Presentation to: Standing Senate Committee on Fisheries and Oceans

Re: Maritime Search and Rescue (SAR) activities

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Topic: Modelling of Maritime Risks and SAR Resource Planning

BACKGROUND

The location (i.e. placement) of Canadian Coast Guard (CCG) Search and Rescue vessels is one of the key determinants of the effectiveness of response. This aspect can be evaluated and optimized using computer models. This can include lifeboat station placement, allocation of SAR vessels to stations, and patrolling plans for SAR vessels. The effectiveness of a location plan is based on the expected demand for service; typically this is based on historical incidents (recorded in the CCG's SISAR – Search and Rescue Program Information Management System – database).

While historical incidents are a good indicator of the need for service in general, their usefulness diminishes if underlying conditions changes, and they are not good predictors for rare events (such as a major ferry accident). Therefore, risk analysis of (current or projected) maritime traffic is also a useful tool for estimating the demand on which to base SAR vessel asset planning and location decisions. Risk analysis also provides useful insights for incident prevention plans.

MARIN HISTORY

In 1997, the MARIN (Maritime Activity & Risk Investigation Network) was founded in Industrial Engineering at Dalhousie University to conduct research on the issues described above. We have completed a broad range of studies, published numerous articles and reports, and completed many graduate theses in this area (a full list is available upon request). Topics include:

- Rescue Vessel Location Modelling
- Lifeboat station placement recommendations
- Spatial and Temporal Analyses of Maritime Fishing and Shipping Traffic and Incidents
- The Influence of Weather and Ice on Ferry Operations
- Risk Analysis of the Effects of Extreme Weather Conditions on Commercial Fishing Vessel Incidents
- Characterizing Recreational Boating Patterns
- Coastal Vulnerability for Ship-Source Oil Spill Preparedness and Response Planning
- Predictive Modelling of Vessel Casualty Rate for various categories of commercial ships

MODELLING APPROACHES

- The analytics used by MARIN serve to provide insight into issues affecting Search & Rescue asset planning
- The expected demand for SAR service is largely based on historical SISAR incidents, but this can be bolstered by maritime traffic risk analyses
- The incident patterns used for SAR needs assessment can be done on an annual, seasonal, or monthly basis
- The SAR response vessels are normally grouped into 3 or 4 categories for response modelling
- While several methods have been developed using the Maritimes Region as the case study, many of our studies are also focused on the West Coast, the Arctic, or all of Canada

EXAMPLE #1 – FISHING VESSEL INCIDENTS HOT SPOTS

- Figure 1 shows the smoothed density of fishing vessel incidents around the Maritimes based on several years of SISAR data
- Figure 2 uses the same incident data but divided by the amount of fishing traffic, so it represents the ***incident rate*** (number of incidents per unit traffic)
- Figure 1 shows the largest need for SAR response, while Figure 2 shows the greatest opportunity for prevention planning, where the risk is highest

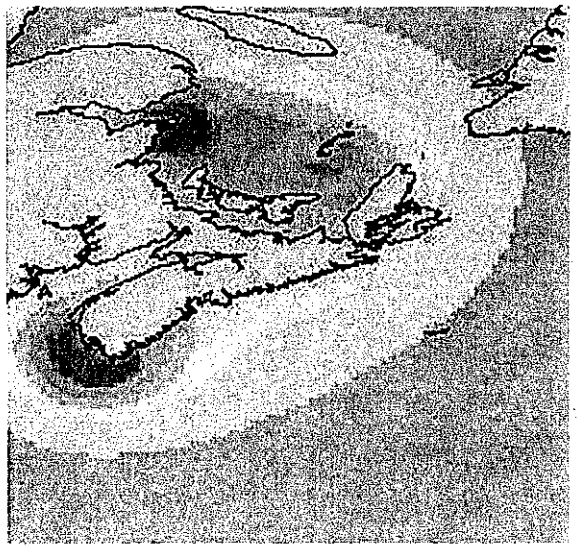

Figure 1: Fishing incident density

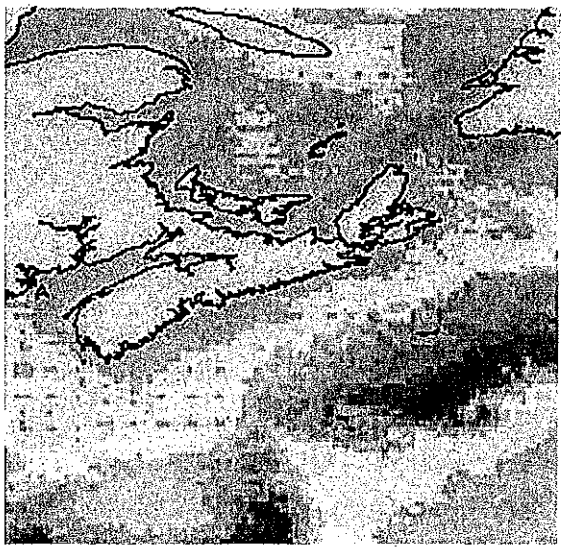

Figure 2: Fishing incidents relative to traffic

EXAMPLE #2 – LIFEBOAT STATION LOCATION

- In the late 1990's – early 2000's, MARIN performed analyses to assess the best locations for 8 new lifeboat stations across the country
- The general locations were pre-established by the Coast Guard; our task was to compare options in an area using several criteria:
    - How average response time would improve
    - How the response time distribution would change
    - How the relative coverage areas would differ
    - How the workload balance with adjacent stations would vary
- Figure 3 shows a sample output: the expected response times in the Bay of Fundy should the station be placed in Saint John, NB. Note that the existing Westport station is shown as well.
- Figure 4 shows the response time improvement should the station be placed in Saint John.

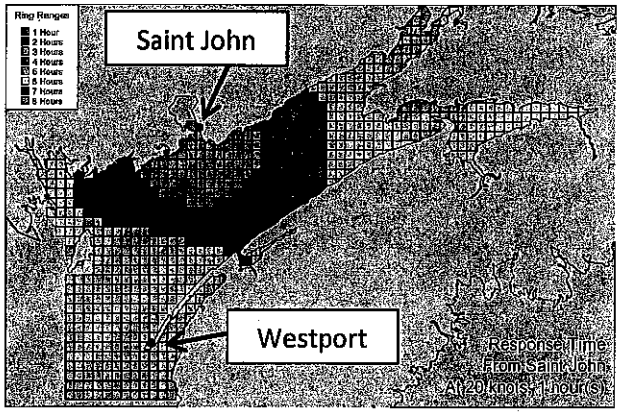

Figure 3: Response time range rings from Saint John and Westport

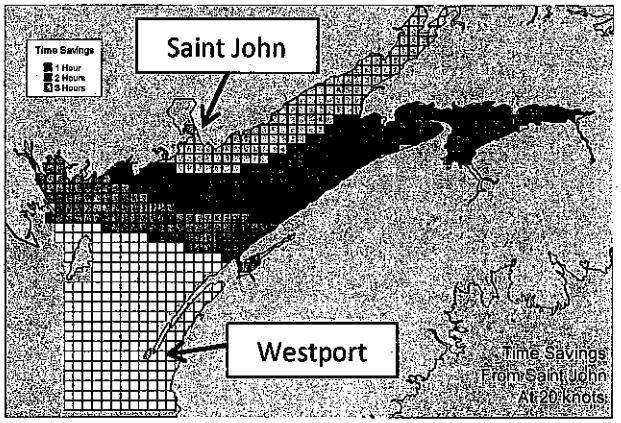

Figure 4: Response time improvements with station in Saint John

EXAMPLE #3 – SAR VESSEL PLACEMENT

- CCG vessels can be repositioned for strategic coverage; seasonal adjustments can be made; some vessels can be relocated due to multi-tasking; if a vessel is unexpectedly out of service, other vessels may be move to cover the gaps.
- We can calculate the implications of different positioning of CCG vessels; assessment criteria include:
  - *primary coverage*: percent of incidents for which a SAR vessel is within a pre-specified transit time (6 hours in this example)
  - *backup coverage*: percent of incidents for which an alternate SAR vessels is within a pre-specified transit time (6 hours in this example)
  - *mean access time to incidents*: access time is expected transit time under ideal conditions; it does not include preparation time, nor search time
- We can also calculate the "optimal" location of all the SAR vessels, to provide insight on possible improvements in the coverage
- These models, while realistic, do not necessarily include all relevant factors
- Key sample results are shown in Table 1 and Figures 5 and 6
- Table 1 shows that the *mean access time* in the Atlantic region could theoretically improve from 3.28 hours to 2.79 hours. The primary coverage could improve by about 5%, and the backup coverage by about 17%.
- Figures 5 and 6 compare the current and "optimal" SAR vessel locations

Table 1- Comparison of optimization solution vs. current arrangement

Resource Arrangement	***Solution (objective values)***		
	Primary Coverage	***Backup Coverage***	***Mean Access Time (hours)***
Current Arrangement	*85.4%*	*63.9%*	*3.28*
Multi-objective model solution	*91.9%*	*81.4%*	*2.79*

SAR VESSEL PLACEMENT – SAMPLE RESULTS

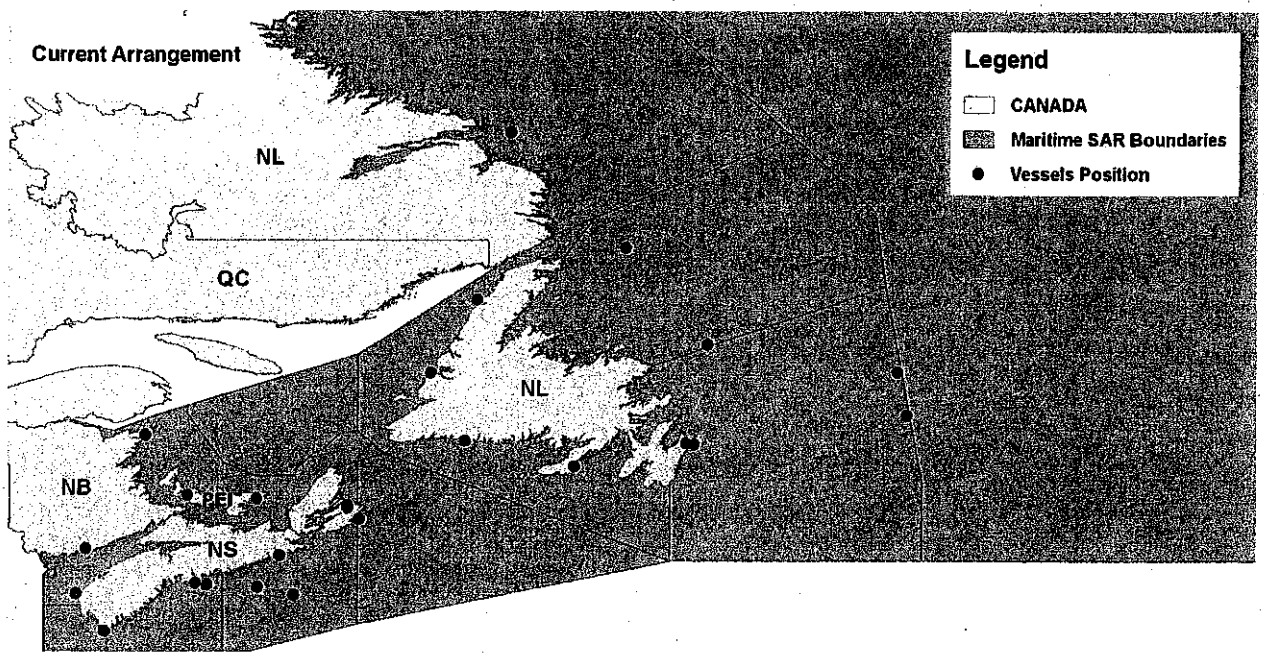

Figure 5: Current Arrangement of SAR vessels (2016)

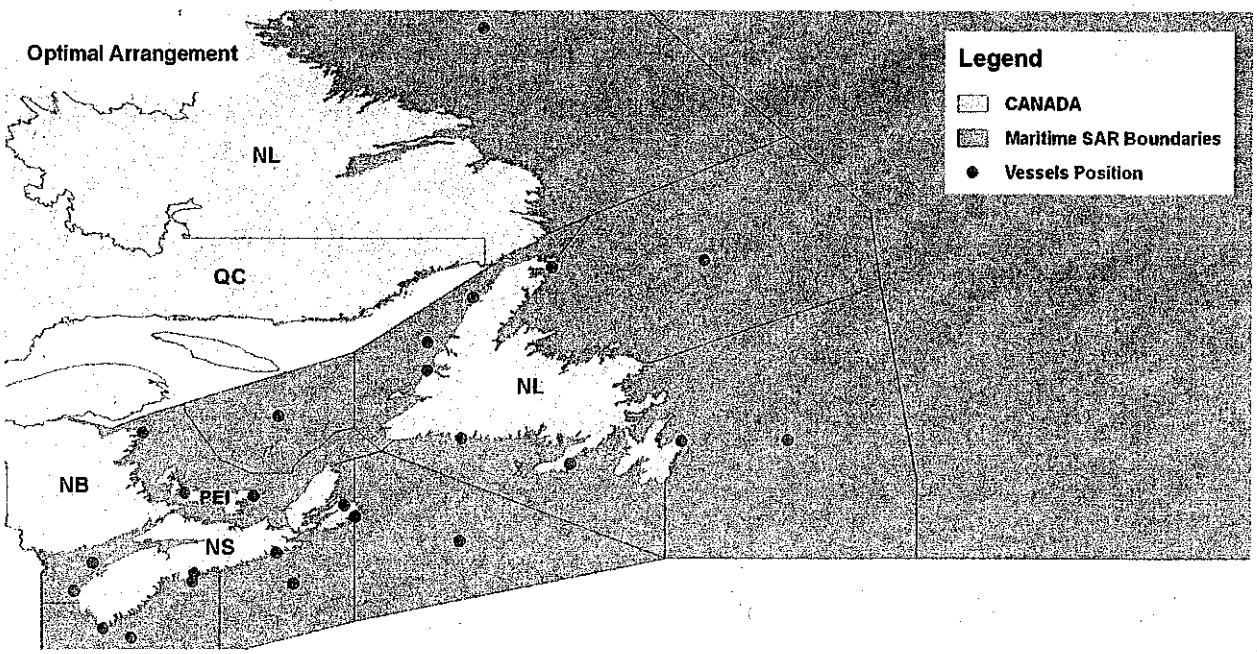

Figure 6: Optimal Arrangement SAR vessels position (using optimization model)

EXAMPLE #4 – ARCTIC MARINE TRAFFIC

- Changes in ice conditions in the North due to global warming and various economic drivers are generating increased Arctic shipping traffic now, and potentially more in the coming decades.
- Figure 7 illustrates future traffic estimates (this 2020 forecast was done in 2012; but the model framework can be used for any future period)
- Figure 8 shows where vessels of various ice classes would, or would not, be able to go based on ice forecasts and Transport Canada's AIRSS system (Arctic Ice Regime Shipping System).
- Our models show the likelihood of being able to pass from points A to B on any given path for a specified Ice Class ship for a given week of the year.

SUMMARY

These four examples provide diverse perspectives on the types of analytical studies that can be done. Risk models can show the probabilistic distribution of maritime incidents, now or in the future. Risk models can help with the need for SAR services in the short run (positioning of SAR vessels), or in the long run (fleet composition, lifeboat station location). They also provide insights for improved prevention strategies (regulations; equipment; education; etc.). Response location models can demonstrate the coverage implications of SAR vessel placement.

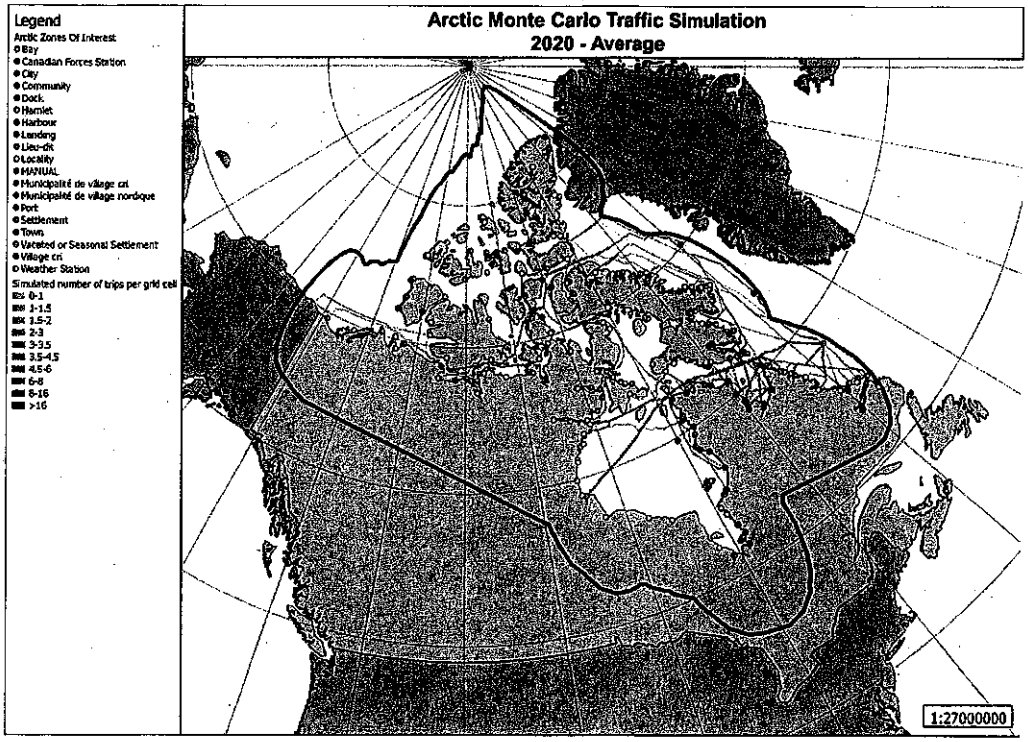

Figure 7: Future shipping traffic estimates in the Arctic (2020)

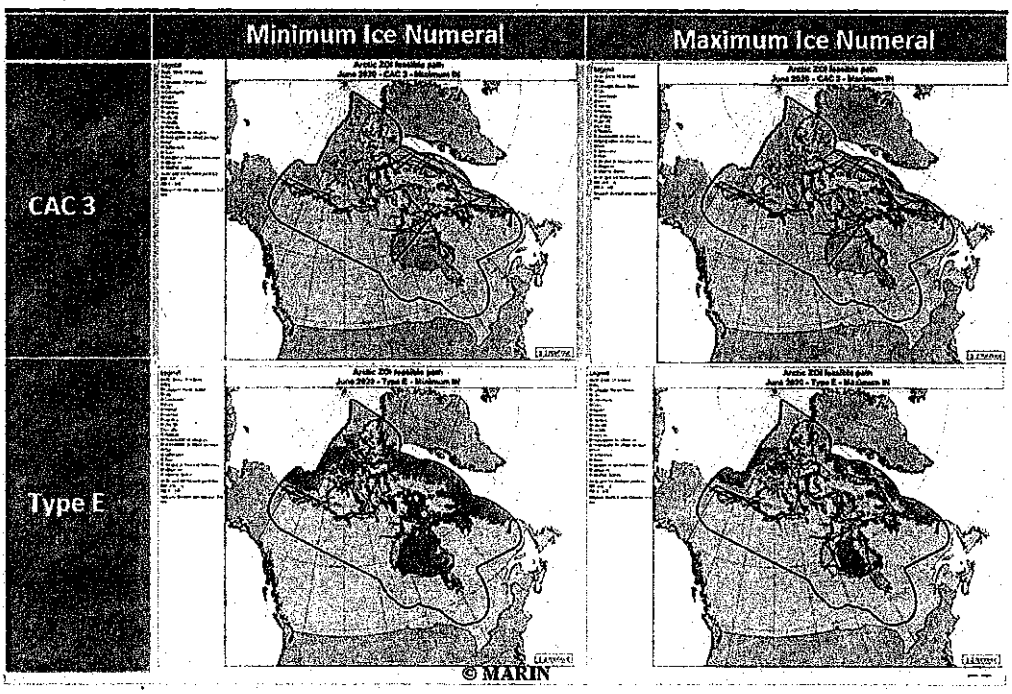

Figure 8: Navigability based on ice (AIRSS) in 2020 for 2 types of ships

ONGOING and FUTURE WORK

Some topics that are being examined now, or are in the research plans for the coming years, include:

- What are the implications of vessel multi-tasking on Search and Rescue metrics?
- Benefit/cost analysis of various fleet mix models
- A comprehensive coverage model including non-dedicated SAR resources: vessels of opportunity; Coast Guard auxiliary; CASARA (Civil Air Search & Rescue Association); DND air SAR assets; private SAR assets (i.e. offshore industry)
- Concepts of "remoteness" of the Arctic (not just distance) and implications for SAR
- Maritime traffic risks in the North based on the proposed POLARIS system (Polar Operational Limitations Assessment Risk Indexing System), and assessment of multiple risk factors.

LIMITATIONS

Many of the studies we have done have been conducted in collaboration with, and validated by, the client. However, aside from the normal limitations of any modelling exercise, some of our studies have been developed as proof of concept whereby the sample outcomes are illustrative only, and cannot be used for decision support without further refinement.

ACKNOWLEDGEMENTS

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Ronald Pelot is a Professor in Industrial Engineering, and the Associate Scientific Director of the MEOPAR NCE (Marine Environmental Observation, Prediction and Response Network of Centres of Excellence). Dr. Pelot is also a lecturer in the Marine Affairs Program at Dalhousie, teaching risk analysis with a focus on maritime issues. He is a member of the Faculty of Graduate Studies, and is the Assistant Dean of Engineering Cooperative Education.

In 1997, Dr. Pelot founded the Maritime Activity and Risk Investigation Network (MARIN) at Dalhousie. Since then his team has developed new software tools and analysis methods applied to maritime safety (accidents), coastal zone security, and marine spills. Many of these studies have been conducted for various government departments including the Canadian Coast Guard, Canadian Hydrographic Services, Transport Canada, The Department of National Defence, Defence Research and Development Canada, and Environment Canada. Quantitative Risk Assessment (QRA) has been applied to better address decisions regarding where to position response vessels or other assets for accidents or spills at sea, which coastal areas are most vulnerable with respect to marine spills, what the marine traffic patterns are and trend analysis for traffic management and coastal defence, and what the main risks are in the arctic surrounding current and future maritime activity in that region.

Dr. Pelot has authored 50 refereed publications, over 125 conference proceedings and technical reports, and co-authored a textbook on Engineering Economics. With respect to risk and decision analysis, the most pertinent journals that I have published in include: Risk Analysis: An International Journal, International Journal of Decision Support Systems, Risk Management: An International Journal, Safety Science, Ecological Indicators, European Journal of Operational Research, Arctic Yearbook, Geomatica, Journal of Applied Sciences, Journal of Coastal Conservation, Journal of Industrial Ecology, Pattern Recognition Letters, and the Journal of Ocean Technology.

Dr. Pelot has taught Engineering Economics, Operations Research, Decision Analysis, Human Factors Engineering, Industrial Psychology, Simulation, and Production Management. In 1998 he won the DalTech Award for Teaching Excellence. He is a member of INFORMS (Institute for Operations Research and the Management Sciences), IIE (Institute for Industrial Engineering), CORS (Canadian Operational Research Society) and the SRA (Society for Risk Analysis). He also holds a Professional Engineering designation.