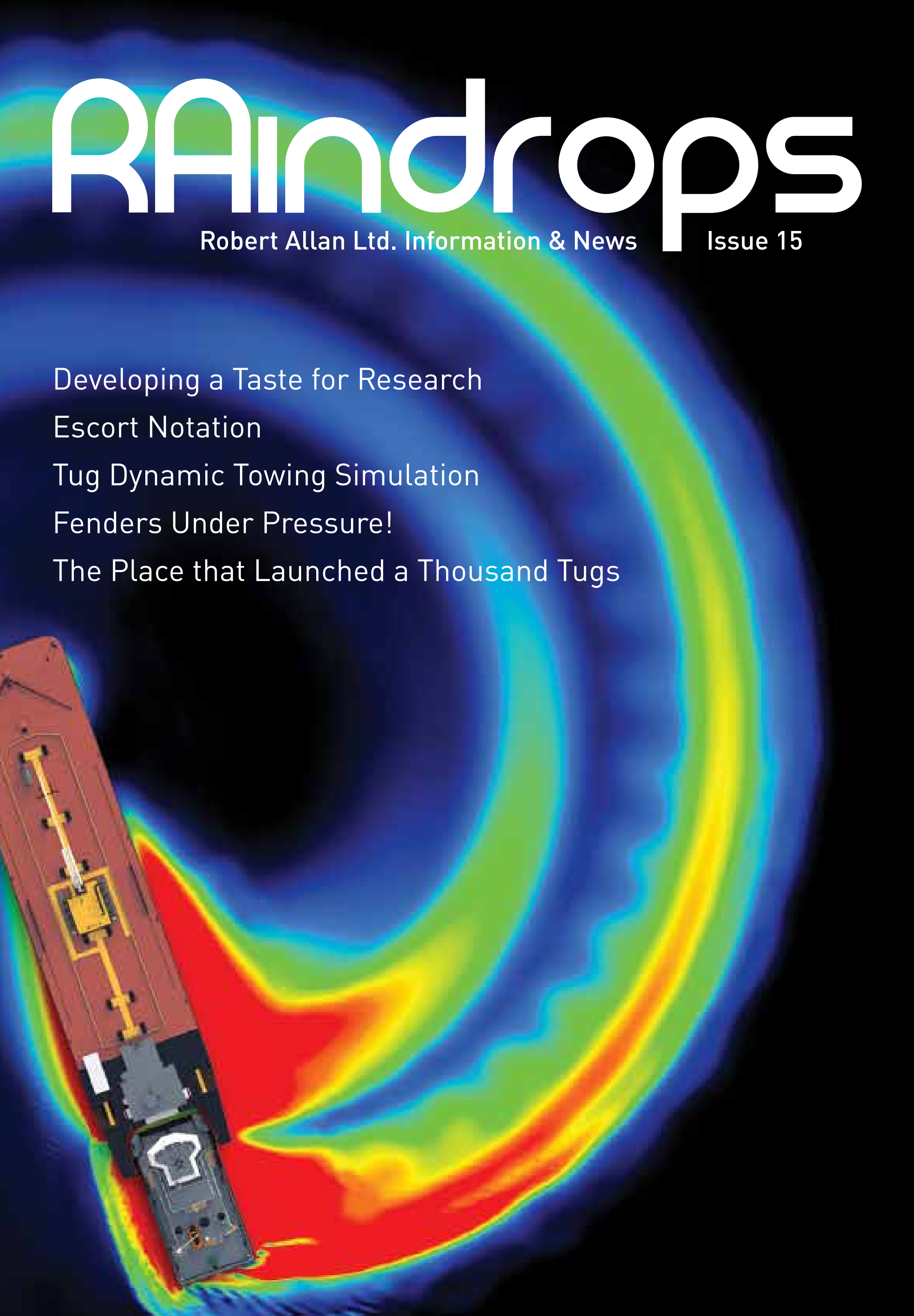


RAindrops

Robert Allan Ltd. Information & News

Issue 15

Developing a Taste for Research

Escort Notation

Tug Dynamic Towing Simulation

Fenders Under Pressure!

The Place that Launched a Thousand Tugs

ROBERT ALLAN LTD.

NAVAL ARCHITECTS AND MARINE ENGINEERS

Research & Development

by: Vince den Hertog, P.Eng.
Vice President, Engineering

At any one time, we have between 20 and 30 active R&D projects on the go. Some are small and some span years. A gain in performance or safety is usually the objective of an R&D project, but often gains in both are the result.

Being in tune with our clients' needs today and into the future is very important to us, and we do the R&D at our cost or sometimes on a shared cost basis on their behalf.

Predicting escort performance is an example. In 2013 we were the first to get classification society approval for our CFD-based methodology to obtain escort notation without the need for costly and time consuming sea trials. Since then, we have extended the methodology to include our RotorTugs and Voith Schneider Propeller (VSP) tug designs, no mean feat considering all the variables.

Then there is escort in seas. Motions can be hard on towlines, equipment and crew. Active winches that pay-out and haul-in line can make a big difference, but they need to be well-matched to the tug. In this issue, you will read how our new *TDT-Sim* system will simulate the complex interplay between seas, tug motions, towline and winch to make sure the complete *system* - tug, winch, towline and fittings - is right for the job at exposed locations subject to waves.

Of course, tugs push as well as pull, and we've got that end well covered too. Today, 80 tonnes of bollard pull capability is not unusual even for a harbour tug, and the immense pushing force such a tug can bring to bear needs to be distributed evenly over the side shell of a tanker or other ship through careful fendering design. As you will read, we can now predict the pressure distribution of our fendering designs more accurately than ever before to ensure safety.

Behind the scenes, R&D continues in other fronts. Remotely operated tugs and workboats remain a hot topic. Late last year, experienced tug captains put our remotely-operated *RAmora* tug design through its paces in a simulator, working from a prototype operator console. For our inland waterways clients, we're using CFD to demonstrate the dramatic improvement in safety and manoeuvrability with azimuthing drives instead of fixed propellers on shallow draft pushboats; a long overdue improvement in our opinion!

While gains in performance and safety are the obvious fruits from R&D, for us the quest for innovation also comes from the heart. Good design and a passion for continuous improvement are values we share with our clients. Being involved with R&D it is something we all thoroughly enjoy. And who wouldn't.

Developing a Taste for Research

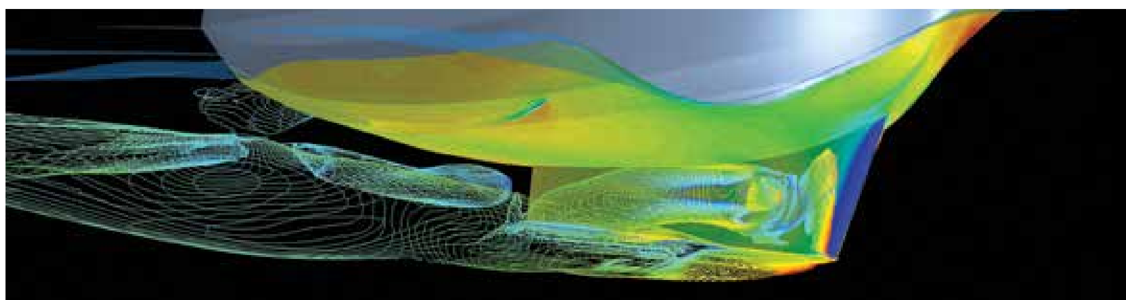
by: Robert G. Allan, P. Eng.
Executive Chairman of the Board

It doesn't seem that long ago that the concept of doing R&D for a vessel type perceived to be as "basic" as the tugboat was extremely remote. Until the '90's the number of tug designs that were model-tested (the naval architect's basic R&D tool) was very small. Designs evolved bit by bit, largely based on classical round bilge hull forms, then transitioned into single or double chine forms as yards sought less expensive forms of construction. For many years however we had performed model testing to refine barge hull forms and verify the performance characteristics of different skeg configurations. This work established our company as a leader in progressive barge design in the 1960's and '70's and the work done here saved our clients tens of thousands of dollars in fuel costs annually.

However with the development of escort tugs in the early '90's it was apparent that to establish these new tug concepts as safe and capable of the extreme performance demands placed upon them, some extensive new research was required. One of the primary demands of our clients was to develop an ASD tug design that could perform indirect escort towing at least at the same level as a VSP tractor, then considered the "best available technology" in the field. Our first challenge was to find a hull form that could generate the steering forces required. Our long-time friend and "ship science" consultant Alan Reynolds of Offshore Research Ltd. and I spent a week at the small model basin then located at the B.C. Research facility at UBC exploring and testing ideas. Using an existing tug model we systematically explored concepts for variations in side geometry and skeg configurations. That process resulted in the "ah-ha" moment which eventually led to our *RAstar* hull forms; a shape which achieves very high levels of stability in the heeled attitude of indirect escort towing without the burden of dragging a wide beam through the water all the time. Testing of several further projects has enabled us to refine that shape to the stage where it truly is the "state of the art" in escort tug hull forms today, and has been extensively and successfully used on tugs with both cycloidal and Z-drive propulsion.

But of course the game-changer in R&D capabilities came with the development of "affordable" CFD capabilities in this office; not just the very high-powered computer system required to run this powerful software, but most critically the very skilled and talented team of Bart Stockdill, Brendan Smoker, Scott Newbury, Jonathan Reaume, and Mike Shives that run the system today. A decade ago it was hard to imagine that CFD would even have a place in our office but today it is a highly valued and key part of our commitment to ensuring our designs are truly the best they can be. Similarly the use of FEA enables us to ensure that the structural aspects of our designs are not only safe and robust but also efficient.

The Robert Allan Ltd. tug design of today is no simple hull/engine/winch combination. It embodies the results of decades of design research, development and refinement, and the application of the most up-to-date scientific methodologies to ensure that the entire 'system' is thoroughly engineered and safe for the operations intended.



Escort Notation

by: Brendan Smoker, P.Eng.
Mechanical Engineer/CFD Analyst

A classification society notation provides the assurance that a vessel has met a standard, both in design and construction, to safely carry out certain duties. An escort tug notation is no exception. The purpose of an escort notation is to indicate that a tug is capable of applying indirect steering and braking forces on an escorted vessel by way of a tethered towline at transit speeds. Escort operations are typically carried out at 8 and 10 knots and an escort notation is a common requirement for tugs operating in oil and LNG terminals.

To receive an escort notation, an escort performance analysis must be presented to class. The analysis must include the anticipated escort force capability (i.e. the maximum steering and braking forces) as well as the corresponding safe operating limits, which include the maximum allowable heel angles and speed. It is critically important to assess the escort performance in conjunction with the safe operating limits to ensure the required forces can be exerted reliably and safely.

The development of Robert Allan Ltd.'s escort performance prediction methodology began with an R&D program in 2009. With hydrodynamic forces calculated using computational fluid dynamics (CFD), the method and resulting performance report has matured to the point of being accepted by several major class societies as the key document required for a tug to receive an escort notation. This particular R&D work has resulted in Robert Allan Ltd. remaining on the leading edge of escort tug design and has also been the spring board for consultations with several class societies on rule harmonization and updating regulatory requirements.

The overriding advantage of this form of analytical approach is that we can evaluate the full spectrum of operational conditions for the tug, and ensure ourselves and the Owners that the tug truly is safe for the intended operations. That scope of evaluation is simply not possible during a full-scale trial where the tug master may not be familiar with what is most likely a new tug, and time and cost constraints do not permit a full series of tests.

Tug Dynamic Towing Simulation

by: Scott Newbury, P.Eng.
Hydrodynamicist/Naval Architect

It was a very exciting moment when I was first asked about creating a numerical prediction model for tug escort manoeuvres in waves under a new R&D project at Robert Allan Ltd. After all, it's not every day that a naval architect is provided access to several very sophisticated numerical analysis tools and is given the opportunity to create a new type of simulation model.

The indirect escort manoeuvre has many of the elements of a very complex seakeeping problem, with the coupled dynamics of the tug rigid body motions in waves and the influence of extreme dynamic towline tensions, as well as the effects of an active haul-in/payout winch and the changing hydrodynamics of the skeg as the flow varies with tug yaw angle and speed.

After several months of development effort we have created a numerical simulation model that can accurately predict towline tensions and tug motions during escort manoeuvres in waves. The simulation model has been dubbed TDT-Sim (Tug Dynamic Towing Simulation). TDT-Sim incorporates high fidelity models for the active escort winch, the towline, the tug rigid body motions, hull and skeg hydrodynamic loads under high yaw angles, as well as the propulsion thrusters. We have determined that an active winch with the right performance can eliminate slack line events that can lead to high snatch loads, drastically reduce extreme towline peak tensions that can lead to line failure, and even reduce tug roll and pitch motions during escort in waves. Most importantly, we are now able to evaluate the performance of an escort tug in waves so that we can optimize the design of our escort tugs and verify that the installed towing-related equipment is appropriate for the application.

The illustration below (Figure 1) plots towline tension during an indirect escort maneuver for two cases: with the winch 'on the brake' (locked); and with the winch in active mode. These plots are from a TDT-Sim analysis of one of our *RAstar* escort tugs in 2 m waves (Figure 2).

I'm really enjoying working with my colleagues at Robert Allan Ltd. on this project, and we're also grateful for the financial support provided by the Industrial Research Assistance Program (IRAP) - National Research Council Canada.

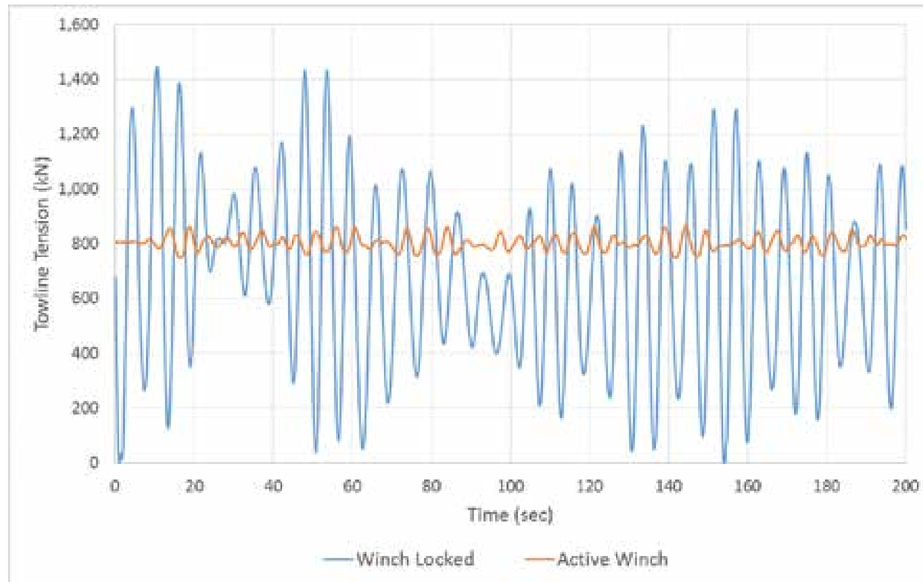


Figure 1: Towline Tension during an Escort Manoeuvre in Waves

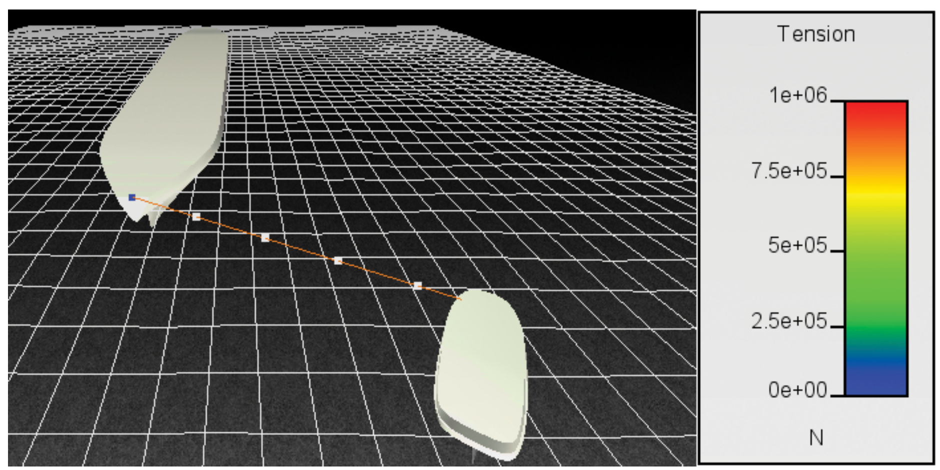
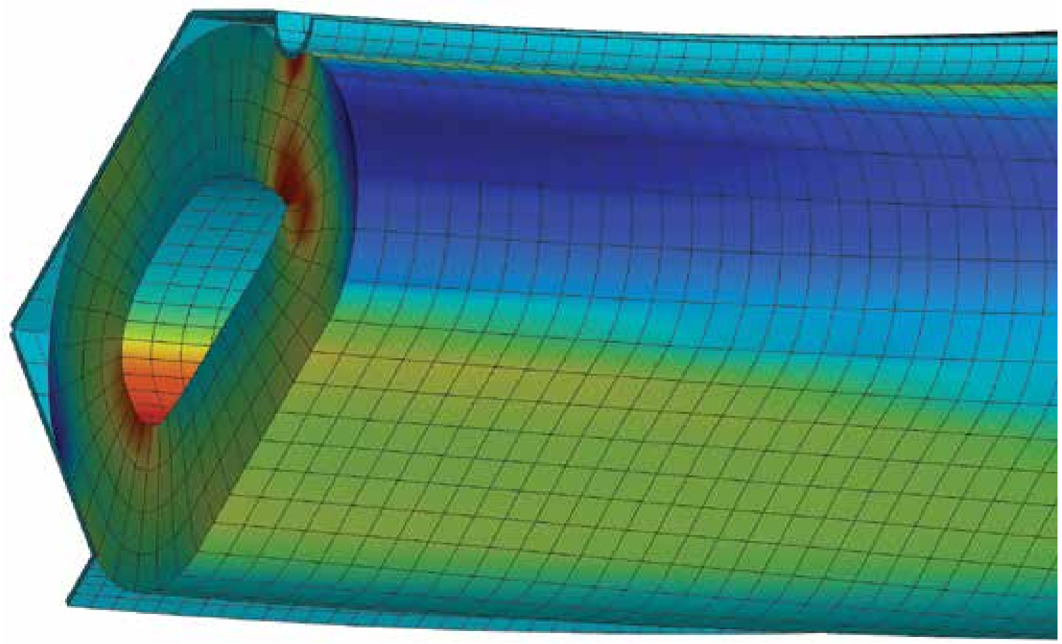


Figure 2: Simulation of a *RAstar* Escort Tug Applying Steering Force to a Tanker



Example of a 3D non-linear finite element analysis for a cylindrical fender on a curved bow section.

Fenders Under Pressure!

by: Lawren Best, EIT
Supervisor, Design Development

Greg Bossons, EIT
Naval Architect

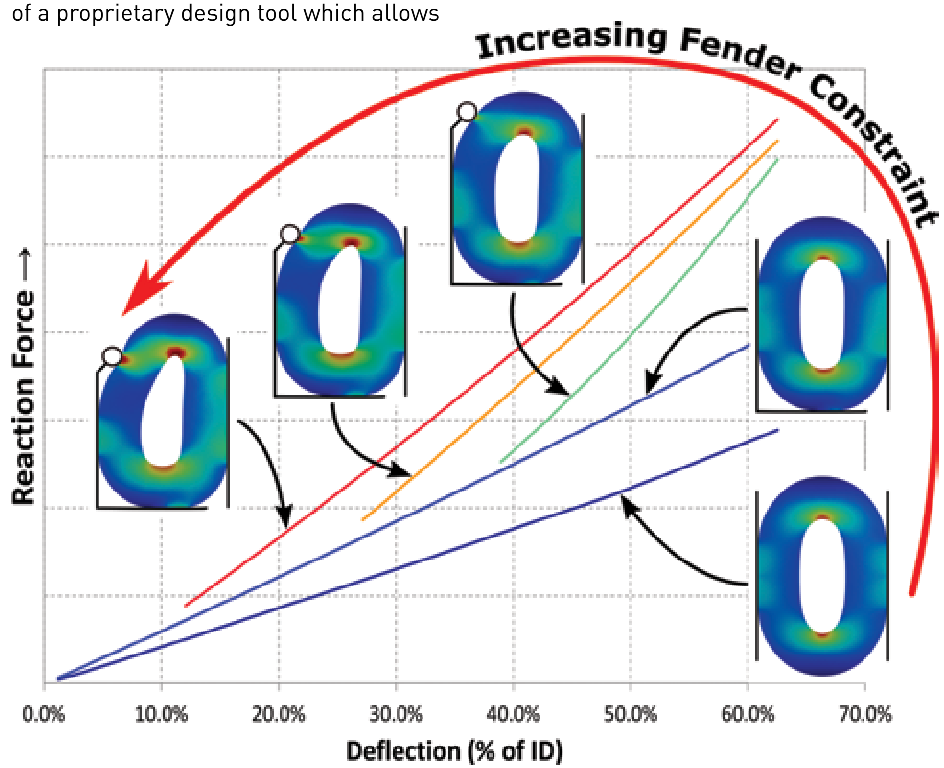
Matthew Buat, EIT
Naval Architect

Fenders are the primary point of contact between a tug and an assisted ship and as such they are an essential component to ensure safe operation when pushing. The long hours and variable environmental conditions mean that no other vessel type has fenders which work harder than those of a tug. The continually increasing power of tugs coupled with the more demanding pressure requirements of commercial ships (often 20 t/m^2 or lower) means that accurate and suitable fender selection is now more critical than ever.

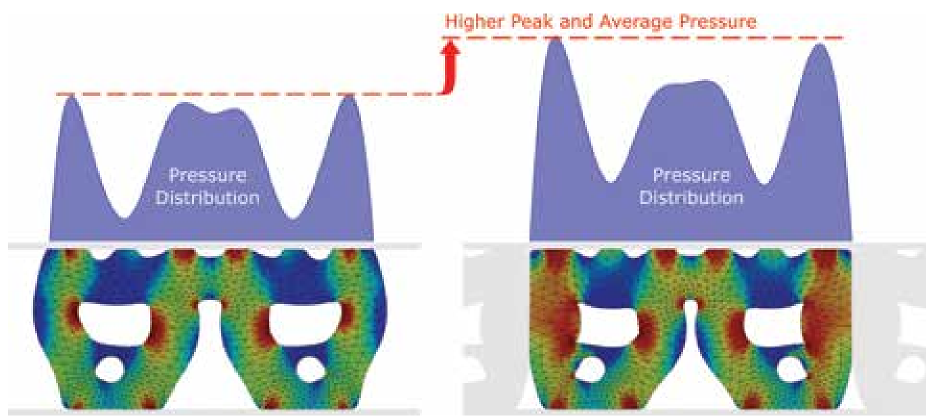
Traditional methods for determining fender system performance have made little effort to account for the complex geometry seen on actual tugs. As such, various interactions exist in real world pushing operations which are not accounted for by most methods. In the case of cylindrical fenders, the curve of the bow, shape of the bulwarks, and even the amount of friction between the fender and contacted objects can have a significant impact on the effective stiffness of the fender and in turn, the energy absorption and contact pressure. Likewise, W-fenders are also influenced by real world factors, most notably their proximity to one another. As W-fenders are compressed, they expand outwards, interacting with other nearby fenders and resulting in a significant increase in the actual stiffness of the fendering system.

Unlike most other common engineering materials, rubber does not behave linearly under stress. Because of this, the use of a non-linear "hyperelastic" material model is crucial to being able to accurately predict fender system performance. Robert Allan Ltd. has undertaken a research and development initiative to further our understanding of fender materials and configurations, and to develop the in-house knowledge and expertise to accurately model fendering systems. Using finite element analysis (FEA), we are able to accurately model the behavior of most common fender systems in use today.

Our work has culminated in the creation of a proprietary design tool which allows us to work with clients to evaluate potential configurations, different material properties and design a customized fendering arrangement to suit each individual client's requirements, including those with pressure requirements of 20 t/m^2 or lower.

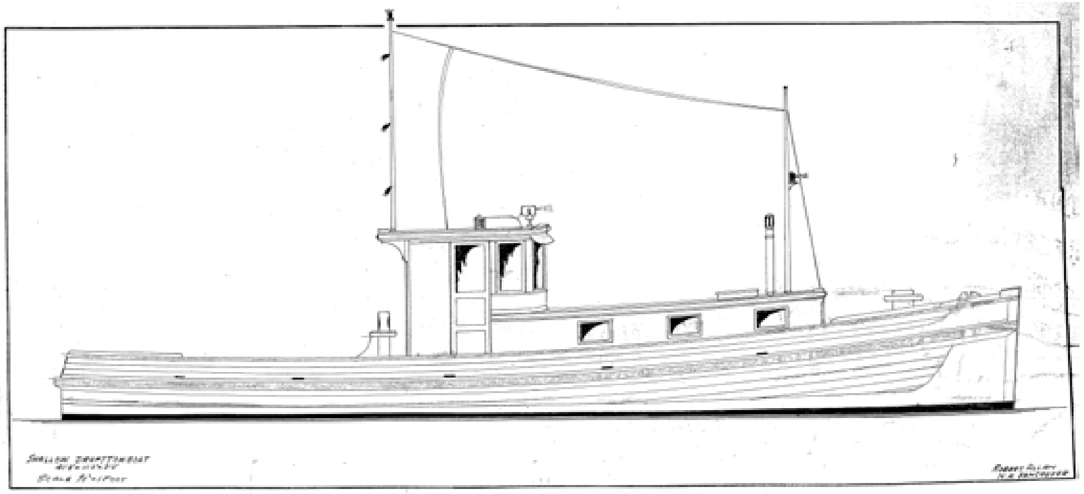


Impact of increasing levels of constraint on fender stiffness.



Comparison of the pressure distribution and deformed shape of an isolated w-fender (left) with an array of closely packed w-fenders (right).


The Future is Clear
CLEARVIEW WHEELHOUSE R&D PROJECT



The Place that Launched a Thousand Tugs

by: Robert G. Allan, P. Eng.
Executive Chairman of the Board

As the design output from Robert Allan Ltd. to the global tugboat community began to border on the prodigious, we were often asked "how many tugs has your company designed?" Until recently we didn't have a good handle on that number, so the answer was usually either "a lot" or "many hundreds", neither of which were particularly illuminating! We reviewed our archives to determine the tally more precisely. Would we rival Helen??

Although accurate project records from the earliest years are not available, through the Harbour & Shipping archives at UBC we identified the first mention of a tug designed by Robert Allan, the ***Weaver Lake***, built in 1934 for Capt. E.C. Merchant. In our archives there is an undated set of drawings, including the very handsome little ink on linen profile drawing (above) for a "shallow draft towboat" whose dimensions at 41'-8" x 11' match the ***Weaver Lake***. A query to the Vancouver Maritime Museum turned up a photo of the ***Weaver Lake*** which certainly reflects the drawing. So we can, with considerable confidence, declare her as our "Eve"!

The 1940's were a time of the construction of many fishboats and of course the distraction of the war effort where both Robert Allan's were engaged in design activities with local shipyards. There are only 4 tugs in our files from that decade.

The 1950's began with our first steel coastal tug design. The 330 bhp ***Black Bear*** (below, in its "post refit" stage, showing little in common with the original other than the hull) was designed in April 1950, and built by Victoria Machinery Depot for Black Ball Towing Co. Ltd. Dimensions were 42.7' x 15.1' x 6.3'. A highly innovative feature was a hydraulically elevating wheelhouse, indicating that the tug needed to duck some bridges! At some point it was extensively rebuilt. It was still registered in 2003 and owned by a numbered company in Kitimat, but the registry of the tug closed in 2011.

The 1950's may have marked the real beginning of steel tug construction in B.C., but there were still wooden tugs being designed and built including the ***Tugger Yorke*** (above, R.F. Allan at the aft window) for F.M Yorke and Sons. Built in 1955, she was still in service on the B.C. coast in 2013.

A milestone tug designed in 1959 was the ***Ocean Master***, an early large tug design and almost certainly the first internationally-built tug from this office. This 125' tug was built in Holland in 1961 for Great West Towing and Salvage Ltd., and appears to still be in active service in Canadian registry.

The last years of the '50s marked the beginning of a transformation of the B.C. towing industry, with a federal shipbuilding subsidy providing significant financial incentives to owners to replace their aging wooden fleets with new steel tonnage. The ***Lorne Yorke***, designed in 1959, was billed as "The first modern twin-screw tug in BC" at her launching. Robert Allan Ltd. designed about 14 tugs in the 1950's.

The boom in new steel tugs continued in earnest throughout the 1960's, and Robert Allan Ltd. was at the forefront of these developments. 1969 was a year of very significant output from what was then an office of only 8-10 people. It also marked the first exchanges between Robert Allan Ltd. and C.H. Cates and Sons... a relationship which would have lasting and dramatic impact on our future. The following table lists some of the many notable tug deliveries from the total of 106 tugs built to our designs in that decade.

Notable Tugs from the '60's

1961	Jacques Cartier
1962	Evco Wave/Spray/Breeze
1963	La Reine
1963	Harmac Fir/Cedar/Pine/Spruce
1964	Gibraltar Straits
1964	Haida Brave
1964	Capt. Cook
1964	Harold A. Jones
1965	Island Chief/Island Master
1965	Irving Birch
1965	Irving Maple
1965	Le Mars
1966	Island King
1967	Irving Beech
1968	Jose Narvaez
1969	Hecate Crown

As the 1970's dawned, tugs for the Mackenzie River System and ice-class vessels for the Beaufort Sea consumed much of our talents, but there were some coastal highlights too, notably the 114', 2600 hp ***Jervis Crown*** (above) in 1976.

The early 1980's were dominated by projects for the Beaufort Sea and in particular with the design of ***Ikaluk*** and ***Miscaroo*** for Gulf Canada Resources Inc. These 78 metre,14,900 bhp icebreaking supply vessels were the only high ice-class AHTS's of their kind anywhere in the world at the time, and are still operating effectively in Sakhalin today. It was a very large and significant project for our office, and introduced me to the marked contrasts in efficiency and quality between domestic and Japanese yards. Those heady days of 1981-82 however soon led into the doldrums of the mid-1980's, a period of very little activity in the maritime world anywhere. There were however some notable bright spots in the '80's, not least of which was the development of the first Z-Drive tugs for C.H. Cates & Sons. The ***Charles H. Cates II*** (below) was first of a new generation of ASD harbour tugs, built 1983 with 2,400 bhp, 30 tons BP and a 76' LOA. She was followed by the ***Cates I*** in '86 and the ***Cates III*** in '90. These were among the very first Z-drive tugs in North America.

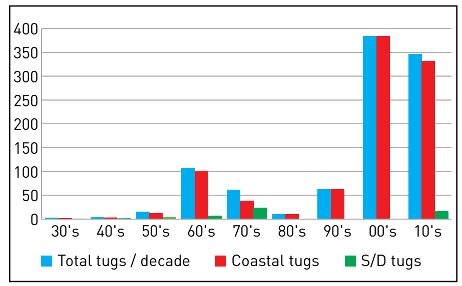
With the 1990's the era of the Z-drive tug really began in earnest. The small but mighty Cates tugs attracted attention and prompted enquiries from around the world. The lessons learned from working closely with Terry Waghorn and later with Claire Johnston of Cates stood us well. We had learned what works best in terms of hull form for these agile tugs and applied those lessons to ever-larger ASD type tugs. In 1993 a series of 4000 hp, 30 metre ASD tugs were built by East Isle Shipyards of PEI. These were highly successful boats and some were bought by major operators in Europe. That connection to major European owners, and in particular to Østensjø Rederi AS of Norway opened many doors for Robert Allan Ltd. and led to the opportunity to design several major and innovative tugs for the emerging tanker escort tug market. The business for new tugs was on a tear and we were well-placed to serve the burgeoning market with advanced designs.

In about 1995 I had a phone call from a university student in Turkey. Ali Gurun wanted to talk about escort tugs. Several months later he called again and advised me that his family wanted to build some new tugs. An amazing relationship between our companies was born and to date Sanmar has built more than 150 tugs to our designs in the process establishing themselves as a premiere tug-building shipyard. That connection quickly led to relationships with other shipyards in Turkey, notably Uzmar and Med Marine, and soon we were seeing more than 40-50 tugs per year being built in Turkey alone.

The development of ever larger container ships, major LNG terminals, expanding bulk carrier ports, and of course the rapid evolution of tanker escort technology demanded a whole new generation of high-performance specialized tugboats. Since 2000 Robert Allan Ltd. has had more than 720 tugs built to our designs worldwide. Added to the historical database the total number of tugs delivered stands, at time of writing, at 1005! The figure below illustrates this amazing growth! Note that the last column only includes the first 6.3 years of the decade, so we can safely anticipate that the next 3 years will show further growth.

And so to crown the "*KiloTug*"...the 1000th tug delivery in the now 87 year history of our firm!

That honour, most fittingly, goes to the *RAstar 4000-DF* ***Dux*** (above), the first of three ultra-high performance dual fuel escort tugs for Østensjø Rederi of Norway. Johannes Østensjø was the first Owner in Europe to purchase a Robert Allan Ltd. designed tug and our subsequent work with that fine company has always been "extra special". The ***Dux*** and her sisters are extremely powerful and capable escort tugs by any standard, and will be the first dual-fuel escort tugs in the world.



We extend sincere thanks to those many long term clients who have shown their continued faith in our work and who have supported Robert Allan Ltd. for many years.

And finally a special tribute and hearty thank you to Terry Waghorn and the late Claire Johnston of C.H. Cates & Sons whose vision of the "perfect tug" and whose initial trust in our design capabilities helped to spawn the whole modern Z-drive tug movement.

Deliveries

RAmpage 6500-ZH built by Eastern Shipbuilding Group

RAlly 1600 built by ICDAS Shipyard

ART 100-42 built by ASL Shipyard

RAmparts 3300 built by Jiangsu Zhenjiang Shipyard

RAstar 2800 built by Sanmar Shipyards

RAmparts 2200-SX built by Sanmar Shipyards

RAstar 85 built by ASL Shipyard

ART 80-98US built by Master Boat Builders

RAmparts 2400-W built by Astilleros Armon

RApide 2000-Z2 built by Estaleiro Rio Maguari

RAnger V-3300 built by Foss Maritime Company, second vessel on trials

RAmparts 2400-W built by Astilleros Armon

RAIndrops

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On the cover is a CFD generated wake pattern from an Articulated Tug and Barge (ATB) carrying out a self-propelled turning manoeuvre.

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