Feasibility Evaluation of a Tug Assisted Locks Vessel Positioning System

Evaluación de la Viabilidad de un Sistema de Posicionamiento de Buques en las Esclusas Asistido por Remolcadores

ACP

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Resumen Ejecutivo

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1. EXECUTIVE SUMMARY

The vessel-positioning system is a key element necessary to determine the new Post Panamax lock size and will have a direct impact in the locks cost and the eventual locks alternative analysis.

One gap in the ongoing locks conceptual design studies has been identified as the lack of feasibility studies for alternatives to the existing locomotive ship positioning system. The only previous study available is a brainstorming-type study made by Texas A & M University, "Project to Identify and Evaluate Alternative Concepts for Vessel Positioning at the Locks", in June 1999, which evaluated concepts and presented six final concepts that would require further studies.

To address this situation, the Canal Capacity Projects Division made a proposal to the Maritime Operations Department to assemble a team consisting of Canal Pilots, Tug Masters and Locks engineers to travel to the Port of Antwerp to visit the largest Post Panamax locks in the world, Berendrecht and Zandvliet, to observe and evaluate their operations and how they position these vessels with the assistance of tugs.

The trip was made on October 19-26, 2002, and this report is the result of the team's observations and professional judgment in trying to determine the feasibility of using a tug assisted vessel-positioning system in the proposed Panama Canal Post Panamax locks.

Locks of one, two and three lifts were considered and from the operations standpoint; the single lift was discarded because of the line or wire angles from the top of the locks wall to the vessel, the double lift was estimated as borderline because of the same reason and the triple-lift lock was considered the most feasible and the one for which the different lockage procedures were developed.

Four scenarios were developed for two types of Post Panamax vessels: a container vessel and a Dry Bulk / Tanker vessel. The scenarios included: tug assisted tying up to one lock wall, 4th generation locomotives on just one wall, tug assisted tying up to one lock wall using a line-carrying vehicle, and tug assisted tying up in the middle of the chamber to both lock walls. Two more scenarios were developed for Panamax-Plus vessels (Panamax size with more than 12.04 m of draft) and an additional one for a multiple vessel lockage.

The lockage procedures and preliminary lockage times were developed by Canal Pilots, based on the observed times in Belgium and their professional judgment. Filling-and-emptying and tying-up times were introduced to establish the total lockage and relays lockage cycle times for the Post Panamax tug assisted options. They are summarized and compared to the locomotive scenario in the following table:

Container Vessels	**Lockage Time** (min)
Locomotives on one wall	148.7
Tug assisted tie-up to one wall	185.7
Tug assisted tie-up in the middle of the chamber	160.7
Tug assisted tie-up to one wall with LCV	165.7
Tug assisted tie-up in the middle of the chamber with LCV	140.7
Dry Bulk /Tanker Vessels	**Lockage Time** (min)
Locomotives on one wall	188.7
Tug assisted tie-up to one wall	220.7
Tug assisted tie-up in the middle of the chamber	195.7
Tug assisted tie-up to one wall with LCV	200.7
Tug assisted tie-up in the middle of the chamber with LCV	175.7
Container Vessels	**Lockage Cycle Time** (min)
Locomotives on one wall	102.8
Tug assisted tie-up to one wall	113.8
Tug assisted tie-up in the middle of the chamber	103.8
Tug assisted tie-up to one wall with LCV	93.8
Tug assisted tie-up in the middle of the chamber with LCV	83.8
Dry Bulk /Tanker Vessels	**Lockage Cycle Time** (min)
Locomotives on one wall	128.8
Tug assisted tie-up to one wall	133.8
Tug assisted tie-up in the middle of the chamber	123.8
Tug assisted tie-up to one wall with LCV	113.8
Tug assisted tie-up in the middle of the chamber with LCV	103.8

Table 1-1. Total Lockage and lockage cycle times for a three-lift lock for different types of Post Panamax vessels and modes of operating with tugs.

With a tug assisted vessel-positioning system some lock infrastructures are not required, such as the approach walls, towing tracks and conductor slots, track transformers and switchgears. Changes are needed because of the increased chamber dimensions for the gates, length of walls and water saving basins. Additional chamber fenders will probably be required**.**

Estimates of the infrastructure changes required by a tug-assisted system were made and compared to the assumed locomotive system requirements. Operations and maintenance, labor and materials annual costs were also developed for both options and considered for a 30-year life cycle using a discount rate factor of 12%. An optimistic unit price of $3.0 million was assumed for a 4th generation

locomotive and a consulted price of $ 5.6 million for the lock tugs. In this case, a difference of $***70.58 million*** is found in favor of the locomotive positioning system. The following tables summarizes the cost estimates:

Locomotive Positioning System (working similar to existing)	**USD in million**
Initial Infrastructure Investment	168.31
Initial Equipment Investment	60.00
Annual Operations, Materials and Maintenance for 30 years (includes additional purchase of locomotives for relays & Rio Indio)	147.26
Total Cost at Net Present Value @ discount rate factor of 12%	**375.57**
Tug Assisted Positioning System (using LCV)	
Initial Infrastructure Investment	203.25
Initial Equipment Investment	36.10
Annual Operations, Materials and Maintenance for 30 years (includes additional purchase of LCV for relays & Rio Indio)	206.80
Total Cost at Net Present Value @ discount rate factor of 12%	**446.15**

Table 1-2. Total Costs breakdown for the Locomotive and the Tug Assisted Vessel Positioning Systems in a lock with wider and longer chambers.

It is very important to note that for whatever vessel positioning system alternative is selected, new 50- to 60-ton bollard pull tugs will be necessary to assist shipping throughout the Canal's navigable channels. This will be especially true in the lock entrances, Gaillard Cut and possibly beyond, and the new bypass channel leading to the new Pacific lock structure. The number of these tugs that is required will be dependent on the expected amount of traffic derived from the ongoing Marketing studies. Since these new tugs are necessary, independent of the vessel positioning system selected for the locks, and will be used mainly outside the locks, their costs were not included as part of the economic evaluation.

The primary conclusion of this study is whether a tug assisted locks vessel-positioning system is feasible navigationally, technically and economically for the new Post Panamax locks and should be considered as one of the alternatives for decision-making analysis.

For the tugboat system to work safely and efficiently in the locks, the following conditions should be met:

A. The width of the proposed chamber should be 20 % wider than the beam of the design vessel, or at least 12.2 m (40 feet) more, to allow bow tugs to leave the chamber if they are not needed.

B. The length of the proposed chamber should be at least 100 m (328 feet) longer than the design vessel to allow maneuvering space for the bow tugs and the possibility of Panamax tandem lockages.

C. An under-the-keel clearance (UKC) of 3m (10 feet) is paramount in allowing these vessels to move through the locks in a timely manner.

D. The filling and emptying system of the locks should work in such a way that little or no turbulence, longitudinal or transverse forces are developed to allow safe tie-up to the walls or in the middle of the chamber. The hydrodynamic forces that would develop during water exchanges should not create a dangerous situation of parting mooring lines.

E. The Compact Lock tugs concept should be implemented to reduce the requirements on the ACP Post Panamax tug fleet.

It is our recommendation that the ACP should make a field test of this system in our existing locks with an actual transiting vessel proportioned to the Post Panamax chamber. This will confirm the safety of the operation, the system's behavior in multiple-lift locks and estimated lockage times. The results of this test can be introduced as an update or revision of this report, to enhance its thoroughness and documentation.

Locks Locomotives

Because of the large displacements of Post Panamax vessels, the existing locomotives will not provide adequate assistance to these vessels because of a lack of space for their proper positioning alongside the vessel at points where effective forces can be exerted. A team of transportation, electrical, mechanical and structural engineers should be contracted to develop a conceptual design for the 4th generation of towing locomotives. The technical and economical feasibility of the locomotives can then be properly evaluated, and a revisit of this report should be made, especially in the costs section where the $ 3.0 million / unit locomotive price was used.

Also, the previous ACP-developed, Post-Panamax Canal Capacity study should be revisited to introduce these new lockage time estimates and reevaluate the previously estimated capacity, especially for financial feasibility purposes.