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MAZATLAN FERRY TERMINAL EVALUATION

OVERVIEW

This report describes the results of a full mission ship handling simulator based operational evaluation that was conducted at STAR Center (STAR) on August 3rd and 4th, 2010. The objective was to determine if a planned 300 meter long berth along the north side of the Port's ferry terminal slip will safely and efficiently accommodate car carriers and cruise ships up to 280 meters in length. Simulation tests were conducted using STAR's full mission bridge ship handling simulator that features a 360-degree out the window view and a full complement of modern ship's control and navigational equipment.

A Mazatlan Harbor Pilot participated in the testing by controlling the simulated ships. He also verified the accuracy of the simulation modeling and provided expert recommendations for selection of the test conditions and for the interpretation of results. A representative from API Mazatlan and a representative from the construction firm that may participate in the project also observed some of the test runs.

STAR Center's research staff observed all simulation transits, noted results and conducted debriefings after each exercise. STAR provided an experienced helmsman to execute the mariner's steering orders and a simulator operator to configure the simulator, monitor proper operation of the simulator, capture data, and make track plots for each test run.

The Pilot completed 18 simulation test runs during the two evening test sessions and observed results of the tests verified the suitability of the design of the planned new berth. Detailed descriptions of the simulation models, tests and results are provided in this final report.

Simulator Model of Mazatlan

STAR had previously constructed a visual, radar and bathymetric database for the Port of Mazatlan that was used in earlier simulator tests of the inner harbor and of the Ferry Terminal. This database was modified to include the planned new ferry terminal berth based on engineering drawings. Data used to modify the simulator database was provided by API Mazatlan.

Ships were docked at the piers close to the new berth to constrain the area available for maneuvering. This included a ferry boat alongside at the ferry berth and a large cruise ship at the cruise pier northeast of the ferry slip. The occupied berths also provided for a more realistic view. The docked ships appear on the attached track plots.

Water current conditions were modeled and adjusted per the Pilot's recommendation to simulate the effects of both a 1.5 to 2.0 knot flood and a 1.5 to 2.0 knot ebb condition. The accuracy and realism of the currents and other model components was verified by the Pilot and he rated all aspects the simulation modeling as very realistic in the "FINAL EVALUATION FORM" (attached).

Simulator Test Ship Models

Two ships, a car carrier and a cruise ship, from STAR's library of validated ship models, were used in the evaluation. The ships were selected by API Mazatlan in consultation with STAR's modeling and research department. The dimensions and characteristics of each of the test ships are discussed below.

- *FIGARO: car carrier, LOA = 198 m, max beam = 32.2 m, draft = 9.5 m*
  The *FIGARO* is a car carrier representative in size of the largest vessel of its class likely to use the new berth. This ship provided for a good test of berth access in high wind conditions because of its large sail area. The ship's bow thruster was not used during the simulations to provide for a worse case analysis.
- *RHAPSODY OF THE SEAS: cruise, LOA = 279 m, beam = 32.2 m, draft = 7.6m*
  The *RHAPSODY OF THE SEAS* was chosen as representative of the longer cruise ships likely to use the new berth. The ship has a conventional propulsion arrangement and is equipped with bow and stern thrusters. Given its large size and conventional propulsion the ship provided a good test of cruise ship access into the planned ferry terminal. Tug boats were not used to assist during the simulations on the cruise ship.

Tugboats, Side Thrusters and Other Ship Maneuvering Aids

Two azimuth drive type assist tugs, one rated at 5000hp and the other at 4,200hp, were used during simulation tests on the car carrier, *FIGARO*. Tug horsepower was selected to be representative of the tugs presently available in Mazatlan. The tugs were made fast to the vessel per the Pilots direction and he controlled the tugs via a radio from the simulator wheelhouse with the simulator operator acting as the tugboat Captain. The *FIGARO* is equipped with a 1,475hp bow thruster; however, the thruster was not used during the simulation tests. This was done to represent car carriers in cases where a bow thruster may not be available to assist in maneuvering at the berth.

As it is the common practice with cruise ships in Mazatlan, the Pilot maneuvered the *RHAPSODY OF THE SEAS* using the ship's thrusters, engines and rudders; the assist tugs were not used. The *RHAPSODY* is equipped with two 2,347hp bow thrusters and one 2,347hp stern thruster. She is also equipped with Becker type rudders which provide very powerful steering forces and side thrusting forces at the stern.

Wind Conditions

The Pilot selected the S to SE wind as the most challenging for docking and leaving the berth so the majority of test runs used a wind from this quadrant. While this is not the most common wind direction in Mazatlan, the Pilot selected the southerly wind direction because it pushes the ship towards the berth and it is also makes stopping an inbound ship with a flood tide much more difficult. The more common (but less problematic for the new berth) NW wind direction was tested on the runs 17 and 18 using the cruise ship.

All test runs, except familiarization run #'s 1 and 11, used the maximum credible adverse wind speed for maneuvering each class of ship. For the car carrier, the maximum wind speed was in the 15 to 20 knot range; for the cruise ship, in the 20 to 25 knot range.

SIMULATION TESTS

A total of 18 simulation test runs were completed by the Pilot. The following table lists the run identification number with associated test conditions and the Pilot's overall safety rating as assigned in the "Run Evaluation Form".

Record of Test Runs

Run #	Ship Class	Direction/ Maneuver	Side To Berth	Wind Speed (knots)/tide	Safety Rating*	Comments
1	Car C.	Inbound	port	E 10/15 slack	3	Simulator and ship familiarization run, no problems observed
2	Car C.	Inbound	port	E 10/15 ebb	3	Stopped too soon due to strong ebb , tugs worked ship up against current
3	Car C.	Inbound	port	SE 15/20 flood	3	Pilot set up for ebb tide so ship went north of slip, good tug power allowed ship to be brought back against flood
4	Car C.	Inbound (turned in basin)	stbd.	SE 15/20 flood	4	Demonstration of preferred maneuver on flood tide - i.e., by-pass ferry slip and turn ship in inner turning basin
5	Car C.	Inbound	stbd.	SE 15/20 ebb	4	Pilot set up for port side docking, then changed to starboard
6	Car C.	Outbound	stbd.	S 15/20 flood	3	Bow tug got too close to docked ferry, otherwise no problems
7	Car C.	Outbound	port	S 15/20 flood	4	Good undocking and departure against strong wind and flood tide
8	Car C.	Outbound	stbd.	S 15/20 ebb	4	Good undocking and departure against wind and opposing ebb tide
9	Car C.	Outbound	port	S 15/20 ebb	3	Good undocking and departure against wind and opposing ebb
10	Car C.	Inbound	stbd.	SE 15/20 ebb	4	Good positioning for turn and clean turn into slip, perfect maneuver
11	Cruise	Inbound	stbd.	SE 15/20 slack	4	Familiarization run, slack tide, repeat of perfect run#11 but with large ship
12	Cruise	Inbound	port	SE 20/25 ebb	4	Good approach and landing with large ship,
13	Cruise	Outbound	port	SE 20/25 flood	1	Test stopped after hitting berth at port quarter, in real world pilot would have turned in the inner harbor
14	Cruise	Outbound	port	SE 20/25 flood	1	Repeat of last run – ship set too far north, in real world pilot would have turned ship in the inner harbor
15	Cruise	Outbound	stbd.	SE 20/25 flood	3	Same conditions as run 13 & 14 but 100% better with stbd. side to berth
16	Cruise	Inbound	stbd.	SE 20/25 flood	2	Difficulty stopping ship, in real world pilot would have bypassed ferry slip and turned ship in the inner harbor,
17	Cruise	Inbound	stbd.	NW 20/25 ebb	3	Difficult with wind and current forces combined, Pilot would have used tugs for added security
18	Cruise	Outbound	stbd.	NW 20/25 ebb	3	Good undocking and departure with wind and ebb pushing same direction
*Safety Rating Scale of 1 through 5: Rating of 1 = Not Safe, rating of 5 = Absolutely Safe						

A track plot and the associated "Pilot Evaluation Form" for each test run are attached to this report. Note that the Pilot assigned ratings to ten different performance parameters using the scales in the "Run Evaluation Form". These data should be consulted when reviewing the results in this section.

Testing Procedures

The testing on each ship was started with a familiarization exercises (test run #'s 1 and 11) that included a moderate wind condition and slack water (i.e., no tidal current) to give the Pilot some time to become acclimated with the ship's characteristics. The results of the familiarization runs also provide a baseline of performance for each ship under moderate conditions.

The inbound runs, with the exception of run #'s 1 and 4, were started with the ship at the breakwater entrance. The ship' ground speed and heading passing through the breakwater was as requested by the Pilot, in the 9 to 10 knot range. The Pilot noted that ships are brought through the breakwaters at a relatively high speed because of the strong cross currents that can be present just outside of the breakwater entrance.

Run # 1 was started one mile south of the harbor's breakwater entrance to provide familiarization time for the Pilot to become accustomed to both the ship and the simulation environment. Run # 4 tested the situation where the Pilot proceeds past the ferry slip and turns the ship around in the inner harbor turning basin. Therefore run # 4 started with the ship leaving the inner harbor.

The assist tugs were made fast to the inbound car carrier as the ship passed through the breakwaters. In all cases, the 5000hp tug was assigned to the bow and the 4,200hp tug at the stern. Assist tugs were not used with the cruise ship. The inbound test runs were terminated when the ship was under control and making a final approach to the berth.

Outbound tests were started with the ship alongside at the new berth with mooring lines released. In the case of the car carrier, the testing started with the two tugs already made fast. As was the case for the inbound runs, the Pilot assigned the 5,000hp tug to the bow and the 4,200hp tug to the stern. On occasion, the Pilot shifted the tug position after leaving the berth. The outbound tests were terminated when the ship had undocked and was turned outbound.

Testing on Car Carrier FIGARO

The Pilot completed a total of 10 test runs on the car carrier, six were inbound docking maneuvers and four were undocking maneuvers. There were no significant problems or safety issues observed during runs on the *FIGARO*. Operational related observations that were noted during the tests are as follows:

- The approach for a port side landing resulted in the ship being turned out in the current stream where a bow tug was needed to keep the bow in position while backing to the berth (see run # 3)
- A starboard side to landing allowed a cleaner direct approach out of the current stream (see run #10), also the Pilot's safety ratings for the starboard side to dockings are all higher
- Landing starboard side to the berth, whether approaching directly from the breakwater entrance or approaching from the north after turning the ship in the inner turning basin (see run # 4), allowed the ship to maneuver to the berth safety without any noticeable difference.
- The tug support (5000hp on bow and 4,200hp at stern) was adequate for docking this ship at the new berth as demonstrated in run # 3 where the two tugs easily moved the ship against both the wind and flood current

- The ferry slip was observed to be wide enough to accommodate the car carrier with assist tugs alongside and with a ferry at the opposing berth

Testing on Cruise Ship RAHASPODY OF THE SEAS

The Pilot completed a total of eight test runs on the cruise ship, four were inbound docking maneuvers and four were undocking and outbound maneuvers. Three of the four inbound runs (run #'s 11, 12 and 17) were completed without any issues. Problems were observed on this ship when trying to dock in run # 16 when the Pilot had a difficult time stopping the ship due to the combined effects of the following flood tide and southerly wind.

Similarly, the Pilot had difficulties when undocking with the ship port side to the berth in run #'s 13 and 14. Undocking with the "Rhapsody of the Seas" starboard side to the berth didn't pose any issues and was easily accomplished with both the flood tide and southerly wind and an ebb tide and northwesterly wind in test run #'s 15 and 18 respectively.

Despite these extreme conditions, only one test run resulted in an unsatisfactory result (run # 13) and additional three test runs were completed without incident (run #'s 13, 14 & 16), but were given unsatisfactory safety ratings by the Pilot. In each of these instances, the Pilot stated that, in actual practice, he would have turned the ship in the inner turning basin and would not have attempted to turn the ship in the area adjacent to the ferry slip. The inner turning basin provides a larger area to maneuver the ships.

Summary of Simulation Results

In the extreme weather conditions, when inbound and passing through the breakwater entrance at higher speeds of 9 or 10 knots, slowing the ship down with the following wind and current was difficult. The Pilot was able to complete this maneuver on each of the test ships (run #'s 3 and 16), however, he noted that in actual practice, he would have bypassed the ferry slip and turned the ship around in the inner harbor turning basin. This strategy would avoid the risk of losing control by trying to stop in the short distance between the breakwaters and the ferry slip.

In using the inner turning basin during extreme weather conditions; after completing the turn and approaching the ferry basin from the north, docking starboard side to the berth, with the ship already turned and headed outbound is easily accomplished. Even during the most extreme operational conditions as demonstrated in test run # 4.

Undocking with the flood tide and SE wind was difficult when the ship was docked port side to the berth. This condition was tested in run #'s 13 and 14. After each test, the Pilot commented that in actual practice, he would have proceeded directly to the turning basin and not attempted to turn the ship near the ferry slip.

CONCLUSIONS

Turning Ship in Inner Harbor Turning Basin

Difficulties when maneuvering adjacent to the ferry slip were observed with a flood tide combined with the strong SE wind. The combination of wind and current forcing the ship to the north as the ship was adjacent to the ferry slip was problematic when docking and undocking.

The simulation results clearly support the Pilot's recommendation that turning the inbound or the outbound ship in the inner harbor turning basin verse in the area adjacent to the ferry slip provides a better safety margin for the ship handler (**See figure – 1 Mazatlan inner Harbor**).

Starboard Side Berthing Favored

The simulations demonstrated that the orientation of the new berth relative to axis of the main channel favored starboard side to the berth docking and undocking maneuvers.

When docking, the Pilot was able to shelter the bow of the vessel, out of the main flow of the tidal currents. When undocking, the ship's bow remained sheltered from the current while moving clear of the berth, and the turn to the left is only 45 degrees vs. 135 degrees for a ship docked port side to the berth. Comparing the results in run #'s 14 vs. 15 clearly illustrates these points.

When docking port side to the berth, a prolonged backing maneuver is needed and the bow of the ship is exposed to the current with only the tug boat or bow thruster available to control the bow. Docking the ship port side to the berth would not be practical after turning around in the inner harbor because the ship would need to be turned a second time for nearly 135 degrees before backing to the berth.

Convenient starboard side docking is a desirable design characteristic for the new berth given the types of ships that will use it. Most car carriers with side ramps or slewing ramps need to be landed with the ship's starboard side to the berth. With regard to cruise ships, cruise ship Master's prefer to dock with the ship's bow pointed to sea to facilitate the undocking maneuver in the afternoon when the stronger winds prevail.

Maneuvering Room Inside of Slip

Another favorable design feature of the new berth arrangement is that the ferry slip is wide enough to accommodate the assistance tugs working alongside of a car carrier with a ferry boat docked at the opposing berth. There was only one instance (run # 6) where the stern of an assisting tugboat got close to the bow of the docked ferry. This was not judged to be a critical issue however because the wind and tide in run # 6 were both acting to push the *FIGARO* to the north, i.e., away from the ferry. Slip width was not an issue for the cruise ship.

The layout of the basin for the proposed ferry terminal was shown through the simulator to be adequate for the maneuvering of both the car carrier with assist tugs and cruise ships the size of "Rhapsody of the Seas" in the future. It is preferable to berth the vessels starboard side to the dock when ever possible.

The use of the inner harbor turning basin is the preferable area to maneuver the vessels in extreme environmental conditions. An example would be the combination of winds out of the southeast and a strong flood current. This maneuvering area in the main channel adjacent to the proposed ferry terminal is only 300 meter width compared to the inner harbor turning basin width of 400 meters.

Fourteen of the eighteen simulation exercises were completed under extreme environmental conditions which included:

- The maximum credible wind speed for the class of ship being tested. Specifically winds of 15 to 20 knots for the car carrier and winds of 20 to 25 knots for the cruise ship.
- Wind direction of South and Southeast that created difficult ship handling scenarios.
- Strong flood or ebb tide currents of 1.5 to 2.0 knots.

It is concluded that the new ferry terminal berth will safely and efficiently accommodate ships that are similar in size and maneuvering capability as those tested. The simulation tests demonstrated the safety advantage of turning the ship using the inner harbor for both docking and undocking evolutions under extreme weather conditions. The berth placement and orientation was shown to favor starboard side to berth docking and undocking maneuvers. Maneuvering the car carrier into the slip with tugs shows the slip width is adequate for maneuvering ships with tugs alongside, even when there is a ferry boat docked at the opposing berth.

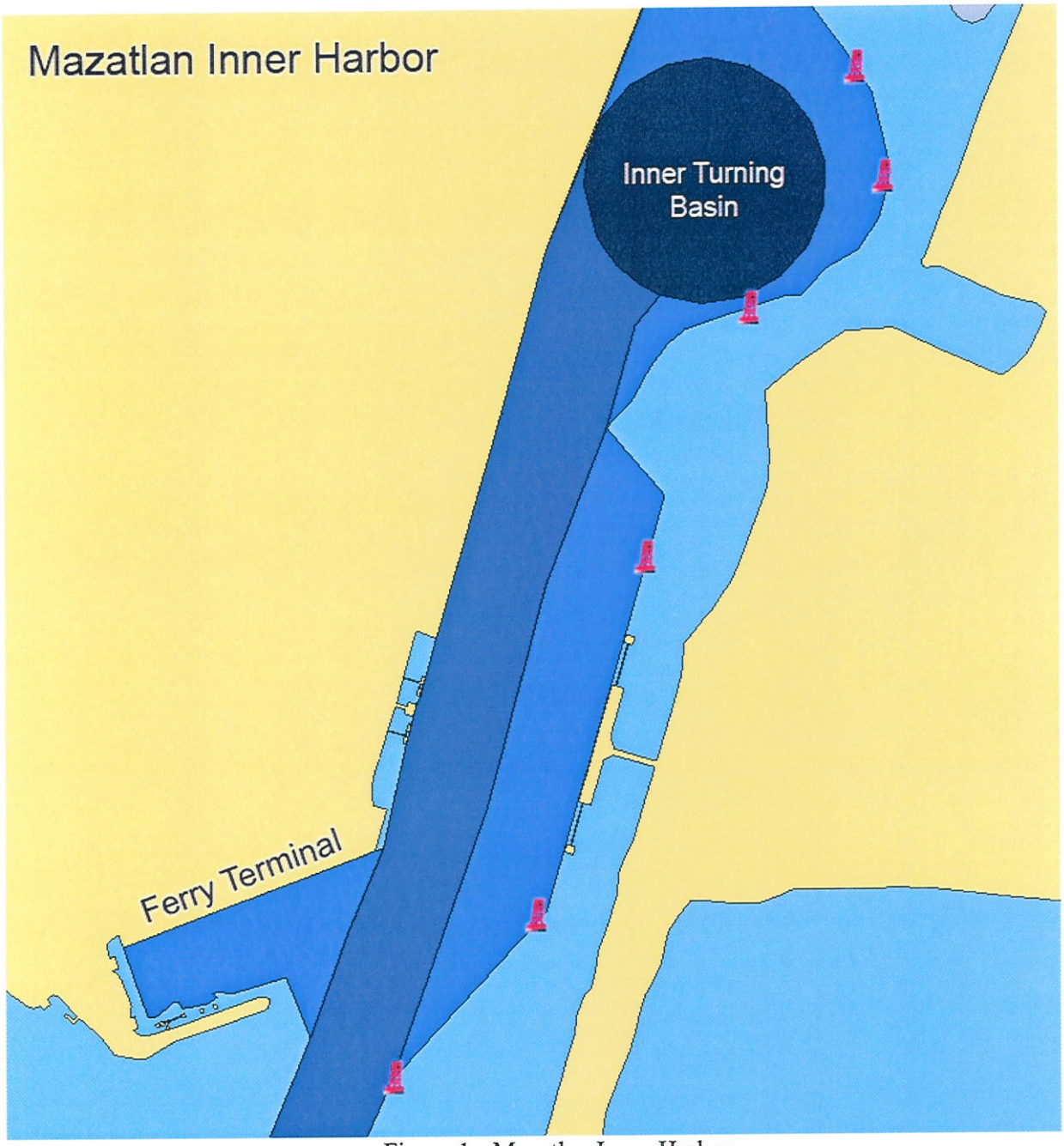

Figure 1 - Mazatlan Inner Harbor