HINCHINBROOK ENTRANCE ETV BAT ASSESSMENT

FINAL REPORT

PRINCE WILLIAM SOUND REGIONAL CITIZENS' ADVISORY COUNCIL
ANCHORAGE, AK

21 APRIL 2021
RCAC CONTRACT NO. 8012.21.01
FILE NO. 20099.01
REV A

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Revision History

Section	Rev	Description	Date	Approved
All	-	Initial Release	4/9/2021	GW
Appendix D	A	Reduced Appendix D file size to facilitate document sharing.	4/21/2021	GW

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Definitions

ABS	American Bureau of Shipping (Classification Society)
ADEC	Alaska Department of Environmental Conservation
AFFF	Aqueous film-forming foam
AHTS	Anchor Handling Towing & Supply
ASD	Azimuthing Stern Drive
BAT	Best Available Technology
BHP	Brake horsepower
BP	Bollard Pull
BV	Bureau Veritas (Classification Society)
CCTV	Closed-circuit television
COG	Course Over Ground
CPP	Controllable Pitch Propeller
DGPS	Differential Global Positioning System
Dk	Deck
DP	Dynamic Positioning
DWT	Deadweight Tons
ECDIS	Electronic Chart Display and Information System
ECO	Edison Chouest Offshore
ECS	Electronic Charting System
EEIPS	Extra Extra Improved Plow Steel
EIPS	Extra Improved Plow Steel
ERRV	Emergency Response and Rescue Vessel
ETV	Emergency Towing Vessel
FiFi	Fire Fighting (Class Notation)
FLIR	Forward-looking Infrared
FPP	Fixed-pitch propeller
GM	Metacentric Height
GT	Gross Tons
HMPE	High-modulus polythylene
IACS	International Association of Classification Societies
IBS	Integrated Bridge System

IMO	International Maritime Organization
kW	Kilowatt
LOA	Length overall
LT	Long Tons (Imperial Tons)
MBL	Minimum Breaking Load
MCR	Maximum Continuous Rating
m	Meter
MT	Metric Tons
nm	Nautical Miles
NRT	Net Register Tonnage
OSV	Offshore Support Vessel
PA	Public address
PFD	Personal Flotation Device
POVTS	Port Operations & Vessel Traffic System
PPE	Personal Protective Equipment
PTO	Power take-off
PWS	Prince William Sound
PWSRCAC	Prince William Sound Regional Citizens' Advisory Council
RA	Righting arm
RAL	Robert Allan, Ltd.
RPM	Rotations per minute
SASEMAR	Spanish Maritime Rescue and Safety Society (Sociedad de Salvamento y Seguridad Marítima)
SERVS	Ship Escort/Response Vessel System
SOLAS	International Convention for the Safety of Life at Sea
SRP	Schottel Rudderpropeller
ST	Short Tons
SWL	Safe Working Load
TAPS	Trans Alaska Pipeline Service
TSS	Traffic Separation Scheme
USCG	United States Coast Guard
VERP	Vessel Emergency Response Plan
VHF	Very High Frequency
VSP	Voith Schneider Propellers/Voith Schneider Propulsion
VTS	Vessel Traffic Service
WLL	Working Load Limit
XIP	Extra Improved Plow Steel

Abstract

The Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) retained Glosten under Contract No. 8012.21.01 to assess and describe the current worldwide best practices being used in the design and operation of highly capable rescue tugboats, develop a description of best available technology in way of rescue tugs, identify a towing vessel in the worldwide fleet that represents best available technology (BAT) for service at Hinchinbrook Entrance, and compare that vessel to *Ross Chouest*, the current Utility/Sentinel Tug serving Hinchinbrook Entrance. The conclusions presented herein are the product of Glosten's research, and the opinions expressed in this PWSRCAC-commissioned report are not necessarily those of PWSRCAC.

Glosten first reviewed the relevant background work and literature on the topic of emergency towing vessel design and discussed findings with Prince William Sound stakeholders at a roundtable meeting. Glosten then developed a set of size, performance, and equipment parameters for a rescue tug serving at Hinchinbrook Entrance and identified 17 candidate vessels in the worldwide towing vessel fleet with the potential to qualify as BAT for the subject application.

After collecting data on the 17 candidate vessels, Glosten quantitatively and qualitatively scored each candidate on a variety of relevant characteristics and parameters, ultimately identifying the Spanish emergency towing vessel *Luz de Mar* as the vessel best suited for the application.

Glosten concluded the study by performing a gap analysis comparing *Ross Chouest* to *Luz de Mar*, identifying several shortcomings in the current Utility/Sentinel Tug that could be improved by use of the *Luz de Mar* design, or one analogous to it.

Section 1 Introduction and Overview

1.1 Introduction

PWSRCAC contracted Glosten to perform the following scope of work:

1. Assess and describe current worldwide best practices used in the design and operation of highly capable rescue tugs.
2. Compare the resulting description of best practices to the Edison Chouest Offshore (ECO) anchor handling towing and supply (AHTS) vessel M/V *Ross Chouest*.
3. Identify and quantify gaps between *Ross Chouest* and BAT in way of rescue towing vessels.

Ross Chouest is currently under contract as the Alyeska Pipeline Service Company's Ship Escort/Response Vessel System (SERVS) Utility/Sentinel Tug (hereafter, "Hinchinbrook Tug" or "Hinchinbrook ETV") in Prince William Sound, and effectively serves as a dedicated emergency response vessel for tankers entering and exiting Prince William Sound.

1.2 Overview

Glosten's assessment proceeded through five successive interim deliverables, each of which makes up a section of this final report.

Deliverable A: Literature Review
Deliverable B: Definition of Hinchinbrook ETV Parameters
Deliverable C: Identification of BAT Design Standards and Equipment
Deliverable D: Comparison of Presently Used ETVs
Deliverable E: BAT Evaluation and Gap Analysis

Glosten completed and submitted these deliverables in sequence; as such, each section builds upon the last and represents an improvement on the knowledge gained in the creation of the previous. A narrative description of the major project milestones is provided below.

1.2.1 Review the Literature

Glosten performed a literature review on the topic of rescue tugs (Section 2), generally referred to as emergency towing vessels (ETVs) or emergency response and rescue vessels (ERRVs). The review was restricted to reports published within the last 10 years, except in the case of relevant older reports specific to the Trans Alaska Pipeline System (TAPS) and SERVS tugs operating in Prince William Sound. The reviewed documents included reports previously commissioned by PWSRCAC and regionally relevant reports such as the Clear Seas' Towing Needs Assessment for the Canadian Pacific Coast, but also international sources including multiple studies on ETV needs and methods of funding and procurement for the British Isles.

1.2.2 Identify Parameters and Create Towing Vessel Inventory

After reviewing the literature, Glosten engaged in a roundtable discussion with PWSRCAC and regional stakeholders (Reference 19), assembled an inventory of towing vessels in service worldwide (Reference 20), and developed ranges of operating, design, and performance parameters the Hinchinbrook ETV must meet (Section 3).

Glosten's worldwide towing vessel inventory drew from a variety of sources (outlined in Reference 21) and ultimately identified over 4,000 towing vessels in service worldwide. The parameter ranges Glosten identified provided a basis for filtering the inventory to the subset of best candidate vessels in the worldwide inventory. For example, filtering the initial list of over 4,000 vessels by the length, bollard pull, and build year parameters reduced the number of vessels under consideration to just over 400.

1.2.3 Identify BAT Design Standards and Equipment,

Glosten then developed a report further detailing the ETV design standards and equipment introduced in References 18 and 22, with the goal of producing a comprehensive discussion on the combination of design features and/or new technologies that would constitute BAT for a world class Hinchinbrook ETV(Section 4). This report, which investigated individual phases of an emergency towing operation, produced better detail on requirements for aft deck and stern arrangements, maneuverability characteristics, and areas in which design requirements for different phases compete with rather than complement one another, effectively requiring a balance to be struck.

1.2.4 Downselect Inventory

Glosten's next task was to identify the top echelon of modern ETVs in the worldwide inventory considered representative of BAT for ETV service at Hinchinbrook Entrance. Section 5 details the methodology used to downselect from over 4,000 towing vessels to 17 candidate vessels and provides an overview of each candidate vessel's characteristics.

1.2.5 Score Candidate Vessels and Perform Gap Analysis

Glosten evaluated and scored the 17 candidate vessels using an adaptation of the eight BAT evaluation criteria used by the Alaska Department of Environmental Conservation (ADEC), ultimately identifying the Spanish ETV *Luz de Mar* (pictured below) and its sister vessel *Miguel de Cervantes* as the vessels most representative of BAT for Hinchinbrook Entrance. Using the same scoring method, Glosten conducted a gap analysis of the *Ross Chouest*, identifying shortcomings or deficiencies that could be improved by the use of the identified BAT.

Figure 1 ERRV *Luz de Mar* (image courtesy of https://twitter.com/salvamentogob)

Section 2 Literature Review

2.1 Introduction

Glosten performed a literature review on the topic of rescue tugs, generally referred to as ETVs. The review was restricted to reports published within the last 10 years, except in the case of relevant older reports specific to the SERVS tugs operating in Prince William Sound. The reviewed documents included reports previously commissioned by PWSRCAC and regionally relevant reports such as the Clear Seas' Towing Needs Assessment for the Canadian Pacific Coast, but also international sources such as investigations of ETV needs and operating models for Australia, South Africa, and the British Isles.

The literature review showed that the term "ETV" is not consistently used to describe one vessel type but refers instead to a range of vessel types that may perform emergency towing as part of their operating mission, which may include other duties as well. Thus, ETVs can take many different sizes and forms, from relatively simple oceangoing tugs to highly complex 70–90 meter (m) multi-mission vessels. Despite this variability, what ETVs all share in common is, within a certain mission radius or area of service and within a range of limiting metocean conditions, the capability to establish a secure towing connection to a distressed, disabled, or otherwise affected vessel, turn it head-to-weather or other desired heading, and (at a minimum) arrest its free drift movement. The literature primarily defines ETVs operationally, rather than by describing a specific vessel type. In summary, an ETV is any vessel with mission requirements that include responding and rendering assistance to an oceangoing vessel that is disabled and drifting or otherwise at risk.

While the current body of work touching on ETV design is composed of a relatively small number of sources, it does include several detailed studies that help clarify the requisite vessel performance and standard equipment complement (generally) for emergency towing applications. References 5, 8, 11, and 42 were particularly informative with regard to preferred ETV characteristics and basic performance requirements, while Reference 16 provided an excellent overview of the equipment installed on board one particular ETV that represented the state-of-the-art circa 2011. The remainder of the works reviewed provided more general guidance, focusing in large part on bollard pull requirements for a given set of ship types and metocean conditions, or discussing different, but related vessel types such as tanker escort tugs. No detailed ETV design specifications were found, nor did much of the literature focus specifically on optimizing ETV design.

Robert Allan Ltd's (RAL) reviews for PWSRCAC on BAT for a Sentinel Tug stationed at Hinchinbrook Entrance (References 2, 3, and 8) provide important detail on bollard pull requirements for the subject application, and Reference 8 offers good discussion on additional desired characteristics for the Hinchinbrook Tug, focusing primarily on speed, bollard pull, seakeeping, maneuvering, and stability characteristics. RAL's *Summary of Current BAT Requirements for Escort and Rescue Towing Tugs* (Reference 42), lists specific design traits that, from RAL's perspective, constitute BAT for the Hinchinbrook Tug. Reference 40 also provides good discussion on desired ETV attributes, though not specific to the Gulf of Alaska region.

In summary, the literature provided a reasonable level of detail on general characteristics that are typical and desirable within the spectrum of ETVs, but little direct discussion on what constitutes BAT outside of bollard pull targets. RAL's work in References 8 and 42 is a notable exception, as it provides specific speed, maneuverability, range, endurance, seakeeping, and equipment parameters that the Hinchinbrook Tug should meet.

2.2 ETV Types

The literature distinguished between three vessel types in particular:

1. Smaller tugs such as harbor and ship-assist tugboats that may perform occasional emergency tows (generally not regarded at suitable for designated ETV service).
2. Large, oceangoing towing vessels designed to tow large barges and/or vessels at sea. This category of vessel technically includes standard ocean towboats that can serve as "tugs of opportunity," AHTS tugs, and purpose-built ETVs.
3. Even larger multi-mission or multipurpose vessels that incorporate rescue towing amongst a greater suite of design functions and capabilities.

2.2.1 Smaller Tugs (under 40m)

Notwithstanding the occasional emergency towing duties of smaller ship-assist and harbor tugs, the literature generally agreed that such tugs are not optimal for performing an open ocean emergency tows, particularly when metocean conditions are severe. Primary reasons for this include, but are not limited to:

- Comparatively poor seakeeping characteristics.
- Vessel motions that are unsafe/unmanageable for the crew to work safely and/or effectively.
- Lack of sufficient bollard pull.
- Inadequate equipment (particularly the winch).
- Loss of towing efficiency in waves.

Two of the reports noted that DNV-GL Offshore Standard H202 recommends against using tugs under 40m in length for open ocean tows in harsh conditions, providing a good minimum length parameter for an ETV.

2.2.2 Large Ocean Service Tugs

The second category of vessel discussed in the literature – a large, purpose-built towing vessel for ocean service – is the vessel type that appears to be most applicable to the subject of this study. Given that these vessels are designed explicitly for heavy ocean tows, this category forms the best selection set from which to identify state of the art ETV design trends and/or technologies. As noted above, relatively few vessels in this category are designed specifically to serve as ETVs, but most can still serve in this capacity when the need arises; and they will generally be more capable of doing so in rough conditions than smaller harbor or ship-assist tugs. The capabilities of large ocean service tugs far exceed those of a harbor assist tug, as does their capital and operating costs. However, as emphasized throughout the literature, the potentially devastating consequences of a vessel running aground may justify the costs to procure, crew, and operate a dedicated ETV of this type.

2.2.3 Large Multi-Mission Vessels

The third vessel type listed (large, multipurpose vessel) is of significantly greater capital and operating cost. However, the literature indicated that these vessel types are sometimes preferred outside of the US because their ability to perform other functions can be leveraged to procure funding and/or offset operating costs. Additional functions discussed in Reference 13 included marine salvage and firefighting, dive support, national sovereignty-related patrol, fisheries enforcement and research, or oceanographic research. Reference 13 further noted that military or coast guard vessels are increasingly used to fill this niche in many coastal states. Reference 5 mentioned two other vessel types that fit this third category (very large, multi-mission): deep sea salvage tugs and offshore vessels, including larger-scale offshore support vessels (OSVs) and AHTS vessels used commonly in the marine oil and gas industry.

While such vessels are generally designed with towing power and capability more than adequate to perform an openocean rescue tow, they are generally less optimized for coastal/nearshore emergency towing operations, where both time and sea room may be in critically short supply. As a result, this category of vessel does not lend itself to close consideration in a BAT investigation focused on nearshore emergency towing for a particular subset of Suezmax tank vessels.

2.2.4 Summary of Vessel Type Findings

Vessel size (namely overall length) is a convenient initial indicator of emergency towing suitability and serves to distinguish between the three broad categories of emergency towing capable vessels listed above. Within the size class of towing vessels above the 40-meter threshold, the literature discusses a number of characteristics and capabilities that distinguish a standard ocean capable tug from one optimized to perform high stakes emergency towing duties in adverse conditions.

Throughout the literature, the driving case for determining ETV performance and outfitting requirements is a worst-case or near worst-case tow; that is, the vessel type/class requiring the most towing force to arrest in a given operating area, drifting in a given worst case metocean condition (typically 95th or 99th percentile). There was general agreement within the literature as to the many challenges this type of rescue operation poses and the primary vessel capabilities needed to meet these challenges. An overall narrative description of an emergency tow sequence and its corresponding challenges, distilled from the literature, would be as follows (see also the BAT Design Standards and Equipment section).

To successfully execute an emergency tow under worst case weather conditions outside of protected coastal areas, an ETV must contend with dangerous winds and high seas while transiting (at highest achievable speed) and upon approach to the affected vessel. Once close enough to the affected vessel, and after conducting a visual assessment of the situation, the master may attempt to establish a towing connection. To accomplish this safely, the ETV must be maneuverable enough to make a stern-first approach and maintain its position relative to the affected vessel while contending with wind, wave forces, and the relative motions of the two vessels. As the master endeavors to hold position, the ETV's crew must be able to work safely and effectively on the exposed aft deck of the ETV. They must have appropriate towing gear at the ready and the deck machinery necessary to handle it safely and deploy it. Once the connection is made, the ETV must be powerful enough to turn the drifting vessel into the direction of the wind and waves and fully arrest its movement downwind, or at least slow its progress enough to prevent grounding while waiting for conditions to abate. The towing winch and all components of the towing system must be designed to withstand dynamic loads resulting from the towing force of the tug, acting in concert with the wave-induced motions of both vessels.

The section that follows presents a list of the vessel characteristics and capabilities the literature indicates an ETV must have to perform these duties successfully.

2.3 Summary of Capabilities

Broadly speaking, there is consensus in the reviewed body of work that in order to respond effectively to an oceangoing vessel in heavy weather offshore, an ETV must have:

- Sufficient free running speed to reach the affected vessel in time to prevent a casualty.

- The ability to make headway in heavy seas while steaming toward the affected vessel.
- Good seakeeping characteristics for safe operation in heavy weather and to allow the crew to make up a towing connection to the affected vessel in a timely manner.
- Excellent maneuvering/stationkeeping capabilities in order to maintain position relative to the affected vessel.
- All equipment necessary to establish a towing connection safely, efficiently, and reliably to the affected vessel.
- Bollard pull sufficient to arrest the drift of the affected vessel (at minimum).
- Towing equipment (both towing gear and deck machinery) able to handle dynamic towline loads experienced during the towing operation.
- Sufficient range and endurance to intercept the affected vessel and tow it to safe harbor, or until the ETV is relieved by a commercial salvage vessel.
- Crew with adequate training, experience, and numbers to accomplish the mission.

The next section explores the vessel characteristics, desired performance, towing gear, and ancillary equipment that the literature identifies as best providing the above capabilities. The range of sizes, superstructure arrangements, propulsion systems and towing capabilities, and optional deck equipment presented herein served to inform a roundtable discussion with PWSRCAC, regional stakeholders, and members of industry, to clearly define the operating mission of the Hinchinbrook ETV.

2.4 ETV Equipment and Characteristics

Optimal ETV characteristics and performance requirements cannot be identified in the absence of a definitive operating profile. The operating profile is defined by existing vessel types and traffic patterns, site climatology, best industry practices, regional navigation restrictions, desired geographic coverage, required response time, and risk profile.

For purposes of the Hinchinbrook ETV, these details were ultimately refined in the roundtable discussion. Where helpful in narrowing the focus of this literature review, however, general Hinchinbrook ETV parameters known at the time of this report were taken into consideration.

In the sources reviewed, several recommended various complements of emergency response equipment not directly related to emergency towing operations, such as marine salvage and firefighting equipment and oil/hazardous materials spill response and recovery equipment. These are discussed briefly because, while they may be advisable to include in a particular ETV's equipment complement, they are considered ancillary to an ETV's core emergency towing function. Additionally, as noted above, few sources reviewed provided detailed lists of desired or optimal vessel characteristics or equipment, with References 5, 11, 16, and 42 being notable exceptions.

Table 1 provides a very high-level matrix of key ETV equipment, attributes, and characteristics gleaned from the literature review. These items are organized according to the step under which they fall in an emergency towing evolution.

Table 1 ETV attribute and equipment matrix

Step	Description	Key ETV Capabilities	Equipment & Characteristics Involved
1	Transit to affected vessel in heavy weather	Free running speed (generally 15-20 knots), seakeeping, range	Length, bow form, propulsion type, hull appendages, superstructure design
2	Approach affected vessel and maintain position alongside	Seakeeping, maneuvering, station-keeping	Length, bow form, hull appendages, anti-roll systems, navigation suite
3	Make up towing connection to affected vessel	Seakeeping, maneuvering, working deck safety, gear handling, crew training	Omni-directional thrusters, freeboard, stern/aft deck geometry, towing equipment, line throwing devices, line handling equipment, winches
4	Take affected vessel under tow	Bollard pull, endurance, load management	Ducted propellers, tankage, winch package
5	Arrest drift for duration required to prevent casualty	Range, endurance	Tankage, ship's stores

2.4.1 Principal Dimensions

A vessel's principal dimensions include its length, breadth, and draft (depth below the waterline). The final values of these dimensions are a function of tankage requirements, desired arrangements (including accommodations for crew rescued from the affected vessel), hull form considerations for improved seakeeping and towing efficiency, aft working deck layout, and numerous other design considerations. Some of the most relevant design considerations, expressed consistently in the body of work reviewed, are discussed individually below.

Reference 15 provided a detailed table of vessel particulars for a concept South African ETV, including principal characteristics and numerous other relevant aspects. The author generated these characteristics using a design model that rapidly prototypes a concept design by iteratively determining necessary vessel characteristics.

Table 2 Concept South African ETV characteristics (reproduced from Reference 15)

Length OA	*87.17*	*m*
Length PP	74.95	m
Beam	14.25	m
Draft	7.36	m
Depth	8.40	m
# propellers	2	-
Propeller diameter	4.78	m
Bollard pull	213	ton
Stability (GM)	4.05	m
Speed	20.2	kts
Speed 10 Bft.	13.6	kts

Displacement	*5404*	*ton*
Lightweight	3078	ton
Deadweight	2331	ton
Fuel capacity	1967	ton
Fresh water	83	ton
Range	17500	Nm
Power	11605	kW
Electric power	2025	kW
Fire fighting	Fifi 1	-
Survivor capacity	20	-
Accommodation	13 + 10	cabins

No other source in the literature surveyed provided equivalent in-depth detail, but several sources did identify ranges within which ETV principal dimensions should fall. References 5 and 11 note that DNV Offshore Standard H202 recommends a length of greater than 40m for vessels performing open ocean towing in adverse conditions. Reference 11 goes on to provide rule of thumb values for all three principal dimensions. Reference 5 provides a high-end estimate for length only, noting the length of two recent deep sea towing and salvage tug newbuilds with substantial towing capability (at 300 tonnes bollard pull). Reference 42 provides a length range specifically for a Hinchinbrook ETV.

Table 3 summarizes the range of dimensions gleaned from these sources. It should be noted that the difference in the values below is extreme, with the length on the upper end being more than twice that of the lower end (a 50m spread). This table serves primarily to illustrate the high degree of variability in ETV design. These references may incorporate different assumptions due to the different intended areas of service they discuss.

Table 3 Typical ETV principal dimensions

Source	Ref #	Length (OA)	Breadth	Draft	Description
DNV-GL	5, 11	>40m	-	-	Minimum recommended length
RAL	42	50-52m	-	-	Hinchinbrook Tug recommended length
London Offshore Consultants	11	60-70m	15-16m	~6m	Estimate for typical ETV
Clear Seas	5	90m	-	-	High end estimate; deep sea towing and salvage tugs

2.4.2 Installed Power

2.4.2.1 Bollard Pull

Bollard pull (BP) is an industry standard measure of vessel towing power. Simply stated, it is a measure of the towing force a vessel is able to exert through its towline on a bollard fixed in place on shore. Because the bollard is fixed in place, bollard pull is a zero-speed value. Bollard pull is among the attributes that would typically be specified for a tugboat in the design phase as it is an important metric in determining the types of duties a tugboat can perform. Bollard pull is, of course, an extremely relevant parameter for an ETV given its primary duty of executing heavy ocean tows, and as such was discussed extensively in the literature.

ETV bollard pull values are discussed in more detail than are principal characteristics in the literature. This is in part simply because towing power is one of the overriding and most important aspects of ETV performance, along with speed and maneuverability. It is also true, however, because the analytical means exist to identify target numbers for this aspect of vessel performance. References 3, 4, and 5, for example, examine ETV bollard pull requirements for specific regions of interest by profiling specific vessel types that transit through their respective subject areas. Using site climatology data and vessel hydrodynamic characteristics, these studies determine the towing force that must be exerted to turn and arrest the drift of these vessels under severe, worst-case metocean conditions. Over the full set of vessel types investigated, the type requiring the greatest towing force becomes the driving case for establishing a minimum bollard pull requirement for the subject ETV. As noted in Reference 5, the bollard pull rating for a tug is measured statically in calm seas, so an efficiency loss factor must be applied to determine bollard pull performance in the heavy weather conditions in which a worst case emergency tow would actually take place.

To provide a sense of the availability of existing towing vessels meeting various bollard pull parameters, the below is excerpted from Reference 12, which classified tugs of opportunity on Canada's Pacific coast by bollard pull. The study placed tugs in four categories as follows; for bollard pull upwards of 90 metric tons (MT, the number of available tugs drops precipitously:

1. All tugs present in Canada's Pacific Region in 2016 for which bollard pull or horsepower was known. Data were insufficient to estimate bollard pull for 47 tugs, but all of these were less than 150 GT and 30 m in length and thus likely not suited to emergency towing operations. Sufficient data were identified to estimate the bollard pull of 232 tugs.
2. 50 metric tons (MT) or greater includes the minimum bollard pull required for an emergency towing vessel (ETV) as mandated by Washington State. Previous examinations of emergency towing needs for the region have concluded that tugs with less than 60 MT of bollard pull are unlikely to be suitable for emergency towing. Of the 232 tugs in the first category, 76 were included in this second category.
3. 70 MT or greater represents the minimum bollard pull required to respond in sustained winds of 21 knots (93rd percentile weather conditions) as determined by Robert Allan Ltd. (2013). This category included 35 of the 76 vessels greater than 50 MT.
4. 90 MT or greater represents the tugs with the highest bollard pulls active in the Pacific region, and those most likely to be able to provide effective rescue assistance. This category included 12 of the 76 vessels examined. (directly quoted from Reference 12).

Table 4 provides a sample of the range of recommended bollard pull capacities given in the reports reviewed. These should be taken as representative rather than indicative, as they depend very much on the climatological particulars and expected ship types that characterize the regions of interest, as well as on the varying assumptions included in the analyses reported on. Values reported from Reference 6 are taken from a summary table in which results of other reports were shown.

Table 4 ETV bollard pull characteristics

Source	Ref #	BP (MT)	Region	Driving Case
Clear Seas	5	>220	Canada Pacific Coast	Very Large Container Ship
London Offshore Consultants	11	132	NW Scotland	Various
UK Maritime and Coast Guard Agency	11	165	Not listed	Not listed
Robert Allan Ltd.	2	185	Prince William Sound and Gulf of Alaska	193,000 DWT tanker
San Francisco Harbor Safety Committee	6	90-125	Alaska	265,000 Ton Tanker
San Francisco Harbor Safety Committee	6	120	South British Columbia	265,000 Ton Tanker
San Francisco Harbor Safety Committee	6	220	North British Columbia	265,000 Ton Tanker
San Francisco Harbor Safety Committee	6	125	UK	265,000 Ton Tanker
Glosten	17	120	Aleutian Islands	675,930 BBL Tanker, 7,500 TEU Class Container Ship

2.4.2.2 Power Plant

There was surprisingly little discussion in the literature about the type of power plant that should be installed on board an ETV. Reference 5 does note that a diesel-electric power plant may be desirable over a diesel mechanical power plant due to the increased flexibility it can provide in terms of machinery location and equipment electrical load handling. Within the realm of diesel-electric plants, a wide range of configuration options exists that will be evaluated and discussed in more detail in a later section of this report.

2.4.3 Propulsors

Maneuverability is a key consideration in ETV design, as the ETV operator must maintain close but safe proximity to the affected vessel while the crew makes up the towing connection (the ability to maintain position and heading relative to another vessel is known as stationkeeping). Maneuverability is determined in large part by the propulsion system type and arrangement. The literature generally agreed that the ability to control the direction of thrust produced by the propulsors is highly desirable in a range of emergency response scenarios, as it allows for enhanced vessel handling. Directional control of thrust can be achieved via the main propulsors as well as by lateral or omni-directional bow and/or stern thrusters.

References 8 and 42 recommend a specific maneuverability parameter for the Sentinel Tug:

> To satisfy BAT, a Sentinel Tug should have omni-directional propulsion and be able to execute a zero speed, 360° turn within no more than 110% of its own length, and within no more than 60 seconds (Reference 8).

2.4.3.1 Main Propulsors

Main propulsors should provide excellent directional steering capability and low speed power. In multiple sources, azimuthing thrusters, which can rotate 360º in the horizontal plane, were recommended to achieve the former, while ducted propellers, which improve propeller efficiency by conditioning the inflow of water, may improve the latter. Both azimuthing and conventionally-shafted propellers may be ducted. Generally speaking, propeller ducts, or “nozzles,” do increase high-speed resistance, potentially reducing an ETV's free running speed, but the tradeoff may be worthwhile, particularly in circumstances where lower free-running speed can be compensated for by increasing the ETV's effective mission radius.

A few vessels described in the literature were noted to have controllable pitch propellers (in Reference 16, for example), while Reference 5 simply stated that ETVs may have either fixed or controllable pitch propellers. Reference 42 states that the Hinchinbrook Tug should “have any type of propulsion system which in combination with lateral thrusters would satisfy the requirements for maneuverability and position-keeping” but goes on to suggest that, in order to satisfy BAT, an omni-directional drive system that incorporates some form of "tractor" configuration (namely VSP, Z-Tractor, or Rotor Tug) should be considered due to better maneuverability, safer towing characteristics, and less loss of effectiveness in heavy seas (Reference 42).

Other propulsor options that may warrant investigation for the Hinchinbrook ETV, such as Voith Schneider Propellers (VSP), were mentioned in Reference 8, which states, “the operational advantages of having omni-directional propulsion such as Voith Propellers or Z-drives are so significant that they cannot be ignored and should be an essential feature of a dedicated rescue tug today; essentially the Best Available Technology for this task” (Reference 8). These propulsor options are further investigated in later sections of this report, as they have the potential to provide unique advantages that warrant consideration as BAT.

2.4.3.2 Bow Thruster

Several references recommended the incorporation of a bow thruster, particularly on longer ETVs. Bow thrusters provide improved maneuvering in close quarters and may be configured to provide dynamic positioning capability as well, by providing a means of producing lateral or omni-directional thrust near the forward end of the vessel. Bow thrusters may either be of tunnel type (i.e., housed in an open, transverse tunnel at the forward end of the vessel) or retractable type (i.e., housed within the hull but deployed by lowering). For ETVs outfitted with conventionally shafted propellers, stern thrusters may be utilized to enhance maneuverability in close quarters.

2.4.4 Hullform and Seakeeping

Hull and superstructure geometry, acting in parallel with the vessel's propulsion system, largely determines how a vessel will perform in a seaway. Its overall length and beam, block coefficient, and hull fairness all have an effect on stability, the ability to resist wave-induced motions (seakeeping), and the resistance it must overcome as it propels itself through the water. It is important to note that a towing vessel's stability is driven in large part by bollard pull requirements which, as beam is increased to add/enhance stability, can have an adverse impact on vessel speed.

In addition to many general seaworthiness and stability requirements already noted, an ETV's hull form must serve to:

- Enable the vessel to make headway in heavy wave conditions with minimal pitching and bow slamming.
- Keep the propellers immersed and working as efficiently as possible in seas.
- Keep the vessel from boarding seas, which if sufficiently severe can downflood into vents and spaces, break wheelhouse windows, or completely inundate the working decks.
- Maintain positive stability in conditions that could cause extreme rolling.
- Minimize motions in waves to the extent needed to enable the crew to work safely and efficiently.

As noted previously, vessel length, bow form, and freeboard were discussed in the literature as parameters of primary importance for meeting ETV performance requirements.

Reference 16 profiles the *Nordic*, a German ETV that entered service in 2011. It notes the following hull form characteristics.

> A hull form was chosen which incorporates a prominent bulbous bow with a considerable flare, and a forecastle two decks high and extending aft to beyond amidships. This combined with a sheltered after deck, with high bulwarks and an enclosed, rounded stern, enables the vessel to operate at high speeds in rough weather conditions and affords a safer working environment when making a towing connection (Reference 16).

Reference 5 notes that an inverted bow design, generally referred to as X-bow, may reduce vessel pitching motions in heavy seas, but that this design diminishes forward working deck area, which is crucial for recovering pick-up gear/fixed emergency towing systems off the stern of a vessel. Higher freeboard generally results in drier working decks, which in turn improves crew performance and safety; but this also increases sail area and may exacerbate vessel motions for crewmembers on deck.

The literature does note that additional measures can be taken to improve seakeeping beyond the capabilities intrinsic to a vessel's hull form. An aft skeg, for example, may provide increased directional stability in seas. References 5 and 10 recommended incorporating bilge keels to dampen roll motions. Reference 5 also notes that an anti-roll tank, which counteracts vessel roll by using a system of baffles to trap a volume of water on the high side of the vessel as it rolls, may be advisable.

2.4.5 Range, Endurance, Speed

2.4.5.1 Free Running Speed

An ETV must have adequate free running speed to transit to an affected vessel in time to effect a rescue. While clearly an important attribute, the literature characterizes free running speed as secondary in importance to characteristics such as towing power (bollard pull) and seakeeping. The sources reviewed did not prescribe minimum free running speeds. In general, however, the literature tended to show free running speeds in the range of 15-20 knots.

2.4.5.2 Endurance and Range

A vessel's endurance is the number of days it can operate before depleting onboard consumables (fuel-oil, lube-oil, potable water, provisions, etc.) or exhausting waste storage capacity. An ETV may, depending on its operating area and several other factors, remain at sea with the affected vessel in tow for several days or even a week or more. Most are also required to remain on station (standing by) for weeks at a time without re-provisioning, sometimes in very remote areas. As a result, endurance becomes an important design attribute in ETV design, generally.

Whereas endurance refers to the length of *time* a vessel can operate before running out of fuel, provisions, etc., range refers to the *distance* in nautical miles that a vessel can travel before all fuel-oil is consumed. To achieve a desired operating range, a vessel must have adequate capacity or “tankage” for the required quantity of fuel (plus safety margin), which is often a primary design driver. That noted, range is of less importance for this investigation than endurance, as the Hinchinbrook ETV has a mission radius of 30 nautical miles, as identified in Reference 3. The operating mission radius was later redefined as 200 nautical miles in the PWSRCAC roundtable discussion, but endurance remains the more important metric for this application.

Reference 11 includes as an appendix a Statement of Requirements for provision of an ETV published by the UK Maritime and Coast Guard Agency (MCA). This list includes the requirement that the ETV be able to "operate continuously at sea for no fewer than 10 days at the maximum rate of consumption." Little else was found in the literature in way of specific range and endurance recommendations, although endurance was noted to be an important attribute in several reports. The lack of specificity may be due to variability in ETV operating profiles, as well as the large number of unknowns that characterize any heavy weather emergency towing effort. Variables include: the size and condition of the affected vessel, total distance to intercept, time required on-scene, standby time for conditions to abate, total distance to the destination to which the vessel is to be towed, and changing weather conditions.

2.4.6 Deck Machinery and Layout

It was noted throughout the literature that the winch package on an ETV must be able to withstand dynamic loads resulting from wave induced motions on both the tug and the vessel in tow. Reference 5 simply recommends a constant-tension, or “render/recover” type winch, while Reference 11 recommends a waterfall type winch. Both winch types offer certain operational advantages and disadvantages which will be discussed in detail in later sections.

With a few exceptions, details in the literature on optimal deck layout were scant aside from general recommendations for efficient and flexible layout with ample open deck space. Reference 11 recommends incorporating heavy weather safety lines and guardrails to increase crew safety, while Reference 16 notes that the new German ETV *Nordic* incorporates a large, grating-covered channel at the forward end of the working deck to help shed water more quickly.

2.4.7 Towing and Line Handling Gear

Reliable, easily deployable, high performance towing gear is crucial to establishing a towing connection in a safe and timely manner, and once established, ensuring that it does not separate from the vessel under tow. The following basic rescue tug complement is quoted (and thus not edited or converted to metric) from Reference 6, although it was not noted what bollard pull this equipment is sized for (the list below is quoted directly):

1. 600' of 8" polypropylene float line;
2. a line throwing gun;
3. 1 ea 150' x 2 ¼" wire pendants;
4. Orville Hook or special towing shackle which could choke the ship’s anchor chain;
5. 250’ X 14" nylon shock line;
6. 400’ X 1¼" wire (Reference 6).

Reference 11 provides a similar although less basic complement (the list below is quoted directly):

- Main and spare towing wire 1000m - 1500m;
- Synthetic rope stretcher and spares;
- Fore runner wire towing pennants;
- Dyneema pendants;
- Tow chain bridle with ancillary equipment;
- Connecting shackles with adequate SWL against bollard pull;
- Light and wide bodied “D” type shackles;
- All towing wires, stretchers and pennants to be fitted with hard eye thimbles;
- Adequate spares;
- Line throwing equipment, light and heavy messengers. (Reference 11)

As noted in Reference 5, International Maritime Organization (IMO) regulations require tankers to be provided with dedicated strong points for towing on deck, but other vessel types may not have towing fittings of similar strength. The risk for vessels not outfitted with such strong points is that deck fittings and/or their supporting structure may fail under load. As a result, it may be advantageous for ETVs to carry towing gear that can distribute the load to a greater number of connection points on the deck of the affected vessel. Samson Rope's EVATS system provides one such application.

2.4.8 Navigation Suite, Bridge Equipment, and Communications

2.4.8.1 Dynamic Positioning

While having dynamic positioning (DP) capability is useful in certain circumstances, often the urgency and time-sensitive nature of a nearshore rescue effort, or the severity of conditions at the time, precludes the use of a DP system for emergency towing purposes. There was surprisingly little on this topic in the body of work reviewed. Reference 5 did note the following, however:

> Taking up a tow does not require true DP capability, but the same attributes are very useful in allowing the towing vessel to maintain station and adjust heading while line handling or recovering lifesaving equipment. (Reference 5)

Interestingly, in Reference 42, RAL makes no mention of DP capability as being recommended for the Hinchinbrook Tug. This topic is discussed in more detail in the sections that follow.

2.4.8.2 Bridge and Comms Equipment

Reference 11 recommends the following bridge and communications equipment (directly quoted):

Bridge equipment and passage planning

- Compliance with SOLAS V Safety of Navigation;
- ECDIS type approved with duplicate back-up system and TotalTide overlays;
- 3cm and 10cm ARPA radars;
- Automatic pilot;
- Log speed indicator;
- CCTV monitoring of hazardous areas.

Communications equipment

- Compliance with SOLAS IV radio communications;
- Satellite communications for telephone and internet access;
- Suitable communications equipment to act as On Scene Commander;
- Intrinsically safe portable VHF handsets for deck and boat operations;
- Mobile phone;
- Upper tannoy covering all decks audible in bad weather. (Reference 11)

2.4.9 Crewing and Accommodation

Reference 11 recommends a crew complement of at least 10 on board an ETV, including the Master and two watchkeepers in the Bridge, a Chief Engineer and one watchkeeper for the Engine Room, four deck crew, and one crew member for the Mess. Multiple sources recommended extensive crew training, including but not limited to live exercises, simulated rescues, and best practices training through maritime academies or regulatory bodies, although Reference 5 noted that little existed at the time of its writing in way of official ETV crew certification via regulatory bodies or classification societies.

Crew personal protective equipment (PPE), apart from lifesaving equipment required by flag state rules and the International Convention for the Safety of Life at Sea (SOLAS), should include personal floatation devices (PFDs) and waterproof extreme cold weather gear suitable for heavy rain, freezing conditions, and heavy spray. Extreme cold weather gear is particularly crucial for deck crew, who may face prolonged exposure to hazardous conditions while working on the aft deck to make up a towing connection to an affected vessel.

Reference 11 states that an ETV should have sufficient accommodation to house some number of crew evacuated/recovered from vessel in distress.

2.4.10 Miscellaneous Equipment

A vessel disabled in heavy weather is subject to many dangers besides grounding. These dangers include, but are not limited to:

- Shipboard fire.
- Parametric rolling.
- Extreme wave heights causing excessive stresses and potential structural failures.
- Shaft line failure or other cause of flooding.
- Loss of stability causing immediate threat to the vessel and crew.
- Cargo damage/loss.

The literature discussed various other ETV design considerations for rendering aid to a vessel in such circumstances, including high-capacity firefighting systems, onboard salvage gear/equipment, helicopter landing pads and/or designated pick areas, sophisticated towing winches, and onboard dive support systems. The collective interest in such systems and capabilities for the Hinchinbrook Tug was later discussed at the PWSRCAC roundtable discussion and clarified in Reference 22.

2.4.10.1 Oil Spill Response

It is often desirable to equip an ETV to respond to a non-towing or ancillary emergency by outfitting it with firefighting capability and/or oil spill response equipment. In the event that a grounding has already occurred or cannot be prevented, this equipment could be used to mitigate the resultant risks to life, property, and the environment. An ETV's complement of oil spill response equipment can prove crucial in the initial response and containment of oil released into the environment.

2.4.10.2 Lifesaving

Standard lifesaving gear complement, according to Reference 11, should include the following (quoted directly):

- Compliance with SOLAS III Life-saving appliances and arrangements;
- Type approved davit launched rescue boat protected from heavy weather;
- Jason’s Cradle;
- Rescue Strop and stretchers;
- Safe means of access for emergency rescue with suitable illumination;
- Additional lifejackets, immersion suits and thermal protective aids;
- Emergency clothing;
- Additional food and potable water;
- Medical facilities suitable for rescued personnel. (Reference 11)

Section 3 Hinchinbrook ETV Parameters

3.1 Introduction

PWSRCAC's Port Operations and Vessel Traffic Systems (POVTS) Committee believes that adopting the highest standards representing use of BAT for rescue ETVs represents a true chance to implement a preventive measure that will reduce the likelihood of crude oil spills in Prince William Sound and the Gulf of Alaska. To that end, Glosten assessed and described the current worldwide best practices being used in the design and operation of highly capable rescue tugboats. Using the resulting description of best practices, a comparison was made with the AHTS tug *Ross Chouest* and any gaps in use of this technology were identified.

During the literature review (Section 2) and in the subsequent stakeholder meeting (Reference 19), it was established that the range of candidate vessels and vessel designs to be evaluated as BAT must be reduced. As shown in the ETV Inventory Glosten assembled (References 20 and 21), many of the vessels currently serving as dedicated ETVs worldwide far exceed the size, complexity, cost, and towing power necessary and/or feasible for the Hinchinbrook Tug, and the list of tugs not specifically designated ETVs but with sufficient bollard pull to satisfy the mission requirements is extremely long. To provide a focused comparison of the most appropriate vessel designs, the selection set needed to be narrowed. To achieve this, a clear understanding of the Hinchinbrook Tug's intended operating mission was needed.

3.2 Hinchinbrook Tug Operating Mission

The Hinchinbrook Tug is defined in Section 2 of the Vessel Emergency Response Plan (VERP) (Reference 1), as "a vessel capable of ocean escort and rescue service." This section further states, "the vessel is underway in the vicinity of Hinchinbrook Entrance to provide assistance as a sentinel escort for tankers in ballast transiting Hinchinbrook Entrance, and laden tankers transiting into or out of the Gulf of Alaska within 17 miles seaward of Cape Hinchinbrook." Section 5.2 of the VERP outlines the required movements of the Hinchinbrook Tug during normal tank vessel operations, which involves being underway between Cape Hinchinbrook and 17 miles to seaward as outbound tank vessels transit this area and enter the Gulf of Alaska. It is noted that escorting ballasted (inbound) tank vessels in this area is not required in the language of the VERP, and in any case, the Hinchinbrook Tug is permitted to seek a lee (i.e., stand by) during severe weather conditions. The VERP also states, "in the event of a steering and/or propulsion failure, the tanker master shall immediately order the Hinchinbrook Tug to proceed to the tanker's location."

We infer from this language that the primary function of the Hinchinbrook Tug is to be underway and near-to outbound tankers as they exit Prince William Sound and begin their ocean transit, such that the tug can respond quickly to a steering and/or propulsion system failure in this open water environment and work effectively to prevent a grounding or other casualty. We assume, though it is not directly stated in the VERP, that the Hinchinbrook Tug would also be called upon to respond to an affected tank vessel, inbound or outbound, beyond the 17 nautical mile distance from Cape Hinchinbrook. While there is mention in the VERP that the Hinchinbrook Tug may also serve as a "Secondary Escort for laden tankers transiting through Hinchinbrook Entrance," it is clear that the vessel is not intended for tanker escort service in the strict sense (applying steering and/or braking forces at speed using the indirect mode), but rather as an emergency towing vessel capable of taking an affected tank vessel in tow. There is no language in the VERP requiring, or even discussing, other functions or capabilities for the Hinchinbrook Tug (e.g. spill response and recovery, firefighting, dive support, etc.) nor any mention of a broader mission to serve as a salvage tug for the Gulf of Alaska region. We also assume, in the event that the Hinchinbrook Tug were to take an affected tank vessel in tow, it would *not* be expected to actually tow (transport) the stricken vessel to a specific port for repairs, but only to control the vessel's heading and, if necessary, gain sea room to reduce the probability of a casualty. Maintaining the integrity of the towing connection far outweighs the need to achieve a certain speed through the water. Ultimately, once the tank vessel's response plan is activated, a commercial salvage tug would be dispatched to relieve the Hinchinbrook Tug and transport the vessel to its final destination.

Based on the above interpretation of the VERP, and following our review of previous analytical work performed in relation to the Hinchinbrook Tug, we understand the primary operating mission of the Hinchinbrook Tug to be as follows:

The Hinchinbrook Tug is intended to serve as an actively crewed standby ETV for rapid deployment to the aid of a tank vessel that has become disabled or otherwise not under command in the Gulf of Alaska, within an approximate 200 nautical mile radius from Cape Hinchinbrook. The Hinchinbrook Tug shall be capable of safely and efficiently transiting to the scene at high speed in closure conditions, where its primary responsibility is to take measures to reduce the probability of loss of life or property and of damage to the environment, namely by taking the vessel in tow, controlling its heading, and towing it in a manner that stabilizes the situation and reduces extant risks until it can be safely relieved or otherwise directed.

3.3 Design and Performance Parameters

Given this interpretation of the Hinchinbrook Tug's operating mission, Glosten selected the parameter ranges below as the constraints vessels and vessel designs must fall within to be considered candidates for BAT evaluation.

Table 5 Hinchinbrook ETV parameters

Parameter	Range	Notes
Dimensions		
Length Overall	40-80 m	Adequate DP required if over 60m.
Length at Waterline		No range required
Beam		No range required
Hullform and Stability		
Displacement		No range required
Metacentric Height (GM)		No range required
Aft Freeboard	Lower limit = larger of B/10 or 4' (1.2m)	Variation with L and B makes a range difficult to define; higher is better for this application
Bow Form (X, Axe, Conventional)		All acceptable but considered in relation to other design elements/parameters herein
Bow Bulb		Considered in context with bow form, but generally preferred
Bilge Keels or Other Anti-Roll Systems		Preferred, but not required
Aft Bulwark Height		Sufficient height for crew safety but low enough to allow visibility over the side; 4-5 ft. high

Parameter	Range	Notes
Powering		
Free Running Speed	Not less than 12 knots at full load	
Range & Endurance	Minimum 3,000 nm / 14 days	
Propulsion Machinery (Bow and/or Stern Thrusters)		Some form of directional thrust in bow is required; stern thrusters not required but will be considered in relation to other design elements/parameters if present
Primary Propulsion Type (VSP, ASD, Tractor / Reverse ASD, Rotor-Tug, Conventional)		All acceptable, but considered in relation to other design elements/parameters herein
Ducted Propellers / Nozzles		Both acceptable, but considered in relation to other design elements/parameters herein
Bollard Pull	Not less than 120 MT. 185 MT considered practical maximum, but higher bollard pulls are considered	No advantage to be afforded for specific propulsion types (for example, a tractor with marginally less BP than a competing ASD design will not be considered equivalent in terms of BP)
Brake Horsepower	Not less than 10,000 BHP	Considered if certified BP not available
Fuel Oil Capacity		Considered if range data not available
Towing		
Towing Equipment		Waterfall or double-drum tow winch configuration required, with constant tension (render/recover) functionality preferred
Deck Machinery / Equipment		Prefer no A-Frame or large deck cargo cranes aft; small stores cranes and davits acceptable
Other		
Dynamic Positioning System		If LOA <60m, DP not required but considered advantageous; if LOA >60m, DP required
Dive / Subsea Support Systems, Oil Recovery & Storage Systems, Other Special Systems		Will be regarded as deleterious/unfavorable to the operational and cost feasibility of the tug
Accommodations (Number of Berths)	Minimum 12 berths, plus adequate space for rescued vessel crewmembers	
Firefighting & Safety Equipment	FiFi 1 or higher preferred	Must have or be possible to outfit with fire monitors
Anchor Arrangement		Required
Heated Decks / De-icing Gear		Not required, as most designs can be outfitted if necessary

3.3.1 Notes on Bollard Pull

3.3.1.1 BP Parameters

The Hinchinbrook Tug is required to rescue a 193,000 deadweight ton (DWT) Tanker, fully loaded or in ballast, in closure conditions. Forces are for turning and towing from the bow and allow for yawing of the tow. Reference 3 sets a maximum requirement of 185 MT, with the caveat that wave heights have been increased 20% from condition at seal rocks to account for wave sheltering in that location.

The minimum parameter used for this study assumes a 45 knot wind and a one knot towing speed. While the 185 MT parameter identified in Reference 3 is considered a practical upper limit, no maximum bollard pull parameter was enforced, as the maximum vessel length parameter of 80m ultimately limited the set of vessels considered to a reasonable upper BP limit.

3.3.1.2 US Coast Guard (USCG) Towline Stability Criteria

The Hinchinbrook Tug ultimately must be US flagged and must meet US stability regulations. The US towline pull requirements contained in US Code of Federal Regulations 46CFR 173.095 are of particular interest in this regard. These requirements compare a tug's stability to a heeling arm defined by the bollard pull and the distance from the propellers to the tow point. There are two forms, a GM calc limited by deck immersion, and a residual area between the heeling arm curve and the righting arm (RA) curve limited by max RA, downflooding, or 40 degrees. The original regulation is set up for standard propellers and assumes thrust at 45 degrees. There is a modification contained in the USCG Marine Safety Manual for azimuthing drives (Reference 23), specifically for VSP drives but often used for Z-drives, which uses 2 times the bollard pull for the heeling force.

There is no equivalent IMO criterion. Historically, class societies had towline pull criteria in their rules, but they were all somewhat different in heeling force requirements and application details. None were or are as stringent as the US criteria.

There is now an International Association of Classification Societies (IACS) agreement between class societies on applying a consistent towline pull criteria (Reference 24). The residual area between heeling and righting arms curves is compared as above but uses 70% of the bollard pull. The 70% thrust corresponds to a thrust direction of 45 degrees, cos(45) = 0.71. Also notable is that the required residual area is much higher than the US criteria but is not limited by max RA, downflooding, or 40 degrees.

It is not possible, within the scope and information limitations of this study, to determine whether a foreign flagged vessel would meet the US towline criteria. Any foreign design considered for service as the Hinchinbrook Tug should be thoroughly checked against US stability criteria before proceeding in the acquisition process. It is possible that Z-drive vessels will be more affected by this than vessels with non-azimuthing drives.

Section 4 BAT Design Standards and Equipment

4.1 Methodology

While it is relatively easy to summarize an ETV's mission (intercept a disabled or otherwise affected vessel and tow it until safe), it is not trivial to identify the specific set of best available technologies that together make a vessel maximally capable of performing this mission. The various stages in an emergency towing sequence present different and sometimes competing demands and optimizing a design element for one step in a rescue sequence may penalize the vessel's performance in another phase of the rescue. For example, increasing the vessel's length may improve free-running speed but may also inhibit close-quarters maneuverability (denoted "agility" in this report), enabling the ETV to reach the affected vessel more quickly but potentially complicating its effort to make up a towing connection once on-scene. In short, identifying BAT for an ETV requires reaching a careful balance of sometimes competing properties and design elements.

To help illustrate this point and to aid in the discussion, this report has been organized around five basic stages of an emergency towing sequence:

Stage 1: Transit to the Affected Vessel
Stage 2: Intercepting and Surveying the Affected
Stage 3: Close-Range Maneuvering & Establishing Towing Connection
Stage 4: Towing the Affected Vessel
Stage 5: Cessation/Handoff of the Towing Operation

These stages are discussed in this section. The discussion of each stage begins by presenting and explaining what occurs during that stage in an emergency towing operation. Following this are detailed examinations of the corresponding major design considerations, vessel arrangements, and equipment that enhance a tug's performance for the corresponding stage.

The intent of this organizational scheme is to present design elements, arrangements, and equipment optimal for each individual stage without diluting the discussion with conflicting design requirements from other stages. At the end of this section, we identify areas in which design factors conflict across the different stages and discuss how best to balance these competing demands in pursuit of BAT for the Hinchinbrook Tug.

4.2 Stage 1: Transit to the Affected Vessel

The first stage of any tanker rescue operation the Hinchinbrook Tug will undertake begins with gathering pertinent information to make an informed go/no-go decision. A ‘no-go’ decision is conceivable during a major storm event, when the severity of conditions may preclude a rescue attempt for safety reasons – particularly in cases where the affected vessel is relatively far offshore and in no immediate danger.

In the event of a ‘go’ decision, parties involved in the rescue must take immediate action to minimize the time to intercept the affected vessel, to the extent that weather and safety considerations allow.

A basic operational sequence for this stage is as follows:

1. Receive initial request for assistance.
2. Confirm request.

3. Gather basic information about the situation.
    a. Current position of affected vessel.
    b. Condition of affected vessel.
    c. Immediate threats to crew and/or cargo.
    d. Any other pertinent information.
4. Check current weather conditions and near-term forecast.
5. Go/no-go decision.
6. Crew up (ensure all crewmembers are aboard).
7. Start main engines and ready for departure.
8. Ensure all necessary equipment is on board.
9. Pre-call Prince William Sound Vessel Traffic Service (VTS).
10. Get underway.
11. Maintain communication with affected vessel.
12. Determine best course/route to intercept.
13. Determine maximum safe speed given conditions.
14. Increase engine RPM as weather and safety permit.

In the event that the Hinchinbrook Tug is already underway or actively escorting a vessel when the initial request for assistance is received, the operational sequence must be adapted to suit those circumstances. In any case, the most critical element of this phase of the rescue operation is minimizing the time to intercept the affected vessel, thereby reducing the probability of a casualty or loss of life:

> The duty of an ETV is to attend the casualty as quickly as possible and render whatever assistance is necessary, the priority being to prevent the ship foundering and/or becoming a pollution hazard (Reference 13).

4.2.1 Major Design Considerations

While the total elapsed time from the initial request for assistance to getting underway depends largely on established procedures and routine crew training and drills, the remainder of the sequence (i.e., the actual transit to intercept) depends largely on the equipment itself, namely the vessel's free running speed and its ability to operate safely and effectively in a range of conditions. Safe and effective operation, in this context, means:

- Ability to operate in conditions with near-constant airborne spray and frequent boarding seas;
- Ability to keep propulsors fully immersed and maintain an acceptable free-running speed in high sea states;
- Ability to maintain acceptable vessel motions and accelerations at speed in high sea states, for crew safety; and,
- Design traits and seakeeping characteristics that minimize boarding seas and deck wetness.

4.2.1.1 Free Running Speed

The basic mission of the Hinchinbrook Tug (described as the Sentinel tug in the language of the VERP) is to accompany a loaded tanker from Hinchinbrook Entrance to 17 nautical miles offshore. For this application, the tug simply needs to be able to match the tanker's speed, which is expected to be 15-16 knots. Speeds less than the tanker speed will result in the Hinchinbrook Tug losing contact with the tanker. For example, at a 12-knot free running speed, the tug would be 20 minutes behind when the tanker reaches the 17 nautical mile line.

To be most effective, the Hinchinbrook Tug should be able to maintain contact with the outbound tanker in any sea state up to closure conditions. Since there will be a speed reduction in waves, the tug's calm water speed would be higher than 16 knots.

The Hinchinbrook Tug's broader mission is to undertake the rescue of inbound as well as outbound vessels, up to 200 nautical miles offshore. Most vessel casualties will have a time urgency and tug speed will matter a great deal. At 200 nautical miles, a 16-knot tug could arrive on scene in 12.5 hours. A 12-knot tug would arrive 4.2 hours later. Since this is a secondary mission scenario, there does not appear to be a need for speeds higher than 16 knots.

4.2.1.2 Powering

As a general rule, tugs with sufficient bollard pull (at minimum 120 MT but preferably higher for this application) will have enough installed power to make the speed goal. The difficulty will be propulsor efficiency at higher speeds. Systems optimized for bollard pull conditions will be far off their design point at 16+ knot speeds. This means that either extra power will be required to overcome low propulsor efficiency or the propulsors will need to be adjustable to address differing loads and speeds. Controllable pitch propellers (CPPs) may be a good adjustable propulsor solution, as they would enable the tug operator to change the pitch of the propeller blades between a setting optimal for full speed versus a setting best suited for towing.

Additionally, nozzles are frequently installed on vessels to achieve higher bollard pull, but the typical 19A nozzle will have high drag at 16 knots. However, there are nozzles that will work for bollard and high speeds. For example, while not yet commonplace, the Schottel SDV45 is available on their Z-drive units, and Nautican nozzles are available for fixed propellor installations and can be retrofitted onto Z-drives.

4.2.1.3 Range

The range requirement should not be a driving design factor. The Hinchinbrook Tug must be capable of reaching a distance of 200 nautical miles offshore at high speed and returning to port at cruising speed. Any tug capable of voyaging to Alaska will have this capability. For the purposes of this study and in consultation with PWSRCAC and Alaska stakeholders, a minimum range of 3,000 nautical miles was agreed upon (Section 3). The Hinchinbrook Tug's range should also be sufficient to transit at least as far south as San Diego, California, for maintenance and repairs.

Note that range, which is defined as the distance in nautical miles that the tug must be able to travel, is considered separately from endurance, which is defined as the number of days underway its complement of fuel and provisions can support. Endurance is discussed separately in subsequent sections.

4.2.2 Optimal Vessel Arrangements and Equipment

4.2.2.1 Bow Form

The Hinchinbrook Tug's bow should have sufficient freeboard and adequate bulwark height to reduce water on deck as the tug transits to the affected vessel's location at speed. The primary bow shape candidates for this application include:

- Conventional bow form.
- Axe bow.
- Inverted bow (also known and an X-bow).

None of these bow forms represent new innovations; however, designers have refined and improved their integration into overall design in recent decades.

The bow's performance in terms of ship motions and deck wetness while in transit is coupled with other design features, so any of these bow shapes can perform well if the design is carefully balanced. A conventional bow is flared above the waterline to push water away from the vessel as the ship pitches. A well-designed vessel with a conventional bow form and adequate forecastle (focsle) height provides a dry foredeck; however, flare increases added resistance in waves, leading to increased power requirements to achieve the 16-knot speed desired during this phase.

An axe bow has a long and narrow entry with a deep forefoot and high freeboard with little flare. The long narrow entry reduces resistance, and the lack of flare minimizes response to passing waves, particularly pitch. The stem of an inverted bow, or X-bow, slopes aft, maintaining a long waterline for reduced resistance and shaping the bow above the waterline to reduce resistance in waves. Both of these bow forms may offer an advantage over a traditional bow form in terms of resistance and reduced slamming while in transit through rough seas, but detailed design studies are needed to quantify their benefits since they add cost and complexity and decrease forward working deck area.

4.2.2.2 Draft

Deeper hull draft, particularly at the bow, will reduce slamming in the transiting phase. Reduced slamming increases speed at high sea states and will increase the crew's comfort and effectiveness. In higher sea states, deeper navigational draft will also indicate less susceptibility of propulsors to ventilate (i.e., to pull in air forced beneath the hull and into the propeller's flow path). Reducing propeller ventilation increases efficiency and will translate to higher sustained speeds.

4.2.2.3 Length

This stage of the rescue sequence will favor longer vessels for lower resistance and lower added resistance in waves. Speeds of 16 knots are certainly possible for vessels with lengths in the 40-80m range under consideration, but the power requirements for reaching this speed become much more reasonable as length increases.

It will be quite difficult for the lower half of the length range (40-60m) to achieve 16 knots given a typical tug hull form (i.e., large beam to length and displacement to length ratios). As length increases, the beam and displacement will not increase in proportion, leading to lower beam to length and displacement to length ratios. These lower ratios mean that longer vessels, in the 60-80m range, will be much more likely to achieve 16 knots.

Vessel motions during transit are much more difficult to quantify or predict in the absence of intensive analysis; this point is discussed in more detail in the following section.

4.2.2.4 Pilothouse Location

Motions in the pilothouse are of primary interest during transit for crew safety. Pilothouse locations closer to midship and lower in height will tend to decrease accelerations for the crew. The location specific criteria published by NORDFORSK (Reference 27) are recommended as a quantitative measure of acceptable motions when detailed analysis is applied. This reference also provides guidance on acceptable deck wetness and propeller emergence.

4.2.2.5 Propulsors

Given appropriate powering and hull design, numerous propulsor types and arrangements are capable of meeting the 16-knot speed desired for keeping pace with outbound tankers. Notably, conventional VSP systems would likely not be able to make this speed, despite some significant advantages they might afford in terms of maneuvering and minimizing vessel motions. It is beneficial to reduce the drag created by the propulsors at high speed, so if drag-inducing features such as nozzles are incorporated, they must be selected carefully for efficiency at speed, adding cost to the design and procurement of the vessel. A tractor tug arrangement, with the propulsion units located roughly one-third of the vessel's length from the bow, would be particularly beneficial for keeping the propellers immersed in seas.

4.3 Stage 2: Intercepting and Surveying the Affected Vessel

This stage of the rescue operation includes arrival at the scene and an initial survey of the general condition, attitude, and movement of the affected vessel in relation to metocean conditions at the time. The master of the tug is in constant communication with the master of the affected vessel at this stage, obtaining and relaying pertinent information and, eventually, developing a mutually agreeable a plan of action.

Unless immediate action is required (e.g., firefighting or rescue of personnel), the master of the tug will generally circle the affected vessel to inspect any known or possible damage and assess options for establishing a towing connection, if appropriate. Important factors at this stage, apart from the condition of the affected vessel and the safety of its crew, are wind speed and direction, wave heights/sea state, the motions/attitude of the affected vessel, and its position relative to land masses, islets, or undersea structure that could pose a grounding risk. Any forecasted change in weather conditions is also a driving factor in deciding whether or not to connect, and how.

If the risk of a drift grounding is low, attributable to the geographic position of the vessel or favorable weather conditions at the time, the master of the tug will generally opt for a “hard gear” connection using chafe chain and/or wire rope, which is preferred to ensure the integrity of the connection while the affected vessel is in tow. If conditions are unfavorable, the master may opt to stand by until the weather moderates, as a “hard gear” connection takes time to establish and requires limited relative motions between the two vessels to be attempted safely.

In the event that immediate action is necessary to stabilize the situation and/or prevent a drift grounding or other casualty, the tug master will likely opt to deploy an emergency towing system or ‘kit’ composed of high-modulus polyethylene (HMPE) synthetic rope. HMPE-based systems are lightweight, positively buoyant, and extremely strong, which makes them comparatively safe and easy to deploy in an emergency; but they are susceptible to abrasion at connection points as well as chocks and other fittings that may come in contact with the line body under tension. For this reason, synthetic emergency towing systems are generally used as a stop-gap measure to mitigate a dangerous situation, or for short-distance tows only. However, in the most extreme circumstances (e.g., extreme wave heights, shipboard fire, compromised vessel stability, rapid downflooding, etc.), it may not be possible or prudent to attempt a towing connection of any kind because the risks to the crew of either vessel are simply too great.

Once the decision is made to attempt a towing connection, the crew must prepare the deck, readying deck machinery/equipment and towing gear accordingly. These activities are considered in the next section (Stage 3), as they are considered subsequent to the intercept and survey activities discussed within this section.

4.3.1 Major Design Considerations

As evidenced by the sequence above, the total elapsed time between the tug's arrival on-scene and its attempt to establish a towing connection can vary greatly, from a matter of minutes to several days in some circumstances. In 2016, during the week-long *Modern Express* evolution in the Bay of Biscay, salvage tugs stood by for more than four days before a towing connection was deemed safe to attempt. During this stage of the rescue operation, the tug is standing by at a safe distance, powering at low speed as required to keep pace with the affected vessel as it drifts downwind. Remaining on-scene in this capacity means the tug may have to endure periods of severe weather; and, at such low speeds, it may experience extreme motions. As conditions worsen, the tug may need to maintain a heading into the direction of the wind and waves to minimize roll motions for crew safety.

Extreme vessel motions are not merely uncomfortable; they can be fatiguing, debilitating, and dangerous. An exhausted crew poses hazards that threaten not only the lives of those on board, but the success of the entire rescue operation.

The design of the tug can critically impact the safety of this stage of the rescue operation. There are a number of fundamental design best-practices that, applied properly, can mitigate the hazards crew and equipment face while standing by in heavy weather and extreme sea states. These include, but are not limited to:

- Hullform and seakeeping characteristics that minimize boarding seas and deck wetness;
- Optimized motion characteristics for operating at low speed in high sea states, with a focus on metacentric height (GM) and roll period;
- Longitudinal position and elevation of the pilothouse;
- Structural protection for crewmembers on exterior decks; and,
- Structural protection for deck machinery and lifesaving equipment.

4.3.1.1 Crew Protection

This topic is discussed in the next section (Stage 3), as that stage presents the greatest demands on external working decks. Several of the working deck design features highlighted as beneficial during Stage 3 (deck de-icing and adequate bulwark height, for example) will also benefit any external crew activities that take place during the intercept and survey stage.

4.3.1.2 Endurance

As mentioned in the description of this stage, the Hinchinbrook Tug may need to stand by for several days prior to commencing actual towing operations. Endurance, which is discussed in more detail under Stage 4, should be adequate for a standby time of at least three days.

4.3.1.3 Motions

During this phase, the Hinchinbrook Tug may loiter on station or proceed at low speed for an extended period of time. This creates a different set of motions-related challenges in heavy seas than those faced during full speed transit to the affected vessel. Roll stabilization, bow form, vessel length, and propulsor selection can all influence the type and magnitude of motions expected, but the precise impacts and benefits of these design features will vary with external factors such as heading, wave amplitude and period/wavelength.

4.3.2 Optimal Vessel Arrangements and Equipment

4.3.2.1 Bow Form

As with Stage 1, the primary bow shape candidates for this application are conventional bow form, axe bow, and inverted bow (e.g., the Ulstein “X-bow”), and again the bow's performance in terms of ship motions and deck wetness will be coupled with other design features, making any of these bow shapes potentially competitive in a well-balanced design. The difference at this stage is that the bow form's effectiveness in reducing vessel motions and deck wetness must be considered at low speeds or while loitering rather than at free running speeds. Further research is needed to determine whether axe bows and inverted bows can provide benefits at both high and low speeds, or whether their benefits at one vessel condition are offset by poorer performance at another condition.

4.3.2.2 Draft

Deep hull draft, particularly at the bow, will reduce slamming while the vessel is loitering. Stern draft, typically in conjunction with high deadrise, will also reduce slamming in loitering phases. Reduced slamming will increase crew comfort and effectiveness.

In higher sea states, large navigational draft will indicate less susceptibility of propulsors to ventilating. This will be less of an issue at loitering speed but is still an important consideration.

4.3.2.3 Dynamic Positioning (DP)

DP systems use all propulsion and maneuvering systems, including bow and/or stern thrusters, to position or move the vessel in relation to a set of geographic coordinates. As such, DP systems are capable of providing much more precise tracking and course keeping than is achievable with a standard autopilot system.

In addition to basic stationkeeping, DP systems have the following features that could prove useful for the subject application:

- Track following, which enables matching of the tug's movements to the speed and course over ground (COG) of the affected vessel.
- Full programmable control of both heading and COG independently. This can be particularly useful in closer maneuvering (weather permitting) and could help keep fire monitors on target in the event fire suppression is required.
- Single joystick control of heading, surge and sway. This allows more precise control and reduces operator fatigue in a long term loiter.

While the tug operator can attempt to match a drifting vessel's course using a standard autopilot system set on a desired course, standard autopilot requires that the tug be oriented more or less head-on to the desired course. Depending on wind and wave conditions, following the drifting vessel's course in this manner may subject the tug to beam seas or following seas that put the tug at risk, or subject the crew to more unfavorable motions than a head-to-weather heading might induce. A DP system, by comparison, allows control of vessel heading independent of course and speed, enabling the vessel to remain head-to-weather while following the drifting vessel’s track. In rough weather, this would reduce risk to the vessel and minimize motions experienced by the crew. If the Hinchinbrook Tug were required to loiter near an affected vessel for a significant amount of time, managing vessel motions by using DP in this way - remaining course at an optimal heading - could help prevent excessive operator fatigue. It should be noted, however, that DP systems do have weather limits and some may perform quite poorly in any kind of heavy weather.

The features listed above are most beneficial for tugs on the larger end of the size range. Smaller tugs can perform the requirements of this stage with manual controls, while larger tugs would be unwieldly and difficult to control manually in the same conditions. A DP system makes the larger tugs, which have many other beneficial features, feasible to consider from a maneuvering and stationkeeping standpoint. Even smaller tugs can benefit from a DP system, however, as using the DP system during loitering takes the burden of hand-steering off of the operator.

DP1 class is all that would be necessary for the Hinchinbrook Tug given that the tug could still perform its mission in the event of a DP failure, just with more difficulty. The requirement to track-follow on any heading necessitates powerful lateral/omnidirectional thrust at the bow and stern. The power requirement is alleviated somewhat by the assumption that the affected vessel and tug are drifting downwind rather than holding a fixed position in closure conditions.

4.3.2.4 Length

It is not possible to assess or rank specific vessel lengths within the 40-80m range in terms of seakeeping performance without a comparative analysis of vessel motions. In general, tugs in this length range will wave follow in fully developed, long period sea conditions typical of the North Pacific. In general, wave following means the motions of the vessel tend to be synchronized with the free surface elevation of the waves. The average zero-upcrossing period for waves in the North Pacific ranges from about 7 to 12 seconds, with a most probable value of 10 seconds (Reference 25) and a characteristic wavelength of 150m. Vessels with wavelength to vessel length ratios greater than about 1.8 will tend to wave follow, exhibiting heave amplitudes equal to the wave amplitude and lower added resistance (Reference 26). In short-period developing wave conditions, all vessels in this length range will experience periods of amplified heave, pitch, and added resistance.

4.3.2.5 Navigation System

This section omits many of the standard elements of a complete navigation system typical on board on oceangoing tug. The items below are highlighted as additional elements, supplementary to those required by regulation, that would be considered BAT for this stage of the rescue operation and for the purposes of ocean rescue towing in the Gulf of Alaska more generally.

The vessel should be outfitted with an integrated bridge system (IBS). The IBS should integrate the propulsion machinery controls, the control/monitoring functions, and the navigation instrumentation. The configuration should be ergonomically designed to maximize the effective utilization of the installed equipment, with appropriate interfaces to any integrated alarm and monitoring systems installed on the vessel.

The IBS should include two (2) flat screen multi-function displays at the main conning stations to display navigational information, required steering and propulsion data, and alarms on operator-selected data display graphic pages. Multiple displays that allow the operator to select which feeds to display are crucial for bolstering the master's situational awareness during close quarters maneuvering and when crew are working on the aft deck.

The system should be designed for redundancy and resistance to vibration, dampness, and low humidity.

The main control console should contain the following:

- Vessel controls for propulsion engines, thrusters, pitch, and steering.
- Navigation and other light controls, watertight door indications/controls, ventilation shut-down actuators, fire control actuators, etc.

- Electronic navigation systems described later in this section.
- Not less than two (2) VHF radios and sound-powered telephone.
- A machinery alarm and monitoring system display.
- Speed log, depth (echo) sounder, gyro display, differential global positioning system (DGPS) display, gyropilot/autopilot controls/display, and magnetic compass.

The vessel should have port and starboard bridge wing stations, each containing all propulsion and steering controls, loudhailer/public address (PA) system controls, a gyrocompass repeater, and one or more VHF radios.

An aft control station in the pilothouse is also imperative for the Hinchinbrook Tug – particularly to enhance the safety and efficacy of Stages 3 and 5 of the rescue sequence. This station should contain all propulsion and steering controls, winch controls, tow pin assembly and shark jaw controls, loudhailer/PA system and searchlight controls, and at least one VHF radio. The aft control station should also have repeater screens for at least one radar and electronic charting system/electronic chart display and information system (ECS/ECDIS). Closed-Circuit Television (CCTV) screens of the tow winch/winch house should also be provided, unless the operator has an unobstructed line of sight to this machinery from the aft station.

For the subject application, which may involve recovery of ships' crew or other persons out of the water, an ultra-high-powered xenon searchlight (1000 watts or greater) is appropriate. Additionally, and for the same purpose, a forward-looking infrared (FLIR) thermal imaging camera (as listed above) is strongly recommended and will be regarded as BAT for the purposes of this study. A FLIR system, particularly if integrated with the IBS displays, could greatly improve the odds of identifying poorly lighted lifeboats or personnel in the water in in heavy seas, low light, and/or low visibility conditions.

4.3.2.6 Pilothouse Location

As with the previous stage, motions and accelerations within the pilothouse can be minimized by locating it closer to midship and lower in height.

4.3.2.7 Rescue/Recovery/Firefighting

It may be the case that conditions on the affected vessel have deteriorated to such an extent that its crew must be evacuated immediately and/or a fire has broken out on board; conversely, a shipboard fire could have caused the vessel disablement. In either event, even though they are ancillary to the towing task, it is crucial that the Hinchinbrook Tug have firefighting and personnel rescue capabilities.

In the event the affected vessel must be abandoned, the tug will be required to recover the crew either from the water or from lifeboats. This is difficult in the best of conditions and much more so in closure conditions. The only practical method of accomplishing this with the Hinchinbrook Tug would be with the use of a Dacon Rescue Scoop (or similar) or the deployment of one or more fast rescue boats. This report assumes that the Hinchinbrook Tug will not be outfitted with a helicopter landing pad.

The Hinchinbrook Tug should be equipped with two SOLAS approved fast rescue boats with davits capable of manned launch and retrieval in heavy weather. The rescue boats should be as large as practical to transfer rescued crewmembers in the fewest number of trips. Having two boats stowed port and starboard affords equipment redundancy and would allow launch and recovery from the leeward side of the tug irrespective of heading and relative wind direction.

Firefighting capability is also desirable. The Hinchinbrook Tug will likely be first on the scene of a casualty and early action can be critical to success. With a focus on human and environmental safety, the tug should be capable of fighting small fires and containing larger fires for the purposes of crew evacuation and possibly towing gear rigging (hook-up). It is expected a standoff mode would be employed rather than close range firefighting.

The Hinchinbrook Tug should have a minimum of two high-capacity monitors, be provided with a large quantity of foam, and be classed FiFi 1 at minimum.

4.3.2.8 Roll Stabilization

For maximum crew effectiveness on a relatively small vessel, some sort of roll stabilization will be required. Given that crew performance is particularly important in low speed phases, passive devices will be most appropriate. At a minimum, the Hinchinbrook Tug should have maximum sized bilge keels. The best performing tugs will also include roll stabilization tanks integrated in the hull. Bilge keels may be applied to any tug with a modest increase in drag. Stabilization tanks, if integrated, should be U-shaped tanks in the hull and designed so as to not compromise stability while towing. Hull tanks will require significant space and will impact the arrangement.

VSPs offer an active roll stabilization feature which could be quite effective at low speeds if VSPs were selected for the tug.

4.4 Stage 3: Close-Range Maneuvering & Establishing Towing Connection

This stage of the rescue operation and the actions of the master and crew on both vessels can vary greatly depending on several factors including, but not limited to the following:

- Metocean conditions at the time, namely: wind speed and sea state.
- The condition and motions of the affected vessel.
- The seakeeping and motions characteristics of the tug.
- The relative motions of the two vessels in proximity.
- The height and geometry of the affected vessel's bow (or stern, as the case may be).
- Availability of usable mooring and/or towing fittings on the deck of the affected vessel.
- Availability of auxiliary power to deck machinery on the affected vessel.
- The size and nature of the towing system/gear to be used.
- Planned methods for deployment and connection of the towing system/gear.
- The arrangement and outfitting of the working deck on the tug.
- The size and agility of the tug (in the existing metocean conditions).
- The level of training and experience of the crew (on both vessels) with regards to emergency towing procedures.

In nearly all circumstances, however, establishing an emergency towing connection by conventional means requires the tug to make a relatively close approach to the affected vessel. This typically involves backing or otherwise positioning the tug's stern near the affected vessel on the windward side of the bow, such that the tug master has an open 'escape route' (given that the affected vessel will tend to drift away from the tug, rather than toward it) during the operation. By holding the tug's bow to windward, the tug master can better hold position and afford his or her crew a degree of protection from oncoming weather and/or boarding seas while they attempt to work the aft deck. At this stage the agility of the tug – particularly, the availability and power of directional thrust in the bow – becomes paramount. Without it, environmental forces acting on the tug bow and superstructure can make it difficult or impossible to maintain the requisite position (relative to the affected vessel) and heading (relative to the direction of wind and seas) to complete the operation safely.

Except in very rare cases where an Orville Hook may be used to connect to a length of chain hanging from the affected vessel (likely not possible with a disabled tank vessel), the first step to establishing a towing connecting is to pass a relatively small diameter “messenger line” by some means, which is then used to facilitate passage of the towing gear itself. Glosten completed a BAT review of towline deployment technologies for PWSRCAC in 2020 (Reference 28); the following two paragraphs are condensed from that study.

The messenger line can be deployed from either vessel. Usually this is achieved using a marinized line throwing device fired from the deck of the tug over the bow or mid-body of the affected vessel. Line throwing devices work by activating a propellant (e.g., solid rocket fuel, granular explosives, or compressed gas) to launch an airborne projectile with light cordage attached. Once recovered on deck, the cordage is secured to one end of the messenger line and used to draw it across the distance separating the two vessels. The opposite end of the messenger line is retained on board the ‘deploying’ vessel and used to pass successively larger messengers, if necessary. Ultimately, the messenger is used to haul (by manual or mechanical means) a larger-diameter synthetic hawser, wire rope, or connecting hardware.

Alternatively, if the messenger line is to be deployed by the affected vessel, it can be paid out directly onto the surface of the water, provided it is of sufficient length, conspicuously colored, and positively buoyant. The responding tug can then recover it from a safe distance as the affected vessel drifts downwind. This method avoids reliance on the use of line throwing devices and may be safer and more effective in certain circumstances - generally foul weather and when the intention is to connect using an HMPE hawser or other synthetic towing system. One drawback to this method, however, is introduced risk of propeller entanglement for the responding tug. To mitigate this risk, it is recommended that the end of the messenger line be fitted with one or more buoys/floats and a strobing light, if available.

Any dedicated ETV should be capable of establishing a towing connection using either method described above. The first method – using a line throwing device to pass a messenger line and, ultimately, the towing gear itself – requires the tug to hold position quite close to the affected vessel, particularly if a ‘hard gear’ connection is to be attempted. However, if the tug approaches too closely, it is possible for it to collide with/impact the flare of the bow, the bulb, or other areas of the affected vessel. To complicate matters further, crewmembers must be on deck to make the connection, which means they are physically exposed to the elements. The master of the tug must actively consider their safety while at the same time attempting to maneuver. As the two crews begin passing the actual towing gear, which is obviously much larger and heavier than the messenger line, the ability of the tug to maintain position and heading becomes critical. This is generally the most difficult and dangerous stage of any at-sea rescue operation, but obviously crucial to affecting a successful outcome.

4.4.1 Major Design Considerations

It should be noted that the towing capability of the tug (i.e., bollard pull ahead) is almost completely irrelevant at this stage. The most important elements of the vessel design at this stage are:

- Agility (defined below) - determined by hull form/displacement, installed power, the size and location of sail area (chiefly bow and superstructure geometry), and the availability of directional thrust in the bow and stern.

- Seakeeping and motions characteristics - determined by hull form, deck arrangement/freeboard, and the location/distribution of weights and centers in relation to centers of buoyancy.
- Vessel size and geometry – particularly the geometry of the aft deck in relation to that of the accommodation and pilothouse.
- Location of the pilothouse in relation to the aft portion of the working deck.
- Clear lines of sight from the pilothouse to the aft deck, and to any deck machinery to be used during this stage of the operation.

Having the most modern and sophisticated towing vessel and equipment available is no guarantee of success but, coupled with a regimen of crew training and routine drills/exercises, it does increase the probability of establishing an emergency towing connection more safely, reliably, and efficiently.

The following section discusses current best practices and design features that enhance a vessel's utility and performance for this stage of the rescue operation.

4.4.1.1 Agility

Even a large and otherwise unwieldy vessel (a modern cruise ship, for example) can be considered highly maneuverable if outfitted with propulsion machinery that enables it to control its own movements with precision. The Hinchinbrook Tug, however, must be able to maneuver quickly and precisely in relatively close quarters and in high sea states. There are existing metrics to quantify vessel performance in this regard, for example: the ability to execute a zero speed, 360 degree turn within no more than 150% of the vessel's own length, and within no more than 60 seconds. Such performance capabilities are typically specified during design and assessed and quantified during sea trials to validate performance.

This report uses the term "agility" to distinguish this type of close-quarters, time critical maneuverability from the concept of maneuverability more generally.

4.4.1.2 Crew Protection

Several design features promote crew safety:

- Locating the pilothouse such that the distance between the master and crewmembers on deck is minimized (for visibility/prevention of injury).
- Good lines of sight from pilothouse to working deck and machinery/equipment.
- Sufficient bulwark height that affords protection for the crew on deck, but does not impede situational awareness (by obstructing field of view).
- Good seakeeping performance with acceptable accelerations in both the pilothouse and working decks.
- Ability to de-ice working decks.

4.4.1.3 Motions

Motions on the working deck are of primary interest when establishing a towing connection for crew safety. Tug motion performance is difficult to assess without analytical work; but in general, larger vessels with lower deck heights will exhibit lower working deck accelerations. The location specific criteria published by NORDFORSK (Reference 27) are recommended as a quantitative measure of acceptable motions when detailed analysis is applied.

4.4.2 Optimal Vessel Arrangements and Equipment

4.4.2.1 Bulwark Height

Bulwark height provides another design parameter to help control deck wetness and protect the crew from boarding seas. Excessive bulwark heights can obscure the crew's vision from the working decks (reducing situational awareness) and make working over the side difficult. Excessive bulwark height can also drive up the installed height of the tow winch, which can have a negative effect on vessel stability, hamper engagement of the tow wire in tow pins and hooks, and compromise deck safety when making and breaking tow.

4.4.2.2 De-icing

Having some deicing capability would be beneficial. A vessel operating in the Gulf of Alaska is very unlikely to accumulate enough superstructure ice to affect its stability, so the need for deicing is primarily confined to working decks, where ice accumulation can create a working hazard for the crew. An external heating pad type system would likely be unable to withstand the repeated impacts associated with towing gear moving around the aft deck, so an underdeck system would be preferable. Underdeck deicing systems add considerable cost and piping complexity, however. A heating pad system may be sufficient for the forward working deck and any breezeways or other external walking areas.

4.4.2.3 Dynamic Positioning (DP)

The discussion of DP under Stage 2 generally holds for Stage 3 as well. However, to the extent that the connection phase requires more close-in maneuvering than the loitering phase, DP may offer a distinct advantage in light to moderate weather. This will especially apply for larger tugs and indeed, the lack of DP would eliminate larger tugs (> 60m) from consideration as BAT.

It should be noted, however, that the use of DP in this stage of the operation may become impossible or not advisable as conditions become more severe. In heavy weather, large and quick forces are needed to maintain position close to the ship as lines are being passed. There is a level of unpredictability in this situation that, most experienced masters might agree, forbids the use of DP – particularly in consideration of the amount time it takes to switch all thrusters/rudders back to hand steering in the event of a failure or system anomaly.

4.4.2.4 Freeboard

High freeboard will reduce deck wetness, but it also increases transverse accelerations and makes recovery of crew and messenger lines from the water more difficult. Optimal freeboard is a balance between keeping the working deck close to the water and just high enough to avoid frequent water on deck.

4.4.2.5 Length

Contrary to the transit phase, in which maximizing vessel length to the greatest reasonable extent will tend to provide the maximum benefit in terms of achieving higher free running speeds, the intercept and survey phase may be hampered by the decreased agility and higher windage area that result from greater vessel length.

In terms of minimizing vessel motions, as with the length discussion in Stage 1, it is not possible to identify an optimal length within the range considered for this vessel (40-80m) in the absence of many more design specifics and an intensive seakeeping study.

4.4.2.6 Line Handling Equipment

An independently operated suitcase drum and warping head should be integrated into the design of the tow winch to assist with gear handling in this stage of the rescue sequence. These items should be located on opposite sides of the winch body.

The inclusion of one or more small tugger winches or deck winches is also regarded favorably for the purposes of evaluating BAT. Though not essential, this equipment can significantly enhance the safety and efficiency of gear handling operations on deck.

4.4.2.7 Pilothouse Location

As with the previous stages, motions and accelerations within the pilothouse can be minimized by locating it closer to midship and lower in height. Locating the pilothouse at midship rather than closer to the bow is also crucial for improving the master's visibility and proximity to crew working on the aft deck.

4.4.2.8 Propulsor Configuration

Superior agility requires independent control of fore and aft motion, transverse motion, and rotation. Both tractor and rotor tug configurations will do this very well. A conventionally configured vessel with DP capability will also provide good maneuverability, particularly for a standoff mode in which the tug does not need to closely approach the affected vessel. Suitable machinery options for this purpose may include:

- Bow thruster can be tunnel or retracting ASD type. Multiple thrusters would likely be required for vessels on the larger end of the size range considered.
- Stern tunnel thruster(s) with conventional propellers.
- ASD propulsion with or without supplementary stern tunnel thruster(s).
- Conventional propellers in nozzles with flapped rudders; one or more stern thrusters would likely be required for vessels on the larger end of the size range considered.

4.4.2.9 Roll Stabilization

The requirements and recommended outfitting for roll stabilization at this stage are essentially the same as those discussed above for Stage 2; minimizing motions at low speed is arguably even more important for Stage 3 given the importance of the crew's effectiveness on the aft deck in securing the towing connection.

4.5 Stage 4: Towing the Affected Vessel

The primary function of an ETV is to intervene and prevent the escalation of a low consequence ship disablement event turning into one of catastrophic proportions (Reference 13).

This excerpt from the 2012 Irish Coast Guard *Study on the Provision of an ETV* provides a concise description of the primary goal of any ship rescue effort - to prevent a drift grounding or other major casualty. The ability of the responding tug to tow (i.e. transport) the affected vessel from its location to a place of refuge, a port of call, or even to make immediate headway is secondary. The overriding priority for the tug master during this stage of the rescue effort, second only to the safety of the vessel and crew, is maintaining the integrity of the towing connection.

In moderate to severe conditions, when environmental forces and the relative motions of the two vessels are high, extreme caution should be exercised to minimize loading of the tow wire, towing gear, and engaged bitts and/or fittings onboard the affected vessel. This is especially important in the initial moments of the towing operation when the affected vessel is in a free drift state. Most vessels in this state will lay perpendicular to the dominant wind and wave direction, or “in the trough.” Free drift velocity may exceed 3 knots in some circumstances (Reference 29). Turning and arresting an oceangoing tank vessel at this speed, in any condition, requires tremendous force. In a dynamic environment involving *two* oceangoing vessels (tethered to one another) and high environmental loads, overloading/failure of one or more of the components that comprise the towing connection is a distinct possibility.

It is important to note that simply upsizing towing gear and equipment foundations on board the tug, though beneficial, does not reduce the risk of overloading bitts or, more likely, their foundational structure on board the affected vessel. In fact, without the exercise of good judgement on the part of the tug master, such upsizing may actually increase the likelihood of overloading shipboard components/structure.

To minimize the risk of component and/or structural failures, the tug master should generally refrain from attempting to immediately arrest the downwind momentum of the affected vessel unless grounding appears imminent and unavoidable without such action. Because maintaining the integrity of the towing connection is paramount, a more tempered and cautious approach should be adopted if circumstances allow.

Provided there is ample water depth at the location, the tug master may opt to spool out several hundred feet of tow wire, or more, before engaging the winch brake and attempting to build forward momentum with the affected vessel in tow. The weight of the tow wire suspended between the two vessels causes it to hang in an arc, called catenary. Catenary serves to dampen the dynamic forces at play and prevents shock loading of the tow wire and other components comprising the towing connection. If the tow winch on the tug features a slip brake (automatic rendering functionality) or a constant tension (i.e., render/recover) control system, this affords another means to manage line tension/load during this important first step of the towing operation.

Another strategy that the master can utilize to mitigate risk, in most circumstances, is to begin towing the vessel in the direction of its natural free drift orientation (i.e., heading) before attempting to turn it head-to-weather. Previous simulation of this operation at Glosten – using an internal suite of numerical-modeling software tools - has demonstrated that considerably less towing force is required to turn a drifting ship head-to-weather in this manner (with forward inertia), as compared to pulling directly upwind. This makes for less strain on towing gear and shipboard fittings.

All ship disablements present a unique set of towing challenges. There is no one plan of action that is applicable in all circumstances. In each case, the master must take several factors into consideration in real-time, including, but not limited to:

- Current and forecasted metocean conditions.
- The presence of tidal or wind-driven surface currents.
- The size and condition of the affected vessel.
- Directional stability (“tracking”) and steerability of the affected vessel in tow.
- The location of the affected vessel in relation to shore or other hazards.
- Depth of water and bottom composition.
- The size and capabilities/limitations of the tug.
- Limitations of the tow winch, towing gear, and fittings onboard the affected vessel (if known).
- The availability/proximity of other rescue support and/or marine salvage assets.

As weather conditions change, or if the condition of the affected vessel changes while in tow, the towing operation may need to be adapted accordingly. As wind speeds and wave heights increase, for example, the tug master may choose to spool out additional tow wire and/or reduce engine RPM as necessary to maintain line loads/tension below the working load limit (WLL) of the towing gear. In extreme cases, the tug master may opt to apply only as much power as necessary to maintain steerage, even if no forward progress is made, as this is obviously preferable over a failed towing connection and loss of the affected vessel.

4.5.1 Major Design Considerations

As with preceding stages of the rescue sequence, the design of the responding tug can critically impact the safety and success of this stage of the rescue operation. First and foremost, the tug must be large enough, and have sufficient power, to assist casualties in a variety of different and in most cases difficult circumstances (Reference 13). A good tow winch is also critical – ideally a double-drum winch of side-by-side configuration, such that a redundant tow wire can be rigged and deployed, if circumstances allow. A double-drum winch also affords operational redundancy and allows a second attempt at recovering the affected vessel if the tow wire parts or becomes damaged on the first attempt. State-of-the-art towing winches that employ adjustable slip brakes (automatic rendering capability) also improve the probability of a successful outcome as compared to conventional towing winches. Other important elements of the vessel design for this stage of the rescue sequence include, but are not limited to:

- Hull form and efficiency in seas.
- Propulsor type and efficiency in seas.
- Seakeeping and motions characteristics.
- Aft deck geometry and arrangement.
- Stern shape (outline), bulwark design, and fendering.
- Tow winch location.
- Structural foundations for the tow winch and towing fittings.
- Tow winch configuration, direction of winding, capabilities, and drum capacities.
- Tow wire construction (size and WWL) and total length.
- Fixed towing gear/equipment (e.g., stern roller, towing pins, towing hooks, jaws, etc.).
- Ancillary deck machinery (e.g., capstans/warping heads, suitcase drums, tugger winches, etc.).

These and other design elements that enhance tug performance for this stage of the rescue operation are discussed below.

4.5.1.1 Bollard Pull

This study's minimum bollard pull requirement for the Hinchinbrook Tug assumes towing a 193,000 DWT tanker at a towing efficiency factor of 0.79. This minimum parameter, 120 MT, additionally represents:

- Wind and seas at closure conditions, 45 knots, seas 6.1m.
- Yawing limited to 30 degrees.
- Fully loaded tanker.
- Towing at 1 knot.

Reference 2 provides a higher-end value, 185 MT, based on:

- Increased wind speeds over closure conditions.
- Increased wave heights over closure conditions.

- Extra forces for tanker yawing under tow.
- Tanker in ballast condition (high windage).
- Towing directly upwind prior to building headway.
- Towing at 4 knots.

Tugs with less than 120MT bollard pull will not be considered, and increasing bollard pull above that level will generally result in an increasingly capable tug, although the impacts on other factors (e.g., free running speed, vessel size, agility) must be considered.

Tugs with bollard pulls over 185 MT that meet the length requirement (80m or under) are considered in this study, but their greater size and power carry cost penalties that limit their feasibility for this application.

4.5.1.2 Endurance

The vessel should have a minimum endurance of 14 days (Section 3). The basis for this is that this is the assumed worst case duration for a rescue towing evolution.

At a minimum, the tug should have adequate endurance to complete the following sequence starting with a 50% fuel load:

1. Make 200 mile run out to affected vessel.
2. Stand by the vessel for a period up to 3 days.
3. Hook up and tow at max bollard for 3 days.
4. Run back to Valdez with 15% fuel margin remaining.

4.5.2 Optimal Vessel Arrangements and Equipment

4.5.2.1 Primary Propulsors

Any propulsor that can produce the required bollard pull will work for the towing phase. Two factors that drive the selection are towing efficiency and propulsion efficiency. Towing efficiency is a function of propellor ventilation, which occurs as the propeller nears or breaches the surface of the water while the tug pitches. Factors that influence propulsor ventilation are:

- Pitching behavior of the hull form.
- Size of the hull form.
- Propulsor distance from vessel ends.
- Propulsor distance inboard from sheer strake.
- Propulsor distance below the waterline.

Hullform behavior is difficult to evaluate without extensive calculation but see discussions on bow in previous sections of this report. There will always be a specific wavelength that excites a certain hull; however, larger hulls will generally have an advantage with increased momentum and a length that is excited by longer waves, which are less likely to occur.

Tractor tugs, either ASD or VSP, and Rotor tugs typically locate the propulsors well under their hulls, both deeper and further from the ends. This will afford an efficiency advantage due to decreased propeller ventilation, particularly with smaller tugs in the size range considered since their draft will tend to be shallower.

Propulsive efficiency is a function of propellor type and size. Factors that influence propulsor efficiency are:

- Propeller type (VSP, CPP, or fixed pitch propeller (FPP)).
- Propeller blade configuration, pitch, and skew.

- Propeller ducts/nozzles and type.
- Propeller size (diameter).

VSP drives are considerably less efficient than the alternate propeller configurations noted above. CPPs are less efficient than FPPs due to the larger hub required, though this only holds true near the design point. CPPs can be adjusted to perform over a wider range of loading and speeds.

Fitting the propellers with nozzles will generally improve bollard pull by conditioning the flow of water through the propeller, improving low-speed efficiency and thrust.

Increased size leads to increased efficiency for all propulsor types. As a practical matter, VSPs are not made large enough to meet the minimum bollard pull requirement. Also, for the same basic hull, ASD propellors will be smaller than fixed propellers due to the need to rotate 360°.

4.5.2.2 Stern Geometry and Bulwarks

The aft deck arrangement has major impacts on ability to manage the tow wire safely and effectively. Squared-off corners on the stern are problematic, as the tow wire and/or gear can sometimes hang up on the corners while making/breaking tow, or when towing in closer proximity to the affected vessel (generally the beginning and ending stages of the towing operation). A fully rounded stern is also problematic in that it constrains the tow wire too little. This can cause the tow wire and/or gear to slide excessively along the deck edge or bulwark, which puts the deck crew at greater risk, particularly when towing gear is being deployed or recovered on deck. A flat transom with radiused corners is optimal, as it provides some containment of the tow wire over the stern yet allows the gear to slide fairly easily around the port and starboard corners during gear deployment and recovery.

The aft deck area should be large enough to support crew operations but not so large that it overly distances the operator in the pilothouse from crew working near the transom. Visibility between the operator and crew, particularly for Stages 3 and 5 of the rescue sequence, is paramount. The aft deck should also incorporate deck camber to aid in shedding water.

Bulwarks in the aft portion of the vessel should be of sufficient height to protect crewmembers from oncoming seas and from falling overboard, but not so high as to disrupt crew line of sight to the horizon, which can reduce situational awareness. Excessively high bulwarks are also considered a design detriment for this application because they drive up the elevation of the tow wire and the installed position of the winch, which can negatively affect vessel stability and crew safety on deck. Aft bulwarks should be 4-5 feet in height and should feature a cutaway area, or transition to no bulwark on the transom, such that the tow wire and gear does not have to pass over structural interferences as it is deployed and recovered on deck. A cutaway bulwark also facilitates making and breaking tow and enhances crew safety by keeping the tow wire and gear as low to the deck as possible. This type of ‘flush-deck’ stern is particularly important for establishing hard gear connections because of the ease with which a wire pendant can be stopped off, worked, and connected by the crew. Lastly, bulwark height and geometry should allow free/easy movement of the towline across bulwarks when towing out of pins. The top edges of the bulwarks should not have any sharp edges or angles that could potentially kink or otherwise damage the tow wire. For this reason, a rounded pipe edge cap rail is preferable for all areas of the aft bulwarks within the design sweep angle of the tow wire.

4.5.2.3 Tow Winch and Related Deck Equipment/Machinery

The tow winch is an obviously vital piece of equipment for any tug expected to perform ship rescues at sea. While towing winches are manufactured in a variety of configurations and for a broad range of applications, there are few production models ideally suited for rescue towing. The primary reason for this is that purpose-designed rescue towing winches are regarded as a niche market for most winch manufacturers. The severity of the application generally translates to large-scale winches, mission specific performance requirements, and high cost of development, while demand for such equipment is low in comparison to other winch types. The lack of demand may be attributable to two inherent drawbacks:

1. A winch optimized for rescue towing has a large footprint that occupies valuable deck space needed for other purposes and may drive an increase in vessel beam.
2. A winch optimized for rescue towing may mean sacrificing other desirable vessel functions (e.g., anchor/buoy handling, salvage work, etc.), thereby hampering the overall versatility of the vessel.

From a commercial perspective, these drawbacks, coupled with the high cost of developing a customized piece of equipment, reduce the attractiveness of a purpose-designed rescue towing winch for vessel owner/operators. Consequently, most rescue capable tugs today are outfitted with a winch package that is a practical compromise - balancing ocean towing capability with competing space, versatility, and cost considerations. Nevertheless, there are good examples of existing winches that have been optimized for towing large vessels in rough, mid-ocean conditions. The salient characteristics of such winches are described in this section, following a brief clarification of the term "towing winches."

Responding to market demand, many tugboat winch manufacturers have focused their efforts over the past two decades on maturing sophisticated hawser and/or escort winches designs for use in vessel assist and tethered escort operations. It is important to understand that these winches are fundamentally different from a winch designed for towing large vessels astern in an open ocean environment.

Hawser/escort winches are most often located on the "working end" of a tug, opposite the propulsion units, and are designed for use with HMPE-based hawsers exclusively. The operational requirements of assist/escort work, namely the application of steering and braking forces from a position directly astern of a moving ship, ultimately led to the development of the modern high speed constant tension or render/recover "towing winch" – a somewhat misleading term given that these winches are not intended for towing in the conventional sense using wire rope. Because HMPE rope is roughly one-seventh the weight of the equivalent strength wire rope (and positively buoyant in water), there is little or no catenary, and thus very little natural shock absorption afforded by the relatively short length of stiff line spanning between the tug and the vessel being assisted/escorted. To compensate for this, render/recover winches are designed to render out when a specific tension is reached to prevent shock loading of the hawser. As tension is relieved, the winch stops rendering and hauls in (recovers) as needed to maintain a taut line and consistent application of steering/braking forces during a critical maneuver. The recovery function also serves to manage line capacity limitations by recovering any "slippage" back onto the winch drum. It also serves to maintain the requisite/desired distance between an escort tug and the vessel it is escorting by keeping the total line length more or less constant during the operation (within scope brackets).

Towing astern, by comparison, requires placement of the winch aft of the house on the "power end" of the tug (except on tractor/reverse ASD configurations). In exposed/open water locations (oceans especially), towing astern involves deploying anywhere from several hundred to more than 2,000 feet of heavy wire rope (of steel construction) into the water, except in circumstances where local geography or water depth may be limiting. The weight of the wire suspended in the water column serves as a natural shock absorber; and while rendering capability is still desirable for a purpose-designed rescue towing winch, particularly to avoid shock loading in the initial moments of the operation (with limited wire out), the recover function of modern hawser/escort winches is not necessary. This is because it is not critically important to maintain a precise distance from the affected vessel when towing offshore, nor is there the same need to conserve line capacity on the drum as with hawser/escort winches. If a significant distance of wire rope is rendered or "slipped" during the towing operation, the master, under most circumstances, can reduce speed/RPM and recover tow wire, if necessary.

The most important elements of winch design for rescue towing purposes are:

- Arrangement.
- Available power in the prime mover (without compromising available thrust).
- Total wire rope capacity.
- Brake holding capacity.
- Global strength of winch body, winch foundation, and supporting underdeck structure.
- Robustness/reliability of operation.
- Vertical center of gravity.
- Elevation of the drum(s) and tow wire above the main deck.
- Direction of winding (overwound or underwound).
- Automatic level winds.
- Free-spooling capability.
- Load instrumentation and displays.
- Adjustable render or slip functionality.

While the capacities and performance requirements for any rescue towing winch are application specific, the design must satisfy Class-required safety standards for wire rope, winch scantlings, emergency control functionality, foundations, and supporting structure.

Such requirements notwithstanding, the following general tow winch characteristics, taken together, would be considered optimal for the purposes of rescue towing in the Gulf of Alaska in closure conditions:

- Longitudinal placement of the winch forward of the stern by a distance approximately 20-30% of the total vessel length.
- Side-by-side double drum winch design with each drum sized to accommodate an equal complement of not less than 2500' of 2½"-3" diameter wire rope, as may be required.
- 6 × 26 or 6 × 37 class wire rope of extra improved plow steel (EIPS or XIP) or extra extra improved plow steel (EEIPS) construction.
- Under-wound wire deployment on both drums for lowest achievable tripping point, and to allow aft components such as tow pins, tow hooks (hold-downs), and shark jaws to easily engage the wire for safe towing and making/breaking tows.
- Each drum serviced by an automatic level wind, independent jaw clutch, and independent conventional band brake (air and manually actuated).
- Instrumentation points on band brakes to provide real-time tensiometer displays in the pilothouse and data acquisition recording.
- Integrated and fully adjustable slip brake system – water-cooled multi-disc type or alternate – for operation in heavy surge scenarios typical of foul weather and bar crossings. A band brake type automatic rendering/slip system is not regarded as BAT for this application.
- Power provided by a dedicated and internally protected diesel engine, either direct coupled with a torque converted multi-speed transmission, or paired with a generator

supplying electrical power to one or more winch motors. Having a dedicated diesel engine is preferable to avoid drawing power from the main engines.

- Independently operated suitcase drum and warping head to assist in gear handling operations, located on opposite sides of the winch body.
- Remote (pilothouse) control console incorporating variable speed winch controls, clutch and band brake controls, slip brake tension control, engine gauges, and real-time line tension feedback from tensiometers.

Figure 2 Example of a side-by-side double drum ocean towing winch, configured for underwound wire deployment; photo courtesy of Markey Machinery

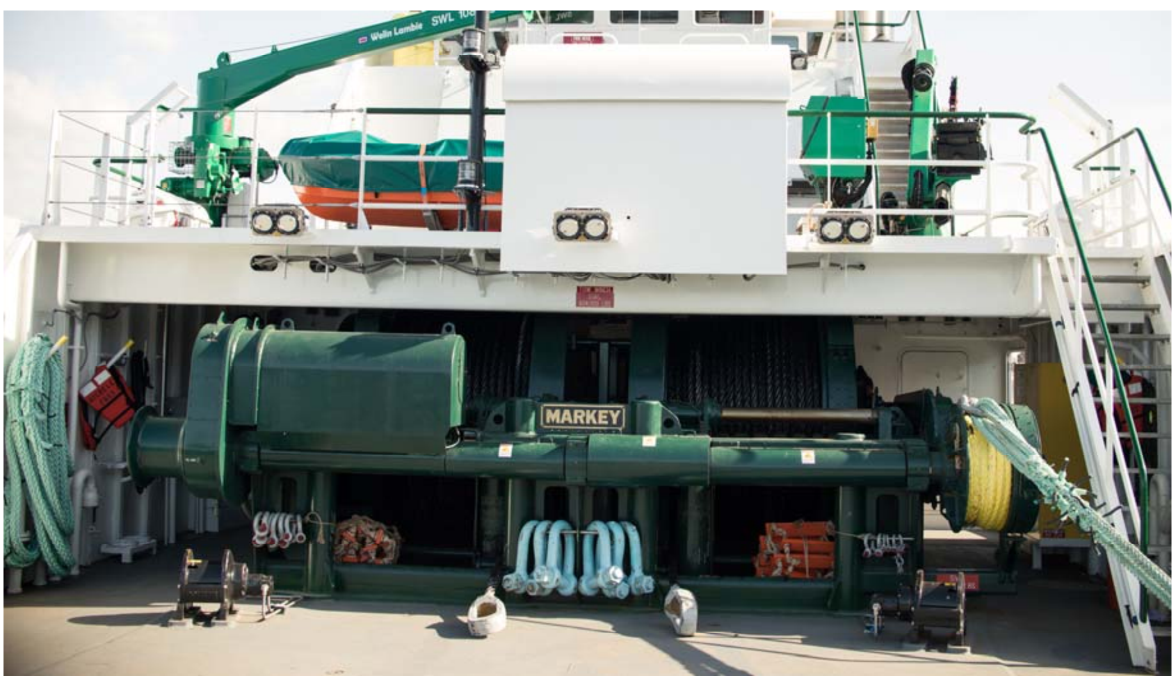

Figure 3 Photo of the same winch shown in Figure 2, outfitted and installed on an oceangoing tug; photo courtesy of Markey Machinery

It is recognized that several of the candidate tugs/ETVs presented for evaluation as BAT in this report are outfitted with waterfall type towing winches. This is believed to be the result of the commercial decision-making process described above (i.e., owners attempting to strike a balance between availability and cost and maximizing the utility/functionality of the vessel). Another likely reason may be a preference for very high bulwarks extending aft to the transom. This not only affords protection for the crew but increases compatibility with multiple winch types because the elevation of the tow wire at the winch position must match the height of the bulwarks. This is a very common arrangement on AHTS vessels where the house is located forward, the working deck is long (occupying almost half the vessel's total length), and crews are required to work outside, in seas, for extended periods.

It should be noted, however, that the waterfall winch arrangement, though it does offer a narrower footprint than a side-by-side double drum design, has some drawbacks. The primary drawback is that a conventional waterfall arrangement requires the higher winch drum to be overwound, which results in a comparatively high tripping/overturning point and may present challenges for engaging the tow wire in tow pins, tow hooks (hold-downs), or shark jaws due to steeper line angle.

Figure 4 Photo of the conventional Smith Berger tow pin and hook assembly installed on the current SERVS escort tugs, accessed from https://maritime-executive.com/corporate/tow-pins on 3/20/2021

A conventional waterfall arrangement also presents challenges for integrating an automatic level wind over the top of the adjacent winch drum and makes it difficult – potentially impractical in an at-sea emergency - for the crew to draw wire out on deck for rigging purposes.

Some of the drawbacks noted above can be mitigated, to an extent, by selecting a reverse waterfall arrangement, which features the higher winch drum located aft and the lower winch drum located forward. This makes it possible to configure the upper drum for underwound wire deployment; however, lower tripping points and a lower vertical center of gravity are still best achieved with a side-by-side configuration, given that the drums are not stacked (lower profile) and both can be arranged for underwound deployment. For this reason, the double-drum waterfall arrangement is not regarded as optimal/BAT for rescue towing, which is a slight departure from some of the source information in Reference 1.

Additional deck machinery/equipment is necessary for engaging the tow wire near the stern, to prevent tripping, and to enhance the safety and efficiency of gear handling while making and breaking tows. The following equipment, complementary to the tow winch, is considered optimal/BAT for the purposes of rescue towing in the Gulf of Alaska. It should be noted that this equipment, as described, requires a cutaway bulwark or no bulwark at the transom.

- A minimum 4 pin, 2 hook/hold-down tow-pin assembly flush-mounted in the main deck aft. To the extent possible, tow hooks (hold-downs) and pins should be positioned to align with the center of the correlating drum on the tow winch to minimize fleet angle.
- One or two shark jaw assemblies flush-mounted in the main deck aft, immediately forward of tow pin assembly(ies). If one assembly, shark jaws should be located on centerline. If two assemblies, shark jaws should be located port and starboard, in-line with tow-pin assembly(ies).
- Structurally integrated stern roller mounted at main deck height and overhanging the stern sheer strake.

The inclusion of one or more small tugger winches or deck winches is also regarded favorably for the purposes of this study. Though not essential, this equipment can significantly enhance gear handling operations on deck.

4.6 Stage 5: Cessation/Handoff of the Towing Operation

The final stage of the rescue operation for the Hinchinbrook Tug involves recovery of most or all of the towing gear on deck and disconnecting from the affected vessel. However, because the towing operation can play out in a number of different ways, the circumstances in which the tug ceases towing and intentionally disconnects from the vessel can vary considerably. The Hinchinbrook Tug must be capable of accomplishing this in all foreseeable practical cases.

One conceivable scenario is that metocean conditions offshore are rough and predicted to remain so or worsen, so a decision is reached to tow the affected vessel to a nearby area where the local topography affords some protection from the oncoming weather (e.g., behind land masses or rock structure that affords a lee and/or some degree of wave shadowing). This is generally referred to as sheltering. For tank vessels inbound or outbound from Prince William Sound, the options for sheltering are quite limited if the ship disablement occurs in the open waters of the Gulf of Alaska. In this case, the best option may be to tow the affected vessel through Hinchinbrook Entrance and into Port Etches, Zaikof Bay, or other sheltered location behind Hinchinbrook or Montague Island. If the affected vessel has auxiliary power and is able to anchor safely, the tug can disconnect in relative safety and stand by the affected vessel until additional support arrives.

Another conceivable scenario is that metocean conditions during the towing operation are relatively calm, or predicted to become so, and the favorable weather “window” coincides with the arrival of a commercial oceangoing/salvage tug dispatched to relieve the Hinchinbrook Tug and tow the affected vessel to a port destination for repairs. Disconnecting from the affected vessel in this environment (offshore) should only be attempted if at least one of the following conditions are met:

- The rigging of the emergency towing gear is such that it is reasonably practical to connect the oceangoing/salvage tug before disconnecting the Hinchinbrook Tug.
- The rigging of the emergency towing gear is such that the tow wire socket on the oceangoing/salvage tug can be shackled directly to the end of a length of chain or wire rope pendant composing an established “hard gear” connection. This avoids the need to detach already rigged towing gear from the deck of the affected vessel, but generally

requires very calm conditions to be carried out safely. This is effectively a vessel-to-vessel "handoff" (requires physically passing the tow wire or pendant from one vessel to another) and thus should not be attempted in wave heights more than a few feet.

- Metocean conditions are extremely calm, such that the masters of all vessels involved have confidence that the Hinchinbrook Tug can safely disconnect, and the oceangoing/salvage tug will be able to reestablish a towing connection with little difficulty.

Whether it is a handoff at sea or simply disconnecting after the affected vessel is safely at anchor in a protected area, the towing gear must be recovered on the deck of the tug in order to "break tow" (i.e., remove connecting hardware and recover the tow wire on the winch drum). This is a relatively simple task if a synthetic towing system was used for the rescue. Synthetic line can be spooled directly onto the tow winch, hauled aboard using a capstan or warping head, or even hauled aboard manually if necessary. If a "hard gear" connection was used, the process of breaking tow is more complicated and involves greater risk. The gear itself is substantially heavier than synthetic systems, which can result in tremendous friction and pressure on areas of the tug's stern as it is hauled aboard. This is especially true for the recovery of any stud-link chain gear used in the towing system. Once the intended disconnect point is recovered, the gear must be restrained on deck – typically using shark jaws or Karm forks - to prevent it from slipping back overboard under its own weight as the crew works to unfasten shackles and/or other connecting hardware. At this stage excessive movement of the two vessels in relation to one another can cause the gear to shift or "jump" on deck, which can cause serious injury to crewmembers as they work around the connection point. The risk of injury increases if crewmembers become too focused on the task of disconnecting and lose situational awareness. For this reason, positive directional control of the stern is very important at this stage. Because oncoming waves and the resulting vessel motions that can cause gear to shift on deck are somewhat foreseeable, the master can often thrust the stern in one direction or another proactively to alleviate relative motions and avoid putting undue strain on the gear.

4.6.1 Major Design Considerations

Apart from the required equipment and machinery mentioned above, there are a number of other, more general, vessel design considerations that have implications for the safety and efficiency of this phase of the rescue evolution.

- Propulsor type and the availability of directional thrust in the stern.
- Seakeeping and motions characteristics.
- Aft deck geometry and arrangement.
- Stern shape (outline), bulwark design, and fendering.
- Tow winch location and tow wire angle in the vertical plane.
- Tow winch configuration, direction of winding, and capabilities.
- Fixed towing gear/equipment (e.g., stern roller, towing pins, towing hooks, jaws, etc.).
- Ancillary deck machinery (e.g., capstans/warping heads, suitcase drums, tugger winches, etc.).

4.6.1.1 Motions

Many of the most important factors at this stage depend on the tug's towing equipment complement, stern geometry, and aft deck arrangement. However, minimizing vessel motions is still crucial for ensuring crew safety during gear recovery and tow handoff. The motions discussions for Stage 2 and Stage 3 generally hold at this stage as well.

4.6.2 Optimal Vessel Arrangements and Equipment

4.6.2.1 Stern Geometry and Bulwarks

Performing the initial gear recovery operation safely and efficiently in a seaway requires a flat surface along the transom to help keep the tow wire/gear contained in this area of the vessel until it can be secured by shark jaws or other means. A flat transom minimizes the probability and extent of any shifting of the gear under strain up until the time it is secured. A softened deck edge and radiused corners at the quarters (free of fendering) will also prevent gear from hanging up and/or shifting unexpectedly as it is recovered on deck.

In addition, a structurally integrated stern roller and specialized deck equipment for temporarily securing the tow wire and/or stud-link chain on deck is needed (e.g., tow pins, tow hook [hold-down], shark jaws). Tow pins with "top locking" capability are strongly preferred for safety reasons.

Figure 5 "Top locking" type tow pins with Karm forks, accessed from https://www.maritimejournal.com/news101/onboard-systems/deck-equipment-and-lifting-gear/second-generation-towing-pins-popular on 3/20/2021

This equipment is discussed in more detail under Stage 4. Tugger winches or compact deck winches are also beneficial for enhancing the safety and efficiency of gear handling on deck (i.e., hauling chain aboard in bights, dragging/repositioning chain or other hardware on deck, or for relieving tension on hardware and securing fittings as may be necessary).

4.7 Conclusion

Examining Hinchinbrook Tug BAT in light of the distinct stages of a rescue towing sequence reveals a complicated interplay of competing demands and design constraints. Three general considerations apply across the five stages of a rescue towing operation.

- The computational tools used to evaluate vessels during the design phase have improved considerably in recent decades, enabling designers to better predict and optimize motions and propulsive efficiency.
- Redundancy and reliability are crucial considerations given the scope of activities that must be accomplished to successfully complete a rescue tow.
- The optimum design points of several important vessel characteristics vary over the different stages of a rescue operation; therefore, BAT for these characteristics will achieve an effective balance between these conflicting demands.

4.7.1 Improved Design Tools

While not discussed in depth thus far, several important "best available technologies" to consider actually come to bear before the tug is even built. Design practices have continued to advance, improving the designer’s ability to develop cohesive designs that balance the design elements discussed above. Formal multi-objective hullform optimization using computational fluid dynamics software can achieve significant reductions in resistance over a range of operating conditions. The ability to optimize for seakeeping or added resistance objectives is limited only by the time, budget, and computing power available. As design tools advance, costs and time requirements tend to reduce or allow for more iteration and refinement of the design.

Employing advanced analytical tools during the design phase can be particularly important for understanding and subsequently refining a hullform's motion characteristics in the range of ocean conditions likely to be encountered. Given the difficulties crew are likely to face while working on the aft deck in closure conditions, achieving even a modest improvement in seakeeping characteristics in the design phase provide a crucial advantage during a rescue operation. Use of advanced computational design tools should therefore be considered within the scope of BAT if plans are made to procure a newbuild tug.

4.7.2 Redundancy and Reliability

Redundancy and reliability are considered throughout many of the arrangement and equipment discussions above; however, certain equipment, arrangements, and/or practices are particularly relevant and bear mentioning:

- Double drum winch configuration and dual tow pin/tow hook (hold-down) assemblies.
- Dedicated diesel engine for towing winch.
- Decoupling main engines and port/starboard propulsion trains from one another in any way practical.
    - Segregation of fuel tanks.
    - Redundant fuel filtration systems port and starboard.
- Backup power generation capability.
    - Backup generator(s) capable of carrying full hotel load and powering any connected equipment.
- Total redundancy in the power generation and distribution system.
- Thoughtfully designed default and failure modes for machinery and equipment that ensure continued vessel operability.
- Towing gear spares.

4.7.3 Balancing Conflicting Demands

4.7.3.1 Bollard Pull

Bollard pull capabilities above 185 MT will increase the cost and size of the tug above the level identified as necessary in Reference 2 while penalizing the vessel's performance at other stages, particularly the vessel's agility in Stage 3. Within the BP range under consideration in this report (at least 120 MT), though higher bollard pulls are generally preferred, it may be prudent to accept a bollard bull below 185 MT if lowering this design criterion sufficiently benefits the tug's performance in other areas – particularly its agility in close-quarters maneuvering scenarios.

4.7.3.2 Bow Form

Conventional bow forms incorporate more flare than inverted bows or axe bows, which adds resistance during high-speed transit in heavy weather. On the other hand, inverted and axe bow forms reduce foredeck area, hamper the ability to make a close approach to the affected vessel with the bow, and are more costly to construct.

The added motions and speed benefits of incorporating an inverted bow or axe bow cannot be analyzed in sufficient depth within the scope of this study. Both show promise for improving these characteristics, but their drawbacks with regards to operations at the bow of the tug may make them incompatible with the subject application.

Inverted bows require any working foredeck area to be positioned well aft of the stem. It is also not possible to fender an inverted bow, such that the tug can make direct contact with an affected vessel if need be. These factors seriously hamper the ability to make a rapid bow-first approach to a disabled tank vessel with forward inertia (e.g., to recover the pickup gear/fixed emergency towing system installed on the stern).

4.7.3.3 Length

Increasing the tug's length will make it easier to achieve the 16-knot speeds desired for keeping pace with outbound tankers and minimizing Stage 1 response time in general. However, as length increases, the tug's agility in close-quarters maneuvering begins to suffer and the power requirements to stay on station increase due to the vessel's larger sail area. An optimum length will enable the tug to make speed while retaining the ability to make time critical adjustments and maneuvers in heavy weather and in relatively close proximity to the affected vessel. Propulsion system selection (i.e., presence of stern thrusters, ASD, etc.) will impact both the ability to make speed as well as what lengths are feasible for maintaining the necessary agility, as discussed in the following section.

4.7.3.4 Propulsors

VSPs offer excellent maneuverability characteristics and active roll stabilization but have speed and bollard pull limitations. ASD tugs offer more versatility for towing purposes and their agility characteristics are quite good but achieving the desired free running speed of 16 knots presents challenges.

ASD tugs are fitted with nozzles, which increase thrust but introduce significant drag at higher speeds. Engineering work would be required to ensure that any nozzles fitted would allow the tug to achieve the desired 16-knot speed without an impractical increase in requisite installed power. Nozzles can be designed for high bollard pull and good high-speed performance, but such designs are not commonly seen in existing vessels. The ubiquitous 19A nozzle, the worldwide standard nozzle profile developed by MARIN, is not efficient at the transit speeds required. High performance nozzles are somewhat rare in fixed propeller installations and ASDs, but there are options for both.

Twin screw propulsion with one or more stern thrusters is a great candidate for making the desired speed, but this option will likely be less agile than an ASD configuration.

Section 5 Comparison of Presently Used ETVs

5.1 Methodology

The ETV Inventory (Reference 20) Glosten assembled contains around 4,000 vessels. A small minority of these vessels are purpose-built ETV's and/or were identified as having served in a dedicated ETV role at some point. The remainder of the vessels in the inventory were gleaned from various towing vessel datasets (details provided in Reference 21).

The procedure below was used to downselect to the top echelon of vessels considered representative of BAT for the Hinchinbrook application. These candidate vessels are further evaluated for suitability in Section 6.

Preliminary scoring results are provided in Appendix B.

5.1.1 Phase 1: Parametric Filtering

1. The candidate vessel pool was reduced from 4,000 vessels (in the original inventory) to around 400 by removing vessels outside of the length and bollard pull (BP) ranges identified in Section 3.
    - There was no upper BP limit, as the length requirement practically limited the vessels under consideration to an appropriate powering range.
    - Some well-known and highly capable vessels were excluded from consideration because they exceed the 80m maximum length identified in in Section 3, including *Normand Jarl*, *Smit Amandla*, ICGV *Þór* (*Thor*), *Bergen*, *Sortland*, *Barentshav*, *Nene Hatun*, *El Mous'if*, *El Moussanid*, *El Moundjid*, KBV 001 (*Poseidon*), KBV 002 (*Triton*), and KBV 003 (*Amfitrite*).
2. The pool was further reduced to 387 vessels by filtering to include only vessels delivered 2005 and after.
    - Pre-2005 vessels known to have performed ETV functions in the past were checked. The only competitive/suitable hullforms identified were for pre-1980 builds, which are considered outside the age range acceptable for this study.
3. The pool was further reduced to 190 vessels by eliminating duplicate designs as follows:
    - For groups of known off-the-shelf designs, all but the most recent builds were removed.
    - Where owner, length, and BP were the same, vessel names were compared. If vessel names were part of a numerical series (e.g., *Caspian 1*, *Caspian 2, Caspian 3*, etc.), only the most recent build was retained.

5.1.2 Phase 2: Preliminary Scoring

1. Vessels in this reduced set (~190 vessels) were scored on suitability for Hinchinbrook services based on their physical attributes. Vessels for which photos could not be found in a standard web search were eliminated. Vessels found were scored from 1-3 (Unacceptable, Acceptable, and Optimal, respectively) in the following categories:
    - Bow Form.
    - Pilothouse Location/Sail Area Balance.
    - Crew Protection/Bulwark Height.
    - Rescue/Recovery/Firefighting Outfit.
    - Freeboard.
    - Stern and Aft Deck Geometry.
    - Tow Winch and Related Deck Equipment/Machinery.

2. Vessels were scored based on bollard pull.
   - BPs of 152.5 MT and greater (midway between the min and max parameters in Section 3) received a score of 3 (optimum). BPs of 120 MT - 152.5 MT were ranked from 1-3, linearly increasing from 1 at 120MT to 3 at 152.5 MT.
3. Composite visual scores and bollard pull scores were then calculated. Given that some vessels scored well visually but were on the low end of the bollard pull range (and vice versa), there was some discussion on how to weight bollard pull scores against visual scores. A hybrid approach was selected:
   - Three different composite visual + BP scores were calculated, in which bollard pull score was weighted at 1, 2, and 3 times that of the individual visual categories listed above. Vessels with aggregate scores ranking below the 50th percentile at each of the three weighting factors were eliminated.
4. Of the roughly 50 vessels remaining, there were numerous clusters of AHTS tugs of very similar length, BP, and appearance, as this vessel type was by far the most prevalent in the non-ETV towing vessel data imported into the inventory. Amongst clusters of AHTSs nearly equal in appearance, length, and BP, only the most recently constructed was retained. The remaining pool of 17 vessels constitutes the subset of vessels to be evaluated as part of the next task.

5.2 Candidate Vessels

The 17 candidate vessels are listed in Table 6. Candidates known to be part of a series (i.e., having 'sister' vessels) are marked with an asterisk. Bollard pull is determined empirically and can differ somewhat between sister vessels; therefore, this study evaluates a single representative from each vessel series.

Table 6 Hinchinbrook ETV candidate vessels

Name	Flag	Owner	LOA (m)	Bollard Pull (MT)
*Abeille Bourbon**	France	Groupe Bourbon	80	201
Almisan	Italy	Augusta Offshore S.p.A.	52	149
Alp Ace	Netherlands	Alp Maritime Services BV	59	192
Baltic	Germany	Arbeitsgemeinschaft Küstenschutz	61	127
Britoil 41	Singapore	Britoil Offshore Services Pte. Ltd.	60	150
*Bylgia**	Netherlands	Heerema Marine Contractors	72	199
Guardian	Netherlands	Multraship	66	149
*Luz de Mar**	Spain	Spanish Maritime Safety Agency	55	129
*Maersk Tender**	Denmark	Maersk Supply Service	73	171
*Marty Quist Tide**	Vanuatu	Tidewater Marine Service Inc.	70	154
Nordic	Germany	Nortug Bereederungs GmbH & Co	78	201
Ocean Response	Norway	Atlantic Offshore AS	75	120
*Ocean Sun**	USA	Vessel Management Services	44	165
Skandi Ipanema	Brazil	DOF Navigacao Ltd.	74	174
*Skandi Rio**	Brazil	NorSkan Offshore/DOF ASA	80	206
Skandi Saigon	Norway	Aker DOF Deepwater AS	75	196
*Vrana Tide**	Vanuatu	Tidewater Marine Service Inc.	51	127

*Vessel is known to have at least one sister

The 17 candidate vessels are a diverse group, with lengths ranging from 45-80m, bollard pulls ranging from 123-209 MT, and propulsion systems that include ASD and conventionally shafted configurations. Four of the candidates are purpose-built ETVs, while at least four others were identified in Reference 17 as having performed emergency towing operations in the past. Eleven were found in the larger datasets outlined in Reference 21.

Figure 6 shows a scatter plot of the distribution of bollard pulls and lengths represented in the list candidate vessel subset.

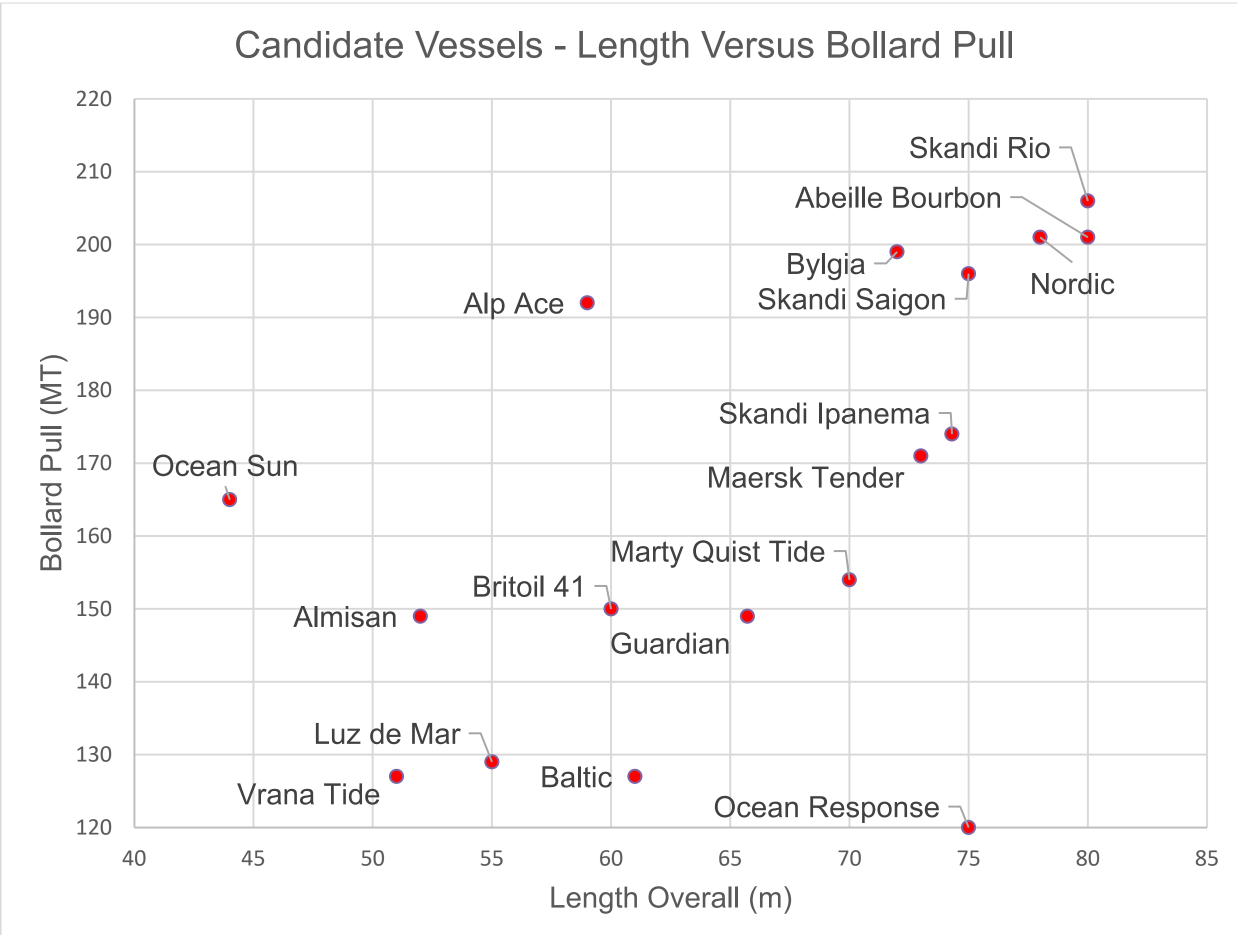

Figure 6 Candidate vessels length versus bollard pull plot

5.3 Emerging Designs

The designs shown below have not yet been proven in service, but they were developed recently with emergency towing in mind and should be monitored for future developments.

5.3.1 New SASEMAR Vessel

Spain's Sociedad de Salvamento y Seguridad Marítima (Maritime Rescue and Safety Society) or SASEMAR, which owns and operates the *Luz de Mar* ETV class featured in this report, released a tender in early 2021 for construction of a new 83m, 200 MT bollard pull ETV. The design was developed by Seaplace, a Spanish ship design and offshore engineering firm. Glosten reached out to SASEMAR to request information on the design and SASEMAR graciously provided Glosten a copy of the design package put out to shipyards for bids. Selected design details from the technical specification are presented below (translated from Reference 31).

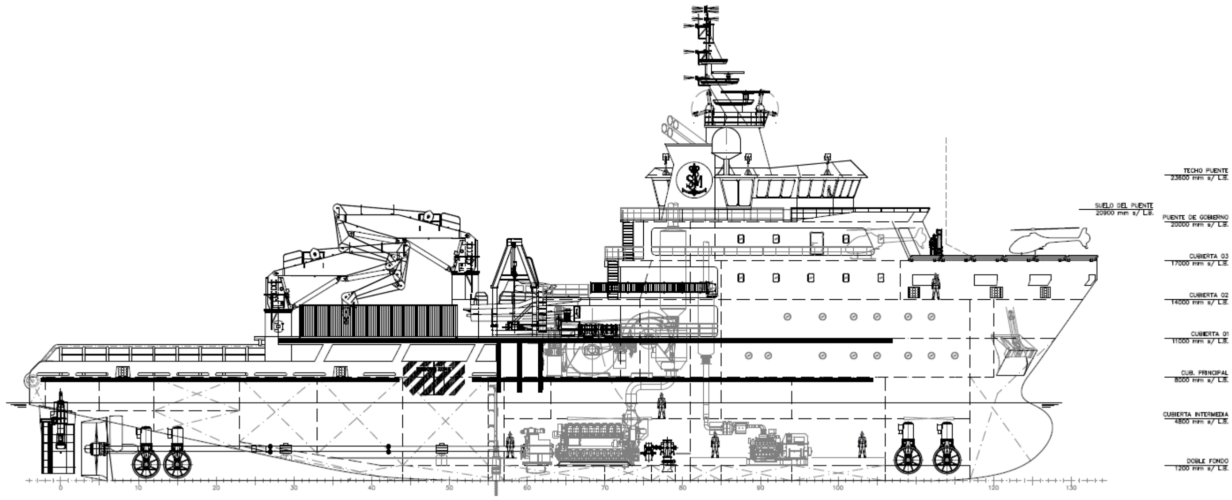

Figure 7 New SASEMAR 83m ETV design – general arrangement

- Description: A salvage ship with a length greater than 80m, equipped with the necessary means for the rescue and rescue of vessels and human lives, and that additionally has the capacity to fight against oil pollution, suppress fires, provide humanitarian aid, and patrol in the SAR zone assigned to Spain.
- Accommodations for 16 crew and 26 special persons.
- 30-day endurance, 8,000-mile range.
- Maximum speed 17.5 knots.
- Propulsion and power generation plant will be optimized for the ship's operational profile. To meet this objective, a hybrid plant will be set up that will move the two (2) axle lines through two (2) gearboxes, each driven by a high-power main diesel engine and a medium-power electric motor/generator. In high demand situations, the medium power electric motor/generator will function as an engine receiving power from the auxiliary generator sets fitted to the ship, and in low demand conditions it will be able to propel itself without the need to operate the diesel engines, or only one of them working.
- Four (4) transverse tunnel thrusters, two (2) forward and two (2) aft.
- IMO class 2 dynamic positioning requirement for design conditions.
- Waterfall type winch, two speeds, with a pull of 200 tons and a brake power of 500 tons. Initially, it will be electrically driven by two clutchable motors, which can work in parallel and obtain the maximum draft when they work together on the same drum.

5.3.2 Robert Allan Ltd. RASalvor Series

Another ETV design that appears promising is the Robert Allan Ltd. (RAL) RAsalvor series, shown below in Figure 8, which was created to address the growing worldwide demand for large and powerful rescue/salvage tugs (Reference 50). RAL describes this as a series of "fast and powerful tugs…designed to provide long range towing, anchor-handling, rescue and salvage capabilities, and typically…equipped with significant fire-fighting and spill response capacity" (Reference 32). Additional functions such as dive support, DP operations, and standby functions can also be accommodated. The standard RAsalvor design is 60m overall, but variants as short as 44m can be developed. Maximum bollard pull is reported as 160 MT (Reference 50).

Appendix E includes a general arrangement drawing and marketing sheet for the RASalvor 6000 series provided by Robert Allan Ltd. for inclusion in this report.

Figure 8 RAsalvor 6000 Series vessel concept, courtesy of Robert Allan Ltd., Reference 32, accessed 22 February 2021

At the time of this writing, no RAsalvor tugs have been delivered and proven in service, so this design was not included in the BAT downselection process described above. Nevertheless, and though publicly available information on the RAsalvor concept is limited, there are number of incorporated design elements that are appropriate for ETV service in the Gulf of Alaska and consistent with the operating requirements of the Hinchinbrook Tug. These include:

- Appropriate length.
- Conventional bow form with fine lines and bulb.
- Raised focsle with high freeboard extending aft to midships.
- Fully fendered prow.
- Favorable length to beam ratio (3.66) for achieving higher free running speeds.
- Max operating draft of 7.6m (25 feet).
- Twin ASD propulsion with bow thruster.
- Cropped aft skeg for directional stability while towing.
- Raked stern for improved performance operating in stern-first mode.
- Rolling chocks at the turn of the bilge near midships
- Favorable wheelhouse location with aft end cantilevered (aft) to enhance visibility/sightlines.
- Nested vertical exhaust pipes (allows unobstructed view from aft control station).
- Fully enclosed wing stations.
- Spacious aft deck with reasonable bulwark height.
- Cutaway in bulwark at transom to facilitate gear handling on deck.
- Double drum tow winch aft and hawser/tow winch forward.
- Telescoping deck crane with RIB/fast rescue boat.
- Firefighting capability.

RAL further states, "the hull form for this series has been extensively model tested and subsequently refined through Computational Fluid Dynamics analysis, resulting in a truly optimized design, delivering high speed and excellent seakeeping capability as befits the role of these major tugs" (Reference 32).

Figure 9 Photo of the RAsalvor 6000 series hull form undergoing model testing; photo courtesy of RAL, 3/30/2021

5.3.3 T-ATS 6 Class

The US Navy is in the midst of procuring a series of new T-ATS 6-class towing and salvage vessels, several of which are currently under construction at Gulf Island Shipyard in Houma, LA.

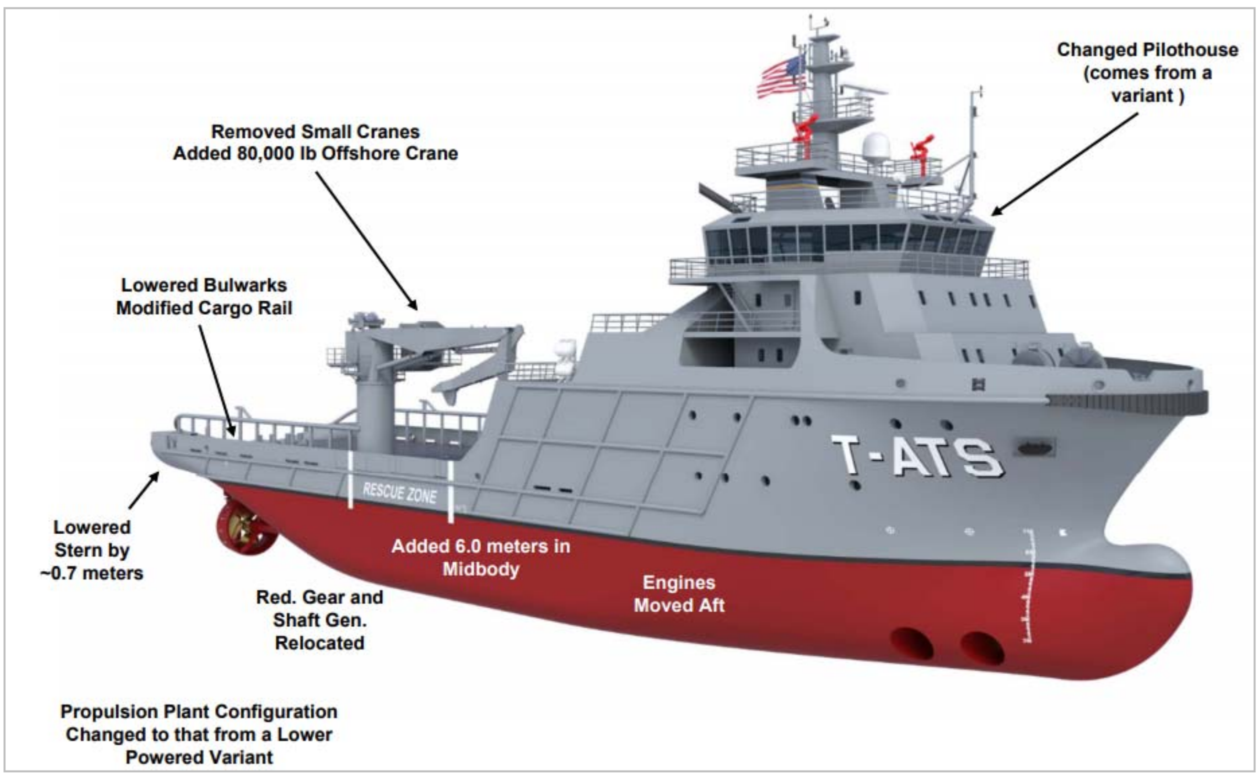

Figure 10 T-ATS 6-class labeled with alterations from previous T-ATS class, Reference 33, accessed 22 February 2021

The T-ATS 6 vessel class's characteristics include the following (Reference 33):

- LOA: 80.1 m (262.8 feet).
- Bollard pull: 176 short tons.
- Speed, Sustained: 15.1 knots.
- Endurance Range: 8170 nm @ 10 knots.

Section 6 BAT Evaluation and Gap Analysis

6.1 Methodology

The scoring methodology used to evaluate candidate vessels was necessarily complex, as numerous mechanical, arrangement, and performance details for each vessel needed to be identified, compared, ranked by relative importance, and scored. This study attempted to provide an objective, holistic evaluation by ranking 17 candidate vessels on 19 scoring parameters and two cost parameters, as detailed below.

6.1.1 Limitations of This Study

Before discussing the details of how scores were generated, two limiting factors affecting the analysis must be addressed.

6.1.1.1 Availability of Information

Glosten made every effort to gather detailed information on candidate vessels, up to and including contacting owners and operators to request cutsheets and technical data. Glosten was able to acquire, at minimum, a cutsheet for each vessel, plus in some cases news articles, drawings, and promotional materials that contained additional relevant characteristics.

Nevertheless, some cutsheets provided less detail than others, some owners were less forthcoming with information, and only a few vessels had been the subject of detailed articles in the press. As a result, a small number of relevant parameters were unknown for some vessels; for example, free running speed was unavailable for *Guardian* and *Maersk Tender*. Furthermore, details such as displacement were not typically available, which limited options for making rudimentary speed or powering calculations. As a result, interpolation was required in some cases, and in the few cases in which a parameter was altogether missing for a vessel, a lower score was assigned.

6.1.1.2 Scope, Schedule, and Budget

Scope, schedule, and budget limitations for this project particularly drove the methods used to evaluate and score costs for the candidate vessels. Capital costs for vessel acquisition were in most cases unavailable, and even where available, differences in build location and build year made direct cost comparisons difficult. Annual operating costs were also unavailable. As a result, vessel cubic number (length * breadth * draft) and powering details were used as proxies for capital and operating costs. This approach is explained further in the Cost Parameters section.

6.1.2 Scoring Parameters

Vessel characteristics and parameters were scored from 1-5 according to the ranking scheme shown in Table 7.

Table 7 Ranking scheme

Number	Description
1	Unacceptable
2	Marginal
3	Acceptable
4	Favorable
5	Optimal

The categories scored for each vessel are shown in Table 8, accompanied by a description of the method used to derive the score. The weighting factors applied to each category in the combined scoring are also shown; bollard pull was weighted as the most important, followed by maneuverability and free running speed.

Some categories were qualitatively assessed, and vessels were scored at integer or half integer intervals in these cases. Other categories were quantitative (i.e., derived from numerical parameters of the vessels). In these cases, scores may have ended up as decimal values. All scores are shown rounded to the nearest hundredth.

Table 8 Scoring categories and evaluation

Category	Weighting Factor	Explanation
Accommodation (Pax + Crew)	1	Vessels having berths for crew complement plus a rescued tanker crew of 20 received a score of 5. Scores for vessels with fewer than 20 extra berths decreased linearly along with the number of extra berths, with a minimum score of 3. Minimum score was set at 3 because all vessels were considered to have acceptable accommodations.
Bow Form	1	Finer bow forms with substantially raised focsle deck and sufficient flare above the waterline scored highest.
Bollard Pull (BP)	6	A bollard pull of 120 MT, the minimum considered in this study, was assigned a score of 2 (Marginal). Scores linearly increase from 2 at 120 MT to 5 at 152.5 MT; all vessels with BP at or above 152.5 MT receive a 5. 152.5 MT was selected as the upper end parameter because it is midway between the minimum acceptable BP of 120 MT and the practical upper end BP of 185 MT identified in Section 3. Given uncertainties regarding the conservatism of this 185 MT figure and stakeholder concerns expressed during the 10 November roundtable discussion, this study selected a lower BP value as the optimal target but did not penalize vessels exceeding that number.
Bulwark Height	1	Bulwarks low enough to provide visibility overboard to enhance crew situational awareness received higher scores; overly low bulwark height that presents a danger to crew penalized in the next category, Crew Protection.
Crew Protection	1	Degree to which protective structure wraps from the bow aft, protecting exterior decks/passageways from weather; aft bulwark height.
Dynamic Positioning (DP)	1	Vessels of length 60m or less with DP capability received a score of 5. Vessels of length greater than 60m with DP were scored linearly, decreasing from 5 to 3 as length increases from 60m, with vessels of 80m scoring a 3. Vessels over 60m length with no DP capability were eliminated from contention. DP redundancy (i.e., DP 1, 2, or 3) was considered in the redundancy category, not herein.
Firefighting	1	FiFi Class 2 received a 5, FiFi Class 1 received a 3, and vessels with no fire monitors received a 1.
Flag	2	US-flagged vessels received a 5, non-US flagged vessels received a 3, as US flagging represents known compatibility with relevant US regulations for towing vessels. Extra weighting was applied to this factor due to the US-flagged vessels' known compatibility with the potentially more stringent USCG towline stability criteria discussed in Section 3.3.1.2.

Category	Weighting Factor	Explanation
Free Running Speed	5	15.5-16 knots free running speed was considered acceptable (a score of roughly 3), as this should be sufficient to match the typical speed of an outbound tanker while fulfilling Sentinel Tug duties. Scores were linearly distributed between 2 for the minimum speed in the dataset (*Ross Chouest*, 13.4 kts at working draft & 85% MCR according to Reference 35) and 5 at the top speed represented in the dataset (19.9 kts, Nordic). Free running speeds were not found for *Maersk Tender* and *Guardian*, so these vessels were given the same rank as the minimum of the dataset, *Ross Chouest*.
Freeboard	1	Qualitatively ranked based on adequacy of fore and aft freeboard for operating in seas.
Length Overall (LOA)	1	60m was considered an ideal LOA, providing the best balance between maneuvering and speed characteristics. A length of 60m resulted in a score of 5, and scores linearly decreased to 3 at 40m and 80m.
Maneuverability	5	Maneuverability score was quantitatively derived using a formula that accounted for main engine power, vessel length, stern, bow, and dropdown azimuthing thrusters, ASD configuration if applicable, existence of flap rudders if applicable, and pilothouse location/sail area imbalance score. Scores were normalized to be distributed between 3 and 5, as all vessels were considered to have acceptable maneuvering characteristics at minimum.
Pilothouse Location/Sail Area Imbalance	1	Qualitatively ranked based on longitudinal position of pilothouse, considering its impact on proximity and lines of sight to aft deck, favorability of motions at a roughly amidships location, and overall balance in sail area.
Power Plant	1	Power plants were scored for flexibility and efficiency; one diesel electric plant was represented in the dataset (*Ocean Response*), and this vessel received a score of 5 given the significant advantages of this configuration during loitering or low power operations. Vessels with four main engines and shaft generators received a 4.5, vessels with four main engines and no shaft generators received a 4, vessels with two main engines and shaft generators received a 3.5, and vessels with two main engines and no shaft generators received a 3.
Redundancy	1	Scored using a formula that considered redundancy in power plant, bow/stern/retractable thrusters, DP, FiFi, and number of towing winch drums.
Rescue & Recovery Equipment	1	Quantitatively scored on number of rescue boats and qualitatively scored on robustness of deployment equipment, arrangement and reach of cranes on the aft deck, and suitability of aft deck for recovery operations.
Roll Reduction	1	Vessels confirmed to have anti-roll tanks received a score of 5, other vessels received a score of 3.
Stern and Aft Deck Geometry	1	Qualitatively scored on overall fitness of stern and aft deck arrangement for safety of towing operations and gear handling on deck.
Tow Winch and Related Deck Equipment/ Machinery	1	Scored on number of towing drums, arrangement (side by side, reverse waterfall, etc.), approximate height of tow wire off aft deck, presence of a slip or dynamic brake, and drum capacity.
Overall Score		**Scores for each category were multiplied by their respective weighting factors. Total scores for each vessel were then divided by the maximum possible score (a 5 in all categories) such that total score for each vessel is shown as a fraction of total possible score.**

6.1.3 Cost Parameters

As discussed previously, scope, schedule, budget, and information availability limitations precluded performing detailed cost estimates for the vessels evaluated and historical cost data was in most cases unavailable. In the absence of historical capital and operating cost data, it was necessary to develop estimates. However, developing detailed capital and operating cost estimates for each vessel was not within the scope of this study, nor was it feasible given the somewhat constrained set of technical data available for each vessel.

As an alternative, this study used vessel cubic number (length * breadth * draft) and powering details (further described in Table 9) as proxies for both capital and operating cost. Vessel size and installed power/power plant complexity are major drivers of both capital and operating cost, and as an added benefit, these parameters were known to a good degree of certainty for every vessel evaluated.

The limitations of this approach are acknowledged; other significant cost and complexity drivers such as towing outfit and equipment complement were excluded from consideration. It may be worthwhile to perform a more detailed cost analysis at a future date in order to better define and understand the cost/benefit tradeoffs for various vessel sizes, configurations, and system complexities.

Table 9 provides a summary of the methods used to evaluate cost in this study.

Table 9 Cost categories and evaluation

Category	Weighting Factor	Explanation
Dimensional Cost	1	The numerical value of each vessel's cubic number at working draft; (length overall)*(beam)*(draft).
Powering & Propulsion Cost	1	Calculated as the sum of main engine power, thruster power, and ship service diesel generator power. This number was then multiplied by a powering factor to account for differences in power plant complexity. Vessels with two main engines were assigned a powering factor of 1, vessels with four main engines were assigned a powering factor of 1.2, diesel electric vessels were assigned a powering factor of 1.3, and *Nordic's* power plant, which is capable of operating in hazardous atmospheres, was assigned a powering factor of 1.5.
Overall Score		**Each vessel's dimensional cost and powering & propulsion cost were added together and divided by the sum of the respective maximum scores in the dataset for each category, such that each vessel's cost is shown as a fraction of highest possible cost represented in the dataset.**

6.1.4 Combining Score and Cost

Rather than incorporating cost into each vessel's overall final score, this study took the approach of identifying the vessel with the best score to cost ratio (see Table 11 and Figure 11 in the BAT Evaluation and Gap Analysis section). In other words, points for the scoring categories listed in Table 8 were summed and shown as a fraction of total possible score, and totals for the cost items in Table 9 were summed and divided by the sum of the highest costs in the two cost categories. This produced final score rankings and cost rankings for each vessel as fractions of the maximum possible scores and costs represented in the dataset. These two items were plotted against each other for each vessel, with cost ranking plotted along the y axis and score plotted along the x axis. Drawing a line from the origin, the vessel that is intersected by the line of least slope has the best score to cost ratio (Figure 11).

6.1.5 ADEC Criteria

The eight BAT evaluation criteria originally developed by the Alaska Department of Environmental Conservation (ADEC) were adapted to incorporate the 19 scoring parameters and the two cost parameters discussed above (Table 10). While every effort was made to align the analysis with the original formulation of the ADEC criteria, the types of vessel information available, the complex interplay between ETV design elements, and the uncertainties inherent to evaluating vessel cost necessitated some flexibility in interpreting the criteria.

Ultimately, the 19 scoring categories were assigned across seven ADEC criteria; some ADEC criteria encompassed multiple scoring categories while others incorporated only a single scoring category. Cost, which is the eighth ADEC criterion, was formulated as described in Table 9.

Table 10 shows the assignment of scoring subcategories to the ADEC criteria and provides descriptions of each ADEC criterion that have been adapted to apply to the specifics of ETV design and operation.

Table 10 Scoring subcategories assigned to the ADEC BAT criteria

Criterion	Description	Subcategories
Effectiveness	What is the expected efficacy of the technology for the Hinchinbrook Tug operating mission as described in Section 3, *Hinchinbrook ETV Operating Mission and Design and Performance Parameters.*	• Bow Form • LOA • BP • Tow Winch & Related Deck Eqpt./Machinery • Stern and Aft Deck Geometry • Power Plant Score (flexibility, efficiency)
Feasibility	Is it feasible to use this technology from an operational perspective, to include consideration of operational complexity and required crew training /certification?	• Maneuverability • DP
Transferability	Can the technology be used across all possible/ foreseeable emergency towing scenarios in PWS, Hinchinbrook Entrance, and the Gulf of Alaska? Can the technology be used safely and effectively in all metocean conditions/at night or in reduced visibility?	• Roll Reduction • Pilothouse Location/ Sail Area Imbalance • Accommodation • Freeboard
Compatibility	Is the technology compatible with the current Hinchinbrook Tug operating requirements, as defined in the VERP?	• Free running speed
Age and Condition	Can the technology withstand and perform in the harsh marine environment where it is intended to operate, and can it be expected to work reliably (over time) as designed? Is the technology reasonably easy to maintain in good working order over a 30-year service life?	• Redundancy
Availability	Is the technology commercially available/viable for private-sector marine operators for supporting Prince William Sound tank vessel operations (i.e., can such equipment be practically designed and constructed in US shipyards)? Is the technology US-flagged, representing compatibility with applicable US rulesets?	• Flag

Criterion	Description	Subcategories
Environmental Impacts	What impact does the use of the technology have on maintaining a safe working environment on the deck of either vessel?	• Crew Protection • Bulwark Height • Rescue & Recovery • Firefighting
Cost	What is the estimated capital cost of the technology? What is the estimated operating cost of the technology?	• Dimensional Cost • Powering and Propulsion Cost

6.2 Results

Full results showing scores for each subcategory may be found in Appendix C; a summary is shown in Table 11 below. Noteworthy vessels include the following:

- Highest raw score: ***Abeille Bourbon***
- Lowest cost ranking: ***Vrana Tide*** (also received the lowest score)
- Best Score to Cost Ratio: ***Luz de Mar***

Table 11 Score and cost ranking results; top performers in each area in bold, overall BAT selection in red

Vessel	Score	Cost Ranking	Score/Cost Ratio
Abeille Bourbon	**0.87**	0.52	1.68
Almisan	0.74	0.32	2.29
Alp Ace	0.81	0.48	1.67
Baltic	0.74	0.38	1.95
Britoil 41	0.72	0.42	1.71
Bylgia	0.75	0.66	1.14
Guardian	0.69	0.38	1.82
Luz de Mar	0.76	0.33	**2.32**
Maersk Tender	0.72	0.67	1.07
Marty Quist Tide	0.69	0.42	1.64
Nordic	0.86	0.93	0.93
Ocean Response	0.70	0.74	0.95
Ocean Sun	0.72	0.32	2.28
Ross Chouest	0.63	0.50	1.26
Skandi Ipanema	0.68	0.46	1.47
Skandi Rio	0.76	0.69	1.09
Skandi Saigon	0.72	0.58	1.24
Vrana Tide	0.58	**0.28**	2.07

As the vessel with the highest score to cost ratio, *Luz de Mar* was selected as the candidate that best represents BAT for the Hinchinbrook Tug.

It should be noted that two other vessels, *Ocean Sun* and *Almisan*, came close to matching *Luz de Mar's* score to cost ratio. The score to cost ratio is sensitive to small adjustments to the scoring or cost evaluation methodology; for example increasing the weighting factor applied to the bollard pull score by one places *Almisan* just ahead of *Luz de Mar* in the final score to cost ratio ranking. On the other hand, adjusting some other weighting factors (for example, increasing the maneuverability weighting factor by one) increases *Luz de Mar's* margin over the other vessels.

Luz de Mar emerged as the vessel with best score to cost ratio at the weighting factors Glosten selected, and its higher raw score over the other two vessels solidifies its places as the vessel best representing BAT amongst the vessels examined in this study.

Figure 11 plots each vessel on a scatterplot with final score as the x axis and cost ranking on the y axis. For a line emanating from the origin, decreasing slope corresponds to better score to cost ratio.

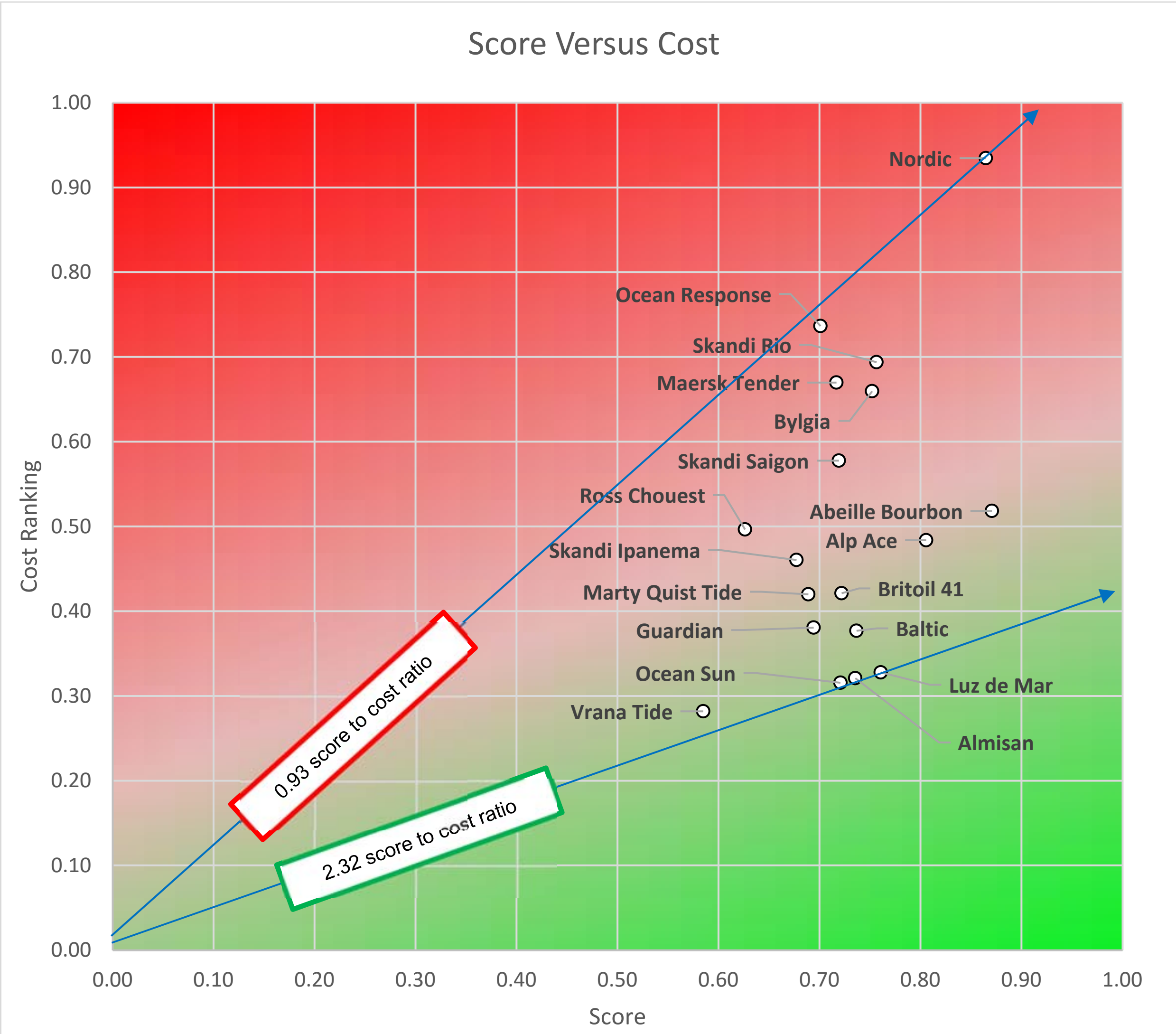

Figure 11 Score versus cost plot; *Luz de Mar* shows most favorable score to cost ratio

The *Luz De Mar* Class Profile section below provides a description of the *Luz de Mar*. This vessel has one sister ship, the *Miguel de Cervantes*, and these two vessels are considered functionally equivalent for purposes of this study. This report confines its focus to the *Luz de Mar* for the sake of simplicity, but it should be assumed that any discussion applicable to *Luz de Mar* applies to *Miguel de Cervantes* as well.

6.3 *Luz De Mar* Class Profile

The two *Luz de Mar* class vessels are operated by SASEMAR, the entity primarily responsible for maritime rescue and pollution prevention in Spain's coastal waters. Among the most important features of their design are their speed, agility, bollard pull, and the ability to give assistance to vessels in difficulty (Reference 48).

Both vessels were delivered in 2005 by the Spanish shipyard Astilleros Armón de Vigo. According to Reference 39, *Miguel de Cervantes*, shown in Figure 12, operates primarily around the Canary Islands, while *Luz de Mar* serves the northwest Iberian Peninsula, specifically the Traffic Separation Scheme off Cape Finisterre, and the Strait of Gibraltar.

Figure 12 *Miguel de Cervantes*; photo courtesy of Rick Vince

Reference 47 states that SASEMAR's statutory mission, which "is specifically established in article 268 of the Consolidated Text of the Law on State Ports and the Merchant Marine," can be summarized as "Protecting Life at Sea" and includes the following:

- Rescue of human life at sea.
- Prevention and fight against pollution of the marine environment.
- Provision of monitoring and assistance services for maritime traffic, maritime safety, and navigation.
- Trailer and auxiliary vessels.
- Those complementary to the above (Reference 47).

SASEMAR characterizes the *Luz de Mar* as a modern and powerful rescue tug and summarizes its capabilities as follows (translated from Spanish):

> In any situation and in the most adverse weather conditions, this ship performs multiple tasks: towing of large ships and barges on the high seas, work in oil terminals, rescue operations, rescue, support, anchor handling, anti-pollution, firefighting, and others. It offers excellent maneuverability with integrated propulsion and control systems and is equipped with two azimuth thrusters and a bow side thruster (Reference 45).

Pertinent vessel characteristics are summarized in Table 12. The Gap Analysis section provides a more detailed tabular presentation of *Luz de Mar's* characteristics, along with an in-depth discussion of the vessel's capabilities. A vessel cutsheet is provided in Appendix C.

Table 12 *Luz de Mar* class characteristics

Flag State	Spain
Year Built	2005
DWT	1190
Length Overall (m)	56
Beam (m)	15
Draft (m)	5.5
Main Engine Power (kW)	7680
Bollard Pull (MT)	129
Propulsor Type/Number	2xASD (Z-Drive)
Max Speed (knots)	16.4
Crew Complement	8
Total Accommodation	18
Tow Winch Details	The ship has 3 primary winches (1 bow, 2 aft) and 2 auxiliary winches.
FiFi Class	1
DP Class	2

6.4 Gap Analysis

This section presents the findings of a gap analysis comparing the present Hinchinbrook ETV, *Ross Chouest,* to the SASEMAR ERRV *Luz de Mar,* identified by this study as representing BAT for rescue towing service near Hinchinbrook Entrance. The objective of this analysis is to identify shortcomings or deficiencies in the present Hinchinbrook Tug that could be addressed or improved by adopting BAT.

6.4.1 Summary

What follows is a line-by-line comparison of the vessels' available design specifications and known towing equipment, along with a qualitative discussion of their general design traits and overall suitability for the subject rescue towing application. A detailed breakdown of their respective scoring in this BAT assessment is also provided for context. This section concludes by summarizing the most relevant "deficiencies" of the *Ross Chouest* relative to the identified BAT and presenting specific operational advantages that might be gained by addressing those deficiencies through the implementation of rescue tug BAT in the Prince William Sound SERVS.

Although the *Ross Chouest* is considerably larger than *Luz de Mar* — which likely makes for more favorable vessel motions and accelerations on deck — and though it outscored *Luz de Mar* in certain subcategories in our BAT evaluation process, *Luz de Mar* significantly outscores *Ross Chouest* in several key areas of general vessel design, performance, and equipment for rescue towing purposes, namely: free running speed, maneuverability/agility, rescue and recovery equipment, firefighting fitness, and operational redundancy/versatility. Overall, *Ross Chouest* remains a very capable vessel for the subject application, but the additional capability of *Luz de Mar* in these specific areas would markedly enhance the effectiveness and reliability of the Hinchinbrook Tug for its intended operating mission.

6.4.2 Vessel Particulars

Figure 13 and Figure 14 show the two vessels considered in the gap analysis, taken from a similar ‘outboard profile’ perspective.

Table 13 presents a side-by-side comparison of characteristics of the *Luz de Mar* and *Ross Chouest*, divided into basic design and equipment categories. Noteworthy disparities or “gaps” between the two vessels are highlighted in blue and discussed in the sections that follow.

Figure 13 Present Hinchinbrook Tug *Ross Chouest* in Valdez, Alaska; https://www.flickr.com/photos/captainb/31654038517/, accessed 3/16/21

Figure 14 SASEMAR vessel *Miguel de Cervantes* – sister to the *Luz De Mar*; https://www.fleetmon.com/vessels/miguel-de-cervantes_0_29662/photos/455467/, accessed 2/22/2021

Table 13 General characteristics of *Luz de Mar* and *Ross Chouest* compared

Vessel Particulars	*Luz de Mar*	*Ross Chouest*
Vessel type	Multipurpose Salvage and Rescue Tug, Oil Spill Response Vessel	Anchor-handling, Towing & Supply (AHTS) vessel
Length overall	183' 09" / 56.00m	256' 06"/ 78.18m
Beam	49' 03" / 15.00m	54' 00" / 16.46m
Molded Depth	23' 00" / 7.00m	24' 00" / 7.32m
Draft (min operating)	18' 00" / 5.50m	13' 00" / 3.96m
Draft (max operating)	19' / 5.80m	18' 00" / 5.49m
Freeboard (at loadline)	Not available	07' 00" / 2.13m
Gross Tonnage	1780 GT (international)	1599 GT (US domestic tonnage)
Deadweight	483/1,190 MT	2,540 MT
Displacement	2,791 MT	4,245 MT
Displacement (summer load line draft)	2,940 MT	Not available
Speed (Maximum)	16.4 knots	13.4 knots
Speed (maximum draft)	Not available	12.5 knots
Speed (cruising)	13.0 knots	Not available
Speed (astern)	15.8 knots	Not available
Bollard Pull	128.5 MT	125 MT
Range	5,230 nm	Not available
Range (80% MCR)	6,000 nm	Not available
Class Notation and Registry		
Classification	BV-I HULL MACH, Fire Fighting ship, Tug, Water Spraying-1, Unrestricted Navigation, AUTUMS, Dynypos-R, IG	ABS-+A1 (E) Unrestricted Ocean Service, Sub Chapter L (O.S.V) & I (Cargo)
Flag	Spain	US
IMO Number	9320104	9085833
MMSI	224311000	366342000
Year Built	2005	1996
Tonnage	1,780 GT / 534 NRT	2,719 GRT / 815 NRT
Callsign	ECIJ	WCW7550
Machinery		
Propulsion Machinery	2 × MaK 8M 32C (mfg. by Caterpillar) 3,840 kW / 5,150 BHP ea	2 × Caterpillar 3612 5,700 BHP
Reduction Gears	Kumera 4FGCCC500/525 (3.246:1)	2 × Unknown
Propellers	2 × 4-blade 134" / 3400mm diameter CPP (Z-drive w/ Nozzles)	2 × 4 blade 134" diameter CPP (in Nozzles)
Thrusters		
Bow	1 × 536 BHP / 400kW Schottel STT 330 LK CPP (Tunnel)	1 x 855 BHP / 637.5 kW CPP (Tunnel) 1 x 1200 BHP / 895 kW dropdown azimuth
Stern	2 × Schottel SRP 3040CP Azimuthing Ruderpropellers	1 x 1200 BHP / 895 kW dropdown azimuth
Rudders	See above	2 x Spade – Independent Operation
Dynamic Positioning	DP1 – DYNAPOS AM	Joystick (Both ends of wheelhouse)

Vessel Particulars	*Luz de Mar*	*Ross Chouest*
Auxiliary Engines / Generator Sets		
Main	1 × CAT 3508-B 910 kW	3 x 500 kW
Emergency	1 × CAT 3406 352 kW 2 × Stamford Shaft Generator (800 kW)	1 x 300 kW
Fire Fighting		
System Type	2 pumps driven by a PTO on each main engine	Not applicable
Class Rating	BV FiFi 1	None
# of Water Monitors	2	None
Discharge Rate / Monitor	1500m³/h	N/A
Number of Pumps	2	Not available
Total Capacity	1500m³/h (each)	Not available
Monitor Range	120m	N/A
Height, Monitor	50m	N/A
AFFF Foam	62m³	Not applicable
Dispersant	22m³	None
Deluge system	Yes	No
# Hose Connections Each Side of Vessel	Not available	Not available
# of Fire Outfits	Not available	Not available
Fuel Oil Capacity	293m³	Not available
Capacities		
Fuel Oil	155,333 gals. / 588m³	208,621 gals. / 798m³
Lube Oil	Not available	Not available
Recovered oil	293m³	USCG Oil Rec Authorization of 20% DWT
Ballast	113m³	281,336 gal. / 1065 MT
Deck Cargo	Not available	1,219 MT / 1200 LT
Potable Water	114m³	36,128 gal. / 136.8 MT
Tow Winch and Auxiliary Winches		
Type	Two separate winches arranged waterfall	Waterfall
# of Towing Drums	2 (+ 1 additional forward)	1 (+ one anchor handling)
Manufacturer	Ibercisa	
Primary Drum Capacity	1,300m / 4,265' of 2 ⅜" / 60mm (MBL estimated as 274.05 MT)	1,981m / 6,500' of 3 ¾" (MBL 500 MT)
Second Drum/Anchor Handling Drum	1,300m / 4,265' of 2 ⅜" / 60mm (MBL estimated as 274.05 MT)	1,981m / 6,500' of 3 ¾" (MBL 500 MT)
Brake Power	353 ST / 320 MT	750 MT
Line Pull	99,208 lbs. / 45 MT @ 14m/min	600,000 lbs. / 272 MT at 4000' of 3 ¾" wire
Auxiliary Winches	2 × 1,050'/320m of 13/16" / 20mm wire	Not available
Tugger / Storage Reels	2 × 160m of 2⅜" / 60mm (line pull not available)	4 x 6,500' of 3 ¾" wire 30,000 lbs. / 13.6 MT pull
Capstan	One bow, one stern (winch integrated)	Not available

Vessel Particulars	*Luz de Mar*	*Ross Chouest*
Bow Winch		
Type	Combined aft towing winch (for stern first towing) with anchor windlass	Double wildcat anchor windlass – 18.1 MT w/ mooring winch
# of Towing Drums	1	0
Manufacturer	Ibercisa	Not available
Capacity	600m of 2¾" / 70mm synthetic	N/A
Brake Power	320 MT	Not available
Line Pull	47 MT @ 13m/min	18.1 MT
Towing Gear		
Tow pins	2 × retractable Karm pins (hydraulic)	2 × retractable hydraulic
Shark Jaws	1 × Karm Fork	2 × Karm Forks
Stern Roller	19-11/16" / 500mm diameter x (length not available) SWL 200 MT	9' diameter × (length not available) SWL 680 MT
Clear Deck Area	Not available	557m³ / 5,995 sq. ft.
Chain Locker	2 × (exact volume not available)	2 × 4,750 cubic ft.
Deck Strength	Not available	2636.5 kg/m² (540 lb./sq.ft.)
Cranes		
Knuckle Boom	No knuckle boom crane fitted	No knuckle boom fitted
Telescopic	2 × hydraulic: 1 × 20 MT w/ 12.7m outreach, 1 × 10 MT w/ 12.0m outreach	2 × Alaska Marine Crane MCT-840 2.7 MT (6,000 lbs.) at 11.2m / 37' outreach
Fixed	Ferri rescue boat davit, designed for use in rough sea states (specs unavailable)	Alaska Marine Crane MCF-2045 7.0 MT (15,400 lbs.) at 10.7m / 35' outreach
Motion Dampening		
	Bilge keels	Bilge keels
	Not available	2 x passive anti-roll tanks
Accommodations		
Berthing	26 persons	39 persons
Galley Seating	Not available	Not available
Certified to Carry	Not available	Not available
Hospital	15 berths	2 berths
Lifesaving Equipment		
Rescue Boat	1 ×(dims not available) and 1 × 32' 08" / 9.9m aluminum workboat	1 × 19' / 5.8m
Rescue Basket	Not available	1 each
Life Rafts	4	6 × 20 person inflatable
Other	Other as required by SOLAS	Other as required by USCG/SOLAS

6.4.3 Detailed Scoring Breakdown

Section 6.1, Methodology, explains the scoring criteria and methods used to evaluate the candidate vessels, and Appendix C provides all subscores and total scores for the vessels evaluated. This section confines its focus to presenting scores for *Ross Chouest* and *Luz de Mar* for purposes of the gap analysis.

Table 14 presents detailed subcategory and ADEC scores for *Ross Chouest* and *Luz de Mar*. Table 15 presents final score, cost ranking, and score to cost ratio for these vessels. Cell colors represent the vessels' ranking relative to all 17 candidate vessels.

Table 14 *Luz de Mar* and *Ross Chouest* scoring breakdown

	Scoring Subcategories						ADEC Scores
	Bow Form	LOA	BP	Tow Equip. / Machinery	Stern & Aft Dk Geometry	Power Plant	Effectiveness
Luz	3.00	4.60	16.98	4.00	5.00	3.50	37.08
Ross	3.00	3.20	14.77	4.00	3.00	3.00	30.97

	Maneuver-ability	DP	Feasibility
Luz	23.00	5.00	28.00
Ross	17.99	3.20	21.19

	Roll Reduction	House Loc'n / Sail Area	Accomm. (Pax + Crew)	Freeboard	Transferability
Luz	3.00	5.00	4.00	4.00	16.00
Ross	5.00	3.00	5.00	4.00	17.00

	Free Running Speed	Compatibility
Luz	16.92	16.92
Ross	10.00	10.00

	Redundancy	Age & Condition
Luz	4.50	4.50
Ross	2.50	2.50

	Flag	Availability
Luz	6.00	6.00
Ross	10.00	10.00

	Crew Protection	Bulwark Height	Rescue & Recovery	Firefighting	Environmental Impacts
Luz	4.00	5.00	5.00	3.00	17.00
Ross	4.00	4.00	3.00	1.00	12.00

	Dimension Cost Rank	Power Cost Rank	Cost Rank
Luz	0.05	0.09	0.33
Ross	0.73	0.20	0.50

Table 15 *Luz de Mar* and *Ross Chouest* total score and cost ranking breakdown

	Total Score	Total Cost Ranking	Score to Cost Ratio
Luz de Mar	0.76	0.33	2.32
Ross Chouest	0.63	0.50	1.26

As noted in Table 15, *Luz de Mar* outscores *Ross Chouest* on five important aspects of rescue tug/ETV design: free running speed, maneuverability/agility, rescue and recovery equipment, firefighting fitness, and operational redundancy/versatility. These and other important design topics are discussed below, with any significant BAT gaps, or "deficiencies," noted explicitly.

6.4.4 Bollard Pull

The *Ross Chouest* and *Luz de Mar*, although powered differently, are quite similar in terms of achievable bollard pull. *Luz de Mar* has a rated bollard pull of 128.5 MT, while *Ross Chouest* is generally described as having 125 MT bollard pull – a difference of only 3.5 MT. However, a recent bollard pull estimate for *Ross Chouest* carried out by NaviForm Consulting and Research in Vancouver, British Columbia, put the number slightly higher, at 126.1 LT (imperial tons) or 128 MT (Reference 36). In either case, it appears that the two vessels are nearly equal in this respect – with neither significantly outperforming the other in terms of maximum thrust in a controlled environment. What is less well understood is the vessels' respective towing efficiency (i.e., the practical achievable thrust) in higher sea states. Again, this requires a degree of analysis not included the scope of this study; but it would be expected, given deeper operating draft across all loading conditions and deeper in the water positioning of the Schottel rudderpropellers that *Luz de Mar* would experience lower percentages of reduction, or loss of thrust, in higher sea states. The aforementioned seakeeping analysis of *Ross Chouest* did conclude that *Ross Chouest* would experience propeller emergence in closure condition wave heights (15 feet), limited to running speeds of 6 knots or greater and in quartering and following seas (Reference 37).

6.4.5 Seakeeping and Motions

A rigorous analysis is necessary to quantify the seakeeping capabilities of the two vessels and to accurately predict their respective motions and accelerations in various sea states. While a seakeeping analysis of the *Ross Chouest* was carried out in 2017 and provided to the Glosten team for review (Reference 37), an equivalent analysis of the *Luz de Mar* was not available. Conducting such an analysis was not within the scope of this study; however, given the perceived benefits and/or drawbacks of larger vessels for rescue towing purposes, a rigorous comparative analysis of both vessels could prove informative in a follow-on work phase.

Several observations can be made that influence our expectations for the relative seakeeping performance of the two vessels:

- As previously noted, *Luz de Mar* operates at deeper drafts across all loading conditions. Deeper drafts are expected to reduce frequencies of propeller emergence and bow slamming. Less frequent propeller emergence improves average thrust, so we expect that *Luz de Mar* will be able to operate at higher running speeds in a sea state.
- The larger displacement of the *Ross Chouest* suggests lower heave motions and accelerations of the vessel at midships. However, the forward bridge may lead to higher accelerations than the *Luz de Mar* on the bridge deck.
- The high-freeboard focsle on *Luz de Mar* extends well past midships, offering more protection for the aft deck in bow quartering seas than the shorter house of the *Ross Chouest*.

6.4.6 Structural Crew Protection

Luz de Mar features a hydraulically actuated telescopic "breakwater" positioned just forward of the stern roller. This breakwater can be remotely raised and lowered from the pilothouse to effectively open and close the bulwark as circumstances require. Putting the bulwark in the up position serves two purposes: 1) it encloses the stern and thereby provides structural protection for cremembers on deck when the vessel is not actively engaged in towing operations; and, 2) it provides watertight containment of the deck area during fueling, fuel transfer, and spill recovery operations to prevent the escape of oily water or other hazardous materials (Reference 38).

Figure 15 Stern gate or "breakwater" on *Luz de Mar* in the up position (Reference 39)

For towing operations, and to facilitate gear handling on deck, the breakwater is moved to the down position. The breakwater can also be lowered while transiting in seas to allow the deck to shed water more freely.

Figure 16 Stern gate or "breakwater" on *Luz de Mar* in the down position while taking a disabled vessel in tow, accessed from https://www.fleetmon.com/maritime-news/2020/29453/disabled-container-ship-towed-valencia/ on 3/22/21

The *Ross Chouest* has a fully open transom arrangement typical of AHTS vessels and, though it does not afford structural protection for the crew on deck from directly astern, this arrangement is regarded as preferable in this BAT assessment over "Dutch style" aft deck arrangements with fully-enclosed bulwarks such as that of the *Abeille Bourbon* and the *Nordic*.

Figure 17 ***Ross Chouest* transom, https://www.flickr.com/photos/captainb/32712566338/sizes/k/, accessed 3/16/21**

A partially open stern arrangement, such as that on *Luz de Mar*, is regarded as optimal. Though the hydraulically actuated stern gate is a nice addition and is featured on other vessels in the subset as well, it is not considered a requirement in this BAT assessment, and thus vessels without this feature were not penalized in the scoring process.

With respect to other structural crew protection, *Luz de Mar* and *Ross Chouest* both have raised focsle decks with high freeboard that extend aft. The focsle deck on *Ross Chouest* extends aft about one-third of the vessel's total length, while that of *Luz de Mar* extends past midships, approximately two-thirds of the vessel's total length. The latter is generally treated as optimal in this BAT assessment, but given the higher aft freeboard on *Ross Chouest*, this is not deemed a significant gap.

Both vessels have fairly similar bulwark heights in the 4-6-foot range, which is regarded as optimal for the purposes of this assessment. Though the bulwarks on *Luz de Mar* appear to be approximately one foot lower than those of *Ross Chouest*, both are of an appropriate height to afford a high degree of protection from boarding seas without obstructing lines of sight for crewmembers on deck, which is important for maintaining situational awareness while making and breaking tow.

In summary, while *Luz de Mar* slightly outscores *Ross Chouest* in terms of structural crew protection and bulwark height, this gap is not regarded as a significant BAT deficiency in the current Hinchinbrook Tug that needs to be addressed.

6.4.7 Free Running Speed

Ross Chouest has a maximum free running speed of 13.4 knots according to Reference 35, while *Luz de Mar* has a maximum speed of 16.4 knots - a full 3.0 knots faster. The following examples are provided to illustrate the practical implications of this difference in speed performance between the two vessels.

At a best achievable speed of 13.4 knots (i.e., in calm water conditions), *Ross Chouest* would reach a position 17 nautical miles seaward of Cape Hinchinbrook in 01:16 (hh:mm). In the same conditions, *Luz de Mar* would arrive in 01:02 – 14 minutes faster. A disabled tank vessel, at an assumed free drift velocity of 3.0 knots, could drift 0.7 nautical miles during this time.

In transiting to a position 200 nautical miles seaward of Cape Hinchinbrook (again assuming calm water conditions), *Ross Chouest* would arrive in 14:56 at best speed, while *Luz de Mar* would arrive in 12:12 – 2 hours and 44 minutes faster. A disabled tank vessel drifting at 3.0 knots could move 8.2 nautical miles during this time.

While these times and distances may not appear significant at first glance, they must be considered in context with the following variables:

- The geographical location of the ship disablement
- Distances from lee shores or submerged reefs/structure that could pose a grounding risk
- The condition of the affected vessel
- The time required to establish a towing connection and arrest the downwind momentum of the affected vessel
- Metocean conditions (wind, sea state, and current) at the time of the disablement
- The possibility of rapid changes in metocean conditions

Using the example of the 17 nautical mile case above, a run distance of 17 nautical miles from Cape Hinchinbrook does not necessarily mean the affected vessel is 17 nautical miles from grounding on a lee shore (see Figure 18 below). The distance may be less or greater, depending on the position of the affected vessel and the wind direction.

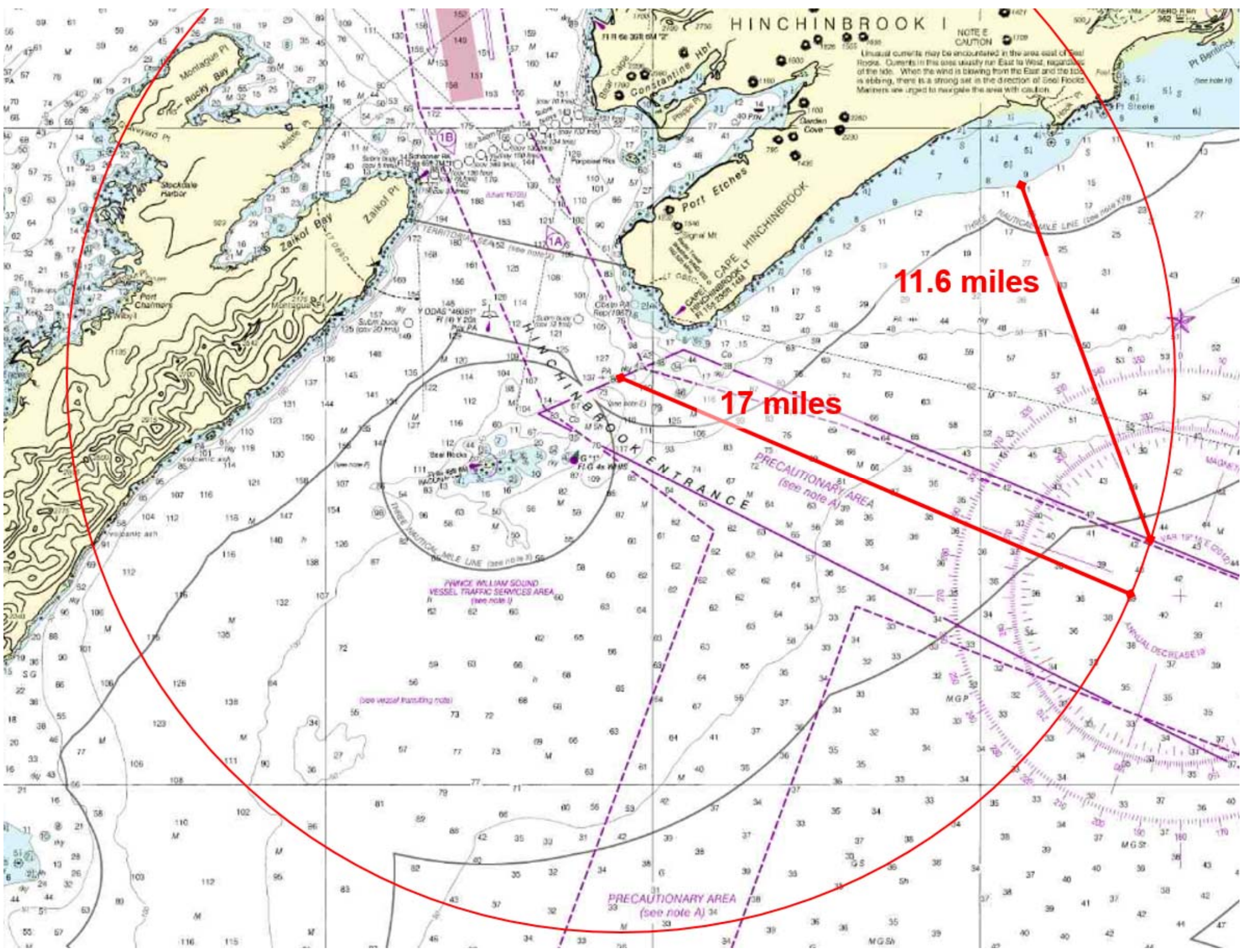

Figure 18 National Oceanic and Atmospheric Administration (NOAA) Nautical Chart No. 16700 showing 17 nautical mile line seaward of Cape Hinchinbrook, adapted from similar figure in Reference 40

Considering the possibility of a situation similar to that illustrated in Figure 18, and that this study uses closure conditions as the basis for BAT assessment, the 'loss' of approximately .25 hours and, potentially, nearly a mile of sea room in transiting to the scene should be regarded as significant.

More importantly, however, without more rigorous analysis, it is unclear how each vessel's maximum speed (i.e., calm water speed) is affected as sea states increase. Speed losses will certainly occur, but the degree of such losses could vary considerably between the two vessels. The *Ross Chouest* is longer with greater displacement, but it has a higher block coefficient and the propellers are located much shallower in the water. By comparison, *Luz de Mar* is shorter with less displacement, but with finer lines and propulsors located deeper in the water. Given the uncertainty, more work is required to determine whether this 3.0 knot speed "gap" is widened or narrowed at closure conditions, and what that could mean with respect to gaps in the vessels' practical ability to affect a successful ship rescue.

6.4.8 Range and Endurance

Luz de Mar has a design range 6,000 nautical miles at 80% of maximum continuous rating (MCR) and a stated practical operating range of 5,230 nautical miles. This is sufficient range to cross the Pacific Ocean from the North American West Coast to Busan, South Korea, with more than 15% fuel margin. Range data for *Ross Chouest* was not available; however, Reference 40 provides an estimated range for *Ross Chouest*, given in hours, as opposed to nautical miles. Little River Consultants estimated the range of *Ross Chouest* at 355 hours or 14.8 days, based on 80% of the total fuel capacity (0.8 × 208,621 gal. = 166,897 gal) and an assumed fuel consumption rate of 470 gal/hr. at "full load" (Reference 40).

By comparison, *Luz de Mar* consumes 453 gal/hr. at 85% MCR (References 39 and 41). Based on 80% of the total fuel capacity, the range of *Luz de Mar* in hours/days is 274 hours or 11.4 days (0.8 × 155,333 / 453 = 274). It should be noted, however, that *Luz de Mar's* higher speed would likely mean more distance covered per hour when running light. Without more detailed analysis, the practical operating range of the two vessels in seas cannot be accurately compared. Moreover, the difference is very likely irrelevant for the purposes of this assessment. Both vessels appear to have more than adequate range to carry out any emergency towing duties the Hinchinbrook Tug might reasonably be expected to perform.

6.4.9 Rescue & Recovery Equipment

Complete data on lifesaving and rescue equipment was not available for either *Ross Chouest* or *Luz de Mar*, though some information was obtained from cut sheets and general arrangement drawings. Normally, complete information would be provided on a vessel's Fire and Safety Plan, or Life Saving and Fire Control Plan, which were not provided.

From the information obtained, and in reviewing design plans and photos of the two vessels, it is clear there are some equipment gaps that deserve mention in way of rescue boats, deck cranes, and ships' hospital.

Both vessels are equipped with a SOLAS-compliant fast rescue boat, but *Luz de Mar* carries a second and larger 9.9m (32' 08") aluminum workboat as well. This larger vessel is intended primarily for the deployment and recovery oil containment boom but can also serve as a second rescue boat.

Figure 19 9.9m aluminum workboat in its stowed position on the port side; SOLAS compliant fast rescue boat also visible on the starboard side; photo courtesy of https://twitter.com/salvamentogob

Luz de Mar is equipped with two telescopic deck cranes installed on the main deck and a smaller fixed-boom rescue boat davit on the 02 deck. *Ross Chouest* has three cranes as well – two installed on the 02 deck (telescopic type) and one on the main deck (fixed boom). The notable differences between them are their installed positions, as described, and their relative size, capacity, and working radius (outreach).

The two primary working cranes on *Luz de Mar*, located port and starboard on the main deck, are rated for 20 MT and 10 MT respectively, with a maximum outreach of 12.7m (41.7') and 12.0m (39.36'). Both are capable of launching and recovering the rescue boats on their respective sides, which means *Luz de Mar* can always (weather and safety permitting) launch and recover a rescue boat on its lee side, irrespective of vessel heading and relative wind direction. This is not possible on *Ross Chouest*. The positioning of these cranes on the main deck is also ideal for rescue and recovery purposes, such that lifeboats, life rafts, etc., can be safely recovered and landed onto the main deck aft.

The two telescopic type cranes on *Ross Chouest* are installed on the 02 deck, which means the crane operating stations (unless remotely operated) are inherently quite high above the waterline. Increasing the vertical distance between the crane operator and objects - potentially human subjects - being recovered makes it more difficult for the operator to judge distances. In a dynamic wave environment, particularly higher sea states in which vessel motions would be high, this puts survivors in the water at even greater risk. Additionally, these telescopic cranes have a capacity of only 2.7 MT and a maximum outreach of 11.3 m (37') which severely limits, if not precludes, their use for at-sea rescue purposes. For rescue operations, the single fixed-boom crane installed on the main deck of *Ross Chouest* is the appropriate choice. This crane has a maximum 9.1 MT capacity and a maximum outreach of 13.7m (45'). It lacks telescoping capability, but is otherwise comparable to the starboard deck crane installed on *Luz de Mar*. However, it is the only such crane onboard, which limits rescue operations to the starboard side of the vessel only. For this reason, and because of the additional capacity of the port-side deck crane on *Luz de Mar*, the crane package on *Ross Chouest* is regarded as a BAT deficiency.

Little information was available on the ship's hospital on either vessel apart from number of berths. The ship's hospital on *Ross Chouest* has two (2) berths available, while *Luz de Mar* has 15 berths in its combined hospital/survivor room (Reference 51). Though obviously beneficial for an offshore rescue scenario, hospital capacity was not a defined requirement for the Hinchinbrook Tug in Section 3 and thus was not an evaluation criterion in this assessment. Therefore, *Ross Chouest* was not penalized in the evaluation/scoring process for having far fewer hospital berths than *Luz de Mar*, nor was *Luz de Mar* credited for having 15 additional survivor berths in its total accommodation.

In summary, having only one fast rescue boat and one viable deck crane for rescue/recovery operations is a seen as a deficiency that could potentially limit *Ross Chouest's* effectiveness in responding to an at sea emergency. The addition of second fast rescue boat and deck crane on the port side (with crane installed on the 01 deck) would provide a layer of redundancy in the most important equipment items for this purpose and afford the ability to launch and recover small craft of either side of the vessel.

6.4.10 Firefighting Fitness

With a Bureau Veritas FiFi 1 class notation, *Luz de Mar* is far better equipped than *Ross Chouest* with respect to firefighting fitness. The vessel has an exterior fire-fighting system, composed of two engine-driven pumps, each with a capacity of 1,500 m3/hr. and enough power to project water (or Aqueous Film-Forming Foam (AFFF) fire suppressant foam) 120m away and 50m high from two joystick-controlled high-pressure fire monitors (Reference 39). *Luz de Mar* is also capable of applying dispersant and has 293m³ of dedicated tank capacity for storage of recovered fuel-oil. The vessel also has an auto protection (deluge) system which covers the hull by means of water diffusers, protecting the vessel and the crew from flames and high temperatures (Reference 39).

Figure 20 *Luz de Mar* firefighting system working demonstration, accessed from https://www.astillerosarmon.com/tugs/item/544-luz-de-mar.html on 3/24/2021

Though the initial 10 November 2020 roundtable discussion determined that oil spill recovery capability was not a requirement for the Hinchinbrook Tug (and thus is not scored in this BAT assessment), it is nevertheless noteworthy that *Luz de Mar* was designed, in part, with this purpose in mind. The vessel is equipped with two floatable skimming arms that attach to the aft part of the hull and angle obliquely forward during spill recovery operations. The arms are operated by two telescopic deck cranes, one for each arm. A suction pump at the inboard end, near the hull, collects the oily water and discharges it into a pair of aft tanks. Seawater is then separated from recovered oil by decantation (Reference 39).

Figure 21 Deployable skimming arms on *Luz de Mar*, used for oil spill recovery (Reference 39)

Luz de Mar also carries specialized dispersant equipment, oil containment boom, and an inert gas system (Reference 39).

Ross Chouest has no class rating as a firefighting vessel and is not equipped with fire monitors. It has no known means of applying AFFF fire suppressant or dispersant, and no designated tank capacity for recovered oil. That noted, it does have a U.S. Coast Guard Oil Recovery Authorization for up to 20% of its deadweight tonnage, which could possibly be carried in its mud tank or rig fuel tank (Reference 40). Yet it has no means for recovering oil from the surface of the water.

Ross Chouest's lack of firefighting equipment or classification constitutes a deficiency of firefighting capability in the present Hinchinbrook Tug that would be rectified with the implementation of BAT.

6.4.11 Length and Maneuverability

It is the opinion of the subject matter experts on the project team that the optimal vessel length for rescue towing in exposed near-coastal waters such as the Northern Gulf of Alaska is approximately 60m (197'). The primary reason for this is that 60 m allows an equitable balance between speed and seakeeping, on one hand, and maneuverability and agility, on the other (see Section 4 for additional discussion on these ‘competing’ design requirements for rescue tug/ETVs service). As vessel size decreases from 60m, it becomes increasingly difficult to achieve the desired >15-knot free running speeds – particularly in higher sea states. Conversely, as vessel size increases from 60m, it becomes increasingly cumbersome to maneuver in proximity to an affected vessel in higher sea states. This is, in part, because additional vessel length inherently means a longer object to be pivoted, rotated, and pushed about through the water. It also often means more sail area above the waterline as compared to shorter vessels. While these factors can be compensated for, to an extent, by adding additional lateral/omni-directional thrust in the bow and stern, at some point the sheer size and mass of a vessel becomes a significant detriment to responsiveness. Sometimes referred to as “unwieldiness” in the literature, excessive vessel length can be problematic for the most crucial stage of the rescue effort, establishment of the towing connection (Reference 42).

These assertions are supported by the fact that the mean overall length among the vessel subset is 67m, with some notable purpose-built salvage and rescue tugs/ETVs (e.g., *Baltic*, *ALP Ace*, and *Luz de Mar*) falling in the 55-65m range. Additionally, a number of the purpose-designed ETV and Emergency Response & Rescue Vessel (ERRV) concepts being actively marketed by leading naval architecture firms today fall with this length range, including the Ulstein SX 173 design (63m) and the RAL RAsalvor design (60m), the latter of which was discussed previously in Section 5.

It is further noted that some of the largest and best-known purpose-built rescue tugs in the subset, namely *Nordic* (78m) and *Abeille Bourbon* (80m), were intended for North Atlantic and North Sea service and were designed to achieve very high speeds (approaching 20 knots) in storm force conditions. These operating requirements are not analogous to those of the Hinchinbrook Tug.

At 56m overall, *Luz de Mar* is 6.67% shorter than the 60m length determined to be optimal for Hinchinbrook service. *Ross Chouest*, by comparison, is 78.18m overall, which is 30.3% longer than that the optimal 60m length.

Of course, in evaluating vessel maneuverability/agility and the matter of being wieldy or unwieldy for a particular rescue towing application, vessel length must be considered in context with other elements of the design and the intended operating area of the vessel. For the purposes of this assessment, and given practical limitations of the project scope, the team evaluated vessel length in relation to the power and type of installed tunnel and azimuthing thrusters (see the Tunnel and Azimuthing Thrusters section for additional discussion on this topic). Figure 22 below is a plot showing available power of lateral/omni-directional thrusters in relation to overall length for all vessels in the subset. Flap rudders were included as contributors to lateral/omnidirectional thrust in the calculation for those vessels known to have them installed.

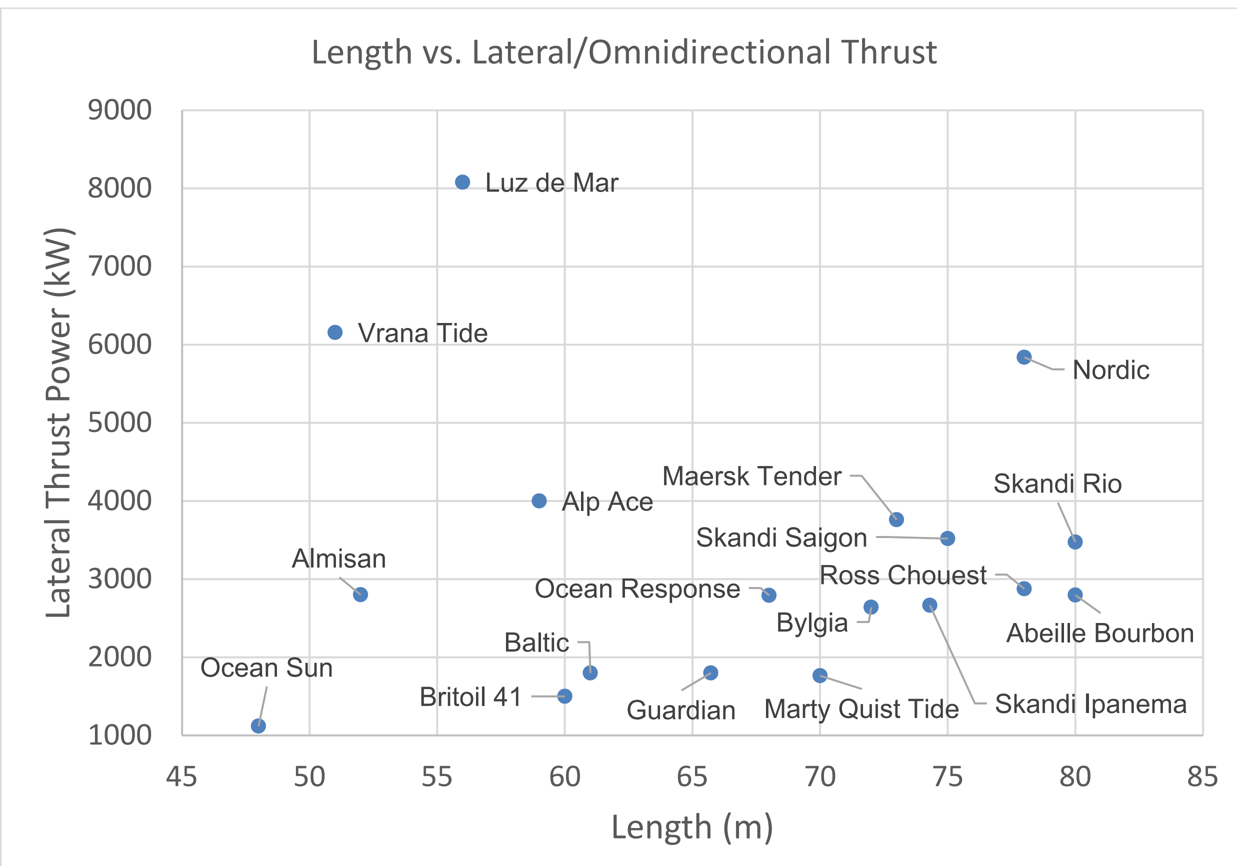

Figure 22 Plot of complete vessel subset showing vessel length in relation to available lateral thrust

If lateral/omnidirectional thrust vs. length is interpreted as a proxy for maneuverability, given the lack of consistent maneuvering data among vessels in the subset, this plot shows *Luz de Mar* as the clear standout. With 8,080 kW of available lateral/omni-directional thrust, *Luz de Mar* is capable of executing a 360º turn within its own length in 30 seconds, or 39 seconds in the case of using only one rudderpropeller (Reference 39). In this respect, *Luz de Mar* exceeds (by a factor of 2) the RAL Sentinel Tug maneuverability recommendation:

> *In order to satisfy current BAT, the Sentinel Class tug should…have omni-directional propulsion and be able to execute a zero speed, 360 degree turn within no more than 150% of its own length, and within no more than 60 seconds* (Reference 42).

Figure 23 *Luz de Mar* during a 360º turn demonstration, accessed from https://www.astillerosarmon.com/tugs/item/544-luz-de-mar.html on 3/24/2021

No data on the actual maneuvering characteristics of the *Ross Chouest* was available to the project team. Nevertheless, it is clear from the plot in Figure 22 than the maneuverability gap between *Ross Chouest* and *Luz de Mar* is a significant one and is therefore regarded as a BAT deficiency. It is emphasized that without actual maneuvering data on *Ross Chouest*, it is unclear if *Ross Chouest* is capable of executing a zero speed, 360º turn in the manner described above. It is clear, however, that maneuvering characteristics similar to *Luz de Mar* would constitute a marked improvement in capability for the Hinchinbrook Tug, and would enhance its ability to maneuver more safely, and with more agility, in close proximity to an affected vessel.

6.4.12 Propulsion

Ross Chouest is a conventionally shafted twin-screw tug with 134" diameter controllable pitch (CP) propellers in nozzles. *Luz de Mar* is an Azimuthing Stern Drive (ASD) or "Z-drive" tug, also with 134" diameter CP propellers in thruster-integrated nozzles. As noted above, the *Ross Chouest* and *Luz de Mar* are 11,400 and 10,300 BHP respectively, and nearly identical in terms of bollard pull. Both vessels are powered by two mechanically coupled medium speed diesel engines. The power plant on *Ross Chouest* is older (manufactured in 1994), but is otherwise comparable to that of *Luz de Mar* (Reference 40). The only notable difference is the installed position of the propellers, which sit shallower in the water on *Ross Chouest*. This has implications for vessel speed and towing efficiency, which are addressed in other sections of this analysis.

It is the opinion of the Glosten team that conventionally shafted twin-screw propulsion systems are not in any way intrinsically inferior to ASD propulsion for rescue towing applications. In fact, depending on design and performance objectives, it may be prudent to select twin-screw propulsion over ASD propulsion in some cases – particularly for vessels where very high free running speeds must be achieved. The lack of omni-directional thrust with conventional propulsion systems can be compensated for with the addition of stern thrusters, bow thrusters, retractable thrusters, and/or flap rudders such that a comparable level of maneuverability can be realized.

No significant gap is deemed to exist between the primary propulsion system of the *Ross Chouest* and *Luz de Mar*. It is noted, however, that a number of other candidate vessels in this BAT assessment are outfitted with more sophisticated propulsion systems that afford a higher degree of redundancy in the prime movers, as well as the ability to operate more efficiently at low loads. These vessels are:

- *Maersk Tender* (4 main engines with combination gearboxes)
- *Abeille Bourbon* (4 main engines with combination gearboxes)
- *Bylgia* (4 main engines with combination gearboxes)
- *Skandi Rio* (4 main engines with combination gearboxes)
- *Ocean Response* (full diesel-electric plant with 4 automatic paralleling auxiliary engines)

Despite the attractiveness of highly redundant power plants and the opportunity to operate with greater efficiency over the life of the vessel, these plants bring added complexity to the vessel and are significant capital cost contributors. The operational benefits and added cost are both accounted for in this BAT assessment and reflected in the scoring.

6.4.13 Tunnel and Azimuthing Thrusters

The *Ross Chouest* has 1 × 638 kW tunnel thruster and 1× 895 kW retractable azimuthing thruster installed in the bow, as noted in Table 3. In the stern it has a single 895 kW retractable azimuthing thruster. The total combined power of installed lateral/omni-directional thrusters is therefore 2,428 kW, with two thrusters being omni-directional.

Luz de Mar has 1 × 400 kW tunnel thruster in the bow and 2 × 3,840 kW azimuthing rudderpropellers in the stern, which also serve as the vessel's prime movers. The total combined power of installed lateral/omni-directional thrusters is therefore 8,080 kW, with both thrusters (rudderpropellers) in the stern being omni-directional.

With an additional 5,652 kW, *Luz de Mar* has 3.33 times the lateral/omni-directional thrust of *Ross Chouest*, in a vessel that is 73 feet shorter and with 34% less displacement. *Luz de Mar* also has a more favorable sail area balance than *Ross Chouest* – meaning that the sail area of the vessel's superstructure is concentrated closer to midships and/or distributed more evenly along the vessel's longitudinal axis. Taken together, these factors (shorter overall length and favorable sail area balance) reduce the amount of lateral/omni-directional thrust necessary for maneuvering and station keeping. Therefore, while it may seem intuitive to penalize *Luz de Mar* for having only a single 400 kW thruster in the bow, as compared to two higher powered thrusters on *Ross Chouest*, there is less need for lateral/omni-directional thrust in the bow on *Luz de Mar* – particularly when accounting for the power of the two azimuthing rudderpropellers in the stern.

ASD tugs can use the omni-directional thrust available in the stern to apply ‘leverage’ to the bow in a way that conventionally-shafted vessels cannot, making it far easier to hold the vessel at a certain attitude/heading relative to environmental forces. This was undoubtedly accounted for in sizing the tunnel thruster on *Luz de Mar* during the design phase.

Though the disparity in available lateral/omni-directional thrust between the two vessels is great, the actual thrusters installed on *Ross Chouest* do not constitute a BAT deficiency. In fact, retractable thrusters are a preferred equipment option for conventionally-shafted ETVs, and several vessels in the subset are similarly equipped. It is further noted that stern thrusters for most conventionally shafted vessels in the subset were tunnel type rather than the more advantageous azimuthing dropdown type found on *Ross Chouest*. The disparity between *Ross Chouest* and *Luz de Mar* in lateral/omni-directional thrust has been accounted for in the Length and Maneuverability and Redundancy sections.

6.4.14 Stationkeeping

Both *Ross Chouest* and *Luz de Mar* are equipped with dynamic positioning (DP) systems for controlled maneuvering and stationkeeping. These systems work by adjusting the power and direction of thrust automatically in response to environmental forces. The *Ross Chouest* has a joystick controlled IMO Class 2 system rated as American Bureau of Shipping (ABS) DPS-2 - generally referred to as DP2. *Luz de Mar* has a BV DYNAPOS AM/R system, also a joystick controlled IMO Class 2 system. For the purposes of this assessment, the DP systems on each vessel are considered equivalent in terms of both functionality and system redundancy. Therefore, there is no significant BAT gap or deficiency in the current Hinchinbrook Tug in this regard.

6.4.15 Towing Gear

The *Ross Chouest* has a winch package that, in certain respects, exceeds all others among the subset of vessels evaluated in this BAT assessment. It has 1,980m (6,500 feet) of 95.3mm (3¾") diameter wire rope on the primary towing drum and the same complement on its anchor-handling drum, which effectively serves as a redundant towing drum. This is the largest tow wire in the vessel subset, and with a nominal ultimate strength of 641 short tons (582 MT) – more than 4.6 times the bollard pull of the tug – it affords the highest factor of safety by far. The next largest tow wire in the subset is 89mm (3½") in diameter, installed on one vessel only, the tug *Bylgia*, which has a rated bollard pull of 199 MT – 59% higher than that of *Ross Chouest*. *Luz de Mar*, by comparison, has a 60mm (2⅜") diameter wire on both aft tow winches. Specifications on the exact wire rope installed on *Luz de Mar* were not available, but standard 6×19 and 6×37 class wire rope in this diameter has a nominal ultimate strength of 274 ST (249 MT) if Extra Improved Plow Steel (EIPS) construction, and 302 ST (274.05 MT) if Extra Extra Improved Plow Steel (EEIPS) construction. In this respect the winch package on *Ross Chouest* clearly outshines that of *Luz de Mar*. It is noted, however, that the most widely accepted standard for sizing of the main towline, the IMO *Guidelines for Safe Ocean Towing* (Reference 43), calls out a minimum breaking load (MBL) of 2.0 × BP for tugs greater than 90 MT bollard pull (Reference 43). It is further emphasized that the tremendous strength of the tow wire on *Ross Chouest* may offer limited benefit for practical emergency towing purposes in the vicinity of Hinchinbrook Entrance (namely weight of catenary), as the overall strength of the towing connection would still be limited by the weakest component in the system – generally the bitt foundations or other towing fittings onboard the affected vessel, or, in the event of a nearshore ship disablement in closure conditions, the synthetic hawser or pendant. A “hard gear” connection is not appropriate to attempt in higher sea states or when immediate action is necessary to prevent a grounding.

The length of the primary and secondary tow wires installed on *Ross Chouest* (1,980m) is also impressive – fifth longest in the vessel subset and 34% longer than that of *Luz de Mar*. The winch itself is described as having a line pull of 500 MT and a brake holding power of 750 MT – 50% higher than the next closest vessel in the subset. All three towing winches on *Luz de Mar* have a brake holding power of 320 MT, which equates to 2.5 times bollard pull. In terms of brute strength, the winch package on board *Ross Chouest* is essentially unmatched.

The arrangement of the winch drums on *Ross Chouest* also appears favorable. Though detailed information on the winch package was not provided, it is known to be a waterfall arrangement (indicated as reverse waterfall in Reference 44), and from Figure 24 below, it is inferred that the primary towing drum is positioned low to the deck and that both drums are configured for underwound wire deployment (Reference 44). This winch arrangement is regarded as near-optimal in this BAT assessment, second only to a side-by-side arrangement with both drums configured for underwound deployment.

Figure 24 Aft deck and winch package on *Ross Chouest*, accessed from https://westseattleblog.com/ on 3/18/2021

For the reasons provided above, *Ross Chouest* scored very highly in this subcategory of the assessment. The highest scoring winch package was that installed on the *Bylgia* - another reverse waterfall arrangement with both drums configured for underwound deployment, but incorporating an adjustable disc-type dynamic brake, or "slip brake," which prevents overloading of the towing system in a highly dynamic environment (i.e., elevated sea states). See Section 4 for more discussion on dynamic winch brakes.

Luz de Mar scored on-par with *Ross Chouest* in this subcategory, but for different reasons. *Luz de Mar* is equipped with two completely independent single-drum aft towing winches arranged in waterfall fashion, as visible in Figure 25. This is viewed as enhancing the operational redundancy of the overall winch package, given that the winches are two standalone machines, each with its own separate drive assembly. There are no shared systems or components between the two winches. The winches are configured for overwound deployment, which is not regarded as optimal, but the elevation of the tow wire at the fairleads is still relatively low in comparison to most vessels in the subset – estimated as 1.5m (primary drum) and 2.5m (secondary drum) above the deck.

Figure 25 Aft towing winches on *Luz de Mar* prior to installation of the tow wire, taken from Reference 45

Luz de Mar also has a combination aft tow winch and anchor windlass installed on the bow, which is nearly unique amongst all vessels in the subset (*Vrana Tide* has a similar, though less capable, bow winch). This is not a mooring or hawser winch, but a full-scale single drum marine towing winch outfitted with 600m (1,968') of 70mm (2¾") HMPE synthetic towline. Given that *Luz de Mar* is ASD, with a hull form designed to operate both ahead and astern (or "stern-first), this winch is considered a viable third towing drum. It is not known if the winch has automatic rendering capability or a render-recover (constant tension) control system; but given that the drum is outfitted with HMPE synthetic line, this functionality would be considered important for Hinchinbrook service.

Figure 26 Combined towing winch and anchor windlass installed on the bow of *Luz de Mar*, taken from Reference 46

It was determined in the 10 November roundtable discussion that tethered escorting and the application of braking and steering forces using the indirect mode was not a requirement for the Hinchinbrook Tug. For this reason, Glosten did not evaluate vessels for the presence or absence of a hawser/escort winch installed on the bow. This winch, therefore, apart from marginally augmenting the *Luz de Mar* winch/towing gear score on the basis of redundancy, was not regarded as representative of BAT in the assessment. Nevertheless, its potential advantages for Hinchinbrook Tug service are worthy of some discussion.

An ASD tug similar to *Luz de Mar*, outfitted with a similar forward winch and fendered bow, could potentially render aid in the following scenarios, where other vessels in the subset might have difficulty:

- Recovery of pick-up gear/fixed emergency towing system on the stern of a disabled tank vessel with forward inertia (i.e., propulsion or steering system failure while being escorted in the vicinity of Cape Hinchinbrook)
- Recovery of pick-up gear/fixed emergency towing system on the stern of a drifting tank vessel where immediate action is necessary, or if for any reason a stern-first approach is deemed unsafe to attempt
- Tethered escort of an inbound vessel with a mechanical or other system issue that could affect safe navigation through Hinchinbrook Entrance.

Figure 27 Bow form and fendering on *Luz de Mar,* accessed from https://balearicyachtshow.org/2020/stand/100/salvamento-maritimo on 3/29/2021

In general, the combination of a snubbed and fendered bow with a high-strength towing winch would enhance the versatility of the Hinchinbrook Tug and its ability to respond to a broader range of conceivable tank vessel emergencies.

Ross Chouest and *Luz de Mar* have a comparable complement of auxiliary/tugger winches, both of which are suitable to facilitate gear handling on deck. *Luz de Mar* is outfitted with a single set of Karm type towing pins and a single Karm fork, whereas *Ross Chouest* has two pairs of Karm pins and two sets of shark jaws. The towing pin and shark jaw arrangement on *Ross Chouest* is considered optimal, and thus there is no BAT deficiency in this regard.

In conclusion, despite the high level of operational redundancy and versatility afforded by the winch package on *Luz de Mar*, the winch and towing gear installed on *Ross Chouest* fares very well in comparison and is considered favorable for the operating mission of the Hinchinbrook Tug. The winch lacks automatic rendering functionality (i.e., a slip brake), which could be used to prevent overloading of ship fittings or a synthetic hawser composing part of the towing system; however, this is not viewed as a significant BAT deficiency.

6.4.16 Operational Redundancy

Luz de Mar has a very high level of redundancy in its electrical power generation and distribution system. In addition to its main auxiliary group, the vessel is equipped with one emergency generator and two independent shaft generators driven off a power take-off (PTO) on the forward end of each main engine. Each shaft generator has a power output of 800 kW, which is the same output as the main auxiliary group, such that one shaft generator alone is capable of carrying roughly the full hotel load, including winch loads, during normal vessel operations (Reference 39). This effectively means that *Luz de Mar* has two layers of complete redundancy in the onboard power generation system.

Luz de Mar also has two independent mechanically-driven fire pumps (also driven off each main engine), which means that the firefighting system is not dependent on vessel electrical power;

and in fact, even with one main engine disabled, the full system can be operated, albeit at reduced capacity, by the fire pump on the opposite engine. Figure 28 below shows the basic propulsion and equipment configuration on each main engine.

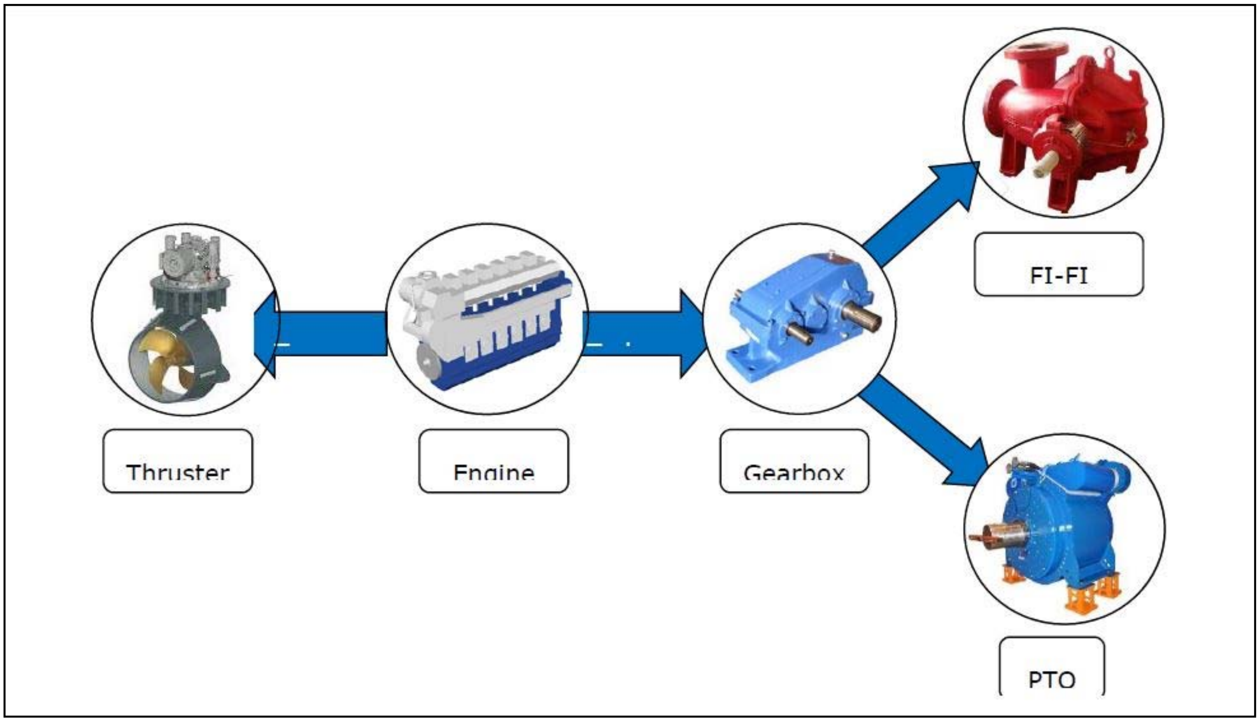

Figure 28 Schematic showing the propulsion & equipment arrangement of each main engine on *Luz de Mar*, Reference 39

Ross Chouest has 3 × 500 kW generator sets and 1 × 300 kW emergency generator. An electrical load analysis conducted by North American Shipbuilding for Hull #140 (*Ross Chouest*) shows an estimated maximum electrical load during anchor-handling operations (considered analogous to rescue towing in this context) of 595.6 kW and 623.3 kW when the dynamic positioning system is in operation. This would seem to indicate that *Ross Chouest* does not have equivalent redundancy in the electrical power generation system as compared to *Luz de Mar*. However, in both load cases, the vessel's shunt generator fault, which trips off non-essential electrical components (namely space heaters) when power demand exceeds capacity, automatically reduces the total electrical load to 418.0 kW and 394.5 kW, respectively (Reference 49). Considering this, an argument can be made that *Ross Chouest* also has two layers of complete redundancy in the onboard power generation system, though not in the form of one or more shaft generators.

Ross Chouest and *Luz de Mar* both have DP2-rated dynamic positioning systems, which means, in theory, that loss of position will not occur in the event of a single fault in any active component. In this respect, the two vessels have equivalent system redundancy; but it is noted that a mechanical failure of the retractable stern thruster on *Ross Chouest* would likely render the DP system unusable for establishing a towing connection in closure conditions, given that it is the only lateral/omni-directional thruster installed in the stern of the vessel. *Luz de Mar*, by comparison, has two omni-directional thrusters in the stern (the rudderpropellers) – each one with 5.75 times the power of the retractable stern thruster on *Ross Chouest*. Because it has two omni-direction thrusters in the stern, as opposed to one, and because these thrusters alone have sufficient power to control the aspect of the bow and propel the vessel in any direction, *Luz de Mar* is considered to have superior redundancy in this regard (DP and lateral/omni-directional thrust).

As discussed in detail in the Towing Gear section, the redundancies in the winch package installed on *Luz de Mar* exceed that of *Ross Chouest*. *Luz de Mar* has three viable and completely independent towing winches – two on the stern and one on the bow. All three winches are equal in terms of capacity and performance, though the bow winch is outfitted with 600m (1,968') of 70mm (2¾") synthetic towline instead of wire rope. This is also viewed as advantageous, as having synthetic towline pre-spooled onto one of the winch drums, coupled with the vessel's ability to approach bow-first (and tow in stern-first mode), affords the vessel the ability to very quickly connect and apply braking/towing forces if conditions allow. In situations where immediate action is necessary to prevent a grounding (e.g., a nearshore disablement where the ship has forward inertia), or to mitigate the impact of a grounding or other emergency, the combination of ASD propulsion with a viable tow winch on the bow bestows *Luz de Mar* with a degree of operational capability and flexibility not extant on any other vessel in the subset, and one that could prove vital in certain circumstances.

In comparison, *Ross Chouest* has one designated towing drum and one secondary anchor handling drum arranged on a common reverse-waterfall winch body. The vessel has no towing or hawser winch installed on the bow, nor does the vessel have the ability to tow in stern-first mode.

Overall, the level of operational redundancy in the design and outfitting of *Ross Chouest* is less than that of *Luz de Mar*. With respect to the BAT gaps noted above, only the lack of redundancy in way of lateral/omni-directional thrust is viewed as a notable deficiency. Yet this is an area where adoption of BAT would significantly enhance the reliability of the vessel to carry out its intended mission. This applies especially in foul weather conditions (i.e., higher sea states and/or wind speeds) when mechanical failure or disablement of the single azimuthing thruster in the stern of *Ross Chouest* would make it much more challenging to hold position and safely and efficiently establish a towing connection to an affected vessel.

6.5 Conclusions

The SASEMAR tug, *Luz de Mar*, is recognized in this assessment as the vessel most representative of rescue tug BAT for service at Hinchinbrook Entrance. In direct comparison with *Luz de Mar*, the current SERVS utility/sentinel tug, *Ross Chouest* has deficiencies on five important aspects of rescue tug/ETV design. These deficiencies are:

1. Lower free running speed
2. Less maneuverability/agility
3. Less capacity and redundancy in rescue and recovery equipment
4. No capability as a firefighting vessel
5. Less overall redundancy and versatility of operation.

Considered independently, no one deficiency identified in the Gap Analysis is justification for characterizing *Ross Chouest* as somehow unfit for its present role. *Ross Chouest* is irrefutably a highly capable oceangoing tug, as evidenced by its total score in this assessment (0.63) - putting it ahead of the 2009-built CPP/Z-drive tug, *Vrana Tide* and marginally behind several other more recently constructed tugs.

Considered collectively, however, the deficiencies are not inconsequential and could seriously impact the *Ross Chouest's* effectiveness in a practical rescue effort as compared to *Luz de Mar*.

Some of the deficiencies noted in the analysis could be addressed with retrofitting – namely those related to rescue and recovery equipment and firefighting fitness – but others are more intrinsic to the design and could have compounding disadvantageous effects in certain circumstances. Specifically, the principal dimensions, hull form, and powering/propulsion of

Ross Chouest are practically unalterable design traits that combine to limit the vessel's speed and maneuverability/agility. *Luz de Mar* significantly outperforms *Ross Chouest* on these two aspects of performance. For a nearshore ship disablement, at or near the 17 nautical mile line from Cape Hinchinbrook, a vessel that is slower to arrive on scene and slower (or unsuccessful) in establishing a towing connection could mean the difference between a vessel "save" and a grounding or other casualty. In such circumstances, particularly if crewmembers are injured or in the water, every minute is critical.

Luz de Mar's high overall score in this BAT assessment illustrates the advantages inherent in a purpose-built ETV design. It achieves high performance in each of the *Ross Chouest* gap areas identified above, and at 55m overall, it offers these capabilities at a likely lower capital and operating cost than many of the larger designs considered in this study. It is the opinion of the study team that a length of approximately 60m is not only a preferable cost alternative to some of the larger AHTS, salvage tug, and ETV options profiled herein, but also the best balance for the competing speed and maneuverability/agility demands an ETV must satisfy. The *Luz de Mar's* 129 MT bollard pull is on the lower end of the range considered acceptable in this study, and further study is advisable to determine the possible implications of adapting such a design for construction and operation inside the US (see the USCG towline stability criteria discussion in Section 3.3.1.2). Nevertheless, within the scope of this study, *Luz de Mar*, of all towing vessels constructed after 2005 worldwide, appears to be the maximally capable rescue tug in this size and horsepower class and the best achievable balance of capability and total cost of all vessels among the subset evaluated. The adoption of this technology (i.e., this design or a design analogous to it) would constitute a marked improvement in the overall capability of the Hinchinbrook Tug and, in the hands of an equally capable crew, would further reduce the probability of a tank vessel casualty in the vicinity of Cape Hinchinbrook.

Appendix A Candidate Vessels in Alphabetical Order

Figure 1 ***Abeille Liberté*****, sistership to *****Abeille Bourbon*****; image courtesy of https://alchetron.com/Abeille-Libert%C3%A9, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Abeille Bourbon	France	Groupe Bourbon	2005	80	201	*Abeille Liberté*

Figure 2 ***Almisan*****; image courtesy of https://www.rosetti.it/projects/aht-almisan/, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Almisan	Italy	Augusta Offshore S.p.A.	2011	52	149	None Identified

Figure 3 ***ALP Ace*****; image courtesy of https://www.fleetmon.com/vessels/alp-ace_9344966_683/photos/2686257/, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
ALP Ace	Netherlands	ALP Maritime Services BV	2006	59	192	None Identified

Figure 4 ***Baltic*; image courtesy of https://www.fairplay-towage.group/flotte/baltic/, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Baltic	Germany	Arbeitsgemeinschaft Küstenschutz	2010	61	127	None

Figure 5 ***Britoil 41*****; image courtesy of https://www.fleetmon.com/vessels/britoil-41_9257230_10460964/, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Britoil 41	Singapore	Britoil Offshore Services Pte. Ltd.	2006	60	150	None Identified

Figure 6 ***Bylgia* and sistership *Kolga*; image courtesy of https://www.pinterest.com/pin/819373725924927513/, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Bylgia	Netherlands	Heerema Marine Contractors	2013	72	199	*Kolga*

Figure 7 ***Guardian*; image courtesy of https://www.kustwacht.nl/en/node/206, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Guardian	Netherlands	Multraship	2013	66	149	None

Figure 8 ***Miguel de Cervantes*****, sistership of *****Luz de Mar*****; image courtesy of https://www.fleetmon.com/vessels/miguel-de-cervantes_0_29662/photos/455467/, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Luz de Mar	Spain	Spanish Maritime Safety Agency	2005	55	129	*Miguel de Cervantes*

Figure 9 ***Maersk Tracer*, sistership of *Maersk Tender*; image courtesy of https://www.fleetmon.com/vessels/maersk-tracer_9388613_49845/, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Maersk Tender	Denmark	Maersk Supply Service	2009	73	171	*Maersk Tracer*

Figure 10 ***Marty Quist Tide*; image courtesy of http://www.shipspotting.com/gallery/photo.php?lid=1164858, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Marty Quist Tide	Vanuatu	Tidewater Marine Service Inc.	2010	70	154	*J Keith Lousteau*

Figure 11 *Nordic*; image courtesy of https://www.mtu-solutions.com/na/en/applications/commercial-marine/commercial-marine-solutions/special-purpose-vessels.html, accessed 22 February 2021

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Nordic	Germany	NORTUG Bereederungs GmbH & Co.	2010	78	201	None

Figure 12 ***Ocean Response*****; image courtesy of https://gcaptain.com/atlantic-offshore-convert-multipurpose-standby-vessel-ocean-response/, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Ocean Response	Norway	Atlantic Offshore AS.	2013	75	120	None

Figure 13 ***Ocean Wave* and *Ocean Wind*, sisterships to *Ocean Sun*; image courtesy of https://blog.crowley.com/jones-act-0, accessed 22 February 2021**

Name	**Flag**	**Owner**	**Year Built**	**Length (m)**	**Bollard Pull (MT)**	**Sistership(s)**
Ocean Sun	USA	Vessel Management Services	2013	45	165	*Ocean Wave*, *Ocean Wind*, *Ocean Sky*

Figure 14 ***Skandi Ipanema*****; image courtesy of** https://www.shipsandoil.com/ShipInformation/0Ship%20Info%20South%20Atlantic/DOF%20Brasil/Skandi%20Ipanema%20arriving%20Niteroi%2014.1.13%20@%20j.plug%20(27)S.jpg **, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Skandi Ipanema	Brazil	DOF Navigacao Ltd	2010	74	174	None

Figure 15 ***Skandi Rio*****; image courtesy of https://www.upstreamonline.com/rigs-and-vessels/budget-busting-bids-land-in-petrobras-vessel-tender/2-1-791718, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Skandi Rio	Brazil	NorSkan Offshore/DOF ASA	2007	80.0	206	*Skandi Fluminense*

Figure 16 ***Skandi Saigon*; image courtesy of https://ddwoffshore.com/skandi-saigon/, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Skandi Saigon	Norway	Aker DOF Deepwater AS	2011	75	196	None

Figure 17 ***Vrana Tide*****; image courtesy of http://www.sywyy.com/en/Product/34.html, accessed 22 February 2021**

Name	Flag	Owner	Year Built	Length (m)	Bollard Pull (MT)	Sistership(s)
Vrana Tide	Vanuatu	Tidewater Marine Service Inc.	2009	51	127	*O'Rourke Tide*

Appendix B Preliminary Scoring

Vessel	Bow Form	Pilothouse Location / Sail Area Imbalance	Crew Protection / Bulwark Height	Rescue / Recovery / Firefighting	Freeboard	Stern and Aft Deck Geometry	Tow Winch & Related Deck Equipment / Machinery	Visual Composite	BP	Total Composite, BP*1	Total Composite, BP*2	Total Composite, BP*3
Abeille Bourbon	3	3	2	3	3	1	2	17	3.00	20.00	23.00	26.00
Almisan	2	2	2	2	3	2	2	15	2.78	17.78	20.57	23.35
Alp Ace	2	2	3	2	3	2	2	16	3.00	19.00	22.00	25.00
Baltic	3	3	3	3	3	2	2	19	1.43	20.43	21.86	23.29
Britoil 41	2	2	2	2	2	2	2	14	2.85	16.85	19.69	22.54
Bylgia	2	2	2	2	3	2	2	15	3.00	18.00	21.00	24.00
Guardian	3	2	3	3	3	2	2	18	2.78	20.78	23.57	26.35
Luz de Mar	3	3	3	3	3	3	2	20	1.55	21.55	23.11	24.66
Maersk Tender	2	1	2	2	3	2	2	14	3.00	17.00	20.00	23.00
Marty Quist Tide	2	2	2	2	3	2	2	15	3.00	18.00	21.00	24.00
Nordic	3	3	3	3	3	1	2	18	3.00	21.00	24.00	27.00
Ocean Response	3	3	2	3	3	1	1	16	1.00	17.00	18.00	19.00
Ocean Sun	2	3	2	2	2	2	2	15	3.00	18.00	21.00	24.00
Skandi Ipanema	2	2	2	2	3	2	2	15	3.00	18.00	21.00	24.00
Skandi Rio	2	2	2	2	3	2	2	15	3.00	18.00	21.00	24.00
Skandi Saigon	2	1	2	2	3	2	2	14	3.00	17.00	20.00	23.00
Vrana Tide	2	3	2	2	3	2	2	16	1.43	17.43	18.86	20.29

Appendix C Final Scoring Matrices

Full Scoring Detail

	Scoring Categories																				Cost Categories		
ADEC Criteria	Effectiveness						Feasibility		Transferability				Compatibility	Age & Condition	Availability	Environmental				Total Score	Cost		Total Cost Rank
Scoring Subcategories	Bow Form	LOA	BP	Tow Winch & Deck Equipment / Machinery	Stern & Aft Deck Geometry	Power Plant (flexibility, efficiency)	Maneuverability	DP	Roll Reduction	Pilothouse Location / Sail Area Balance	Accommo-dation (Pax + Crew)	Freeboard	Free Running Speed	Redundancy	Flag	Crew Protection	Bulwark Height	Rescue & Recovery	Firefighting		Dimension Cost Rank	Power Cost Rank	
Abeille Bourbon	5.00	3.00	30.00	3.00	2.00	4.50	18.81	3.00	5.00	5.00	4.30	5.00	24.08	5.00	6.00	5.00	5.00	5.00	5.00	0.87	0.52	0.30	0.52
Almisan	3.00	4.20	28.06	3.50	4.00	3.50	20.74	5.00	3.00	4.00	3.00	4.00	11.85	2.50	6.00	3.00	4.00	3.00	5.00	0.74	0.02	0.09	0.32
Alp Ace	3.00	4.90	30.00	3.00	5.00	3.50	22.90	5.00	3.00	4.00	3.00	4.00	19.46	2.17	6.00	3.00	5.00	3.00	3.00	0.81	0.11	0.35	0.48
Baltic	5.00	4.90	15.88	2.50	3.00	3.50	17.96	4.90	3.00	5.00	3.60	5.00	18.31	3.00	6.00	5.00	5.00	5.00	5.00	0.74	0.17	0.15	0.38
Britoil 41	3.00	5.00	28.62	4.00	4.00	3.50	16.26	5.00	3.00	4.00	4.20	3.00	13.69	1.83	6.00	3.00	5.00	3.00	3.00	0.72	0.30	0.19	0.42
Bylgia	4.00	3.80	30.00	4.50	4.00	4.50	19.02	3.80	3.00	4.00	3.00	4.00	15.31	4.17	6.00	4.00	3.00	3.00	1.00	0.75	0.75	0.48	0.66
Guardian	5.00	4.43	28.06	1.00	4.00	3.50	15.63	4.43	3.00	3.00	5.00	5.00	10.00	1.50	6.00	5.00	3.00	4.00	3.00	0.69	0.26	0.13	0.38
Luz de Mar	3.00	4.60	16.98	4.00	5.00	3.50	23.00	5.00	3.00	5.00	4.00	4.00	16.92	4.50	6.00	4.00	5.00	5.00	3.00	0.76	0.05	0.09	0.33
Maersk Tender	3.00	3.70	30.00	4.50	3.00	4.00	18.37	3.70	3.00	2.00	3.00	5.00	10.00	5.00	6.00	4.00	3.00	4.00	3.00	0.72	1.00	0.42	0.67
Marty Quist Tide	3.00	4.00	30.00	4.00	3.00	3.50	16.29	4.00	3.00	4.00	3.00	4.00	11.38	2.50	6.00	3.00	2.00	4.00	3.00	0.69	0.25	0.20	0.42
Nordic	5.00	3.20	30.00	3.00	2.00	3.50	25.00	3.20	3.00	5.00	4.60	5.00	25.00	2.17	6.00	5.00	4.00	5.00	3.00	0.86	0.59	1.00	0.93
Ocean Response	4.00	4.20	12.00	1.50	2.00	5.00	20.67	4.20	3.00	5.00	4.10	5.00	17.15	4.83	6.00	5.00	2.00	5.00	5.00	0.70	0.56	0.66	0.74
Ocean Sun	2.00	3.80	26.95	3.50	5.00	3.50	17.00	5.00	3.00	5.00	3.00	1.00	16.00	2.17	10.00	1.00	5.00	3.00	3.00	0.72	0.00	0.09	0.32
Ross Chouest	3.00	3.20	14.77	4.00	3.00	3.00	17.99	3.20	5.00	3.00	5.00	4.00	10.00	2.50	10.00	4.00	4.00	3.00	1.00	0.63	0.73	0.20	0.50
Skandi Ipanema	4.00	3.57	30.00	3.00	2.00	3.00	16.89	3.57	3.00	2.00	3.00	5.00	13.69	1.00	6.00	4.00	2.00	3.00	3.00	0.68	0.47	0.21	0.46
Skandi Rio	4.00	3.00	30.00	3.00	2.00	4.50	18.21	3.00	3.00	2.00	4.80	5.00	18.31	4.00	6.00	4.00	2.00	3.00	5.00	0.76	0.74	0.54	0.69
Skandi Saigon	4.00	3.50	30.00	3.00	2.00	3.50	17.67	3.50	3.00	2.00	3.00	5.00	16.00	2.00	6.00	4.00	2.00	3.50	5.00	0.72	0.69	0.35	0.58
Vrana Tide	3.00	4.10	15.88	1.50	3.00	3.00	20.47	3.00	3.00	4.00	3.00	2.00	11.38	1.17	6.00	2.00	3.00	4.00	3.00	0.58	0.10	0.00	0.28

Simplified ADEC Scores

Vessel	Effectiveness	Feasibility	Transferability	Compatibility	Age & Condition	Availability	Environmental Impacts	Cost Rank
Abeille Bourbon	47.50	21.81	19.30	24.08	5.00	6.00	20.00	0.52
Almisan	46.26	25.74	14.00	11.85	2.50	6.00	15.00	0.32
Alp Ace	49.40	27.90	14.00	19.46	2.17	6.00	14.00	0.48
Baltic	34.78	22.86	16.60	18.31	3.00	6.00	20.00	0.38
Britoil 41	48.12	21.26	14.20	13.69	1.83	6.00	14.00	0.42
Bylgia	50.80	22.82	14.00	15.31	4.17	6.00	11.00	0.66
Guardian	45.99	20.06	16.00	10.00	1.50	6.00	15.00	0.38
Luz de Mar	37.08	28.00	16.00	16.92	4.50	6.00	17.00	0.33
Maersk Tender	48.20	22.07	13.00	10.00	5.00	6.00	14.00	0.67
Marty Quist Tide	47.50	20.29	14.00	11.38	2.50	6.00	12.00	0.42
Nordic	46.70	28.20	17.60	25.00	2.17	6.00	17.00	0.93
Ocean Response	28.70	24.87	17.10	17.15	4.83	6.00	17.00	0.74
Ocean Sun	44.75	22.00	12.00	16.00	2.17	10.00	12.00	0.32
Ross Chouest	30.97	21.19	17.00	10.00	2.50	10.00	12.00	0.50
Skandi Ipanema	45.57	20.46	13.00	13.69	1.00	6.00	12.00	0.46
Skandi Rio	46.50	21.21	14.80	18.31	4.00	6.00	14.00	0.69
Skandi Saigon	46.00	21.17	13.00	16.00	2.00	6.00	14.50	0.58
Vrana Tide	30.48	23.47	12.00	11.38	1.17	6.00	12.00	0.28

Score to Cost Ratios

Vessel	Score to Cost Ratio
Luz de Mar	2.32
Almisan	2.29
Ocean Sun	2.28
Vrana Tide	2.07
Baltic	1.95
Guardian	1.82
Britoil 41	1.71
Abeille Bourbon	1.68
Alp Ace	1.67
Marty Quist Tide	1.64
Skandi Ipanema	1.47
Ross Chouest	1.26
Skandi Saigon	1.24
Bylgia	1.14
Skandi Rio	1.09
Maersk Tender	1.07
Ocean Response	0.95
Nordic	0.93

Appendix D Candidate Vessel Cutsheets

ABEILLE BOURBON

Newbuilding No. 39 from Myklebust Verft AS – 2005
Design UT 515

MYKLEBUST VERFT AS	N-6082 Gursken, Tel: +47 70 02 62 00, Fax: +47 70 02 62 01
	e-mail: firmapost@mmv.no, Org.no.: NO 983145310 MVA www.klevenmaritime.no

KLEVEN MARITIME®

ABEILLE BOURBON

GENERAL INFORMATION

Owner	GIE Abeille Bourbon, Marseilles, France (Groupe Bourbon)
Operator	Les Abeilles International, Le Havre, France (Groupe Bourbon)
Long term charterer	French navy
Port of registry	Brest, France
Builder	Myklebust Verft AS, Norway
Yard No.	39 – deliverd April 2005
Hull	Maritim Ltd., Gdansk, Poland
Design	Rolls-Royce
Type	UT 515 - Multi Purpose Salvage Tug / Coast Guard and Stand By Safety Vessel
Class	BUREAU VERITAS I * Hull* MACH TUG/SALVAGE TUG, AUT-UMS, Fire-fighting 2, DYNAPOS AM/AT
Call signal	FZTC
IMO-number	IMO 9308687

MAIN DIMENSIONS

Length o.a.	80,00 m
Length b.p.p.	68,60 m
Breadth	16,50 m
Depth main deck	8,00 m
Draught, service max	6,00 m
Draught, design	5,60 m
Speed, approx.	19,8 knots
Bollard pull	201 tonnes
Accommodation	14 persons, 8 pass.
Cargo deck area	350 m^2
Cargo deck capacity	300 tonnes

TONNAGE

Gross tonnage	3249
Net tonnage	974
Deadweight, dr.6,0 m	1813 tonnes

TANK CAPACITIES

Fuel oil	1 645,30 m^3
Fresh water	125,80 m^3
Fresh water ballast	70,9 m^3
Water ballast	1011,70 m^3

MACHINERY AND PROPULSION

Main engine	4 x 4 000 kW/600 rpm
Shaft generator	2 x 2400 kVA
Main propeller	2 x diam. 3900 mm
Auxiliary engine	3 x 615 kW/1500 rpm
Auxiliary generator	3 x 662,5 kVA
Em. Auxiliary engine	181 kW/1500 rpm
Em. Auxiliary generator	204 kVA, type
Tunnel thruster, bow	2 x 883 kW
Tunnel thruster, stern	2 x 515 kW

DECK MACHINERY AND CRANES

Towing winch	Based on 200 tonnes bollard pull. 500 t Brake holding load on first layer Wire capacity: 2 x 1600 m
Deck Crane	23 tonnes/11 m
Stores and prov. crane	10 tonnes/10 m

RESCUE CRAFTS

MOB-boat	2 x MP-741 Springer 1 x Weedo 17

FIRE FIGHTING

Monitors	3
Capacity	7 200 m^3/hour

TANK CAPACITIES

Fuel oil	1 645,30 m^3
Fresh water	125,80 m^3
Fresh water ballast	70,9 m^3
Water ballast	1011,70 m^3

MYKLEBUST VERFT AS

N-6082 Gursken, Tel: +47 70 02 62 00, Fax: +47 70 02 62 01

e-mail: firmapost@mmv.no, Org.no.: NO 983145310 MVA www.klevenmaritime.no

AHT
ALMISAN

Year	2011
Flag	Italian
Builder	Rosetti Marino SpA - Ravenna - Italy
Class society	RINA
Class notation	RINA C+; +AUT UMS; +AUT PORT; OIL RECOVERY SHIP F.P.> 60; SALVAGE TUG; FIRE-FIGHTING SHIP-2; DP2; INWATERSURVEY; UNRESTRICTED NAVIGATION
IMO number	9553581

GENERAL INFO

Year	2011	
Flag	Italian	
Builder Rosetti Marino SpA - Ravenna - Italy		
Class society	RINA	
Class notation RINA C+; +AUT UMS; +AUT PORT; OIL RECOVERY SHIP F.P.> 60; SALVAGE TUG; FIRE-FIGHTING SHIP-2; DP2; INWATERSURVEY; UNRESTRICTED NAVIGATION		
IMO number	9553581	

MAIN PARTICULARS

Length OA	52,34	mt
DWT	1.264	T
Breadth moulded	15,00	mt
Depth moulded	7,00	mt
Gross tonnage	1659	T
Net tonnage	497	T
Maximum draft	6,40	mt

CARGO CAPACITIES

Working Clear Deck - space 225		
Working Clear Deck - length x breadth 18,00mt x 12,50		
Fuel Oil	600	cbm
Fresh Water	multipurpose - 458	cbm
Drill Water	multipurpose - 198	cbm

MACHINERY/PROPULSION

Bollard pull continuous 142,5		
Bollard pull max	149,2	T
Main Engines 2 x Wartsila 8L32 - 4000kW each @ 750 rpm		
Total power (BHP)	10.728	
Bow thruster(s) (number and BHP) 2 x Schottel transverse 600kW		
Diesel generator 2 x Volvo Penta/Marelli 250 kW - 450 V - 60 HZ		
Emergency generator 1 x Volvo Penta/Marelli 120 kW - 450 V - 60 HZ		
Fuel type - (MGO / IFO / HFO) MGO		

ANCHOR HANDLING CAPACITIES

Winch Type - Double/Triple Drum MEP Waterfall double drums SL 250 W/2T		
Winch - Pull Rating	250	T
Winch - Brake Rating	350	T
Towing Drum wire capacity 1.200mt x 70mm dia.		
Work wire A/H - length / diameter 400mt x 70mm dia.		
Tow wire - lenght / diameter 1.200mt x 70mm dia.		
Tugger Winch (number / capacity / rating) 2 x 10		

Capstan	5	T

DECK EQUIPMENT

Chain lockers	115	cbm
Stern Roller	3,00 x 2,00 SWL 300T	
Towing Pins (type and number) 2 remote controlled karm 250		
Crane Electro-hydraulic SWL 3,9/2,35 T at 8/12,35 mt		

CARGO DISCHARGE CAPACITY

Fuel Oil 2 x 35cbm/hr @ 50mt head
Fresh Water 1 x 100cbm/hr @ 60mt head
Drill Water 1 x 100cbm/hr @ 60mt head

SPEED/CONSUMPTION

Max Speed/Consumption	14,2 knots @ 28 M/T
Economical Speed/Consumption 9 knots @ 7 M/T	
Port Consumption	0,5 T/day

ACCOMODATION

Total number of beds	23

FI-FI

FiFi	FiFi2
Number of monitors 4 x 1800cbm/hr each @ 12.50bar; 150mt lenght; 70mt height	
Number of pumps	2 x 3600cbm/hr each

ANTI POLLUTION EQUIPMENT

Dispersant	28,5	cbm
Spray booms	yes	
Oil Recovery capacity	not dedicated - 210	cbm

RESCUE EQUIPMENT

Rescue Boat Hatecke RB 400 - 6 persons	
Inflatable life rafts	4
Life jackets	29 adults + 2 children

NAVIGATION AND COMMUNICATION EQUIPMENT

DP	Class2
DP type	Kongsberg DP2
Radar (number and type) 1x10 cm ARPA T.M RADAR - 1x3 cm ARPA T.M. RADAR	
Inmarsat 2x JRC JUE85 + 1 x JRC JUE500	
VHF 2 VHF WITH DSC AND MULTIWATCH - 1 VHF 55 Channel Dual Watch.	
DGPS/GPS	1 DGPS SAT NAV
Echo sounder	1 Echo Sounder
Speed log	Doppler Speed Log

Radio Telex	1 Navtex Receiver
Gyroscopic compass	
2 Gyrocompass interchargeable	

DP II Anchor Handling Salvage Tug

ALP ACE | 192 mt Bollard Pull

General Data

CALLSIGN
PCBN

FLAG
The Netherlands

PORT OF REGISTRY
Rotterdam

IMO NUMBER
9344966

BUILT
2006 - Mützelfeldt Yard, Cuxhaven, hull 252

DESIGN
MAN Ferrostaal AG / Hitzler Werft

CLASSIFICATION
DNV-GL
+ 100 A5 E2 Deep Sea Tug Boat (NAV - A4)
+ MC AUT, FF1, DP2

DP II
ERN 99, 98, 97, 59

BOLLARD PULL
192 mt cont.

MAXIMUM SPEED
17,5 knots

SERVICE SPEED
11,5 knots

Main Dimensions

LENGTH O.A.
58,55 m

LENGTH B.P.
52,29 m

BEAM O.A.
14,80 m

DEPTH TO MAINDECK
7,65 m

MAX. DRAUGHT
5,82 m

DEADWEIGHT
1.694 mt

GROSS TONNAGE
1.767 mt

NETT. TONNAGE
530 mt

CARGO DECK AREA
220 sqm

DECK LOAD
10 mt / sqm max.

CHAIN LOCKER CAPACITY
2 x 33 cbm

Towing / Anchor Handling

TOWING WINCH
Electr. driven 100/200 mt @ 15/7,5 m / min

BRAKE HOLDING LOAD
300 mt drum's 1st layer

DRUMS
2 x 1.600 m, 76 mm

CONTROL
Remote controlled from bridge

CABLE LIFTERS
1 x 76 mm and 1 x 126 mm

TOW WIRE
1 x 1.600 m, 76 mm
1 x 300 m, 76 mm

STORAGE REEL
1 x 1.200 m, 76 mm

STERN ROLLER
300 mt SWL, 3,00 m length / 2,00 m diameter

TUGGER WINCHES
2 x 10 mt @ 15 m / min

TOWING PINS
2 x Karmoy, 300 mt SWL

KARM FORKS
2 x Karmoy, 650 mt SWL, various inserts

Tank Capacities

BALLAST WATER
140 cbm

FRESH WATER
77 cbm

MARINE GAS OIL
131 cbm

HEAVY FUEL OIL / MARINE GAS OIL
1.132 cbm

Machinery

MAIN ENGINES
14.000 kW / 750 rpm
2 x 7.000 kW MAN B&W 14V32/40

PROPELLERS
2 x CPP 3.800 mm in nozzle

RUDDERS
High performance Becker rudders

BOW THRUSTERS
2 x 400 kW tunnel thrusters, CPP

STERN THRUSTERS
1 x 400 kW tunnel thruster, CPP

GENERATORS
2 x 500 ekW, 50Hz auxiliary generators
2 x 1.500 ekW, 50Hz shaft generators
1 x emergency generator

Accommodation

TOTAL CAPACITY
24 persons

CABINS
Single berth 13
Double berth 2
Four berth 1

HOSPITAL
Single berth

Arbeitsgemeinschaft **Küstenschutz**

BALTIC

Schottel ASD Tug

MAIN DATA	
Call sign :	
Length over all :	61,36 m
Breadth over all :	15,00 m
Draft :	max 6,00 m
GRT :	2.068 GT
Class :	GL 1400A5 Es IW Tug, Suitable for Operations in Oil covered Waters Machinery MC E2 AUT FF1
Bollard Pull :	127,2 t
Speed :	17 kn
Built :	2010, Astilleros Armon Vigo, Spain
Capacities :	abt. 577 m^3 gasoil, abt. 126,52 m^3 fresh water
ENGINES	
Horsepower :	2 x 5.766 BHP = 11.532 BHP
Main Engines :	2 x GE 16V 250MDB4
Auxiliary Engines :	2 x MAN D2840LE301 of 443 KW 1 x MAN D2866 LXE20 of 177 KW
Propulsion :	2 x Schottel SCO 100/4 XG 2 x Browthruster STT 001 FP 450 KW, 2 x Sternthruster STT 001 FP 450 KW 2 x active Becker rudders

EQUIPMENT	
Towing Winch :	2x Ibercisa MR-H/300/500-70 hydraulic towing winches, 500 m / 62 mm galvanized steel wire, Breakhold 2.557 KN, Shark Jaws, Fork Pins Karmoy 300 tons SWL 2x Capstan 2 tons, Tugger winch 10 KN, 150 m / 25 mm Deck Crane 16 m reach SWL 6,0 tons Equipped according GMDSS area 3
Fire Fighting :	FiFi 2 Monitores each min 600 m^3 and up to 1.200 m^3 per hour / 140 m throw 40 m height
Foam :	16 m^3 multi purpose foam available
Rescue :	High Speed Rescue Boat Hatecke, 7,20 m, 120 KW
COMMUNICATION	
Com. Equipment :	Fleet Broadband 500, Satellite Fax Phone - GSM Phone

Bugsier Reederei- und Bergungsgesellschaft mbH & Co. KG I FAIRPLAY Schleppdampfschiffs-Reederei Richard Borchard GmbH, Hamburg

c/o Bugsier Reederei- und Bergungsgesellschaft mbH & Co. KG · Ludwig-Erhard-Strasse 22 · 20459 Hamburg
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February 23, 2021

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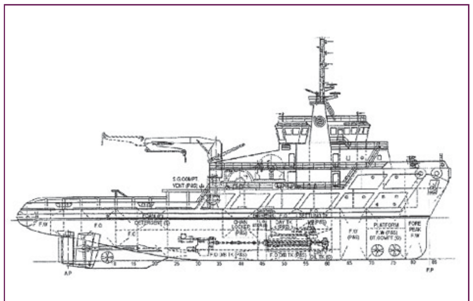
Anchor Handling / Tow Tug Britoil 41



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Vessels Specifications

Britoil 41

Name of Vessel	Britoil 41	**Registry**	Singapore
Year of Delivery	2007	**Type**	Ocean Going / Anchor Handling / Towing Tug
Classification	ABS + A1, Towing Vessel, Fire Fighting Vessel Class 1, (E), + AMS, + DPS-1	**Dimensions**	60m x 17.8m x 7.5m
GRT / NRT / DWT	2610T / 783T / 1545T	**Draft**	6m (Designed) / 6.3m (Max)
Clear Deck Space (Main Deck)	25m x 14m	**Speed**	15 knots
Deck Strength	5.5 mt/m²		
Bollard Pull	150T	**Endurance**	35 days
Accommodation	Fully air-conditioned for 28 men Complement: 16 men Pax: 12 men	**Lifesaving**	Comply to SOLAS requirement
Fuel (90%)	1235 mt	**External Firefighting**	FiFi 1
Fresh water	386 mt	**Freshwater Maker**	20 mt/day
Main Engines & Gearboxes	2 x 5500 bhp ULSTEIN BERGEN propulsion engine type BRM-9 MCR: 11000 bhp at 750 rpm c/w x gearbox of 5.69:1 ratio	**Generators**	Cat 3508B, 3 x 800KW, 415/3/50, diesel driven generators. 1 x 300KW, Cat 3408 Dita 415/3/50, radiator-cooled emergency generator, 2 x 1400 kW shaft alternator
Main Engines Consumption	42,144 litres MGO and 100 litres lube oil per 24 hours @ full power. 31,608 litres MGO and 75 litres lube oil per 24 hours @	**Generator Consumption**	600 ltrs MGO & 15 ltrs L.O. / 24 hrs

	economic cruising speed of 10 knots		
Propulsion	2 x Ulstein C.P. propulsion system type 1500 AGSC-KP25-950/4 c/w 4.2mm diameter, 4 bladed propeller in kort nozzle	**Steering Gear**	Ulstein Tenfjord electro hydraulic steering gear, type : 2 x SR662. Torque : 136 kn m each
MGO Purifiers	2 x Mitsubishi self cleaning fuel oil purifiers with MGO with capacity of 2900 litre/hr	**Lube Oil Purifiers**	2 x Mitsubishi self cleaning lube oil purifiers with capacity of 2900 litre/hr
Towing Pins & Sharkjaws	2x Karmfork towing pins 4x Karmfork shark jaws	**Bow Thruster/ Stern Thruster**	3 x Brunvoll C.P. transverse thruster, 2 Bow, 1 Type : FU-63-LTC-1550- 650W Thrust : 9.1T
Anchor Windlass	1x BRATTVAAG hydraulic windlass Type : BFMG 63.048 Duty of cable lifter : Pull â€“ 10T at 0-15m/min	**Anchors**	2 x 2280kg stockless Bower anchor
Anchor chain	2 x 440m x 48mm diameter U2 steel stud link chain	**Towing/Anchor winch**	BRATTVAAG triple drum waterfall hydraulic winch.Type : BSL 350 WX/2SL 350WX with remote control in wheelhouse 1. At low gear (AH & towing drum) Line pull 1st layer : 350T @ 0-9m/min At low gear Top layer :- 150T, 0-20.8m/min 2. At high gear Line pull – 1st layer : 130T @ 0-24.5m/min Line pull – Top layer : 56T @ 0-56m/min Wire Cap : 2 x 2000m x 83mm dia & 1 x 5390m x 83mm dia wire Brake holding : 500T on 1st layer
Stern Roller (Size) SWL	L-8.05m; Dia-2.4m 300 mt	**Capstan**	2 X BRAVTTAAG hydraulic capstan 15T line pull @ 0- 22 m/min
Crane	North American Offshore Crane Model MCT2-2581. 2.65T at 24.5m radius. 9T at 12m radius.	**Tugger Winch**	2 X BRAVTTAAG hydraulic tugger winch – Type : AKM 6318, 18T line pull at 0-43m/min
Wire Storage Reels	2 x 20T line pull at 0- 35m/min hydraulic wire storage reels of		

	2000m x 83mm dia. wire capacity		
Fendering	Flat doubler plates of 24â€ x 25mm cross section welded to side shell. Bow plate of approx 50mm thick section secured vertically	**Cutting Equipment**	Two bottles oxygen and one bottle acetylene c/w torch
Life rafts	4 x 30 men	**Radar**	1 x FURUNO model FR- 2125 c/w 6.5ft scanner, 21″ CRT display. 0.25- 96 nm range c/w performance monitor
Rescue Boat	1 x 6 men	**VHF**	2 x VHF/FM multi-channel marine radio telephones. FURUNO model FM-8500-25W
SSB	Radio console, FURUNO RC-1800-IT-25-250, 24V DC/220V AC c/w DSC & NBDP to meet GMDSS requirements. FURUNO SSB model FS-2570-250W	**Weather Facsimile**	1 x FURUNO Type FAX-207
Gyro & Automatic Pilot	1 x Gyro-Tokimec TG- 6000. Autopilot-Furuno model NAV PILOT-500	**Fire Monitors**	2 fixed foam/water fire monitors of 10000 litres/min each @ 130m head capacity. 1 x fire pump of 1400m^3/hr each
Other Navigation Equipment	2 x INMARSAT-C, EPIRB, Radar Transponder, P.A. System, Navtex Receiver, GPS Navigator, 1 x Satellite Mini M Tel & Fax, Echo Sounder (Colour), 2 VHF Walkie Talkie, Anemometer, Speed Log, AIS, etc.	**External Firefighting**	FiFi 1 – 2 fire pumps of 1500m^3/hr each
Dispersant Booms	2 x 8m dispersant booms fitted	**Sewage Treatment Plant**	Taiko Kikai SBT-40 for 40 men

August 2017

MARINE CONTRACTORS

Equipment

A HEEREMA COMPANY

Support Equipment

HMC operates a large variety of marine equipment:

- Anchor handling tugs
- Cargo barges
- Cargo / launch barges
- Offshore pile driving hammers

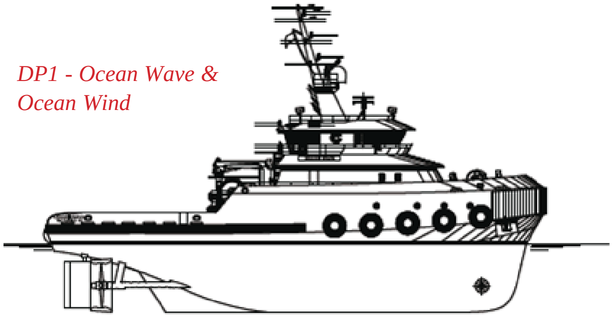
Anchor handing tugs

	Length	Width	Depth (work deck)	Summer draft	Bollard pull
Bylgia	72.0 m (236 ft)	18.0 m (59 ft)	8.5 m (27 ft)	7.37 m (24 ft)	199 t
Kolga	72.0 m (236 ft)	18.0 m (59 ft)	8.5 m (27 ft)	7.37 m (24 ft)	203 t

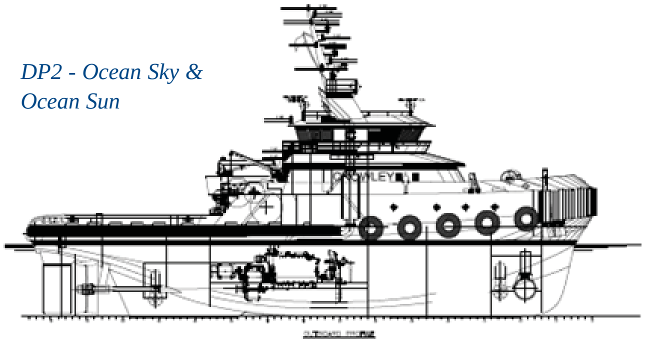
OCEAN CLASS DP1 & DP2

The ocean-class vessels are twin screw with controllable pitch propellers (CPP), in nozzles with independent high lift rudders. Their hulls are welded steel construction and each is outfitted for long range ocean towing, dynamic positioning, firefighting and general purpose vessel requirements. The vessels are transverse framed with transverse and longitudinal bulkheads and is designed with all tanks containing oil and oil traces inboard of the side shell to create a double hull. Propulsion is provided by two (2) Caterpillar C-280-12 Tier II* diesel engines, designed to operate on Ultra Low Sulfur Diesel fuel and each is rated at 5440 BHP @ 1000 RPM driving the CPP Propellers through Reintjes LAF 5666 reduction gears. Electric power is provided by one (1) 340 kW Caterpillar C-18 Tier II* auxiliary generator (Harbor Generator), two (2) 1475 KVA, for the DP1 and 1.5 for the DP2 version, shaft generators and one (1) 125 kW Caterpillar C-6.6 Tier II emergency generator system. The vessel is flagged in the Registry of the United States of America and complies with all applicable rules and regulations for unrestricted ocean towing. **capable of being upgraded to Tier III or IV*

DP1 - Ocean Wave & Ocean Wind



DP2 - Ocean Sky & Ocean Sun



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Houston, TX 77060
(281) 774-5400

9487 Regency Square Boulevard
Jacksonville, Florida 32225
(904) 727-2200

www.crowley.com

OCEAN CLASS DP1 & DP2 VESSEL SPECIFICATIONS:

FLAG
United States

PORT OF REGISTRY
San Francisco, CA

BUILDER
Bollinger Shipyards
Amelia, LA

OVERALL DIMENSIONS
Length: 146' (44.4m)
Ocean Wind/Ocean Wave
156' (47.5m)
Ocean Sky/Ocean Sun
Breadth: 46' (14.03m)
Depth: 25' (7.62m)
Design Draft: 21' (6.4m)

TONNAGE
<1600GRT

CONSTRUCTION
Steel

OPEN DECK SPACE
47' x 45' 2115 sq2
13.71M x 14.32M 196.48 sq m2

FUEL CAPACITY
234,738 Gallons (888.58m^3)
Ocean Wind/Ocean Wave
251,700 Gallons (973.20m^3)
Ocean Sky/Ocean Sun

FUEL OIL OVERFLOW
2,118 Gallons (8.02m^3)

DIRTY OIL
1,153 Gallons (4.36m^3)

OILY WATER
1,225 Gallons (4.64m^3)

HYDRAULIC OIL
570 Gallons (2.16m^3)

FRESH WATER
19,060 Gallons (72.15m^3)
Ocean Wind/Ocean Wave
24,700 Gallons (93.5m^3)
Ocean Sky/Ocean Sun

GRAY WATER
6,474 Gallons (24.51m^3)

SEWAGE HOLDING
5,582 Gallons (21.13m^3)

FOAM STORAGE
1,436 Gallons (5.44 m^3)

LUBE OIL
2,900 Gallons (10.98m^3)

MAIN ENGINES
(2) Caterpillar C-280-12 Tier II*
Developing 10,880 (8,113kW) Total BHP

HARBOR GENERATOR
(1) 340kW Caterpillar C-18 Tier II*

EMERGENCY GENERATOR
(1) 125kW Caterpillar C-6.6 Tier II*

SHAFT GENERATORS
(2) 1,475 KVA
Ocean Wind/Ocean Wave
(2) KATO rated 1.5MW each
Ocean Sky/Ocean Sun

PROPELLERS
(2) 4 Blade Cu-Ni-Al CPP
153.5" (3.9m) Diameter

NOZZLES
High Efficiency

REDUCTION GEARS
(2) Reintjes LAF 5666

SPEED
16 Knots

BOW THRUSTER
(1) Berg (Electric) VFD 850HP
Ocean Wind/Ocean Wave
(2) Berg (Electric) VFD 500HP
Ocean Sky/Ocean Sun

STERN THRUSTER
(1) Berg 500HP - *Ocean Sky/Ocean Sun*

CRANES
Aft Deck 25T Capacity
Foc's'le Deck Crane 5T Capacity

BOLLARD PULL
165 tonnes minimum

TOWING WINCH
Intercon - DW275 Hydraulic
Min. Holding Power 350 S.T. (317.51 M.T.)
500,000lbs (226.80 MT) @ 20 Ft/Min (6.1m/Min)

WIRE GUIDE PINS
200 MT Triplex

INDEPENDENT AUXILIARY WIRE DRUM
300'of 1" Wire rated @ 40,000 Lbs (18.14 MT) @ 100 Ft/Min (30.48 m/Min)
Independent Capstan
Rated @ 23,000 Lbs (10.43 MT) Line Pull @150 Ft/Min (45.72 m/Min)

BOW WINCH
Intercon - VMS Winch
Electric Windless Mooring 1.25" chain
Independent Capstan
Line Drum 600' of 1.25" Jacketed Plasma Line

TOWING WIRES
3,000' (914m) - 2.5" (63.5mm) Wire (Upper)
4,200' (1,219m) - 2.75"(69.85mm) Wire (Lower)

SHARK JAWS
350 MT Triplex Quick Release

STERN ROLLER
6' (1.83m) Diameter

ACCOMMODATIONS
13 total available
Three (3) 1 person staterooms
Five (5) 2 person staterooms

NAVIGATION/ COMMUNICATIONS EQUIPMENT
Radar - (2) Furuno FAR2117BB
GPS - (2) Northstar 952XD DGPS
GMDSS - Furuno RC1815 GMDSS
Autopilot - Robertson
Gyrocompass - Robertson
Depth Sounder - SOLAS Approved
Radios - (5) Furuno FM 3000
World Phone -Sailor (Thrane & Thrane)
EPIRB - (2) COSPAS-SARSAT 406MHz
Dynamic Positioning - Kongsberg

CLASSIFICATION
✠ A1, Towing Service
✠ AMS
✠ ABS
✠ ABS Fire Fighting Vessel Class 1
✠ ABS DP-1 *Ocean Wind/Ocean Wave*
✠ ABS DP-2 *Ocean Sky/Ocean Sun*
USCG Certificate of Inspection
Green Passport
SOLAS
International Load Line Certificate

DP1 only specs listed in red
DP2 only in blue

**capable of being upgraded to Tier III or IV*

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GUARDIAN

CALL SIGN	: PCSY
YEAR BUILT	: 2013
CLASSIFICATION	: Lloyds Register, Emergency Towing Vessel, FiFI 1, AHTS, Oil Recovery Vessel Class 1, LMC UMS
FLAG	: Dutch
HOMEPORT	: Den Helder-Netherlands
IMO	: 9637363

DIMENSIONS

L.O.A.	: 65.72 m
L.B.P.P.	: 60.50 m
Breath	: 15.50 m
Gross tonnage	: 2637 tons
Net tonnage	: 820 tons

PERFORMANCE

Max. bollard pull	: 149 tons

PROPULSION

Main engines	: MAK 8M32C, 2x 4000kW at 600rpm
Propellers	: BCP Dia 3400 mm Variable pitch in fixed nozzeles / feathering type
Tunnel thruster	: 2 Tunnel bow thruster, 2x 600 kW, 1 Tunnel stern thruster, 1x 600 kW
Steering gear	: 2 pcs Hydroster Ship Machinery, Works Ltd.

FIFI SYSTEMS

System 1	: 2 pcs fire-fighting centrifugal pumps FFS SNT250/550
Capacity	: 2x 1742 m³/h
Head	: 11.8 mlc 1800 rpm / 790 Kw
System 2	: 2 single/dual flow monitors FFS 1200/300LB
Control	: Joystick controlled from bridge
Capacity	: 1200 m³/h - 10.0 bar
Throw length - capacity full	: 120 m
Throw length - capacity reduced	: 75 m
System 3	: 1 foam pump DPVSF 18-100
Capacity	: 18 m³/h - 18.5 Kw
Head	: 185 mlc 3420 rpm
System 4	: 2 fog monitors for own protection type ABS
System 5	: Water spray system with standard tug nozzles
Capacity	: 900 m³/h at 7.6 bar

LAY-OUT

Lenght	: 28 m
Breath	: 12 m
Total	: 340 m²
Max. deck load	: 750 tons
Deck strength m²	: 7.5 t/m²

DECK LAY-OUT

Towing/anchor handling winch	: - 1 towing drum Wire 1500 m / 70 mm Line pull 150T - 15 m/min (1st speed) Brake holding 300 tons, 1st layer - 1 Anchor handling drum Wire 1000 m / 86 mm line/9 layers. pull 200 tons, 12 m/min (1st speed) Line pull 200 tons Brake holding 400 tons, anchor drum - All drums are declutchable - Automatic tension compensator - 2 gypsies for 76 & 90mm rig chain
Spooling device	: 20 tons spooling device for towing drum
Capstan	: 2x 10 tons

Crane	: 6 ton/15 m, knucle type
Tugger winch	: 2x 12 tons 15 m/min Brake capacity 15 tons
Windlass	: 83,8 KN 10 m/min Brake capacity 633 KN Chain diameter 42 mm
Shark jaw	: SWL 400 tons Operated from bridge and locally
Towing pins	: Angular Type - SWL 300 tons Operated from bridge and locally
Stern roller	: Diameter 2500 x 5700 mm SWL 320 tons
Spare wire reel	: 1500 mtr, 70mm wire, hydraulically controlled

AUXILIARY EQUIPMENT

Shaftgenerator sets	: 2x AVK 1250 KVA
Aux generators	: Volvo Penta D16-MG, 2x 410 kW
Emergency genset	: Volvo Penta D7A-AT, 1x 100 kW
Voltage, frequency	: 3x 400V, 50 Hz

TANK CAPACITY

M.F.O.	: 634 m^3
M.G.O.	: 361 m^3
Fresh water	: 291 m^3

ACCOMMODATION

1-man cabin	: 17 (seventeen)
2-men cabin	: 6 (six)
Survival	: 4 (four)
Hospital	: 1-2 persons (one-two)
Dispensary	: 1 (one)
Meeting room	: 1-10 persons (one-ten)
Mess rooms	: 2-30 persons (two-thirty)
Daily rooms	: 2 (two)

NAVIGATION EQUIPMENT

Radar,JRC Marine ARPA X-band	: 1
High resolution color display, radar plotter 21"	: 2
Radar, JRC Marine ARPA S-band	: 1
Radar repeater (slave radar) at aft wheelhouse console	: 1
GPS JRC	: 1
DGPS JRC	: 1
Navtex JRC	: 1
Echo sounder JRC ESOND	: 1
Speed log JRC	: 1
AIS JRC	: 1
Gyro compasses YOKOGAWA	: 2
Magnetic compass C-PLATH	: 1
Autopilot navitron	: 1
Wind speed/direction SENSORS	: 2
Weather fax JRC	: 1
Ecdis dual alphachart	: 1

COMMUNICATION EQUIPMENT

GMDSS station area A1+A2+A3

- HF/MF DSC sailor	: 1
- Emerg portable VHF GMDSS JOTRON	: 3
- VHF DSC JRC	: 2
- Portable UHF Alphatron	: 3
- Inmarsat C JRC (SSAS & LRIT))	: 2
- Radio telex Felcom 15	: 1
- EPIRB JOTRON	: 1
- SART JOTRON	: 2
- BNWAS NAVITRON	: 1
- Public Address System	: 1
- V-SAT Intellian V-60 Ku-band	: 1
- SEATEL TV system TV80	: 1

Dynamic Positioning System (DP-2)

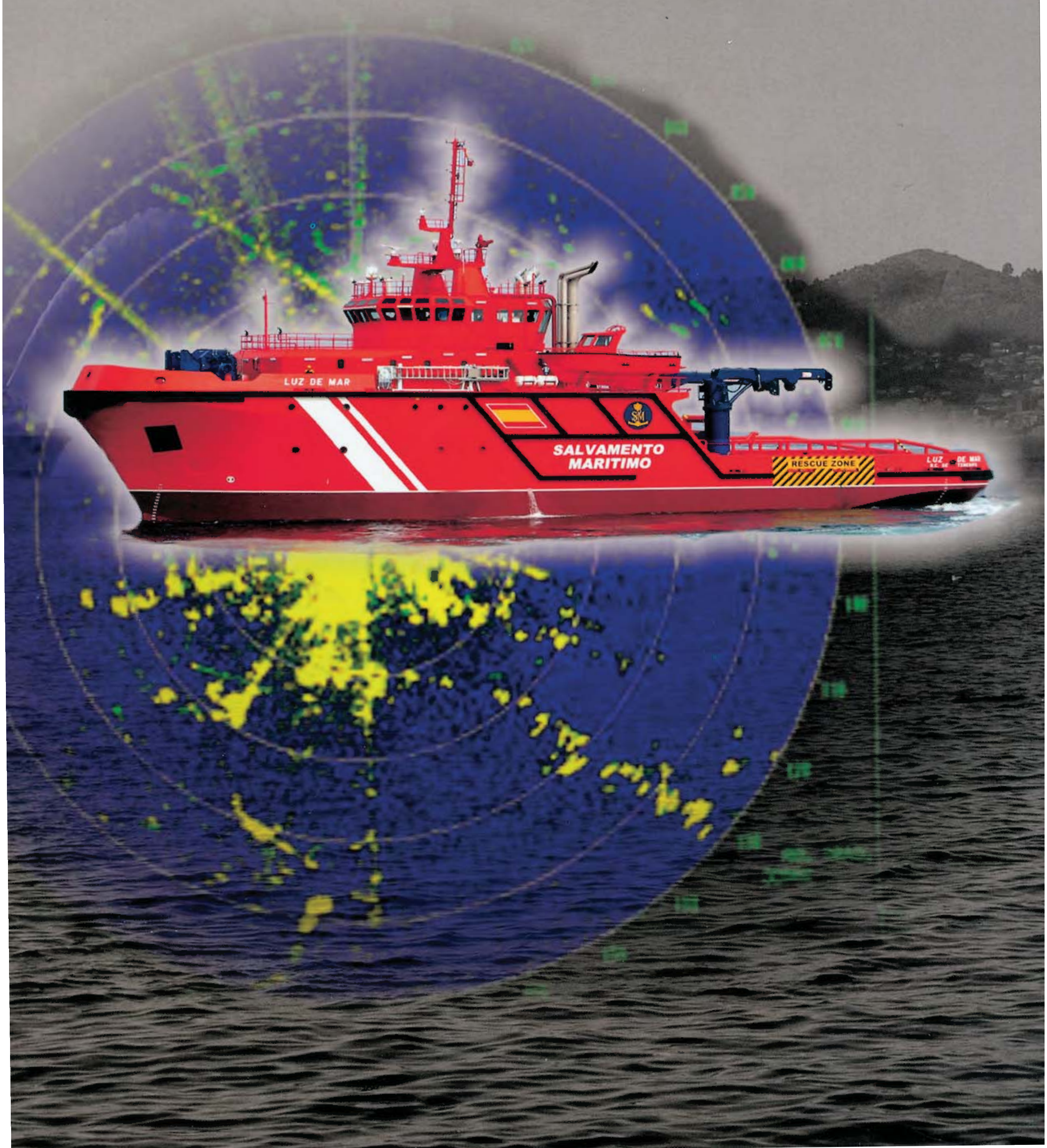
Maker	: KONGSBERG
Type	: K-Pos DP-21 Dual redundant positioning system

Equipped with Trunk & valve for easy future installation of High Precision Acoustic Positioning system (HiPAP, Kongsberg 501).

RESCUE AND LIFESAVING EQUIPMENT

Rescue Boats	: 1 NORSAFE Matrix
Dimensions	: 4,50 x 1.96 x 1.75m
Capacity	: 6 persons
Engine	: Outboard engine (20Hp)
Lifecrafts	: 4 Vikings
Capacity	: 20 persons/each
Search lights	: 2 Seematz
Control	: Remotely from bridge
Lifebuoys	: 6 provided with strobe lights and lifelines
Hospital	: 2 treatment bench, racks for stretchers, desk, medicine, poison locker
Dispensary	: 1 including medical equipments / medicine in accordance with Flag's State and International requirements

REMOLCADOR DE ALTURA DE 56 m. PARA SALVAMENTO Y ANTICONTAMINACION



UNA NUEVA GENERACIÓN

Salvamento, Rescate, Remolque, Antipolución, Lucha contra incendi

En cualquier situación y con las condiciones climatológicas más adversas, este buque desarrolla múltiples tareas: remolque de grandes barcos y barcazas en alta mar, trabajos en terminales petrolíferas, operaciones de rescate, salvamento, apoyo, manejo de anclas, lucha anticontaminación, contra incendios y otras.

Ofrece una excelente maniobrabilidad con propulsión y sistemas de control integrados, y está equipado con dos hélices azimutales y una hélice lateral de proa.

Este buque enfrenta eficazmente la contaminación derivada de accidentes marítimos graves posibilitando la recogida de residuos de hidrocarburos. Estas operaciones las realiza mediante brazos flotantes –con bombas de aspiración y tanques de almacenamiento y decantación– disponiendo de barreras de contención y equipos skimmer portátiles. Permite la evacuación –tanto al propio buque como a otro– de los hidrocarburos de un barco siniestrado. Para ello cuenta con un sistema de posicionamiento dinámico y dispone de suministro de fuerza eléctrica, neumática e hidráulica en cubierta para dar servicio a otros buques. También incorpora un equipo para dispersantes.

Funciona como buque de apoyo para equipos externos (buceadores y otros), y ofrece soporte para maquinaria y personal.

Un conjunto de dos pines de remolque y mordaza, accionados hidráulicamente, permite desempeñar labores de manejo de anclas y boyas en alta mar.

Características Principales

Eslora total	56,00	m
Eslora entre perpendiculares	48,00	m
Manga	15,00	m
Puntal a cubierta principal	7,00	m
Puntal a cubierta superior	9,70	m
Puntal a cubierta puente	12,40	m
Velocidad avante	16,40	nudos
Velocidad atrás	15,80	nudos
Tiro a punto fijo a 100% de potencia	128,50	t
Tiro a punto fijo a 80% de potencia	107,00	t
Autonomía	5.230	millas
Capacidad de agua	114	m^3
Capacidad de combustible	588	m^3
Lastre	113	m^3
Capacidad de almacenamiento de residuos	287	m^3
Espumógeno	62	m^3
Dispersante	22	m^3
Tripulación	18	personas
Técnicos y servicios auxiliares	8	personas

PRINCIPALES EQUIPOS ELECTRÓNICOS

- 2 radares ARPA de 30 y 25 kW.
- 2 receptores direccionales (MF/HF) (VHF).
- Sistema de Identificación Automática (AIS).
- 2 giroscópicas.
- 2 GPS diferenciales.
- 1 sonda de 50 kHz.
- 2 equipos de monitorización de viento.
- Registrador de travesía VDR.
- Inmarsat Flip 77.
- Inmarsat Standard C.
- Equipo para cumplir con cota GMDSS zona A3.
- Piloto automático.
- Cartas electrónicas ECIDS.
- 1 corredera Doppler.
- 1 sistema CCTV.
- 1 Cámara Giro-estabilizada para visión nocturna Sea Flir II.

PROPULSIÓN Y MANIOBRABILIDAD

Dispone de 2 motores propulsores de 3.840 kW a 600 r.p.m. cada uno acoplados a dos líneas de ejes.

Incluso con avería en una línea de propulsión, el buque sigue navegando con total maniobrabilidad y seguridad.

Cuenta con propulsión azimutal por popa con dos propulsores de paso variable que giran 360º y que, junto a la hélice lateral de proa, le dotan de total maniobrabilidad a cualquier régimen.

Dispone de sistema de posicionamiento dinámico DYNAPOS AM para mantener la posición con los medios de maniobra de a bordo.

Se desplaza lateralmente en maniobras de aproximación y atraque.

El buque realiza un giro de 360º en 30 segundos utilizando ambos propulsores y en 39 segundos con sólo uno de ellos.

SISTEMA CONTRA INCENDIOS EXTERIOR

El equipo de lucha contra incendios exterior cumple los requisitos del Bureau Veritas para la cota FI FI 1.

2 bombas contra incendios exterior, de 1.500 m³/h, impulsan el agua-espuma a 120 m de distancia y 50 m de altura desde dos monitores.

El sistema de autoprotección del casco mediante difusores es alimentado por las bombas contraincendios.

El control es por joy-stick y consola en el puente.

MAQUINILLAS

El buque dispone de 3 maquinillas y 2 cabrestantes auxiliares.

- 1 maquinilla en Proa combinada con el equipo de fondeo con capacidad de 600 m de estacha de 70 mm de diámetro, y tiro al freno estático de 320 t.
- 2 maquinillas en Popa dispuestas en cascada con capacidad para 1.300 m de cable de 60 mm de diámetro en cada tambor, y con un tiro al freno estático de 320 t.
- 2 maquinillas auxiliares de 300 m de cable de 20 mm de diámetro.
- 2 cabrestantes verticales para operaciones de atraque.
- 2 maquinillas para estibar estacha con capacidad para alojar 2 estachas de 160 m de 60 mm de diámetro cada una.

GRÚAS

Dispone de 2 grúas de accionamiento hidráulico:

- Grúa de 20 t a 12,7 m y máximo de 15,9 m con cabrestante auxiliar de 5 t.
- Grúa de 10 t a 12,0 m de alcance, con un cabrestante auxiliar de 5 t.
- Estas grúas permiten las operaciones habituales y las maniobras de los brazos flotantes de recogida de residuos.

RECOGIDA DE RESIDUOS Y ALMACENAMIENTO

Se efectúa desde dos brazos flotantes posicionados oblicuamente al sentido del avance en la mitad de popa del buque.

Una bomba de aspiración en el extremo próximo al casco descarga los residuos a los tanques.

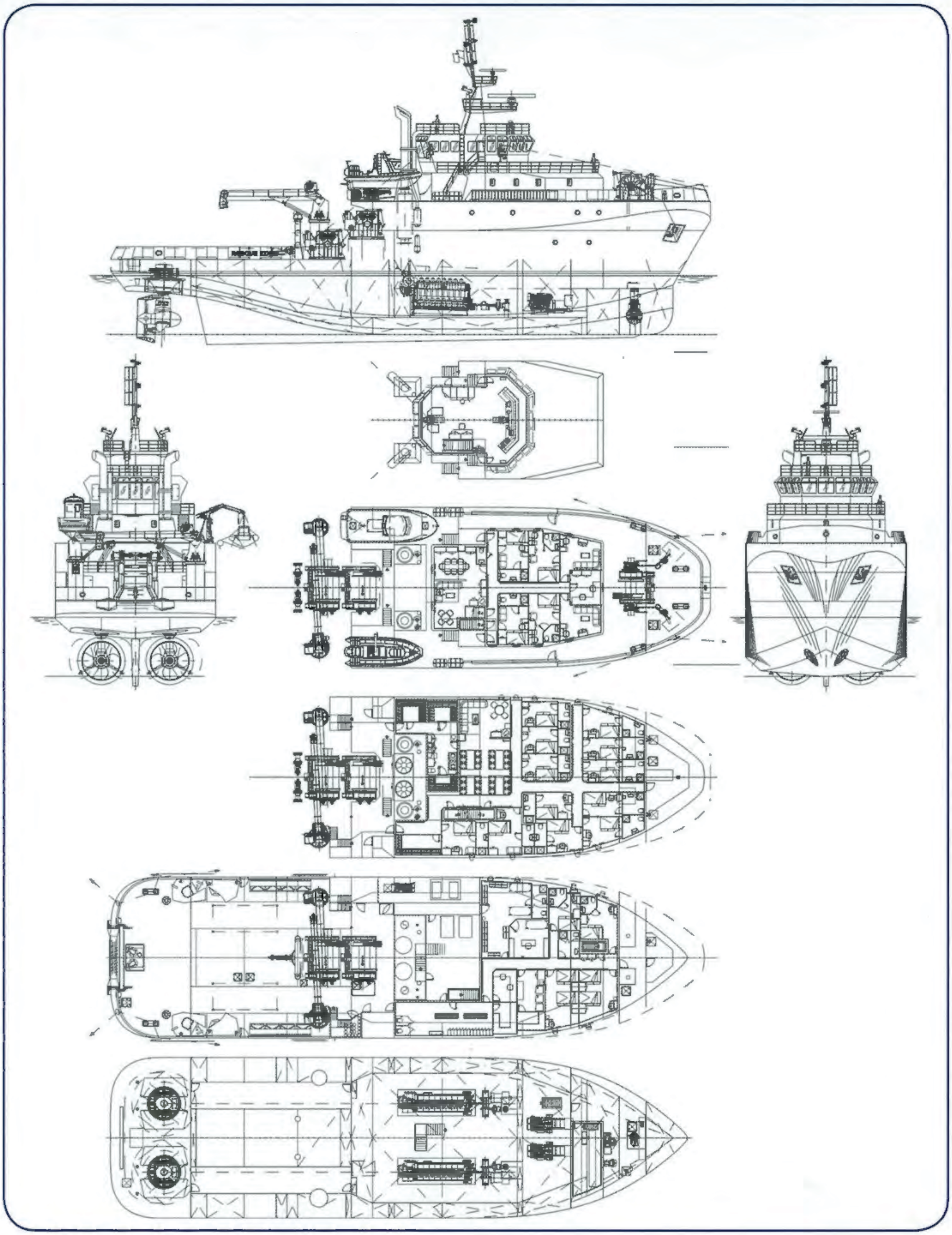
Estos residuos vierten en los tanques de recoil de popa que pueden ser individual o conjuntamente utilizados y que, por decantación, separan el agua del residuo.

Otra bomba descarga los tanques a tierra o a otros sistemas.

La cubierta de popa puede estibar y transportar tanques portátiles adicionales que, junto con los estructurales, aumenta la capacidad de almacenamiento de residuos.

CONFORT

Este buque establece un concepto de habitabilidad realmente funcional, sin renunciar a los espacios amplios y confortables.



ASTILLEROS ARMON VIGO, S.A.

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Tlf. (34) 985 631 464
Fax. (34) 985 631 701
web: www.astillerosarmon.com

ARMON

SALVAMENTO MARÍTIMO

MINISTERIO DE FOMENTO

Este nuevo Remolcador de altura para Salvamento y Anticontaminación es un buque de intervención rápida polivalente para trabajos en alta mar y en condiciones meteorológicas extremas.

Ha sido diseñado por la oficina técnica de **Astilleros ARMON** para cubrir las más altas exigencias que **SALVAMENTO MARÍTIMO** ha propuesto para la actuación ante cualquier contingencia en situaciones extremas.

Salvamento Marítimo

MINISTERIO DE FOMENTO

ANCHOR HANDLER

Maersk Tender

The Maersk Supply Service multi-purpose Anchor Handling Tug Supply Vessels (AHTS) are uniquely designed for a variety of work roles including deep water anchor handling and mooring operations, towing of rigs, subsea and ROV support work, as well as general supply and cargo support operations for customers world-wide. These specialized vessels have highly skilled crews, optimal safety conditions and state-of-the-art equipment to helpour customers achieve their goals in a professional and cost-effective manner.

Key features

- Dynamic position class 2
- 171 t bollard pull
- 600 m² open deck space
- 400 t anchor handling/towing winches
- Clean Design/Comfort Class

MAERSK
SUPPLY SERVICE

Maersk Tender

Classification

	A1 Offshore Support Vessel (TOW, Supply) OSR-S1 HAB++(WB) ACCU LR FiFi1 Compliant
Dynamic positioning	DP2
Reference systems	2 x DGPS Seatex 1 x Fanbean MDL 1 x HiPAP Kongsberg
Motion reference units	3 x Gyrometer Raytheon 2 x Wind sensor Gill 2 x Motion sensor Seatex

Deck Equipment

Anchor handling winch	1 x 400 t
Tow winches	2 x 400 t
Chain lockers	1 x 245 m³ + 1 x 264 m³
Shark jaws	2 x 700 t
Stern rollers	2 x 3.0 m x 3.0 m
Stern roller SWL	2 x 800 t
Towing pins	2 x 300 t
Capstans	2 x 15 t
Tugger winches	2 x 17 t

Dimensions

Length (LOA)	73.2 m
Beam	20.0 m
Depth	9.1 m
Draft scantling	7.75 m
Deadweight	3523 t
Gross tonnage	4678

Deck capacities

Deck load capacity	1030 t
Deck strength	Aft 15 t/m² Fwd 10 t/m²
Free deck area	600 m²
Length	35.8 m
Width	16.8 m

Propulsion / Bollard pull

Main engines	13872 BHP 2 x MAN 8-27/38 + 2 x MAN 7-L27/38
Thrusters	2 x CP main propellers 2 x bow tunnel 1200 BHP 2 x stern tunnel 680 BHP
Bollard pull	171 t

Accommodation

Person capacity	30

Tank capacities

Base oil	129 m³
Brine	769 m³
Drill/ballast water	1808 m³
Dry bulk	207 m³
Fresh water	618 m³
Fuel	1191 m³
Oil based mud	640 m³
Oil recovery	769 m³ Including multi-purpose tanks

*All figures and data believed to be correct, but not guaranteed

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Contact Information

For further information on vessel specifications, capacities or vessel availability, please do not hesitate to contact the Commercial Department at
chartering@maersksupplyservice.com or +45 73 73 73 73

Version Number 1.3

MAERSK SUPPLY SERVICE

J KEITH LOUSTEAU as shown
MARTY QUIST TIDE similar

TIDEWATER®
MARTY QUIST TIDE

Remontowa 13,750 BHP
Anchor Handling Tug

Vessel Characteristics

Length, Overall:	229.7 ft	70 m
Beam:	50.8 ft	15.5 m
Depth:	21.7 ft	6.6 m
Maximum Draft:	18.4 ft	5.6 m
Minimum Height:	75.8 ft	23.1 m
Freeboard:	4.9 ft	1.5 m
Displacement:	3,980 lt	4,040 mt
Deadweight:	2,000 lt	2,040 mt
Clear Deck Space:	110 x 39 ft	35.2 x 12 m
Clear Deck Area:	4,380 ft^2	410 m^2
Deck Strength:	1,130 lb/ft^2	5.5 t/m^2

Class Notations:
ABS: +A1, (E), OSV, FFV-1, +AMS, +DPS-2, +ACCU, AH, Towing Vessel

Last update: 6/15/2016

TIDEWATER® MARTY QUIST TIDE

Capacities

Deck Cargo:	980 lt	1,000 t
Fuel Oil:	193,000 gal	730 m^3
Potable Water:	26,200 gal	99.1 m^3
Fresh Water:	135,000 gal	510 m^3
Drill/Ballast Water:	206,000 gal	780 m^3
Bulk Tanks (4 tanks):	6,840 ft^3	190 m^3
Liquid Mud (20 lbs/gal):	2,990 bbl	480 m^3

Machinery

Main Engines (2):			CAT C280-16 DITA
Total HP:			13,600
Propellers (2):			CPP; 3700 mm; SCANA VOLDA
Kort Nozzles:			2
Primary Generators (2):	250 kw	440 v	60 hz
Driven by:			DIESEL
Secondary Generators (2):	1,720 kw	440 v	60 hz
Driven by:			SHAFT
Emergency Generators (1):	150 kw	440 v	60 hz
Driven by:			DIESEL
Bow Thruster (2):			BRUNVOLL
Driven by:			789 hp, CPP Tunnel
Total Thrust:		19.7 st	17.9 mt
Stern Thruster (1):			BRUNVOLL
Driven by:			789 hp, CPP Tunnel
Total Thrust:		9.8 st	8.9 mt

Performance

(Approximate values assuming Ideal Conditions)		
Fuel Consumption Vs Speed		
Maximum:		37 m^3/day (410 gph) @ 14 knots
Cruising:		29 m^3/day (320 gph) @ 12 knots
Economical:		18 m^3/day (190 gph) @ 8 knots
Standby:		1.4 m^3/day (15 gph) @ 0 knots
Range @ 12 Knots:		7,000 nm
Bollard Pull	170 st	160 mt
Transfer Rates		
Fuel Oil:	660 gpm @ 300 ft	150 m^3/h @ 92 m
Fresh Water:	660 gpm @ 300 ft	150 m^3/h @ 92 m
Drill/Ballast Water:	660 gpm @ 300 ft	150 m^3/h @ 92 m
Bulk:	28.5 cfm @ 190 ft	48.4 m^3/h @ 57 m
Liquid Mud:	660 gpm @ 470 ft	150 m^3/h @ 140 m

Tow/Anchor Handling

Winch:	FUKUSHIMA
Model:	2 DRUM HP HYD (450T BRAKE)
Line Pull:	350 mt
Tow Wire:	1,500 m of 76 mm
Work Wire:	1,500 m of 76 mm
Pennant Reels (2):	1,500 m of 76 mm
Shark Jaw:	2X KARMOY 300 MT
Tow Pins:	2X KARMOY 160 MT
Chain Lockers (2):	610 m of 76 mm chain
Chain Handler:	7 x 3in
Stern Roller:	SMITH BERGER 2.5Mx4M; 450 mt SWL

Deck. Equip.

Anchors (2):	2100 KG SPEK
Anchor Chain:	270 m of 40 mm chain per side
Crane:	2 t @ 10 m
Capstans (2):	10 t FUKUSHIMA
Tugger (2):	10 t FUKUSHIMA

Nav/Comms Equip.

Radar(s):	2
Depth Sounder:	1
Gyro Compass:	2
Doppler Log:	1
Radio:	3 x VHF; 1 x SSB
Sat Com:	1xINMARSAT-C

Accommodations

Nº of Berths:		28
1-man cabins: 2	2-man cabins: 9	4-man cabins: 2
Certified to Carry:		28
Galley seating:		14
Hospital:		Yes

Special Equip.

Firefighting:	FiFi-1
Dynamic Positioning:	DP-2 CLASSED
Ref. Systems:	2 x MRU; 2 x DGPS 1 x Laser-based
Mud Circulation System/Mud Mixers:	Yes/Yes
Tank Cleaning:	Yes
Rescue Boat:	SOLAS

Registration

Flag: Vanuatu		IMO Nº: 9476903
Year Built: 2010		Call Sign: YJVZ7
Builder:		REMONTOWA
Tonnage (ITC):	2301 GT	690 NT

Last update: 6/15/2016

Arbeitsgemeinschaft **Küstenschutz**

NORDIC

Schottel ASD Tug

MAIN DATA	
Call sign :	DIBL
Length over all :	78,00 m
Breadth over all :	16,40 m
Draft (min/max) :	6,00 m
GRT :	3300 GT
Class :	GL + 100 A5 IW TUG MC AUT (Suitable for use in hazardous atmosphere)
Bollard Pull :	201 t
Speed :	19,9 kn
Built :	2010
Capacities :	Fuel Oil: 1.050 m³
Accomodation :	32 x Berth
ENGINES	
Horsepower :	23.065 BHP (17.200 kW)
Main Engines :	2 x MTU 20V8000 M71L GSB
Propulsion :	2 x pitch propellers in Kort - Nozzles 2 x reduction boxes

EQUIPMENT	
Equipment :	Bow Thruster 2x 800 kW Stern Thruster: 800 kW Double drum towing winch 2.500 kN Tugger winch 2 x 10 t Towing pins 2 x 300 t Karm fork 300 t Shark jaw 300 t FiFi 2x 1.200 m³/h Deck crane, offshore/port 4.0 t / 6.5 t – 16 m Helicopter winching area First aid equipment Citadel, overpressure system supported by breathing air reservoir
COMMUNICATION	
Inmarsat :	Tel.: 00870 773 185 871, Fax: 00870 783 184 255
Mobile GSM :	Tel.: +49 151 426 426 86, Fax: +49 151 426 607 45
E- Mail port / sea :	nordic@bugsier.de / Nordicc1@SkyFile-C.com
IMO Nr. :	9525962
MMSI No. :	211 574 000

Bugsier Reederei- und Bergungsgesellschaft mbH & Co. KG I FAIRPLAY Schleppdampfschiffs-Reederei Richard Borchard GmbH, Hamburg

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Phone +49-40 30 70 68 - 100 · Fax +49-40 30 70 68 - 299 · info@kuestenschutz.com · www.kuestenschutz.com

Skandi Ipanema

Vessel built	2010
Vessel design	STX AH05
Class definition	✠ 1A1 Fire fighter(I) Tug DK(+) DYNPOS(AUT) E0 SF TMON
LOA	74.3 m
Breadth mld	17.0 m
Summer draught	6.0 m
Deadweight	2250 t
Accommodation	38
Gross tonnage	2771 t
Main engines	2 x 4500 kW
Bow thruster	1 x 880 kW
Azimuth thruster	1 x 905 kW
Stern thruster	1 x 880 kW
Deck dimensions	654 m²
Deck strength	7.5 t/m²-10 t/m²
Deck capacity	1000 t
Fuel oil	850 m³
Pot water	741 m³
Dry bulk	216 m³
Brine	549 m³
Base oil	266 m³
Drill water	660 m³
Bollard pull	174 t
AH drum	310 t
Towing drum	310 t
Chain locker	2 x 139 m³
Shark jaws	2 x Karmoy
Towing pins	4 x Karmoy, 350 mm / 270 t SWL
Deck crane	1 x SWL 5 t 1 x SWL 1.5 t

Skandi Rio

Vessel built	2007
Vessel design	UT 722 L
Class definition	✠ 1A1 Tug Supply Vessel Fire Fighter I and II OILREC SF COMF-V(3) E0 DYNPOS-AUTR CLEAN TMON
LOA	80.5 m
Breadth mld	18.0 m
Summer draught	6.6 m
Deadweight	2660 t
Accommodation	40
Gross tonnage	3519
Main engines	2 x 3535 kW 2 x 2650 kW
Bow thruster	1 x 883 kW
Azimuth thruster	1 x 1120 kW
Stern thruster	2 x 736 kW
Deck dimensions	590 m²
Deck strength	5 t/m² - 10 t/m²
Deck capacity	800 t
Fuel oil	1124 m³
Pot water	647 m³
Base oil	193 m³
Mud	445 m³
Dry bulk	334 m³
Brine	872 m³
Drill water	1330 m³
Bollard pull	206 t
AH drum	500 t
Towing drum	400 t
Chain locker	570 m³
Shark jaws	2 x 700 t
Towing pins	4 x 300 t
Deck crane	SWL 10 t SWL 2 t SWL 3 t

Skandi Saigon

Vessel built	2011
Vessel design	STX AH08
Class definition	✠ 1A1 Fire fighter(I+, II) Tug Clean(Design) DK(+) DYNPOS(AUTR) E0 HL(2.8) NAUT(OSV(A)) OILREC SF TMON
LOA	75.0 m
Breadth mld	17.4 m
Summer draught	7.0 m
Deadweight	3170 t
Accommodation	27
Gross tonnage	3181 t
Main engines	2 x 6000 kW
Bow thruster	2 x 880 kW
Stern thruster	2 x 880 kW
Deck dimensions	525 m²
Deck strength	10 t/m²
Deck capacity	1000 t
Fuel oil	1685 m³
Pot water	641 m³
Dry bulk	264 m³
Brine	430 m³
Drill water	1950 m³
Bollard pull	196 t
AH drum	350 t
Towing drum	350 t
Chain locker	2 x 150 m³
Shark jaws	2 x 600 t
Towing pins	4 x 300 t
Deck crane	SWL 5 t SWL 3 t

Vessel Characteristics

Length, Overall:	167.3 ft	51 m
Beam:	49.2 ft	15 m
Depth:	21.3 ft	6.5 m
Maximum Draft:	23 ft	7 m
Minimum Height:	74.5 ft	22.7 m
Freeboard:	2.6 ft	0.8 m
Displacement:	2,650 lt	2,690 mt
Deadweight:	1,220 lt	1,240 mt
Clear Deck Space:	65 x 38 ft	20 x 12 m
Clear Deck Area:	2,510 ft^2	230 m^2
Deck Strength:	1,020 lb/ft^2	5 t/m^2

Class Notations:
ABS: +A1, (E), +AMS, TOWING VESSEL, OSV,FiFi-1, AH

TIDEWATER®
VRANA TIDE

100 t Bollard Pull
Azimuthing Stern Drive Tug

Last update: 5/7/2018

TIDEWATER® VRANA TIDE

Capacities

Deck Cargo:	197 lt	200 t
Fuel Oil:	206,000 gal	780 m³
Potable Water:	42,800 gal	160 m³
Drill/Ballast Water:	84,400 gal	320 m³
Oil Dispersant:	2,110 gal	8 m³
Fire Fighting Foam:	2,110 gal	8 m³

Machinery

Main Engines (2):			GE 16V228/7FDM16
Total HP:			7,820
Propellers (2):			CCP-Z Drive
Z-Drives:			Yes
Kort Nozzles:			2
Primary Generators (3):	420 kw	440 v	60 hz
Driven by:			CAT C18
Emergency Generators (1):	72 kw	440 v	60 hz
Driven by:			CAT C4.4
Bow Thruster (1):			Tunnel
Driven by:			Electric Motor (325kW)
Total Thrust:		6.2 st	5.6 mt

Performance

(Approximate values assuming Ideal Conditions)

Fuel Consumption Vs Speed		
Maximum:		16.9 m^3/day (190 gph) @ 14 knots
Cruising:		13.6 m^3/day (150 gph) @ 11 knots
Economical:		8 m^3/day (88.1 gph) @ 8 knots
Range @ 12 Knots:		9,000 nm
Bollard Pull	140 st	120 mt
Transfer Rates		
Fuel Oil:	440 gpm @ 170 ft	99.9 m^3/h @ 51 m
Drill/Ballast Water:	310 gpm @ 160 ft	70 m^3/h @ 50 m

Deck. Equip.

Anchors (2):	3174 lbs.
Anchor Chain:	270 m of 38.1 mm chain per side
Crane:	1.8 t @ 14 m
Capstans (2):	5 t Electric-Hydraulic
Tugger (2):	10 t MacGregor HUW10DL (15m/min)

Tow/Anchor Handling

Winch:	MacGregor Double Drum Waterfall
Model:	AHTW/WF-150/250 (250T Brake)
Line Pull:	150 mt
Tow Wire:	3,280 m of 2.5 mm
Work Wire:	3,280 m of 2.5 mm
Shark Jaw:	(2 sets) 300t SWL
Tow Pins:	(2) 160t SWL
Stern Roller:	16.27 ft. x 6.5 ft.; 350 mt SWL
Additional Towing Equipment:	Bow Winch - Brake: 250t; Linepull: 75t; 350m of 64mm

Nav/Comms Equip.

Radar(s):	2
Depth Sounder:	1
Gyro Compass:	2
Doppler Log:	1
Radio:	2 x VHF; 1 x SSB
Sat Com:	Inmarsat C

Accommodations

Nº of Berths:	20
1-man cabins:	2
2-man cabins:	3
4-man cabins:	3
Certified to Carry:	20
Galley seating:	20
Hospital:	Yes

Special Equip.

Firefighting:	FiFi-1
Oil Dispersant Equipment:	2 x 5m Booms
Recovered Oil Capacity:	125 m³
Rescue Zone:	Yes
Fast Rescue Craft:	JYB55KR 6-Man FRC
Rescue Boat:	6-Man SOLAS Approved MOB

Registration

Flag:		VANUATU
IMO Nº:		9556351
Year Built:		2009
Builder:		YUEXIN SHIPBUILDING
Call Sign:		YJVN3
Tonnage (ITC):	1370 GT	411 NT

Last update: 5/7/2018

Appendix E Robert Allan RASalvor 6000 Datasheets

RASalvor Class

Salvage/Ocean Rescue Tugs

The ***RAsalvor*** Class tugs are a new design development from Robert Allan Ltd., created to address the growing worldwide demand for large and powerful rescue/salvage tugs. The ***RAsalvor*** Class tugs are designed to provide long range towing, anchor-handling, rescue and salvage capabilities, and fire-fighting capacity. Additional functions such as dive support, DP operations, and standby functions can also be accommodated.

The hull form for this class has been extensively model tested and refined through CFD analysis, resulting in a truly optimized hull to deliver high speed and excellent sea-keeping capability as befits the role of these tugs. Designs are currently under development for tugs for 120-220 tonnes BP, and range from 55-75 metres in length. The first of Class design is for a 60 metre, 160 tonne BP tug.

Particulars

Length Overall	-	60.0 m
Beam, moulded	-	15.0 m
Depth, Moulded	-	7.8 m
Operating Draft	-	7.6 m (with skeg)
Power	-	10000 kW
BP, ahead	-	160 tonnes
BP, astern	-	150 tonnes
DWT	-	1000 tonnes
Range	-	5000 n.miles @ 15 knots

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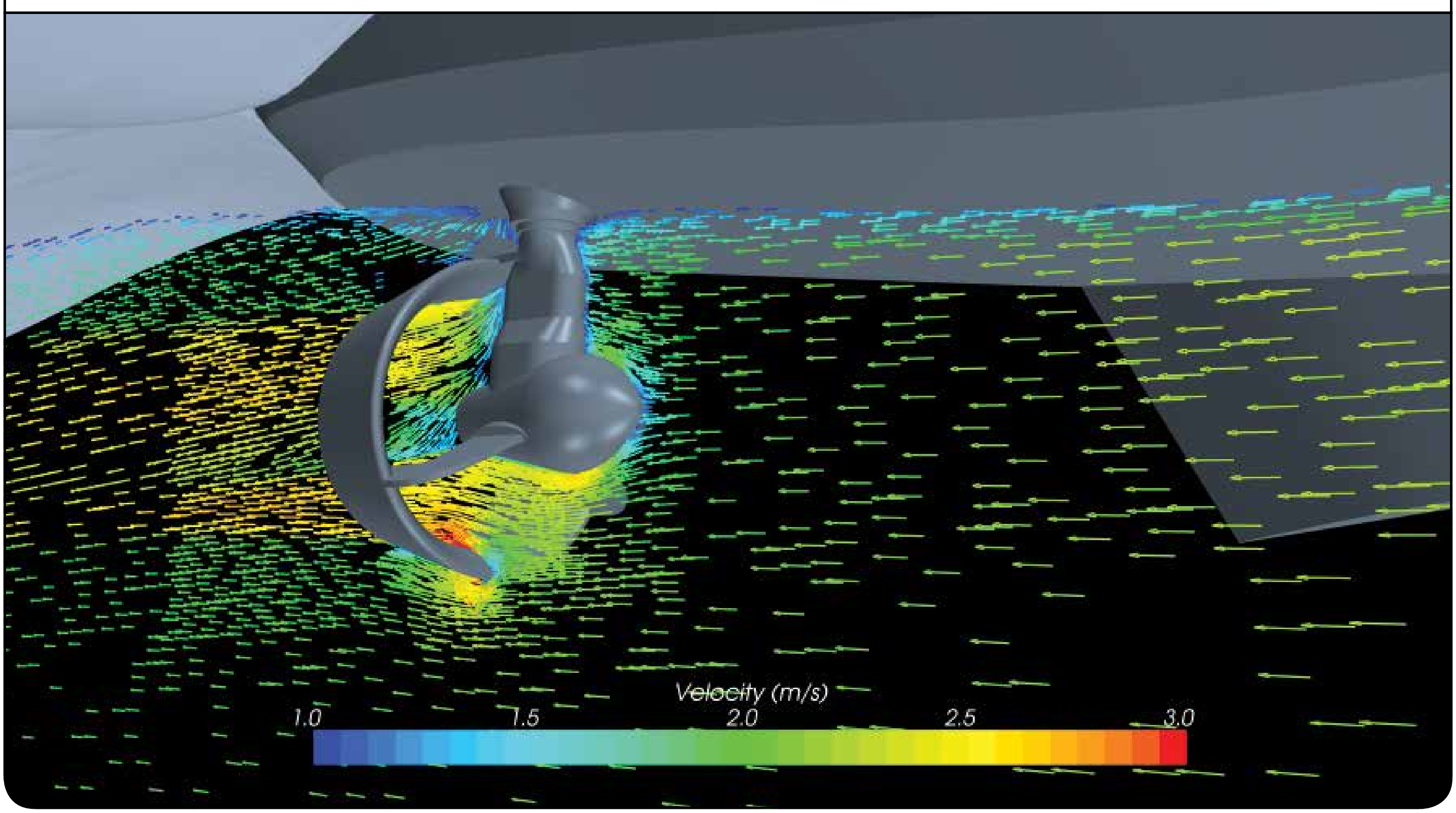
RESCUE


Velocity (m/s)
1.0
1.5
2.0
2.5
3.0

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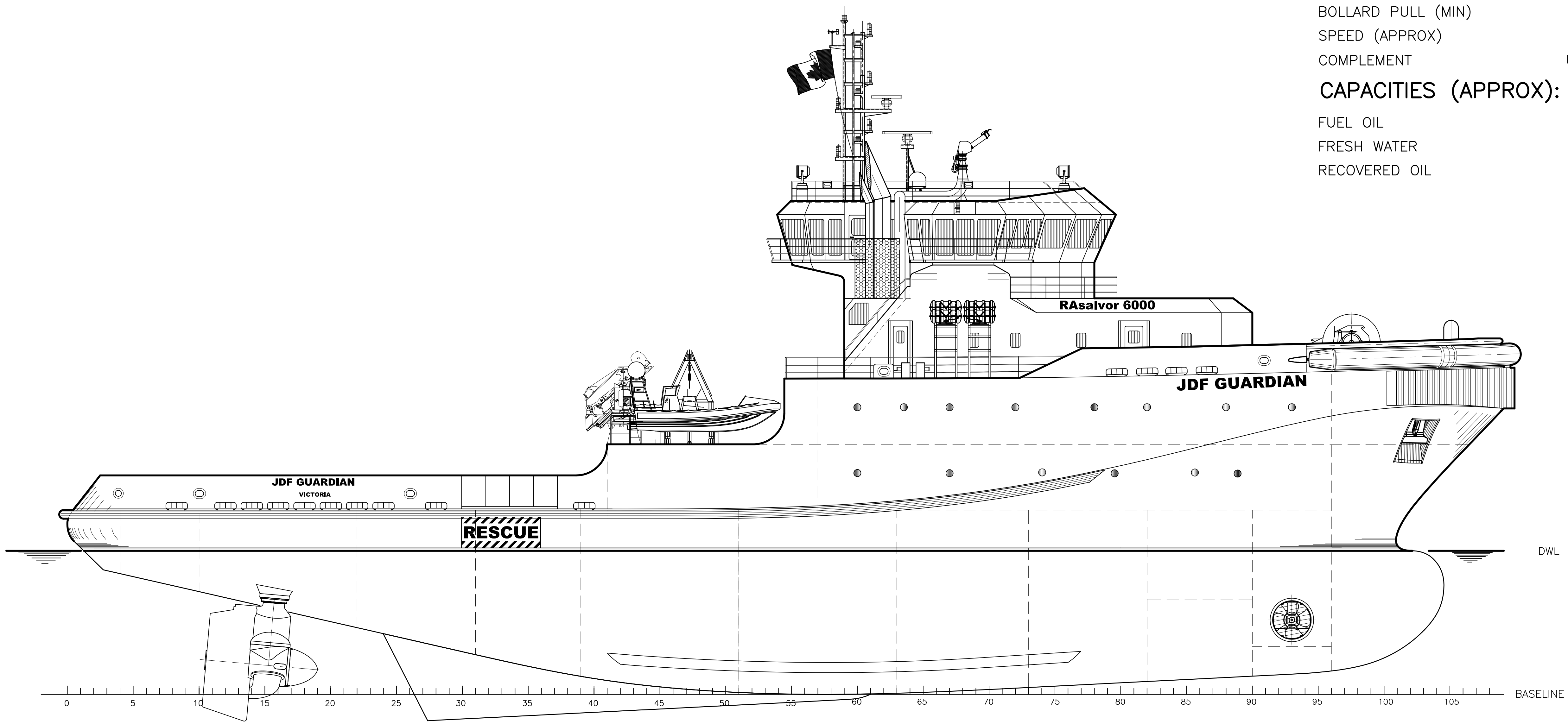
RAsalvor 6000 OFFSHORE SALVAGE TUG

GENERAL PARTICULARS:

LENGTH OVERALL	60.0 m
BEAM, MOULDED	15.0 m
DEPTH, LEAST MOULDED	7.7 m
DRAFT, LIGHT OPERATING	6.7 m
DRAFT, MAXIMUM	7.2 m
BOLLARD PULL (MIN)	110 TONNES
SPEED (APPROX)	15 KNOTS
COMPLEMENT	UP TO 22 PERSONS

CAPACITIES (APPROX):

FUEL OIL	510 m^3
FRESH WATER	40 m^3
RECOVERED OIL	490 m^3



PROFILE

0 2 4 6 8 10
SCALE – METRES

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TITLE GENERAL ARRANGEMENT			
DRAWN BY LB	CHECKED ----	DATE MAY 19/20	SHEET 1 OF 4
ENQUIRY No. 19–317	REF. No. 18–104	DRAWING No. 30000	REV. ----

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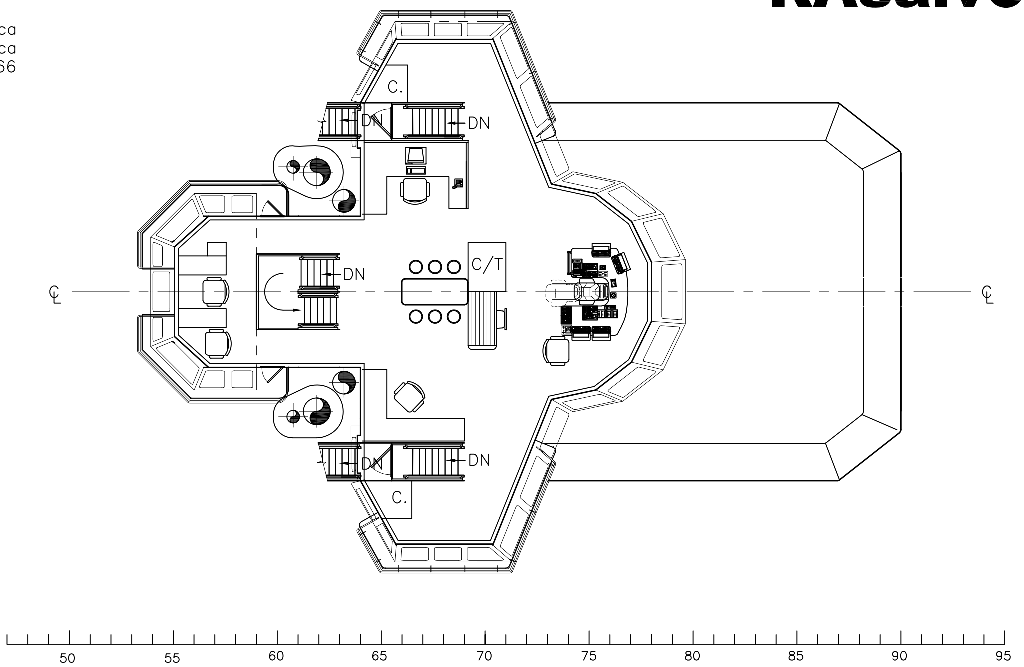
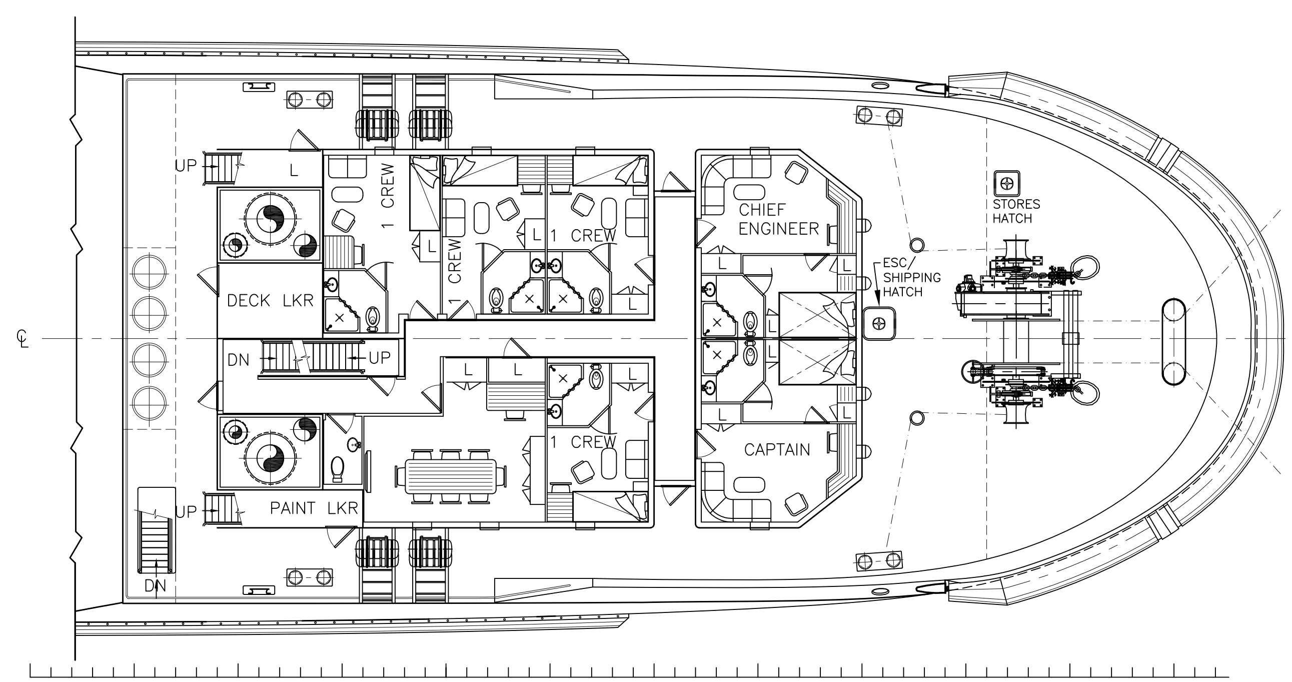
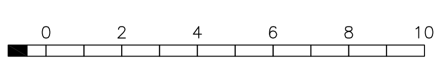


WHEELHOUSE DECK



FORECASTLE DECK



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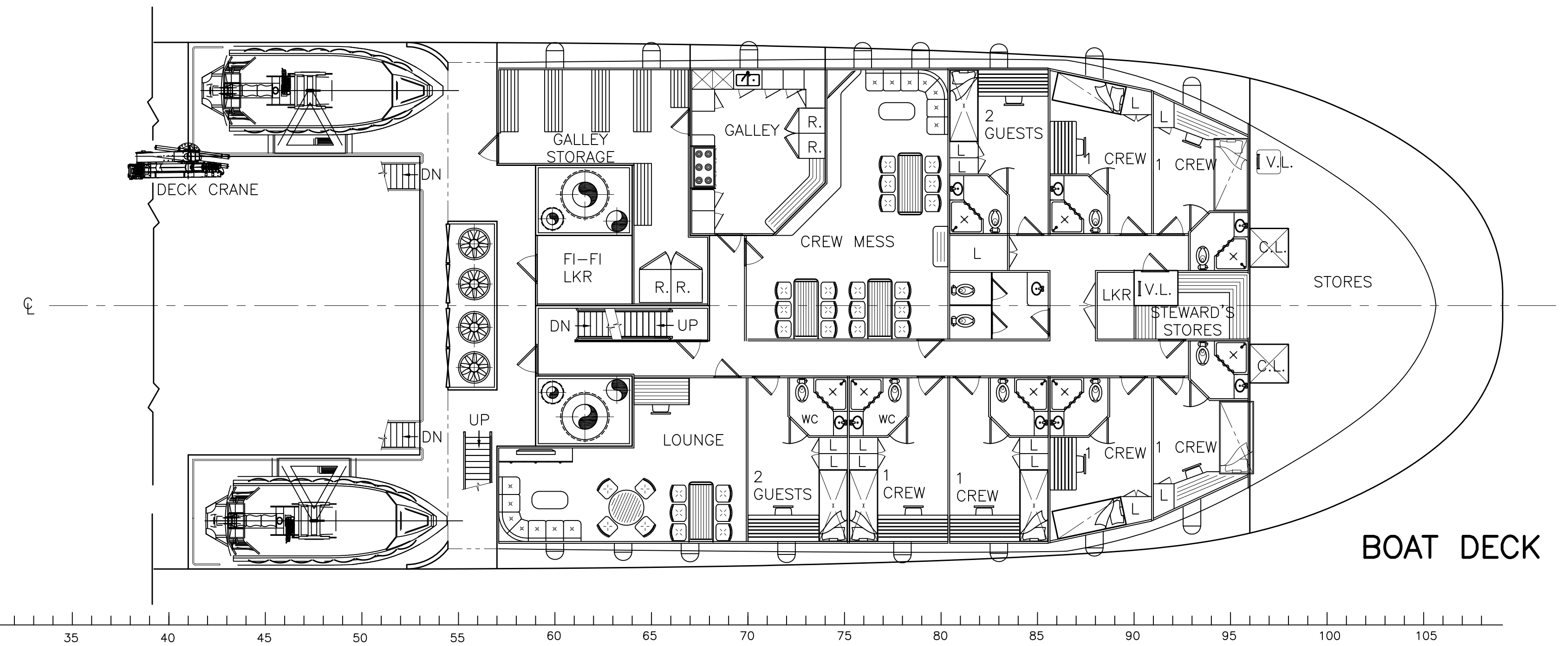

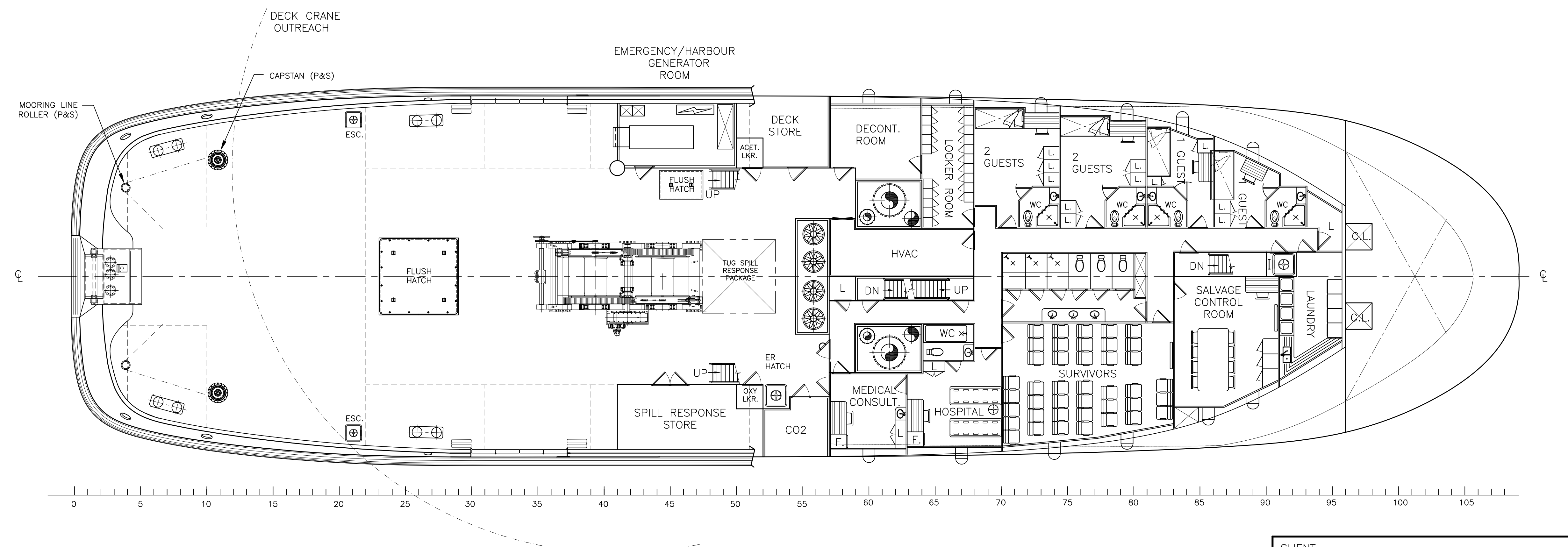

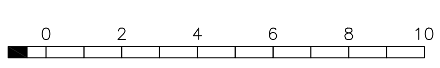

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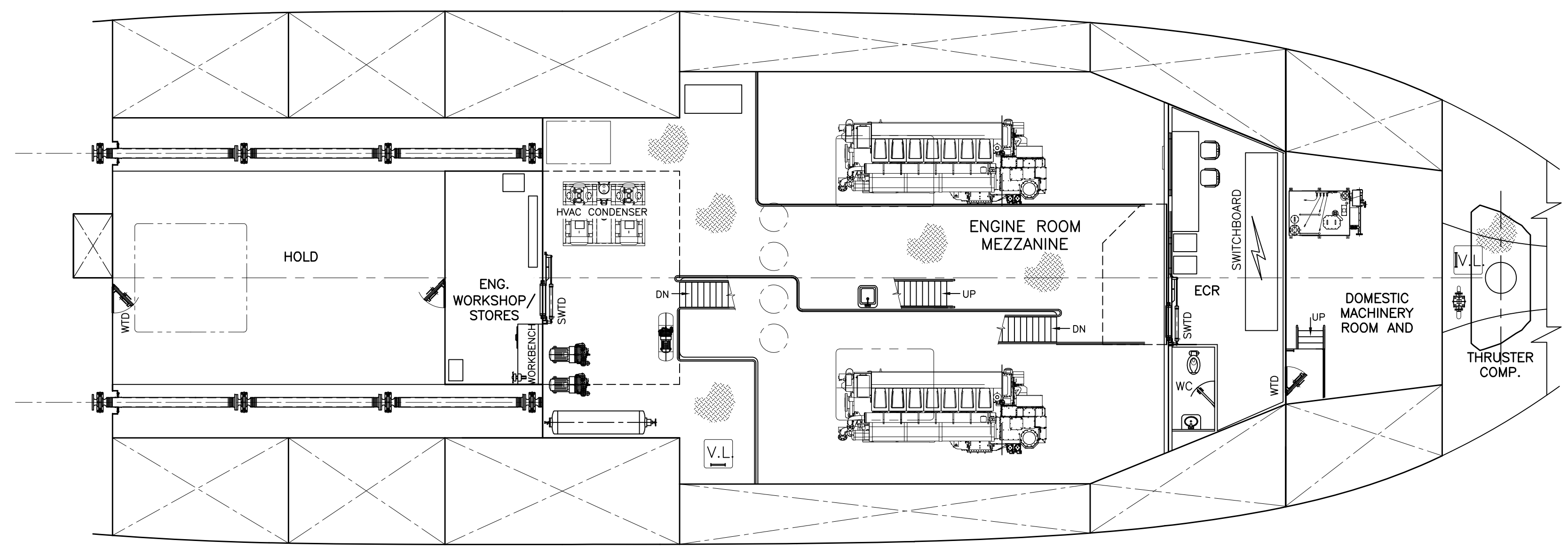

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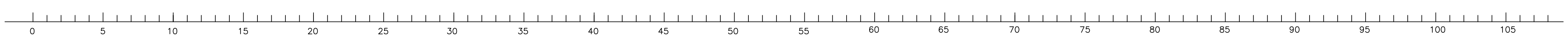
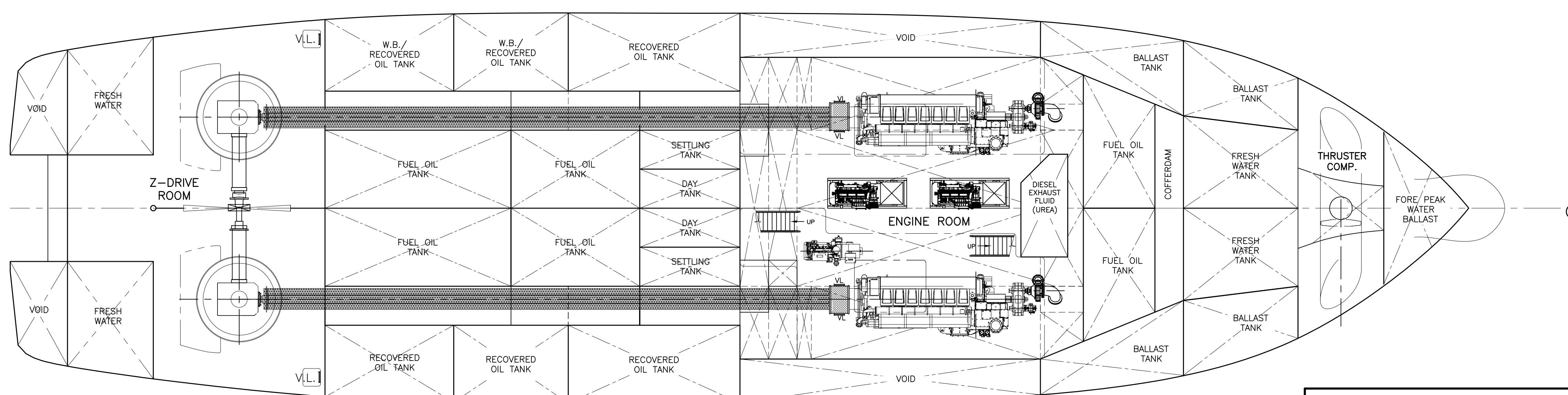
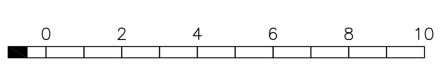




HOLD PLAN



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