# The ARTICULATED TUG/BARGE - AT/B
# The History and State of the Art

**By Robert P. Hill, N.A.**
**President - Ocean Tug & Barge Engineering Corp.**

**Historical Background**

The American coastwise shipping business has grown in a way that differs from many other nations. The high cost of manning and building ships has led over the years to a coastwise transportation network dominated by tugs and barges. But this system of water transport, has been lacking in several respects:

- Weather delays caused by the uncertainties of towing of a barge in heavy weather, especially a barge carrying petroleum and chemical products, are a constant problem. Towing a large barge in heavy seas just off the coast is a risky business. The possibility of parted towlines, (not to mention the reality in several hundred cases) and lost, drifting barges, has haunted tug and barge operators – as well as the customers they serve - for years.
- Towed barges are extremely slow vessels, and as the cost of a tug/barge has risen, the need to move faster has also risen.
- Towed barges are hard to control in congested areas, and often require helper tugs in port.
- Towed barges must also often wait for seas to subside before attempting to cross bars at harbor entrances. Once in the harbor, they must switch between towing and pushing gear. This adds delay time and further operational risk.
- Changes in petroleum terminal operations which are built around reduced inventories, and "on-time" delivery of replacement product, was in conflict with the towed barge's inherent lack of reliability where scheduling was concerned. The towed barge was influenced negatively by weather, sea conditions, speed variations, and traffic conditions. All of these things conspired to make a towed barge's ETA subject to constant change – sometimes by days.

Towing tugs too, were often smaller vessels, with cramped quarters, and the ride the crew experienced at the end of a towline was anything but comfortable. Yet, even given these various negative factors, the almost universally lower costs associated with barging have generated the business that sustained the industry for well over 100 years. As of the early 1990's, towing technology - which in the 1990's still operated with the same procedures as it did in the1890's, still moved most American coastwise cargoes.

There were attempts to "fix" these problems by creating the ITB, or "Integrated tug-Barge", which was essentially, a rigidly connected unit which was not a true tug and barge, but rather, a thinly-disguised ship.

There were also brushes with a switch back to coastwise ships briefly, after the oil shortages of the late 70's. As fuel costs and the cost to build a tug and barge rose with the inflation of the period, the need to move cargo faster with greater fuel efficiency and reliability caused many firms to look at ships again. Sun Oil Co went as far as to build two small coastwise (25 to 40,000 bbl capacity) tankers in the early 1980's, an experiment that was not repeated. These small tankers were intended to compete with tugs and barges, and featured "tugboat" machinery plants, automation, and layouts conducive to reducing manning. A reduced manning schedule was in fact, obtained for both the vessels.

But ships in general, were still markedly more expensive to build in the 80's than in previous decades, and the larger crews and pilotage and assist tugs needed for a tanker of any size drove up the cost of operation. Through visionaries like the Hoopers of Interstate Oil Transport, who built the "Ocean" class barges from 90,000 up to 250,000 bbl, and Spentonbush, with the building of the HyGrade 95, barge sizes increased through the 70's and 80's, to where tanker-sized barges were now available. This size increase further eroded the tanker position, and upped the ante to where the small tankers such as the ones Sun built, were just not economical competition to these slow, large and lumbering barges. They were effective competition however, to the smaller towed barges. But over time, as oil companies closed smaller, less efficient terminals, the small capacity of these ships just could not be put to economical use serving larger terminals.

**Attempts To Make Ships Of Barges**

The hydrodynamic disadvantages inherent in towing a barge at sea were well known for years. The evolution of the towed barge was stalling, as designers had gotten to the point of wringing every fraction of a knot possible out of existing designs. So over time, attempts were made to improve this situation by pushing the barge instead of pulling it. As early as the 1880's, people were patenting various designs that linked a powered vessel and a non-powered vessel. These were however, largely "rigid" systems, wherein the combined unit looked and behaved, like a ship. This was the genesis of the ITB.

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 notched barge, traded successfully on the New York canal system and the Great Lakes for many years, hauling grain products. However, for various reasons, she was not repeated in quantity. The trade in which she 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 ITB's (for which patents exist even in the 1800's) such as the "CARPORT", shared the design feature of a nearly equal depth barge and tug.

ITB's 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" lost off the Azores when it was somehow disconnected from its' barge, 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, ITB's were never designed to operate as separate units and were truly conceived as "rule beaters" Stories abound, of ITB's unable to be disconnected before drydocking, as long-unused and seized connecting devices made separation difficult.

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

Contemporaries of the "CARPORT" which were operating in the New York Barge Canal were the conventional tugs pushing various barges in a stern notch, linked together by cables. (Actually, "backing wires"). As such they were able to be assigned where needed in a mix and match fashion and the "rigid" ITB tug and barge, found itself facing the same problem it's larger "ship" cousins faced. - A lack of flexibility vs. an independent tug and barge. However, as efficient as the notched barge was for inland operation, the notch was really not developed on canal barges to improve the ability to push offshore. Rather, the notch was a concession to the limited length of the New York Barge Canal locks, and the notch depth was set to allow the tug and barge to fit in the lock together. As economics drove the need for larger capacity barges, the notch gave way to added cargo capacity, and double-locking began to appear in various forms. The barge HyGrade 42 was among the first to eliminate the notch, and it was equipped with a Schottel over-the-bow azimuthing drive. This allowed the barge to be sized to the full dimension of the locks, and the

Schottel drive was used to move the barge in and out of locks, while the tug was locked through behind it.

Of course, the elimination of the notch added capacity, but it did nothing for pushing at sea. Even with their relatively deep (for that time) notches, the canal units towed when they got to large lakes, and when they were required to travel coastwise.

So, the stage was set for someone to come along and take the large towed barge, and the canal notch – and find a way to make them work at sea. Interstate, with its new large barges, did in fact manage to push cross-Gulf, and to New England from Chester, in the notch in seas up to 6 feet using face wires. Moran also did some open water pushing with the large Atlantic Cement barges, Alexandra, Adelaide and Angela. However, the majority of the time was still spent on the hawser dealing with weather delays. The "someone" who was determined to change all that, appeared in the form of two contemporaries - Edwin Fletcher and the Bludworths.

**The AT/B Arrives**

A Florida Naval Architect, named Edwin Fletcher, sowed the first seeds of that solution. His "ARTUBAR" system, conceived in the early 70's, was the first single-degree-of-freedom system to be applied to a large tug and barge. Originally tried with limited success in Japan, the system was eventually applied here in the United States. The road to application in the US was a difficult one. Prevailing U.S. Coast Guard attitudes at the time were a great hindrance. Fletcher's system and its' ship-like seakeeping capability was seen as just that - creating a ship in the USCG's eyes, and unreasonably large crews and regulatory burdens were going to be placed on the design. At the same time, the Bludworth system, with less emphasis on its' seakeeping abilities, was finding at least limited success in evading USCG regulation. However, in 1981, the author, working on an AT/B project for Sun Transport, worked with the USCG to help formulate a new policy toward what would become the AT/B – an enlightened policy whereby the inherently greater safety of pushing with a mechanical connection – on a true tug and barge – was seen as a positive development. Regulations reverted to the "norm" for a tug and barge built this way, and Artubar was allowed to implemented. While there are not a large number of these designs at work, the units all continue in service, and the principal of the establishment of a transverse pitch-axis through the tug in the barge notch, led to the development of other types of connectors.

Over the years, the pioneering work in the ARTUBAR system and the work of the Bludworth family in developing their flexible push system – and the work of Takeo Yamaguchi of Taisei Engineering, with his "ARTICOUPLE" system, slowly began to cause people to take a second look at mechanically linking a tug and barge. But this time, the idea would be to try and use a real tug and a real barge, as opposed to trying to create a "separable ship". . If the barge hull could be optimized for pushing, and speed increased, and weather delays ended - then maybe the barge could be resurrected in a new form which was at the same time familiar to operators, regulators and shipyards. In his early model testing, Fletcher proved his point well. But the industry was historically a conservative one and acceptance was slow. The connecting draft limitations of Artubar's concept put off oil barge operators, and until the Bludworth System began to be widely applied in the latter half of the 70's, AT/B development moved at a slow pace. Companies like Interstate Oil Transport continued to spend money model testing various ideas for an AT/B. Their work focused on creating a system capable of connecting at any relative draft of tug and barge.

This changed in 1981, when the USCG created NAVIC 2-81. Under this NVIC tug-barge units were split into two distinct groups; Push-Mode ITB's and Dual mode ITB's. These rules now recognized the unique safety advantages of mechanically connecting a tug and barge at sea, and these improvements were given full recognition and approval. As long as one created a real tug and a real barge, the regulatory and manning standards for an everyday tug and barge, were applied. This is the "Dual-Mode" ITB. (Which we also refer to as the "AT/B"). For those units where the tug was in fact in essence a separable engine room, the term "Push-Mode" ITB applied

and the regulatory and manning situation followed more along ship lines. Save for occasional updates, this NVIC still stands as official USCG policy.

Then in the mid-80's, the author approached the Intercontinental Engineering-Manufacturing Corp. in Kansas City, MO., with an idea for a new connection system, that solved many of the differential loading/draft problems and mechanical problems of the current systems available, From this collaboration the "INTERCON" system was created. Engineers at Intercon, working with the author, along with naval architect Corning Townsend, and the Netherlands Ship Model Basin, developed the all-important mechanical details of the system. Later in the process, the engineering staff of the first customer, Sonat Marine, also contributed to the research effort as their INTERPID/OCEAN 250 combination was to be the first application of the system.

The new Intercon device incorporated Articouple's unlimited-draft-connection capability while eliminating the hydraulic ram as a means of extension, replacing it with a mechanical screw drive. Concurrently, the Bludworth and Artubar designs were being improved, and the Articouple system was gaining wide acceptance overseas. Thus, the successes began to outweigh the problems, and more and more operators began to see the AT/B as a true transport solution. A 1999 Wall Street Journal editorial contained a quote attributed to a prominent ( and obviously very uninformed ) opponent of the Jones Act, labeling the tug/barge unit, a "sorry excuse for a ship. Far from a "sorry excuse", the modern AT/B is not only the equal of the ship in many areas today, but it eclipses the ship on so many levels. New connection methodologies have been devised in the person of the JCOMARIN system from Finland, the new improved Articouple designs, and improvements to the Bludworth system. Intercon as well has devised new versions of its' system.

All of these systems provide some sort of hinged connection, which allows the tug to pitch independently of the barge. These systems give the AT/B much better sea-keeping ability than the previous ITB systems or conventional towed barge systems. So much so, that, in fact vessels equipped with systems such as Intercon, and Bludworth, have proven to be a very good, safe, less expensive alternative to a ship in many services. The sea-keeping ability of the AT/B is so good that many operators say they push virtually all the time. Though AT/B tugs are able to tow, few ever do. The ship is the "old" technology now.

**Why The AT/B?**

The AT/B, or "Articulated Tug/Barge" unit is designed to combine the economics of tugboat and barge operation with the speed and weather-reliability of a ship. A hallmark of this concept that makes it different from the ITB or "Integrated Tug/Barge" is the fact that both the tug and the barge are truly independent vessels able to operate successfully even if not together. The tug is a full ABS or internationally-classed ocean tug, capable of meeting all SOLAS regulations where required. It can be made capable of towing and other traditional tug missions. It features lines developed to allow for the best possible flow when connected to the barge, yet is capable of operation as a towing vessel. AT/B barges are designed for maximum speed now instead of maximum towing stability. We have worked with hydrodynamicists to create a parent barge shape which maximizes speed yet reduces construction costs. The notch of the typical AT/B barge is designed such that in the absence of the "parent" connection-equipped tug, the barge can be pushed in calm seas by any tug capable of handling it with backing wires. The barge can also be towed. Even though the speed of the unit is reduced when towed, at least the cargo unit can keep earning if the tug is in shipyard for any length of time. The tug is also capable of working with other barges, either towing, pushing (if the notch fit is correct) or alongside. AT/B units can be designed around any of the existing successful connection systems. Gone are the 7 knot average speeds of towing - here to stay are speeds up to 13 knots for barges in light product services – 15 knots in RO/RO or container services.

The introduction of this type of vessel allows for the best of both worlds. A fully classed, dual-mode unit capable of operating in the pushing mode nearly 100% of the time, with a fully ocean-

capable tug that is not a compromise design.. The barge and tug hulls are complimentary designs optimized for pushing, and able to take advantage of the fuel savings and speed advantages of controllable pitch propellers should the owner desire.

The AT/B will obviously steer far better than a towed barge. However, steering performance is even better than deep-notch or other designs mating the tug to barge with fenders and backing wires. This is because the connection between tug and barge is made with a rigid, transverse axis. Steering then is positive, absolutely identical to that of a ship. There is no play in the cables or the fenders to throw off the autopilot on long voyages and emergency turning maneuvers are made instantly and at full power if required. This is also a great benefit when entering ports with tricky bar situations, where towed barges often wait long periods for seas to subside before entering or departing in what can be very heavy seas. Recent model tests run on our vessels, were designed to provide proof to Pacific Northwest pilots, that an AT/B could effectively steer over the bars on the approaches to ports in that region, including the difficult Columbia River Bar. The model tests proved conclusively that in fact, the AT/B could steer very effectively in both head and following seas, in departing bar situations.

The AT/B requires less time and effort to both connect and disconnect on departure or arrival. There is no lost time and effort required to rig heavy backing wires or to work on the after-deck of the tug making up to a chain bridle. There is no necessity to go from towing gear to pushing gear when entering a harbor. This is not only a time consuming maneuver, it is also a dangerous one. All such operations are eliminated, saving as much as an hour inbound and outbound, not to mention reducing the risk of injury to crew members.

Pushing in a notch in a conventional manner creates major wear and tear on bow and side fenders on tugs, as well as creating damage to the notch side plating.. This expense is eliminated in the AT/B, particularly in the Intercon-equipped units, because the only points of contact between tug and barge are the connecting helmets on each side of the tug. Also, tow wire replacement becomes infrequent due to the fact that the tug will push all the time. Also, in unmanned barges, bow damage will be greatly reduced because the tug will feel the slamming on the barge as opposed to feeling nothing while towing.

***Some Advantages of the AT/B Over Towed Barges***

- *Greatly reduced bow damage to barges, because the crew can feel pounding, unlike in towed barges.*
- *Greatly reduced fender replacement (virtually none in 14 years) and tow wire replacement costs.*
- *Elimination of back injury incidents by deck crew by not having to handle heavy towing gear.*
- *More control over barge with a more powerful tug, reducing chances of groundings and dock damage because control of the vessel on approach is so vastly improved.*
- *Ship-reliable ETA's. Improved scheduling capability. Higher average speeds.*
- *Greater crew comfort at sea, as opposed to on the end of a towline.*
- *25% fuel saving vs. towing for the same speed, or a 25% increase in speed for the same fuel.*
- *Ability to sail from port with predicted heavy weather, just as a ship would - unlike towed barges.*

- *Reduced port time/elimination of transfer time from pushing to towing gear and back*
- *Availability of a large, ocean tug for emergency and salvage work, and a means to deploy a spill boom in an accident, or essentially providing for the crew, a large, seperable seagoing lifeboat.*
- *Full access to the barge at sea for emergency situations.*
- *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 powerplant.*
- *Ability to transit less congested "outside" routes as opposed to following protected routes.*
- *Speed capability limited only by installed horsepower.*
- *Increased safety when pushing by the elimination of backing wires that can part in emergency maneuvers.*
- *Ability of both tug and barge to function as fully independent units when one or the other requires shipyarding.*

It is important to note, from the view of this design office at least, that the AT/B is not a “rule beater”. The term implies that somehow the AT/B gets around safety issues. Nothing could be further from the reality of the situation, when you talk of these large, AT/B’s. The gross tonnage advantages found in smaller units disappear, and the type of operation envisioned does not allow for skimping on the regulations. The true value of the AT/B comes in being able to build it in specialized yards, where the tug yard can concentrate on the tug, and the barge yard on the barge – or both can be in one yard, under the overall design responsibility of the owner’s architect. The key is design. This office has participated contractually in the design of over 25 ***operating*** AT/B’s. This experience spans over 22 years for me, and never once, have I ever found an owner for whom safety was not the top priority.

The AT/B concept is also interesting from the standpoint of versatility. The barge can be anything, outfitted for almost any service. From a design standpoint this allows the use of the same propulsive system (tug) and same connection system (coupler and notch) and the same basic barge hull for a variety of different services, from liquid cargo, to bulk, to self-unloader, to containership. The extent to which this design benefit is of value to the owner, really does depend however, on whether or not there are significant differences in the configurations of these type barges, as each service has differing requirements for speed, dock limitations, turning basin limitations, air and water draft, pilotage, etc. Our experience is that while cookie-cutter designs are a great idea, like in ships, they only work in a very narrow field of application.

It is often noted and claimed that the only disadvantage to an AT/B is its overall speed when compared to a typical ship of the same capacity. The AT/B is indeed slower, but not to the point where the speed of the ship will give the ship any economic advantage especially in coastal trade or short trade routes (like trans-Gulf trade) where speed is not as critical as in actual transoceanic trade. And like most axioms, this is only true given similar installed horsepower for the two options. In general the AT/B is capable of very good speeds, especially in the container and other light DWT capacity applications, where speeds upward of 14 - 15 knots are economically possible. AT/B’s are also regularly utilized by companies like K-Sea and Teco Shipping, in trans-oceanic service. Companies like Penn Maritime operate AT/B’s into Central and South America. Reinauer, Keystone, Bouchard, Sea River Maritime and others operate AT/B’s on long coastal voyages.

Another advantage often attributed to the AT/B, which should be addressed, is the ability to "drop and swap". Drop and swap refers to the logistics possible in building multiple barges and utilizing a lesser number of tugs for moving the barges. (i.e. drop off an empty barge, turn the tug immediately, and pick up a loaded barge ) This has been looked at for some types of operations like fuel barges for power plants in remote regions, certain bulk trades, container shuttle services, etc. . Our firm had designed just such a system about to be built, which employs three tugs and six barges shuttling crude. One tug handles three barges – one loading – one discharging – one in transit. The third tug is a spare, needed because the barges truly are a pipeline which will be intolerant of downtime.

However, the advantages of this sort of system are available generally if the pick-up and drop locations are a distance apart that is conducive to closely matching load and discharge times to transit times; it is also a requirement that the pick up and rop off site be largely in protected waters. Despite advances in AT/B technology, there is no connection system presently available which will allow you to reliably and safely pick up a barge offshore in a significant seaway and securely lock into it. The issue is however, being addressed, and the ability to leave the tug and barge safely connected during lightering type operations offshore has been proven with Maritrans' lightering operations in Delaware Bay.

Another consideration when discussing the connection system is size. Technologically speaking, according to manufacturers of these systems it is possible to build a coupling system for AT/Bs up to and possibly beyond the 500,000 bbl. size. Designs have been initiated for barges of up to 100,000LTDWT capacity, with tugs of 25,000 HP. However the largest pure AT/B now in service is a 300,000 bbl. capacity unit, and it is utilizing a modified version of the standard Intercon system. However, our Voyager class tug, which is 155 feet long, is being created for three different owners with three different connection systems. This adaptability and flexibility is one of the reasons AT/B's are so economical to build.

We are currently engaged in a number of international AT/B projects, with contracts for vessel designs to operate in the Far East, South American, and South Pacific regions. This shows just how widely applicable this marine transport system is – and dispels the misconception that the AT/B is a limited-use concept that is useful only in the States.

Pending AT/B's for companies like Sause Bros., to an Elliott Bay design, and VMS, to their own design, are expanding the concept to the West Coast. AT/B's by our firm and Bay Engineering, utilizing the Hydraconn Connection; and companies like Hannah Marine and McKeil, utilizing the hydraulic pad type systems, are making AT/B's a reality on the Great Lakes. Acomarin's orders in various parts of the world, including western Canada, are also noteworthy.

In conclusion, the AT/B has made its' mark on US coastal and ocean shipping. This "sorry-excuse-for-a-ship", is making believers out of former skeptics. The greatest compliment to a designer however, is not just the kudos from the management and executives of the companies that operate these units - it is also the way that the crews have embraced and accepted the AT/B. It is the fact that the men and women who go to sea on these units are enthusiastic about their charges. We continue here to develop new applications for the AT/B, and to refine the technology even further. As environmental forces apply pressure to reduce oil spills, the days of the large towed oil barge are certainly numbered. As scheduling of inventory in various product terminals tightens, the days when a customer could live with weather delays of the towed barge are past . The AT/B is here to stay.

*The author is the President of Ocean Tug & Barge Engineering Corp., a leading specialized designer of AT/B units, and he is co-inventor of the proprietary Intercon connection system. His firm has had a hand in over half of the currently operating AT/B's in the United States, and is currently involved in a number of design contracts for additional AT/B's for both domestic and overseas customers. Mr. Hill has over 22 years experience in AT/B design. His firm's website with additional information on AT/B's, can be viewed at www.oceantugbarge.com.*