# QinetiQ support to the Canadian Coastguard

# Value for Money through analysis of Vessel Life Extension

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ISMOR 36






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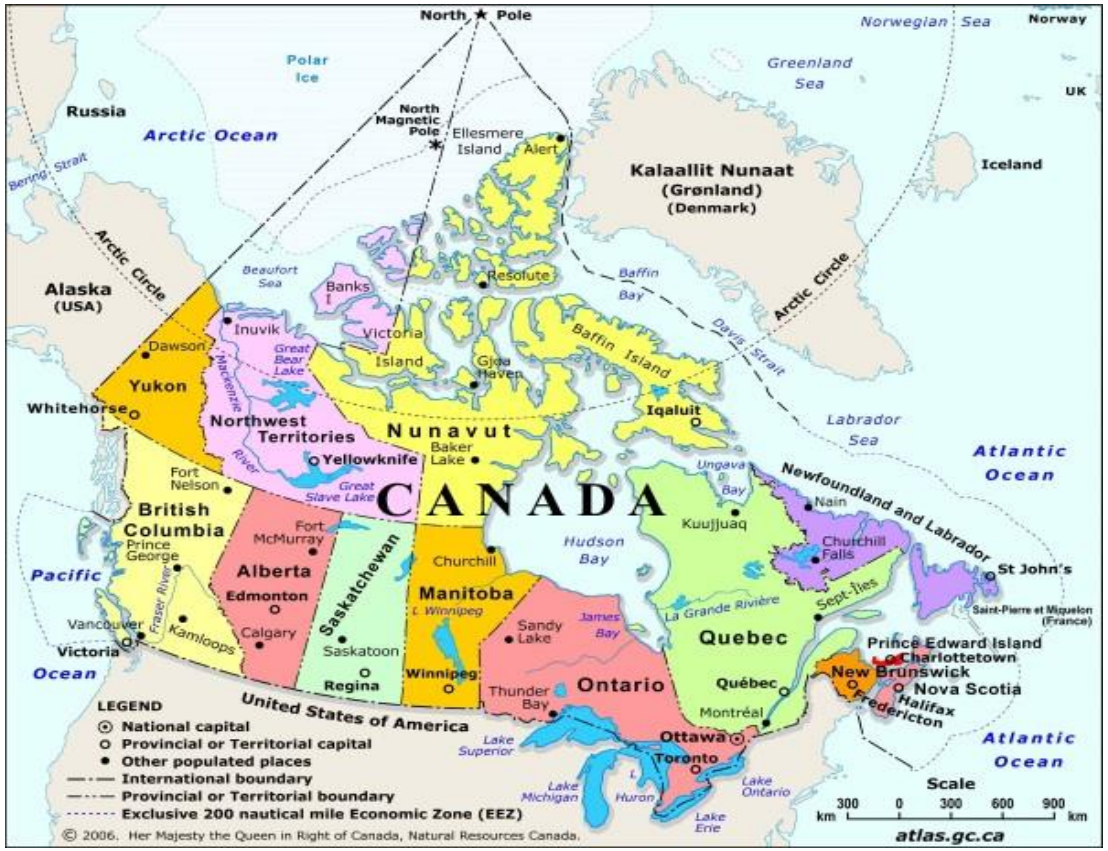
# Background – Who are the Canadian Coast Guard (CCG)

- The Coast Guard is a Special Operating Agency within the Department of Fisheries and Oceans Canada (DFO).
- The overarching mandate of the DFO is to protect Canada's three oceans, coasts, waterways and fisheries, and ensure that they remain healthy for future generations.



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# Background – What does the CCG do

- Canada has a coastline of over 200,000 km
- At time of analysis, CCG had 67 major vessels in service, including 17 icebreakers
- Icebreakers keep ports open all year – enabling billions of CAN$ in trade
  - Escort vessels through ice
  - Resupply people in the Arctic
  - SAR where others can't reach

# Background – The problem

- Vessels are well maintained, but nothing lasts forever. There is limit to the lifespan you can get out of a hull
  - Many of the current vessels are approaching their Out-of-Service Date (OSD) over the next 10 years
  - CCGS Louis S. St-Laurent was commissioned in October 1969
- CCG is proposing the largest re-capitalization of its fleet in a generation

# Analysis

- The Fleet Replacement Programme 2017 options proposed the construction of over 60 vessels, of which at around 30 would be between 1,000 and 23,000 Tonnes displacement – representing major construction effort.
  - Around 25 of the new vessels would be classified as Medium or Heavy Icebreakers.
  - Each of these represents a major construction effort, with a limited number of shipyards big enough
- CCG asked QinetiQ to undertake a program of analysis to inform their decision-making process in formulating the optimum structure for the future fleet. This analysis included modelling the capability that would be delivered by the proposed options, as well as the associated costs.
- We also examined how Vessel Life Extension (VLE) could act as an alternative to new construction or alter the order in which new vessels were commissioned.

# Linear Programming

| | Resources (Legacy Vessels and New Construction) |
|---|---|
| Requirements (Tasks by Season) | Capability of each Vessel against each Task |

- Proposed an LP to optimize the allocation of the available CCG fleet to requirements – showing an upper limit on effective utilization.
- This is based around an ‘objective function’ which considers the overall capability against requirement. The construction of this objective function is discussed on the next slides.

# Constructing the Requirement

- The CCG fleet covers a wide range of mission types with different priorities. These priorities reflect legislative, political and practical considerations – e.g. SOLAS.

  1 Search And Rescue

  2 Heavy, Medium, Light and ACV icebreaking

  3+ Conservation And Protection, Environmental Response, Hydrography, Marine Aids To Navigation, Maritime Security, and Science (Fisheries Research, Geoscience and Oceanography).

- Tasks were split between 3 administrative Regions – transformed into 4 discreet operational areas
- Tasks were divided by season – you can't make up for the lack of Winter Icebreaking by doing more of it in Summer
- Tasks were also divided into Nearshore, Midshore and Offshore areas, with specific needs for the Arctic, High Arctic and Great Lakes zones

# Constructing the Requirement 2

- QinetiQ developed a representation of the scale of the CCG task:
  - Icebreaking requirement based on international treaty obligations
  - Other requirements based on past activities
    - 5 years of vessels activity records – what they were doing, when
    - Publicly-available AIS data – where they were doing those activities
- All requirements were expressed as a number of days of ship activity required, normalised against the capability of legacy vessels to conduct those activities.

# Constructing the Capability

- Not all ships are equally capable of each task, for example:
  - Only Heavy Icebreakers can do heavy icebreaking tasks
  - Deepwater vessels not ideal for Nearshore operations – they can do them, but not as well.
- This is reflected in the LP through the objective function:
  - A vessel not capable of a task would score zero units, no matter how many days allocated
  - A vessel which is half as capable, would score 0.5 per day = c.45 units per season.
- Routine maintenance also reduces the number of days a vessel has to spend each season.
  - Legacy vessels have seasonal availability based on their historic patterns
  - New vessels have a percentage availability, in a seasonal pattern based on an equivalent legacy vessel

# The Power of the Model

- So this one LP was trying to cover 50 years, 4 seasons, 108 mission types (across the operational areas), 137 vessels (current, replacements, some replacements of replacements) – all for different fleet options.
  - Run times were impractical

- The LP matrix was very sparse: individual vessels can only undertake a small proportion of the mission types and is constrained to one operational area.
  - Even breaking the LP into four operational areas, there are still many vessels that are not in service in a given year and tasks that might not occur in all seasons.

- So we considered each year, season and region separately and had the model construct bespoke LPs for each season. That LP would only consider the relevant vessels and tasks they could do.

# Results of the Model

- Our Headline Measure – Operational Effectiveness
  - This was a measure of the overall capability of the CCG fleet to meet their prioritized requirements over time.
- Supporting detail includes:
  - The output sheets recorded information for each season, each year for 50 years.
  - Results were broken down by requirement – overall, or by operational area.
  - Results also broken down by vessel – their utilization each season and what tasks they were doing.

# Use of the Model

- The model went through iterative development cycle with the customer helping us refine the information each time.
- We informed the customer, improved their understanding of the problem and answered specific queries.

- We ran cases varying:
  - Procurement strategy;
  - Target fleet mix;
  - Vessel build order; and
  - Vessel allocation order.

- And we offered other options…

# Vessel Life Extension

- Ships take time to construct.  Complex, icebreaking ships displacing 4,000T or more can take over a year to build, fit and shake down – and the number of shipyards big enough to do so and with experience constructing icebreakers is limited.
  - As a result, some vessels may need to be kept running in order to maintain capability until the new vessels are constructed.
- A selection of 20 vessels were proposed for Vessel Life Extension, with 5, 10 and 15 year extensions proposed.
  - Some vessels had already been extended before - extensions were limited to initial lifespan +50%
- Vessel condition surveys were used to confirm the feasibility of VLEs and refine proposed costs.

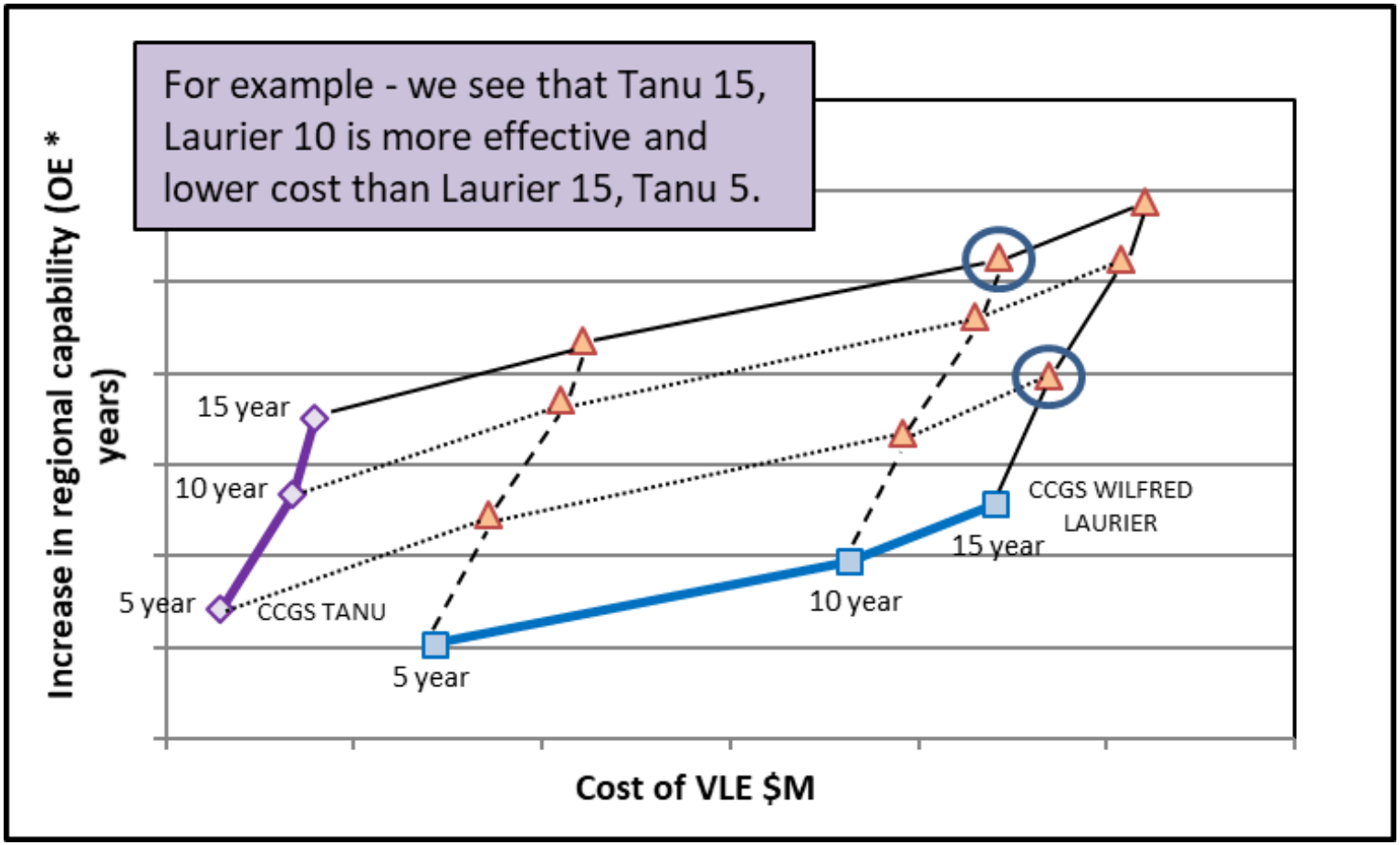
# The investigative process

- Model a VLE by changing the OSD of one or more legacy vessel(s). Re-run the model, compare the results to the baseline and investigate the reasons.
  - For each year, the difference in Operational Effectiveness (OE) between the VLE case and the Baseline case was added up to give an overall score of OE*Years

- Compare, Contrast and Combine

# Comparison within an Operational Area

- In the Central (Great Lakes) and Western regions, there were only 2 viable options each, so we compare their cost-effectiveness.





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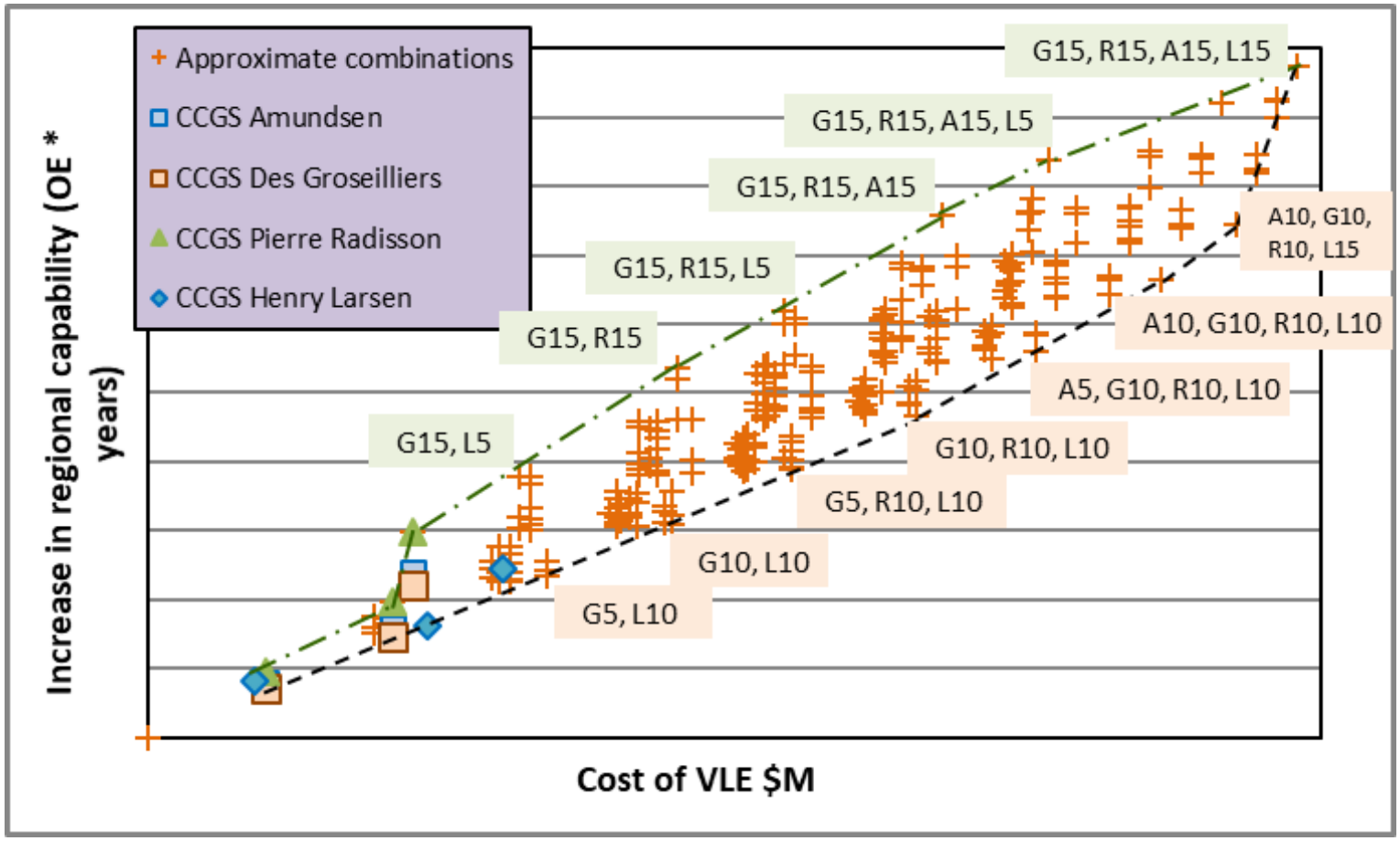
# Comparison with a class of vessel

- In the Atlantic and Arctic operational area, there were multiple options for which Medium Icebreaker to perform a VLE on, so we compare their cost-effectiveness.





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# Output

- We used the comparisons to run an informed subset of all potential combinations, baselined against each of three procurement options.
- For each procurement option we divided the possible VLEs into priority categories:
  - Recommended VLEs – sometimes ranked into Batches 1 and 2 based on the cost-efficiency of the VLEs.
  - Optional VLEs – these vessel extensions don't add much benefit to their current region, but could be transferred to another region for greater benefit.
  - Discouraged VLEs – these vessel extensions don't add much capability at the time they would occur. Due to...new builds, and the balance between vessel types
- This allowed the customer to assess the needs of the interim capability and prioritize their spending on VLEs.
- It also illustrated another factor of the differences between procurement strategies.

# Result?

- We just advised the customer – their decisions are their own and they have data and considerations beyond what we provided. However…
- In 2018, CCG purchased 3 vessels to covert to Medium Icebreakers
  - CCGS Vincent Massey
  - CCGS Captain Molly Kool
  - CCGS Jean Goodwill
- So we think we made a difference.

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