The ATB – A Viable Transportation Solution in the Americas and the World

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SYNOPSIS: This paper is designed to build on the current worldwide AT/B experience, and bring the audience current on the state of the art in AT/B design, economics and application. The paper will explore the following topics, based on the Author’s 23 year and ongoing experience in designing this type of vessel:

- Broad economics
- Flexibility
- Technical design issues
- Operational experience & practical operational considerations
- Construction issues
- Trades suitable for an AT/B
- Regulatory history & current Issues
- Brief history
- Speed & power considerations
- Crewing issues
- The value of tank testing
- Comparison of the available connection systems

The aim is to convey a practical, broad-based yet technically correct paper, that provides a basic understanding of what an AT/B is and can do; vs. what it is not and cannot do. We will provide actual operational and design information based on real-world experience.

BACKGROUND:
The author and his firm provide the observations, technical data, and opinions included in this paper, based on 24 years of experience in the AT/B marketplace. Currently, the firm has either directly designed, or been a fully participating engineering partner, for 28 operational AT/Bs in the US market. A further two conversions were designed in 2003, and under construction in 2004. In 2004, the firm is designing two different AT/B tugs currently under construction, with a further two under engineering contract. The firm is also in 2004, completing two different AT/B conversions of existing tugs and barges. By the end of 2004, 32 units will be in service, which means the firm will have had a hand in over 60 per cent of the operational AT/Bs in service in America – including, 85 per cent of those built or converted since 1994. The experience encompasses connection systems of all kinds, including Intercon, of which the Author is co-inventor; Bludworth, Hydracoonn, and Articouple. The firm has also now entered the international marketplace, with units under design for service in the Far East, and Eastern Europe. This paper outlines the history leading up to the AT/B in North American service, as well as many of the most important issues in the design and application of AT/Bs. The paper also compares the AT/B to towed barges, ships, and ITBs. The paper is very much more a practical treatise, than a highly technical one – designed to educate shipowners and charterers regarding this type of marine transportation system.

TRADEMARKS:
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WHAT IS THE AT/B?
The AT/B, is an all-weather-capable, performance-oriented tug/barge marine transportation system based on proven technology, designed to operate with the same weather and schedule reliability of a ship, at a significantly lower capital and operational cost without sacrificing safety. The key element in the success of this technology is the mechanical connection system, which links the tug and barge together in a solid, single-degree-of-freedom configuration – and – in addition, the tugboat is designed to be ocean tow-capable in ALL loading conditions.

The Development of Coastwise Barge Transport in North America
As was the case with all seafaring nations, the United States and Canada both built their coastwise transportation networks around self-propelled vessels. Once the age of powered vessels was born, the development of barges, towed by powered tugboats, began in earnest. The earliest barges were created from sailing vessels, and indeed, some even retained their sails, to assist in the movement of the tow. In fact, non-self-propelled vessels pulled by mules, or free-drifting in the current, had been common along North America’s rivers and canals for many years.

However, over time, all of the vestiges of self-propulsion were removed from coastwise barges and the tug and barge industry we know today, pretty much held to two methods of moving barges for nearly 100 years. There are numerous references available to allow the reader to delve more deeply into the history involved here, so we will move now to the methods used to handle barges.

Barges used to be handled alongside, or in tow.

Initially, barge notches were non-existent. Pushing a barge was rare. More often, it was handled alongside the tug, or towed behind the tug. Handling alongside, obviously allowed the tug better control over the barge. Lines were made up from the tug’s towing and quarter bitts, to the barge. The tug
was placed at a slight angle to the barge centreline in order to provide for better directional stability underway.

It should be noted that even to this very day, tugs move larger barges alongside. Our AT/B tugs engage in the same sort of hook-up, when shifting barges from place to place in the harbour. This is sometimes mandated by the need to put a barge stern-first into a particular dock, for example. Visibility also plays a role, as the clear view alongside the barge may be better than the view over the barge pushing it. Even though early barges had no notches, they were still pushed at times, and visibility was not always the best.

Taking alongside was the best option for controllability, but obviously, it was impractical at sea.

Towing was the only way to handle a barge over a long distance in open water. It was also needed when the barge freeboard exceeded the tug's height of eye.

**Towing had its own problems**

While towing was the preferred means of handling a barge offshore, it is not without its hazards. Many different kinds of "mechanical" problems can befall a towed tug and barge combination.

- **Weather delays either current or anticipated.**
- **Accidental or unintended parting of the hawser.**
- **Failure of the towing gear.**
- **Inability to control the barge.**
- **Crew injuries from handling towing gear.**
- **Man-overboard hazards.**
- **Lack of control of the barge if the tug loses power.**
- **Tripping of the tug.**

In addition, there are business-related concerns when working with towed barges:

- **Need for additional assist tugs.**
- **Port limitations on night transits into ports or through canals.**
- **Potential damage claims from third parties when barges are lost while under tow.**
- **Potential damage claims when towed barges break free and run aground.**
- **Additional insurance charges.**

**Why push? Wasn't towing effective?**

Towing was hazardous to the tug and crew. As barge sizes grew, handling them on a towline required heavier towing briddles and gear, more horsepower, and added manoeuvrability. Larger towed barges were also harder to control in congested waterways, or when going on the hawser initially.

When towing, the barge has no "brakes". If the tug gets in trouble, the barge can catch up rather quickly, especially on a short hawser.

There is a positive "modern" development in ocean towing, that needs to be mentioned. The photo below shows's Nautican's "Hydralift" skegs, which can improve the yaw stability of a towed barge with minimal added resistance, and it works by all accounts. [Editor's note; all photos in this paper will be available on CD after the presentation].

Many of these problems were certainly well known and appreciated within the contemporary towing industry, but there were no obvious, alternative ways to operate a tug and barge at sea, so the problems were accepted as being inherent to the nature of the industry. Over time of course, efforts were made to improve, but as we will see later in this paper, other forces would compel a fundamental change in the tug and barge industry.

**Stern notches, were pretty much non-existent, because there was no need for them.**

Most early barges did not even have the simple "dimple" to receive the tug bow. If a scow was pushed, it was pushed by the tug centreing up best it could on the stern of the barge, and connecting to the barge via "face wires". These were soft lines, and later wire ropes, that went from the stern quarter bitts of the tug, to the outboard corners of the barge.

Also, in order to tow well, and "follow", barges tended to have raked bows and sterns. Pushing such a bow through a heavy sea, where the broad surfaces of plate and frame (or plank and frame) met the waves at nearly a right angle, could cave it in if the speed and waves were high enough.

However, you have to remember that no one was even TRYING to compete with a ship. Barging was its own niche. There was enough business for all modes.

**The New York Barge Canal – and notches were born.**

The notch in a barge stern we are so familiar with today, had its roots at least partly in the New York State Barge Canals (Erie & Champlain).

The locks were of limited length, and to fit the barge in the lock and the tug with it, the stern rake was excavated to create a place to hold the tug, and as a result, shorten the overall length of the combined unit to fit in the lock. A bearing surface for the tug to push on was created, and wires were used to hold the tug in, and primarily to allow the tug to back with the barge.

Most aft rake compartments were not used for cargo, so this confiscation of space made a great deal of sense. The added benefit was controllability. Backing wires, were set from the aft quarters of the tug to hold it in place when backing, with added rope over the stem for emergencies, just as before. However, at least some of the steering forces (lateral forces) were now being taken on fenders at the forward quarters of the tugs. This in turn reduced at least some of the stresses on the face wires. The result was an ability to turn a little bit quicker than was possible without a notch. It was also a bit less dangerous getting to the barge from the tug, as it was no longer necessary to go over the narrow tug stem. Boarding could be accomplished from the quarter bulwarks, with a reduced danger of falling.

Given that most pushing was done in calm water, this simple system worked well.

**Face/Back ing Wires – Not Very Reliable in Waves.**

As pointed out previously, heavy steel cables were used to hold the tug in the notch, and to provide a connection for steering and backing the barge. However, the use of such cables was limited in coastwise operation, even with a stern notch.

These could not be used in seas over one metre in the relatively shallow notches of early barges, and even that was
a stretch. Tug/barge units entering the Great Lakes from the Erie Canal, would switch from pushing gear, to towing gear, once on the Lakes. Tugs of the Matton Transportation Co, of Cohoes, NY, for example, were fitted with towing winches. Indeed, as late as the 1970s, a purpose-built tug for the NY Barge Canal, James Turecamo, was fitted with a towing winch because its trade route with a new Cleveland Tankers’ barge, routinely took it out onto the Lakes.

So as we can see, even an operation that was largely pushing, switched to towing once it encountered open water.

**Deepen notches were developed in the hope of increasing pushing ability in larger seas.**

Logic eventually dictated that if you could push in small waves with a small notch – perhaps you might be able to immerse the tug in a deeper notch and push in larger waves.

In the era of the 1960s and then the 1970s, companies like Bulkfleet Marine and Interstate Oil Transport both developed deep notch arrangements. Where Interstate had previously built 30,000dwt oil barges with a relatively shallow notch (12m), the next generation of barges they constructed, of 20-25,000dwt, employed a much longer (25m) notch that covered over two-thirds of the tug’s length. The tugs were fitted with large rubber fender pads to cushion it in the notch and attachment was made to the barge by face wires. Later versions of this design included a “stinger” on the bow of the tug, to hold the stem of the tug in place relative to the barge. It was hoped that in association with the side pads, the tug would “articulate” in the notch. The pads worked well, but the stinger was never much of a success and was eventually removed.

The notches of the Bulkfleet (now owned by Penn Maritime) units, were well over half the 45m tug length, and relied wholly on rubber fenders, and a tight fit in the notch, to push at sea. The units did in fact push routinely in seas of 3m, but the fenders were a maintenance cost item, and at times, the tight fit of the tug to barge resulted in the tugs being literally stuck in the notch. However, Bulkfleet eventually worked out the fit issue and one of the units operates today on fenders and face wires alone. The second unit has been converted to a Bludworth connection. The first unit has been now scheduled for refit as well. In a tribute to the foresight of Bulkfleet's founder, the tugs and barges were structurally designed so that a later refit of the Bludworth System (the prevalent system of the 1970s) could be easily accomplished. As the engineer who refit the tugs and barges, the author can attest to the validity of this foresight, as both tug and barge were relatively easy to refit.

However, even deep notches were limited to 3m to 4m seas, and as petroleum terminal operations changed from a philosophy of topped-off tanks all the time, to requiring just-in-time delivery because inventory was no longer kept on hand – even the improved seaweeding of the “deep notch” tug/barge was not reliable enough.

**What other market forces were at work? Some examples…**

In America, where the movement of petroleum products was one of the most important uses for tugs and barges, there was a steady reduction in the number of marine terminals, and in the amount of inventory kept on hand at those which remained. When inventories were always kept in a “topped off” condition, the weather-reliability and speed of the barges serving those terminals was relatively unimportant. If a spate of bad winter weather hit the US East Coast, for example, the terminals could easily operate off the inventory on hand, and then top off when the weather improved to the degree that towed barges could again operate. There was also a growing shift, in transport patterns. Less and less refined product moved from the Gulf to East coasts on the water, rendering the higher speed of a tanker, less important.

The early “notched” barge, then ITB, and now AT/B, all grew out of the demand for low cost, safe, reliable, and more rapid marine transportation. While transportation using the conventional towed barges was less expensive than a ship, they were extremely weather dependent making them unreliable in some conditions and they were also much slower than the ships they often replaced. Towed petroleum and petrochemical barges have historically suffered horrendously as far as weather-induced delays. In some operations in the Gulf, annualised weather delays for long-term operations of some tug/barge fleets averaged 30 per cent or more. In the Northeast, it ran as high as 40 to 50 per cent, especially in the winter.

Towed barges provided very low rates, but were very unreliable schedule-wise, and subject to extensive weather delays. The low rates more than made up for the weather unreliability when terminal inventories were kept high. However, once terminals began operating on thin inventories, the need for reliable transportation became vital. Where terminals once carried 30 days inventory, they now carried 3 to 5 days. A run of three or four bad days weather was suddenly the catalyst for a shortage of product such as home heating oil. Having towed barges out of service for that amount of time was unacceptable. Ships were more reliable, but rate still mattered.

The cost to operate tankers and other US flag self-propelled vessels was increasing past the point where coastwise operation became less and less profitable, save for times when spikes in the spot market rates made some ships an acceptable substitute.

During recent years there has also been an increase in the direct importation of refined product into the US market. This has reduced the need for coastwise, Jones Act product movement. This fact then acted to hold the price level for product movement fairly steady, and despite the market’s need for reliability, those forces never did put the more-costly ship back into the picture to any great extent. Despite large increases in refined product retail prices, rates for water transport of those products did not increase proportionately. Tankers were increasingly priced out of the low-rate market.

Towed barges did not provide the weather-reliable transportation needed to work with reduced terminal inventories – but low rates excluded tankers from competing. The weather was not going to change, tankers were not going to get cheaper to build or to crew/operate. Somehow, the tug and barge solution had to be improved. The initial attempt to solve this problem was the development of the ITB. When that fell on hard times, in both technical or regulatory environs, the response was the continued development of the AT/B.

**What was the solution? Who saw it coming?**

Looking at the entire situation, the solution was obvious enough. Create a tug and barge that could operate cheaply, yet could be weather-reliable and safer to operate in heavy seas, with increased speed where that speed would be useful.
It was long known that pushing a barge yielded better speed than towing it. By its very nature, towing involves adding enough resistance to a barge stern that it will “follow” the tug. If you are pushing, that resistance penalty is removed. However, as we saw earlier, the use of only wire ropes to connect a tug to the stern of the barge, was not the answer. So, various patents to connect a tug and a barge with a more secure mechanical connection, were filed – all the way back into the 1800s. In the late 60s, Edwin Fletcher with ARTUBAR, and the Bludworth family of flexible pushing systems, were pioneering efforts to marry the economies of pushing, with the safety/seakeeping inherent in mechanically linking the tug and barge at sea. While other systems, such as the Glosten-designed SEA-LINK system were developed and tried, they were not extensively applied in North America. We owe our current state of the art, in large part to the progression in development of ARTUBAR, and BLUDWORTH in the U.S., and then ARTICOUPLING in Japan.

The problems that confronted the application of early mechanical connection systems were daunting in the United States. The Coast Guard at that time took a conservative approach that said basically, once you connected a tug and barge, you were a ship. This position greatly affected the application of the ARTUBAR system in its’ early days. The regulatory environment caused the cost to build such a tug and barge unit to increase over a towed unit, and moreover, the policy also asked for ship-sized crews. Modern automation, and the increased use of electronics aboard ship, made the traditionally smaller crews very effective on a tug and barge.

It is interesting to note that even in recent years, as ship owners are touting reduced manning now being “possible” on ships – tugs and barges have quietly and effectively operated this way for generations.

What changed, that allowed the AT/B to be developed and built?

In 1980, the author worked with Taisei Engineering’s Articouple System on a project for an AT/B chemical carrier for Sun Transport. Sun wanted a tug/barge unit, to operate at a certain speed, in all weather, and was ready to take on the regulatory issues. We selected the Articouple design as the connection system to use, and set out to design the vessel. In order to assure that regulators were comfortable with such a vessel, the author, backed by Sun Transport, approached the Coast Guard with the goal of having the policy toward mechanically connected tugs and barges changed. Several meetings and exchanges of correspondence ensued. The argument made was based on safety and weather reliability and a provision in return from us, that the tug would be a TRUE tugboat – not a separable engine room. The argument would be able to operate independently of the barge, in all weather, and would thus be “dual-mode”. As a result of those discussions, and the further input of industry and engineering professionals, NVIC 2-81 was born. This Coast Guard document declared a new official policy on this matter. As long as a true tug was created, meeting all stability requirements as a towing vessel, and as long as the connection was not 100 per cent rigid in all planes, the tug would be treated as an independent towing vessel for both regulatory and crewing requirements. This NVIC, was and remains, the single most important and influential event in the continued development and deployment of the AT/B in America.

AT/B VS. TOWED BARGES – WHY THE AT/B?

What advantages then, are inherent in the AT/B versus its less expensive, time-tested ancestor, the towed barge? As one can see below, the advantages are in fact many.

An AT/B offers:

• Full and safe access to the barge at sea for emergency situations.
• Ability to transit less congested “outside” routes as opposed to following protected routes. This is particularly important in areas that also host large numbers of pleasure boats, or busy ship channels.
• Speed capability limited only by installed horsepower, as opposed to towed barges that must be more heavily tował-stabilised as speed rises.
• Increased safety when pushing by the elimination of backing wires towed barges use to be pushed in port – wires that can part in emergency manoeuvres.
• Ship-reliable ETA’s. Improved scheduling capability.
• Greater crew comfort at sea, as opposed to the quality of ride and motion on the end of a towline.
• A possible 25 per cent fuel saving vs towing for the same speed, or a 25 per cent increase in speed for the same fuel. This is largely due to the elimination of the towing “resistance augment”, plus the greater hydrodynamic efficiency of a well designed, pushed barge.
• Ability to sail from port with predicted heavy weather, just as a ship would – unlike towed barges.
• Greatly reduced bow and other damage to barges, because the crew can feel pounding in heavy seas, unlike in towed barges where the crew of the tug cannot fully appreciate the pounding that the barge some 450m or more behind is taking.
• Greatly reduced fender replacement (virtually none in 14 years) and virtually no tow wire replacement costs.
• Elimination of back injury incidents related to towing operations by deck crew by not having to handle heavy towing gear.
• More control over barge with a generally more powerful tug, reducing chances of groundings and dock damage because control of the vessel on approach is so vastly improved.
• The foregoing advantages are not theoretical, they are the results obtained in actual everyday operation of AT/Bs. Unlike “new” marine transport systems, the AT/B is a low-risk proposition, which has been tested in the marketplace, with excellent results. It essentially marries a group of tried and proven technologies, into a single concept.

AT/B VERSUS ITB?

Where are they the same?

ITBs and AT/Bs have few similarities. In fact, the only real similarity is that the power unit of both can separate from the cargo unit. Beyond that, they are entirely different concepts.

Where do they differ?

AT/Bs are as different from ITBs, as AT/Bs are different from ships. Some history is in order: For definition purposes the AT/B must be differentiated from the original ITB.
(Integrated Tug/Barge) where the tug and barge were locked together in a rigid configuration and became for all practical purposes a single unit. My firm, coined and uses the acronym ‘AT/B’ as a trademark, with a deliberate separation being made with a “” between T (tug) and B (barge), to show that the two units of the articulated tug-barge, are indeed separate, independent units joined by choice, not necessity. The common characteristic of the most widely applied rigid ITB systems is the fairing and co-ordination of the hull shapes of both the tug and the barge, especially in the area where the “tug” mates to the “barge”. They are actually, in essence, “separable” engine rooms.

ITBs date back many years, and the first practical application of the technology came in the 1950’s, when the ITB Carport was built. This vessel, which essentially was a tug locked onto a stern “ramp” of a barge, traded successfully on the New York canal system and the Great Lakes for many years, hauling grain products. However, for various reasons, it was not repeated. The trade in which it engaged was also populated by conventional tugs working with “notched” barges, and some towed barges. Such units were simpler, less costly to build and more practical. The added speed Carport was able to attain, was of little advantage in the New York Barge Canal, where locks and narrow channels greatly restricted unit speed. In heavy seas with the ITB, the tug functions in the same way as the stern of a ship. It pitches with the barge and heaves with it. However, because the ITB tug is built to a depth to match the companion barge hull, the motions are no worse, or no better, than a ship of the same size. The exception to this of course, would be a case where the ITB tug was built with LESS depth. However, even the earliest ITBs (for which patents exist even in the 1800s) such as Carport, shared the design feature of a nearly equal depth barge and tug.

ITBs are also designed to remain coupled in all sea states. To the author’s knowledge, no ITB currently in use has disconnected and successfully towed the companion barge. The few times such separate operations have been attempted, there were casualties or near-casualties. One such loss was Cat-Tug OXY 4102. The “tug” was a total loss, as the unseaworthy hull design of the “tug” foundered after damage in heavy seas. During the attempted delivery of a lone “Cat-Tug”, the vessel so badly pitched and poled offshore, that the tug was forced to turn back and the barge was brought to it from another shipyard. In short, ITBs were never designed to operate as separate units and were truly conceived as “rule beaters” Stories abound of ITBs unable to be disconnected before drydocking, as long-unused and seized connecting devices made separation difficult.

Therefore, over time, the ITB fell into disfavour as the cost to build these units spiralled to numbers, which were in excess of an equivalent ship. The issue of NAVIC-2-81, by the US Coast Guard, also closed many loopholes in regulations, of which the ITB was supposed to take advantage. Thus, no ITB has been built since the early 1980s. Because the ITB was falling from favour, the need for economical transport meant that another solution had to be found.

Very Different Concepts.
The ITB is essentially a separable engine room/cargo box, designed to get around rules, albeit for the added purpose of less resistance of the total unit, vs a towed unit or a conventional AT/B. The AT/B is the marriage of a conventional tug and barge, designed for operational flexibility, and is designed to be hydrodynamically superior to a towed unit. The ITB tug is totally rigid relative to the barge in all degrees of freedom, and the AT/B has at least one degree of freedom.

The ITB tug cannot perform any other mission or work with conventional barges. It is generally not very seaworthy when operating alone. It is dangerous to disconnect at sea.

The AT/B tug can disconnect at sea to tow, do ship work if so designed, and handle conventional barges.

• The ITB is designed for higher speed.
• The AT/B balances regulatory load, with speed and reliability.
• The ITB has a larger crew generally.
• The ITB is a “push-mode” unit under USCG Regulations
• The AT/B is a “dual-mode” unit under USCG Regulations
• The ITB is more costly to construct, and more costly drydock and repair due to the need for more extensive and specialized blocking.

AT/B VS SHIP – WHY THE AT/B?
What the AT/B did was to solve most of the technical impediments to being ship-competitive, while maintaining the crew and capital cost advantage of the tug and barge. What you have is weather reliability, in a REAL tug and barge. An AT/B is not a rule beater. So for many types of services, the AT/B shines, as compared to a ship. But what ARE those services? How does the AT/B fill that mission? That is the purpose of this paper, to show through real-world experience, how the AT/B can be used to fill a transportation need, efficiently, vs other modes of transport, including other marine systems.

Later in this paper, we will examine when an AT/B can substitute for a ship, and when it cannot.

Comparing the AT/B to a ship, the following characteristics stand out by comparison;
• An AT/B has individual units for insurance purposes – loss of one does not mean a unit CTL.
• As compared to a ship, a wider availability of shipyard sites for drydocking the power plant.
• Ability of both tug and barge to function as fully independent units when one or the other requires shipyarding.
• Smaller crew and different, more efficient crew culture.
• This culture in turn, drives design toward a simpler vessel to maintain and operate.
• Ability to build both vessels in specialised shipyards, lowering costs.
• Ship-reliable ETA’s at greatly reduced operating costs.

The Available Connection Systems
There are a number of systems available to connect a tug and barge at sea. They vary in experience from many years, to just a few months—from many applications, to just one application. We’d like to introduce you to the most commonly applied systems and some of the newer ones OT&BE has wide experience with many of these systems, and a full understanding of all.
The ARTUBAR system was the very first “axial” connection system. It is a single-degree-of-freedom system wherein the tug rolls with the barge, heaves with it at the connection point, but pitches independently. ARTUBAR utilises a port and starboard, large diameter pin, which is extended hydraulically from the tug hull.

This pin is fixed in rotation relative to the tug hull, and it engages a pair of holes in the barge notch walls port and starboard. These holes are located approx. 7 feet apart vertically, and tend to be located at the loaded draft of the barge, the light draft, and the ballast draft. The barge holes are lined with bearing material such as Ultra-Poly or rubber. The large pin then rotates in this bearing material, relative to the barge, as the tug pitches.

The pin does not bottom-out on the notch wall, and therefore, a small space is left between the tug and barge. Experience has shown that this space will allow the tug to slide back and forth and slam into the barge notch. Therefore, a recent modification of the system includes a set of pads port and starboard, aft of the pins, to fill this space and prevent such slamming.

Benefits – ARTUBAR is a relatively simple system, machinery-wise. The pins on the tug are extended by hydraulic rams and all the parts are accessible for maintenance and repair. There are some tight tolerances to be dealt with, but overall, you can troubleshoot the system easily. Because the pin does not bear on the notch wall, the internals of the ram assembly and pin are heavy, but simple.

Known issues/resolution – ARTUBAR is an old system which is not supported or sold by any manufacturer. The need to position holes in barge notch walls means that you only have a limited number of places to connect. This makes it necessary to ballast one or both to make the pins line up. It is also very unforgiving of relative heel. The system can be noisy, and the bearings must be cooled constantly in heavy seas. Also, the gap between the tug and barge must be filled, as the noise generated when a tug has an inch to move back and forth in, can be horrible on the crew. This has led to some ARTUBAR units being fitted with movable pads to fill the gap.

ARTICOUPLE

This was a Japanese invention designed to solve the shortcomings of ARTUBAR. It came about when a Japanese ARTUBAR unit (the first built), suffered prototype pains, and a Japanese architect, (Mr Takeo Yamaguchi) set out to improve the connection design. The result was ARTICOUPLE. The system is similar to ARTUBAR on the tug in that hydraulic rams actuate a pin outward from each side of the tug. However, this pin is in actuality a large ram, which has a ball on the end of it. Affixed to this ball is a “helmet” with teeth. These teeth come hard against a vertical row of similar teeth on the barge notch walls. Thus, the tug is prevented from side to side motion allowed by ARTUBAR, and the multiple teeth up and down the notch wall allow connection at virtually any draft of tug or barge. Similar to ARTUBAR, ARTICOUPLE utilises a port and starboard, large diameter pin, which is extended hydraulically from the tug hull.

The ball on the helmet allows a certain amount of angular misalignment as well, in heel. All side to side movement is halted because the helmet lands hard against the barge ladder. The system allows only relative pitch. This is also the most widely applied system in the world, with the greatest experience in application, model testing, and operation.

Known issues/resolution – Hydraulics are relied upon to hold the tug in position in the centre of the notch. Large side forces put a tremendous load on the hydraulic components holding the rams out. The hydraulic system, with accumulators, hold piping, etc., is relatively complicated, but also has the benefit of many years of refinement to solve any problems that may have come up. There are no US applications, and one Canadian one, using an older Russian tug, that was purchased and refurbished. The unit is operating successfully with a large asphalt barge along the Canadian East Coast, down into the United States. The author’s firm is presently looking into ARTICOUPLE for a project in the Far East. The system is not supported in the US service-wise, as yet though Taisei will support the system from Japan. The system does not have current ABS or USCG certification for dual-mode service, but would obtain it easily. ARTICOUPLE is otherwise, a long-experienced and proven connection system design.

INTERCON

The INTERCON system was developed to re-examine and re-engineer many of the problems inherent in hydraulic pin-connected systems such as ARTUBAR and ARTICOUPLE. The operation of the system is straightforward. The system is a single degree of freedom connection that, like other systems, establishes a transverse, fixed axis between the tug and barge, around which the vessels are allowed free relative rotation, or pitch. All other movements such as yaw, roll, and heave are restrained. Thus the tug heaves and rolls with the gentler motion of the barge, and unlike systems that allow motions in more than one axis, the system forces are predictable. In the system, the port and starboard sides of the notch wall are fitted with a vertical channel member with the open side facing the barge centreline. Notches or teeth are incorporated on the fore and aft sides of the channel to eliminate vertical travel. The channel sides are tapered to provide a wider opening to ease connection, and the side taper is flat enough to minimise resultant thrust from higher bow to stern loads imparted on the barge by the tug. The notches lie on the taper of the sides and are of equal angle, peaked to balance forces and to minimise multi-angle planes of contact when engaged by the tug’s connecting helmet. The vertical extent of these connection ladders is determined by the relative draft range desired for operation, and they can be supplied in a skeg module, prefabricated for installation as a unit into the barge. The machined steel connecting heads of the tug, which are inserted into the channels port and starboard to make the connection, are configured to match the channel tooth pattern.

Each head is mounted on a spherical support to allow auto-alignment to the channel while retaining the greatest load carrying capacity in a minimal space. The ram is a heavy fabricated steel cylinder supported on the OD by a bronze bushing. The bushings are mounted in the ID of a “Load Box” structure which is a stress-relieved steel fabrication designed to transfer all structural loading, shaped to suit the tug and pre-fabricated and outfitted at Intercon with full lighting, access, wiring, piping etc. for insertion into the tug as a module. To extend or retract the head, the rams are moved
along the horizontal axis by a large, male threaded shaft turning in the female boss on the inside of the ram. The threaded shaft is operated by electric motors through gearing mounted to the housing. Two drive motors are provided—one for low-torque high-speed operation, the other for high-torque low-speed operation. Emergency drives are also available, for use in the event of an electrical power failure.

Benefits – Like some other pin-connected systems, INTERCON allows connection at multiple drafts. No ballasting is required. The system also is part of a large manufacturer’s product line and, as such, enjoys solid engineering and service support. There is a large population of the units in existence with long experience. The system is built in pre-fabricated hull modules for ease of installation. The system has ABS and USCG approval and certification for dual-mode service. The gear/screw drive, prevents accidental retraction at sea, and allows for finer control of the units. Only this system provides a positive means to prevent retraction at sea. The unit is designed as well, to a very high safety factor.

Known issues/resolution – The gear drive system and controls are relatively expensive to manufacture and maintain as compared to simple hydraulic cylinders. However, the overall complexity does not exceed that of a properly-designed hydraulically driven system of this type. This mechanical drive also results in a heavier piece of machinery, which is difficult to retrofit to older tugs with less stability, but relatively easy to design into a new vessel. The "load box" structure also carries gross tonnage implications for US vessels. INTERCON is constantly upgrading the product, through feedback from owners.

Addendum – INTERCON has released a new, lighter weight connection system. Based on the current design’s general principles, the INTERCON-C features a simpler drive, lighter components, and a lower price. The trade-off comes in component life over longer time periods for the same loading. This new unit will need shorter overhaul periods, but that is based on operation continually in heavy seas, which most times is not required.

McKeil Marine (BLUDWORTH), and BLUDWORTH/COOK SYSTEMS

Both of these systems operate by establishing a pivot, or relative pitch point about the bow of the tug. A clamp or calliper is deployed here, which attaches to a vertical bar at the head of the notch. Once gripped to the bar, the calliper is the pitching point. The tug has two sidepads at about midships, with either one or both moveable. The tug enters the notch with one pad retracted. The tug bow clamp is engaged and the pad(s) extended to fill the notch. The result is that the tug pitches about the bow clamp, with roll restrained by the moveable pads on the tug. The system has been in existence for many years, and BLUDWORTH-COOK is designing a new version that will eliminate many of the shortcomings found in the current design. The system is also sold in another version by McKeil Marine, of Canada, which is also making improvements to its system for commercial application.

Benefits – A simple system with light weight and easily retrofitted. The hydraulic components are fairly simple, and take up little space and power. Installation on the tug is straightforward and usually requires little in the way of structural changes. OT&B’s standard tug designs can all take this system. The system is sold and serviced by a reputable organisation and has a long history, with many applications.

Known issues/resolution – The tug’s bow unit holding the calliper can hole a barge easily if the tug comes alongside at too sharp an angle of encounter, or gets loose in the notch. The helmsman can’t see it in most cases, and it limits the tug to pushing in the notch, as opposed to working along side, or approaching the barge from a tow in heavy weather. The system does have a 17 degree pitch limit, at which it will automatically disengage, in order to prevent the sidepads from coming far off the barge side skegs and in some vessels, to prevent the tug’s keel or deck from hitting the head of the notch. The barge notch in the present system needs to meet very tight tolerances in construction which many yards have a difficult time meeting. The bar at the head of the notch also prevents other tugs from easily pushing the barge, and the longer notch needed as opposed to other systems, adds to barge cost. As noted above, there are planned improvements to allow full fendering, while retaining the functional capabilities of the system, as well as a new tug bow design and notch design to allow the units more flexibility.

Other systems

HYDRACONN – This system is a mixing of a multiple-tooth engagement such as ARTICOPPLE, with the central hydraulic ram idea of the ARTUBAR. The teeth on the barge notch are individual paired weldments of three teeth each installed in number as required on each notch wall. The main ram assembly is held in the tug with a chocking material such as Chockfast. Rotation of the tug in relative pitch, is via a bearing/axle on which the connection head rides, at the end of the ram. This system needs to be exactly aligned in the tug and barge. While it simplifies installation in some ways, it also marries many of the negative features of other systems. Still, the system has worked very well in the Great Lakes, though it has not been used in regular service on the open sea on the coast. The systems in use on the Lakes report good reliability. The system is not manufactured by a large company. Each is custom-built. The system has a history going back over 10 years.

ACOMARIN/JAK – This system is the newest on the market and the list of applications has grown quickly. It marries some of the ideas of ARTUBAR with a unique approach to connection. In this system, a pin on each side of the tug, self-aligns to a connecting hole as the tug enters the notch. This is done via wedges in the barge notch sidewalls directing the pin to the proper hole. The system is relatively light in weight. Like ARTUBAR, the JAK pin does not bottom out on the receiving hole in the barge. The loads in this case are said to be much lower, by the builder, due to the reduced span/cantilever of the engaged pin, vs. other systems. However, as originally configured, there are drawbacks. The free space between tug and barge, like in ARTUBAR, needs to be filled to prevent movement of the tug back and forth across the notch. ACOMARIN’s web site is refreshingly forthright in disclosing this information during the maiden voyage of its first application, the K-Sea Transportation tug Kara-Sea. K-Sea, which owns the initial unit and later sisters, is planning further conversions to it and is said to be generally happy with the cost and operation. This system has potential, but is very young. If it holds up, it will be a serious contender for retrofits due to its light weight, and newbuilds due to its cost, and the speed with which the relatively simple units can be manufactured. Other sales of the system have been made overseas and in Canada.

AT/B Vs. Ship or Towed Barge – When the AT/B?

So here, we are at the point in which we ask ourselves
whether the AT/B is the correct answer for your transportation requirement. There is a misconception out there, that there is an upper size limit for the AT/B that runs in the 40,000 ton range. This is simply not true. We have tested AT/Bs for shuttle service up to 70,000 LTDWT; and we have a contract in hand to design a 72,000 MTDWT AT/B ore carrier. We are also currently designing a 50,000 LTDWT AT/B self-unloading bulk carrier, and a highly specialised 44,000 DWT bulk AT/B that will run in both deep sea and rivers. This unique unit can run at deep draft, discharge 29,000 tons cargo, and then go upriver at light draft with the remaining 15,000 tons.

We have designed AT/B tugs of up to 24,000hp and 55m in length. The R/O AT/B will feature a 12,000hp tug. Our current designs being completed include 37,000 DWT clean product AT/Bs with 12-15,000hp tugs. We are also handling an inquiry for a 100,000 ton unit as well. So, size, up until you get to 100,000 DWT, is not really an issue.

What are issues are speed and power, and fuel. The current upper practical limit for an AT/B, speed-wise, is 13 to 15 knots. Our container feeder design has a range of FEU capacities, all designed to make 14 knots. There is adequate operational data to back up the fact that a Ro/Ro AT/B will make 15 knots. Our petroleum units all make 11 to 13 knots. However, once you start trying to go over 12 knots in a deep-draft, large DWT AT/B of “conventional design”, or 15 knots in a lighter draft, light DWT AT/B, the resistance curves, go nearly vertical. This means that the horsepower required to move the barge above that speed, grows at such a rapid clip that it is impractical. So my advice on the “limit” for an AT/B, is not always centred on size, but rather, on speed and fuel.

Even our 70,000-ton unit, at 10 knots, is practical fuel-wise. Make it 15 knots, and the best course of action is to build a Panamax ship.

Another time we would not recommend an AT/B, when size IS an issue, is when the unit gets too SMALL. For example, a petroleum barge of less than 10,000 BBL should be self-propelled. Between 10 and 30,000 BBL, a case needs to be made based on solid savings through crew or construction costs. From 30,000 BBL upward to 50,000, with realistic speeds, the AT/B can be cost effective if weather delays are a concern. Above 50,000 BBL, it depends really on the route, and the weather delay tolerance. Once you reach 80,000 BBL, it is hard to not make a case for the AT/B – but it does depend on the weather of the intended route, and also, if it is desired to run internationally.

The AT/B is not a panacea. It is a functional tool that has a range of applications for which it is suited.

Basically, one can argue for an AT/B in almost any situation if you have one of these considerations present:

- Unacceptable weather delays/hazards from towing.
- Availability of Crew vs. a larger ship crew.
- Capital cost issues vs. a ship.
- Operating cost vs. a ship.
- Drydock limitations along a trade route.
- Draft or other physical limitations vs. a ship of the same size.

Obviously, there are exceptions to the above list. For example, “crew culture” is something that can be changed within a fleet. One example is the increased application of AT/Bs on the Great Lakes, where the predominant transportation mode was ships with fairly large crews. It was necessary to educate the crews to the tug/barge concept, and also to make sure the accommodation of the tug was of a very high quality. To this end, we designed the tug Dorothy Ann for Interlake Transportation, Inc, with large staterooms, and public areas more akin to those of a ship. There was still a saving, due to there being less of the rooms and spaces than on a ship, due to the smaller crew (14 against 29).

THE AT/B REGULATORY ENVIRONMENT IN THE UNITED STATES

The AT/B is NOT and SHOULD NOT be a “Rule Beater”.

- The purpose of building an AT/B is to create a flexible, safe, and economical marine transportation system. The purpose should not to compromise safety by avoiding regulation.
- USCG NVIC 2-81 is the US flag-state guide for the classification of tug/barge units for regulatory purposes.
- The ABS Rules for Building & Classing Steel Vessels Under 90M, and the Ocean Barge Rules, govern AT/B tug and barge design in most cases.
- The USCG stability and loadline regulations govern AT/B loadline and stability issues.
- Gross Tonnage of the AT/B tug governs the regulations applied to the tug, provided, the AT/B qualifies for “Dual Mode” designation under NVIC 2-81.
- An AT/B can be built to meet full SOLAS regulation/certification on the tugboat. SOLAS rules do not apply to unmanned barges.

The author cannot stress enough, the principle that in designing and building an AT/B, one must not forget that safety is of the utmost importance. While current regulations do allow us to dispense with some things on a tug and barge, it is prudent to design to a safety standard consistent with the very best practice. The Owners we work with routinely ask us to add equipment, structure, or propulsion machinery that is in excess of the “Rules”. The AT/B design must be viewed in the context of what it is – a tug and a barge. However, it must also be viewed in terms of what it DOES. This is as individual a set of decisions, as the units themselves. This view is basically one that transcends flag-state considerations. We are asking people to go to sea in these units, in most all weather. Safety must be first.

AT/B Design – What is Important?

Knowledge Base:
- 29 Operational AT/Bs
- 23 Model Test Programs
• 18 Major Hull/Connection System Structure Analyses

DOZENS OF TRIPS ABOARD OPERATING AT/BS

Our experience tells us, that the following things need to be front and centre, during the design process:

• Flexibility in Operation
• Adequate Structural Design
• Not Seeking Steel Weight Savings Just For the Sake of Saving Steel
• Not Blindly Minimising Parts to Save MH
• Not Welding to Regulatory Minimums
• Practical Layout and Design on Tug & Barge
• Utilising Tried and Tested Configurations
• Using Experience to Avoid Things That Don’t Work
• Understanding the Animal

Flexibility in Operation

An AT/B tug has the advantage of being able to be used for a number of purposes. While it is certainly advantageous to design the AT/B tug from the keel up to be the best pusher she can be, it is also possible to diverge off that path to some degree, to build in flexibility. Tugs utilising systems like Intercon and Artubar – can be made to operate in “ordinary” notches pushing on fenders. The ability to work a barge alongside – even an AT/B barge, should not be overlooked. Many terminals do require a barge to be set in stern-first for various reasons. An AT/B tug can also function as a ship-handling tug when required. Follow the rules of good tug design when designing an AT/B tug. Recess the bitts; keep deck and working areas clear of obstructions. While it is not prudent to try to make the boat good for all purposes at the expense of being optimised for pushing – with careful thought, the tug’s capabilities can be maximised at little or no cost.

Adequate Structural Design

AT/B tugs must be designed not with LESS structure, but with more, and better-placed structure. The Author was given a shipyard-created AT/B tug design to review recently. The yard’s goal was to save steel and money. The boat, had it been built, would have been dangerous to work aboard. Brackets were eliminated everywhere. Stringers were eliminated from bulkheads, and racking strength was all but abandoned as a design principle. Yes, it would be cheap to build, but experience tells us that strength is a great concern.

Because the barge is going to move less in a sea than the tug, especially in stern-quartering seas – the barge provides significant damping of tug motions. This damping greatly increases the loads on the connection system and therefore, increases the load on the tug structure. A towing boat, as badly as it is tossed about in a sea, does not experience the type of structure loading an AT/B tug will experience in heavy seas. All of our boats are nearly totally double-continuously welded. While computer-modelling of structure may lead to a desire to reduce scantlings, the lesson taught by the structural failures in bulk carriers is of note. The tug has to meet stability, and there is not unlimited displacement available to support a heavy steel structure. However, careful initial design and planning will include a recognition that these types of tugs are heavier structurally and this needs to be accounted for from the outset.

Practical Layout and Design on Tug & Barge

Because an AT/B tug must work with a smaller crew than a comparably sized ship, it is doubly important that both the tug and the barge be designed with ergonomics in mind. The living and working environment must be as well designed as possible, given the constraints present in the design of this type vessel generally. Quarters must be comfortable in both size and arrangement. Crew work areas must be well arranged, to minimise the amount of work needed for everyday tasks. Piping and machinery must be accessible, for both operation and maintenance. Attention must be paid to making environmental systems more reliable.

Most AT/Bs, because they tend to run over traditional “ship” routes, have longer crew rotation periods. Therefore, it is imperative that crew comfort be a primary design factor. With more female crew members, it is also important to think in terms of private staterooms toilet/shower spaces.

Visibility from the pilothouse is vitally important – not only over the barge in all conditions – but also down to crew working areas when handling lines. Because an AT/B tug is hard to “fee” in close, light tug manoeuvring situations, it is imperative that the pilot be able to see his or her deck crew working below.

The widespread use of AT/Bs in SOLAS/International service means that the added weight and complication of being SOLAS-compliant must be taken into account.

Understanding the Animal

AT/Bs can be quirky things to design. I am constantly amazed as time passes, to find that there are constantly new things to consider in design of AT/B’s. Most all of these things, are subsets of any or all of the listed items below:

• Ergonomic Design
• Model Testing
• Understanding Maneuverability as it Applies to AT/B’s
• Tug Stability
• Visibility
• Designing for a Small Crew
• Noise and Vibration Control
• Working With a Proven Connection Design

Like any engineering system, there are good ways to design an AT/B, and there are less than stellar ones. So, to this end, it is useful to look at the sorts of things that can go wrong in an AT/B design, to avoid major problems later.

Manoeuvring/Steering – Because of the relative complexity of the tug/barge interface from a hydrodynamics standpoint, seemingly innocuous changes in design can have huge implications on the ability to manoeuvre underway. Worst of all, they are not universally predictable.

Over-complexity – Like any engineering system, one can go overboard in adding “features” and technology to an AT/B. It must always be remembered that anything you put on a boat WILL one day fail and someone has to fix it. There are fewer “someone’s” on an AT/B than on a ship.

Litigation-Proof Design – Because of their service, AT/Bs need to meet a higher standard with regard to crew safety and avoidance of introducing unnecessary hazards in the way they are designed. Attention must be paid to stair angles, tripping hazards, overhead clearances, working deck design,


engine room design, fire safety, escape plans, fire suppression, provision for handrails, and most of all, stability.

**Failure to Make Speed** – Model tests are amazingly cheap compared to having your planned 12 knot AT/B do only 10 knots. There are things that affect speed – many multiples of sensitivities that experience has shown are not present in other types of vessels – that must be considered from the outset. Again, they are not always universal enough to be covered in “rules of thumb”.

**Inadequate Structure Design** – If your boat starts coming apart in big seas, the cost to gas-free tanks and do maintenance welding time and again, will mount up. Given that tug hulls do have so many fuel tanks, relative to their total volume, you can pretty much count on having to gas-free often, if you over-save on steel. Steel installed in a newbuilding at the time of construction, is cheap compared to steel installed in a repair yard.

**Poor Stern Design on the Barge** – The bow is not as important in AT/B design, as the stern. It is at the stern where things can go awfully wrong. Our experience tells us that most of the steering, powering, and vibration-related problems on an AT/B – if you have them at all – have at least something to do with the stern design of the barge. It’s not rocket science to do it right, but it does require some thought.

**Stability** – By its nature, an AT/B tug is going to be tall. This is because to see over the barge, the pilothouse height of eye should meet IMO requirements, even when the barge is in ballast. With the trend toward single, high pilothouses, attention must be given to weights and stability all through the design and build process. Shipyards, by nature, do not usually worry about such things. It is for Owners to insist that stability be a fundamental part of the initial design package and an adequate up-front estimate of light ship weight and centre be part of the contract design.

**Utilising a Poorly Designed/Installed Connection System Beyond its Capability** – The truth is, any mechanical connection, has a limit as to how far you can push it before it fails. Nothing has an infinite use factor. Everything fails, at a certain number of cycles. What you want to do is use a system that has the greatest number of cycles prior to failure. In theory, overhaul then is accomplished prior to failure. Every AT/B connection system can fail, if:

- It is installed without adequate backup structure on the tug or barge.
- Has not been sufficiently model tested to determine forces acting on the connection and the tug/barge structure.
- It is operated beyond its’ design point.
- It is operated in a new service without regard for the original design parameters.
- Is poorly designed or constructed.
- Is poorly maintained and/or inspected over its’ lifetime.

There are some things to ponder for each of these points. There is a lot of debate over forces introduced into a tug/barge connection system. You have to be careful that in the rush to find inexpensive alternatives, you don’t ignore the loading such a system sees in a heavy sea.

There is no substitute in assessing a system’s application potential, for experience. After that, there is the model test history. Large models accurately measure forces – small ones do not. There is a proven scaling effect to model size vs. accuracy of load prediction. Anything smaller than 1:30 in a tug/barge unit is a small model. We routinely test with models ranging from 1:25.4 for our 500,000 bbl capacity ATB, which is quite a large model. (as you can see.) to a low of 1:30, and a high of 1:18

As is the case with self-propulsion tests, bigger is better. Having said that, getting a lot of data is pretty useless unless it is interpreted properly. We advocate testing any new AT/B design. We also advocate having someone experienced in AT/B’s oversee the testing and design. There are people out there such as Taisei, CT Marine, Guarino & Cox, ourselves and others.

**Poorly Designed Fuel Fill/Transfer Arrangements** – Making sure that your system is spill-proof. A tug deck is a lot closer to the water than a ship deck is. Overflows when taking on fuel can be expensive. You have fewer tankermen to monitor fuel loading, so it is essential that the fuel load/transfer system be designed with that in mind. It is very possible to have zero-spills. Our new-design AT/B tugs have never had a spill.

**Provide for Adequate Barge to Tug, and Barge to Shore Access** – I am always amazed then people spend millions on a barge, and expect someone to board it from a dock via an old 40-foot aluminium house ladder. Ditto getting from tug to barge at sea. Safe, planned access is very cheap as compared to injuries and fatalities. It need not be elaborate (ladders at the pitch center are OK on tug/barge access.) Larger barges need real accommodation ladders.

**Provide a Clear Path the Length of the Barge** – A crew should be able to run the length of the barge on one side without breaking stride.

**Poor Pilothouse Visibility** – As mentioned before, this is not only an issue seeing over the barge, it is an issue seeing the working deck crew who are 40 feet below you, working lines at a fuel dock.

There should also be good visibility over the barge when the barge is light, because you’re not going to ballast down to shift a few miles from one terminal to another. Our design standard is 1.5 unit lengths visibility. You can help this enormously by locating pump houses off centreline, as well as large masts and booms. Visibility from the tug, should be an equal concern in BARGE design.

**BASIC AT/B ECONOMICS**

**AT/B Design – What Can You Build.**

- Petroleum and Chemical Carriers
- Container, Ro/Ro, and Railcar Carriers
- Bulk Carriers, Including Self-Unloaders
- Special Products Carriers
- LPG/LNG/Ethylene Carriers

**An AT/B SAVES Money Vs a Ship:**

- Reduced Capital Cost
- Reduced Crew Size and More Flexible Culture
- Repairs at Smaller, Less Expensive Yards
- Easier Drydocking
• Lower Maintenance Cost Due to Less Machinery
• Reduced Port Fees
• Lesser Number of Assist Tugs
• Larger Unit Can Be Built to Overcome Speed Disadvantage
• Generally Lighter Draft and Access to Smaller Ports

An AT/B COSTS Money vs a Ship:
• Increased Fuel Cost at Higher Speeds
• For the Same Deadweight Lower Speed CAN Mean Lower Annual Delivered Tonnage

An AT/B SAVES Money vs a Towed Barge:
• Increased Speed for Same Deadweight
• Increased Annual Tonnage Delivered
• Less Fuel/Ton Delivered for the Same Power
• Reliable ETA's/Reduced Overtime
• Lower Insurance Due To Lowered Crew Accident Occurrence
• Lesser Number of Assist Tugs

An AT/B COSTS Money Vs a Towed Barge:
• Increased Capital Cost for Same Deadweight
• Increased Fuel Cost IF Max. Power is Used for Greatest Speed Possible

AT/Bs and “Drop & Swap”
It is the dream of every tug and barge operator, to find a trade where one can build fewer tugs and more barges. Obviously, as my friend Mr. Yamaguchi often reminded me – the barge is the “Earning part” – the tug is the “Expense-part”. We have investigated more than a few possibilities where we had more barges than tugs. However, it is important to remember that even the best-built tug can have unexpected downtime. If you run a 3-barge, one tug system, you’re golden – until the tug breaks down. For one project we investigated, we suggested the Owner build six barges, and three tugs. One pair of tugs was always working the 3-barge/1-tug trade. The third tug was a swing tug, able to step in if one of the other boats went down. It also allowed other tugs to be taken out of service and cycled for routine maintenance.

The counter-argument is, that by the very flexibility of having a barge notch another tug can fit into – even a conventional one – the lack of need for a “swing-tug” is part of the very attraction of an AT/B system.

SUMMARY
The AT/B has a place in the world merchant fleet. Use of AT/Bs is expanding to all corners of the globe. Safety, efficiency, economy and practicality are the hallmarks of a good AT/B design. AT/Bs can go anywhere a ship can go, in the same weather – sometimes MORE reliably. This “sorry excuse for a ship”, is anything but. It is an advanced marine transportation system for the 21st Century.

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I’d also like to dedicate this presentation to the Memory, of the late Mr. Larry Hoefer, who passed away suddenly earlier this year. Larry’s knowledge, friendship and willingness to share his vast and practical experience in engineering, has enriched everyone with whom he interacted – especially, the author. Godspeed, my friend.