The Evolution of the Z-Tech Concept

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SYNOPSIS

This paper traces the brief history of the Z-Tech series of omni-directional tug designs, from the original concept as a dedicated harbour ship-handling tug to its present status as a major contender for use at LNG and other offshore terminal operations. The various stages of design development and refinement which have occurred since the first Z-Tech entered service in 2004 are discussed and illustrated, as are some recent model tests undertaken to enhance and verify overall performance. Concepts for applying the Z-Tech design principles to larger tugs for more severe offshore operations are presented.

1. ORIGIN OF THE SPECIES

The origins of the Z-Tech tug design are amply described in the paper presented to *ITS 2004* by Lee[1]. Less than four years later, there are now 21 Z-Techs in active service, with another 19 under construction or the final stages of design, giving a total of 40 of these tugs now complete or committed at the end of 2007. There are also numerous serious active proposals for further applications around the world. By any measure, but especially in this traditionally conservative sector of the marine industry, this is quite a remarkable success story for what is certainly an unusual tug design.

Briefly recapping, Robert Allan Ltd was retained by PSA Marine in 2002 to evaluate its existing fleet of tugs, and to propose a new design that would suitably address the future needs of the Port of Singapore. A detailed study followed, with a first-hand examination of the tug operations in Singapore.

A clear understanding emerged from that investigation that some crews had a distinct preference for the Z-drive tractor style of tugs, (drives forward), while others favoured the ASD type, with drives aft. Certainly each had specific operational advantages in different aspects of the ship-handling tasks undertaken there. Our suggestion was to develop a single, unique design that would economically incorporate the best features of both types. After some brain-storming about what such a vessel would look like, the Z-Tech concept was born. By reversing the sheer line of a typical Robert Allan Ltd-style ASD design, and shifting the deckhouse relatively far aft (towards the drive units), this new design concept was defined.

2. CONCEPT FUNDAMENTALS

The first Z-Tech concept design was as illustrated in *Figure 1*. With some minor refinements this became the starting point for the entire design series.

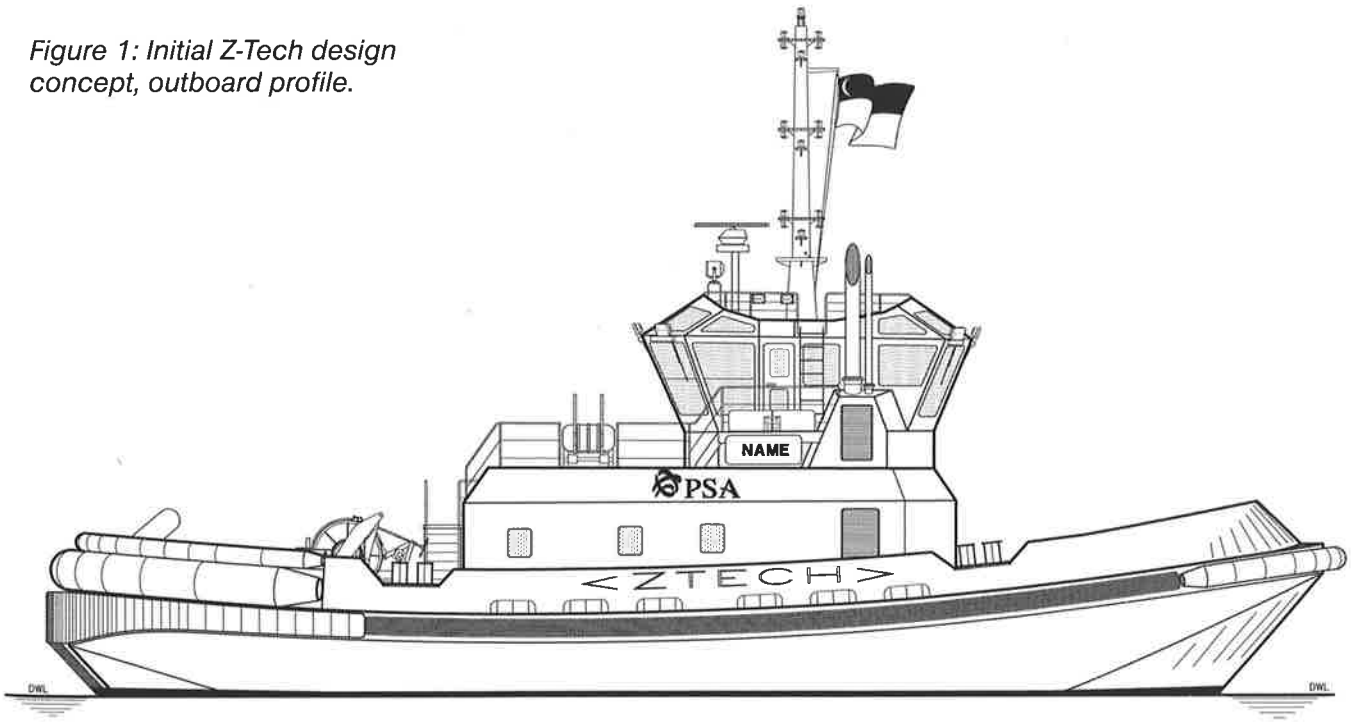


Figure 1: Initial Z-Tech design concept, outboard profile.

At once the following advantages of this unique configuration became apparent:

- The forward deck has a low flat sheer, creating a spacious, relatively flat and safe working deck in comparison to a typical ASD layout, without any obstructive anchor chains etc. The entire working deck is immediately in front of and directly visible from the wheelhouse.

- The deckhouse and wheelhouse are biased aft in the arrangement, which, coupled with the low sheer forward, enable a Z-Tech to work safely under large overhanging ship flares.

- The aft deck, a largely redundant area, is reduced in size to provide just sufficient space to install or withdraw the Z-drive units. A small anchor winch can be fitted on this deck, clear of the critical working deck areas. For most harbour operations a large anchor (or anchors) and windlass is completely unnecessary, and therefore a 'fishboat'-style anchor and winch combination is more than adequate.

- For 'sea-going' operations, the Z-Tech is meant to run astern in tractor mode, so the shape of this part of the hull is much more rounded in plan than would typically be seen in other ASD designs. The sheer aft is raised to provide a decent height when in a seaway.

- Only one winch is required for both harbour and short haul or near-coastal towing operations. When towing, the Z-Tech simply tows in tractor mode going 'astern'. This represents a very significant reduction in capital costs (one winch vs two).

In every other respect a Z-Tech is essentially no different from any other well-designed ASD tug, at least in terms of its machinery components and basic outfit.

3. Z-TECH 6000 CLASS

The first requirement of PSA Marine for the new tug type was for a relatively compact vessel with minimum 60 tonnes BP. After some initial model designations by length and bollard pull (eg Z-Tech 28/60), the baseline design for the first tug designed to fulfill this objective was eventually designated as the Z-Tech 6000 Class, signifying a nominal 60 tonnes BP. Its development has gone through a number of iterations, as described below.

3.1 Mk I design

The final design configuration for construction of the first Z-Tech 6000 is illustrated in *Figures 2a, b* and *c* (below, and next page). The deckhouse is biased aft, as is the wheelhouse, and both are also set well inboard from the tug sides. The single control station within the wheelhouse is positioned to provide the best possible sight lines in both directions, but obviously with priority given to the sight lines over the working deck forward, and to the primary fender contact points of the tug.

The tug featured a large skeg in order to achieve a high capability of indirect towing and braking. Although actual tanker escort operations were not a key part of the initial design mandate for the Z-Tech, the need to control large container ships and similar high windage ships in close quarters would clearly benefit from a good indirect towing capability.

Before it was completed, the first Z-Tech was sold to BHP Billiton Iron Ore, and is now operated by the towage division

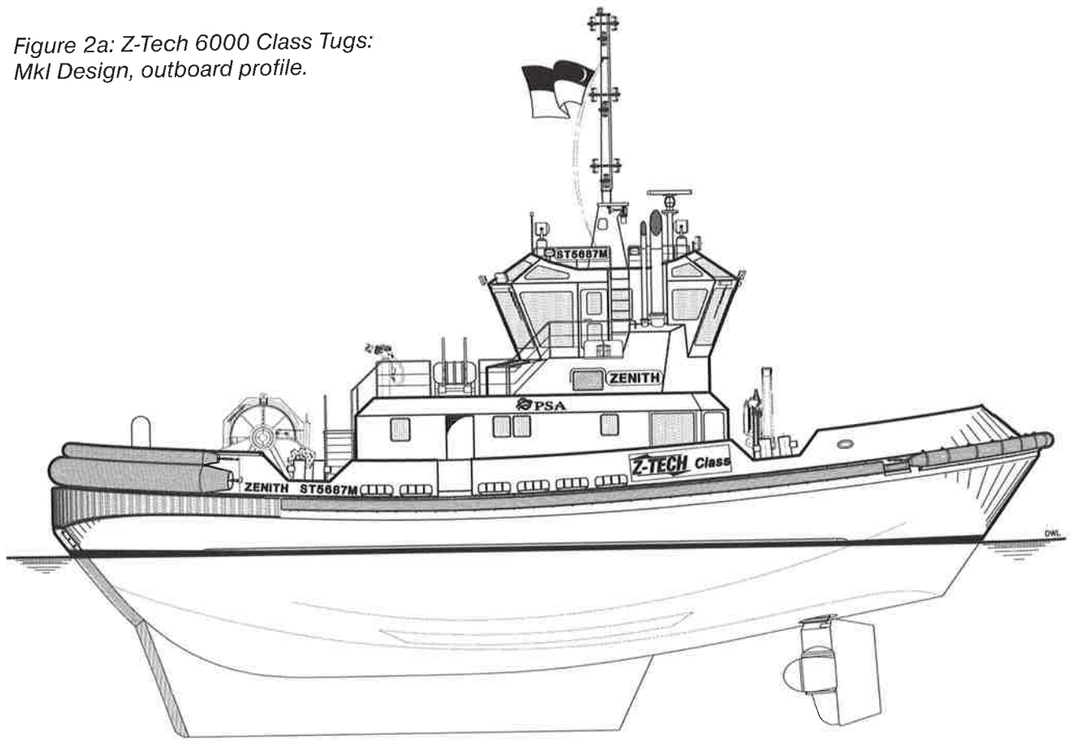
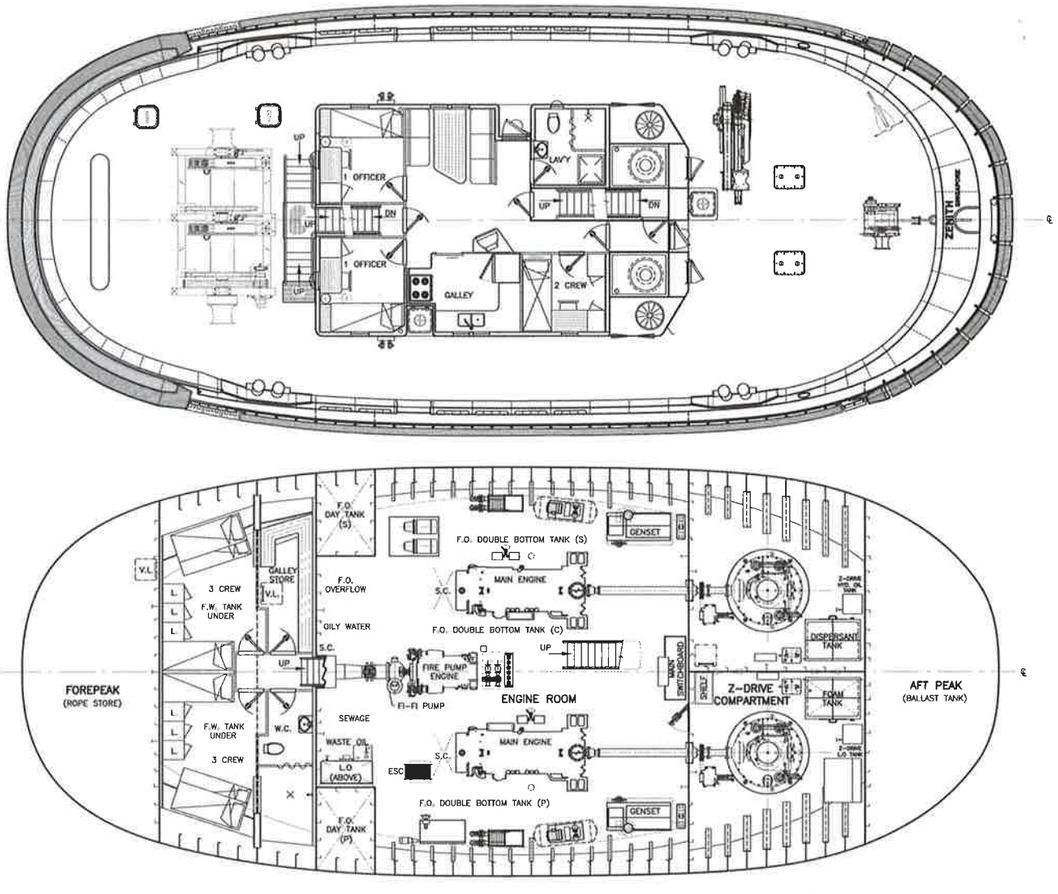


Figure 2a: Z-Tech 6000 Class Tugs: MkI Design, outboard profile.



Figures 2b & c: Z-Tech 6000 Class Tugs: MkI Design – top, main deck; bottom, hold.

of Teekay Shipping Ltd, for operation at Port Hedland in NW Australia. Christened ***Indee***, (*Figure 3*), the tug was delivered in April, 2004. There is however, something in the nature of Australian tug crews that causes them to embrace change and fresh ideas rather reluctantly, and the initial responses from the crew were not unanimously positive. However the owners provided the services of a highly skilled training master, Capt Ken Schmidt of Vancouver, who was soon able to demonstrate the capabilities of the Z-Tech hull form, and teach the crews how to get the most performance out of the new tug. A further

Figure 3: First of Class Z-Tech 6000: **Indee**. *Photograph: Al Lindner.*

five tugs of this type (Mk I, II & III) have since been delivered to the same owner, with another scheduled for delivery later this year, and a further one was delivered to Adsteam in early 2007. So it is fair to say that the Z-Tech design is now fully accepted in that difficult proving ground.

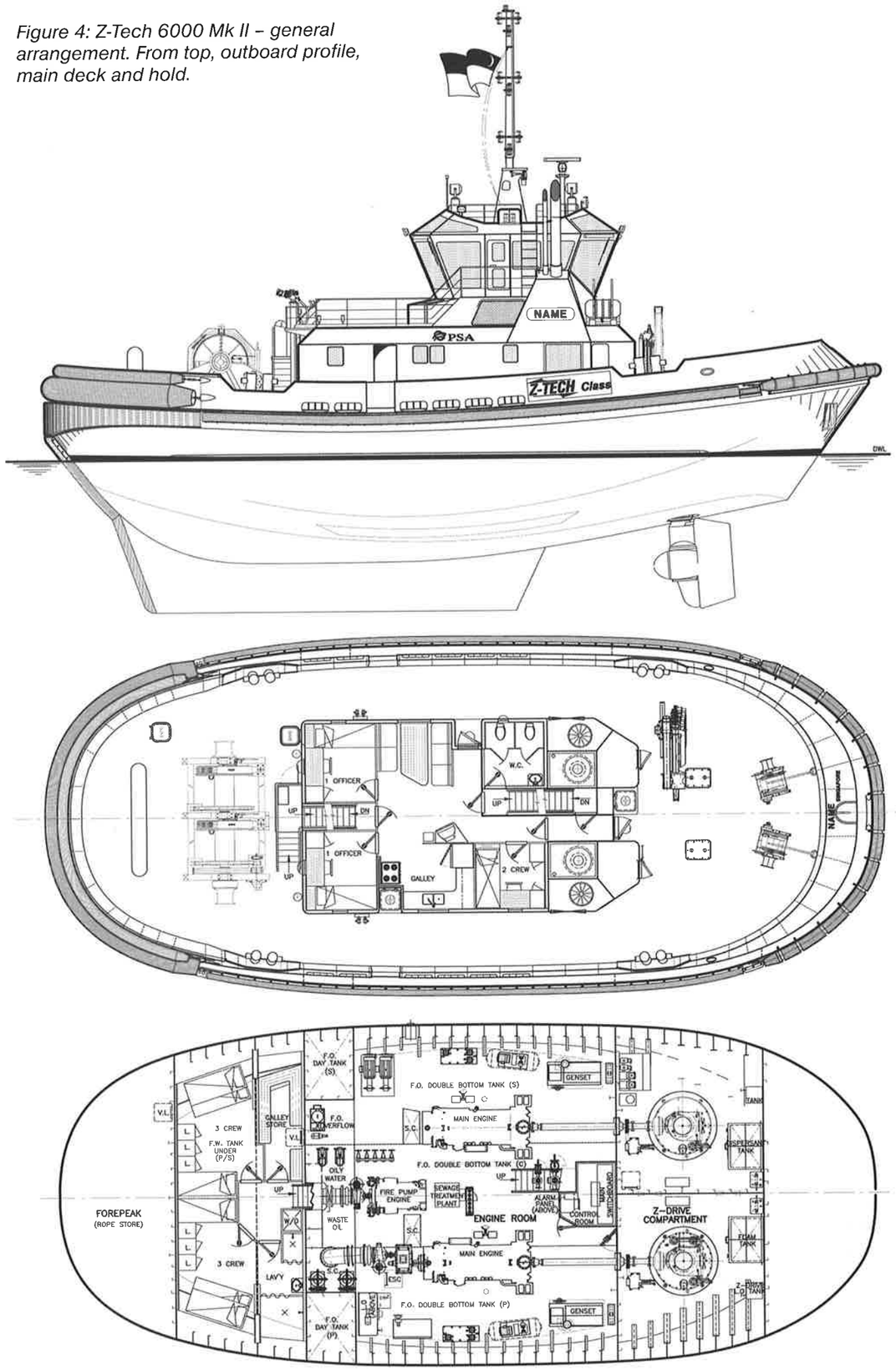
Capt Schmitt also provided the Robert Allan Ltd design team with very valuable feedback concerning the overall layout and handling of the tug, and that led to a series of relatively minor design refinements which were incorporated into the fourth and subsequent tugs of the series.

3.2 Mk II design

The primary critical feedback received regarding the first vessels of the series was that the visibility aft was not as good as desirable, and therefore the geometry of the wheelhouse was re-worked to provide much better sightlines from the control position to the aft deck and aft bulwarks. Other relatively minor changes were made to improve visibility from the wheelhouse, including relocating liferafts and sidelights that had proved to be minor visual irritants.

With the fourth vessel of the series finally destined to operate in Singapore, the owners, PSA Marine, felt that the handling of the tugs with the large skeg was going to prove difficult for their crews. An alternative skeg with reduced area was therefore designed and introduced on ***Stirling***, the first Z-Tech to operate in Singapore. The feedback from PSA Marine

Figure 4: Z-Tech 6000 Mk II – general arrangement. From top, outboard profile, main deck and hold.



crews was very positive regarding the change in handling characteristics that resulted from this change. Of course the indirect force generation capability was reduced slightly, but this was not felt to be detrimental to the PSA operations. This new skeg geometry is now offered as an option, depending on the required role of the tug. *Figure 4* (previous page) illustrates the initial Mk II design. *Figure 5* (below) illustrates the change in skeg geometry between Mk I and Mk II.

Figure 5: Comparison of Mk I and Mk II skeg designs.

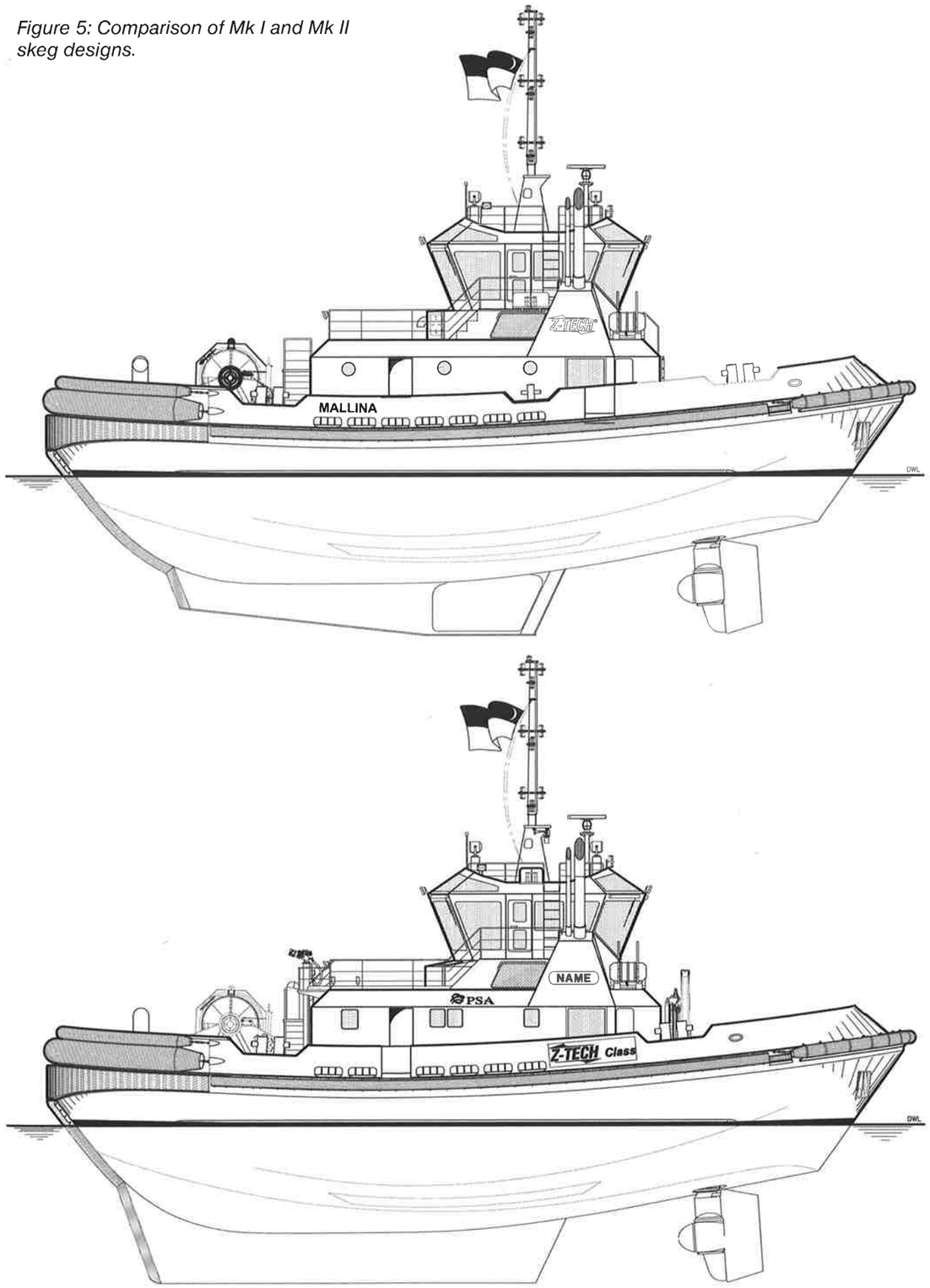


Figure 6 illustrates several of the Z-Tech tugs of the Mk II variety built to date. All were essentially identical, although some incorporated a full FiFi 1 capability, rather than the standard 1/2 FiFi 1 capacity. These tugs have all been delivered on their own bottoms to Australia, the Middle East and to Singapore, including several extended delivery voyages across the Indian Ocean in which severe sea states were encountered. In every case the tug received praise from the delivery master for its performance in heavy weather.

All of these tugs have been very ably built by Cheoy Lee Shipyards in their Hin Lee shipyard in southern China, with a quality generally expected only of better European shipyards.

Figure 6: Z-Tech 6000 Mk II Class tugs.

4. Z-TECHS FOR THE PANAMA CANAL

Very early in the development of the Z-Tech design it became obvious to the designers that this style of tug would be ideal for the type of ship-handling operations performed in the Panama Canal. The primary mode of towage in the canal, outside the locks, involves connecting the tug right against the transom of an attended ship with a bridle connection to each corner of the ship, in the so-called 'cut-style' as described in *Keeping You Safe Between the Seas – The Panama Canal Tug Operations*[2], and as illustrated in *Figure 7*. The tug hull therefore acts as an extended rudder for the ship which has to transit at low speed, and which therefore has limited self-steerage.

Figure 7: Typical tug-ship bridle connection configuration used in Panama Canal. Photo courtesy of Capt Max Newman, Panama Canal Authority.

4.1 Owner's operational requirements

In early 2004, the Panama Canal Authority (ACP) issued a Request for Proposal for delivery of new tugs for operation within the Panama Canal system. The Statement of Requirements (SOR) for these tugs included the following fundamental design criteria:

- Minimum Bollard Pull ahead = 60 tonnes
- Double winches forward
- Maximum 1,000 rev/min main engines
- Tug must fit within a 35 degree overhanging flare angle

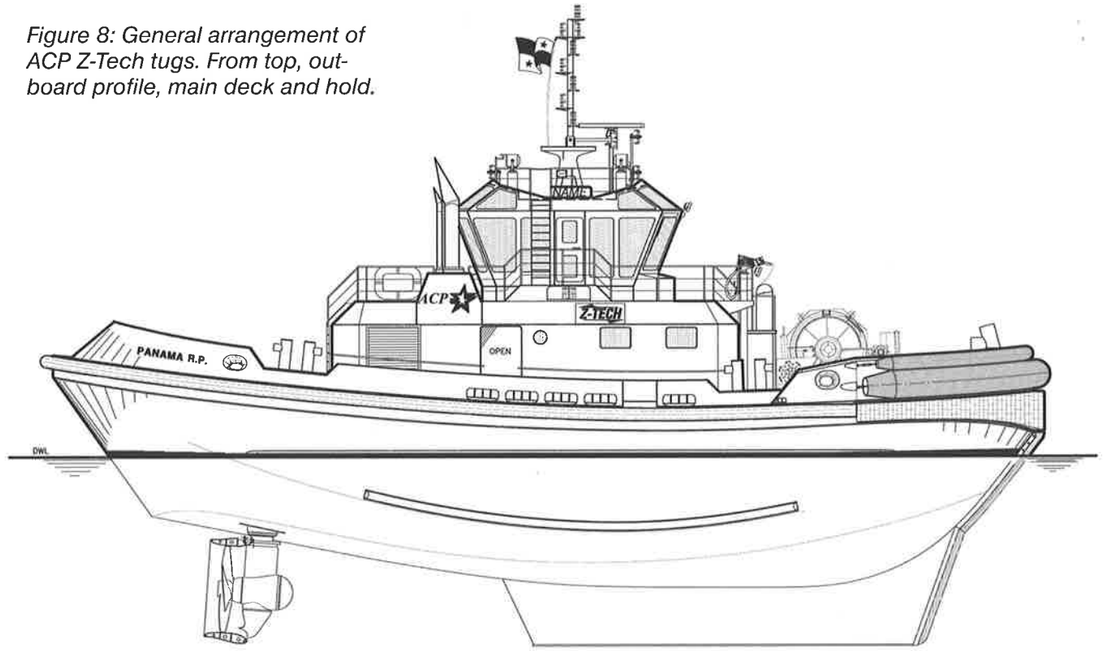
Cheoy Lee Shipyards Ltd, supported by PSA Marine and Robert Allan Ltd, bid the Z-Tech design for this contract and were ultimately successful in obtaining a contract for seven tugs. This contract was later expanded to a total of eight tugs of this Class, all of which will be delivered by the end of 2008.

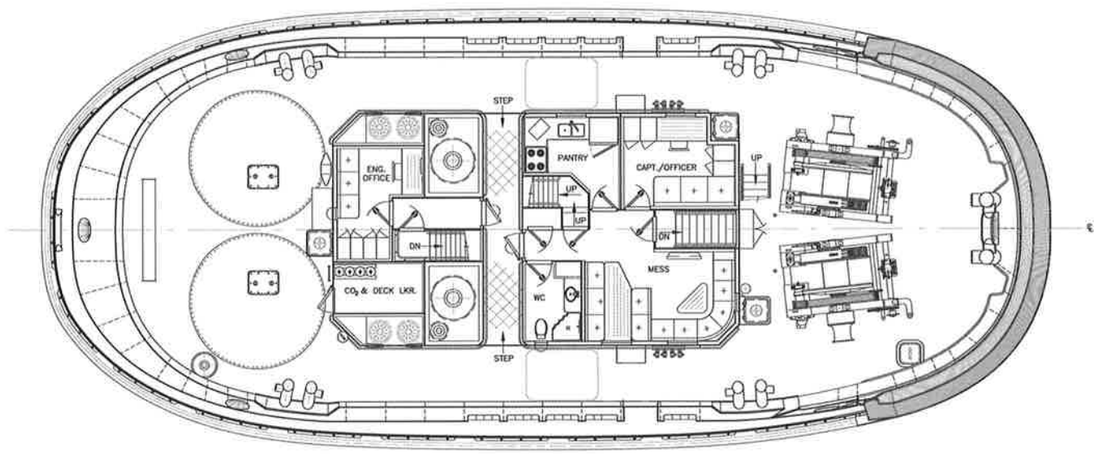
4.2 Design modifications

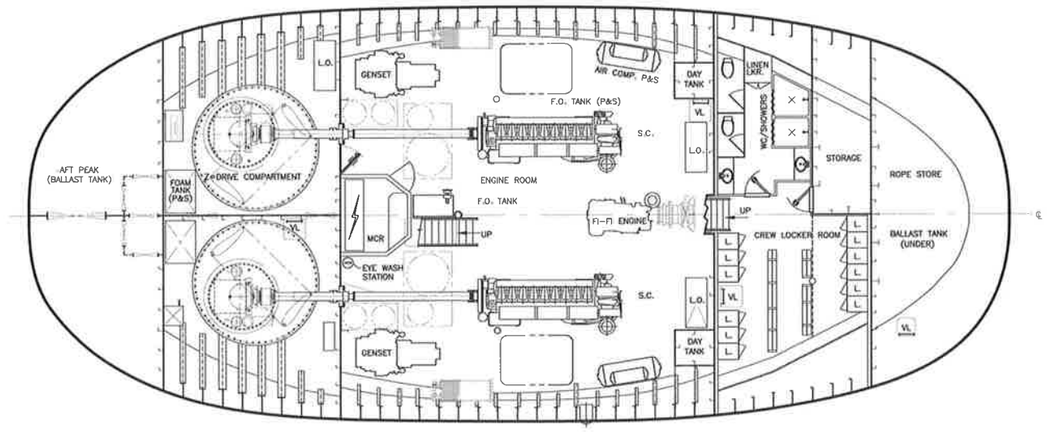
The basic Z-Tech 6000 design was an almost perfect match to these requirements; however some adjustments were necessary to fully satisfy the ACP Statement of Requirements. These changes included:

- A slight increase in beam and a reduction of the overall superstructure height to meet the 35 degree flare angle criteria. The result is a somewhat 'squat'-looking tug, but all sightlines were preserved or even enhanced with this change. As part of the design process, the complete design was modelled in 3D, and proved the

Figure 8: General arrangement of ACP Z-Tech tugs. From top, outboard profile, main deck and hold.







capability to sight the fender contact line along the majority of the length of the hull.

- A major design impact involved replacing the high-speed engines used in the original design with medium-speed main engines. The ACP tugs were constructed using Wartsila Model 9L-20 diesels, rated 1,800 kW at 1,000 rev/min, each driving a LIPS LCT FS250-2/BN-K model Z-drive unit. This change necessitated a complete re-work of the engine room layout and systems designs for the tug.

- ACP required two totally independent winches, and a centrally focussed towing staple. Accordingly the two winches are toed inwards towards the bow staple.

4.3 Layout

Figure 8 (see previous page) illustrates the general arrangement for the ACP Z-Tech tugs. In comparison to the previous 6000 series tugs, the accommodation spaces are configured much more as a 'day-boat' with crews working shifts and not living on board. This provided the opportunity to revamp the deckhouse design in order to give better noise isolation between the engine casing and the accommodation spaces, which was achieved by the creation of a complete open breezeway behind the accommodation block.

Figure 9 shows ***Bocas del Toro***, the first tug of its class delivered to ACP, and several of the more recently delivered sister vessels.

Figure 9: Z-Tech 6000 Class tugs in service with the Panama Canal Authority.

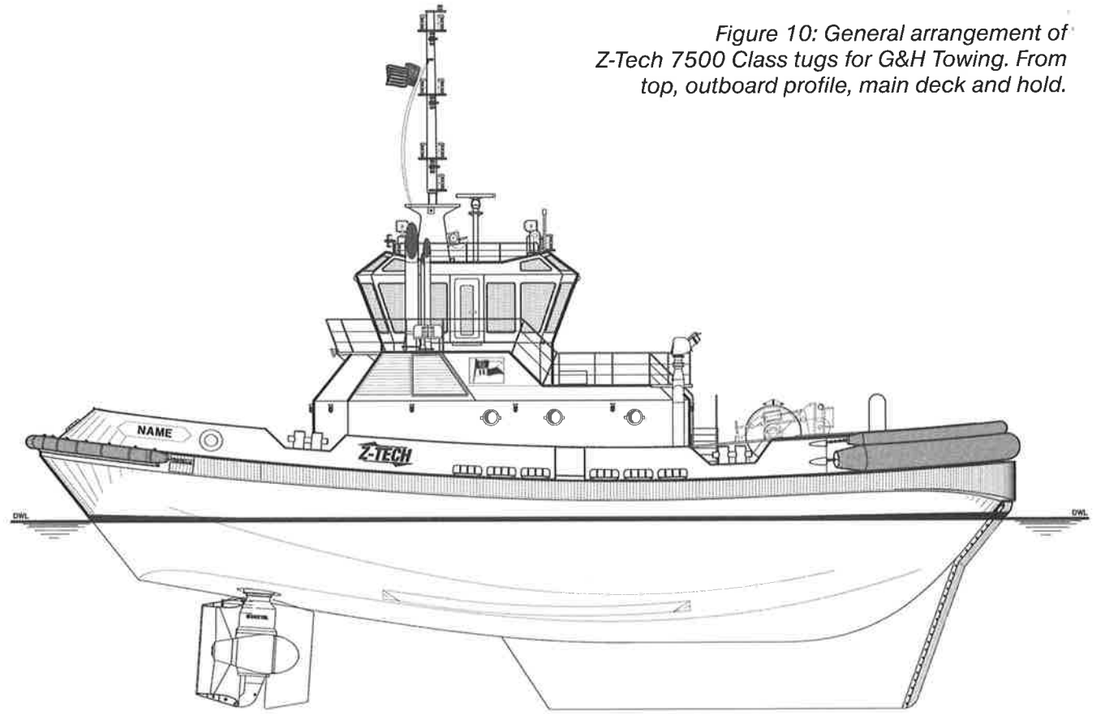
4.4 Delivery Challenges

A major challenge for the builder in fulfilling the contract with ACP was how to deliver these new tugs from China to Panama, a distance of at least 16,000km or 8,640 nautical miles. To deliver them 'dry' on a heavy lift ship would have meant stock-piling at least six tugs to make such a voyage economic, but that would entail a delay of at least a year for the first tug. In the end, the builders contracted with Redwijs (now Redwise) to deliver each tug on its own bottom across the Pacific, a voyage certainly never contemplated for a 27m tug with a hull form and layout optimised for harbour towage duty. However, laden with an extra 10,000 litres of fuel in containers on deck, the tugs have made the crossing from Hong Kong to Panama typically taking 60 days, with a 2-3 day respite in Hawaii. The four voyages to date have involved encounters with several quite severe storms, but the tugs have experienced no difficulties. The delivery crews, in spite of a lack of 'full' accommodation for such a voyage, were full of praise for the manner in which the tugs handled en route.

5. Z-TECH 7500 SERIES

In 2004, Robert Allan Ltd was contracted by the associated companies Bay-Houston Towing, G&H Towing and Suderman & Young Towing of Galveston, Texas, to design a 75-tonne BP tug. This was the beginning of a new, larger and more powerful design, designated as the Z-Tech 7500 Class.

Figure 10: General arrangement of Z-Tech 7500 Class tugs for G&H Towing. From top, outboard profile, main deck and hold.



5.1 Mk I Series: Main Iron Works

The owners contracted with Main Iron Works of Houma, Louisiana, a shipyard with which they had a long and successful relationship, to build two of these new tugs. The shipyard building methodology however did not lend itself well to the theme of modular, unit construction incorporated into the basic Z-Tech design. It was necessary therefore to revise the fundamental structural design to suit the yard's practice of setting up a large keel profile frame and then setting up each frame in a 'stick-build' fashion (*Figure 11*).

Figure 11: First Z-Tech 7500 commencing construction at Main Iron Works.

Given the presence of the large skeg, conceived as a structural appendage in the earlier Z-Techs, this meant that the entire construction had to take place in a very 'elevated' configuration. The tugs were built under the approval and inspection of ABS with an ✠A1 Towing Service, Escort, ✠AMS, Fi-Fi1 notation. These new tugs, as illustrated in *Figure 10*, were configured not unlike the smaller Z-Techs, with accommodation for a crew of up to six persons. Main propulsion machinery comprised CAT 3516B-HD main engines, rated 2,350kW (3150bhp) at 1,800 rev/min, driving Schottel model SRP 1520 Z-drives. The hawser winch is a hydraulically-driven, Markey Model DYSF-52, designed for full render-recover escort rating, with a brake rating of 225 tonnes and a full-load line recovery capacity of 9 tonnes at 38m/min.

The owners also requested, late in the construction period, the addition of two 'docking struts' aft on the tug to facilitate dry-docking without additional blocking aft. These struts, as clearly shown in *Figure 12*, were very similar to those designed in some of our very earliest Z-drive tug designs, the Cates 2400 series of tugs, as described in *Compact Tugs*[3].

Hurricane Katrina played a key, if seriously negative, role in the construction of these tugs, as the shipyard and many of its employees were significantly impacted by this powerful storm in August, 2005, resulting in a delay of the better part of a year in completing the vessel. The shipyard also realised very late in the construction process that they lacked sufficient depth of water at their slipway for launching this deep-draft vessel, and thus the launching required that a heavy-lift crane be brought into the yard to lift the tug on to a barge for transport to a deeper launch site (*Figure 12*).

Upon delivery of the lead vessel ***Thor*** to G&H Towing in July, 2007, the vessel went immediately into service in the Houston Ship Canal. Feedback from the operating

Figure 12: Transfer of **Thor** *for launching.*

crews was extremely positive, and in spite of the large skeg, (intended to maximise escort steering performance), the handling of the tug was deemed 'excellent' by the tug masters. The second Z-Tech 7500, christened ***Wesley A*** under the house colours of Bay-Houston Towing Co, was commissioned in December, 2007.

5.2 Mk II: Orange Shipyard orders

During the latter half of 2006, the owners elected to build more of the Z-Tech 7500 Class to serve several pending LNG port operations, as well as their regular harbour towage operations. Due to the problems with draft etc, encountered at Main Iron Works, the construction of the next batch of tugs was negotiated with Conrad Industries Inc, for fabrication at their shipyard in Orange, Texas.

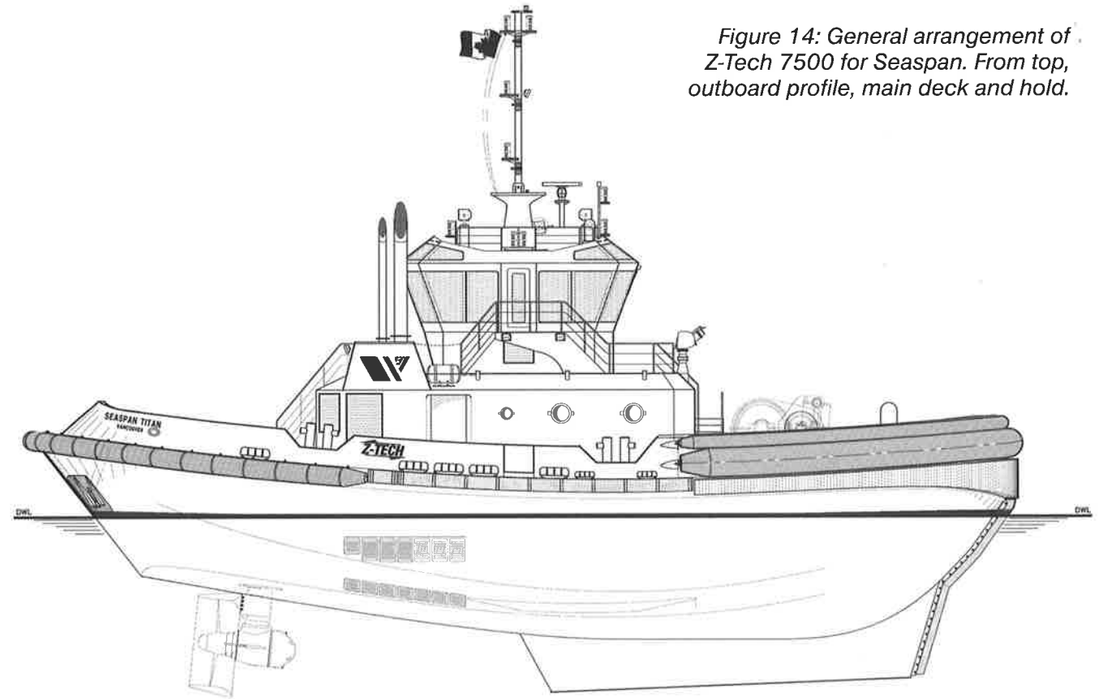
The next design (Mk II) was not significantly different from the Mk I, and the owners elected to continue with the structural configuration of the lead vessels, in spite of the construction taking place in a yard more attuned to unit construction techniques. A number of minor refinements were implemented however, primarily reflecting owner preferences in some layout details, and incorporation of 'as built' information into the new baseline design. At the time of writing, a Mk III version is being developed with an alternative skeg geometry reflecting the outcome of the model tests described in Part 7 of this paper. These tugs will be delivered during 2008 and 2009.

5.3 A Canadian Z-Tech

In 2007, Robert Allan Ltd contracted with one of its oldest clients, Seaspan International Ltd, of North Vancouver, BC, and a division of the Washington Marine Group, for the design of a Z-Tech 7500 Class tug to support its operations at Deltaport, a coal and container terminal south of Vancouver (*Figure 13*).

Figure 13: Deltaport, BC.

Figure 14: General arrangement of Z-Tech 7500 for Seaspan. From top, outboard profile, main deck and hold.



This terminal, although located within the generally benign Strait of Georgia, is still relatively exposed and can experience waves of 2.0-2.5m H_s in winter. Thus a reasonably large tug with good seakeeping and high bollard pull is required. The Z-Tech 7500 design suited these requirements very well.

Using the original US design as the basis, the design was modified to accommodate the owners' selection of main machinery package and a number of layout changes necessary to suit the vagaries of the Canadian regulations and local Union standards for tug construction.

The owners opted to use medium speed main engines, installing a pair of EMD 12-710 main engines, rated 2,238kW (3000bhp) at 900 rev/min, driving a pair of Niigata ZP-41 drive units through a vertically offset (step up) gearbox.

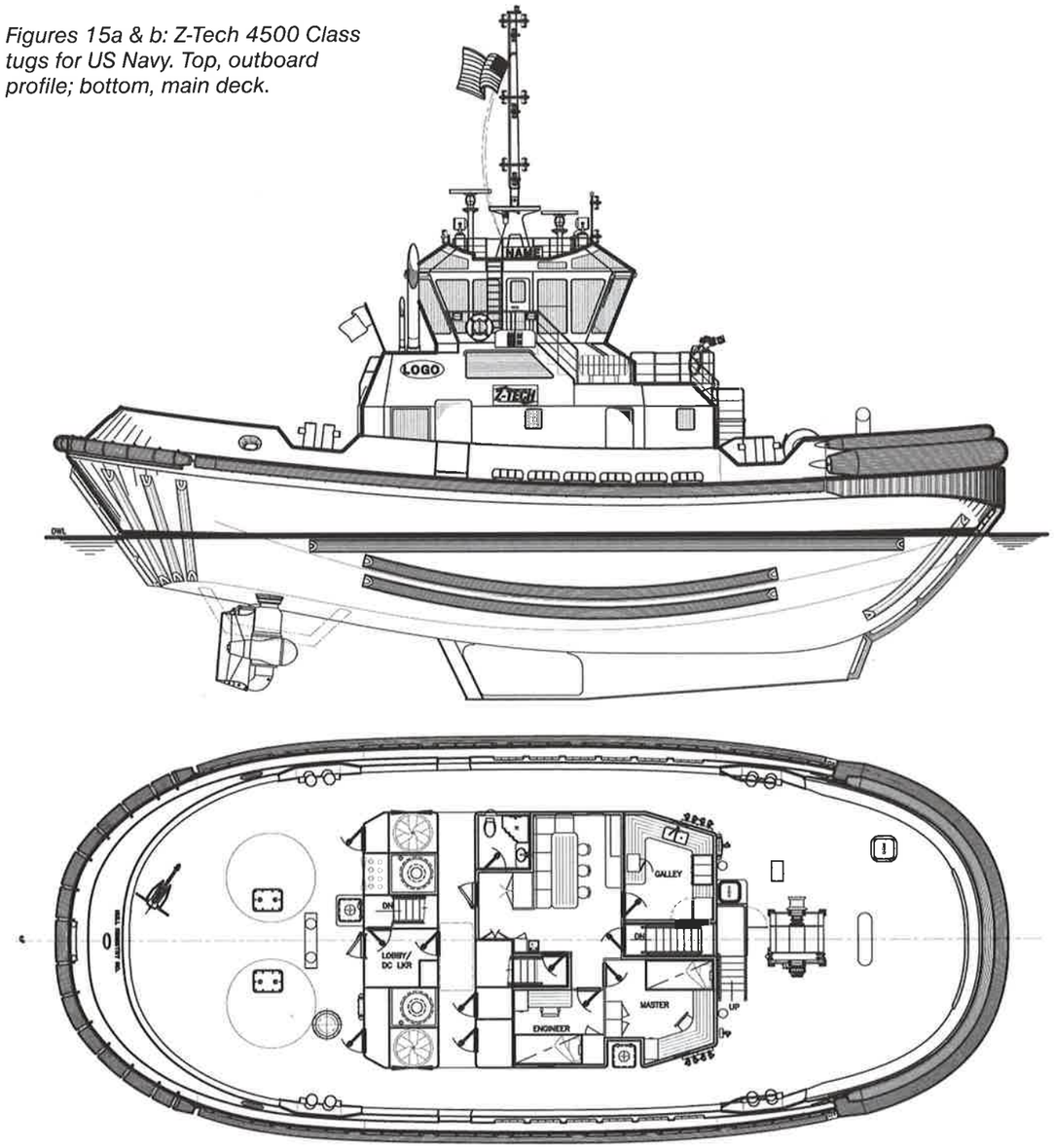
The final arrangement of the tug is as illustrated in *Figure 14* (previous page), reflecting the Canadian regulations which preclude any crew sleeping quarters below decks in a tug in excess of 27.4m in length; hence the galley and mess areas, where the crew on this 'day boat' spend the vast majority of their non-working time, are pushed below decks.

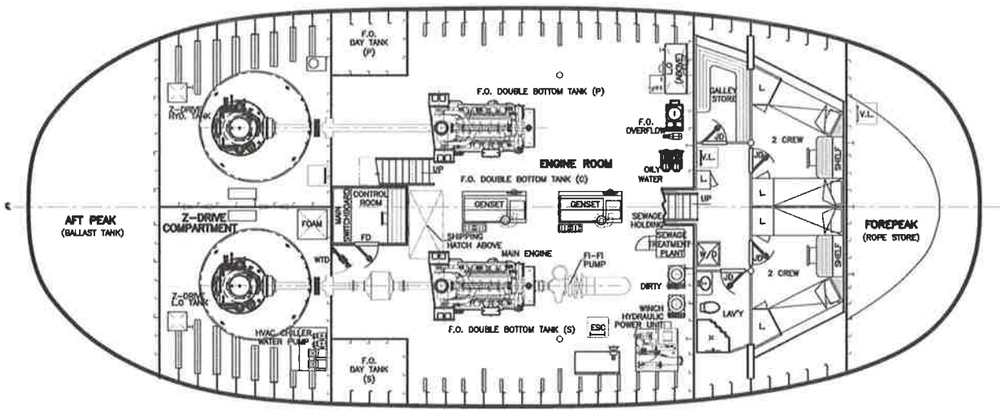
A major feature of this design is the complete isolation of the crew accommodation from the machinery-related noise sources, by the creation of an open breezeway between the engine room casing and the deckhouse as illustrated.

6. Z-TECHS FOR THE US NAVY

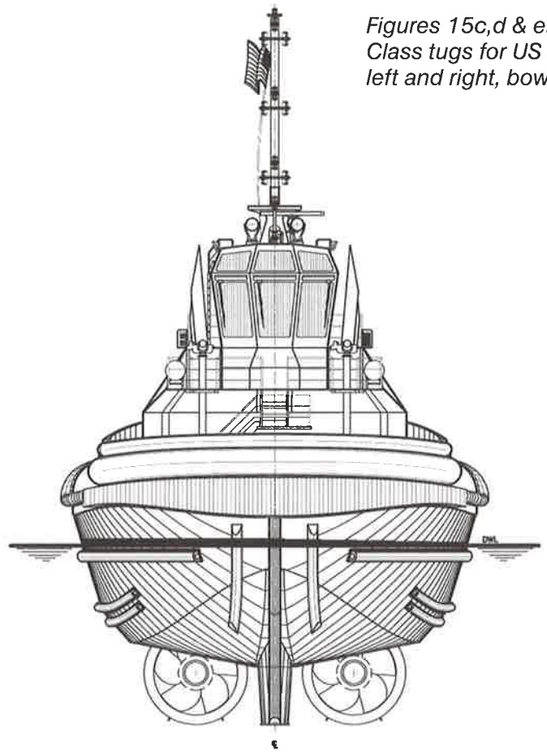
In November, 2007, Robert Allan Ltd was pleased to announce a contract for at least three new Z-Tech tugs for use at the US Navy base in Bremerton, WA. The contract was awarded to Pacific Tugboat Service of San Diego, with

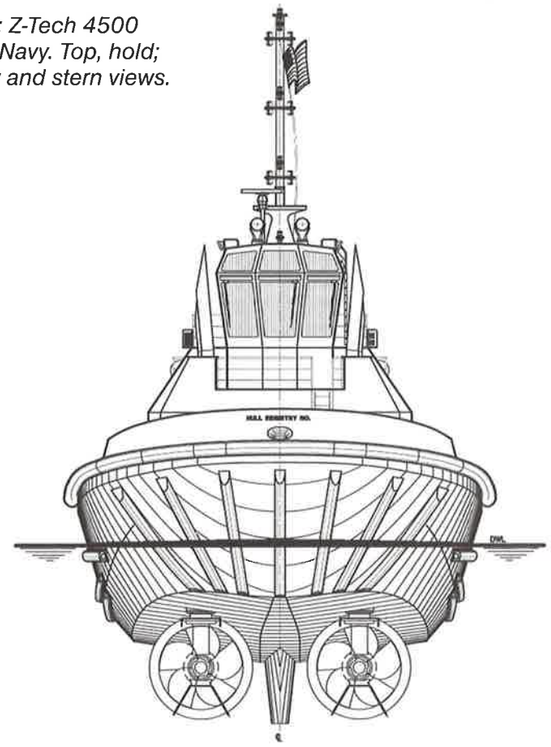
Figures 15a & b: Z-Tech 4500 Class tugs for US Navy. Top, outboard profile; bottom, main deck.





Figures 15c,d & e: Z-Tech 4500 Class tugs for US Navy. Top, hold; left and right, bow and stern views.





construction by JM Martinac Shipbuilders Ltd. of Tacoma, WA. Based on the requirements of the US Navy Pilots for both warship and submarine handling, the new tugs will be based on the hull geometry of the Z-Tech 6000 Class tugs as built for Panama, but with a different powering configuration and deck arrangement.

Designated as the Z-Tech 4500 Class, these new tugs will incorporate numerous features, particularly those specifically intended to deal with their role in handling submarines: essentially a significantly different fendering arrangement, with a lot of underwater fendering. The propulsion machinery consists of a pair of CAT 3512C main engines, each driving a Schottel SRP 1010 Z-drive unit with fixed pitch propellers. This combination is expected to deliver the required modest 45 tonnes of bollard pull.

The main layout features of this new design, as illustrated in *Figures 15a-e* include:

- A deckhouse configuration featuring a transverse breezeway, similar to that on the Seaspan tug, for maximum noise abatement;
- Underwater fendering to match submarine contours;
- Day-boat style accommodation, with facilities for up to 24 supernumeraries for short voyage personnel transfer functions, etc.

7. MODEL TESTS: SKEG GEOMETRY

The Z-Tech design, when conceived, was felt to be sufficiently close in concept to many other ASD tug designs developed by Robert Allan Ltd such that model testing of the basic hull speed and thrust performance was unnecessary. At the time we had experimented significantly

with various skeg geometries in more conventional ASD tug designs, and we had the benefit of some full-scale 'before and after' skeg performance tests performed by Ostensjo Rederi on the 30m ASD tug ***Felix***.

Performance predictions were based on the full-scale results of these and numerous other comparable designs. That assumption certainly proved to be the case for both the 6000 and 7500 series of Z-Tech tugs. However a very interesting phenomenon arose when the first tugs entered service in Panama, which was entirely counter-intuitive, and thus led us to conduct a series of investigative model tests.

The ACP tugs experienced control instability when running astern (skeg aft). This phenomenon had not been reported on any of the previous tugs. It is quite common for ASD tugs to be difficult to steer when running astern, especially those designs which have rather square and deep transoms, and which often have skegs biased too far aft, features NOT found on any Robert Allan Ltd designs and certainly totally unlike the geometry of the Z-Techs.

After extensive discussions with the owners, it was determined that this phenomenon was particularly noticeable when working inside the locks. A mock-up of the lock geometry was set up by Offshore Research Ltd at the Vizon-Scitec model basin at the University of British Columbia in Vancouver. A 1:24 scale working model of the Z-Tech design owned by Robert Allan Ltd, was mobilised and operated by Ron Burchett.

Tests were run in both open water and in the lock to observe the tug behaviour. In open water, the tug displayed a distinct, but very modest (and totally controllable) tendency to 'crabbing' when free-running astern at speed, which was attributed to the fact the two propellers were handed in the same direction, and the associated wash impact on the skeg.

Within the lock, with simulated propeller wash from a ship, it was quite remarkable to observe that the tug, under control of a skilled operator, could approach the stern of the other 'ship' more easily skeg first than with drives first. There were obviously a number of factors at play; the ship propeller wash, the constraints of the lock, the propeller wash from the tug reflected off the lock walls, and the force exerted on the skeg by all these various currents.

A number of different skeg geometry variations were tried in this trial, in an attempt to establish a solution to the ACP problem. After several iterations, a new skeg geometry was devised that exhibited much improved characteristics, without sacrificing too much of the indirect steering force generation capability of the original. This new geometry is being introduced on the last four tugs of the first set for ACP, and will be used henceforth on the majority of other Z-Tech designs.

8. Z-TECH 7000 SERIES

In late 2007, PSA Marine committed to a new higher-powered series of Z-Techs for their various harbour applications, and in general response to the current demand for ever-larger and more powerful ship-handling tugs. The new tugs are designated as the Z-Tech 7000 Class, and will provide a minimum of 70 tonnes BP.

The new design will be very similar to the 6000 Class, but obviously larger to deal with the higher power. The arrangement of the new Z-Tech 7000 Class is shown in *Figures 16a-c,* below and on the following page.

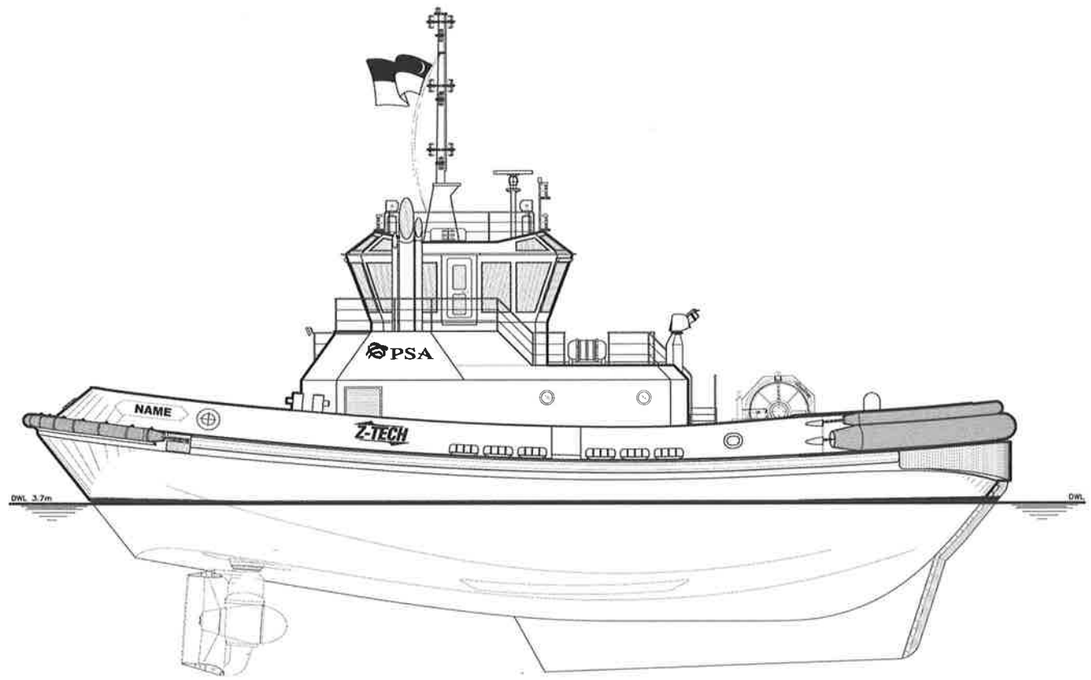
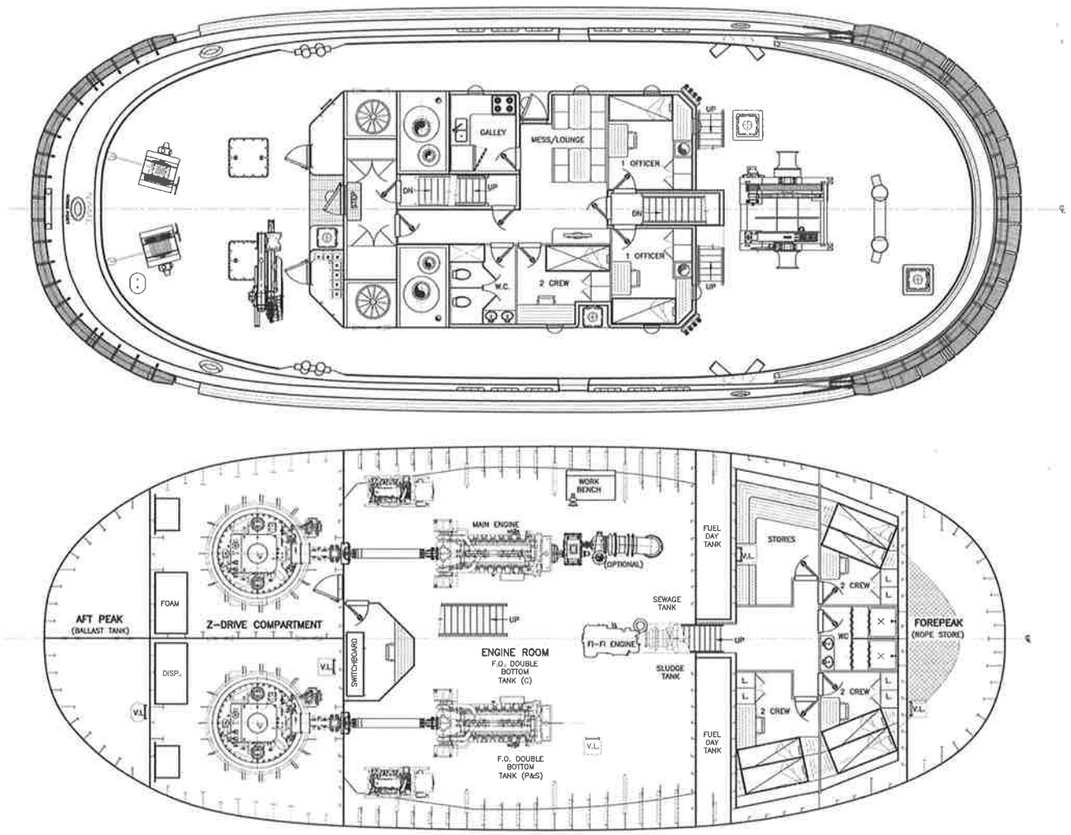


Figure 16a: New Z-Tech 7000 Class tugs for PSA Marine – outboard profile.



Figures 16b & c: New Z-Tech 7000 Class tugs for PSA Marine – top, main deck; bottom, hold.

9 Z-TECH POTENTIAL

Applications for the Z-Tech design concept have, to date, been largely for conventional ship-handling applications. This is not surprising, as the concept was developed for just that very case. However the excellent sea-keeping capability exhibited by these tugs has led the design team to consider the merits of the Z-Tech concept for operation in more exposed conditions. The potential to use the Z-Tech for functions such as SPM hold-back and LNG tanker escort in more exposed conditions is also obvious.

Figure 17, opposite, illustrates how a pair of Z-Techs would operate at a typical LNG terminal with prevailing on-shore winds and related seas. In every attitude these tugs are situated for maximum thrust efficiency and maximum sea-keeping. A typical ASD tug in a comparable situation would have its low stern constantly exposed and susceptible to the weather.

For more extreme sea conditions concepts for 'Offshore Z-Techs' have been developed with a raised 'poop deck' configuration (*Figure 18*, on next page), which could accommodate power sufficient for 80-90 tonnes BP and which would be more than capable of operating in 3m or greater seas.

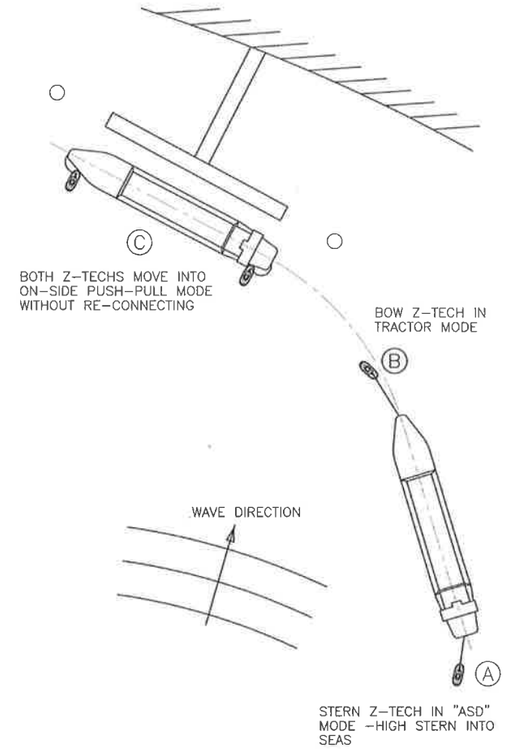


Figure 17: Z-Tech Tugs Docking an LNG Tanker on a Lee Shore.

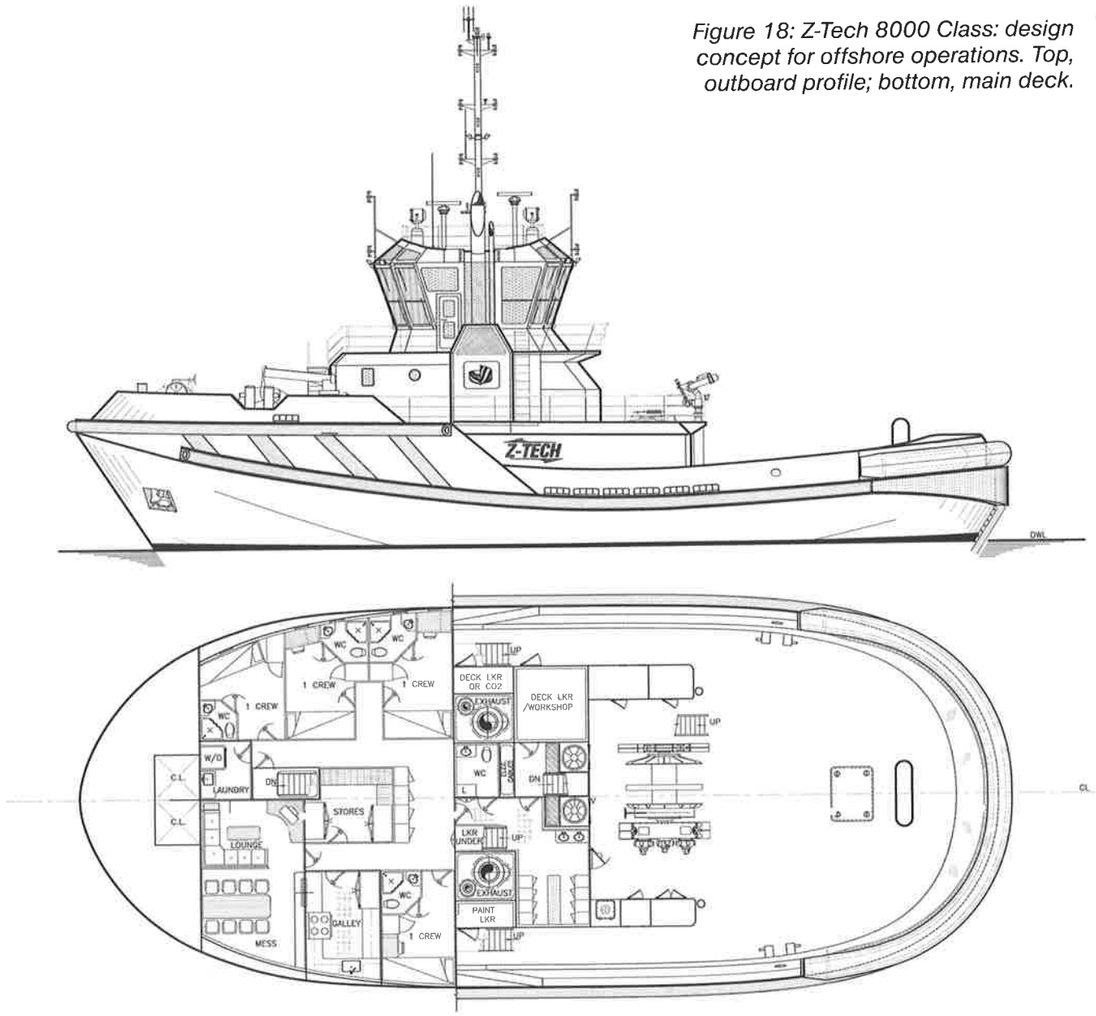


Figure 18: Z-Tech 8000 Class: design concept for offshore operations. Top, outboard profile; bottom, main deck.

10. SUMMARY

Table 1 provides a summary of the salient characteristics of the entire Z-Tech family of designs to date.

The Z-Tech design concept has, by any measure, been a resounding success. The tugs in service to date have exceeded all performance expectations, and although many viewers still puzzle about which end is 'forward' and which is 'aft', the tugs are proving their merit as a true omni-directional high-performance tug in critical harbour towage operations. The most pleasantly surprising aspect of the design, at least to us as designers, has been the exceptional sea-keeping capability demonstrated by these tugs in extended voyages across the Indian and Pacific Oceans, travels that certainly were never envisaged at the design stage.

Class	Length	Beam	Depth	Draft	Power	Engines	Z-Drives	Bollard Pull		Speed		Class
								ahead	astern	ahead	astern	
	metres	*metres*	*metres*	*metres*	*kW*			*tonnes*	*tonnes*	*knots*	*knots*	
4500	27.42	11.65	5.00	4.88	2700	CAT 3512C	Schottel 1012	*45.00*	*44.00*	*12.00*	*11.50*	ABS
6000 Mk.I	27.40	11.50	5.00	5.20	3730	CAT 3516B	Schottel 1215 FP	63.00	58.70	12.65	12.76	LRS
6000 MkII	27.40	11.50	5.00	5.20	3730	CAT 3516B	Schottel 1215 FP	similar data for whole series +/- abt.3% variation				LRS
6000 Mk.III	27.40	11.50	5.00	5.20	3730	CAT 3516B	Schottel 1215 FP					LRS
6000 ACP	27.40	11.65	5.00	5.33	3600	Wartsila 9L20	Lips LCT FS250-S/BN-K	60.94	57.62	12.14	12.20	LRS
7000	30.00	12.00	5.00	5.33	4000	CAT 3516B-HD	Schottel 1515	*70.00*	*70.00*	*13.00*	*13.10*	LRS
7500 Mk.I	30.01	11.98	5.00	5.92	4700	CAT 3516B-HD	Schottel 1520	75.30	73.20	13.50	13.50	ABS
7500 MkII	30.01	11.98	5.00	5.92	4700	CAT 3516B-HD	Schottel 1520	*75.00*	*73.00*	*13.50*	*13.50*	ABS
7500 (C)	30.00	12.00	5.00	5.92	4476	EMD 12-710	Niigata ZP-41	*75.00*	*73.00*	*13.50*	*13.50*	LRS
8000	33.70	14.00	6.20	4.40	5420	options	options	*80-85*	*75-80*	*14.00*	*14.00*	-

Table 1: Particulars of the Z-Tech Series (note: figures in italics are predicted).

The initial design concept was remarkably close to the target objective, and with a few small modifications to achieve better sightlines all around the clock, the concept has proven to be highly successful. The changes made have centered principally on improved ergonomics and sightlines. There has been no alteration made to the hull lines whatsoever from the initial design. The now well-proven 60 and 75 tonne BP series built to date are expected to lead to many more orders, and to concepts for similar vessels for extended offshore operations. The adoption of the Z-Tech concept by no less than the US Navy suggests that the Z-Tech has indeed entered the mainstream of tug technology.

REFERENCES

[1] *The Z-Tech Concept*, Peter Lee, Port of Singapore Authority, *ITS 2004*.
[2] *Keeping You Safe Between the Seas – The Panama Canal Tug Operations*, Max Newman, Panama Canal Authority, *ITS 2004*.
[3] *Compact Tugs*, Robert G Allan, Robert Allan Ltd, *ITS 2002*.

DISCUSSION – DAY ONE, PAPER 2

Mike Allen
Rob, thank you very much for this... three have been supplied. Given the size of the US Navy submarine fleet, do you anticipate that there will be more orders?

Robert Allan
I daren't guess what the US Navy is going to do, but we are optimistic. The first order has now been increased to four, so we are very optimistic that when those are in service, they will lead to more orders, but their whole tug fleet operation is going through a different process. They privatised a lot of it about a decade ago. There are rumblings about not being so happy with how that is working for them, so one can never tell. But we're quite optimistic that once these are in service, we will see more.

Mike Allen
And presumably the underwater fendering is to protect the tug rather than the submarine?

Robert Allan
It's really just to avoid any metal-to-metal contact. It's not providing a great deal of resilience there.

Mike Allen
Do excuse us, whilst we just have a private chat! You are all welcome to join in if there are any questions from the floor.

Andy Smith, International Tug and Salvage
Excellent paper, Rob, as usual. My question is really about the different behavioural attributes of the tractor configuration and the ASD configuration. These tugs exist; what do you think are the main differences in the behaviour patterns of this, and as a rider to this question, how on earth did you manage to sell any in America, where of course, there is no differentiation in fact to an ASD?

Robert Allan
Shall I deal with the semantic issue first, Andy? Operationally, the crew's perceptions of the advantages were primarily in making up on an inbound ship. They felt that a tractor gave them better control getting in alongside, but in some of those tractors, you would have more interference with the ship's wash. I think it was very much an issue of crew preference and crew skills to some degree. But primarily, some were quite happy putting an ASD right in on the stern; some preferred the tractors. I can't honestly tell you that there was a distinct difference there. It was just they seemed to be split into two camps and depending upon the operation; some were quite happy, some were not. So with the Z-Tech and that configuration, we give the operator the choice of going in either way, depending upon the circumstance.

As far as the nomination of the tractor is concerned, you and I share the common bug-bear in the use of the term "tractor", but it is what it is, and anything with omni-directional propulsion in North America tends to get mis-labelled as a tractor. I think the Z-Tech brand created a bit of 'buzzzz', if you'll forgive the term, and people saw the merits in that, not least of which is the saving of a second winch in a conventional ASD configuration. So there is nothing in the design that is significantly different from a conventional ASD, other than if you're going to perform towing operations, you don't need that second winch, so you've immediately saved several hundred thousand dollars.

Michael Vincent, sale and purchase broker
Have you experienced, or do you anticipate a difference in bollard pull between tugs fitted with the harbour skeg and those fitted with the escort skeg?

Robert Allan
No, we see no difference at all.

Mike Allen
Are the Australians in the audience not going to defend the comments about their crews? I quote from the paper!

Robert Allan
That's not fair.

Mike Allen
I would be delighted to hear what they have to say. There is, however, something in the nature of Australian tug crews that causes them to embrace change and fresh ideas rather reluctantly. What is it in the national psyche? Rob, maybe you'd just like to tell us what it was.

Robert Allan
I had one very vitriolic letter from a skipper whose name I cannot, and would not, remember. He was all over us for this contraption, but with a little bit of training, he and his colleagues eventually recognised that this wasn't some evil

demon that was being forced upon them. There was one very upset skipper who obviously had something different in mind, and was being forced to have a little bit of retraining, and so forth. In general, we've had very, very positive feedback from all of the operators, but there were a couple of Australians who felt the need to give me a tongue lashing.

Ben Burns, Svitzer Australia Pty Ltd
Just in defence of Australian tug crews, the Z-Tech in Port Kamblo is very well accepted with almost no reluctance from the crew. They are using that tug both in the ASD mode and in the tractor mode on a regular basis. As far as tug crews and ship's crews generally, I think there is a reluctance to change right across the industry.

Robert Allan
Thanks, Ben. I certainly did not mean by that comment to lash out at the industry in general in Australia, it was just that one doesn't often get such negative letters from people. It was kind of a watershed and I felt it had to be remarked upon, because the concept is different. As you say, Ben, by and large, the vast majority of people have really embraced it, and I have talked to as many skippers as I can, and most of them are just delighted with how these boats handle.

Mike Allen
I think probably of greater concern to the Australians in the room is where they are going to find props before the next rugby World Cup. I'd be interested to debate that later.

Markus van der Laan, IMC Corporate Licensing
First of all, my compliments on the development of the new Z-Tech design. You spent a lot of time explaining the hull shape, the propellers, and the skeg, but there was little attention to the position of the towing staple and the winch, and the tow line coming either from the top of the drum or the bottom part of the drum. I would be interested if you could just briefly elaborate on that part and perhaps also on the possibility of reducing the height of the towing staple to reduce the heeling lever. Is it possible to elaborate on that?

Robert Allan
These boats were conceived as a harbour towing tug. At the time that we were starting this project, we had been doing a lot of work with much more sophisticated escort tug designs and so part of the Z-Tech development was influenced by that, primarily in that we did fit a fairly large skeg to the basic design. But in doing that, it was intended to provide a good indirect steering capability but we did not visualise these tugs being used in aggressive escort work. We wanted to give them an escort capability, but if were going to design a really high performance escort tug, we would have used a somewhat different hull form.

So the winch position and the staple position were dictated very much by more conventional ship handling operations, so if we wanted to maximise indirect force, we would pull the staple further aft than it is presently, and we have deck space available to do that. But both here in Singapore and certainly on the Panama tugs, they all needed, for operational reasons, two winches up forward, and that really dictated the whole deck layout. We could certainly improve the indirect capability of the Z-Tech design by reconfiguring the staple and as you mentioned, making it perhaps a little lower, but the mandate was not for maximum escort capability, but really for maximum ship handling, flexibility and capability.

Hume Campbell, Riverside Marine
I'll come back to the references to Australians shortly. Robert, you've made lots of comments about the skeg and I look at *Figure 5*, and I see where there is an open aperture in the skeg, and we've also had a ship broker asking about the different values in tugs. Have you looked at an opportunity where you could have a moving vertical face to actually enclose that aperture or move it back so the tug could be more flexible in what it's doing in your skeg design, so that an hydraulic ram could actually move a plate out to fill that aperture in, and haul it back if you wanted to open the aperture? Have you looked at that opportunity to make your skeg more versatile?
Now, before I go to the answer to that question, Australia is doing very well financially. We're opening the doors to many people over the world, but as against 150-180 years ago, we're going to be very, very selective as to who comes in. But we are looking for good props from France, Canada and America. Thank you.

Mike Allen
We've got more than enough!

Robert Allan
As far as a flexible skeg geometry is concerned, we've certainly explored that idea, and we have one project that is not a Z-Tech, but the 100-tonne Rotor Tug that we presented a paper on at *Tugnology* last year, and a major part of that underwater design feature was a vertically retractable skeg. Depending upon which mode you were operating in, you could raise or lower this. It introduces a lot of structural and mechanical complexity. My greatest fear is that you get a little piece of wood stuck in there, and all of a sudden something doesn't work, and then you've got to dock the boat to get it out. Anything is possible, but I think in general, if we understand what the owner's operations are going to be at the beginning of the project, we can recommend a preferred skeg geometry. That keeps it nice and simple. The alternatives are possible, but I think they come with significant cost and some operational risks.

Mike Allen
Rob, thank you very much. I think you've got us off to an extremely good start.