“SAFETY BEYOND REGULATION” THE BC FERRIES EXPERIENCE

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ABSTRACT

International and domestic regulatory regimes provide a minimum baseline for passenger ship safety. Stepping beyond minimum requirements involves progressive thinking and a motivated staff. British Columbia Ferry Services (BCF) has initiated the process to develop a “safety beyond regulation” culture within its entire staff. Central to this is a risk-based approach to all aspects of the operation. This applies not only to operational staff, but also to the shore side technical support. Recent safety upgrades have been implemented because it was the right thing to do, despite the additional costs to exceed regulatory minimums.

Recent initiatives undertaken by the BCF Fleet Technical Engineering group include Damage Consequence Diagrams (DCDs) and a Simplified Grounding Calculation procedure. These provide methods for rapidly assessing an emergency situation with limited information.

Another example of this initiative involved the specification for a new open deck ferry, the M.V. *Kuper*. A centerpiece was the installation of fire monitors on a new open deck ferry that provide a superior method to rapidly direct a stream of water on a car deck fire than is possible with the traditional fire team. The regulator had difficulty accepting this approach within the existing regulatory framework, and the process for getting this technology accepted is discussed.

These examples show how BCF is attempting to learn from some of its past incidents and set in place practical procedures which will reduce risk and add value.

INTRODUCTION

BC Ferries (BCF) is an independent marine transportation company that operates a complex coastal ferry system. BC Ferries provides coastal British Columbia with passenger, vehicle and freight delivery services with one of the largest ferry systems in the world. It was created in 1960 and now provides year round services on 25 routes with a fleet of 36 vessels and 47 terminals. More than 21 million passengers and 8.5 million vehicles are carried each year on 166,000 sailings [Reference 1].

BC Ferries is in the beginning of a major vessel renewal program. The current BCF fleet has an average age of 32 years. The oldest vessel was constructed in 1956. There are now three 160 metre Super C-class ferries, one 100 metre Intermediate Ferry and one 150 metre Northern Cruise Ferry on order. All these vessels will be delivered between fall 2007 and spring 2009. This is part of a comprehensive fleet renewal program that will see 21 new ferries introduced by 2020 [Ref.1].

BACKGROUND

With such a large and complex organization as BC Ferries, there are bound to be safety-related incidents. These incidents could be anything from a crew member injury to the sinking of a major vessel.

In March 2006, BC Ferries experienced its most serious incident with the loss of the 125 metre (410 ft.) 6110 tonne (6209 LT) M.V. *Queen of the North* when it struck Gil Island at 17.5 knots and sank in Wright Sound in 78 minutes. [Ref. 2].

This event triggered a change in the corporate culture that would not only involve operational staff, but all elements of the company. British Columbia Ferry Services (BCF) has initiated the process to develop a “safety beyond regulation” culture within its entire staff. Central to this is a risk-based approach to all aspects of the operation.

Figure 1 - The *Queen of the North*

The international SOLAS (Safety of Life At Sea) requirements and the domestic regulatory regime administered by Transport Canada provide a baseline for passenger ship safety that represents the accepted minimum standards. To step beyond minimum requirements involves progressive thinking and a motivated staff.

From a technical perspective, this has involved challenges as many vessels in the BCF fleet are older and operate with varying degrees of regulatory grandfathering and incorporate a patchwork of regulatory regimes. In addition, the *Canada Shipping Act* is being reformed by Transport Canada under the CSA 2001 initiative. While the new regulations will generally affect new construction, the process by which past exemptions and regulatory equivalencies is being reformed and all past decisions will be reviewed over the next five years.

In this environment, recent safety upgrades have been implemented because it was the right thing to do even though it was costly and exceeded regulatory requirements. BC Ferries has introduced several innovations into its fleet in an attempt to create the safest ferry system in the world. This paper describes examples of recent engineering initiatives: Damage Consequence Diagrams, Simplified Grounding Calculations; and the introduction of new safety technology on a small ferry.

DAMAGE CONSEQUENCE DIAGRAMS

The BCF Fleet Technical Engineering group first became aware of the concept of the Damage Consequence Diagram (DCD) following a December 2005 **Ferry Technology** article entitled *Damage Consequences Rapidly Assessed* [Ref.3]. This methodology, originally proposed by a UK consultancy (Burness Corlett-Three Quays), had the potential to be a very valuable tool for the ship's crew in the event of a breaching of the ship's envelope. The purpose of the DCD is to provide the ship's crew with a simple tool for evaluating the survivability of the vessel.

DCDs employ colour-coded graphics that allow the ship's crew to quickly assess the risk associated with damage to the ship's hull. The ship's crew can simply determine which compartments have been compromised and follow down to the color-coded risk assessment to determine what level of risk the ship is in. The DCD involves no calculations and can be read very quickly in an emergency. The Master can thus be rapidly provided with guidance that will assist in the response to the emergency.

The colour-coded risk indicators are the standard green, yellow and red. Green indicates a safe level of risk, yellow indicates moderate risk and red indicates great risk. In the BC Ferries implementation of DCDs, red stripes have been added to the yellow to indicate that there is actually risk involved. Also, it was decided not to use the term Low Risk, but rather just Risk. This was done to remind the ship's crew that due vigilance is required during any incident where damage to a ship's hull has occurred. A plain yellow coding was deemed not to suggest sufficient danger of the situation.

The DCD references all of the vessel's watertight compartments and indicates the level of risk involved when groups of compartments are breached. Calculations are provided for one, two and three compartment damage. The ship's crew can determine what compartments have been compromised by tank soundings or crew observation.

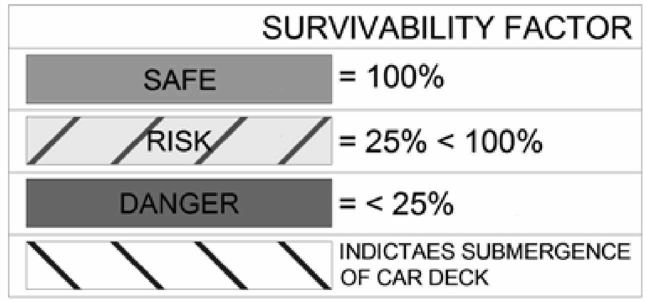

Figure 2 – Survivability Factors

The level of risk is determined by applying the survival probability "s" factor from IMO MSC/CIRC 574 [Ref.4]. When s = 0 there is no contribution to the survivability index 'A' for the damage case being considered. When s = 1 then stated requirements for survivability have been complied with.

It has been elected not to state the calculated survivability factors on BCF DCDs. Only the corresponding risk level colour is shown in order to limit the amount of information that must be processed during an incident. In an emergency situation whether the survivability index is 16% or 6% is of little consequence; there is a significant amount of risk associated with either situation.

DCDs also include the location of damage control items, such as watertight doors, remote watertight door controls, bilge pumps, extended bilge manifold spindles and deck scuppers. The ship is surveyed prior to indicating where a particular item actually is on a drawing. This is to ensure that the most accurate and up-to-date information regarding a vessel is released.

BC Ferries decided to reference the immersion of the Main Vehicle Deck (the bulkhead deck) rather than the margin line. Although immersion of the margin line is referenced in regulation as a limiting condition, practically speaking there is still excess buoyancy available above the margin line. In other words, it does not represent the limit of survivability. The vehicle decks on BC Ferries do not feature any large hatches and are generally configured to limit downflooding. Thus there will always be some residual waterplane available even when the margin line is immersed. In addition, some BCF vessels (and all vessels serving the North Coast) are equipped with weather-tight doors at each end of the Vehicle Deck. This may allow some submergence of the upper most deck before water enters the vehicle space, although the survivability calculations do not consider any reserve buoyancy from the vehicle compartment above the Main Vehicle Deck. The Main Vehicle Deck, as the bulkhead deck, is taken the upper limit of available buoyancy for all configurations.

BC Ferries plans to implement DCDs on all its 36 vessels. To date, it has implemented DCDs on its major northern vessels. There remains significant development effort to adapt SOLAS-based tools to non-Convention open deck ferries. However, BC Ferries is determined to carry forward with the implementation as it is seen as one of the most valuable tools in the event of hull damage.

SIMPLIFIED GROUNDING CALCULATION

On June 30, 2005, the 139 metre (457 ft.) long M.V. *Queen of Oak Bay* lost power and ran aground while entering Horseshoe Bay terminal near West Vancouver, BC. More than 500 passengers and almost 200 vehicles were stranded for several hours while the marina was searched. Fortunately, the tide was rising and the vessel floated off unassisted. No one was injured and the vessel sustained only minor hull damage and was never breached. The incident did, however, raise a very important issue for grounded vessels: to rapidly determine the draft at the point of instability.

The *Queen of Oak Bay* is a double-ended ferry that has a very deep Vee section hull, as shown in Figure 3. The dead rise of the vessel's bottom hull is 24 degrees. In a severely grounded condition, the draft could be reduced to a point where the vessel would suddenly list over, referred to as the draft at instability. In addition to the risk to the vessel, vehicles would be prone to tipping and sliding if the heel angle is sufficient.

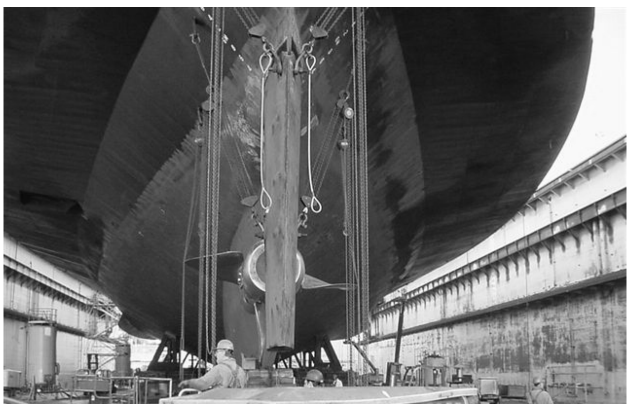

Figure 3 - The *Queen of Oak Bay* in dry dock

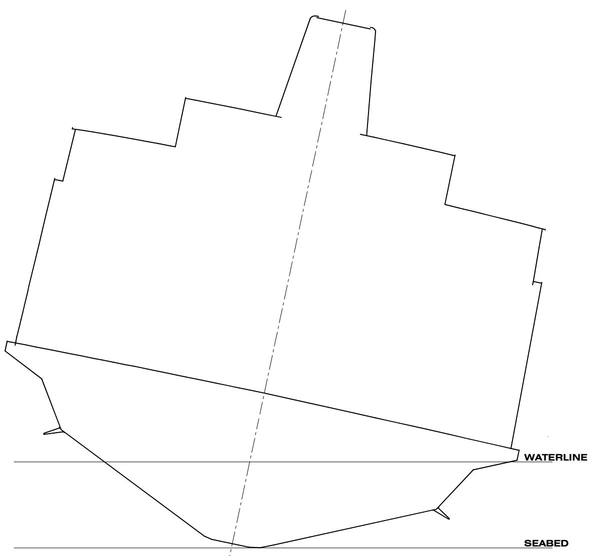

Figure 4 - The *Queen of Oak Bay* midship section indicating deadrise and potential angle of instability

The draft at instability at any particular loading condition is not noted in the stability book or any of the vessel's documentation. Additionally, there is generally not time or resources available during such an incident to do such calculations. Grounding and stability calculations would generally be done remotely at the BCF Corporate Operations Centre (COC) and be relayed to the ship's crew. The vessel's drafts and/or displacement would be forwarded to a naval architect in the COC who can then determine the draft at instability. These calculations would generally be performed using a commercial naval architecture software package.

Unfortunately, precise drafts and the vessel's displacement are not always available in an emergency situation. It may be left to the COC naval architect to estimate the vessel's displacement and draft at the time of the incident. While the calculations for determining the draft at instability are relatively simple, calculating them under stressful conditions with limited information can be a challenge. A quick method of determining the draft at instability was required.

Following the *Queen of Oak Bay* incident, the BCF Fleet Technical Engineering group developed a method of quickly determining the draft at instability. The method involves the use of a spreadsheet and the vessel's hydrostatic values. The spreadsheet allows for three different methods for determining the draft at instability: Average Method, Displacement Method and the Draft Method.

The Average Method is simply that: it actually requires no input and simply states the average draft at instability for all vessel loading conditions. This method would only be used when there is no time or information to give a calculated answer. It states the average draft at instability at an average condition. It is the least desirable method, but attempts to give an answer.

The Displacement Method takes the vessel's displacement and outputs the draft at instability. This method estimates the vessel's center of gravity by comparing known VCGs and displacements from the vessel's Stability Book and interpolating an estimated VCG from a displacement. Although this is not technically correct, determining the actual VCG of the vessel in operation is time consuming and cumbersome in an emergency situation. The main reason for estimating the draft at instability is to determine the level of risk in a particular grounding situation.

The Draft Method takes the forward and aft draft of the vessel and outputs the vessel's displacement and the draft at instability. Again, this method estimates the vessel's center of gravity by comparing known VCG's and displacements from the vessel's Stability Book and interpolating an estimated VCG from a displacement.

While the use of spreadsheets and interpolated VCG values is not ideal, sometimes methods have to be developed to suit the situation. The problem with general naval architecture software is that it requires specific input data and in some cases an exact syntax in its command structure. Such software does not always lend itself to being used by an infrequent user or even an experienced user under stress.

A more general interface such as a spreadsheet with simplified inputs and outputs will provide timely information with sufficient accuracy to assess the risk element of a grounding situation.

Damage Consequence Diagrams and Simplified Grounding Calculators also enable remote technical staff to evaluate a situation and determine the level of risk that is being presented with a limited amount of input data. Remote staff may have clearer heads and be able to offer and arrange for resources that are unobtainable by the crew of a distressed vessel.

CASE STUDY: M.V. KUPER

In September 2005, BC Ferries bought the 20-year-old 26 car ferry, the M.V. *John Atlantic Burr* from the Utah Department of Transportation [Figure 4]. The ferry was built in Utah for service on Lake Powell, a large freshwater reservoir in the Southwestern United States. After BC Ferries bought the vessel, the hull was cut into quarters and transported by truck and barge to North Vancouver, British Columbia, Canada, for reconstruction at Allied Shipbuilders.

The project was managed by BC Ferries' New Construction division with design support from the Fleet Technical Engineering group and route operational staff. It entered service with BC Ferries in early 2007 as the M.V. *Kuper*.


Figure 5 – The M.V. *John Atlantic Burr* (Utah DOT)


Figure 6 – The M.V. *Kuper*

DESIGN PHILOSOPHY

The vessel was obtained to provide additional capacity for the inter-island services operated by BC Ferries that provide an essential link for small communities with larger service centers on Vancouver Island. It bore a general similarity to the K-Class vessels that currently provide service on these routes, but it was determined that the vessel would provide greater benefit if the vehicle capacity was increased and the vessel was rebuilt to a standard suitable for service in coastal British Columbia.

A particular focus was the introduction of the best available technology for safety with minimal manning. This class of vessel has been operated with a crew of five, but the regulator had recently introduced changes to the policy for determining manning levels, particularly with regard to fire response and evacuation scenarios. These vessels are generally crewed from the local community, thus any changes to crewing levels could have an impact well beyond the operating economics, as finding qualified staff is a challenge.

LAYOUT

In the conversion/reconstruction project, the vessel was widened by 3.3m (11 feet) and rebuilt to a standard suitable for service in coastal British Columbia. The final design had an increased capacity of 32 cars and 264 passengers as per the attached table; a general arrangement is shown in Attachment 1.

VESSEL SPECIFICATIONS		
	MV JOHN ATLANTIC BURR	***MV KUPER***
Built/Lengthened	1985/1996	2006
Length	46.8 metres (154 feet)	46.8 metres (154 feet)
Breadth	12.8 metres (42 feet)	15.4 metres (50.5 feet)
Gross Tonnage	15 GT	537 GT
Car Capacity	26	32
Passenger Capacity	148	264
Service Speed	8.5 knots	9.5 knots
Operator	Utah Dept of Transport	BC Ferry Services Inc.

The original layout was substantially modified to include:

- A single large (76 passenger) enclosed passenger lounge at the main car deck level. The space was insulated to an A-30 Fire rating to provide a safe haven for a typical passenger load and to facilitate crowd control with a single crew member. The lounge space is outfitted to a minimal commuter style, with lifejacket stowage inside and direct access to an evacuation slide station. The car deck level location of the lounge eliminated any need for an elevator for disabled passengers. The washrooms located on the opposite deckhouse were also insulated to an A-30 rating.
- A central overhead wheelhouse providing better visibility over the car deck and along each side of the vessel. The original vessel and the similar K-class have an offset wheelhouse (see Figure 4) that is less favoured by the bridge team.
- The main machinery, including thrusters, was enclosed in two deck houses on opposite corners of the main deck. Each machinery space was insulated to an A-60 rating and fitted with a fixed fire fighting system. Thus a machinery fire can be contained remotely without requiring crew entry into the space.
- The engineering control station was located on the main car deck rather than below in the pump room as in other K-class. The engineer thus has more direct access to the safety equipment and may be assigned roles once

engineering duties have been initialized. This arrangement may be regarded as an evolutionary iteration that may eventually see the engineering station combined with the bridge control station.

SAFETY SYSTEMS

In addition to the attention to layout, a number of systems were specified to exceed the previous standard. A major innovation was the fitting of the DBC Emergency Slide System (ESS) comprising short slides and 150 person platforms; see Figure 6. This is the first such installation on a BC Ferry of this size.

Figure 6 – The ESS mass evacuation system

Other key system design initiatives were:

- Ability to run the main machinery from the reserve 24V electrical system;
- A single control station in the wheelhouse; this avoids issues pertaining to control station transfer. In addition, bilge and fire pumps can be run from the wheelhouse, allowing the Engineer to be assigned emergency duties.
- Installation of a high-quality public address system, with careful sound level balance for each space to coordinate the emergency response.
- The main engines were resiliently mounted to limit vibration, but also created a quiet deck environment for communication;
- The emergency fire pumps can be combined with bilge pumps to provide redundant pumping capacity.

Finally, a major innovation for a BC Ferries project was the installation of fixed fire monitors on an open deck ferry**.**

FIRE MONITORS

Four fire monitors were fitted above the Main Car Deck on the deckhouse, as shown in Figure 7. This arrangement allows at least two streams of water to hit any part of the car deck, as well as provide boundary cooling against the deckhouse structures. They are small units compared to the large FiFi units used in the offshore or fireboats. Fire monitors are usually designed to be used with firefighting foam but this system operates with seawater.

A fire monitor is operated manually by a single crew member whereas a standard fire hose requires several crew members to direct and operate. In addition, the operator does not have to change into a fire suit before activating the system. Thus the time to direct a stream of water is significantly reduced: a critical parameter in limiting the extent of damage resulting from a fire.

It was intended that the fire monitors would replace rather than supplement the traditional fire team operating fire hoses. However, this proposal met resistance from the regulators as the fire monitors were not approved equipment in the Transport Canada regulatory regime. In addition, the current Fire Equipment regulations are quite prescriptive and specify that the ship shall generate two streams of water from hoses.

Figure 7 - *Kuper* Fire Monitor Installation – water stream directed overboard

Transport Canada regulations did not allow the substitution of a fire monitor and nozzle for any other system or piece of equipment. It was deemed that the fire monitors would be accepted as supplemental to the required fire control and extinguishing equipment as a deluge system and for boundary cooling.

The fire monitors have proven themselves during Transport Canada safety inspections and have knocked out simulated car fires within three minutes, while the allowable time is 30 minutes. In addition, remotely operated fire monitors have been sourced and trialed in a Quebec ferry. This would permit control and operation directly from the bridge, further reducing response time.

As a result of Canadian ferry operators experience with fire monitors, it is hoped the new Fire Regulations scheduled for implementation in 2008 may be revised to allow monitors for primary response. Regardless, BC Ferries is planning on implementing the use of fire monitors in the fire control systems of future vessels in its upcoming vessel replacement program.

TRAINING

A final initiative involved the training syllabus employed to familiarize the crew with the new vessel. The principles of the High Speed Craft Code were adopted to develop a familiarization regime for the reconstructed vessel. A key point of the program was that all ship's staff were familiarized across departmental roles and with all of the ship's equipment. The concepts of bridge resource management and engine room management were adapted to a small crew operating a small vessel with a large number of docking cycles. The response from the crew was overwhelmingly positive and it is believed that this will be a suitable model for training crews in the future.

The M.V. *KUPER* entered service in April 2007 as the first new vessel of the BCF fleet re-construction program.

CONCLUSIONS

The loss of the *Queen of the North* marked a watershed for BC Ferries. British Columbia Ferry Services has initiated the process to develop a safety beyond regulation culture within its entire staff. Central to this is a risk-based approach to all aspects of the operation. It has resulted in the introduction of new tools and resources that can assist the response to a major incident. In addition, the safety beyond regulation initiative has been taken into the design philosophy for new vessels being introduced in the fleet renewal program. The safety culture of BC Ferries has changed and it needs to look forward to implement the appropriate tools that will aid crews and passengers in distress.

ACKNOWLEDGEMENTS

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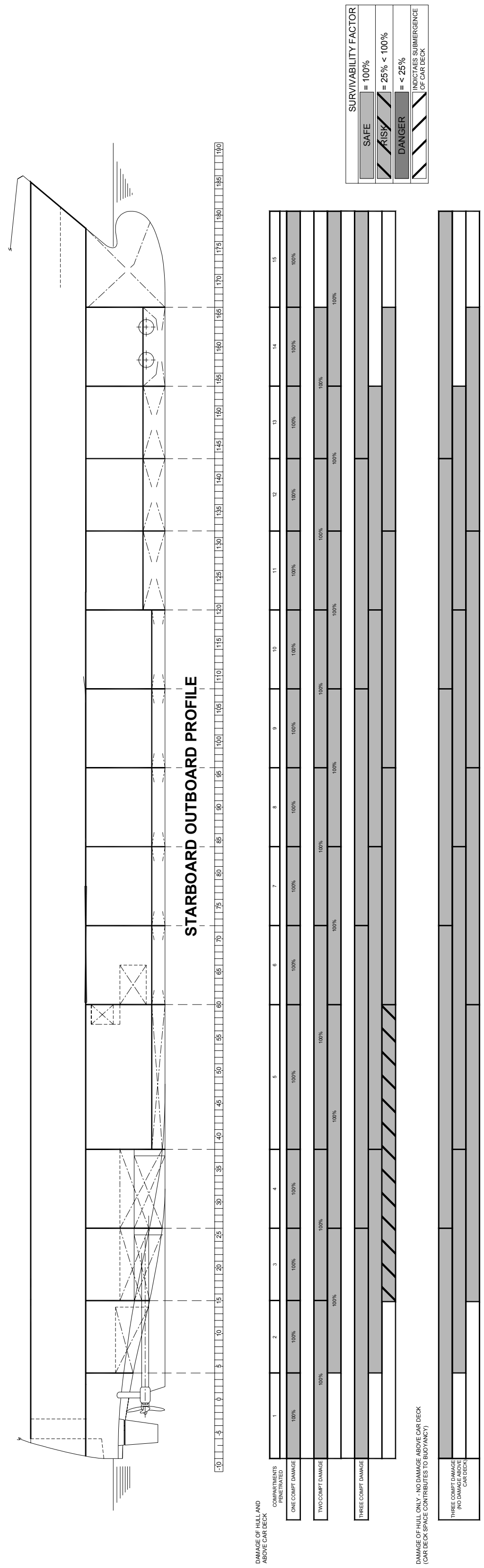
4. International Maritime Organization (1991), “A/AMAX Calculation Procedure“, Marine Safety Committer MSC.CIRC. 574.

ATTACHMENT 1: Damage Consequence Diagram – M.V. GENERIC FERRY



ATTACHMENT 2: General Arrangement – M.V. KUPER