

The Design of Modern Tugboats

By Robert G. Allan P.Eng

In 1970 there were still many single and twin-screw, relatively low-powered tugs performing ship-assist work. The concepts for the first Schottel/BCP Z-drive tractor tugs were introduced by Corlett and Bussemaker at the 2nd International Tug Conference in 1971, and contemplated tugs with from 6.4 to an awe-inspiring 54 tons of bollard pull (BP) in the largest (33 m) tug of the proposed series. How times have changed! Today a new tug of 50 tons BP or less is rare for any ship-handling task in a major port.

The Z-drive tug, and specifically its Azimuthing Stern Drive (ASD) configuration, has evolved as the dominant tug type of choice worldwide; Z-drive tractors are rare, and VSP tractors have their continued share of devotees. (Note that in this article the correct usage of the term “Tractor” is used, meaning a tug with the drive system located forward of midships, rather than as a much misused generic term for any tug with omni-directional propulsion.) The triple Z-drive Rotortug™ initiated the development of a whole range of new ideas about tug design, and ways to do ship-handling with tugs in more efficient

(or at least in different) ways is the subject of ongoing conceptual development, including the potential for completely unmanned tugs like the **RAmora** concept. Unfortunately the measure of merit for tugs, at least in terms of their stability and basic safety, has not changed much since 1970. What have really changed are the size of ships and the pace of international shipping and therefore the commensurate demands placed on tugs, tug crews and on Pilots to move these ever larger and more cumbersome ships into port as quickly as possible. Tugs have grown substantially in power, but not so much in size, at least not in length. Regulations “pressure” owners to build either under 24 meters to avoid Loadline Rules or under about 32 meters in order to stay under 500 GRT and thus avoid SOLAS and various more costly manning regulations and licensing requirements. (The USA has its own

unique and archaic methods of tonnage measurement and associated regulatory hurdles). The consequence is to pack ever more equipment and power into vessels with relatively short, fat hulls in comparison to the more slender styles of a generation or two ago. Accordingly the basis of analyzing tug stability by classical methods is certainly no longer valid. We in the design community must be certain that we can assure our clients and their crews of a safe boat, and the owners

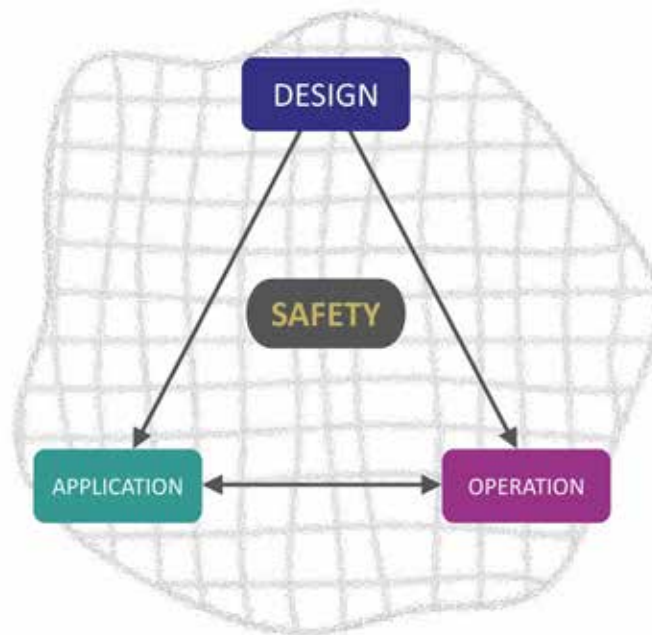
need to know that the tug they purchase can truly be relied upon to work safely and protect their crews in the roles for which it was intended. If a vessel is used inappropriately it cannot be assumed that safety is assured

No-one questions that towing can be a dangerous activity, but why is it that today what can only be considered as “unsafe” vessels are being put into service in such duties? In January 2015 a brand new Chinese-built ASD tug was running on trials, tripped, capsized, and sank within seconds taking with it the lives of 22 persons. “Initial investigations found that it capsized due to “improper operations”.

According to the [local authority], the tugboat operators did not complete the compulsory procedures needed for trial operations, nor did they report the tug’s conditions to authorities. The boat sank in the midst of a full circle swinging due to improper handling.”

Regardless of whether an “authority” has seen the condition of the tug or not, how is it possible that a supposedly modern vessel could be designed and built today, apparently in accordance with current standards and then capsize just by executing a turn, regardless of how fast or “improper”?

It is quite fair to say that this tragic incident is further evidence that the technology of tug design and operations today has far outstripped the regulations that are intended to govern vessel safety. It is now almost solely our responsibility as Professional Engineers and Naval Architects to ensure that the tugs we design are as safe as they can possibly be for our



The overall safety of tugs can be considered as a triad of the highly inter-dependent elements of design, application, and operation. Artwork courtesy of Robert Allan, Ltd.

clients and their operating crews. The limits set by virtually all regulations do not provide a sufficient basis for ensuring safety in tugs today, at least in part because they do not fully address three fundamental elements of safe tugs, namely design, application, and operation. The overall safety of tugs can be considered as a triad of these highly inter-dependent elements.

At the apex of the triangle is *design*. Without a proper design the other two factors cannot be realized, nor can overall safety be achieved. The base of the triangle comprises the sister elements of *application* and *operation*. Before selecting any tug for a job the owner/operator must first know if it is a tug which has actually been designed for the intended application (ship-assist, escort, towing or whatever) and if so, will the intended operations be consistent with the boundaries imposed by the design and the application.

Unfortunately there are those who feel that by relying solely on local or even Class Society regulations for tug safety that all will be well. Even more critically, there are those who believe that by simply just meeting the minimum standards of such regulations that they have designed a “safe” vessel. Nothing could be further from the truth: undoubtedly that tug will be less expensive than one where significant care has been exercised in every aspect of the design, but is it really suitable for the tasks ahead, especially after a few years of weight growth etc.? Some very serious research is required to ensure a much better understanding of how tugs react to all of the forces encountered in typical towing and ship-handling operations today, which are indeed dramatically different from those of 20 or 30 years ago. It cannot be hoped that Flag State authorities will step up to do the research necessary in any reasonable time frame, nor do they typically have the expertise necessary to understand the complexity of a modern tug or even normal tug operations. A few Classification Societies have thankfully embraced the concept of harmonized rules for tug design and tug safety, with Bureau Veritas taking a strong lead and doing excellent work to improve safety

standards aboard tugs. We at Robert Allan Ltd are very pleased to support and participate actively with BV, Lloyds and ABS in this critically important work.

It is likely impossible to develop a completely foolproof design, as designers have no control over the manner in which the vessel will be operated. We can however do our best to identify areas of operation where there are serious risks if the tug is mishandled or used in an inappropriate application. We also have some extremely powerful tools at our disposal today with which to evaluate the “safety envelope” of a tug and then clearly advise the Operator where he may expect to be pressing the margins of safe tug operations.

So there is a collective responsibility within this industry to ensure tug safety:

Naval Architects must do their work professionally and responsibly, with a clear understanding of the intended duties

Owners must ensure that they fully convey to the Naval Architects what tasks they expect a new tug to do, and in what sort of conditions

- Owners must then ensure that the tug is used within those application boundaries
- The builder must adhere to the design and in particular respect the weight and stability characteristics as defined by the Naval Architects
- The Naval Architects must clearly define the boundaries of safe operation for the design in clear terms for the benefit of the crew
- The Operator must ensure that they are familiar with the limitations of the specific tug and not use it for applications for which it was clearly not intended

Unfortunately the industry is now in a situation where the ultimate safety of a tug is often left in the hands of the operator. Tug Masters today are given extremely powerful, complex and versatile machines to work with, and in many instances have not been given a suitable “Instruction Manual” to guide them. At present the engineers at Robert Allan Ltd are actively working to rectify that situation.

While the majority of tugs being built today are well designed and used by very responsible and professional operators, it is unfortunately true that more than a few recent tugs do not reflect best practice of “modern design”. They lack sufficient freeboard and in many cases lack the structural integrity to support the high loads that can be generated. In particular stability standards need to be assessed not just in terms of traditional intact dynamic stability, but with consideration of all the forces that the tug is capable of generating, and in what type of situations. Ideally a tug should be proven to have a “failsafe” design in the circumstances when either an externally applied or a propulsion-generated force is suddenly interrupted. This sort of analysis goes far beyond any conventional form of stability analysis, but is essential today in the world of increasingly high-powered tugs.

As shipping continues to expand and ships grow ever larger it is past time to carefully examine the safe design of tugs and all that entails. It is irresponsible and unprofessional to simply continue to emulate what “has worked fine for years”...the goal posts for safe tug design and operation have moved too far, and we owe every mariner the right to the safest tugs possible. **PMM**

Since graduating with honors from University of Glasgow with a B.Sc. in Naval Architecture in 1971, Robert G. Allan, P.Eng has been designing commercial workboats of all types, especially high-performance tugboats for tanker escort and offshore terminal operations. Allan, Executive Chairman, Robert Allan Ltd., is internationally recognized as a leading authority on the subject of tug and workboat design and has received several major peer awards for this work.

This article is a precis of a far more extensive paper on this topic to be presented by Robert Allan at the 24th International Tug & Salvage Conference in Boston later this month.

