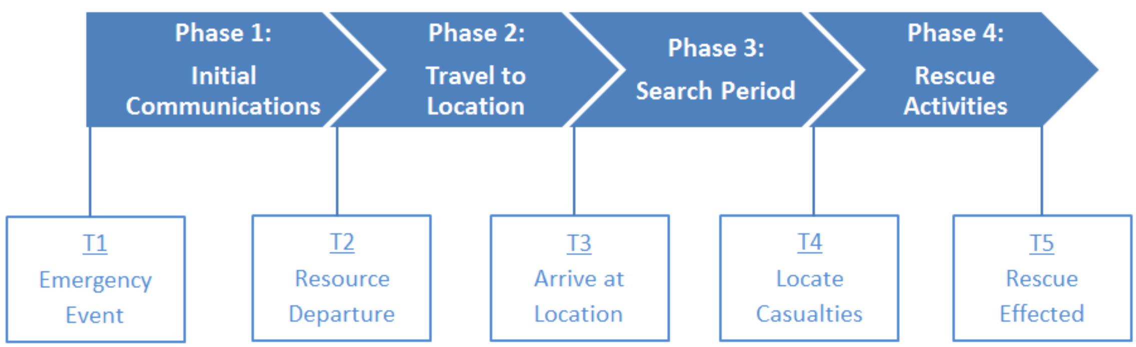

Figure 1. Exposure timeline and relevant phases

The factors that influence exposure time may affect a single, multiple, or all phases of the exposure timeline. A factor that affects multiple exposure timeline phases may be more significant than a factor that only affects one phase depending on the severity of the factor. The severity of a factor is gauged by the magnitude of its potential effect on the overall exposure time.

4 CANADIAN RESPONSE RESOURCES

The National SAR Secretariat (NSS) indicates that in Canada, marine SAR resources are generally provided by the CCG and the CCG Auxiliary while air SAR resources are generally provided by the Canadian Forces (CF) and CASARA. Response resources are divided into two categories namely, primary and secondary resources. Primary SAR resources refer to those resources whose primary function is to respond to SAR incidents. These resources are specially designed and equipped to deal with a SAR event and are continuously held at a standby level so that operations can begin quickly after an alert is received. Secondary SAR resources refer to any CCG or CF resource whose primary function is not SAR operations but could be directed to respond to a SAR event if assistance is required.

4.1 Marine Based Resources

The CCG provides primary and secondary marine SAR resources in Canada. The CCG has three regions across Canada namely, the Atlantic region, the Central and Arctic region and the Western region. The Central and Arctic region covers the majority of northern Canada above the Arctic Circle. The CCG has a number of bases located throughout Canada however; there are no operational bases in the north. All CCG icebreakers are considered secondary resources since their primary operational function is not SAR activities.

The CCG has two Heavy Arctic Icebreakers namely, the *Louis St.-Laurent* and the *Terry Fox*. These vessels generally operate throughout the Canadian Arctic between the months of June and mid-November and within the Gulf of St-Lawrence and East Coast of NL during winter months. The CCG has four Arctic Icebreakers which are capable of ice breaking and escort operations in the Canadian Arctic during the summer months. Additionally a light icebreaker from the Western Region works in the Western Arctic each summer.

The Canadian Coast Guard Auxiliary (CCGA) provides volunteer responders to marine search and rescue incidents across Canada. In the north, the CCGA currently have units in Aklavik, Inuvik, Pangnirtung, Rankin Inlet, Cambridge Bay, Yellowknife, Hay River, Fort Resolution, Fort Chipewyan and Fort McMurray. The response vessels used are typically in the 18 to 24 foot range and ideal for the local areas but not suitable for longer range operation. The CCGA is actively working to expand the network to other communities.

A “vessel of opportunity” is a commercial vessel that is in the proximity of an emergency event at the time of occurrence. Such a vessel could be directed to assist in Search and Rescue operations and may reach the scene first depending on the circumstance. The availability of a vessel of opportunity is by chance and therefore cannot be relied upon for emergency preparedness.

Though Canada is equipped with a strong fleet of primary and secondary SAR vessels, all of these vessels are based in southern latitudes which would lead to large transit times to an emergency scenario in the north. This may result in a heavier reliance on air based response resources for Arctic emergencies. In this assessment the Canadian icebreakers are used as the marine response. The icebreakers are secondary SAR resources however this makes the Arctic no different than any other offshore region in Canada where the SAR coverage is by multi-tasked ships that have other primary programs. None of the icebreakers are based in the north but spend their operational summer period there.

4.2 Air Based Resources

The Canadian Forces provide primary air based resources in Canada. The SAR aircraft are broken into squadrons which are based at different locations across the country. The Canadian Forces SAR squadrons are supported by approximately 750 personnel, including ground crew, air crew, and Search and Rescue Technicians. There are currently five operational SAR squadrons in Canada, as listed in Table 1 (National Defence, 2013a). There is a sub-unit of 8 Wing Trenton located in Alert, Nunavut which is the most northerly location with permanent inhabitants in the world. However, CF station Alert is a signals intelligence unit and is not equipped with any full-time SAR air resources.

Table 1. CF SAR Squadron Locations

Squadron Name	Squadron Location
9 Wing Gander	Gander, Newfoundland and Labrador
14 Wing Greenwood	Greenwood, Nova Scotia
8 Wing Trenton	Trenton, Ontario
17 Wing Winnipeg	Winnipeg, Manitoba
19 Wing Comox	Comox, British Columbia

The Canadian Forces are equipped with three primary aircraft including the CH-149 Cormorant, the CC-130 Hercules and the CC-115 Buffalo. The first aircraft listed, which has the prefix CH is a helicopter, while the last two, with the prefix CC, are fixed-wing aircraft. In general fixed-wing aircraft are used for searching since they have a relatively long range. The rescue capabilities of fixed wing aircraft lag behind those of helicopters. Hence, marine rescue efforts, beyond the dropping of equipment and food, are generally undertaken by helicopters. Disadvantages of a helicopter when compared to a fixed wing aircraft include a smaller range and a higher operational cost.

To elaborate on rescue capabilities of the primary CF air resources: the CH-149 Cormorant can hold 10 seated passengers and four stretchers when configured for SAR operations (McGuire, 2011). CH-149 Cormorant helicopters are based at CF squadrons in Gander, NL, Greenwood, NS and Comox, BC. The CC-130 Hercules can hold 128 non-combat passengers or a maximum payload of 30,000 lbs. This fixed-wing aircraft is located at the CF squadron 8 Wing in Trenton, Ontario. The CC-115 Buffalo can carry a payload of 2727 kg or 41 combat passengers. The CF owns six CC-115 Buffalo aircraft and all are housed at the CF squadron 19 Wing in Comox, BC.

The Canadian Forces also has three secondary air resources. These resources include: the CH-146 Griffon, CH-124 Sea King and the CP-140 Aurora. The CH-146 Griffon has a maximum passenger capacity of 10 and is located at nine different CF squadrons all across Canada. The CH-124 Sea King is based at two locations including Shearwater, NS and Patricia Bay, BC. The Sea King can carry a payload of approximately 2730 kg. The CP-140 Aurora is based in two CF squadrons including 19 Wing in Comox, BC and 14 Wing in Greenwood, NS. This fixed-wing aircraft has a maximum payload of approximately 36,500 kg.

The Civil Air Search and Rescue Association (CASARA) is a provider of secondary air response services in Canada. CASARA is a volunteer organization that has over 2600 members divided into zone organizations located across Canada. CASARA members are trained to assist in SAR operations in support of Canada's National Search and Rescue Program. The location of CASARA zone organizations and their coverage areas are illustrated in Figure 2. In the north the CASARA members are trained spotters with no aircraft owners. In the event of a SAR incident a local aircraft may be chartered and crewed with CASARA spotters. CASARA spotters are also used by the Canadian Forces on their aircraft to supplement regular crew. CASARA volunteers are on call 24 hours a day, 365 days a year.

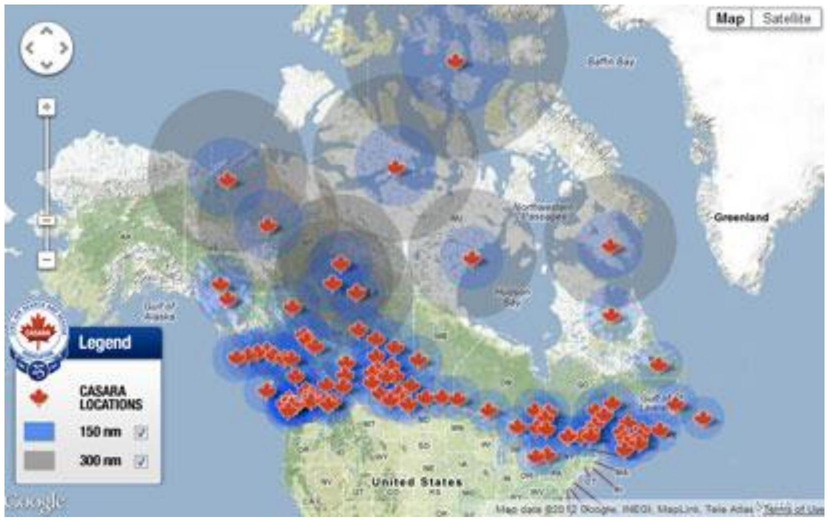

Figure 2. CASARA zone organization locations and coverage areas

5 IDENTIFICATION OF FACTORS AFFECTING EXPOSURE TIME

For a given marine emergency scenario, the resulting exposure time could have a large variation due to a number of key factors. To provide a meaningful representative assessment of exposure time due to a marine emergency scenario throughout Northern Canada these factors must be considered so that comprehensive results are obtained. To identify key factors affecting exposure time a literature review of accident reports, table top exercise summaries and workshop reports relating to Arctic emergency scenario's was conducted. This research was complemented by correspondence and discussions with industry experts. The following sections provide a list of the key factors affecting the exposure time relating to a marine emergency scenario in northern Canada and a qualitative review of how these each factor affects the exposure timeline.

5.1 Distance from airport

This factor refers to the physical distance between the site of the marine emergency scenario and the location of the nearest airport. The nearest airport may be the base site for an airborne SAR resource, in which case it would affect the travel time. This factor may also dictate whether an airborne SAR resource needs to stop to refuel enroute to the scenario location. It could also be a potential site for refueling of airborne SAR resources. If the distance is large, the casualties, whether in a lifeboat or free-floating, would have a longer time to drift while refueling is underway. Thus this factor has a potential effect on the search period as well as the rescue period. To summarize, this factor has the potential to effect phases 2, 3 and 4 of the exposure timeline.

The distance from the airport may be more relevant in northern locations where marine activity is less frequent, the distances from primary marine SAR resources are greater and there is more of a reliance on airborne resources. This factor may also be more important in scenarios that involve a large number of casualties and an air-based rescue since the helicopter may need to drop off some casualties and refuel prior to continuing with the rescue of the remaining casualties.

5.2 Distance from Shore

This factor refers to the physical distance between the site of a marine emergency event and the closest point of land. This factor may have an effect in scenarios where airborne rescue resources are relied upon and the distance to the nearest refueling station is large. In such instances it may be possible for casualties to be lifted from the water and deposited on land while other casualties are rescued. If land were further away, the helicopter may have to refuel before it could continue to rescue additional casualties. This would increase overall travel time and potentially reduce the search period. Hence, this factor has the potential to influence phases 3 and 4 of the exposure timeline.

Since marine activity is not as frequent in the north, and the distance from primary rescue vessels may be large, the effect of this factor may be more common at northern locations than it would be in southern locations.

5.3 Wind and Waves

The wind speed and wave height at the time of a marine emergency event will undoubtedly have a large effect on the resulting exposure time. In terms of the phases of exposure time, the wind and wave conditions will play a role in the duration of phase two, three and four: travel to location, search period and rescue activities. Under high wind and wave conditions each of these phases would potentially be longer in duration in comparison to the same event occurring in low wind and wave conditions.

Besides having the ability to lengthen the exposure time, the effect of wind and wave conditions could potentially prohibit the travel to location phase (for certain resources, specifically helicopters) and the rescue activities phase if the conditions are severe. When wind speeds are above a certain level, airborne resources are not able to fly for safety reasons. For emergency scenario's that occur at a location that is far from any potential vessel rescue resource, this condition could be critical and lead to a significant increase in exposure time. The operational limitation for wind speed is defined for each type of aircraft in the operations manual. Also, weather limits are set by both Transport Canada (TC) and the operator. Take-off and landing limits at airports, set by Transport Canada, reflect the type of landing aids and aircraft at the given airport. For example, at an airport served by an Instrument Landing System (ILD) would have lower take-off and landing limits than an airport served by a Non-Directional Beacon (NDB).

In terms of rescue activities, today's rescue technologies are not proven capable of rescuing casualties in extreme wind and wave conditions. The steepness of a wave plays a large role in successful rescue operations using an FRC. According to a Marine Rescue Advisory Group report "differences in wave steepness could enable a successful launch / recovery in one area whereas it could be prevented in another even though both have the same wave height" (MaTSU, 2001). This report describes wave steepness as being more location specific than wave height and indicates that the steepness is increased due to conflicting ocean current and wind directions.

High wind in flight may delay arrival of helicopters but in prevailing wind conditions it may speed up the process. The main limitation in high winds is the ability to start the rotors. In emergencies, pilots may be expected to disregard operational limits and fly to the limits of air-worthiness.

5.4 Air Temperature and Precipitation

This factor refers to the ambient air temperature during a marine occurrence. If the temperature is cold and there is precipitation, problems could arise relating to SAR efforts. First, airborne SAR resources cannot operate safely under certain conditions where extreme icing is possible. These conditions are defined in the aircrafts operations manual and are distinct for each type of airborne resource. The presence of snow and rain could also restrict a spotter's level of vision and thus hinder a search. Another effect of this factor could be the buildup of ice on emergency equipment, such as the outside of a lifeboat, which could complicate a rescue effort. This factor has the potential to influence phases 2, 3 and 4 of the exposure timeline.

In freezing conditions ice builds up on the helicopter in flight potentially causing loss of efficiency of rotors, damaging vibrations, blockage of intake air, reduced communications capability, and, ingestion of ice into the compressor causing damage and loss of power.

5.5 Ice Conditions

This factor related to the concentration of sea ice in the vicinity of a marine emergency as well as along the route that a SAR vessel would take to arrive on scene. The travel time could be increased for a vessel response when ice conditions are severe. The search period could be increased due to decreased maneuverability and the inability to follow standard search patterns which could create gaps in the planned search coverage leading to missed detection opportunities. The maneuverability issue would not affect an airborne resource however; decreased target detection due to the presence of ice could increase the search time. Rescue operations may be more challenging with the presence of ice since the ease of which to align the rescue vessel would be restricted. Moving ice can also make rescue by a small boat launched from a ship challenging, as an approach could be difficult. The ice conditions could impact phases 2, 3 and 4 of the exposure timeline.

The presence of ice could also damage the structural integrity of evacuation craft and restrict their operational performance. Ice pressure could prevent an evacuation craft from advancing or damage the hull causing it to leak or sink.

Ice conditions could also have some effects that could lead to decreasing exposure time. Under certain conditions, ice could allow a helicopter of opportunity that has no hoisting capability to land on the ice near a casualty and complete a rescue. Also, ice could provide a damping effect on waves allowing for calmer conditions, reducing fatigue of survivors, increasing probability of detection and making a rescue easier.

5.6 Type of Response Resource

This factor relates to the type of response resource that responds to a marine emergency scenario. The resource could be an airborne respondent such as a helicopter or fixed wing asset or a marine respondent such as a SAR vessel or vessel of opportunity. The type of response resource may play a large role in the expected exposure time. For starters, the operational speed capabilities vary for each type of resource which would influence the transit time. Secondly, the rescue capabilities of each resource type could dictate the length of time it takes to rescue casualties. Primary SAR vessels would be equipped with specialized rescue gear while a vessel of opportunity due to structural difference and lack of specialized equipment may take a longer time to complete a successful rescue operation. Another influence on exposure time relates to the search equipment and capabilities of the response resource. An airborne resource would be able to cover a larger search area over the same time period as a marine based resource. Also, an airborne resource may be equipped with dedicated spotters and infrared technologies designed to support search efforts.

The type of response resource aiding in a SAR effort has the potential to directly affect phases 2, 3 and 4 of the exposure timeline. In some instances weakness in communication systems aboard a vessel or aircraft of opportunity may relate to an increase in the initial communications time. Thus, phase 1 of the exposure timeline can also be influenced though perhaps to a lesser extent.

The type of response resource available to a SAR effort may have the potential to prevent certain phases of the exposure timeline as well. Under extreme wind conditions an airborne resource may not be operable. In this case full reliance would have to be placed on a marine based resource until wind speeds diminished. In remote locations of the Canadian north the nearest marine resource may be days away. Alternatively, a fixed wing aircraft may be the first to arrive at the scene while all other resources are still hours away. A fixed wing aircraft does not have the capability to affect a marine rescue and thus rescue operations would have to wait for the arrival of a different type of response resource. The fixed wing aircraft may be able to drop supplies or personnel that can increase the potential of surviving until other assistance arrives but the timeline for the actual rescue is not reduced by these efforts. The fixed-wing aircraft could reduce overall exposure time in a scenario in which it is first to arrive on scene and embarks on a search pattern prior to a helicopter arriving on location. In instances such as this the search time, and overall exposure time, is likely to be reduced.

The exposure time resulting from a marine incident in the north may vary largely depending on the type of resource tasked to assist in SAR efforts. The effect of this factor can be intensified by the occurrence of other factors such as wind, wave and ice conditions. Quantification of this factor is challenging since there are so many possibilities of resources that could be involved in a marine incident in the Canadian North. To provide a meaningful evaluation some limits are implemented in terms of the types of resources considered. Since the availability of a resource of opportunity cannot be counted on for SAR preparedness, this type of resource is not considered in this evaluation. Since traffic in the high north is relatively low in comparison to lower latitudes, this limitation appears reasonable.

The Canadian Coast Guard is currently evaluating a methodology of planning and evaluating SAR coverage that does account for vessels of opportunity. This represents a new dimension in SAR coverage planning in the maritime environment. If the methodology is validated and accepted for use, it may be useful to revisit the assumptions in this report and determine whether there is a measurable effect on the identified outcomes.

5.7 Physical state of response resource(s) and crew

This factor refers to the physical state of a response resource and its crew, which could influence its performance in SAR activities. For example, an icebreaker tasked to aid in SAR operations for an emergency, could have to transit through heavy ice to get to the scene. The current level of fuel onboard may affect the icebreaking efficiency, endurance and ultimately the transit time. Also, a helicopter arriving at the scene of an emergency after a 20 hour trip including stops may not have well rested spotters which may increase search and rescue times. This factor has the potential to affect phase 2, 3 and 4 of the exposure timeline.

The effects of this factor may be hard to quantify since the state of the response resource and crew have many possibilities.

5.8 Communication Effectiveness

This factor involves the process of notifying and directing SAR resources once an emergency alert has been received. For example, the communications time would depend on the number of phone calls required to notify and task the responding resources. Processes in place at JRCC's help alleviate this factor and allow for quick notifications and tasking.

Communication effectiveness can also be a factor in the Search Phase. The effectiveness of communications will be entirely dependent on what communications capabilities are available in the survival craft and whether the survivors can communicate directly with searching craft.

5.9 Preparation of Response Crews

This factor refers to the state of preparation of the response crew members at the time of an emergency alert notification. Whether the crew is on standby or not may play a big role in the time taken to get a response resource actively engaged. Primary SAR resources are always held to a level of standby.

The Department of National Defense maintains a maximum 30 minute response capability during working hours and a maximum two hour response capability during quiet hours. The Canadian Coast Guard maintains a 30 minute response standard 24 hours a day and seven days a week for primary search and rescue vessels (TSB, 2004).

This factor would only affect Phase 1, *Initial Communications*, of the exposure timeline. The factor may be of higher significance when an incident occurs at a location far from the nearest primary SAR resource and thus relying more heavily on a secondary resource which may not have a stand by requirement.

5.10 Communication Capability

This factor relates to the potential for the incapability to send an alert notification in a marine emergency event occurring in northern Canada. It also relates to the capability of an evacuation craft to communicate with search personnel. Hence, this factor has the potential to affect phase one and phase three of the exposure timeline. Previous work, ranging from planning to infrastructure development, has been completed to help improve marine communication capabilities in general, and also with respect to northern regions. An international system, known as the Global Maritime Distress and Safety System (GMDSS), is a significant result of such work.

The GMDSS is an international system designed to automate and improve marine emergency communications. This system is described on the Canadian Coast Guard website. In short, the system uses terrestrial and satellite technology and ship-board radio systems to help ensure a rapid alerting in the event of an emergency. The system also alerts vessels in the area and provides improved means of locating survivors (CCG, 2013). The GMDSS is mandated through the International Maritime Organization (IMO) via amendments to the Safety of Life at Sea (SOLAS) convention.

Terrestrial marine communications in the Canadian north are supported by a High Frequency Digital Selective Calling (HF/DSC) system which is operated by the Canadian Coast Guard. This system is operated at the Iqaluit Marine Communications and Traffic Service Centre and includes a remote receiver which is located in Resolute Bay. The system provides continuous HF/DSC alerting, voice communications and printing broadcasting capabilities through a designated set of frequencies of radio bands. Operational coverage includes Arctic waters above 70^{o} northern latitude (CCG, 2013).

A recent report by the company Marintek indicates that high frequency and medium frequency communications systems may be used in safety communication, but cannot always be relied on, particularly in northern regions. The systems are susceptible to ionospheric disturbances which could occur in polar areas. Also, low temperatures, snow and icing conditions could cause problems for HF and MF communications by reducing signal strength or damaging equipment (Marintek, 2012).

There are two types of satellites that are currently operational for potential use in marine alerting in northern Canada. The first, known as a low earth orbit (LEO) satellite, have a relatively small footprint due to their proximity to the earth. This, combined with the quick travel time, leaves the LEO satellite with a window of approximately 15 minutes for a given area. If an alert is sent out just after this 15 minute window has expelled then it could be hours before the signal is picked up by the next passing LEO satellite (Paiement, 2012).

The second type of satellite, known as a geostationary earth orbit (GEO) satellite, has a high altitude orbit located directly over the equator. These satellite have a very large footprint, however, due to their positioning, they are unable to monitor the poles. Therefore, much of the Canadian north cannot be monitored by these satellites. Also, obstacles such as mountains or other high geographical features may block the satellite from receiving an alert signal (Paiement, 2012).

Despite the extensive effort aiming to implement marine communication capabilities, there still appear to be some weakness, in particular at locations near the poles. In a case where high frequency terrestrial communications are prevented due to snow and icing and GEO satellite coverage is unavailable, there is a dependency on LEO satellite communications. In this case it could take several hours for the alert to be received and communicated by a passing satellite, depending on the time of the alert and the given satellite patterns. In the context of the Canadian north, it is deemed necessary to consider communication capability as a potential factor that could increase the exposure time resulting from a marine emergency scenario.

5.11 State of Evacuees

This factor refers to the physical state of the casualties upon rescue. For instance, the level of fatigue of a casualty could impact their ability to hold on to a rescue aid and thus prolong rescue activities. The level of injury of a casualty may dictate whether they could open and set off a flare which could potentially reduce the search period. This factor has the potential to affect phase 3 and 4 of the exposure timeline. Other factors that may affect the performance of the casualties include hypothermia, dehydration and motion sickness (Golden and Tipton 2002).

5.12 Visibility

The level of visibility at the time of the emergency event would have an effect on the length of the search period and potentially the travel and rescue time. The level of visibility is affected by the time of day, the time of year, the level of fog, precipitation and temperature. In extremely poor visibility airborne resources may be unsafe to operate. The operator sets limits related to visibility, usually at or above those limits implemented by Transport Canada. In general, there are different visual flight limits for SAR aircraft than for non-SAR aircraft. Primary SAR aircraft have been known to operate at a visibility level as low as 1/2 a nautical mile.

The SAR Mission Coordinators in the JRCC will develop a search plan based on the target being looked for, the number of search units searching, the capabilities of the search units, the search methodologies being employed and the visibility. When a search is predominately visual the search pattern is “tighter” so that the area is comprehensively swept visually over the time a search pattern is run. Better visibility allows for wider track spacing which in turn translates into a larger area searched in a given time.

5.13 Bathymetry Charting

The Arctic Marine Shipping Assessment indicated that a large percentage of marine incidents occurring in the Arctic are due to groundings (AMSA, 2009). A review of marine incident reports from the Transportation Safety Board regarding groundings revealed that a large number of these incidents were due in part to insufficient bathymetry charting. If an eligible route to an Arctic location is not charted effectively necessitate a change in routing and lead to an increased transit time. The IMO has also recognized the relative lack of good bathymetric charting in the north, amongst other specific risks, and have developed guidelines specific to the Arctic (IMO, 2002).

5.14 Training of Captain and Crew

This factor has the potential to play a large role in defining the transit as well as search and rescue time of a response resource. For starters, an experienced captain may be able to reduce the travel time to the emergency location by taking different routes or effectively using resources at hand to reduce transit and search time. Specifically for marine resources, an experienced Captain may be better capable of maneuvering through multi-year ice. This could affect both transit and search times where relevant. For air-based resources, an experienced Captain and crew may be more familiar with certain search patters or rescue procedures thus reducing the associated time.

5.15 Accuracy of Environmental Models

Environmental models are used to predict drift patterns and plan search patterns for a given emergency. The accuracy of environmental models is not consistent at all locations. For instance, the accuracy is lower for areas with limited historical physical measurements that are used for validation. The accuracy is also affected by other factors such as water depth and latitude. Hence, drift predictions may be more accurate for certain locations leading to less uncertainty in drift predictions and potentially shorter search periods.

This factor may also affect the transit and rescue phases of exposure time, particularly for air resources. If the weather conditions along the route to an emergency scenario change dramatically from those forecasted, the resource may not be as well equipped to operate through such conditions.

6 SELECTION OF LOCATIONS

A series of locations, at points within northern Canada's oceans, were selected as base-locations for the evaluation of exposure time. By evaluating the exposure time and factor effects at a range of different locations, we will not only obtain and understanding of the variation in potential exposure times across northern Canadian shipping routes, but also get an idea as to why the exposure time varies in terms of critical factors. The following sections describe the justification behind selecting the specific locations for consideration in this analysis, details on each selected location and a discussion on rescue coordination in relation to the different locations.

6.1 Selection Justification

The geographical locations considered in this study were selected based on a number of considerations. The first was to allow for a comprehensive assessment across Northern Canadian shipping routes. As a means of limiting this vast area, the region of interest is described here as Canadian territory that is situated above the Arctic Circle (line of latitude at 66 degrees 33 minutes North) as outlined in Figure 3.

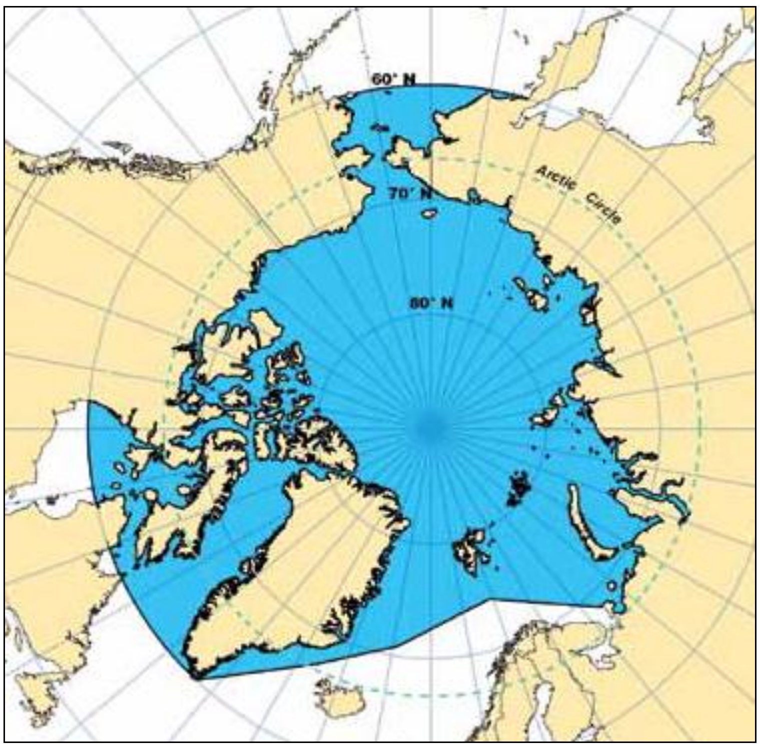

Figure 3. Area of interest for location selection (From AMSA, 2009)

The next consideration involved frequency of travel of current shipping routes across the area of interest. A maritime emergency event is more likely to occur at a location that sits on a frequently traveled route as opposed to one that falls on a route that is not frequently travelled, or not known to have been travelled at all. Travel routes for the area of interest were mapped, based on frequency of travel, as a part of the AMSA as shown in Figure 4. This mapping only includes data up to the end of 2004 and does not include fishing vessel routes.

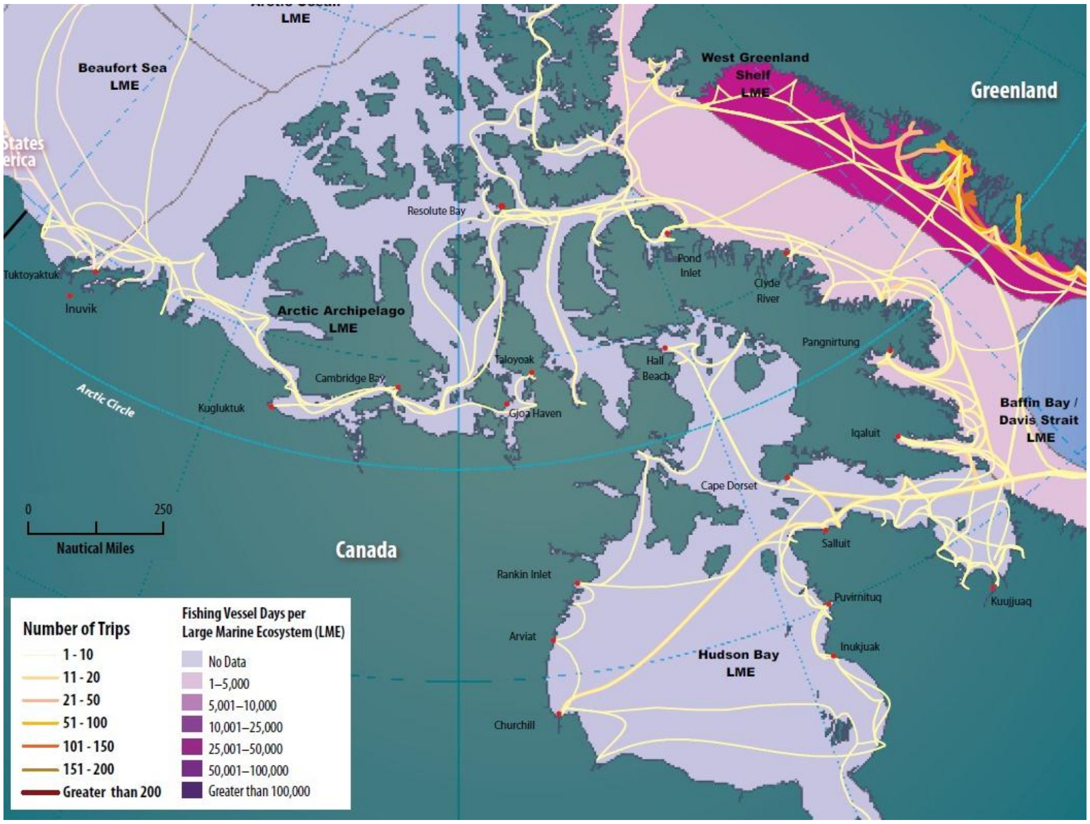

Figure 4. Shipping Activity 2004 (Modified From: AMSA, 2009)

Another consideration in the selection of locations was the possibility of future shipping routes opening within the area of interest. Since climate change is leading to receding Arctic ice conditions, it is probable that future shipping trends will change due to accessibility of more direct routes. Therefore, areas with potential for high future travel frequencies were considered. Projections on the extent of future sea ice throughout the area of interest are graphically displayed in Figure 5. Both of these images are the result of works conducted as a part of the Arctic Climate Impact Assessment (ACIA), an international project of the Arctic Council.

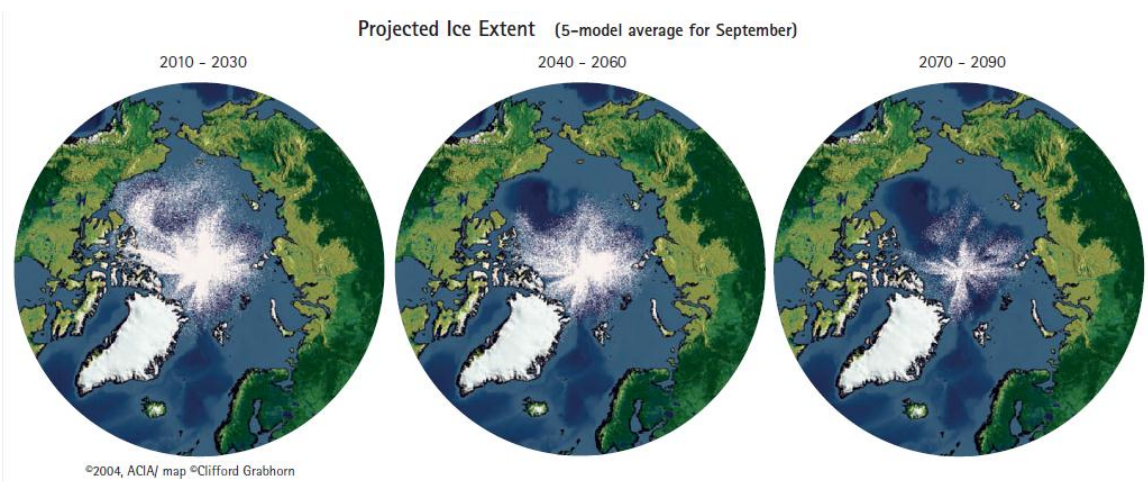

Figure 5. Phased Arctic ice retreat (From: ACIA, 2004)

Predictions indicate that ice cover will decrease initially in the Eastern section of the area of interest, particularly within the Gulf of Boothia, and subsequently decreases will become apparent in the southern section of the Canadian Archipelago. The long term forecast of ice conditions indicate that at the end of the summer months, ice coverage will be dramatically reduced in all locations across northern Canada. Thus, it would be worthwhile to examine locations positioned in the extreme north.

The quantity of locations selected was restricted to eight to allow time for a comprehensive review of each scenario within the bounds of the current project. The locations selected for assessment in this study are indicated in Figure 6. The locations are numbered for ease of reference throughout this report.

Figure 6. Locations for consideration across Canadian North

These eight locations are representative of the considerations presented above, in that they are each located in the area of interest and lie on either shipping routes that are currently travelled frequency or that have potential to have a high travel frequency due to climate change. Another consideration when selecting these locations was to ensure that they were positioned at varying distances from the nearest airport or heliport, since this factor may play a role in the exposure time. The latitude and longitude points as well as enlarged maps for each of the eight selected locations are provided in Appendix A.

6.2 Location Details

Location number one is located at 85.56^{o} N, -81.14^{o} W, and is the most northerly point considered in this assessment. There appears to be relatively little annual shipping activity in this area particularly during the winter months due to the presence of strong, thick ice. The closest Arctic port to location one is the research base Eureka, Nunavut (80.01^{o} N, -86.35^{o} W) which currently has eight staff working on a continuous rotational basis (AMSA, 2009). The research base in

Eureka is supplied by air every three weeks with fresh food and mail. Vessel supply occurs only once annually, in the late summer, during which a vessel from Montreal transfers large and heavy items.

Location number two is situated at 77.12^o N, -98.53^o W, which is north of Bathurst Island, Nunavut. There is currently a relatively low level of annual shipping activity in this area, particularly during the winter months, due to the presence of strong, thick sea ice. The nearest port to this location is at Resolute which is located at 74.68^o N, -94.87^o W, approximately 300 km away from location two. Resolute is one of Canada's northernmost communities with a population of 214 (Canadian Census, 2011). The town is equipped with a gravel airstrip which is 1980 m in length, the longest gravel airstrip in Nunavut. The aircraft operating at this airstrip range from Twin Otters to a Boeing 727.

Location number three, 74.28^o N, -102.77^o W, is situated northwest of Prince of Wales Island, Nunavut. The closest port to this location is Resolute, as was the case for location two. The distance from Resolute is approximately 225 km, shorter than the distance between Resolute and location two. There is relatively little marine travel in the vicinity of location three. Again, most or all marine transportation in this area would occur during the summer months when ice conditions are less severe.

Location number four is situated at approximately 74.10^o N, -80.64^o W, and is northwest of Bylot Island, Nunavut. Marine activity in this area is moderate in terms of activity levels in other northern areas. There are a few ports in the relative vicinity of this location including the ports at Pond Inlet, Arctic Bay, Nanisivik and Sachs Harbour, Nunavut. Pond Inlet is the closest port to location number four. This community is located near the top of Baffin Island and has a population of approximately 1550. Pond Inlet has an airport and fresh food is flown to the town several times a week. The waters surrounding Pond Inlet are ice free for approximately 3.5 months in a given year. During the ice free season cruise ships and re-supply cargo ships operate in the area. The approximate distance between location four and Pond Inlet is 190 km. Arctic Bay also has an airport with a gravel runway that is 1199 m long. Location four is approximately 200 km away from the airport in Arctic Bay. Nanisivik has a port and dock which is currently used by the Canadian Coast Guard for training exercises. The Nanisivik port is to undergo construction and conversion into a naval station to be used primarily for refueling of government vessels. The construction is funded by the Federal government of Canada and planned to begin in 2013.

Location number five is positioned at approximately 70.79^o N, -125.51^o W, which is situated northeast of Tuktoyaktuk, NWT. The level of shipping activity in this area is moderate and the closest ports include those located in Tuktoyaktuk and Sachs Harbour. Sachs Harbour is a small community located on the south coast of Banks Island which has 112 people (Canadian census, 2011). The town has an airport from which it receives supplies year round. Heavy supplies and equipment are supplied via barge during the summer months. The Sachs Harbour airport is approximately 135 km from location five. Tuktoyaktuk is the most northern community that is located on the Canadian mainland. The town has an airport equipped with a gravel runway that can handle jets that have special equipment to prevent damage from gravel. The airport in Tuktoyaktuk is located approximately 325 km away from location number five. During the winter months, the community can be accessed through an ice road which is approximately 150 m long.

Location number six, positioned at 68.12^o N, -112.63^o W, is located in the Coronation Gulf in Nunavut. The level of shipping activity in the area is moderate in relation to the other locations considered. The closest port to this location is the Lady Franklin Point airport which is approximately 45 km away. Other ports in the relative vicinity include the airport in Kugluktuk, NU, which is approximately 115 km away and the airport in Ross Point which is approximately 80 km away from location six. Also, location six is the closest location to a Canadian Forces primary SAR aircraft station. The most northerly Canadian Forces aircraft base, in Yellowknife, NWT, is approximately 650 km away from location six. This base has four CC-138 Twinotter aircraft which are fixed-wing and have a passenger capacity of 20. These aircraft have a cruising speed of 337 km/hr, a range of 1427 km and can drop off emergency kits to stranded personnel.

Location number seven, positioned at 67.11^{o} N, -78.41^{o} W, is located within Foxe Basin, NU. This area has a relatively high level of shipping activity in comparison to the other locations considered in this evaluation. Marine traffic at this location has a high potential to increase with climate change since more vessels may be eligible to travel through the Northwest Passages. Location number seven has a number of ports within a 300 km range including the following airports: Igloolik, Hall Beach, Logstaff Bluff, West Baffin Island, Rowley, Bray Island and Sarca Lake. The closest airports are the Hall Beach airport and the Rowley airport which are both approximately 205 km from location seven. Hall Beach is a town with approximately 546 residents (Canadian Census, 2011). The airport at this location is commercial grade and can accommodate large aircraft. Rowley Island in uninhibited however it houses an automated Surface Observing System and an unmanned Distant Early Warning Line base. Limited information regarding the airport on Rowley Island could be found.

Location number eight is positioned at approximately 68.77^{o} N, -65.08^{o} W and lies within Davis Strait. There is a relatively high frequency of marine traffic at this location in relation to the other locations considered. There are three airports in relatively close proximity to location number eight including: Cape Hooper, Kivitoo and Broughton Island. The Cape Hooper airport is the closest at a distance of approximately 80 km. Cape Hooper airport has a gravel airstrip of approximately 920 m in length. The airstrip at Kivitoo is relatively short and the level of upkeep is uncertain. The airport at Broughton Island (also known as Qikiqtarjuaq) has a gravel runway of approximately 11,500 m in length. This airport is a common stopover for small planes that fly to and from Europe. This airport has refuel services as well as deicing services.

All locations selected for consideration in this study fall within the jurisdiction of JRCC Halifax and JRCC Trenton. JRCC Halifax governs eastern Canada and only the most easterly locations, location number 7 and location 8, falls within its jurisdiction. All other selected locations are governed by JRCC Trenton. The Canadian JRCC coverage areas are outlined in Figure 7.

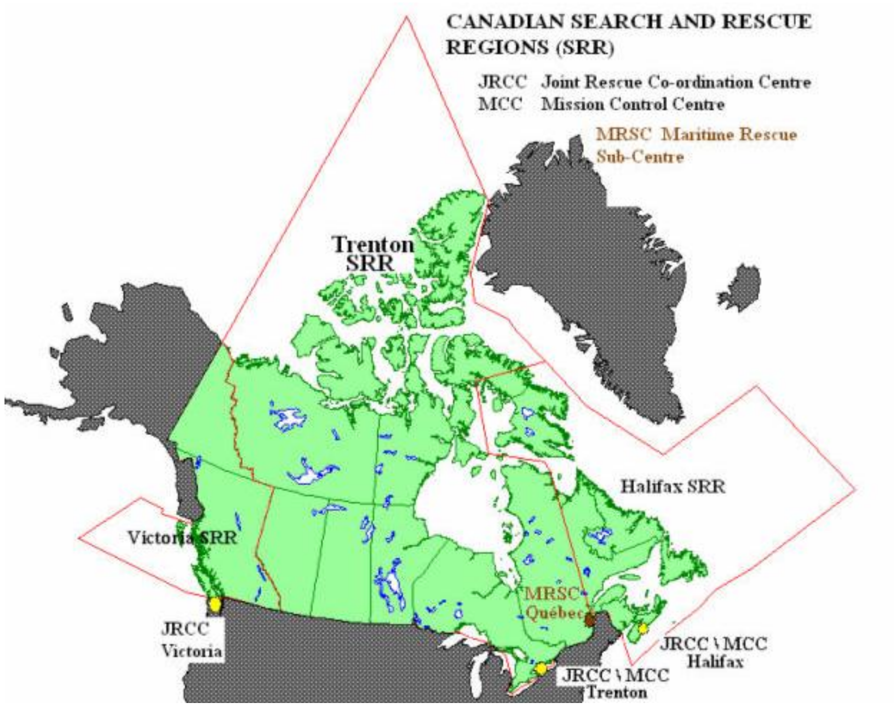

Figure 7. JRCC coverage areas

6.3 Environmental Conditions

The environmental conditions relating to each location are a key consideration in the scenario-based assessment of exposure time. Detailed evaluation of historic environmental conditions relevant to each selected location was not in the scope of work for this project. Therefore, general environmental conditions relevant to each location were selected based primarily on archived Environment Canada data. For each location, information pertaining to the wind speed, wave height, ice concentration, ice thickness and air temperature is provided. The visibility and level of precipitation are also considered however these conditions are generalized and assumed the same for each location. All information used to define the environmental conditions is available publically online.

The environmental values are given in terms of a low and high condition for each location. This provides a representative view of the range in conditions at each location. The low condition relates to the value of the condition that would cause the least detrimental effect on expected exposure time. The high condition on the other hand represents the value of the condition that would cause the most detrimental effect on exposure time. For example, in the case of wind speed, the highest winds typical of an area would represent the severe condition while the low wind speed typical of an area would represent the mild condition.

The wind data relevant to each location is determined using data from the Canadian Wind Energy Atlas (CWEA), a set of data made available by Environment Canada (see CWEA, 2013). This database contains 43 years of modeled wind data for most Canadian locations. The data can be sorted to obtain seasonal values of the mean wind speed at 30 m above sea level. Histograms depicting the annual variability in seasonal wind speed are also provided. The mean wind speed was used as the "mild" condition for wind speed and the "severe" condition was taken from the upper extremity of the relevant histogram. The CWEA data did not cover areas in the extreme high Canadian North and thus location one and location two were not included in the database. To find representative wind speed values for these locations archived Environment Canada weather station data was used. The closest weather station to location one was Eureka and the closest weather station to location two was Resolute and thus these weather stations were used to obtain wind speed values for the corresponding locations. The mild and severe wind speed values were derived from mean, hourly wind gust speed for August 2012 between the dates of August 15th and 31st. The mild value was taken as the mean of these values and the severe case was taken as the value of the data point at which 90% of the data was below.

When representative values for the mean and severe wind speed relevant to each of the eight locations were defined, these values were used to correlate with the Beaufort scale. The Beaufort scale is a well-known and commonly used empirical measure that relates the wind speed to wave height (Transport Canada, 2003). The Beaufort scale is represented by the Beaufort number which ranges from 0 to 12. Each number relates to a range in wind speeds and corresponding wave heights. The mild and severe wind speed values obtained from CWEA and Environment Canada weather stations were matched with a corresponding Beaufort number by identifying which range of wind speeds the value fell within. Then the Beaufort range in wind speeds and corresponding wave heights were used for the mild and severe wind and wave conditions.

The ice concentration, thickness and air temperature mild and severe values were determined from data provided in reports written by the Canadian Ice Services (CIS), a branch of Environment Canada. The CIS produces annual seasonal summary reports of Canadian Arctic waters (CIS, 2013). These reports contain maps of different northern Canadian regions with colored contours to represent the ice concentration and corresponding egg code that indicates the thickness. In consideration of recent environmental changes due to climate change, only the most recent five years of data was considered. The most recent five years of data available of CIS website was between 2007 and 2011. The seasonal reports provided monthly data values and the data for August was used for this analysis. The mild value for ice concentration was taken as the lowest ice concentration observed during the month of August during the years considered. The severe value for ice concentration was taken as the highest ice concentration observed during the month of August during the years considered. Similarly, the mild value of ice thickness was taken as the lowest ice thickness observed during the years considered while the severe ice thickness was taken as the maximum thickness observed. In instances where the ice thickness was indicated as a constant minimum value for all years considered generalized values from the International Organization for Standardization (ISO, 2010) were obtained for the mild and severe values of the Canadian Archipelago. The CIS summary report provided air temperature in terms of mean monthly values as well as a value indicating the departure from the mean during the month. These values were provided based on weather stations located at distinct locations. Therefore, the locations were matched to the nearest weather station to obtain air temperature data. The mild air temperature was taken as the average of all of the monthly mean values for a given location and the severe air temperature was taken as the minimum of all of the mean monthly values minus the departure value. The locations and corresponding weather stations are summarized in Table 2.

Table 2. Weather station and corresponding location

Location Number	Weather Station Location	Location Number	Weather Station Location
1	Eureka	5	Tuktoyaktuk
2	Resolute	6	Kugluktuk
3	Resolute	7	Hall’s Beach
4	Pond Inlet	8	Clyde River

Visibility data was considered from Environment Canada weather stations in close proximity to the selected locations. Only data from 2012 during the last two weeks of August was considered here. After observing visibility data from weather stations representative of each location it was observed that the same minimum visibility level was representative of all locations. This minimum visibility value was used for all locations as the severe value of visibility. The data indicated that this value usually occurred as a result of fog. The mild condition for visibility was taken as the most common visibility value from all locations during the period considered. Again, this constant value was used for all locations since it fell within the range of normal data at each location considered. The precipitation was generalized in terms of a rainy and dry condition and this was used for all locations. Rainy is representative of the severe condition since this condition could lead to icing or slippery equipment which could act to prolong the exposure time. Dry is representative of the mild condition for all locations considered. The environmental conditions relating to each location, for consideration in the scenario-based assessment of exposure time, are provided in the table below. This table also includes the source for each data type.

Table 3. Environmental Conditions at Selected Locations

Location	Low Environmental Conditions	High Environmental Conditions
1 Greely Fiord	Wind Speed: 6.5 knots Wave Height: 0.6 m Ice Concentration: 0/10^{ths} Ice Thickness: 30 cm Air Temp: 6.5 ^{o}C Visibility: 25 km (clear) Precipitation: Dry	Wind Speed: 28.1 knots Wave Height: 5.5 m Ice Concentration: 6/10^{ths} Ice Thickness: 220 cm Air Temp: 2.4 ^{o}C Visibility: 0.5 km (fog) Precipitation: Rain
2 Queen Elizabeth Islands	Wind Speed: 12.3 knots Wave Height: 1 m Ice Concentration: 0/10^{ths} Ice Thickness: 30 cm Air Temp: 5.3 ^{o}C Visibility: 25 km (clear) Precipitation: Dry	Wind Speed: 30.2 knots Wave Height: 5.5 m Ice Concentration: 10/10^{ths} Ice Thickness: 220 cm Air Temp: 1.4 ^{o}C Visibility: 0.5 km (fog) Precipitation: Rain
3 Viscount Melville Sound	Wind Speed: 11.4 knots Wave Height: 1 m Ice Concentration: 0/10^{ths} Ice Thickness: 30 cm Air Temp: 5.3 ^{o}C Visibility: 25 km (clear) Precipitation: Dry	Wind Speed: 33.0 knots Wave Height: 5.5 m Ice Concentration: 10/10^{ths} Ice Thickness: 220 cm Air Temp: 1.4 ^{o}C Visibility: 0.5 km (fog) Precipitation: Rain
4 Lancaster Sound	Wind Speed: 13.6 knots Wave Height: 1 m Ice Concentration: 0/10^{ths} Ice Thickness: 10 cm Air Temp: 7.6 ^{o}C Visibility: 25 km (clear) Precipitation: Dry	Wind Speed: 35.0 knots Wave Height: 7.5 m Ice Concentration: 1/10^{ths} Ice Thickness: 70 cm Air Temp: 4.0 ^{o}C Visibility: 0.5 km (fog) Precipitation: Rain

Location	Low Environmental Conditions	High Environmental Conditions
5 Amundsen Gulf	Wind Speed: 11.4 knots Wave Height: 1 m Ice Concentration: 0/10ths Ice Thickness: 0 cm Air Temp: 11.7 ^{o}C Visibility: 25 km (clear) Precipitation: Dry	Wind Speed: 35.0 knots Wave Height: 7.5 m Ice Concentration: 1/10ths Ice Thickness: 70 cm Air Temp: 4.3 ^{o}C Visibility: 0.5 km (fog) Precipitation: Rain
6 Coronation Gulf	Wind Speed: 10.3 knots Wave Height: 0.6 m Ice Concentration: 0/10ths Ice Thickness: 0 cm Air Temp: 11.4 ^{o}C Visibility: 25 km (clear) Precipitation: Dry	Wind Speed: 31.1 knots Wave Height: 5.5 m Ice Concentration: 1/10ths Ice Thickness: 70 cm Air Temp: 7.2 ^{o}C Visibility: 0.5 km (fog) Precipitation: Rain
7 Foxe Basin	Wind Speed: 10.5 knots Wave Height: 0.6 m Ice Concentration: 0/10ths Ice Thickness: 120 cm Air Temp: 6.9 ^{o}C Visibility: 25 km (clear) Precipitation: Dry	Wind Speed: 33.0 knots Wave Height: 5.5 m Ice Concentration: 8/10ths Ice Thickness: 180 cm Air Temp: 3.7 ^{o}C Visibility: 0.5 km (fog) Precipitation: Rain
8 Davis Strait	Wind Speed: 8.9 knots Wave Height: 0.6 m Ice Concentration: 0/10ths Ice Thickness: 30 cm Air Temp: 5.8 ^{o}C Visibility: 25 km (clear) Precipitation: Dry	Wind Speed: 29.2 knots Wave Height: 5.5 m Ice Concentration: 6/10ths Ice Thickness: 120 cm Air Temp: 3.8 ^{o}C Visibility: 0.5 km (fog) Precipitation: Rain

It is important to note that the "mild" or "severe" conditions relevant to a location do not necessarily represent the set of conditions that together would have the largest negative effect on exposure time for that area. In some cases the severe condition for each environmental parameter cannot all occur simultaneously, as is the case for a location 1 which has a severe ice concentration of 9/10th and a severe wave height of 7.5 m. An ice concentration this high would dampen the significant wave height and thus the combination of these two conditions is improbable. Therefore, it is important to consider the environmental conditions independently.

7 SELECTION OF EMERGENCY SCENARIO

This section describes the considerations undertaken when selecting the emergency scenario details for consideration in the assessment of exposure time. The emergency scenario as defined here covers the state of casualties, the time of year, the prevalent environmental conditions as well as other information relevant to the scenario. The majority of event details are consistent for each scenario considered in this study. However, the environmental conditions vary since they relate to different locations, as described in the previous section.

7.1 Event Details

The marine scenario involves the sinking of a vessel with a total of 18 persons on board (POB). Since the vessel in the scenario has sunk, the type of vessel as well as the event that caused the vessel to sink, are assumed to have no relevance to the potential exposure time resulting from the scenario. The fact that the vessel has sunk will add to the difficulties of the search phase and ensure that factors relating to this phase are considered. A POB of 18 was selected to limit the capability to rescue all personnel via a single air resource. Therefore, multiple air resources or multiple trips of a single resource may be necessary. Alternately, a vessel response resource could assist in the rescue of all personnel.

In the emergency scenario, the personnel are assumed to have all evacuated successfully into two Totally Enclosed Motor Propelled Survival Craft (TEMPSC) that meet current SOLAS requirements. It is uncertain how many personnel are in each TEMPSC. It is assumed that all casualties have donned immersion suits and that there are no physical injuries resulting from the evacuation process.

The time of year has been selected as late August since during this time northern shipping operations are at their peak and thus the potential for an emergency scenario is relatively high. The time of day at which the emergency event occurs is selected to be 1:00 pm in the afternoon and the day is assumed to be a weekday. RCAF resources are on 30 minute standby 8-5 Monday to Friday, but two hour standby otherwise. The level of daylight available for search crews will be dependent on the location of the scenario and its proximity to resources. Another key element to the scenario is that it is assumed that there are no vessels or aircraft of opportunity that could support the SAR effort. This assumption is plausible in the Canadian north where marine and air operations have a much lower frequency than the remainder of Canada.

Another aspect of the emergency scenario involves aspects of the communication capabilities of the casualties. It is assumed that the two TEMPSC do not have EPIRB’s and that the casualties have no means of voice contact with SAR personnel. However, a successful alert has gone out prior to the sinking which indicated the location of the vessel at that time. The two TEMPSC are equipped with the SOLAS required flares which could be used to support the search effort. The following table summarizes the key details of the emergency scenario.

Table 4. Emergency Scenario Details

Key Detail	Description
Number of casualties	18
Evacuation information	All successfully evacuated into two TEMPSC
Communications	Initial alert successful. TEMPSC equipped with AIS transponder.

Key Detail	Description
Resource of opportunity	No resource of opportunity available. Need to depend on primary and secondary SAR resources
Time of year	Mid-August
Time of day	Event occurs at 1:00 p.m.
Emergency event	Vessel sinking. Vessel assumed to be completely sunk.
Casualty apparel	All wearing SOLAS approved immersion suits
State of Casualties	All uninjured

8 EXPOSURE TIME SURVEY

A survey was developed to gauge subject matter expert opinion relating to potential exposure times at each of the eight locations considered and the effect of key factors. The primary goal of the survey is to help quantify the range of exposure times relative to each location based on the attributes of that particular location. A secondary goal is to investigate expert opinion regarding the prioritization of key factors at each location and in general, in terms of their effect on exposure time.

There were two separate surveys developed: one for air resources and the other for marine resources. Since experts that are knowledgeable of one type of resource are not necessarily experts in the other resource, this approach lead to a more meaningful and comprehensive response. In general, the two surveys are largely similar, however the questions are tailored to the terminology and factors relevant to the given resource type. The air and marine surveys are provided in Appendix B.

8.1 Survey Development

The survey was designed in two parts. The first part labeled as the questionnaire, included all multiple choice questions and aimed to investigate the exposure time relating to each location. The second part labeled as factor ranking, included fill in the blank sections and aimed to investigate expert opinion on the general significance of key factors including the significance of location. Survey respondents were requested to complete the questionnaire first and to follow up by completing the factor ranking. This way the thoughts emerging from thinking about the exposure time at each location could lead to an understanding of the significance of location in potential northern Canadian exposure times and the general significance of each additional factor.

The questionnaire was designed based on the factors identified in Section 5. The questions attempted to quantify the effect of each factor relevant to each location considered. It was requested that each question be answered with respect to each of the identified locations and corresponding low and high environmental conditions (as described in Section 6.3). The effect of some factors could not be quantified from the survey but were considered in terms of their general significance to determine if subject matter experts would deem the factor as significant. For example, the effect of the level of experience of a Master or Captain on rescue time was considered on each questionnaire to determine if this factor has the capacity to increase the rescue time, prevent a rescue or if it is believed to have no effect. Pending on the aggregated response to this type of question, the factor could be explored further in the exposure time workshop to help quantify the effect.

The factor ranking survey component was also designed based on the factors discussed in Section 5. The respondents were asked to rank each listed factor, from 0 to 100, in terms of its potential effect on exposure time resulting from a marine incident in northern Canada. This allowed for an overall ranking of the key factors, not relevant to any given location. The factor-ranking sheet also requested the respondents to rank the significance of location as a factor in terms of its effect on exposure time and to provide a justification for this ranking value. The factor-ranking sheet also provided space for survey respondents to identify other key factors that were not already identified in the survey and to provide the corresponding ranking value relating to its potential effect.

Both the questionnaire and the factor ranking components of the survey were one page in duration. An effort was made to keep the survey components at or below one page in length. A longer survey would appear more tedious to complete and may lead to fewer responses. This is particularly true since the questionnaire requires a response for the eight locations considered.

8.2 Survey Distribution

The surveys were distributed to both the air and marine representatives of JRCC Halifax as well as JRCC Trenton. These representatives forwarded the survey to experienced delegates in their respective jurisdictions. These representatives were members of both the Canadian Coast Guard and the Canadian Forces. The surveys were also distributed to representatives at CASARA and the Canadian Coast Guard Auxiliary. In addition, surveys were sent to members of the Company of Master Mariners of Canada, the National SAR secretariat and a number of private organizations. The complete list of organizations to which the survey was distributed is provided in Appendix C. To a large extent, the responses were returned on behalf of a given organization.

8.3 Survey Results: Compilation of Data

The returned survey questionnaires were compiled separately in terms of air and marine responses. For each question the most frequent response for each of the eight locations is presented. In some instances there was a tie for the response having the most selections. In these instances all responses that tied for the most frequent response are indicated. The factor-ranking components of the surveys were also compiled separately for both air and marine resources. The consolidated results of the factor-ranking are presented in terms of the averaged ranking value for each factor considered. It is important to note that for the factors listed on the factor ranking sheet as presented to the participants, each factor was ranked multiple times, once by each participant. For factors that were listed by the participants under the heading “other factors and associated ranking” the ranking value may be the opinion of only one respondent. This is particularly true for the air factor-ranking sheet since each additional factor was listed one time only.

8.3.1 Questionnaire

The consolidated results to both the marine and air questionnaires are presented in tabular form below. Please refer to the question details from the relevant questionnaire as provided in Appendix B.

Table 5. Consolidated Marine Questionnaire Responses

Question #	Consolidated Responses							
	L1	L2	L3	L4	L5	L6	L7	L8
1	4 hours	1-4 hours	1-4 hours	1-4 hours	1-4 hours	< 1 hour	< 1 hour	no restriction
2	No	No	No	No	Yes	Yes	Yes	Yes
3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
4	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%	Add <5%
5	No	No	No	No	No	No	No	No
6	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%
7	Ice conditions	Ice conditions	Wind & Waves	Wind & Waves	Wind & Waves	Wind & Waves	Wind & Waves	Wind & Waves
8	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%	Add>20%

Question #	Consolidated Responses							
	L1	L2	L3	L4	L5	L6	L7	L8
10	400 - 600 nm	400 - 600 nm	200 - 400 nm	200 - 400 nm	400 - 600 nm	200 - 400 nm	200 - 400 nm	200 - 400 nm
11	8 - 12 kts	8 - 12 kts	8 - 12 kts	8 - 12 kts	8 - 12 kts	8 - 12 kts	12–16 kts	12–16 kts
12	5 - 8kts	5 - 8kts	5 - 8kts	8 - 12kts	8 - 12kts	12 - 16kts	5 - 8kts	8 - 12kts
13	25-50%	50-75%	50-75%	25-50%	25-50%	25-50%	25-50%	25-50%
14	25-50%	25-50%	25-50%	< 25 %	< 25 %	< 25 %	< 25 %	< 25 %
15	25-50%	25-50%	25-50%	25-50%	25-50%	25-50%	25-50%	25-50%
16	50-75%	50-75%	25-50%	25-50%	< 25 %	25-50%	50-75%	50-75%
17	25-50%	25-50%	25-50%	25-50%	25-50%	25-50%	25-50%	25-50%
18	< 1 hour	< 1 hour	< 1 hour	< 1 hour	< 1 hour	< 1 hour	< 1 hour	< 1 hour
19	1–2 hours	1–2 hours	1–2 hours	1–2 hours	1–2 hours	1–2 hours	1–2 hours	1–2 hours
20	Ice conditions	Ice conditions	Ice conditions	Wind & Waves	Wind & Waves	Wind & Waves	Wind & Waves	Wind & Waves
21	Take Longer	Take Longer	Take Longer	Take Longer	Take Longer	Take Longer	Take Longer	Take Longer
22	Increase Rescue Time	Increase Rescue Time	Increase Rescue Time	Increase Rescue Time	Increase Rescue Time	Increase Rescue Time	Increase Rescue Time	Increase Rescue Time

Table 6. Consolidated Air Questionnaire Responses

Question #	Consolidated Responses							
	L1	L2	L3	L4	L5	L6	L7	L8
1	Not restricted	No restricted	No restricted	No restricted	No restricted	No restricted	No restricted	No restricted
2	Not restricted	Not restricted	Not restricted	Not restricted	Not restricted	Not restricted	Not restricted	Not restricted
3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	Add >20%	Add >20%	Add >20%	Add >20%	Add >20%	Add >20%	Add >20%	Add >20%
6	Add < 5%	Add < 5%	Add < 5%	Add < 5%	Add < 5%	Add < 5%	Add < 5%	Add < 5%
7	Wind	Wind	Wind	Wind	Wind	Wind	Wind	Wind
8	Wind	Wind	Wind	Wind	Wind	Wind	Wind	Wind
9	No	No	No	No	No	No	No	No
10	Add<5% to transit time	Add<5% to transit time	Add<5% to transit time	Add<5% to transit time	Add<5% to transit time	Add<5% to transit time	Add<5% to transit time	Add<5% to transit time
11	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12	visibility	visibility	visibility	visibility	visibility	visibility	visibility	visibility

Question #	Consolidated Responses							
	L1	L2	L3	L4	L5	L6	L7	L8
13	25-50%	25-50%	25-50%	25-50%	25-50%	<25%	<25%	<25%
14	Large effect	Large effect	Large effect	Large effect	Large effect	Large effect	Large effect	Large effect
15	<25%	<25%	<25%	<25%	<25%	<25%	<25%	<25%
16	25-50%	25-50%	25-50%	25-50%	25-50%	25-50%	25-50%	25-50%
17	10-15 min	10-15 min	10-15 min	10-15 min	10-15 min	10-15 min	10-15 min	10-15 min
18	> 20 min	> 20 min	> 20 min	> 20 min	> 20 min	> 20 min	> 20 min	> 20 min
19	All Equal	All Equal	All Equal	All Equal	All Equal	All Equal	All Equal	All Equal
20	Take Longer	Take Longer	Take Longer	Take Longer	Take Longer	Take Longer	Take Longer	Take Longer
21	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
22	Increase time; & Prevent rescue	Increase time; & Prevent rescue	Increase time; & Prevent rescue	Increase time; & Prevent rescue	Increase time; & Prevent rescue	Increase time; & Prevent rescue	Increase time; & Prevent rescue	Increase time; & Prevent rescue

The consolidated responses of the marine survey varied for the different locations considered indicating that the factor effects considered in the survey were unique to the different locations. The consolidated responses for the air survey however, were largely the same for all locations. This indicated that the factors considered may not have distinctive effects on an air resource at the locations considered.

8.3.2 Factor Ranking

The consolidated results of the factor ranking sheet are presented for both the marine and air resources independently. The factors are divided into two categories: "listed" and "other," representing those factors that were listed on the factor ranking sheet and those that were added by the respondents. The factors are presented in ascending order in terms of their ranking value which is indicative of the potential effect that the factor has on prolonging exposure time.

Table 7. Consolidated Factor Ranking Results: Marine – "Listed"

Factor	Ranking (/100)
Sea ice conditions	86
Wind and Waves	85
Visibility	79
Communication capabilities	77
Physical state of marine resource tasked (fuel tank full or low) / Chart adequacy (Bathymetry)	76
Level of experience of the master and crew	72
Physical State of the evacuees (injured / not injured)	69
Training of Master & crew / Distance from shore	66
Type of Marine resource tasked (primary or secondary)	63
Temperature / Quality of environmental forecasting models	58
Precipitation	57

Table 8. Consolidated Factor Ranking Results: Marine – "Other"

Factor	Ranking (/100)
Appropriate cold weather survival equipment	100
Total transit time (remoteness)	100
Presence of glacial ice on route	100
Proximity of air support & infrastructure (Air strip)	100
Availability of shelter	100
Capability of response vessels	100
Ability of local population to assist	95
Quality of protective clothing	95
Ice capability of resources	90
Capacity of rescue vessel (freeboard, emergency equipment)	85
capability of radar/ice detection equipment on SAR resource	80
Availability of Food/water	80
Presence of vessel of opportunity	75
Lifeboat or Life raft evacuation	60
Ice cover to support survivors	60
Whether marine resource has help	50
Whether resource has small vessel onboard such as RHI or workboat	50

Table 9. Consolidated Factor Ranking Results: Air – "Listed"

Factor	Ranking (/100)
Type of resource tasked (Primary or Secondary)	88
Distance from nearest airport	72
Wind and Waves	70
Precipitation / Visibility	64
Distance from shore	62
Level of experience of the pilot and crew	60
Communication capabilities	57
Physical State of the evacuees (injured / not injured) / Training of pilot & crew	56
Fatigue levels of response crew	48
Quality of environmental forecasting models	42
Temperature	40
Sea Ice conditions	39

Table 10. Consolidated Factor Ranking Results: Air – "Other"

Factor	Ranking (/100)
Air assets from adjacent SRR	100
Transit time to reach scene	100
Available protective clothing	100

Factor	Ranking (/100)
Aircraft serviceability	90
Availability of food/water	80
Turbulence	80

The “listed” factors for both marine and air resources were largely the same. The different ranking values for the listed factors for air and marine represent how the significance of each factor is different in terms of the type of resource used. For example, the effect of sea ice conditions on marine resource operations was ranked as 86% while the effect of this factor on air resource operations was only ranked as 39%.

The “other” factors that were indicated for both marine and air resources could be generalized into two distinct categories. The first is those that could affect the rescue resource operations and ultimately the time to arrive on scene and the second being those that could affect the survivability time of an evacuee. For example, when looking at the “other” air resource factors listed, the air assets, turbulence, transit time and serviceability, could affect the resource operations while the others, namely available food/water and protective clothing, could affect the survivability time. This is a noteworthy point that was considered further in the workshop.

8.4 Survey Data Analysis

This section describes the methods that were applied to the consolidated survey results in order to compute the range in exposure time relevant to each considered location. The methodologies for the marine resources and air resources were developed differently and are presented separately, in point form, below. The methodology refers to specific question numbers from the questionnaires and these should be referenced accordingly. The results of the survey data analysis are also presented in terms of the range in exposure time, based on each resource type, at each of the eight locations. In addition, the key assumptions that were made in these methodologies are outlined and described.

8.4.1 Marine Questionnaire Analysis

This method was applied to the consolidated marine questionnaires for each of the eight locations considered in order to gauge the range in potential exposure times based on marine resource rescue only (i.e. excluding air resources).

T1 –Communications Time

- T_{1Low} is taken as 0 hours
  - This is the low end of the range for T1
  - This assumes that contact is received immediately
- The effect of communication capability is taken as the results from question number 1
  - In terms of the average response for each location
  - The upper end of the range is used
- T_{1High} is taken as the sum of T_{1Low} and the effect of communication capability

T2 – Travel Time

- T_{2Low} is calculated using the maximum speed of a general CCG ice classed ship (16 kts) and the response to question number 10
  - Average response for each location

- Low end of range is used for T_{2Low}
- High end of range is used to calculate a component of T_{2High} (T_{2HighA})

- The effect of lack of bathymetric data is calculated using the averaged results of question number 4 for each location
  - The percentage increase is based on T_{2HighA}
- The effect of high environmental conditions is calculated using the averaged results of question number 46 for each location
  - The percentage increase is based on T_{2HighA}
- The effect of the experience level of the master and crew is calculated using the averaged results of question number 9 for each location
  - The percentage increase is based on T_{2HighA}
- T_{2High} is calculated by adding the effect of each factor considered in T2 (bathymetry, environmental conditions and experience of master and crew) to T_{2HighA}

T3 – Search Time

- T_{3Low} is calculated based on the low value of drift speed relevant to the given location (i.e. min drift speed), the value found for T_{2Low} for the given location and the search speed for a given area (the averaged results to question number 11 high range).
  - The drift speed was found from a figure of drift versus wind speeds (see Figure 8) which is used in drift forecast models that assist search and rescue operations in Norway (Maisondieu and Pavec, 2008).
  - $T_{3Low} = (T_{2Low} * \text{Drift Speed}_{Low})/ \text{Search Speed}_{High}$
- The effect of high environmental conditions was calculated using the same framework as used to determine T_{3Low} however the search speed was found using the results of question number 12 and the low range was used (T_{3A})
- The effect of lack of communications capability (T_{3B}) was found using the averaged results of question number 14 (high end range) based on the results of T_{3A}
  - $T_{3B} = Q14(\% \text{ value}) * T_{3A}$
- The effect of lack of bathymetric data (T_{3C}) was found using the averaged results of question number 15 (high end range) based on the results of T_{3A}
  - $T_{3C} = Q15(\% \text{ value}) * T_{3A}$
- The effect of limited experience of Master or crew (T_{3D}) was found using the averaged results of question number 16 (high end range) based on the results of T_{3A}
  - $T_{3D} = Q16 (\% \text{ value}) * T_{3A}$
- The effect of poor forecasting models (T_{3E}) was found using the averaged results of question number 17 (high end range) based on the results of T_{3A}
  - $T_{3E} = Q17(\% \text{ value}) * T_{3A}$
- T_{3High} is found by adding together the effects of all factors considered for T3 (environmental conditions, communications capability, bathymetric data, experience of Master and crew and forecasting models)
  - $T_{3High} = T_{3A} + T_{3B} + T_{3C} + T_{3D} + T_{3E}$

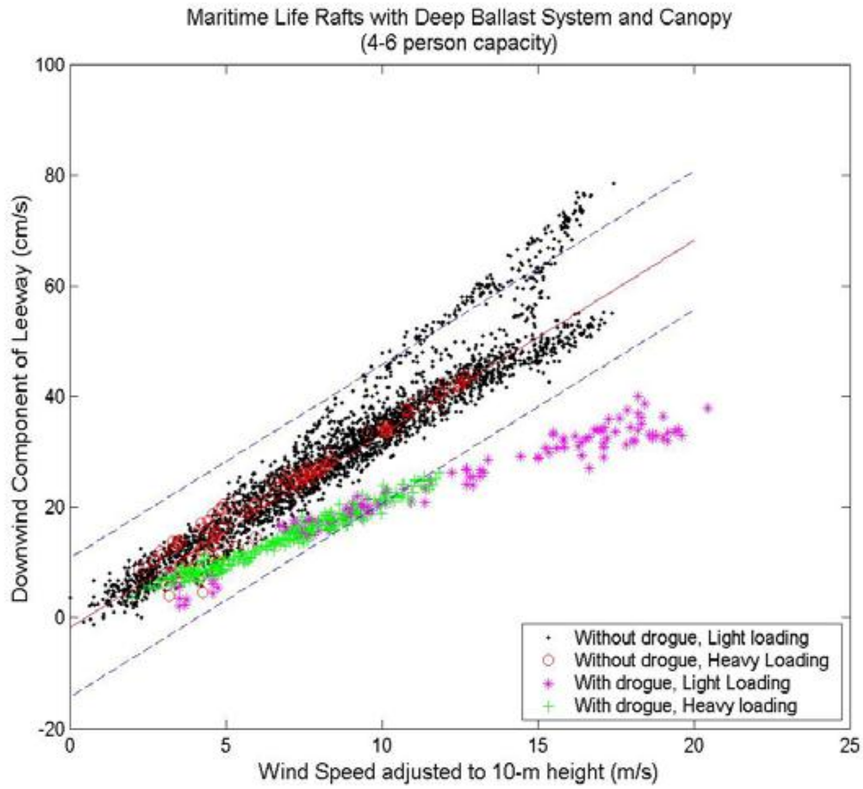

Figure 8. Drift speeds (From Maisondieu and Pavec, 2008)

T4 – Rescue Time

- T_{4Low} is based on the averaged results for question number 18
- The effect of high environmental conditions is found using the averaged results of question number 19
- T_{4High} is taken as the rescue time at high environmental conditions (i.e. the effect of high environmental conditions as found in the last point)

*** The effect of physical state of evacuee and the level of experience and training of Master and crew could not be quantified based on questionnaire results. However, they were deemed important. This is something that could be quantified in the workshop. These effects will not play a large role in the overall exposure time since T4 is a relatively small component.*

Total Exposure Time

- The low end of the exposure time range for each location is calculated by adding the results of T_{1Low} through T_{4Low}
  - $T_{Low} = T_{1Low}+T_{2Low}+T_{3Low}+T_{4Low}$
- The high end of the exposure time range for each location is calculated by adding the results of T_{1High} through T_{4High}
  - $T_{High}=T_{1High}+T_{2High}+T_{3High}+T_{4High}$

8.4.2 Marine Questionnaire Analysis Results

The results for the range in exposure time (in hours) for each location considered, based on the results of the exposure time survey, are illustrated in Table 11. Note that these results are indicative of the exposure times that would result when using **marine resources only**. These should be integrated with the results of the analysis of the exposure time determined based on air resources to get a complete understanding of potential exposure times in northern Canada.

Table 11. Exposure time range based on Marine Questionnaire results (in hours)

Exposure Range	Location Number							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Low Range (hours)	26	26	13	14	26	13	13	7
High Range (hours)	202	222	145	88	123	71	132	33

The largest low end range occurs at location numbers 1, 2 and 5 and relates to an exposure time of 26 hours. The largest high end range occurs at location number 2 and relates to an exposure time of 222 hours (9.3 days). These results indicate that if a marine incident occurred in the vicinity of location two and resulted in evacuation, it could take up to 9.3 days for the evacuees to be rescued, based on a rescue using a marine resource, the factors considered and the environmental conditions relevant to the location. Under circumstances where air resources are not available, such as persistent poor visibility or maintenance issues, these exposure time ranges may be expected.

8.4.3 Assumptions in Marine Exposure Time Analysis

The key assumptions in the methodology used for the evaluation of exposure time based on marine resources are as follows:

- The communications time (relating to time for initial communications and any preparation time required for the vessel to start transiting to the scene) for marine resources has a low range that is set to 0 hours.
    - This assumes that communications of the event occur instantly and the marine resource begins to travel towards the emergency event right away.
- The low-end transit time for a marine resource is based on the transit speed of the Louis St.-Laurent, 16 knots and the survey results relating to the proximity to the nearest CCG ship.
    - The survey results are used to compute the high end transit time (considering factor effects, e.g. environmental conditions) based on this low-end time.
- The search time for a marine resource relates to the response to marine resource search speed found from the survey results. No air search is considered since this assessment was based on marine resources only.
    - The drift speed for low and high environmental conditions (relating to low and high wind speeds) was found from the results of an operational drift forecast model that is used by Rescue Coordination Centres for SAR operations and oil spill mitigation (Maisondieu and Pavec, 2008).

- The low-end rescue time for marine resources was based on the response to the survey question relating to rescue time in low environmental conditions. The aggregated results were all less than 1 hour for each location.
    - Based on this aggregated result, the low end rescue time was set to 0.5 hours for each location.

8.4.4 Air Questionnaire Analysis

This method was applied to the compiled air questionnaire results for each of the eight locations considered in order to gauge the expert opinion of the range in potential exposure times based on air resource rescue. This analysis is conducted based on both fixed-wing and helicopter air resources.

T1 – Initial Communications

- T_{1Low} is set to 0.5 hours
    - This takes into consideration the required time to take off (0.5 hours)
    - This assumes that communications begin immediately
- T_{1High} is found using the maximum of the responses to question number 1 (primary resource) and question number 2 (secondary resource) which considers the effect of environmental conditions.
    - It also considers the time required to take-off during non-working hours (i.e. evenings, nights and weekends) which is required to be less than 2 hours.

T2 – Travel to Location

- T_{2Low} was found based on the range, speed and distance of the nearest CF air resource, both fixed-wing and helicopter
- The effect of environmental conditions (T_{2A}) is found using the maximum of the aggregated responses to question numbers 5 and 6 (helicopter and fixed-wing)
- The effect of experience level of Master and crew (T_{2B}) is found using the response to question number 10
- T_{2High} is found by taking the sum of T_{2Low} plus the effects of environmental conditions and experience level
    - $T_{2High} = T_{2Low} + T_{2A} + T_{2B}$

T3 – Search Period

- The search speed for each CF air resource was found online (RCAF, 2013).
    - This was taken as the high-end search speed.
    - The low end search speed was assumed to be roughly 75% of the high end search speed.
- T_{3Low}, the low end range for T3 is found by multiplying the high range search speed by the minimum forecasted drift distance (minimum drift distance found using low environmental conditions).
    - The minimum drift distance is found by multiplying the minimum drift speed by the minimum travel to location time (T_{2Low})
    - Drift speed is found using search and rescue chart of forecasted life raft drift distance versus wind speed (minimum drift speed found using low wind conditions).

- The effect of high environmental conditions (T_{3A}) is found by multiplying the low range search speed by the maximum forecasted drift distance (minimum drift distance found using high environmental conditions).
    - The maximum drift distance is found by multiplying the maximum drift speed by the maximum travel to location time (T_{2High})
    - Drift speed is found using search and rescue chart of forecasted life raft drift distance versus wind speed (maximum drift speed found using high wind conditions).
- The effect of lack of communications capability (T_{3B}) is determined using the aggregated response to question number 13.
    - The percentage is taken using the search time at high environmental conditions (T_{3A})
    - T_{3B} = Q13% x T_{3A}
- The effect of lack of operator experience (T_{3C}) is found using the aggregated response to question number 15.
    - The percentage is taken using the search time at high environmental conditions (T_{3A})
    - T_{3C} = Q15% x T_{3A}
- The effect of accuracy of environmental forecasting models (T_{3D}) is found using the aggregated response to question number 16.
    - The percentage is taken using the search time at high environmental conditions (T_{3A})
    - T_{3D} = Q16% x T_{3A}
- T_{3High} is found by adding the search time at high environmental conditions to the effects of all other factors considered in T_3
    - $T_{3High} = T_{3A} + T_{3B} + T_{3C} + T_{3D}$

T4 – Rescue Activities

- T_{4Low}, the low end range for T_4 is equal to the aggregated response to question number 17
- T_{4High}, the upper range for T_4 is based on the effect of high environmental conditions and found from the response to question number 18

*** The effect of other factors such as the physical state of evacuees, distance to nearest point of land and experience and training of captain and crew, were indicated as highly relevant as per questionnaire results. However, these factors could not be quantified based on the responses to the questionnaire and were discussed at the workshop. Since T4 is relatively small in comparison to T2 and T3, these effects will not play a large role in the overall exposure time ranges.*

Total Exposure Time

- The low end of the exposure time range for each location is calculated by adding the results of T_{1LOW} through T_{4LOW}
    - $T_{Low} = T_{1Low}+T_{2Low}+T_{3Low}+T_{4Low}$
- The high end of the exposure time range for each location is calculated by adding the results of T_{1High} through T_{4High}
    - $T_{High}=T_{1High}+T_{2High}+T_{3High}+T_{4High}$

For cases in which the transit time for a helicopter is greater than the sum of the transit and search time for a fixed-wing resource, $T_2 + T_3$ is set to the helicopter transit time. Alternatively, for cases in which the transit time for a helicopter is less than the sum of the transit and search time for a fixed-wing resource, $T_2 + T_3$ is set to the fixed-wing transit and search time. This allows for consideration of instances in which a fixed-wing aircraft arrives on scene prior to an available helicopter and proceeds with a search. This may lead to optimistic results in cases where the evacuees are located and the helicopter needs to travel a large distance to affect a rescue.

8.4.5 Air Questionnaire Analysis Results

The results for the range in exposure time (in hours) for each location considered, based on the results of the air questionnaire, are illustrated in Table 12. Note that these results are indicative of the exposure times that would result when using **air resources** only. These should be integrated with the results of the analysis of the exposure time determined based on marine resources to get a complete understanding of potential exposure times in northern Canada.

Table 12. Exposure time range based on Air Questionnaire results (in hours)

Exposure Range	Location Number							
	1	2	3	4	5	6	7	8
Low Range (hours)	18	17	16	14	11	10	12	11
High Range (hours)	26	25	25	21	18	17	19	17

The high end of the air-based exposure time ranges are well below that of the marine-based exposure time ranges, for all locations considered. The low end range on the other hand, is at some locations comparable to that of the marine-based range.

8.4.6 Assumptions in Air Analysis

The key assumptions in the methodology used for the evaluation of exposure time based on air resources are as follows:

- All Canadian air SAR resources at each SAR base is assumed to be operational and available;
- Since all $T_2 + T_3$ for fixed-wing air resources is less than T_2 for a helicopter resource, the exposure time for each location was taken as $T_1+T_2+T_4$ where T2 is the helicopter transit time;
  - o This assumes that a fixed-wing resource searches for and locates the lifeboat while the helicopter is en-route to the scene
- The communications time for air resources includes the time for initial notifications of the event to proceed, the time for response crews to get ready and the time required for the air resource take-off.
  - o The minimum time for this is set to 0.5 hours since this is the minimum time required for resource take-off.
  - o The maximum time considers the effect of poor communications capability from survey results (1 hour for all) and the take-off time during off hours (2 hours for all). This resulted in a maximum communications time of 3 hours.
- The travel time for air resources assumes that any required stops for refueling are along the straight line route from originating air base to event location. When transit time surpassed

the range limit of a given air resource, 1 hour was added for refueling for a fixed-wing resource and 0.5 hour was added for refueling of a helicopter but no additional time was added to account for having to go off route to find an available refuel source.

- The high-range search time for air resources is based on a low range search speed of the Hercules which was found by taking approximately 75% of the known search capability (135 knots). It is uncertain if the search speed would decrease by a larger percentage due to poor environmental conditions (i.e. high wind, wave, sea ice, etc.).
  - The maximum time this added to the search time was less than half an hour.
- The high end rescue time for air resources was chosen based on the results to the survey question relating to rescue time in high environmental conditions.
  - This question should have provided higher time options since all respondents answered greater than 20 minutes.
  - Based on this response, the high end rescue time was set to 1 hour.

8.4.7 Discussion of Marine and Air Questionnaire Analysis Results

The following items of interest relate to the marine and air exposure time analysis that resulted from the assessment of survey results. These points refer to the exposure times that were presented in Table 11 and Table 12 (in hours).

1. The high range of exposure time based on marine resources is unexpectedly high for location 7. This was expected to be lower since it is positioned at a lower latitude and closer to resources.
   - This was investigated further and the justification is twofold: the distance from the nearest CCG resource was set to a relatively large value and the search speed was set low at high environmental conditions. Both of these values were set based on the results of the survey.
   - The distance from nearest CCG resources may have been set low for location 7 due to the positioning of CCG vessels at this time of year. This issue was a discussion point for the exposure time workshop.
   - The search speed may have been set low at this location since the high environmental conditions in this area relate to an ice concentration similar to the high end ice concentration of some of the more-northerly locations. At locations with high ice concentrations the search speed (based on marine resources) was set low.
2. In some instances, the low end exposure time based on marine resources is lower than the low end exposure time range based on air resources. This is the case for location number 3 and location number 8.
   - This may be the case for location number 3 since the closest helicopter resource was Gander, NL. There are helicopter resources in Comox, BC that are closer but information provided from JRCC Trenton did not provide distances from Comox Base to any locations other than 5 and 6. This resulted in the assumption that Comox Base does not provide service for other locations. This needs to be confirmed with JRCC Trenton.
   - For location 8 it is expected that a marine resource will be in relatively close proximity and thus the low end marine based exposure time is smaller.

3. The high end exposure times for air resources are relatively low. The following assumptions may lead to an explanation of this:
    - It was assumed that the aircraft did not have to go off track to refuel. In other words, it is assumed that the required refuel stations are located along the straight line path between the air base and the location. Extra transit time would have to be added if this is not the case.
    - It is assumed that the air resource spots the lifeboat during its first pass of that position; that is, if the air resources fly past the lifeboat and misses it due to stormy conditions or high ice or wave conditions, this is not accounted for. Extra search time would have to be added to account for such incidents.
    - It is assumed that the air resource that leads to the lowest transit time (combination of closest proximity and transit speed) is available and operational at the time of the incident

8.5 Remaining Questions

There were a number of questions that required expert feedback relating to: 1. the consolidated survey results and the assumptions made in the analysis methodologies; and 2. the resulting exposure time ranges. These questions were summarized and listed for discussion in the exposure time workshop. The key questions are described below along with a description of the consolidated survey result relating to this question and how it was applied to the exposure time range (if applicable).

<u>Consolidated Results & Methodology Assumptions</u>

1. How to quantify the effect of high environmental conditions on the transit time to locations 1 - 8? (Q6 Marine Survey)
    - Response: Add > 20% to transit time
    - Exposure Time Analysis: Added 30% to baseline transit time
2. How to quantify the effect of experience of Master and crew on the transit time to locations 1 - 8? (Q9 Marine Survey)
    - Response: Add > 20% to transit time
    - Exposure Time Analysis: Added 30% to baseline transit time
3. How to quantify the effect of high environmental conditions on the transit time of a helicopter (Q5 Air Survey)
    - Response: > 20 %
    - Exposure Time Analysis: Added 30% to baseline transit time
4. How to quantify the rescue time via air resource in high environmental conditions (Q18 Air Survey)
    - Response: > 20 minutes
    - Exposure Time Analysis: Added 1 hour to rescue time
5. How to quantify the effect of high environmental conditions on air-based search rate
    - Response: No question asked to quantify this.
    - Exposure Time Analysis: Decreased search speed by 20%
6. How to quantify the effect of the physical state of evacuees on rescue time (marine and air rescue)
    - Response: No question asked to quantify this.
    - Exposure Time Analysis: Effect not considered
7. How to quantify the effect of the level of experience and training of Master/Captain and crew on rescue time (marine and air rescue)

- Response: No question asked to quantify this.
- Exposure Time Analysis: Effect not considered

8. How to quantify the effect of the proximity to nearest fuel source on transit time and search time (air-based)
    - Response: No question asked to quantify this.
    - Exposure Time Analysis: Re-fuel times now assume that aircraft does not need to go off route to get fuel – i.e. no extra time allotted for transit. Search time all below required refuel time and therefore not considered in this component.
9. How to quantify the effect of the distance to nearest point of land on air-based rescue time
    - Response: No question asked to quantify this.
    - Exposure Time Analysis: Effect not considered
    - This will only be significant if large number of casualties

<u>Exposure Time Ranges (Survey Based)</u>

1. The high range of the marine based exposure time is unexpectedly high for location 7
    - Search speed was set to a low value at high environmental conditions
    - Based on survey results
    - High ice conditions at location 7 similar to those at higher latitudes
2. The high end range of the marine based exposure time at location 2 is larger than that of location 1
    - The "high" ice concentration at location 2 is larger than that of location 1
    - This effects the search speed
3. The high end of the air based exposure time range is relatively small
    - It was assumed that the aircraft did not have to go off track to refuel
    - It was assumed that the air resource locates the lifeboat during its first pass of the position
    - It is assumed that the air resource(s) that lead to the lowest transit time are available and operational
4. In some instances, the low end exposure time based on marine resources is lower than the low end exposure time range based on air resources
    - This is the case for location number 3 and location number 8
    - Possible Justification:
        - Location 3 - Large distance from nearest SAR helicopter
        - Location 8 - Relative proximity of nearest CCG resource is small

9 EXPOSURE TIME WORKSHOP

A workshop was developed with industry experts to obtain additional insight relating to potential exposure times in northern Canada and to capture subject matter expert feedback on the survey data. This section highlights the goals of this workshop, the workshop attendees as well as the key workshop results.

9.1 Workshop Goals

The primary goals of the exposure time workshop are defined as follows:

1. To present consolidated survey results, exposure time analysis methodologies, and the resulting exposure time ranges at each location and get feedback;
2. To determine any key factors that may not have been mentioned on the factor ranking sheets;
3. To discuss any factors that could not be quantified from survey results but were deemed as significant

The workshop agenda was created to ensure that the discussions covered the primary workshop goals and the related key questions that were identified in section 8.5. The workshop agenda can be reviewed in Appendix D.

9.2 Workshop Attendees

There were 14 participants in the exposure time workshop in total. Though this was a relatively small group, it was representative of experts in the area of both marine and air based search and rescue activities in northern Canada. The attendees included representatives of both JRCC Trenton as well as JRCC Halifax, members of the Canadian Coast Guard, the Canadian Forces, the National Research Council and private industry. The list of affiliations that were represented at the workshop is provided in Appendix E.

9.3 Workshop Results

The discussions throughout the workshop were recorded in point form and then summarized. The feedback relating to modifications to the exposure time analysis methodology and resulting survey-based exposure time ranges were highlighted and listed independently. This feedback was applied to the survey-based exposure time results to determine a more representative and experience based potential range in exposure time for each location. The workshop feedback used to revise the survey-based exposure time ranges is summarized below. Note that in order to maintain confidentiality of the workshop participants the name of the individuals who provided each comment is not provided.

Table 13. Workshop Findings: Quantifiable

Item	Comment Details	Applied To
1	At locations 1, 2 and 8 the marine transit time could be increased by 50% due to high ice conditions (sea ice, wind and visibility).	Survey Analysis Methodology
2	Based on experience, in some northern locations it could take up to 12 hours to get satellite connections. This is based on regular type communications and not emergency alerts.	Exposure Time Range

Item	Comment Details	Applied To
3	The low end range of location 1 (26 hours) for marine seems too optimistic based on the strategic CCG positioning of vessels at that time of year. A more realistic low end time would be 48 hours.	Exposure Time Range
4	The low end range of location 7 (13 hours) for marine seems too optimistic. There are rarely any CCG ships in Foxe Basin. The low end value should be modified to 36 hours which is more representative for this location.	Exposure Time Range
5	The low end range of location 5 (26 hours) for marine seems too optimistic. This value should be modified to 48 hours.	Exposure Time Range
6	The low end range of location 8 (7 hours) for marine would only be possible with strategic positioning. A more realistic low end value would be at least 24 hours because this exposure time is based only on primary SAR resources.	Exposure Time Range
7	The high range of location 3 (145 hours) for marine is too high. The high end value should be modified to 48 hours.	Exposure Time Range
8	The high range of location 4 (88 hours) for marine is too high. The high end value should be modified to 24 hours.	Exposure Time Range
9	Experience of the master / crew could negatively impact transit time by >20% because of lack of experience in reading the type of ice.	Survey Analysis Methodology
10	The environmental forecast could impact exposure time by approximately 25-50%. In all northern locations environmental forecasting is weaker than that in lower latitudes due to lack of validation data from weather stations.	Survey Analysis Methodology
11	Helicopter rescue for a hoisting cycle should take approximately 10 minutes, but with the presence of wind and waves there could be an increase of >20 minutes. The effect of sea state on a helicopter rescue will also depend on the experience of the rescuer.	Survey Analysis Methodology
12	For a marine resource 15 knots may be a more appropriate transit speed.	Survey Analysis Methodology
13	For air resources: the location 1, location 2 and location 3 minimum exposure times seem optimistic. These should be larger and based on helicopter refuel pattern.	Exposure Time Range
14	Lack of bathymetric data is a significant factor for marine resources and can result in a > 30% increase in transit time (and even much more than this) at certain locations, particularly high latitudes or near shore locations.	Survey Analysis Methodology

There were additional workshop feedback items that denoted significant factors that were not and could not be captured within the exposure time ranges due to the complexity of the factor itself. Some of these comments and factors relate to limits on the applicability of the exposure time ranges defined from this study. A complete list of these limitations will be presented in a future section. These comments are summarized below. The full details of the workshop discussions are presented as meeting minutes in Appendix F.

Table 14. Workshop Findings Non-Quantifiable

Comment Details	Effect on Exposure Time Range
The high environmental conditions could be much worse during transit – this could cause higher marine based exposure times.	Increase
The air rescue plan changes greatly depending on the number of casualties. If casualties greater than 18 (capacity of the Cormorant helicopter) the plan will change and likely increase exposure time.	Increase
Lack of bathymetric data is a significant factor for marine resources, in certain cases the lack of such data could prevent a vessel from responding to an event.	Prevent

Comment Details	Effect on Exposure Time Range
The marine rescue time was based on the amount of time taken to come alongside a lifeboat. To transfer evacuees onboard the rescue vessel would generally not take much more time. However, under certain conditions: high seas, poor physical condition of evacuee, etc. this extra time could be quite large.	Increase
Vessel or aircraft of opportunity are not considered in this evaluation. If they were, the majority of the factors would have a larger effect on the search and rescue effort using this type of resource. For example, a vessel with no rescue training or equipment would take longer to affect a rescue than one that is trained and better equipped.	Decrease /Increase
The distance to nearest airport (from location of incident) is more important if the number of casualties is large since the helicopter would have to pick up/drop off and maybe refuel before continuing.	Increase
The scenario under evaluation was based on evacuees in a lifeboat. If evacuees were in the water then the search would be more difficult.	Increase
The presence of multi-year ice during transit could significantly increase transit time. The presence of ice detection technologies and an experience captain would reduce this effect.	Increase
It is important to look at the shoulder seasons because there is increasing activity in these areas and a decreased number of CCG vessels in the identified locations. This could significantly increase exposure time because the rescue vessels would be much farther away from the distress call at other times of the year.	Increase
Aircraft serviceability is a factor that could have a significant effect on exposure time. If the aircraft is not serviceable en route then this could lead to delays.	Increase

There was one discussion during the workshop that related to the locations considered in the evaluation. These discussions indicated that from a marine perspective, it would be beneficial to consider another location further west of location 3 but at approximately the same latitude. This location would be within the boundaries of the Northwest Territories and have a unique and relatively high exposure time range based on marine resources due to higher environmental conditions and the strategic positioning of CCG vessels.

10 FINAL DATA ANALYSIS

The exposure time ranges that resulted from the assessment of compiled survey results, as discussed in Section 8, were modified based on the workshop findings that were highlighted in Section 9.3. This section provides details relating to how the workshop feedback was applied to the survey-based exposure time data and presents the results of this application.

10.1 Exposure Time Refinement

The marine-based and air-based exposure time ranges were updated independently since some workshop feedback related to one specific resource type and not the other. As such, the details of how each exposure time range (marine or air based) were refined, are discussed separately. In both cases, feedback relating to the methodology was applied prior to addressing the items that were related to the exposure time ranges themselves. This allowed consideration of the adjusted range values that resulted from the improved methodology. In some instances, the exposure time values resulting from the improved methodology were already in compliance with the feedback relating to the required range adjustments. All modifications to both the marine and air resource based exposure time ranges were a result of the items listed in Table 13.

Marine-Based Exposure Time Refinement

The first adjustment made to the marine-methodology was to decrease the vessel transit speed from 16 to 15 knots. This modification resulted in increased exposure time values for both the low end and high end ranges of each location. Another adjustment was to increase the effect of certain factors based on the modified percentage value discussed in the workshop. For example, the effect of high environmental conditions was increased to 50% for location 1, 2 and 3 (see item number 1 in Table 13). This effect was originally set to 30% based on survey results.

After all feedback relating to the methodology was applied, the resulting modified exposure time values were compared to the feedback relating to the exposure time range values. Adjustments to the exposure time range values were made to ensure that they matched with this feedback. The exposure time range specific feedback includes item numbers 3 through 8 in Table 13. These items are largely based on knowledge of the positioning of CCG vessels throughout northern Canada in mid-August.

Air-Based Exposure Time Refinement

Modifications to the air-based methodology included adding the effect of poor environmental forecasting models to transit time (as per item 10 in Table 13) and adjusting to the low end and high end rescue time (as per item 11 in Table 13). The modifications to rescue time were based on the rescue of 18 people as indicated in the scenario details.

The modified air-based exposure time range was then adjusted for locations 1, 2 and 3 as per item 13 in Table 13. These adjustments were made by making reference to a routing pattern developed by JRCC Trenton for a Cormorant Helicopter, located in Gander, NL, to travel to Resolute, NU. The standard time, including refuel stops and crew-change, was indicated and used as a base-time to get to each of the three locations. The distance from location 1, 2 and 3 to Resolute was obtained and used to calculate the additional transit time required for the Cormorant helicopter to arrive in each location. The additional times were added to the base time (to Resolute) in order to obtain the total refined transit time. The resulting values were higher than the original values which is in agreement with workshop comments.

10.2 Key Assumptions and Applicability of Defined Exposure Times

The exposure time ranges defined in this assessment are based on a number of case specific conditions. Their relevance to other scenarios may vary depending on the parameters of the given event. The parameters from which the exposure time ranges were defined were selected such that the resulting ranges would have a high potential of being representative of exposure times resulting from an incident in northern Canada. The parameters that confine the applicability of the defined exposure time ranges are described below.

Time of Year

The defined exposure time ranges are relevant to the time of year at which they were assessed. Mid-August is representative of the time of year at which peak traffic exists in northern Canada and thus the time at which it is most likely for an emergency event to occur. As such, mid-August is a time when the Canadian north is equipped with the maximum number of CCG vessels. Thus, the exposure time, based on marine resources, relating to an incident at another time of the year may be larger than the exposure time defined for mid-August. The marine operational season in northern Canada, defined by the presence of CCG ships, begins in June and ends in November. It would be interesting to quantify the adjustment to the exposure time ranges required to allow them to be representative of the shoulder months. In terms of air-resource based exposure times, this parameter would not likely lead to any changes. Air resource staffing and preparedness does not change throughout the year.

The defined environmental conditions are relevant to the mid-August time frame. These environmental conditions are representative of the lowest set of conditions that would be encountered throughout the year. Towards the shoulder time of the operational season, the environmental conditions could get much more severe. This adds to the probability of increased marine based, exposure time for an incident occurring during a different time-frame than mid-August. More severe environmental conditions, stronger winds and lower visibility in particular, would also have the capacity to increase the air-based exposure time range.

Number of Evacuees

The defined air-based exposure time ranges are relevant to scenarios that involve equal or less than 18 evacuees. This is due to limitations on the carrying capacity of the Cormorant helicopter. For scenarios involving more personnel than this, the rescue air resource would be required to drop off a portion of the rescued personnel and then returning to rescue the remaining evacuees. This could lead to a significantly larger exposure time for the evacuees left waiting for the second rescue round. This may not be as much of an issue for instances in which there are two helicopters deployed to the scene, given that the number of evacuees can be accommodated by two air resources. Since a rescue via CCG vessel would have the capability to carry many more than 18 evacuees, this restriction does not stand for the marine-based exposure time ranges.

Availability of Resource of Opportunity

The defined exposure time ranges are based on the assumption that no vessel of aircraft of opportunity assist in the search and rescue operations. The presence of a vessel or aircraft of opportunity, in close proximity to the location of the incident, would likely result in a large reduction in the exposure time. The presence of vessel and aircraft of opportunity is random and differs from year to year. The given time-frame, mid-August, has the highest potential of availing from the use of a resource of opportunity since it has the largest activity level. At dates later or prior to this the probability of obtaining assistance from a resource of opportunity is greatly reduced. Since the presence of a resource of opportunity is not scheduled or planned, it would be difficult to quantify this factor in terms of its effect on the exposure time range.

Though the presence of a resource of opportunity would likely lead to a reduction in the exposure time for a given incident, it is also noteworthy that the effect of certain factors on the resulting exposure time would increase. For example, if a vessel of opportunity responded to an incident, high environmental conditions and poor bathymetric data may play a larger role. This is the case since a vessel of opportunity is likely not as equipped to respond to an incident as a CCG vessel.

Availability of Canadian Resources

The defined exposure time ranges are based on the assumption that all Canadian SAR resources are operational and available for service. If a particular resource is off duty for maintenance, this could have a large effect on increasing the transit time to the incident location. For marine based exposure times, this condition relates to the CCG vessels that are deployed annually at strategic positions across northern Canada. For air resources, this condition primarily relates to all CF helicopters since these dictate the exposure time range. The servicing requirements of a Cormorant helicopter have been found to be greater than 6-10 maintenance hours per 1 hour flight (Reid, 2011). In both the marine and air resource case, the availability of additional resources, particularly at more northern locations, would potentially have a very large effect on reducing the exposure time ranges.

No Mechanical Failure or Weather Stops

This condition has the potential to play a large role in the air-resource based exposure time ranges. It has been assumed in the definition of the air-based exposure time ranges that there are no mechanical issues that occur during the trip which extend the time taken to transit to the location. Therefore, if a resource en route encounters a mechanical issue that requires the resource to stop or go off course, this is not considered in the defined ranges. Additionally, if poor weather arises while the aircraft is grounded for refuel it could increase the exposure time significantly. This condition was not considered in the defined air-based exposure time ranges.

No Large Gap in Alert

The exposure time ranges were based on the fact that communication alerting technologies are functioning at the time of the event. Instances in which an EPIRB (for example) was not functioning properly and a distress message was not sent were not considered in the exposure time range. A delay in alerting due to gaps in satellite coverage however, was considered. For this, an additional time of 4-5 hours was added to the high end exposure time range at each location. Events with non-functional EPIRBS or other alert notification devices however, could have a much longer delay between the time of the event and the time that a JRCC recognizes that an event has occurred.

No Major Fuel Stop Diversion

The air-based exposure time ranges were defined based on the assumption that the air resource did not have to stray far from the direct route to an incident in order to refuel. If, while en route to an incident, a helicopter needs to divert off route to refuel, this could add significantly to the transit time and overall exposure time. Thus, the availability of strategically positioned northern fuel sources has the potential to play a large role in the resulting exposure time.

10.3 Exposure Time Results: Map of Expected Ranges

The exposure time ranges presented in this section were defined based on the combined results of the consolidated survey responses and the workshop feedback. The exposure time range is presented for both air resources and marine resources independently in Table 15.

Table 15. Exposure time ranges based on Air & Marine Resources

Resource Type	Exposure Limit (hours)	Location							
		1	2	3	4	5	6	7	8
Air	Low Range	27	24	23	16	14	13	15	13
	High Range	49	45	42	31	27	25	28	26
Marine	Low Range	48	28	14	14	48	14	36	24
	High Range	237	261	48	24	131	75	140	43

When considering these exposure time ranges, one can note that the high end of the marine resource-based exposure time is often quite larger than that of the air-based resources. The only location at which the high range exposure limit based on marine resources is lower than the high range exposure limit based on air resources is location 4. Also, both high range exposure limits at location 3 are relatively similar. The marine exposure time ranges are highly influenced by the strategic positioning of CCG vessels at the time of interest – mid-August. It is for this reason that the high range exposure time limits at location 3, 4 and 8 are relatively small compared to the others. During the shoulders of the operational season (June – November), these marine-based exposure time ranges would change according to the positioning of resources. Once outside the operational period, the high end numbers based on marine resources would jump significantly since the CCG resources that were stationed within the Canadian Arctic have regressed to lower latitudes. Since the base point of air resources is constant, these ranges will not be influenced by the time within the operational period, or throughout the year.

For each location, the marine-based and air-based exposure time ranges are merged to identify the lowest exposure time value and the highest potential exposure time value, when considering all available resources. The resulting exposure time ranges are indicated in Figure 9.

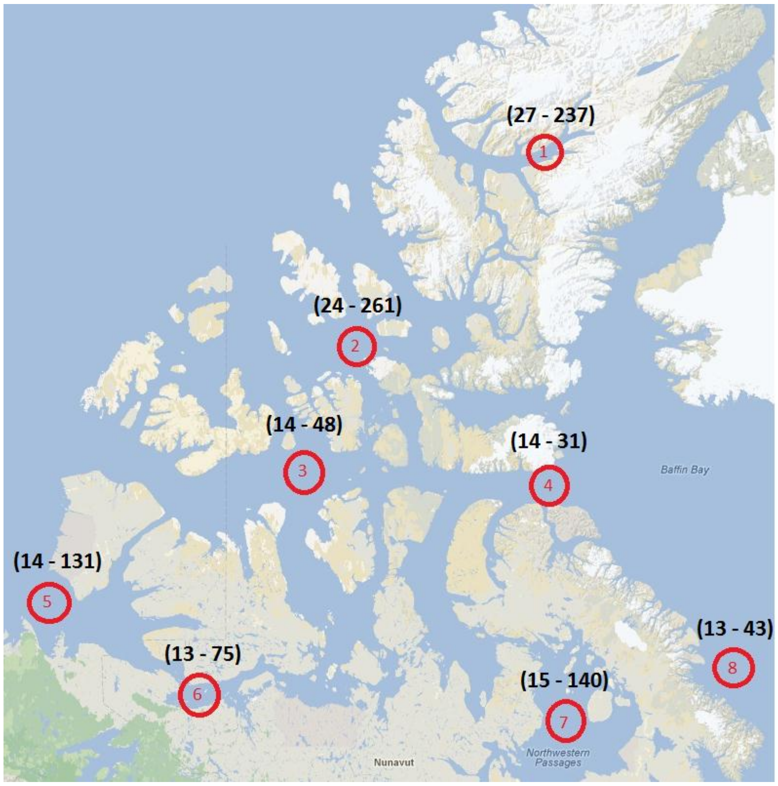

Figure 9. Merged exposure time ranges (based on all Canadian resources)

When reviewing these merged exposure time ranges in comparison to the independent ranges noted in Table 15, it is apparent that the majority of the low limit exposure time range values are based on air-resources while the high end limits are largely based on marine resources. The high range exposure limits are applicable to scenarios in which air resources cannot partake in the SAR operations. This would be applicable in scenarios involving prolonged adverse weather conditions, or in situations in which all helicopter resources are in use or out of service. The low range exposure limits are applicable to scenarios in which the number of evacuees is at or below 18 people, the capacity of the cormorant helicopter. Scenarios in which the number of evacuees surpasses this point will require multiple rescue trips via one helicopter or two or more helicopter resources to be involved in the rescue. Either of these cases would require additional time than a scenario in which the number of people involved is lower than a single Cormorant helicopter capacity.

An interesting point to note relating to the high range exposure limits is that location 7 has a seemingly large value in comparison to other locations at lower latitudes (for example location 6 and 3). Discussions during the workshop indicated that there is a low level of CCG presence within Foxe Basin during this time of year in comparison to the other locations. Also, location 7 has relatively high ice conditions which could extend marine-based transit and search efforts. It is also interesting to point out that location 2 has a larger high range exposure limit than that of location 1. This may be due to the presence of strong multi-year ice in the area which causes CCG vessels to transit at slower speeds and alter routing to maneuver around the floes.

In terms of the low range exposure limits of the merged exposure time ranges, it is interesting that all are relevant to air resources except for those at locations 3 and 4. This again is due to the fact that CCG resources are in relatively close proximity to these locations at the time of year under consideration. Therefore, a vessel would likely be able to affect a rescue prior than an air resource. As such, at these two locations, during the mid-August time-frame, if an incident involving greater than 18 personnel occurred the exposure time should still be applicable to the range value listed. This is the case since a CCG vessel would indeed be able to rescue many more than 18 casualties at one time since it has a much greater capacity than a helicopter.

An overview of the merged exposure time ranges for each location depicts a number of noteworthy points. First off, of all locations across northern Canada considered, the minimum exposure time expected is 13 hours. The low range times are based on the assumption of low level conditions of each factor considered – in other words “optimal” conditions. This includes mild environmental conditions, high level of Captain/Crew training, no lags in communication, etc. The probability of the occurrence of the optimal condition of each factor simultaneously, is unlikely. Therefore, it is probable that the exposure time would be even higher than 13 hours, falling somewhere within the defined range. This fact is consistent for the other locations having larger low range exposure time limits.

11 NEW CANADIAN RESOURCES & POLICY

This section will review the SAR resources that are currently under consideration or development for Canada and the impact they may have on the exposure time ranges defined in this evaluation. These developments are for the most part, components of two Federal Strategies: 1. The Canada First Defense Strategy, and 2. The National Shipbuilding Procurement Strategy.

As part of the Canada First Defense Strategy, the Hercules fixed-wing aircraft has recently been replaced from the C-130 to the C-130J. The key difference between these two aircraft, in terms of northern search and rescue capabilities, is that the CC-130J is capable of transiting over 100 km/hr faster (660 km/hr versus 556 km/hr) than the CC-130 and requires less crew to operate. The CC-130J Hercules is not a primary SAR resource, but it can be used for search activities and to drop a Major Air Disaster Kit to evacuees on the ground. The CC-130J Hercules is part of the Tactical Transport Fleet.

The Canada First Defense Strategy resulted in the Fixed Wing SAR (FWSAR) replacement program. This program aims to replace the ageing Buffalo and the CC-130 Hercules aircraft (National Defence, 2013b). To do this, there will be 17 new fixed-wing SAR aircraft provided, starting in 2015. Since a fixed-wing aircraft does not have the capability to affect a rescue in water, these new aircraft will likely not impact the exposure time ranges as defined. These aircraft do however have the potential of decreasing the time for a resource to transit to scene, locate the evacuees and drop a survival kit to help increase survivability. To do this the new aircraft would have to be faster and have a larger range than the current fixed wind SAR aircraft. Alternatively, they could be positioned higher north which would reduce transit times. The new fixed-wing aircraft type has not yet been selected. It is expected that the final Request for Proposal (RFP) will be released by the Canadian government in early 2014.

The National Shipbuilding Procurement Strategy (NSPS) was developed to help fulfill the mandate of the Canada First Defense Strategy. The key objective of the NSPS is to replace the current surface fleets of the Canadian Navy and Canadian Coast Guard. There are three main projects underway in the NSPS including the Arctic Offshore Patrol Ships (AOPS), the Joint Support Ship (JSS) and the Canadian Surface Combatant (CSC). It is noteworthy that there are zero primary SAR ships contemplated in the NSPS. The first project, Arctic Offshore Patrol Ships involves the delivery of up to eight ice-capable patrol ships that will be built to operate in the harsh conditions of northern Canada. Some of the preliminary requirements and capabilities that have been discussed for the design of the AOPS are extensive. The ships must have sufficient flexibility to operate independently and effectively in various extreme environments such as the Canadian Arctic, the Grand Banks of Newfoundland and Labrador, and off the Northwest coast of the Queen Charlotte Islands. These ships will be able to operate in a variety of roles including search and rescue aid, domestic surveillance and supporting other government departments. They must be able to sustain operations for up to four months, have a range of at least 6800 nautical miles and have sufficient command, control and communications capability to provide and receive real-time information to/from the Canadian Forces Common Operating Picture. Additionally these ships will have a cruise speed of at least 14 knots and a maximum speed of at least 17 knots. Though the primary mandate of these vessels is sovereignty and surveillance operations and not SAR, these vessels will increase the presence of ice-capable vessels in northern Canada during their operational period and thus be available to assist in SAR operations. Another key attribute of these vessels is that they will be equipped with heliports and fuel which could allow helicopters to refuel at a more direct location while en route to a SAR incident. In summary, the AOPS represent a new Arctic capability for Canada which may add two new ships in the Arctic in any given summer. However, the AOPS are not likely to be present during the shoulder seasons. The AOPS will have secondary SAR roles.

The JSS project will deliver two ships, with the possibility of a third. These vessels will act as underway support to naval task groups which help the transfer of solids and liquids between ships at sea and also the maintenance and operation of helicopters. The JSS project will also act as a limited sealift and limited support to forces ashore. This means that the JSS will have space and weight allocated for the potential inclusion of a joint task force headquarters for command and control of forces deployed ashore, and will also have capabilities of delivering a limited amount of cargo ashore. The core capabilities of the Joint Support Ships will replace the current Auxiliary Oiler Replenishment ships offering a wide range of services. The CSC project is known to be one of the largest and most complex shipbuilding initiatives in Canada to date. This project will renew the Royal Canadian Navy surface combat fleet by replacing the multi-role patrol frigates and the destroyers. These new ships will ensure that the Canadian Armed Forces can continue to perform their duties by monitoring and defending Canadian waters and also making significant contributions to international naval operations. The JSS and CSC projects involve combatant ships and combatant support. These new resources will not have an effect on expected exposure times in northern Canada since they are neither designed nor planned for operation in this area.

The Polar Icebreaker project was announced in the 2008 Federal Budget. This project involves the acquisition of a new Canadian-built multi-purpose Polar Icebreaker. This icebreaker will replace the CCG icebreaker, Louis St. Laurent, which is currently the largest and most capable icebreaker of the CCG fleet. The Polar icebreaker is expected to be available for full Arctic service in 2017 which is the same year that the Louis St-Laurent is scheduled for decommission. The new Polar Icebreaker, which will be named the CCGS John Diefenbaker, will be designed with a greater range and endurance than current Coast Guard ships. It will have a secondary SAR role, similar to that of the Louis St. Laurent. In comparison to the Louis St. Laurent which is able to operate in the Arctic for two seasons, the John Diefenbaker will be able to operate for three seasons in the Arctic. The John Diefenbaker icebreaker will have a 45 year operational life and is designed to be operationally flexible and adaptable. This new vessel will have the capability to break ice up to 2.5 m thick, compared to the Louis St. Laurent which can continuously break ice up to 1.3 m thick. The John Diefenbaker icebreaker will be able to operate in conditions of ridges, rubble fields, and pressurized ice which exceeds the capabilities of the current fleet. The crew size will be approximately 50-60 crew members and 40 program personnel with a surge capacity of 25-30 people. Some preliminary characteristics of the CCGS John Diefenbaker in comparison to those of the Louis St. Laurent are summarized in Table 16. In addition to these characteristics, the John Diefenbaker will be equipped with a large cargo carrying capacity and the capability to accommodate two helicopters when required, similar to the Louis St. Laurent.

Table 16. New CCG Icebreaker Particulars

Characteristic	John Diefenbaker	Louis St. Laurent
Length (m)	140	119
Speed (knots)	18	16
Range (nautical miles)	28,600	23,000

The new Polar Icebreaker, although having some enhanced capability, will be a one for one replacement and therefore have little effect on the exposure ranges. Should its new flight deck support a Cormorant SAR helicopter for refueling it may be a valuable resource in remote locations.

The new technologies and increased capacities of the new resources will allow them to push further into more extreme environments without interruption. With the exception of the AOPS, these resources are planned to replace existing SAR resources and there are no plans to complement the existing fleet with additional capacity. Therefore, it is not likely that the low end of the exposure time ranges as defined in this evaluation will change significantly after all new SAR resources and support resources have been deployed. This is particularly the case for the air-based exposure time range since it is dependent on the arrival of a helicopter.

To help reduce the defined exposure time ranges, the new Canadian SAR resources that are under development must be complemented by improvements to SAR related policy. Deficiencies in Canadian SAR policy has been long identified as being an issue. In 1986 the National Search and Rescue Secretariat was to implement a comprehensive search and rescue strategy and a performance measurement framework, but to date neither of these plans have been developed or implemented. The Auditor General Report on Search and Rescue activities, published on February 15, 2013, indicated that the Search and Rescue Mission Management System (SMMS) does not adequately support daily operations and is near the breaking point (Ferguson, 2013). This system, used jointly by Canadian Forces and Canadian Coast Guard personnel, is crucial to a successful search and rescue operation since it involves all stages of initial communications as well as the decision regarding how to respond to a given emergency. Implementation of a new system is not expected until the 2015-16 fiscal year, and in the meantime there is no alternative plan. Another major area that was noted for improvement was the search and rescue prevention framework strategy which would aim to improve safety and reduce the number and severity of accidents, which could hopefully reduce the demand for search and rescue missions. This would involve education, skills training, and equipment training to help minimize the chances of injury or death while at sea. Knowing the dangers associated with marine disasters in northern locations, it seems intuitive to invest in a specific strategy that could help to prevent or decrease marine incidents from happening in the first place.

As activity moves further North there is an increased need for SAR resources to be able to effectively respond to an emergency in more remote locations. Currently, there is no policy to guide federal search and rescue activities even though this has been recommended for many years. To develop such a plan would require involvement of stakeholders from all areas, and previous efforts to make this happen were unsuccessful. The solution is not easy, and will require a lot of investment into Canadian Search and Rescue. However, an active effort towards the development of strong SAR strategies and policy, combined with the current efforts to strengthen SAR resources, will lead to advancement towards an efficient and reliable Canadian SAR system.

12 CONCLUSIONS AND RECOMMENDATIONS

When considering the exposure times defined through this study, one should also consider the limits relating to their applicability, as defined in section 10.2. Since the given range values are largely based on the current positioning and quantity of SAR resources, the ranges should be re-evaluated if any significant change is made to these factors.

As defined, the exposure time ranges are representative of the potential times, at each respective location, that an evacuee would have to wait to be rescued. The low end of this exposure range is representative of optimal conditions while the high end is representative of poor conditions, for the factors considered. It is likely that an emergency scenario would involve certain factors at poor conditions and others at better, or more optimal, conditions. Therefore, it is likely that for an incident at a given location, the exposure time would fall somewhere within the relevant range.

The marine-based exposure time ranges are highly dependent on the time of the year for which the ranges correspond. It is recommended that further consideration be put towards defining the exposure time range at the shoulder seasons of the operational period. It is likely that the minimum exposure time limit would increase at location 3 and 4 during these times since the strategic positioning of CCG vessels is different. It would also be interesting to investigate the marine-based exposure time ranges during the off-season. It is undoubted that the exposure range limits would be much larger during this time.

The merged exposure time ranges presented here, which are representative of mid-August timeframe and consider all Canadian Arctic-capable SAR resources, include a low level value of between 13 hours and 27 hours. Since these low end range values are representative of the minimum exposure time expected for each location, it should be ensured that operations at or in the vicinity of these locations are equipped with lifesaving appliances that can withstand use in the applicable environmental conditions, for a larger amount of time. This would ensure that the survivability potential matches the defined exposure time ranges and helps to ensure that an evacuee could survive until rescue. To help ensure that vessels are equipped with sufficient LSA would require the development of representative guidelines or policy. To complement new policy relating to LSA requirements, policy could be developed to regulate the operations of vessels with large number of POB in the Canadian north. Requirements could include travelling in pairs through northern waters so that if one vessel becomes in distress the other could provide rescue efforts. Additionally, requirements could follow suit with CCG strategic positioning and relevant timeframes. For example, vessels with over X number of personnel are required to stay within a certain distance from the location of CCG ships during the operational season.

The high end range of the merged exposure time ranges are often times quite large and in these instances are based on marine resources. The largest high range value 261 hours or 10.9 days is associated with location number 2. It would be challenging to provide a sufficient level of survivability to allow survival this long in such harsh conditions. Though the high range air-based exposure limit is much smaller than this value (45 hours as opposed to 261 hours) it is still possible that this exposure time could occur in instances where air resources are inoperable or delayed for other reasons due to lack of fuel caches, poor weather conditions, etc. There are two primary options that could be considered in order to mitigate the potential of the loss of lives due to an incident in northern Canada. One is to increase the survivability of personnel operating in these regions as reviewed previously. The other, more costly option is to increase the number of resources and infrastructure present in the north. The most effective approach to this option would be to have a SAR helicopter resource stationed at some northern location year-round. This would be an extremely expensive endeavor and require the construction of sufficient northern infrastructure to house a SAR base. The most cost effective solution to the prevention of loss of lives in the north is to focus on increased survivability and improvements to policy.

To strengthen the goal of increased survivability via the development of relevant policy, the capabilities of Life Saving Appliances must be increased to allow them to work effectively in the harsh conditions of northern Canada for at least the amount of time people could be stranded there. Currently, the majority of LSA are tested in mild, calm conditions which are unrepresentative of the conditions in which they are used (Tipton, 1995). As such, the LSA tend to have a better durability in testing than they would in real conditions. Canadian policy should not only attempt to ensure that all northern marine operations are equipped with the correct type and amount of LSA equipment but also to help ensure that the available LSA meets the performance standard imposed by the harsh Arctic conditions and expected exposure times.

13 ACKNOWLEDGEMENT

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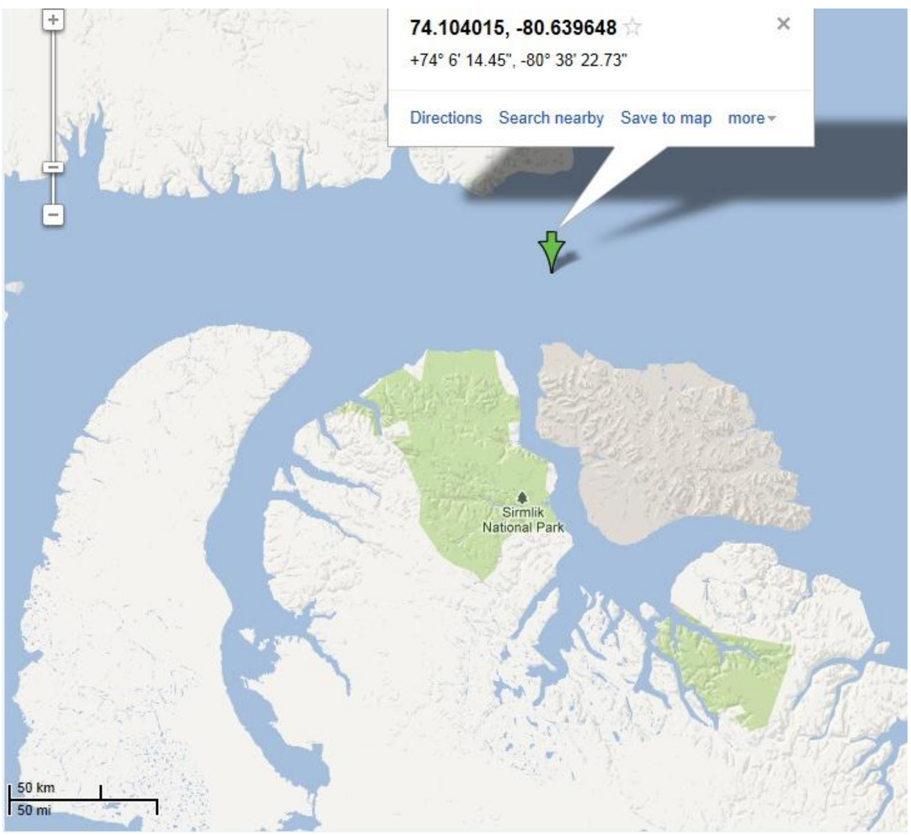
Appendix A – LOCATIONS CONSIDERED IN STUDY

Location 1 – Near Eureka, NU

Location 2 – North of Resolute Bay, NU

Location 3 – Southwest of Resolute Bay, NU

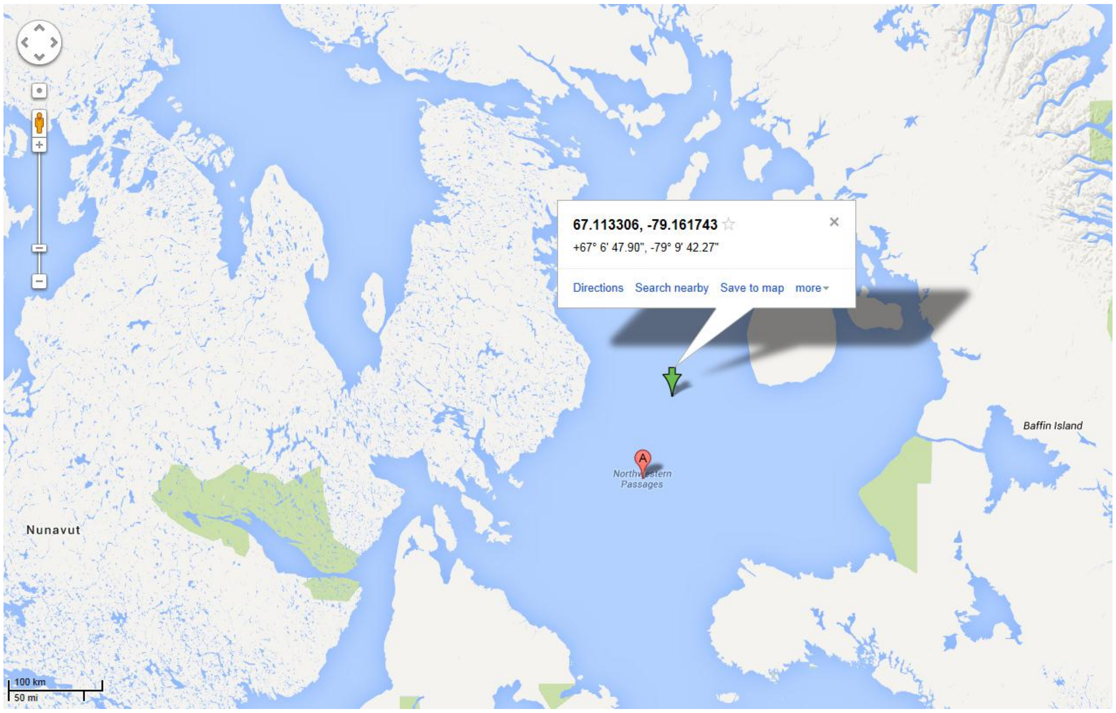
Location 4 – North of Pond Inlet, NU



Location 5 – Northeast of Tuktoyaktuk, NWT

Location 6 – East of Kugluktuk, NU

Location 7 –Foxe Basin, NU



Location 8 – North of Pangnirtung, NU

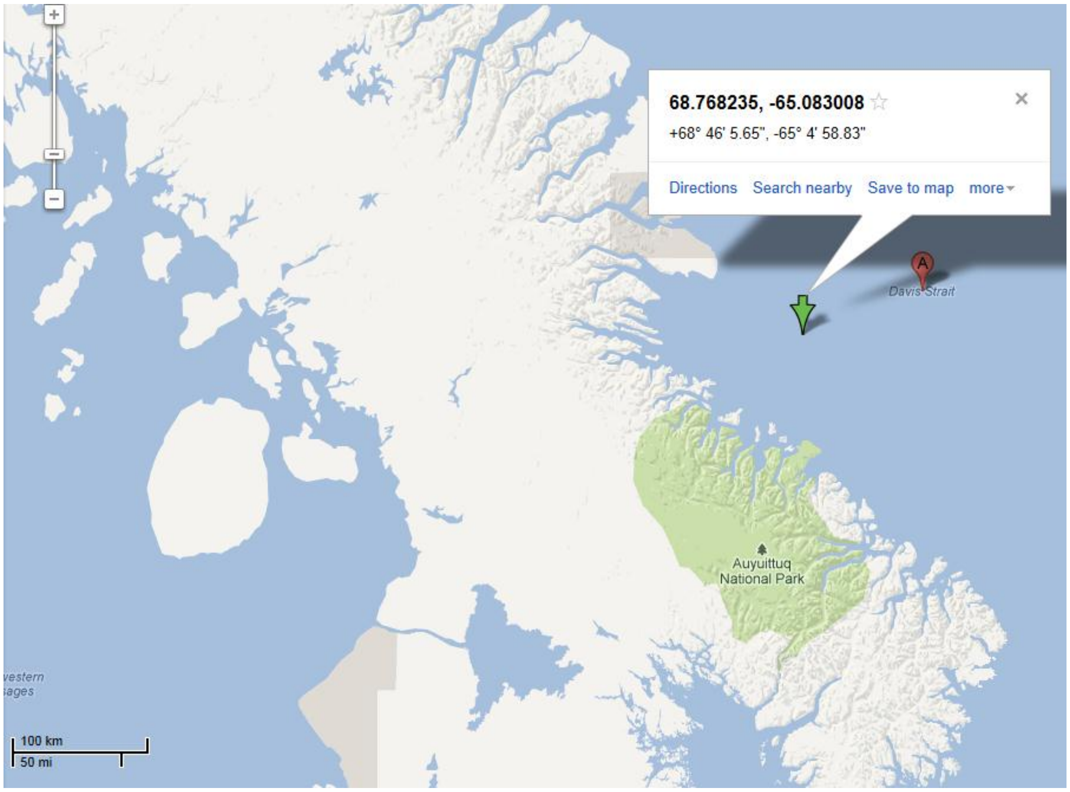


Table A1. Summary of the locations considered in study

Location #	Latitude	Longitude
1	80.564545	-81.145020
2	77.118032	-98.525391
3	74.2823563	-102.766113
4	74.104015	-80.639648
5	70.794139	-125.507812
6	68.124529	-112.626343
7	67.113306	-79.161743
8	68.768235	-65.083008

Appendix B – Air and Marine Surveys

Questionnaire - Marine

Question Number	Question Details and Response Options	Location Number							
		1	2	3	4	5	6	7	8
1	How could communications capability restrict the retrieval of a distress message by a CCG ship near the scene? *No restriction = **1**. Restricted by < 1 hour = **2.** Restricted by 1-4 hours = **3**. Restricted by > 4 hours = **4**.*								
2	In mild environmental conditions would you expect to be able to transit to the scene at maximum speed? *Yes = **1**. No = **2**.*								
3	Could lack of bathymetry data affect the transit time to the scene? *Yes = **1**. No = **2**.*								
4	In those cases where lack of bathymetry data affects the transit response time what is the anticipated effect? *Add < 5% to transit time = **1**. Add 5 to 10% to transit time = **2**. Add more than 10 to 20% = **2**.* *Add > 20% to transit time = **4**.*								
5	In high environmental conditions (see attached for each site) would you expect to transit at maximum speed? *Yes = **1**. No = **2**.*								
6	In those cases where high environmental conditions affect the transit time, what is the anticipated effect? *Add < 5% to transit time = **1**. Add 5 - 10% to transit time = **2**. Add 10 - 20% to transit time = **3**.* *Add > 20% to transit time = **4**.*								
7	Which environmental condition would you expect to have the greatest impact on transit speed? *All conditions equal = **1**. Wind and wave = **2**. Ice conditions = **3**. Visibility = **4**. Precipitation = **5**.*								
8	Would the level of experience of the Master and crew affect the time taken to transit to the scene? *Yes = **1**. No = **2**.*								
9	In those cases where the experience of the Master and crew are a factor, what is the anticipated effect? *Add < 5% to transit time = **1.** Add 5 - 10% to transit time = **2.** Add 10 - 20% to transit time = **3.*** *Add > 20% to transit time = **4.***								
10	Based on your knowledge of marine traffic in mid-August, how close is the nearest CCG resource likely to be to the location? 0 – *100 nm = **1**. 100-200 nm = **2**. 200-400 nm = **3**. 400-600 nm = **4**. >600nm = **5**.*								

Question Number	Question Details and Response Options	Location Number							
		1	2	3	4	5	6	7	8
11	Under low environmental conditions what search speed could be expected from a CCG resource? *0-4 knots =* ***1****. 5-8 knots =* ***2****. 8-12 knots =* ***3****. 12-16 knots =* ***4****. >16 knots =* ***5****.*								
12	Under high environmental conditions what search speed could be expected from a CCG resource? *0-4 knots =* ***1****. 5-8 knots =* ***2****. 8-12 knots =* ***3****. 12-16 knots =* ***4****. >16 knots =* ***5****.*								
13	Under high environmental conditions how much could search productivity be affected? *< 25% =* ***1****. 25-50% =* ***2****. 50-75% =* ***3****. >75% =* ***4****.*								
14	How much could communications capability affect search productivity in this area? *< 25% =* ***1****. 25-50% =* ***2****. 50-75% =* ***3****. >75% =* ***4****.*								
15	How much could limits on bathymetric data in the area affect search productivity? *< 25% =* ***1****. 25-50% =* ***2****. 50-75% =* ***3****. >75% =* ***4****.*								
16	How much could the level of experience and training of the Master and crew affect search productivity? *< 25% =* ***1****. 25-50% =* ***2****. 50-75% =* ***3****. >75% =* ***4****.*								
17	How much could inadequacies in environmental forecasting models relevant to the area affect the search productivity? *< 25% =* ***1****. 25-50% =* ***2****. 50-75% =* ***3****. >75% =* ***4****.*								
18	In low environmental conditions how long would it take to come alongside a TEMPSC and effect a rescue? *< 1 hour =* ***1****. 1-2 hours =* ***2****. 2-3 hours =* ***3****. >3 hours =* ***4****.*								
19	In high environmental conditions how long would it take to come alongside a TEMPSC and effect a rescue? *< 1 hour =* ***1****. 1-2 hours =* ***2****. 2-3 hours =* ***3****. 3-6 hours =* ***4****. >6 hours =* ***5****.*								
20	Which environmental factor will be most detrimental to conducting a rescue? *Wind and waves =* ***1****. Ice conditions =* ***2****. Visibility =* ***3****. Air temperature =* ***4****. Precipitation =* ***5****. All equal =* ***6****.*								
21	To what degree could the physical state of evacuees affect the rescue process? *No effect =* ***1****. Take longer =* ***2****. Halt operation =* ***3****.*								
22	How could the level of experience and training of the Master and crew effect rescue process? *Increase the rescue time =* ***1****. Prevent an effective rescue =* ***2****. No effect =* ***3****.*								

Questionnaire – Air

Question Number	Question Details and Response Options	Location Number							
		1	2	3	4	5	6	7	8
1	How could communications capability restrict the retrieval of a distress message by a secondary resource near the scene? *No restriction = **1**. Restricted by < 1 hour = **2**. Restricted by 1-4 hours = **3**. Restricted by > 4 hours = **4**.*								
2	How could communications capability restrict the retrieval of a distress message by a primary resource near the scene? *No restriction = **1**. Restricted by < 1 hour = **2**. Restricted by 1-4 hours = **3**. Restricted by > 4 hours = **4**.*								
3	In low environmental conditions would you expect to be able to transit to the scene at maximum speed via air resource? *Yes = **1**. No = **2**.*								
4	In high environmental conditions would you expect to be able to transit to the scene at maximum speed via air resource? *Yes = **1**. No = **2**.*								
5	In those cases where high environmental conditions affect the transit time, what is the anticipated effect for a helicopter? *Add < 5% to transit time = **1**. Add 5 - 10% = **2**. Add 10 - 20% = **3**. Add > 20% = **4**. Prevent transit until conditions change = **5**.*								
6	In those cases where high environmental conditions affect the transit time, what is the anticipated effect for a fixed-wing aircraft? *Add < 5% to transit time = **1**. Add 5 - 10% = **2**. Add 10 - 20% = **3**. Add > 20% = **4**. Prevent transit until conditions change = **5**.*								
7	Which environmental condition would you expect to have the greatest impact on transit speed for a fixed-wing aircraft? *All conditions equal = **1**. Wind = **2**. Temperature = **3**. Visibility = **4**. Precipitation = **5**.*								
8	Which environmental condition would you expect to have the greatest impact on transit speed for a helicopter? *All conditions equal = **1**. Wind = **2**. Temperature = **3**. Visibility = **4**. Precipitation = **5**.*								
9	Would the level of experience of the pilot and/or crew affect the time taken to transit to the scene? *Yes = **1**. No = **2**.*								

Question Number	Question Details and Response Options	Location Number							
		1	2	3	4	5	6	7	8
10	In those cases where the experience of the pilot and/or crew are a factor what is the anticipated effect? *Add < 5% to transit time = **1**. Add 5 - 10% = **2**. Add 10 - 20% = **3**. Add > 20% = **4**.*								
11	Could the distance to the nearest fuel source affect the transit time? (Assume resource not originally based at this airport) *Yes = **1**. No = **2**.*								
12	Which environmental factor is the most detrimental to conducting an air-based search? *Wind and waves=**1**. Ice conditions = **2**. Visibility = **3**. Air temperature = **4**. Precipitation = **5**. All equal = **6**.*								
13	How much could communications capability affect search productivity in this area? *< 25% = **1**. 25-50% = **2**. 50-75% = **3**. >75% = **4**.*								
14	What potential affect does proximity to the nearest fuel source have on the total search time? *Small effect =**1**. Large effect = **2**. No effect = **3.***								
15	How much could the level of experience and training of the pilot and/or crew affect search productivity? *< 25% = **1**. 25-50% = **2**. 50-75% = **3**. >75% = **4**.*								
16	How much could inadequacies in environmental forecasting models relevant to the area affect the search productivity? *< 25% = **1**. 25-50% = **2**. 50-75% = **3**. >75% = **4**.*								
17	In low environmental conditions how long would it take to conduct a rescue of a single person from a lifeboat via helicopter? *< 5 minutes = **1**. 5-10 minutes = **2**. 10–15 minutes = **3**. 15 – 20 minutes = **4**. > 20 minutes = **5**.*								
18	In high environmental conditions how long would it take to conduct a rescue of a single person from a lifeboat via helicopter? *< 5 minutes = **1**. 5-10 minutes = **2**. 10–15 minutes = **3**. 15 – 20 minutes = **4**. > 20 minutes = **5**.*								
19	Which environmental factor will be most detrimental to conducting a rescue? *Wind and waves = **1**. Ice conditions = **2**. Visibility = **3**. Air temperature = **4**. Precipitation = **5**. All equal = **6**.*								
20	To what degree could the physical state of evacuees affect the rescue process? *No effect = **1**. Take longer = **2**. Halt operation = **3**.*								
21	Could the distance to the nearest point of land affect the rescue time? *Yes = **1**. No = **2**.*								

Question Number	Question Details and Response Options	Location Number							
		1	2	3	4	5	6	7	8
22	How could the level of experience and training of the pilot and/or crew effect rescue process? *Increase the rescue time =* ***1****. Prevent an effective rescue =* ***2****. No effect =* ***3.***								

Factor Ranking – Marine

On a scale of 0 (not relevant) to 100 (extremely relevant), how important do you think the following factors are in affecting the total exposure time (time from issuing a distress call until rescue is effected)?

Factor	Ranking
Distance from shore	
Wind and waves	
Temperature	
Precipitation	
Visibility	
Ice conditions	
Type of marine resource tasked (primary or secondary SAR vessel)	
Physical state of marine resource tasked (fuel tank full or low)	
Communication capabilities	
Physical state of evacuees (injured or not injured)	
Chart adequacy (bathymetry)	
Level of experience of Master and crew	
Training of Master and crew	
Quality of environmental forecasting models	

Other factors you may consider relevant and rating 0 to 100.

Factor	Ranking

On a scale of 0 (not relevant) to 100 (extremely relevant), how important do you think the location across northern Canada is in determining the total exposure time (time from issuing a distress call until rescue is effected)?

Ranking: ______________________

Rationale for score regarding importance of location:

____
____
____
____
____
____

Factor Ranking – Air

On a scale of 0 (not relevant) to 100 (extremely relevant), how important do you think the following factors are in affecting the total exposure time (time from issuing a distress call until rescue is effected)?

Factor	Ranking
Distance from shore	
Distance from nearest airport	
Wind and waves	
Temperature	
Precipitation	
Visibility	
Sea ice conditions	
Type of air resource tasked (primary or secondary)	
Level of fatigue of pilot and response crew	
Communication capabilities	
Physical state of evacuees (injured or not injured)	
Level of experience of pilot and crew	
Training of pilot and crew	
Quality of environmental forecasting models	

Other factors you may consider relevant and rating 0 to 100.

Factor	Ranking

On a scale of 0 (not relevant) to 100 (extremely relevant), how important do you think the location across northern Canada is in determining the total exposure time (time from issuing a distress call until rescue is effected)?

Ranking: ____________________

Rationale for score regarding importance of location:

____
____
____
____
____
____

Appendix C – List of organizations to which the survey was sent

Table C1. List of organizations that received Exposure Time Surveys

Number	Organization Name
1	Joint Rescue Coordination Centre - Halifax
2	Joint Rescue Coordination Centre - Trenton
3	Canadian Coast Guard Auxiliary
4	Civil Air Search and Rescue Association
5	Company of Master Mariners Canada
6	National Search and Rescue Secretariat
7	Canadian Coast Guard
8	Royal Canadian Air Force
9	Polaris Nautical Advisory
10	Cougar Helicopters
11	Canship Ugland
12	Centre for Marine Simulation
13	Coastal Shipping Limited (Woodward Group)
14	Virtual Marine Technology
15	Isbjorn International

Appendix D – Workshop Agenda

Location: **Dates:**	**NRC – Ocean, Coastal and River Engineering** **July 10-11, 2013**
Wednesday July 10th	
8:30 - 9:00	Registration
9:00 - 9:15	Opening Remarks –Allison Kennedy, Research Associate NRC-OCRE
9:15 - 9:45	Relevant NRC Testing – Jonathan Power, Research Council Officer NRC - OCRE
9:45 – 10:30	Justification of Survey Details – Jack Gallagher, Hammurabi Consulting
10:30 - 10:50	**Coffee Break**
10:50 - 11:10	Review of Survey Results: Marine & Air – Jack Gallagher
11:10 - 11:30	Open Forum - Survey
11:30 - 12:00	Exposure Time Analysis Methodology - Allison Kennedy
12:00 - 12:30	Open Forum - Methodology
12:30 - 13:30	**Lunch**
13:30 - 13:50	Exposure Time Results: Marine & Air – Jack Gallagher
13:50 - 14:30	Open Forum - Exposure Time Results
14:30 - 15:00	Survey Follow-Up Questions – Allison Kennedy
15:00 - 15:20	**Coffee Break**
15:20 - 16:00	Breakout Sessions
16:00 – 16:30	Tour of NRC Test Facilities
Thursday July 11th	
8:30 - 9:00	Doors Open for Coffee and Networking
9:00 - 9:30	Factor Ranking: Marine & Air – Jack Gallagher
9:30 - 10:30	Open Forum - Key Factors: Additional Factors?
10:30 - 10:50	**Coffee Break**
10:50 - 11:10	Overall Factor Ranking – Jack Gallagher
11:10 - 11:45	Open Forum – Overall Ranking Methodology
12:15	Closing Remarks – Jack Gallagher

Appendix E – Organizations Attending Workshop

Table E1. List of organizations that attended Exposure Time Workshop

Number	Organization Name
1	Joint Rescue Coordination Centre - Halifax
2	Joint Rescue Coordination Centre - Trenton
3	Company of Master Mariners Canada
4	Canadian Coast Guard
5	Royal Canadian Air Force
6	Polaris Nautical Advisory
7	Canship Ugland
8	Centre for Marine Simulation
9	National Research Council
10	Hammurabi Consulting

Appendix F – Complete workshop comments

Project No: A1-003482	**MEETING MINUTES**
Project Name: Evaluating Exposure Time until Recovery by Location	
Purpose of Meeting: Exposure Time Workshop	
	**Ocean, Coastal, and River Engineering** **Kerwin Place** **P.O. Box 12093** **Postal Station A** **St. John's, Newfoundland** **A1B 3T5** **Tel: (709) 772-2479** **Fax: (709) 772-2462**

TIME	**DATE OF MEETING**	**LOCATION**	**# PAGES**	**WRITTEN BY**
8:00-16:30	10 & 11 July 2013	OCRE	16	KA

#	DISCUSSION
1	**Introduction to workshop & safety protocol** • Exposure time means: time from when an incident occurs until effective rescue • Purpose of workshop: to quantify factors that affect exposure time and present the consolidated results of the survey to get feedback. Discuss assumptions that were made to get exposure time ranges Gather input on different factors that were considered
2	**Relevant NRC testing** • MSTEE program→ resources pushing into harsher environments, and equipment might not perform as it should • Once you test in realistic conditions, results decrease • We assume performance stays the same as we go further East and North, but problem is performance tends to decrease. Is there a certain point in an environmental condition where performance starts to drop drastically? • Knowledge gap: calm water vs. real world conditions – take multi-disciplinary approach (human factors, training, engineering) **Comments:** o Extremely lucky to have a rescue vessel next to you in 24 hours (IMO standard), better estimate would be 48 hours.
3	**Justification of Survey Details** • Tried to pick locations that were representative of some traffic in the Arctic • In some places the details on the airstrips are not known– we just know they are there. Are they helpful for SAR? • The Port doesn't have the same meaning in the Arctic – more or less a community (may or may not have resources/ fuel) • Environmental factors: how much influence do they have on the process? • Is this historical data representative? Are we seeing big changes? Do long-term averages take out significant peaks that we should be considering? • Survey generally said "low" and "high" – these will have some influence on exposure time, want to know who it will impact more. • Conditions more significant for ships that are responding, sometimes not as

	much for aircraft. • Western Arctic – Higher conditions • People who have worked up there: did you find looking at weather conditions that they were not representative? **Comments:** - The high conditions seem low & there can be a lot of traffic on the Eastern side - Low condition in August could be representative of the environmental condition, but to get there in a rescue scenario they would encounter a lot more variety of conditions. - Air surveys – conditions at the location weren't as significant as the conditions on the way to get to the location. - Marine surveys – conditions represent a large range of conditions from start point to end point - Air: fixed wing vs. helicopter – environment not as significant with fixed-wing. - Air challenges – sometimes need to contract commercial helicopters for fixed -wing - This is difficult because looking at how long to get to location – hoping to add greater exposure time to get ship in there. Takes a bit of different thinking to think about time period in between (exposure). - Even high environmental conditions could be much worse during transit – meaning exposure time could be even greater - For the purposes of this survey the goal was to create a scenario which involved more resources (crews, ships, air resources). There is still a level of complexity in survey scenario. - Wanted ship to be gone, so crew would have to search for lifeboats/ rafts. Didn't want complications of people in the water. - AIR: Rescue Plan: air place caches – the plan changes greatly depending on the number of casualties. Air (fixed-wing) – Griffen not suitable for the Arctic. - Survey questions were worded to quantify single rescue (1-2 people). For report it is important to have discussion on how increasing the number of people/ casualties would have potential to increase exposure times. When looking at locations did they seem different? - Marine surveys – answers quite different for each location – but for air – most had same response for each location. Thought key reason was because the survey gave conditions at the actual site. JRCC representative indicated that once they are up in the air, the conditions at the site aren't' the main factor. - Could extend area further west, because change of conditions if you move that way. Tomorrow there will be drawing on the map to try and get more areas involved.
4	**Review of survey results: Marine** • Knowing communication difficulties: some northern locations it could take <u>12 hours</u> to get satellite connections. This is caused by geography, and some satellite gaps, HIGH LATITUDE is the main issue • Transit to scene: Likely the presence of different kinds of ice first year and multi-year: More multi-year ice = harder to transit Bathymetry: Big issue that can affect how long it takes to get anywhere. What type

	of effect? A lot of >20% answers. Could it be more time than that? • Could definitely be higher. High Conditions: No to maximum speed – how much could it affect? > 20% was the general answer - is 20% reasonable or higher? • Most think it could be higher than 20%. What would the threshold be? Looking at different ice regimes, because these change based on locations. • At some locations it could be up to 50% because of sea state, ice, M.Y ice. • Locations that could be affected by 50% decrease are: Location 1 & 2 (ice). However, could also see great decreases at other locations (wind, visibility). Should have had higher threshold limit in locations 1,2 & 8. • It's not just ice that will affect maximum transit speed, dominant factors change based on locations as to what could cause the greatest hindrance. • Level of experience: Yes this has an effect on exposure time • Master/ crew: >20% increase in time: Reasoning is because of being cautious and how one would read the ice conditions. Ice is very dynamic – this creates difficulty. More likely to end up in tougher ice that could be avoided. • Inexperience is also greatly affected by non CG ships because they don't have the same level of training. • At more severe locations, experience would make a greater difference. Generally: a crew not used to ice- would have tremendous difficulty. Have to think about your crew and safety as well. Experience = big impact. • Search Speeds in low conditions: Still a range in search speeds, lower search speeds (1-6). This answer was based on location for the most part. Even in benign conditions not expected to transit at max speed. Search speed is also affected and limited by hydrographic data & sea ice • **High conditions:** greater decrease in search speeds. L1-L3 & L7 had 5-8knots: could be because L7 had higher ice conditions than L4, L5, L6. • **Communications:** Higher locations had more negative impact (satellite data). • **Bathymetric Data on search productivity:** how close you are to the coast, because there are a lot of communities in that area. If you are further out it's not so much of an issue than if you are closer to the coast. Conditions are often drastically different than reality. • **Experience on search productivity:** Highest answers: L1,L2, L7, L8. This is because environmental forecast. Experience more important there than the middle locations. • **Environmental Forecast:** generally affect 25-50%. • **Effective rescue- what does this mean**? Just looked at coming alongside the distressed vessel and getting the rescue craft secured. Any insight as to how long it would take to actually get people out of the lifeboat? • This will vary dependent on the number of people. Probably wouldn't be a significant increase compared to time it takes to come alongside. Condition we find them in depends if there is sturdy ice, or not. Time to effective rescue depends on condition you find them in. • **Detrimental effect to rescue:** L1-L3: Ice. The environmental conditions will affect how quickly and effectively the people can be transferred to the rescue vessel. • **Rescue time: experience of crew:** L1-8: will increase time. Coast Guard has a lot of experience getting seniors out of ships, but an outside boat (commercial

	ship) would not have this experience and this could have a significant effect. Equipment is a major point: what is available on commercial ship vs. CG vessel
5	**Air Surveys: review of survey results** • It seems the survey either asked the wrong questions or it isn't location dependent because almost everyone said the same answer for all locations. Q1, Q2 etc in this section represent the questions on the slideshow presented. • Q1: Probably thinking about 2- way communications (radio). Generally do you have same level of communications capability it Arctic? • EPIRB – no impact. • For the most part it is not a significant concern; however radio communications would have an impact- satellite communications and HF radio. • Above 75°76° North →Iridium radio's. ERIPB satellite is not picked up by satellite at high locations. • Q2: Initial alert from ship →communications - nobody will get it from JRCC if it's not picked up from the satellite. If you look at marine side: radio coverage (satellite) is fairly limited: can also still rely on ships hearing distress messages. This is a good supplement to radio communications, which are limited. On air side: generally not out there listening for distress calls. • Canadian mission control center (Trenton) monitor all the signals- good people to talk to. There is a new system coming out (MEOSAR) with updates that will make it easier to communicate. LEOSAR there are restrictions. • Difference between marine and air – don't usually have an aircraft up loitering around to hear signal. • Q3: Survival equipment: Initial work and rescue – have to get helicopter there to pull them out, • Distance from various air bases to locations: have to fuel once, 3 times, etc to get there. This could affect transit time quite a bit. If typically pulling from Gander – are there normal places that despite what the range is you should stop for fuel? • Fuel consumption on way back→ If there were 18 people: would you take equipment to provide shelter? • Could only take 6/7 people back. Won't necessarily take equipment for shelter- Russian Ice Station – 300 miles off – one of courses of action: 1.) Utilize Americans 2.) Gander – transited – goose bay, Iqaluit. Major air disaster kit- 4 packs of tents, food, etc. • Will you have to stop more on the way back? If you totally load up with fuel, can you still pack in 15 people? • Not likely, also have to think about weight of the air-craft. But wouldn't necessarily take them all back, could bring them to nearest airport (550-600 mile range) or drop them a major air disaster kit (MADK). The distance to the airport is significant if there are a greater number of casualties. • Will they have to wait longer for their rescue if there are multiple hops? • There would be paramedics there with them, and some equipment and the SAR tech would be there. For example: Baffin Island – dropped radios, and drop SAR tech, provide shelter food, medical kit, and the rest of the crew can work on the rescue. • If there was a major air or marine disaster, 36-48 hours for air craft transiting cormorant → C17 carry sea king. • There is a chance that if 2 trips were necessary, there could be a wait of maybe 5

	hours, to refuel, etc. To complete rescue- time of year could have the same difference as day and night. • Make provision for crew changes. It doesn't usually delay transit to get on scene for rescue. Trying to plan that before, call airports ahead of time, make sure fuel is there etc. • If you are doing that ahead of time: does this process delay the initial process? No, this should not cause a delay because there are other people in charge. The time to response is first priority. Put second crew in Iqaluit, when crew takes off from there, would there be consideration for another further crew, or would just the one crew be capable? • Would probably have to involve another crew if it were a 15 hour day for high locations. Provide standby crews (8 hour response). After that: if it's getting close to end of crew day: the crew is on noon -8:00pm, if at 7:30 launch them – might pull them back. • Getting people in the right place to do the rescue with the helicopter is also an issue. • Fuel source caches: There is usually somewhere to stop in Iqaluit, etc. • Visibility: 1500 ft → 3 miles 1000 ft →2 miles 500 ft → 1 mile • Some locations are fairly far from normal fuel supplies – do locations make a huge difference? Even if you have an optimistic search. Can do the search before you get there. • Q16: Circumstances quite different when you get there than the forecast said. Not a lot of forecasting. This will have significant effects. • Search productivity is not affected as much because crews are trained and have the ability to work without models. (Still has an effect) • Airport north of 60° does not have accurate weather conditions • Would locations 2-4 be on upper range? Have to look at historical weather up there. Forecasting once you get up North gets pretty dodgy. • Don't have the information to build forecast in all Arctic. • Q17 / Q18: This is practiced a lot – so not much difference between low and high conditions → Ice can be used as a drop. However wind and waves could cause an increase of >20 mins. It should take apx/ 10 mins for a hoisting cycle. • Sea state would be dependent on experience of the rescuer. • Q21: If you have more than one load to do: is it part of plan to get them off boat to start drifting? → Yes that is the plan – get them off the boat. • Q22: Could the experience of captain & crew prevent an effective rescue?

6	**Exposure Time Analysis Methodology: Air** • Travel Time (transit to location): May be possible to add more detail eventually about if path of travel led to outside of the straight line. For a lot of locations, they would have to go off straight-line path to get to fuel sources. • Relevant drift models here in Canada: U.S Coast Guard may have used this model as well (the one used in the survey analysis). • Search speed of plane doesn't decrease significantly, because the aircraft still needs to be able to fly. • Search Time: Survey didn't include any instances in which the lifeboat would travel further away from helicopter resource. In cases where lifeboat drifted further, there may be another bit of time that is not accounted for. Opposite is also true, lifeboat could be closer to the helicopter. • Communications phase includes the 30 mins-2 hours as window. Transit to location for air: Primary SAR -30 mins- 2 hours –-> for secondary : 12 hours • Any thought about rescue in darkness and daylight? Survey used August with full daylight, but what about other parts of the year? - With darkness: Search pattern could chance, and it is also easier to see flares. • Most SAR instances – would a lifeboat be found in first look? - This depends on the area given to search (large vs. small). • Once a SAR resource gets message they don't make assumption that it was instantaneous, that the distress had just happened. It is assumed that there would be delays when answering questions about communications. • All communication capabilities potentially have delays or problems. Very rarely accurate- something to look into. **Exposure time Analysis Methodology: Marine** • 15 knots might be a more appropriate transit speed
7	**Exposure Time Results: Marine** • Min & Max values for each location 24 hours is minimum expected response in low environmental conditions • Look at impact of factors on exposure time – that can increase dramatically (33 hours) – 200 hours (well over a week)? • Do the ranges make sense relative to one another for time from distress call to an effective rescue o Looking at L1 – you wouldn't make the low end. Seems too optimistic at 26 hours, unless there is already a ship on the way up (which only happens annually in mid-August). More realistic would be ~48 hours • L5: 2 ships in area, but there are ships in other locations • L7: rarely is there a ship there (Foxe basin), unless there is a ship there you can't make it • Therefore the low number should be doubled (36-48 hours) in L1, L5, L7 Do other low ranges seem reasonable? • L8 (low end of 7 hours) → this would be possible if there was strategic positioning. What would be a more realistic number? • Low end would be at least 24 hours, because this is only primary SAR resource. Only looking at primary assets right now.

	How could the high ranges change? Or are they reasonable? • Seem high, but it is possible for them to occur. Based on the ice conditions it could take a week to get there. L2 is higher than L1; there may be an issue there. • Multi-year ice that you would have to go through is probably reflected in the increased time. • High environmental conditions were listed as more severe at L2 than L1. This could have influenced people's answers in survey. • Multi-year ice flows through those channels – so it is certainly possible to have this long of an exposure time. - L3 & L4 high range is too high →The new high range should be: L4 (24 hours) L3 (48 hours) • Some locations would be more ideal, but M.Y ice sometimes and it can't be avoided. • The range for these values could be very great because: Experience could effect by example- 10%, but maybe that is only expected to happen 10% of the time. This would be interesting to see if it could be quantified. • Generally the real scenario would fall somewhere in the middle of the range. - L7 (Foxe Basin): not usually CG ships there, and limited as to how to get them because of lack of bathymetry but there is only one route to get there. Exposure Time results: Air *Exposure time ranges are a lot smaller compared to marine • The calculated ranges are reasonable • L1 seems fairly optimistic. Between L2 & L3 using 24 hours as a base, so some of the numbers could be too optimistic. • The numbers seem to be on the low side / too optimistic. • Fuel caches we aren't aware of, will also determine exposure time.(Goose bay, Iqaluit, Frobisher Bay: Fuel hop) • Survey question: It said there were 1-2 people to rescue, but if there were others to rescue, the numbers would escalate quite a bit. This could then involve 15 hour crew time, which would mean a crew change for each trip. • L4 is reasonable. • Nothing else seems to jump out – air expert will check with L5 & L6 for actual data. Overall: The numbers (exposure ranges) could seem pretty high and therefore surprising for most people who don't work in the Arctic. 24 hours is more so a starting point (IMO standard) – at least crew change for each transit by the looks of the data. Significant challenges even when you don't have to worry about ice conditions. →L4 one air expert was up there 3 times in the last few weeks →this time range is reasonable.
8	**Combined exposure time results**: • The factors that affect air and marine are so different, so it is too difficult to put them together. • Sometimes a marine resource will actually get there first, if there was a fleet

	close by. • L3 & L4 there is higher CG traffic in mid-August. Significant potential to have closer resources. This may change after some of the other numbers are fixed (low/high range). • L8 will be increased significantly for marine (24 hours as opposed to 7 hours) →Air would now get there first based on modified comments. **Any big surprises in the results?** • High range for marine seems to jump out because it's so high – but when you look at the factors this is possible. • One of the logistical issues: crew time with aircraft • Marine: Concerned about fuel capacity? • Potential because re-fueling is either mid-late August, Sept. Not very capable if the SAR is 600 miles away. When low on fuel – danger of not being able to create enough power to break the ice. • Shoulder seasons need to be looked at more seriously- these cases will come up more. See cases that happen in August, weather at the time is usually the best. But – early in the season shipping schedules high, less resources. **Are all CG resources there in mid-August, if not when is full CG compliment in the Arctic?** • Mid June – mid August everything is up there. Second week of September resources are starting to head back, thanksgiving there are ~ 2 ships left, 3rd week of October there is ~ 1 ship, and mid-November there is no CG activity. It's important to look at time of the year, because activity starting well into April- commercial ships trying to get up in June.
9	**Survey Follow up Questions: Marine** • Q1: Communications could be as big as 10-12 hours. EX: Almost directly east of L1 in the other channel. Large part of the day there was no communication. Some locations the high range could be MORE time. - Potential for L1 & L2 – there may be a significant delay in communications - What about in a real emergency? Could distressed vessel get a hold of help if they need to? Would that change? Would distress call maybe get priority? • Q2: Bathymetry? - This one probably gives false read – might not really effect the total transit. Bulk of transit could be on a charted route, issue could turn up as you approach distressed site. Could get to a place where there is a lot of ice, so you take a lot of time to get around it. That small section it adds a lot of time, but in other places – you don't need to add that much. - Is 30% too high? This is hard to quantify because each location is different. Wouldn't go lower than adding 30% • Q3: Ice conditions different at different areas – some places 50% other places 20%. • Q4: Experience level of master and crew on transit time: In certain locations if there was more ice or more difficult ice: experience more an issue. People with less experience more intimidated by extreme conditions (more cautious = slower). How much experience and who has experience? The captain – fatigue factor – captain may need to stop because he recognizes the dangers and can't go anymore. - Sea-watchers → new watch-keepers in multi-year ice, they may think it was

	just a piece of ice. There are 2 reactions: slow down= no progress OR don't understand and speed up too much. - The big question is based on operational experience: if experienced captain and crew were driving into severe ice conditions. How much do you think people with less experience could get through the same conditions? - Operating the ship during a high priority incident, from rescue center, that they want to speak to the captain – captain has to answer the phone- so the control of ship has to go to another officer. This could add an hour or 2 onto the whole process if something goes wrong. - Overall ICE would be the most important factor for experience of crew **Follow up questions : Air** • Q1: Transit time of helicopter (environmental conditions) → this is more based on environmental visibility conditions, or direction of wind. - Transport Canada could use this – to say that lifeboats need to be looked at – can people survive for this amount of time? They could also look at polar code- you need to be able to survive until help arrives- but this is different in northern latitudes. • What does it mean for ship going up there to prepare to survive? Do we need to substantiate where the 30% is coming from? - Because there are so many factors but want to just know if this is a reasonable standard ballpark. Looking at best case in the middle of August, then what about worst case? If the shoulder seasons are pushing earlier and later, what does that mean to all of this? In report justification will be provided for each item, and how items could be used differently to apply various methodologies. These % values were taken based on the base value (high environmental conditions with no additional factors). • Q2: 1 hour added to rescue time is reasonable • Q3: function of how much air you can cover – you reduce the search area space, reduced altitude, but you don't actually slow aircraft down. Not speed based – rather area covered. **Factors not quantified:** • Distance to nearest point of land: mostly relevant if there was a large number of casualties – to drop them off.
10	**Factor Ranking: Air** * Considerable variability could be caused based on personal experience scenarios. • Visibility and precipitation: have the same effect • Hoisting – you can complete sequence quicker with no wind and waves – could be more significant than precipitation and visibility. • Factor of failure of instruments or mechanical: more we use them, the better they are. Crew fatigue would be higher up than mechanical issues (serviceability). - You always have to have a backup plan in case aircraft is unserviceable. - Higher risk of failure the further distance you go. The more you have to stop; there is greater chance of failure. When you shut them down and start aircraft up again, there is always a chance it will not come back again. • ***Ranking given: seems very appropriate for air resources** Some factors mentioned one time only: - Air assets from adjacent: Very important!! - Aircraft serviceability: 100% - Very important → within an aircraft there can

be certain equipment, but there are certain aircraft that don't have the minimum - this can make it not able to be serviced (MEL- minimum equipment list)

- Very few missions where aircraft is unserviceable
- High serviceability rate??
- Turbulence: wind conditions or air systems that are going through. Not so much for northern – only going 120knots. (Minimal factor here – not 80%).

Factor Ranking: Marine

- Reasonable ranking?
- Location is covered in a separate question all together.
- This reflects the dominant difficulties faced during transit: where most of difficulty comes from.
- Seems surprising that visibility was ranked so high
- Reasoning: it affects speed in ice- drastically → especially glacial ice.

Other factors: Marine

- Total transit time – most important
- Heat illness or experience level of the casualty: The person who is the casualty- if they have been in that environment for a long time (native to the area) they could probably last longer than someone who is not. This could mean well adapted to the cold (add this factor in).

Location of event:

- This is the whole point of the survey – does location matter? Good to be able to see that it is very important.
- It makes sense that air results are higher because air resources located at consistent base whereas marine resources moving around a little more.
- When given opportunity to add other factors: people jumped from exposure to survivability: started looking at clothing, shelter, etc. but will they survive? That questions when we are looking at exposure time, do you think there is a direct correlation between times exposed to capability to survive? Or is it totally independent? Or does it not matter?
- ANSWER: Longer exposed →this decreases survivability.
- There seems to be strong jump to survivability- exposure time was really related to SAR system – not to anything else. We didn't look at community response, etc. Given that if those exposure times are good ranges (valid) and we wanted to do one thing to improve survivability, what would it be? Is it the preparedness side or the response side – if you want to increase survivability, which one is more important?
- <u>Preparedness </u>– ships/ vessels need to be prepared to take care of themselves and the size of the area covered. Can't possibly reduce resources. Has to be a big piece on the regulatory portion. The variability of the conditions means that it is hard to prepare.
- People would be dead in <10 hours if they were wearing cabin wear, so there needs to be suitable capabilities already on the vessels.
- Comes down to cost/ effect (preparedness vs. response)
- Exposure time ranges are high? Then it is not reasonable to expect that the times will be brought down by government resources / SAR resources, so then we need to prepare the people that are in distress (with equipment, etc).
- If you want to reduce ranges – this means a significant change in resources – bases and resources = huge amounts of dollars.

- If we could refine exposure ranges – that would give a better idea as to what has to drive on the other side for preparedness.
- If we were doing this survey again- would it be reasonable given the forecast of traffic to include vessels of opportunity or aircraft vessels, or is it not really viable?

\- This hasn't been put to the test yet. Primary resources are being put to the test now, so it would be difficult to gauge. If it were vessels of opportunity – <u>experience</u> and capability to get there would be important– and capacity and capabilities. Most of these vessels have very little to be able to help.

- Don't want to try to escalate the problem by adding in another craft – in order to add in another fleet – they have to go through a whole briefing process before they can even leave. This really pushes the limits of other resources
- Capabilities – based out of resident – primarily there for logistical support – small aircraft and supplies and fuel caches. There are a lot of problems associated with contracting out secondary resources.
- Picked a time here in mid –August and looked at range of environmental conditions, but is it worth looking at an event happening in February? Or is it unrealistic?

\- In the future yes, seeing huge increase in North West passage – sea-doers going in now. There will be a big increase soon

- Case studies done now and if someone is some gets stuck up there in Arctic they are on their own.
- Right now looking at high traffic – which is good and sends a message. Is high traffic season longer than it was? When does it start?

\- Opening season everyone piles in. Starting to push late into fall, the fishing perspective is going in earlier into the fall. Also cargo ship activity – staying later where marine resources are dying down. The risk changes from ice risk to a weather risk at this time of the year. The tail end of the season is pushing further as more important – earlier too but not as significant.

\- Freight is generally behind –CG resources start to withdraw from there in early September – so the month of Sept and early Oct – seeing major decline in CG resources and air resources don't change over time – always the same

- Shoulder season: how big a change does this have on the exposure times (how long to wait for a rescue?)Reasonable time of year: what kind of magnitude of change are we expecting with exposure time?

\- CG there to support marine activity – although there could be an incident that happens up higher.

\- Closer because they are there to stand by →As the season progresses the locations 1-6 become less relevant because less traffic and location 7 & 8 become more relevant – more likely to be an incident. So you could get there easier. However you would expect there would be an exposure time of about the same (24-48 hour range) because there would be no ice. Conversely if there were an incident in one of the other areas – there would be significant delays. There isn't a possibility that the ship couldn't get there, it would eventually get there, but exposure time would be increased. Therefore there could be a significant increase in exposure time for L1-6.

- Has the most common area/ activity area changed over the years / recently due to environmental changes? CG made any changes?
- Not over the last 10 years, except for extending a little bit longer. Reports usually go through DND. They report on commercial activity.

	Air: • No significant change other than military exercises / training going on. May give better capability because there could be a resource with a more timely response, but it doesn't really affect the exposure time because these are less capable resources (Griffon). • Shoulder seasons: factors that become more important? - Ice is less important in shoulder seasons, search aspect – sun on horizon → search productivity. • Weather always changes at different times of the year. This could increase total exposure time in shoulder seasons – lighting not a big factor, better performance in colder temperatures (better fuel consumption). • As an air resource dealing with ship casualty, more likely to be in L7 & 8 – exposure time change? Not a significant change. • Could darkness affect transit time? - Little adjustment but not much, same with search productivity. Also glacial ice issues not as much a problem late in the season, higher concentrations earlier in the season. • **Biggest issue is the weather – shoulder seasons – much more extreme – temperature, freezing spray, icing,** • For marine resources all phases will be affected by different times of the year. Icebreakers are also now doing SAR – pushing icebreakers beyond capabilities. This adaptation is very slow coming. We have to be clear on the report- when we are talking about response resources – designed and equipped to rescue. In the new icebreaker design hopefully this will be accounted for. • DND on navy side is going to try and purchase a light icebreaker. Bringing them into the mix, they are not a heavy ice class. Some places they won't be able to go- better then what they have now, but still not great. This could even act as a moving fuel cache. • AOPS (arctic offshore patrol vessel) – could act as refueling for cormorant and Griffon. • If Western Arctic region does more O & G – does this increase CCG presence? – No an oil and gas resource must be self-sufficient. • How will new resources affect exposure times? AOPS? - In 5 years it might be worth reviewing this data based on new capabilities.
11	**Day 2 of Workshop: 12 July, 2013** **Discussion:** If oil industry arctic exploration picks up – will oil industry need to cover this increase, or will CG need to help cover / adapt? - Provincial government plays a larger role now – this will increase the oversight, but whether or not more resources will come into play is up for question. - Industry has learned a lot: they have been investing heavily with technology to be able to drill safely (drilling 2 wells). If they are going to move back in – they will bring a lot more to the table (investing heavily here). They are being pushed hard on the environmental side – but are they being pushed on the safety side? Evacuating methods?

	- Hearing good things from TC and CG investing in year round ice-breaker. - Offshore here is not the same as it was 30 years ago, a lot more safety oriented. - Still have same accident rate they had for years, but they will stop an operation if someone isn't wearing safety goggles. Still having explosions, fires on board. However, personal safety has greatly improved. - Oil companies have complete control, but sometimes the people don't have the same stringency by the contractors – there seems to be a difference SAR has done a lot of work with oil companies off the east coast – would there be a big push by SAR system to engage oil companies? - There should be, not sure if there will be. Whether there are assets up there, whomever they belong to, SAR would be aware of them, could volunteer to help or contract them out. Working with Cougar right now, someone on the north side was going to contract them. Just another resource for SAR- way to look at it right now. There might be an increase not only in bulk carrier traffic but also general supplies for the ships that are there. Another area that there is potential for change, some questions asked of CG at some point that if those seasons extend would they look at extending the services they provide them? - Response from CG is yes, but the user fees will increase. Someone needs to pay for it. Look at risk side of the equation, not the exposure side: where are the greatest risks with SAR? Oil and gas, commercial operations, fishers, adventurers? - Greatest risk: large # of people up in the north, cruise ships, <u>major marine disaster, air disaster</u>. Picking up 1-2 people although it is doable, it takes a long time. This will task this system if it happens to a large group of people. There are a lot more polar flights going now that are not seasoned. This is becoming more and more popular because of exploration, and illegal immigrants coming in. This all increases the response to disaster for large amounts of people. Becomes a problem when looking at large groups (air disaster plan is for 320 people) anything bigger than that. A mass casualty could be 40 people because the resources are just not there for it. It would still be a task to rescue these people.
12	**Presentation 1: JRCC Trenton** • Effort that they went through to get the response going for rescue (JRCC Trenton) responds within Canada for domestic issues. • NP40 – 300 NM off boast off Borden Island: Russian Ice floe→ SAR response. Ice researchers on the ice floe. Effort required from SAR: JFTN (joint task air force North) - H60 (air refueling?) - Low long has the fuel cache been there for? - 48 hrs from Vancouver – 25 hrs best case if continuous flying & direct route. - Look at back up capability. - Out of Alaska (15 hrs) – Borden island - Chinook – not primary SAR vessel: 12 hrs, 140 knots, no hoist. - Hercules & Buffalo: fixed-wing – 3-5 years →H60 air-air refueling: no talk of Canada getting this capability. This is too expensive for fuel training →Major air disaster risk increases o 15 new primary SAR fixed-wing

	o 48 hours – 3 days o Sea Kings- Trenton : 12-17 hours o Hercules (MAJD) – shelter, food, medication: resolute, alert, Iqaluit o 15 new Chinooks: Arctic offshore Patrol ships- advanced medical care- they can do the search but won't be of much help for the actual rescue. **Presentation 2: SAR JRCC Trenton** • Northern air routes: Arctic SAR council so important because so much more activity. • More capability based design for new aircraft that will be developed. • If not a primary resource, it can be tasked to go do a search- but they won't have a SAR tech aboard. The aircraft just doesn't have a package. Is there any need to maybe put a base up in the Arctic? • Avoid this question from media as much as possible. 9000-10000 cases a year that someone from JRCC needs to be sent – a lot of them are in city centers off the border. The main operating bases are Victoria, Trenton, and Halifax. There are not that many resources available out of all these bases – this is why they pull in a lot of secondary resources. • Trenton has 2 Hercules for Winnipeg / Trenton and there are only SAR techs on primary resources. • This could include contracting commercial operators. • Greenland only has a few ships and a few helicopters – but not a specific SAR program. • A lot more humanitarian cases lately – they will support if it doesn't affect the mandate – but this is not sustainable. Right now there is no SAR policy or the National SAR program – so because of this there are no specifics for what provinces/ territory is responsible for. JRCC gets requested for assistance – but JRCC needs to make sure they can do it. JRCC Trenton makes all approval for air accidents that are requested by the province. There is a big review going on – that will hopefully say what everyone is responsible for. There should be policies for each province in place. • There is no legislation that covers hardly any component for SAR. Only IAMSAR & CAMSAR. Looking at possibility to see if we could divide Arctic up into zones as far as potential exposure times. If you were to do this, would you do this in relation to lower number (minimum) or higher number (maximum)? Does it make sense to carve up the Arctic to say they are different in different locations? This is not in terms of traffic. If someone asks for help from TC – how long will it take for someone to reach us in this zone? Will it will be different if you are operating in certain parts of the Arctic? If it is different where are those zones? Would advice be changed based on location? • Will be difficult to do this by zone, eastern side of Baffin Island is small, other side of island is much greater. There is a lot of variety in a small span of geographical area. What does it mean to survive until help arrives? This 24 hour polar code – is now wrong, can TC say you should have capability to survive for x amount of time? Should TC give one set of advice for everyone going into Arctic? • This is done for mid-August so in different months you will have different

response times.

- More important when they are there or where they are? It's a combination of both. Is it worth exploring to get more information on that or is it better to give blanket advice – exposure time will be much greater in the Arctic than the South.
- You may be able to break it out in Air response time, but marine response time would be very hard.

Should the marine be part of the discussion at all? Because on the airside even the worst case isn't as large as some of the minimum marine resources.

- Once air knows where to stop for fueling – the exposure time will be fairly standard year round,

It is clear that a lot of exposure times will be >24 hours – don't think TC will want to give times 24-48 hours. Would it be fair to say that the guidelines right now are not sufficient because it may be double that?

- Farther north you go, the longer it will take to get there.
- Looking at certain types of activity: oil companies going into Arctic – they will have their own SAR – they will look after themselves. The worry would be then cruise ships, traffic going through areas where there are no set services that would need to call SAR.
- Oil companies don't care so much about SAR capability – they have helicopter and ships available to get things back and forth quickly.
- Cruise ship goes up it doesn't need a support vessel. TC should try to push pairing up cruise ships with other vessels for going into Arctic.
- Through certain parts of Russian Arctic – it's mandate to be accompanied by Russian Ice breaker.

Anything we think should be done to change exposure times, is there anything on the airside that could materially change these times? Fuel caches you could count on?

- No, the route now is the quickest you can get. The only way from air side to improve would be to send a fixed-wing up and drop a kit to improve survival times for the people in trouble.

How about the marine side? Is there anything that could be done to get faster transit times?

- Populated areas further south L6, along the coast in L8 – hydrographic data (Southern) this would improve marine rescue times.
- While you may have an objective – heading towards area – have one or two lines you have to follow – very often moving off course.
- Presence will be more prevalent – don't have to go to areas if you don't want to or areas that would be dangerous.

Would extending season of CG assets in Arctic be helpful/ change response times?

- If there were more assets yes this would improve response times. If you extend the season either way all the activity moves, may not make a difference.

Does the entire activity move, or 80% -90% moves? Or are there still things happening up there?

- Only things continuing on is the fishing and shipping in Churchill. Best bang for buck is improving bathymetric data. There are so many possibilities of where CG could patrol – still a long ways away for Labrador and even the coast of NL. Doesn't seem to be the best option.

If those are the things that can change response times – look now at survivability.

	This would be prevention to have ships going up and people going up prepared for disaster. They could provide advice quickly to get message out and encourage organizations to improve safety. • At this time ships are required to have an ice navigator – someone who has experience with ice – but not necessarily an expert at sea. • There are dangers here – polar navigation – most people focus on the ice – how to read/ navigate/ work. They don't often talk about how to work with the charts that are there, or the information that is not. How do you best utilize what you do have? Some of the charts available are VERY old. In 1935 they didn't use GPS – to go back and try to correct this information when the land isn't surveyed well would be very difficult. There is potential for a lot of errors here. The area down further south the tides are just as high as in Bay of Fundi. Polar navigation has a lot more issues to consider. You can actually get images on your radar that are false, because atmospheric conditions make wrong readings
13	**Summaries:** <u>*Location does matter</u> to how long you could be exposed, this matters less in air than marine. Doesn't appear very useful to try to segregate areas by zone. It is known that more northern locations more severe. • If anything is needed it should be time of year to classify exposure times, because this will depend on available resources and weather. For those that are carrying high numbers of passengers are there things they can do to better prepare (JFTN- anticipated activity)? Right now they don't have to comply with any special requirements? • Every spring and fall there is an update of anticipated traffic – but there is nothing saying that everyone has to report their traffic. If air knew all traffic that would be going through that area maybe it would help. If you were guaranteed knowing all activity you could plan relocation of air and marine. Should there be something similar a regulatory process in place for people to report regardless of size to prepare for precautions (special gear, etc). Is regulatory approach reasonable? • If TC will be legislating body then this is going to be very difficult. Right now there is some interest in getting things on the legislative agenda that could help Arctic waters. • Need to involve all stakeholders to come up with a decision. Need to consult CMAC, break off into committees. • The term global warming is providing a false sense of security and it might be driving the numbers of adventure tours towards the Arctic. • Sailboat that got through to Arctic- big media thing. Everyone thinks they can do it then. • Need to have some sort of marine activity planning: precautionary preparedness