RAindrops

Robert Allan Ltd. Information & News Issue 17

THE ESCORT ISSUE

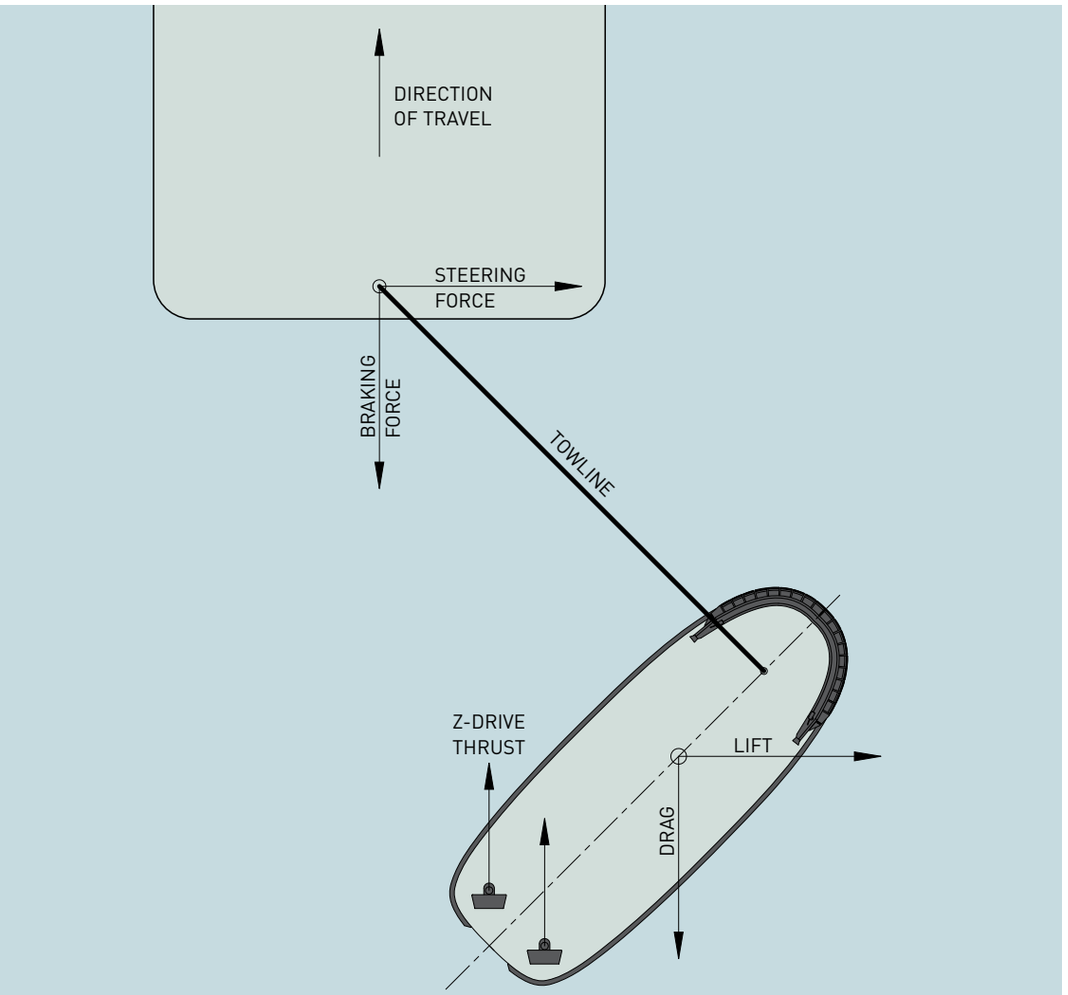
ROBERT ALLAN LTD.

NAVAL ARCHITECTS AND MARINE ENGINEERS

What is an Escort Tug?

by Jim Hyslop

There is a lot of misconception about what truly constitutes an escort tug. In many cases people assume that any tug connected to a moving ship is escorting but this is not the case. When the tug is not imparting any force on the ship and the speed of the connected vessels is less than 6 knots, the situation is properly defined as a ship-assist mode. To be truly considered escort capable, a tug must be able to safely and effectively provide steering and/or braking forces at speeds greater than 6 knots. This is typically done in an indirect towing mode, utilizing a combination of hydrodynamic lift and drag from the hull and skeg providing towline tension, and thrust from the drives to maintain position.



There are two primary reasons that escort tugs are required; to provide routine assistance to a moving ship in a narrow channel that it would not normally be able to navigate on its own (thus requiring steering assistance from the tug). Additionally, escort tugs are used as a safety mechanism in situations where the cargo is particularly valuable or environmentally sensitive, or where the shipping lanes themselves are critical to the operation. In this case the tug would only contribute to the ship's speed or heading when called upon by the pilot.

There are several factors that contribute to an escort tug's suitability for the job, but they can be summarized under the headings of safety and effectiveness. In addition, both the class societies and our own internal design guidelines dictate certain criteria that must be met. To be effective, the tug must have a properly designed hull and skeg, with characteristics that are quite different from typically ship-assist tugs. The size and position of the skeg, coupled with the hydrodynamic characteristics of the hull, have a huge effect on the amount of steering and braking force that the tug can generate. It must also have sufficient propulsive thrust to enable proper positioning at all of the required speeds.

With regards to safety, there are several aspects to consider; primarily stability and towing equipment. The tug must have enough reserve stability in this very dynamic situation to properly counteract the extremely high heeling moment that is generated in escort situations. Additionally, all the towing equipment; winch, line, staple etc. must be engineered for the intended service. For winches this may include an active payout and retrieval system to prevent slack lines and shock loads. All of the components must be designed with sufficient strength to prevent failures, which may put the crew, tug and assisted vessel in jeopardy.

There are several varieties of tug that Robert Allan Ltd. has developed to provide escort services to meet the most stringent of requirements at any port or terminal worldwide;

ART

The *ART* (Advanced Rotortug®) designation applies to tugs featuring the unique triple drive configuration designed by Robert Allan Ltd. under an exclusive agreement with Rotortug® (KST) B.V. Offering enhanced omni-directional maneuverability and control, with a redundant propulsion machinery configuration, the *ART* series offers enhanced performance for ship-handling, terminal support and escort towing. The *ART* series is poised to take the Rotortug® concept to the next level of development: as a truly viable solution for ship-handling in today's ever busier and more congested ports, and for escort towing applications where high performance and reliability are paramount.

RAstar

The *RAstar* escort/offshore terminal tug designation is reserved for a distinctive class of very high-performance ASD tugs, designed with the unique sponsoned hull form developed exclusively by Robert Allan Ltd., which has been proven in both model and full-scale testing to provide significantly enhanced escort towing and seakeeping performance. Escort forces are enhanced by the effects of the sponsons as well as by the prominent foil-shaped escort skeg forward.

Photo courtesy Mike Zelt

RAVE
The *RAVE* (Robert Allan Ltd. Voith Escort) tug is a new concept for a highly maneuverable, high-performance escort and ship-handling tug, jointly developed by Robert Allan Ltd. and Voith Turbo Marine. The most unique characteristic of the *RAVE* concept is the longitudinal alignment of the two VSP drives, in contrast to the more conventional transverse "tractor" configuration. The *RAVE* design offers very precise and improved force generation characteristics, essential for the demands of indirect escort towing, and critically important for working in confined harbour and channel areas. The *RAVE* tug uses the variable pitch characteristics and the X/Y–logic of two Voith Schneider propellers for optimum power allocation and precise maneuvering.


Photo courtesy Novatug B.V.

RAzer
The *RAzer* series are another development in the evolution of Robert Allan Ltd. high performance z-drive ship-assist/escort tugs. These powerful tugs are optimized for every aspect of ship handling and tanker escort service, but due to their "aft-biased" layout are not generally recommended as a configuration suited for towing astern. Generous freeboard ensures a high range of stability and excellent indirect escort force generating capability. The superstructure is kept low and well aft to enable safe working under the flare of ships.

TRAktor
The *TRAktor* designation combines the AVT and AZT series of tractor tugs into a single series. Because the functionality and form of these tugs are so similar, in effect the same design can be offered with either VSP or Z-drive propulsion. The *TRAktor-V* designation applies to Voith-propelled tugs designed for harbour, offshore terminal, or tanker escort duties featuring the unique, sponsoned hull form developed exclusively by Robert Allan Ltd. for superior escort tug performance. This form is similar to that used in the high-performance *RAstar* series tugs. The *TRAktor-Z* designation applies to similar Z-drive-propelled tractor tugs (drives forward of amidships), for the same range of duties. *TRAktor* tugs can accommodate a wide range of powers and other equipment, according to Owner requirements.

Robert Allan Ltd. is a world leader in the design of escort tugs, and this edition of RAindrops is dedicated entirely to the subject. The above topics will be discussed in detail on the following pages – please enjoy the issue!

Escort Stability & Safety

by Darren Hass, P.Eng.
and Chandan Deol, EIT

Compared to typical ship-handling tugs, escort tugs need a higher metacentric height and more freeboard to resist the expected towline forces and wave build up associated with indirect towing operations. For stability, it is also important for the tow point (where the line leaves the staple) to be as low as possible; potential downflooding points should be as high and inboard as possible.

Size matters. Escort tugs are generally between 28 and 40 m in length. Tugs less than 25 m may not be able to generate high enough indirect hydrodynamic forces from their hull and keel. Tugs over 45 m can generate very high escort forces but may have more difficulty managing them if they are not manoeuvrable enough. Typically tugs over 40 m in length are seldom used in ship-handling operations for this reason. Of course, the strength of the towing fittings on the escorted ship may also become a limiting factor with excessive escort forces.

As a consequence of a seminal paper written by Robert Allan at ITS 2006 [1], there has been a concerted effort over the last few years, led by Bureau Veritas (BV), to improve and harmonize escort and towing stability criteria between the major Classification Societies. A big step forward came in 2016 when IMO adopted amendments to the 2008 Intact Stability (IS) code based on BV guidelines that will come into force in January 2020.

Class stability criteria for the design of escort tugs are based on quasi-static, calm conditions, although in reality escort operations will likely involve dynamics from waves and manoeuvring. To help a tug Master keep an eye on stability in terms of heel angle during escort, Robert Allan Ltd. introduced a new escort stability placard for the wheelhouse last year. This is now prepared with our stability books for all new escort tugs.

The placard clearly shows safety zones for heel angle and 'Rated Escort Speed' during escort. There are three heel angle zones: **NORMAL** zone for the average (steady) heel angle, **CAUTION** zone for the maximum dynamic (momentary) heel angle, and **CRITICAL** zone where safe limits are exceeded. Heel angle zone boundaries are derived from heeling energy ratios based on the tug's righting-arm (GZ) curve.

Obviously, keeping escort forces and heel angle within the zone limits requires the tug Master to have reliable real-time information on speed, towline forces and heel angle in the wheelhouse. With that in mind, we continue to advocate for towline tension display and heel angle indication as mandatory under all Classification Society rules, not just under BV. We are also working with winch and inclinometer suppliers on ways to automate winch safety features and alarms.

Maintaining an excellent safety record in escort tug operation must be a priority for designers, Classification Societies, tug operators, ship owners and port authorities alike. To this end, Robert Allan Ltd. is collaborating closely with progressive classification societies to refine and improve stability criteria for escort tugs, particularly as they relate to real-world factors such as dynamics and the best ways to establish and communicate clear & practical operational criteria for escort operations.

[1] A Proposal for Harmonized International Regulations for the Design and Construction of Tugboats: R.G. Allan, Proceedings of ITS 2006, 19th International Tug & Salvage Convention.

ATTENTION

Recommended Limits for Escort Operations

Great care and attention must be exercised when conducting tethered escort operations due to the high forces involved. **Forces generated during escort operations can exceed the stability or towing equipment limits of the vessel leading to sudden capsize or equipment failure.** It is the Master's responsibility to operate the vessel within safe operational limits during tethered escort operations.

Vessel Design: [Design]
Vessel Name: [Name]
Rated Escort Speed: **10 knots** (ship speed through water)

HEEL ANGLE ZONES

Arrival – Condition #X(A)		Loadline – Condition #Y(A)	
< 12°	NORMAL	< 11°	NORMAL
12° < θ < 15°	CAUTION	11° < θ < 14°	CAUTION
> 15°	CRITICAL	> 14°	CRITICAL

NORMAL	CAUTION	CRITICAL
Zone for steady (average) heel	*Zone for max dynamic (momentary) heel*	*Exceeds safe limits of stability*
Attention Required	***Imminent Response Required***	***Reduce Heel Immediately***

References: **(A)** 218-000 11101R1 Final Trim and Stability Book
Notes: The Master ***must*** be familiar with the contents of the class-approved Trim and Stability Book, including the operational guidance related to escort operations, prior to undertaking any escort operations. The limits expressed herein are not to be used as the sole basis for conducting safe tug operations by the Master.

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Getting the Deck Equipment Right

Vince den Hertog, P.Eng.

To get the most out of an escort tug, the towing related deck equipment at BOTH ends of the towline needs to be right. Get it wrong and escort performance can limited by it, or worse, safety is compromised. The escort winch, staple and towline together comprise an 'escort towing system' that serves as the crucial link between the tug and the escorted ship. Each piece needs to be carefully chosen and arranged. So, when it comes to designing the towing system for an escort tug, Robert Allan Ltd. put a lot of thought into designing the escort towing system as a whole to get the most out of escort tugs steering & braking performance capability safely. Unfortunately, we cannot have the same degree of control over the ship fittings to which the towline is attached. Owners, Shipbuilders and Class Societies are urged to pay strict attention to the demands placed on deck fittings by active escort operations.

During escort, particularly in waves, the winch has a critical role to play in preventing the towline from parting, reducing the motions on the tug itself and in limiting heeling to within safe stability limits. Although classification societies require an emergency quick release function as a minimum, for escort in exposed locations an 'active' escort winch may be called for. To be effective, whenever the line goes slack - which can occur momentarily when the tugs bow falls off a wave toward the escorted ship - the winch should be able to haul in line quickly enough to prevent the line from going slack, otherwise damaging 'snatch loading' may break the line. Conversely, whenever the line tension become too high, the winch should automatically pay-out line under tension to keep all forces in the system within limits. This is typically done with an adjustable slipping brake or with motor braking. Consequently, whether or not a winch is right for the job on depends a lot on its speed, pull and braking energy dissipation characteristics.

Coming to grips with required winch performance in dynamic situations is far from straightforward since tug motions and line force variations depend on how the tug moves in waves and the stretchiness and weight of the towline. An undersized winch is an obvious problem, but a needlessly large and high-powered winch can be the wrong choice too, not only because it costs too much, but also because its weight and position may negatively impact stability and trim.

Fortunately, our in-house research and development efforts are paving the way toward a better understanding of dynamics during escort and how they relate to towing system design and stability-related escort tug safety. One outcome is our Tug Dynamic Towing Simulator (TDT-Sim featured in RAindrops 15) which allows us to simulate escort in waves and 'test' how effective different winches are in limiting forces and reducing tug motions. Work continues on other fronts as well, not only to get the deck equipment right, but to get it better in the future.

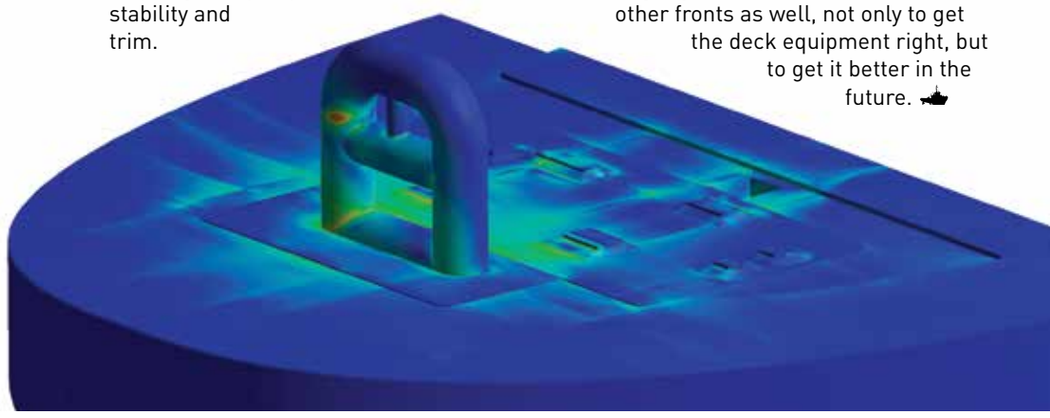


Photo courtesy Gondan

Escort Notation

Brendan Smoker, P.Eng.

Escort tug notation is covered by several Classification Societies such as Bureau Veritas (BV), Lloyds Register (LR), American Bureau of Shipping (ABS), Registro Italiano Navale (RINA), and Det Norske Veritas (DNV). The notation itself typically covers three aspects:

1. The strength and suitability of escort towing equipment (i.e. winch, staple, towline),

2. The escort performance (maximum steering and braking forces); and, most critically,

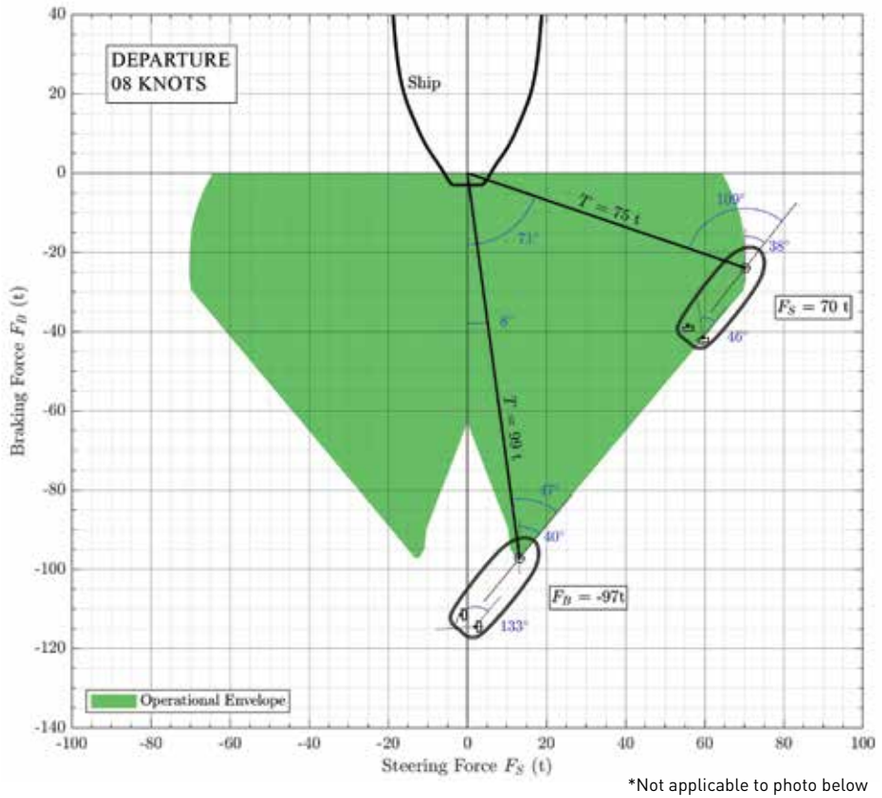
3. The escort limits (rated escort speed, maximum line tension, and maximum heel angle).

Thankfully, significant headway has been made in the last five years to harmonize the various class escort stability requirements so that now every escort tug, no matter which class society listed above, is evaluated to the same stability criteria.

In order to satisfy the class requirements and optimize performance, we carry out a sophisticated escort performance calculation utilizing computational fluid dynamics (CFD) to determine the hydrodynamic steering and braking performance at several speeds. Compliance with class stability criteria is checked on the basis of predicted heeling moments. The flexibility of CFD allows us to fine-tune skeg size and staple position to get the best escort performance possible while keeping stability within safe limits.

Our escort predictions are now accepted by many class societies. Our methodology is constantly evolving as we conduct research & development, work with classification societies and strive to design ever more capable escort tugs. We are also making significant improvements in how we convey predicted escort performance in 'butterfly plots' which show how steering and braking forces relate to tug position, orientation and speed.

2018 promises to be another busy year for escort prediction at Robert Allan Ltd. with research continuing into the dynamic response of tugboats to various emergency scenarios, such as breakage of towline or sudden loss of thrust, and how operations in seas can impact escort performance.



*Not applicable to photo below

Photo by Marijn van Hoorn

Photo by Mike Crane

Awards

Rob Allan (right) was presented with the *Meritorious Achievement Award* as one of the President's Awards conferred by Engineers & Geoscientists British Columbia (EGBC) on October 20th, 2017 at their Annual Award Gala held in Whistler, BC. This award is given annually to a member of the Association who has achieved distinction and outstanding goals associated with his/her profession.

Rollie Webb, Senior Vice President (right) was presented with the *SS Beaver Medal for Maritime Excellence* by the Lt. Governor of B.C. Judith Guichon on behalf of the Maritime Museum of British Columbia in a ceremony held on November 9th, 2017 in Victoria.

Photo courtesy Business in Vancouver

Business in Vancouver (BIV), the Ministry of International Trade and Canadian Manufacturers & Exporters British Columbia (CME BC) presented the *2017 BC Export Award for Leadership* to Rob Allan. This honour is presented annually which "recognizes an individual who actively champions the cause of exporting in BC within their industry or field of expertise". Accepting the award on behalf of Rob Allan was Mike Fitzpatrick (left).

Photo courtesy Novatug B.V.

Bringing it all Together

by: Todd Barber, P.Eng.

My colleagues have discussed many of the key aspects of escort tug design including selection of the appropriate platform (*RAstar*, *ART*, *TRAktor*, *RAVE*), calculating escort performance using CFD methods, ensuring escort stability criteria can be met at the required escort forces, and determining optimal winch performance. One of the interesting challenges as designers is bringing these key components together along with other perhaps less obvious escort tug design details to achieve a successful design. And without fail there will be a myriad of other requirements that the Owner and Charterer inevitably place on an escort tug design bringing further challenges.

Once the platform is selected and hull dimensions determined for safely achieving the required forces, we get into the details such as optimizing appendages (skegs and/or bilge keels depending on the platform), laying out the working deck, and configuring the wheelhouse. Appendages are critical to escort performance and various shapes and configurations are normally analyzed very carefully in the model basin or in CFD. And on the working deck the staple design is equally critical. First, the longitudinal position of the staple needs to be carefully studied. Too far forward and the tug will not generate the full escort capability of the hull and too far aft the tug may not be "fail safe" in the event of a propulsion failure. Also the style of staple is important. For example if the intended operation will utilize the powered indirect manoeuvre with high wrap angles of the towline then a "Wide A" style of staple will help to move the towpoint outboard increasing the possible towline wrap angle before interference with the house works. To minimize line wear from active haul in / pay out winches, staples also need to have highly polished stainless steel liners and water spray for lubrication and cooling the towline. Similarly the bulwarks will normally be lined with polished stainless steel to reduce line wear. For aggressive staple positions escort towing pins are normally fitted in the bulwarks to move the tow point forward during passive escorting to reduce the amount of required operator input on the controls thereby reducing operator fatigue.

In the wheelhouse it is necessary to consider the attitude of the vessel during escorting. While in indirect mode the towline will be well off to the side and thus a clear side view is required and even wipers should be considered for the side windows. The tug will be heeled over during manoeuvres and thus overhead windows at the sides (not just forward) are desirable. Also to be considered is the optimal placement of instruments critical to safe escorting such as the inclinometer and remote tension and towline length display.

There are even special considerations for the engine room such as ensuring the box coolers are adequately submerged when the vessel is heeled over during an indirect manoeuvre.

Of course there are then all the additional functions and requirements that these vessels commonly have placed on them. Typical examples are low flash point oil recovery and storage, alternative fuel and/or propulsion methods, off ship fire-fighting, long line towing, ship docking in confined areas, accommodation challenges due to large manning requirements and ILO MLC compliant cabins, extreme weather operations, even sometimes anchor handling. All of these place additional challenges on achieving a successful design.

One of our recent designs that elegantly brought together all of the requirements placed on it is our 40 m *RAstar 4000-DF* dual fuel LNG/diesel extreme escort tugs. The vessels are capable of exceptionally high escort forces while meeting class escort stability criteria and can achieve very high free running speeds to facilitate connecting to tankers at high speeds. In additional to severe weather escorting and ship berthing, the vessels are further capable of emergency response duties including long line emergency towing, off-ship fire-fighting (FiFi I), and oil spill containment and recovery. The MLC compliant accommodations are generous in size, very well appointed and comfortable for a crew of up to eight, and have exceptionally low noise levels throughout. These innovative vessels, *Dux* (named Robert Allan Ltd.'s 1000th tugboat design), *Pax*, and *Audax* built for Østensjø Rederi AS of Norway, were recently named *Tug of the Year* by Tug Technology and Business magazine and have appeared in both RINA's *Significant Small Ships of 2017* and International Tug & OSV's *Annual Review 2017*.

RAIndrops

Issue 17
April, 2018
On the cover is *TRAktor 3600-V* tugboat *Tenax* undertaking an escort manoeuver near Bergen, Norway in the North Sea.

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