TUG/BARGE OPTIONS

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ABSTRACT

Tugs and barges have operated for over 100 years. Integrated Tug/Barge Systems (TBS), where the tug pushes the barge via a formal linkage, were first developed some 40 years ago. Linkage design, unit construction and operation of such TBS's have been concentrated over the last 25 years, most notably in the US coastal trades and in Japan. The preferred linkages today are articulated systems that permit the tug and barge to move independently of each other while still maintaining the connection. The attraction of TBS's are relatively low capital cost, design and configuration flexibility and low operating costs compared with conventional ships. Of considerable benefit is the ability to design for shallow draft operations without compromising construction values and costs.

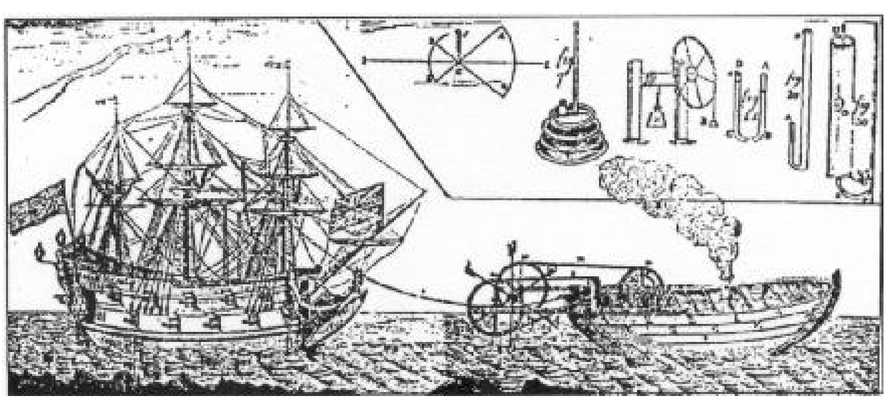
Tugs and barges are an essential component of the marine scene on the West Coast of Canada, and were important for Great Lakes operations. There are a few Canadian tug and barge operations on the Great Lakes, most notably Blue Circle ex St. Marys Cement.

HISTORY

Barges have been part of the marine transportation scene from the point at which the human race started moving goods by water. Tugs appeared somewhat later, but Jonathan Hull's machine (Fig. 1) of 1736 showed that the application of the steam engine to towing ships was well appreciated. The steam tug "industry" was towing barges from Greenock up the Clyde in 1814, and there were similar developments on the Tyne and on the Hudson in the USA in the early 19th century.

However, when tugs and barges actually became Tug-Barge Systems is uncertain. If by a system one means a dedicated tug and barge, then the "Hecla" and the "Ironton" which moved the first iron ore from the Mesabi range in 1884 may be the first such system. The early concept of a tug barge system used to be known as a ship and consort, whereby a conventional ship towed another non-propelled vessel. These "systems" were well known on the Great Lakes of North America throughout the early part of the 20th century .Here the concept was to increase the quantity of material that could be moved by a single ship when most vessels did not exceed 10,000 dwt. Thus a ship and consort could move close to 20,000 tons of cargo.

Figure 1
JONATHAN HULLS' MACHINE -1736



Perhaps the most famous consort system was the "Iroquois" and "Navahoe," owned and operated by Anglo American Oil Company and often referred to as the Horse and Cart of the Atlantic. The "Iroquois" was a 9,000 dwt steam-powered tanker that towed the 8,000 dwt six-masted tanker schooner "Navahoe." The system operated reliably between 1908 and 1931, and the pair could make ten knots. (See Fig. 2)

Figure 2
THE HORSE AND CART OF THE ATLANTIC

Tug-barge systems, as integrated units, did not really develop until George Sharp & Co. in New York built the Carport/GI combination for Cargill Grain in the 1950's. Intended for US coastwise grain trades, the unit never operated as intended because of opposition from the US Coast Guard on tug stability grounds. However, the unit, and sister vessels, ran successfully in the Caribbean under the Panamanian Flag for over twenty years. The Carport was the progenitor of all the tug-docked-in-notch concepts developed during the 1970's, of which the Ingram-Breit design was the most well known. (See Fig. 3) The Wartsila marine locomotive design, and the Murvicker and Waller designs all have the same antecedents. The CATUG system (see Fig. 4) was an inverted concept, in that the tug docked over a tongue protruding from the stern of the barge.

***Figure* 3**
INGRAM-BREIT

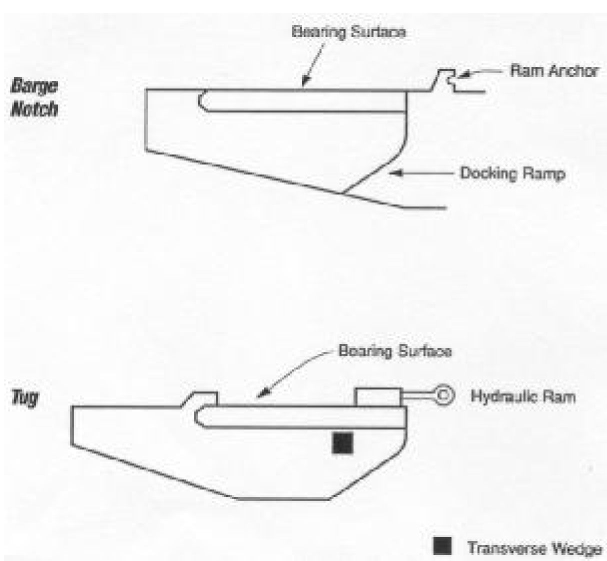
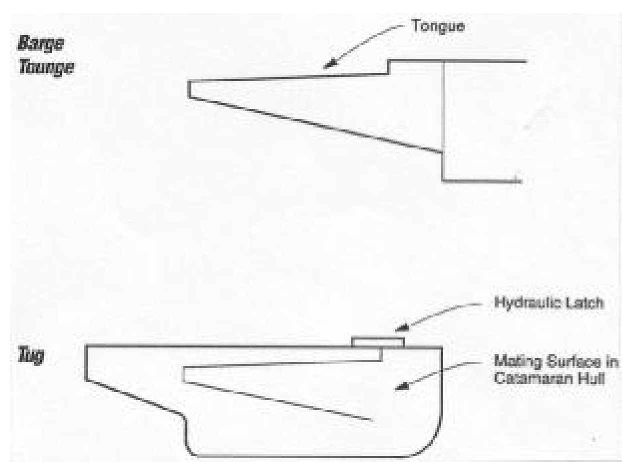
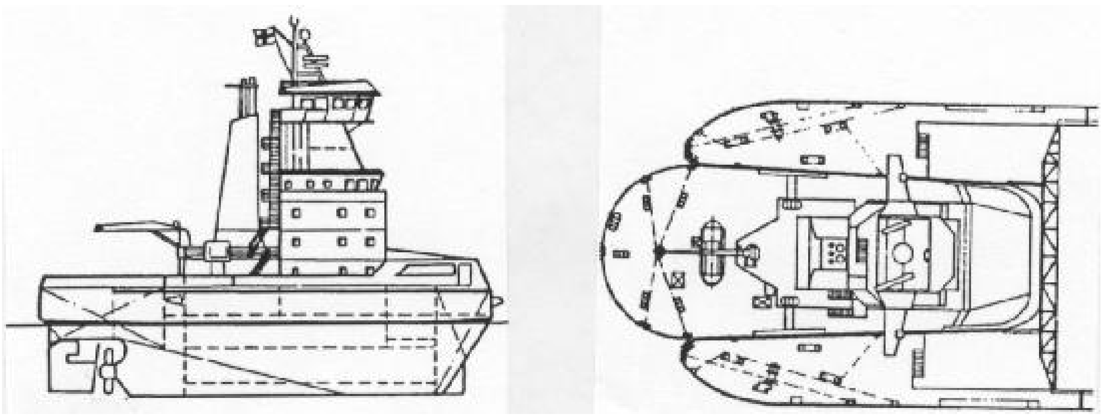


***Figure* 4**
CATUG



It was a CATUG unit that was to lead to a change in direction in tug-barge systems. The casualty of the "Oxy 4102" and its tug, the "Oxy Producer," off the Azores in September, 1981, (the tug sank) precipitated a ruling by the US Coast Guard that effectively put an end to fully integrated tug-barge systems for US operation. The problem with such systems had always been that the tug, in order to be able to dock in or on the stern of the barge, had to be a somewhat unusual shape. It also had to have a very high secondary bridge in order to achieve good forward visibility (see Fig. 5). As a consequence the tug was at best tender, and at worst unstable, when out of the notch in other than calm weather.

***Figure* 5**
THE TUG OUTLINE FOR THE RIGID LINK SYSTEM



The commercial result of the ruling has been to encourage the development of articulated systems. Here the tug is held in the notch for push towing, but is able to readily extricate itself, and is fully stable and able to tow the barge when out of the notch. See Figs. 6 and 7 for typical systems, and Annex 1 for the US Coast Guard definition of TBS types.

Fig. 7 shows the Articouple system, which was developed by a Japanese naval architect outside of US influence, and has been very successfully applied in both the Far East and Europe in a range of small to medium size units since 1972.

Figure 6
MARINE SPECIALTY

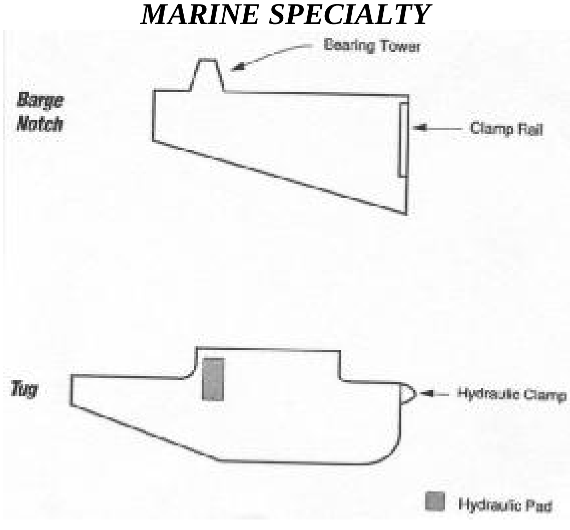
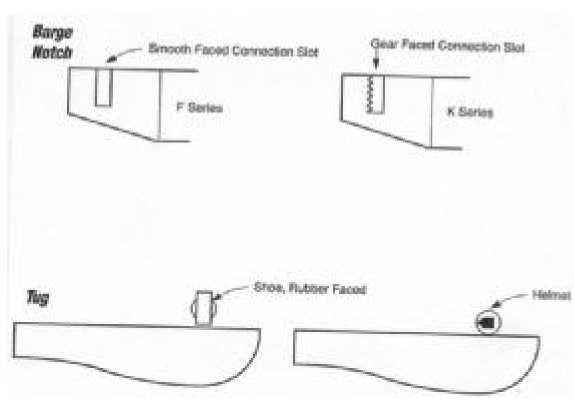


Figure 7
ARTICOUPLE



TUG/BARGE CONNECTION SYSTEMS

There are many ways of handling barges as Fig. 8 demonstrates. However, a tug-barge system is generally either a deep notch or linkage arrangement. Most barge systems in use today were designed from the outset for open sea use. The major ones are as follows:

Fixed Link Types

Ingram-Breit	Fully integrated system where the tug docks in the stem of the barge. Eight systems believed to be built; three understood to be still operating.
CATUG	Fully integrated system where the tug locks onto a tongue protruding from the barge stem. Twelve systems believed built; eleven still operating.
Finnpusku	Similar concept to the Ingram-Breit. Two tugs and five barges built; all still operating.
Triofix	Helmet and ladder connection. Two believed built; both still operating.

Articulated Linkage Types

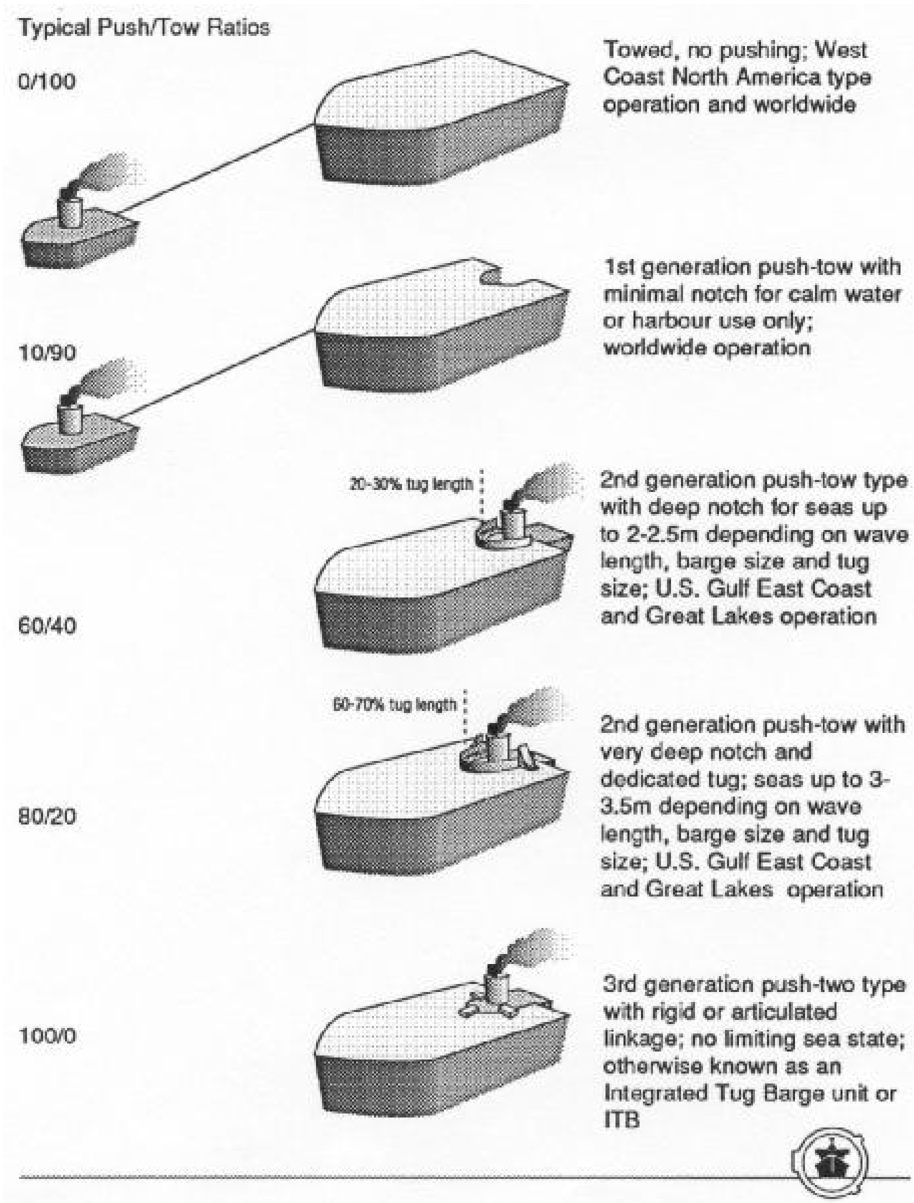
Artubar	Pin type connection Three or four believed built; three still operating.
Intercon	Helmet and ladder connection. Several built and operating for US trades, including the Lakes.
Marine Specialty	Gripper connection. Six-seven built; all still operating.
Articouple	Helmet and ladder connection. About eighty built and one Russian unit believed to have been lost.

Deep Notch Type

Hydropad	Seven units believed built, six still operating, although most have been adapted in some way.
Fendered Deep Notch	Probably in excess of twenty built, about ten still operating. Some of the others have been converted to articulated systems to obtain better weather reliability.

(See Annex 2 for an outline of each of the above systems.)

Figure 8
METHODS OF HANDLING BARGES



MAJOR WORLD BARGING TRADES

The USA has been, and remains, the most active area in the world for tug-barge operations. On the East and Gulf Coasts, most units are integrated in some way. On the West Coast, the tradition has been to tow rather than push. Oil, coal and phosphate are the primary cargoes on the East and Gulf Coasts, but new barges have been delivered with asphalt and liquid sulphur capability. On the West Coast, forest products and oil dominate tug and barge movements. Some containers are moved by barge on both East and West Coasts as feeder operations. Major companies in the Gulf and East Coast trades are Dixie Carriers, Maritrans Partners and Teco Transport and Trade. On the West Coast, Crowley, Foss, Seaspan and Rivtow are major operators.

In Europe, offshore tug-barge operations are dominated by the Danish towing company Svitzer who haul a wide variety of cargoes, including coal, with a fleet of five tugs and nine barges. The tugs and barges all employ the Articouple system. Neste recently delivered a small asphalt carrier also using the Articouple system. In the Baltic, the Finnpusku system of two tugs and five barges hauls coal, iron ore, coke and logs. In the Sea of Japan, and a range that extends from Russia to Indonesia and Papua New Guinea, major trades are stone, cement and logs. In addition to Japanese flag operation, there are some Russian TBS's using the Articouple system. These units are self-dumping log barges.

There are eight shallow draft self-unloading barges (4 x 7,000 dwt and 4 x 3,500 dwt) operating in Indonesia on behalf of BHP. These are towed barges without notches, moving coal from the mine to a deep water export terminal. Current capacity is about 5m tpa.

Barge deadweights range from 3,000 to 52,000 tonnes, with the largest units operating in the Great Lakes of North America and the US Gulf. European equipment is mainly about 12,000 dwt while Japanese and Russian TBS's are generally somewhat smaller.

COMMERCIAL DIFFERENCE TO OTHER SYSTEMS

It must be recognized that although TBS's have advantages, there are also commercial disadvantages.

Pros

- Generally shallower draft for given cargo lift.
- More flexibility in design and configuration.
- Less restrictive construction criteria due to unmanned status.
- Usually lighter scantling giving more cargo capability for a given displacement
- Generally inexpensive to build given the simple shape and machinery structure.
- Tug crew usually much smaller than the equivalent vessel. Typically 6-12 versus 20-30.

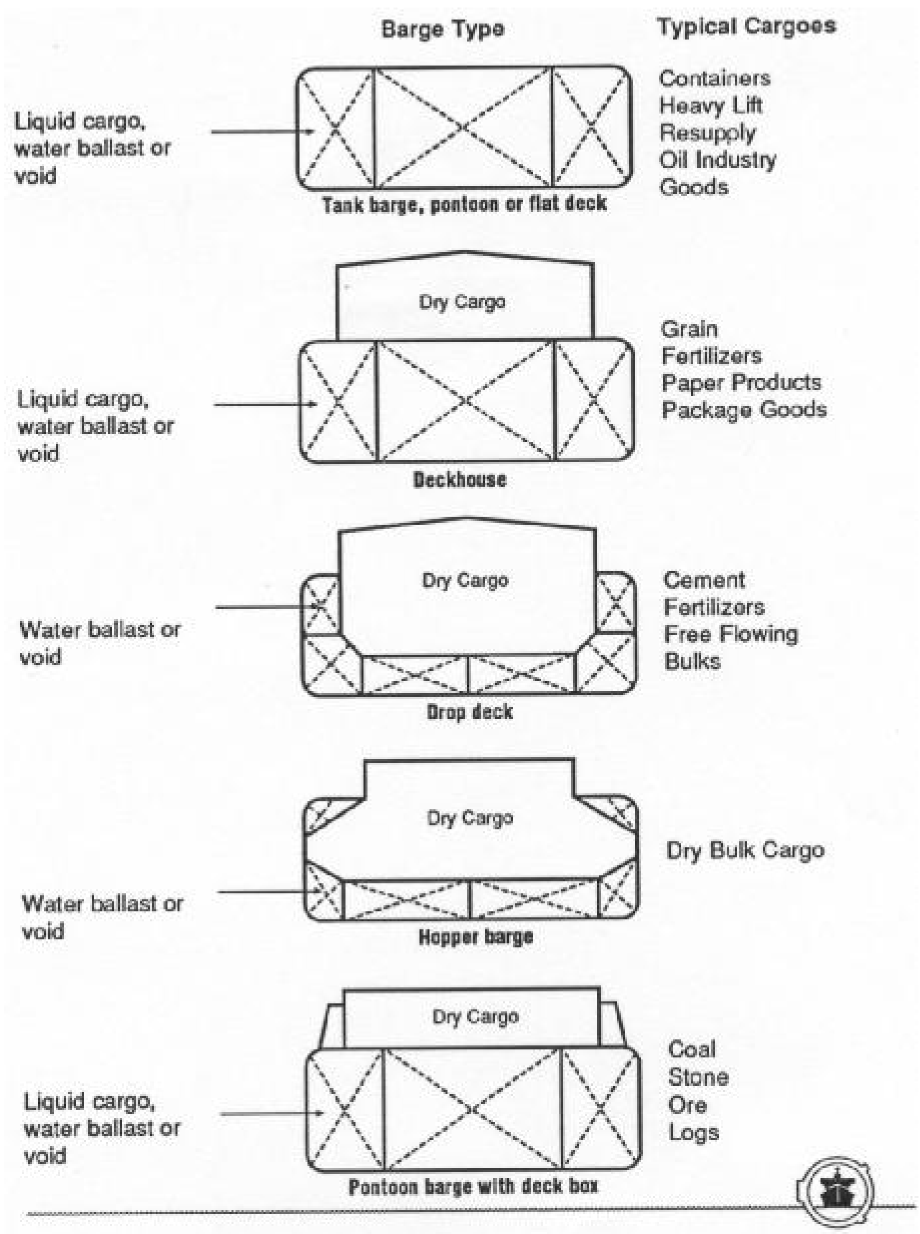
Cons

- Generally less sea capable than a conventional vessel.
- Economic speed usually not more than 10 kn vs 14 kn for a conventional vessel.
- Speed is impacted by adverse sea conditions.

- Often more costly to insure, on a percentage basis than a conventional ship
- Because of small crews and unmanned operation, higher shoreside maintenance effort needed.

As noted above, barges can be configured in ways that a conventional ship cannot. Fig. 9 shows different cross sections.

Figure 9
BASIC BARGE TYPE – TYPICAL MID-BODY CROSS SECTION



TBS's do require careful attention to the connections system, hydrodynamics at different drafts to ensure adequate water flow to the tug propellers, and sea conditions in which the system will operate.

When chartering a TBS, attention must be paid to charter clauses that reflect the differences between a conventional ship and a tug/barge operation. These would be:

- Speed clause covering speeds in/out of notch and weather conditions.
- Towing/pushing clause giving the master complete and absolute discretion.
- For international trade, a further clause should ensure that the connection system is acceptable to local authorities, to ensure that the unit is not detained.

OPPORTUNITIES FOR CANADIAN TRADE

As noted, marine cargo movements on the West Coast are almost exclusively by tug and barge. There is a single very simple tug/barge connection system in operation. On the East Coast there have been some tug and barge operations in support of the forest industry, but no tug/barge systems of which we are aware.

The Great Lakes and connecting channels have a great opportunity for tug/barge systems and new marine operations introduced in recent years, both in Canada and the USA, have been tug/barge. Some have been cut-down Lakers with a notch created in the stern, while others have been large units operating in the cement, stone and ore trades.

However, rather than trying to compete head to head for the mainline trades, tug/barge operations have the ability to reintroduce marine traffic lost to road and rail because of parcel size. A tug/barge operation can probably offer freight cost in a 10-12,000 tonne parcel that would be attractive to smaller shippers. It may also be a way of rebuilding some of the petroleum products trade, lost to pipeline and truck delivery, by building modern double hulled equipment of a size able to meet remaining tank farm capacity.

There are opportunities, but it will take time to identify the trades and develop the necessary commercial linkages to keep equipment fully employed. An example is freight ferries. The “Incan Superior” was chased off the Lakes by the US Harbor Maintenance Tax, and this still prevents very many cross lake ferry operations from being developed. If the ad valorem concept was dropped in favour of a fee geared to use of dredged waterways, then we could see freight ferries between Cleveland and Port Stanley; Oswego and Toronto; Duluth and Thunder Bay and other possibilities. These could well be Canadian operated, with multi-decked barges.

There is also a potential for tug/barge systems to serve Arctic communities, rather than conventional ships. However, this would depend on the comparative economics, particularly for off season employment. With a probable Arctic season of about 150 days, there must be some winter season employment to defray costs.

Conventional ships might be chartered out into European/Baltic feeder trades where their enhanced ice class could be of value. For tugs and barges, the tugs could be built as medium ice breakers and chartered to DFO to provide ice breaking service in the Gulf of St. Lawrence/Newfoundland area during the winter. The tugs could also provide on-demand assist in the Arctic for ships serving mine operations, and tankers. One or more units could well provide standby service for Voisey's Bay for winter trade – if the mine ever gets up and running.

ANNEX l

The U.S. Coast Guard have defined two types of Integrated Tug Barge combinations.

A Pushing Mode ITB

- The unit has the characteristics of a ship of comparable size
- The tug cannot meet towline pull stability criteria.
- Does not have installed or rigged the necessary equipment for hawser towing.
- Cannot demonstrate safe separation of the tug from the barge under all operating conditions for which the combined unit is designed.
- Crew sizes are mandated by USCG at a minimum of 14 persons plus galley and service personnel.

A Dual Mode ITB

- The tug has a hull shape which permits safe hawser towing.
- The tug meets the weather, dynamic and towline pull stability criteria.
- The tug and barge are equipped and rigged with the necessary gear for hawser towing.
- The tug has the capability to separate safely and in a timely fashion a pre-designated sea state. Depending the GRT of the tug, most units would be required by USCG to carry 4-10 persons plus galley and service personnel.

If the TBS is considered to be a pushing mode ITB, then it is classified by the USCG as a ship of equivalent size. If it is a dual mode ITB, then the tug and barge are inspected separately, and may be built and operated according to the relevant rules.

The foregoing is a highly condensed version of a nine page U.S. Coast Guard circular (NVC2-ICH-1 dated 06 Jan. 1982). The points enumerated are considered by the author to embody the key differences.

ANNEX 2

DESCRIPTION OF TUG/BARGE CONNECTION SYSTEMS

Fixed Systems

Ingram Breit

The tug has a specially shaped hull that mates with complementary bearing surfaces in the notch structure. The tug is drawn into the notch and firmly attached to the barge by a large hydraulic ram. There are also hydraulic wedges forward and a wedge arrangement aft that the tug is drawn onto by the ram. A Lakes example of this system is the Presque Isle. The tug and barge must be at the same relative draft for connection and disconnection.

CATUG

The catamaran tug represents the reverse of the Breit system in that the tug mates onto a tongue on the stern of the barge. There are bearing points and wedges between the tug hulls and the tongue, and the units are held together by a pair of hydraulic latches forward.

The tug and barge must be at the same relative draft for connection and disconnection.

Wartsila

This is the system used by Finnlines. The tug requires a specially shaped hull tapered towards the bow, and mates very closely with the barge notch. There are hydraulically operated side wedges port and starboard, with a fixed bow wedge. The tug wedges mate with one of three locations in the barge, generally at barge loaded and ballast draft levels. More or less mating locations can re provided.

Ballasting requirements are thus much simplified compared with the Breit and CATUG designs.

Triofix

This is a fixed linkage system developed by Taisei Engineering in Japan (the designers of the Articouple System). The connection system consists of three wedge shaped rams on the tug, one in the bow and one each port and starboard. The barge notch has three mating surfaces with "Gear" type faces, thus providing complete draft flexibility.

Articulated Systems

Artubar

The connection system consists of a very large diameter hydraulically retractable "pin", that mates with sockets in the notch wall. Typically two sockets are provided, one for loaded and one for light draft.

Articouple

The Articouple system provides for two types of tug restraint in the notch. The F series consists of a shoe travelling in a vertical channel in the barge notch supported freely on the end of a hydraulic ram, port and starboard on the tug. This system was developed primarily for TBS's where there are rapid and extreme changes in draft (e.g., dump barges).

The H and K series are largely similar except that the shoe is a gear shaped helmet that mates with a serrated channel in the tug notch. This enables complete flexibility between tug and barge drafts to be achieved while still effectively restraining the tug in the notch.

Intercon

The system consists of an interface head and ram assembly mounted port and starboard on the tug and connecting ladders set into the notch walls. The interface head is extended by a screw driven ram and consists of a toothed head mounted on a spherical support. The toothed head mates with teeth on both sides of the ladder and permits complete flexibility between tug and barge drafts.

Marine Specialty Connector (Bludworth)

The system holds the tug in the notch by a bow clamp that fits over a vertical rail at the foot of the notch. The tug is free to pitch about this fulcrum, but automatically ejects if the relative angle between tug and barge exceeds 18 degrees. Lateral movement in the notch is controlled by nylon pads that bear on vertical surfaces at the rear of the notch. One of these pads is fixed, the other is hydraulically extended to hold the tug firmly. An example on the Lakes is the St. Marys Cement II/Sea Eagle II.

Fendered Systems

Hydropad

The system was developed by ACB and is essentially a sophisticated fendering system. The barge requires a deep mating notch and there are four hydraulically operated bearing surfaces, two forward and two aft. The tug is held in the notch by wires running from the tug to the barge wing walls.

The concept is very similar to that developed by UBEM for a coal barge operation between Poland and Holland that ran for a few years in the early 1970's.

Fendered Deep Notch

No patents exist for this system, which consists of a conventional deep notch that accepts about 60% of the hull of a heavily fendered tug. The tug is held in the notch by wires. The system is relatively inexpensive, but does suffer from weather delays if seas are in excess of about 3m, although this will depend on wave period.

West Coast Snubber

This is a pad system developed for a freight barge operation on the West Coast between Vancouver and the Island. The tug has fixed pads while the barge has hydraulically extending pads that mate with those on the tug.