

Bill Pelky asked me whether I would contribute to the several ongoing discussions about tugboats and I am glad to do so. First, my credentials: I'm really not an expert but I am verbal and so may so pass for one. (You all know Henry Ford's definition of an "expert," don't you?) I'm a retired technical editor who got into writing about tugboats. My speciality is new tugboat technologies and I'm currently finalizing an article for the next issue of "Pacific Maritime" on what is happening with the new kinds of tugs such as the SDM, Rotor Tug, Carrousel, etc. I am also president of the Tugboat Enthusiasts Society and editor of its quarterly journal "TugBitts." Please check out www.tugboatenthusiastsociety.org if really interested in tugboats.

It was intriguing to read your postings. Much of the information I read was right, some is half-right, and then there is the rest.... My special congratulations to yacht boy, Capntroy and CG Bob for their contributions—useful and largely correct. And I admire the decorum of your group. Not all special-interest groups are so considerate of each other's feelingd!

First, let's define what a "tug" is. The ultra-simple answer is: any pointy-bowed (model bow) vessel that moves other vessels. Its opposite is a square-bowed vessel that pushes barges and that is commonly called a pushboat or towboat.

Much of the blame in achieving a precise definition of what a tug is (and in the past I have tried to fashion one and was derided for my efforts by the *real* experts) can be laid to the vagaries of the ever-evolving English language and the imprecision that creeps into well-defined words. For example, a dictionary tells one that "tug" means to pull or haul (and the generic name for the hauling or pulling vessel came from an 1814 English paddlewheel vessel named TUG) and it is true that tugs do tug. But they also push vessels or move vessels by attaching them alongside. Confusingly, "towboats" don't tow (although some history books says they once

did); they only push. OK so far? But very small towboats on the inland rivers are often called tugs and many tug companies have “towboat” in their names and many tugboaters call their vessels “towboats.” All very confusing and you must decide for yourself.

Defining tug types is not easy because many are multi-purpose vessels but I’ll give the subject a brief swipec. A tug might do ship work (mostly assisting ships to dock or undock) but it may also be equipped for escorting tankers (a very different job needing additional features such as a specialized towing winch and underwater skegs) and it can certainly move a barge or dredge when necessary. Other tugs are specifically designed and equipped for moving barges in harbor, coastally, or across oceans. A barge tug can tow the barge on a long hawser but it is preferable, sea conditions permitting, to push the barge, perhaps by inserting the tug into a notch in the barge’s stern—pushing is about 25% more-efficient process than towing. Increasingly popular and quite efficient are the articulated tug/barge combinations (ATB or AT/B) where tug and barge are rigidly connected so that the tug can only move along one axis (pitch). One unexpected ATB virtue is that the barge may keep the tug afloat if it gets holed—it’s happened! Other big tugs are designed for deep-sea towing while anchor-handling tugs/supply (AHTS) boats carry supplies to oilfield platforms and move their heavy anchors and thousands of feet of chain. Dedicated salvage tugs are now rare. Finally, quite a few tugs, large and small, have been converted into yachts, many of them extremely luxurious.

Now, let’s begin to define the various means of propulsion and their placement on a tug’s hull. For centuries, a vessel was moved by either wind or sweat (either human or animal, perhaps as in “I had a mule. Her name was Sal”). Then along came steam and soon thereafter a fight over whether to use steam engines to drive paddlewheels or propellers. Over a period of several years, the Royal Navy used several pairs of roughly equivalent vessels (for

example, the paddler ALECTO and the screw-equipped RATTLER) in a series of shockingly defined (by today's rigorous engineering standards) but definitive tests and the propeller won. The Royal Navy breathed a sigh of relief: no more paddlewheels exposed to shot and shell, no uneven loads on fragile machinery as a ship rolled, consistent propulsive effort in spite of changes in a vessel's draft; no more machinery using the most-useful space amidship on a warship but safely installed below the waterline, etc.

It was steam and propellers for tugs for over one hundred years although paddlewheel tugs lasted into the Fifties when the stern-paddler PORTLAND, a ship-docking tug in Oregon, was retired to become a museum piece and the final five of the Royal Navy's side-paddlers were taken out of service along with the aircraft carriers they served. Steam engines and fuels of wood or coal gave way to oil fuel and Diesel engines. Life for the tug designer must have been pretty hum-drum!

Then, in 1925. Ernst Schneider invented a cycloidal drive that had a horizontal circular plate with protruding vertical blades that were pivoted to provide thrust in a desired direction as the plate slowly rotated. Voith, a German manufacturer of heavy machinery, bought the rights to Schneider's device to even out its factory workload, developed the Schneider drive, and marketed it. Several decades later, two Voith-Schneider Propellers (VSP) were placed side-by-side under a tug hull and the famed Voith Water Tractor (VWT) was born.

Elsewhere, 1940 saw the invention of the azimuthing drive. In that year, the US Navy defined a general need to engine-makers Murray & Tregutha in Boston and the company came up with the azimuthing drive. The company packaged it as part of a stand-alone deck-mountable unit consisting of a gasoline engine, controls, and a drive unit that could be cranked down and, more importantly, continuously rotated to any direction. These units

were widely used on barges during World War II, especially in the Normandy Invasion, and post-war were named Harbormaster Drives.

Foreign tugowners quickly adopted both propulsion systems but, on the other side of the Atlantic, tugowners maintained that their tugs did everything required of them by the customers, most of the tugs were paid for, and there was simply no need to invest in new, expensive, and very-alien machinery. (However, a few far-sighted North American companies did build a tug or two equipped with Voith or azimuthing drives. One company was Seattle-based Foss Maritime, which built several Voith tractors in the Eighties. We will meet some of them later.

Then came the EXXON VALDEZ oil spill, swiftly followed by enactment of the Oil Protection Act of 1990 with its requirement for tanker escort by tugs incorporating the "Best Available Technology," commonly known as BAT.

What was BAT? Nobody knew for sure. How could a tug weighing a few hundred tons control unanticipated behavior by an out-of-control tanker weighing several hundreds of thousands of tons? (The answer lies on something called the indirect mode, which I will not explain now.) Could a conventionally driven tug (that is, using propellers) qualify as a tanker escort? Or would it be necessary to resort to new tugs equipped with Voith or azimuthing drives? Much sea testing (some of it frighteningly dangerous until the towline snapped), model-basin testing, and many computer runs showed that a big conventional tug (like a MR DARBY) would suffice as an escort up to tanker speeds of a few knots. But tankers are driven to meet tight schedules and don't like to slow down until they have to. (I was once on the mighty LINDSEY FOSS doing 14 knots near the mouth of Puget Sound and the tanker we were to escort passed us. It slowed and we caught up.) Tugs with azimuthing drives performed better (up to tanker speeds

of six knots or so) and tugs equipped with the more-expensive Voith Schneider drives were the best but only up to eight-ten knots.

Suddenly, American tug owners had to do something about adopting the new technology because their customers (meaning the oil companies but also shipping firms and especially the pilots) were demanding tugs with BAT. A building boom, perhaps containing elements of keeping-up-with-the-Jones, started, and is still under way.

(Funnily enough, the average age of an American tug is about 38 years and the current building rate does not allow fleet replacement at a rate that most businessmen and auditing firms would tolerate as good practice. But this is a world in which Air Force pilots fly the same planes their daddies flew....)

Let us look at where propulsion devices can be placed. Propellers, also known to officialdom as screws, are almost always located at a vessel's stern. They may be out in the open or encircled with annular nozzles, aka Kort nozzles after their inventor, Prof Kort, that concentrates the water stream from a propeller to provide additional (up to 40% or so) thrust forward. (Due to a Kort's hydrodynamic shaping, it doesn't work as well in reverse.) Propellers can be right-handed or left-handed (depending on the engine) and may turn inward or outward (depending on the type of work to be done by the tug). A propeller may have three, four, or five blades (the more the blades the less noise and vibration and thus the smoother the ride) and the blades may be highly skewed. The pitch of each blade may be varied from the wheelhouse, thus producing a controllable-pitch prop (or, as the president of one tug company insists, a *reversible*-pitch propeller). I could talk about rudders here but may get to that subject some other time.

Voith-Schneider cycloidal drives (so-called because the blades follow a cycloidal path as they rotate) are usually placed forward of amidships, and need to be counterbalanced by a large skeg at the other end. A single Voith unit has been used on tugs but mostly two units are used, producing what Voith has advocated for years as the only true tractor, the Voith Water Tractor (VWT). Like most modern ship-assist tugs in which a ship is handled at the end of the tug away from its power unit or units, a VWT handles a ship over its stern. But several operators believed that seakeeping and tanker-escorting would be better, and line-handling would be better monitored by the tug master, if performed over the tug's bow so they had fin-first Voiths built.

Azimuthing drives are also known as Z-drives because the power follows a z--shaped path from main engine through the powerhead, down the leg, and around a corner to the propeller. There are many makes of azimuthing drives, with Schottel (Germany) and Rolls-Royce/Aquamaster (Finland and an amalgamation of Ulstein and Aquamaster) being major makers. Others makers include Thrustmaster of Texas, Holland's HRP, Finland's Steerprop, and Japan's Niigata.

By the way, Azipods are pods on a stem. Inside the pod are an electric motor and a propeller, and an Azipod may be either fixed or steerable. Azipods are used on many cruise ships, a few oilfield drilling ships and mobile drilling units, and several modern icebreaking vessels (for example, the Coast Guard's new USCGC MACKINAW) but not, as yet, on a tug.

Before modern tugs came into use, Europeans and the Brits tended to use ship-assist tugs on relatively long lines from the ship to the tugs because of the nature of their ports (often tidal with enclosed docks accessed through narrow passages with tidal gates). Thus the hard, sweaty work was done on the tug's after deck.

Remember my comment about deck work being at the opposite end from the propulsion source? The custom carried over to the first generation of new tugs, whether equipped with Voith or azimuthing drives, and that may be the reason that the early azimuthing-drive tugs were tractors with the drive units extending below the bottom of the tug's hull forward of amidships. A tractor's drive units sat deep in the water (very good for propulsion) but shallow waters posed a peril (bad for the units and tug).

So why not use the azimuthing drives to replace the screws and their struts and stiffing boxes, and the rudders with their accompanying steering apparatus and thus take advantage of shallower draft and use of accustomed space under the stern? Thus was born the azimuthing-stern-drive tug, commonly abbreviated as ASD, and, for a while it was known as a reverse-tractor tug. But it was soon realized that "ASD" and "tractor tug" sounded just great but "ASD" needed explaining and "tractor tug" didn't and, to boot, "tractor" sounded sexy, powerful, etc so ASD soon became replaced, in part, by a triumphant "tractor tug"! It's now proudly emblazoned on the hulls of many tugs even though they are but mere ASDs, and only a few editors of tug magazines try to keep the faith and use "reverse-tractor" wherever appropriate.

By the way, although azimuthing drives are usually used in pairs on tugs, several old, single-screw tugs were rejuvenated by addition of a drive at the bow, thus creating the combi-tug, of which a dozen or two exist. .And then there was the odd case of the Pacific Coast ex-whalekiller-turned-tug that needed a separate get-home power for one contract so a fixed azimuthing drive was installed at the turn of the bilge on each side of the hull. Finally, until recent price increases due to the scarcity of drive units, an ASD could be built for slightly less than an otherwise-equivalent conventional tug. (New azimuthing drives are in short supply now

because the same gears are used in the increasingly popular wind turbines.)

Now let's explore the variations with names like the Ship Docking Module, the Rotor Tug, the Tractor-Plus, the Carrousel Tug, and the Z-Tech tug. (Here I will adapt material from my upcoming article.)

The Ship Docking Module (SDM)

Tug company owner Erik Hvide wanted a powerful ship-assist tug capable of pushing at maximum bollard power in any direction to work in the narrow slips prevailing at Florida's Port Everglades. All that and he wanted a crew of only one! His highly imaginative early sketches of this ideal tug showed a circular vessel with a single azimuthing drive centered under a flat-bottomed hull and, topside, a tiny "command capsule" sitting atop a boxy superstructure holding a head-line winch and a small dayroom. Everything above deck was free to rotate. No deckhand would be required because a retractable crane would lift the wire up to the ship being worked. The concept was so radical and un-tuglike that Erik Hvide called it the Ship Docking Module (SDM).

Seattle's Elliot Bay Design Group explored his initial concept, developed it, and came up with a feasible design. Many thought it looked like a vehicular ferry or a flying saucer because it was 90 feet long and had an amazing beam of fifty feet. (But eyes soon became accustomed to other tugs with today's excessively wide beams.) The SDM was a two-man, twin-engined 4,000-hp tug vessel with an azimuthing drive at diagonally opposite corners and skegs at the other corners. And it could walk sideways at seven knots while producing 95% of the ahead bollard pull! (When an SDSM is required to press a ship against the wharf while moorings operations are completed in a narrow slip, the SDM suddenly becomes a a powerful 50-foot-long tug.) Three SDMs were built

by Halter Maritime and the first unit was a smash attraction at the 1997 International Workboat Show

Hvide expected hundreds would be built; he was wrong for several reasons including bankruptcy. When Hvide lost control of his company, three more SDMs to an improved Mk II design were under construction by Halter. Eventually, most were completed. All SDMs work daily and one hears little about them.

But then, in 2004, Seabulk Towing licensed the European rights to Spanish towage operator Remolques Y Servicios Maritimos (REYSER). For contractual reasons, the design is known over there as the Asymmetrical Tractor Tugs (ATT). REYSER now operates two ATTs and plans to replace its entire fleet of tugs with them.

In addition, Seabulk is having a “green” low-emissions version of an SDM designed. Finally, the SDM is on the short list of the Panama Canal Authority’s request for proposals to supply thirteen tugs?

There is an ironic aspect to the SDM story. Hvide had his attorneys diligently search worldwide for any patent that might compromise his patent application. They found none. But, unknown to the searchers, two tugs remarkably like the SDM had been docking bulkers at the Ridley Island bulk depot at Prince Rupert in British Columbia for some years. Minette Bay Ship Docking has two tugs cobbled together from components from a failed experiment and each tug had a single 3,560-hp engine driving an azimuthing drive at each end of the hull. (The tugs usually work a ship while sidling sideways.) The owners had never bothered to patent their invention; it was “too obvious.”

Rotor Tug

The Rotor Tug also arrived in the late Nineties. Dutch tug operator Ton Kooren had imported several of Thomas Faust's ahead-of-their-time true-tractor tugs from the US and loved them. But he came to wish they had more power, more *everything*! How to get what he wanted? The answer came to him one morning at 2 AM; add a third azimuthing drive as an active skeg! Smart businessman that he was, Kooren promptly set designers to work and invented two important marketing terms: Rotor Tug and *tug*nology. In late-1998/early-1999, four 78-ton-bollard-pull tugs were delivered to his Kotug towage company. Then, as soon as it became obvious to the world that these expensive but very-capable tugs were successful, Kooren created a sales and design company, now known as KST.

Kotug currently owns eight Rotor tugs of two designs and operates them in German, Dutch and French ports. Other European operators and an investment company in Southern Europe are having close to twenty Rotor Tugs built in Japan and Singapore for deliveries into the late-2010 period.

Meanwhile, KST and Robert Allan Ltd are cooperating on a design for an offshore 7,000+-hp escort tug capable of a bollard pull of over 100 tons and sidestepping at 6 knots. The design incorporates an innovative retractable panel ("centerboard," anyone?) in the skeg that can be extended when in indirect modes of operation to help create 165 tons of steering force. And another design is for a specialized tug to support a FPSO (Floating, Production, and Oil Storage) vessel.

Since Man has only two hands, the reader may wonder how a three-drive tug is driven? In the case of a Rotor Tug, there are two ways, both needing just two hands at most. When in the ship-assist mode, the stern drive is locked and provides thrust as needed while maneuvering is done with the two forward units. When barge-towing, the forward units are locked and the stern unit steers,

Tractor-Plus

Hyundai notified Foss that it would be bringing bigger container ships to Tacoma and asked whether Foss would have tugs available to handle them? Maybe something putting out at least 50 tons of bollard pull each? Foss's big tugs at Tacoma were the somewhat-elderly 3,000-hp Voith tractors *Wedell Foss* and *Henry Foss*, each good for about 35 tons of bollard pull, and Foss hope to continue to use them there. Adding more power and installing bigger Voith drives to these tugs might do the trick but examination proved that option impracticable. Adding an azimuthing drive at the stern seemed do-able but consultation with *the* expert (and holder of an vital patent) was indicated. So Foss folk went to Europe for discussions with KST.

The final result of this trans-Atlantic cooperation was what Foss called the Tractor-Plus. The *Wedell Foss* and *Henry Foss* plus sister-Voith *Brynn Foss* stationed at Long Beach each got a new Cummins KTA50 M-2 engine driving a Schottel azimuthing drive installed just in front of a cut-down skeg. Key to final performance was the use of a controllable-pitch propeller with full feathering.

Using the azimuthing-drive as an active skeg, any of the three now-4,700-hp Tractor-Plus tugs can walk sideways at over five knots while still having cycloidal thrust available, and the bollard pull is a satisfying 57 tons. All at a cost of about US \$2 million per conversion, and that is somewhere between 1/4th and 1/3rd the cost of a new tug!

*The Tractor-Plus tale also has an ironic aspect. Unknown to Foss, Finnish tug operator Alfons Håkons had been operating its 1,400-hp tug *Akilles* in the Baltic for some years. It had a Voith drive but, more importantly, aft of a stern skeg, it also had an Aquamaster*

azimuthing drive! True, the little tug had only a single Voith unit but....

Z-Tech Tugs

In 2005, Singapore operator PSA Marine challenged Robert Allan Ltd to come up with a tug design that would satisfy multiple and sometimes-conflicting requirements: a tug that could operate as either a true tractor or as an ASD, do ship assist but make coastal voyages towing barges, work under the flare of a ship without threat to wheelhouse, have a large clear deck, etc. RAL came crashing through! The result was the “push-me pull-you” Z-Tech Tug, currently available in the 4500, 6000, and 7500 types (each number roughly representing a type’s total horsepower).

A Z-Tech tug has twin azimuthing drives forward of amidships, thus making it a true-tractor, but the heavily fendered stern was carefully shaped to act as a bow when the tug is operated as an ASD while working ships over its stern; the wheelhouse was set well forward towards the true bow; and the afterdeck was flat and clear of obstructions. PSA Marine was pleased with the Z-Tech design and quickly ordered several of the 6000-series built Orders soon flooded in and the Panama Canal Authority ordered eight Canal-specific variations. To date, some twenty or so 6000-series tugs have been built or are on order.

Orders for the other two classes, funnily enough, have been confined to North America. Two Houston-based Texan tugboat firms between them ordered several 7500’s from two Gulf Coast builders and in British Columbia, another 7500 is being built at Vancouver Shipyards for sister-company Seaspan. As for the smallest Z-Tech class of all, the 4500—sales there are discussed later.

Carrousel Tugs

The Carrousel Tug concept was introduced at an international tug and salvage conference in Bilbao, Spain in 2002. The intent of the Carrousel concept is to prevent girting (the tug forced to roll down and perhaps over by the pull of a line from one side.) Girting can happen anytime and quickly—only last December the big Scottish tug *Flying Phantom* was lead tug of three escorting a bulker on the Clyde River at night in very thick fog when it ran aground and was rolled upside-down before the line could be released. Only one of four crewmen survived, and he was rescued only because someone on one of the other tugs had an intuition that something was wrong and cell-phoned a pal ashore asking him to take a launch out and check.

The Carrousel Tug principle has a towline connected to a carriage traveling on a circular track encircling the superstructure. The carriage may carry either a towing hook or a winch. No matter what direction the line leads, its pull is always be centered through the tug's center of pull. More importantly, since the track is the full width of the tug's beam, the tug cannot be pulled down and over. (Think of a line tied to the gunwale of a rowboat and visualize trying to dip the gunwale into the water. It can't be done by a steady pull.) As a prototype, an existing small combi-tug with a total of 1,300 hp was fitted with a Carrousel system and proved to be successful. In the indirect mode, this tug, which normally provided 21 tons of bollard pull, provides 115 tons of indirect resistance!

But orders were slow to appear, perhaps due to an inefficient marketing organization that was only interested in designing and selling complete tugs equipped with the Carrousel system. To date, only two Carrousel Tugs have been ordered, and both were ordered by one of the Carrousel Tug's sponsors. These 108-foot, 6,000-hp tugs have a large nozzled propeller at the stern and an azimuthing-

drive at the bow and are being built in Malaysia. A bollard pull of over 80 tonnes (88 tons) is expected.

The Dynamic Oval Towing System

Mampaey Offshore Industries BV, a Dutch maker of towing hooks and other hardware, was another of the three original sponsors of the Carrousel Tug concept but, apparently impatient with the progress not being made, it broke away to push a simpler version of the Carrousel track that it calls the Dynamic Oval Towing (DOT) system. Like the Carrousel Tug, it makes it virtually impossible to girt a tug. Unlike the Carrousel Tug, a DOT has only three add-on components: a track that is, as its name tells everyone, oval and a carriage with a Mampaey towing hook. The first DOT system sold was installed on a 43-foot, twin-screw Scottish tug designed by Macduff Ship Design in conjunction with Mampaey.

Any questions? Bill Pelky will relay them to them. Thanks for reading.