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Mobile Harbor, Alabama Navigation Study

Ship Simulation Report

Morgan M. Johnston, Sung-Chan Kim, and Mary Claire Allison

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Abstract

Mobile Bay is a large estuary located in the southwest corner of Alabama, which connects to the Gulf of Mexico. Mobile Harbor contains the only port in the state that supports ocean-going vessels. Some of the larger vessels calling on the port experience transit delays and limited cargo capacity, so a study was conducted by the US Army Corps of Engineers, Mobile District (CESAM), and the Alabama State Port Authority to investigate channel improvements. In 2017, the US Army Engineer Research and Development Center (ERDC) assisted CESAM in screening proposed deepening and widening alternatives in Mobile Bay by completing a Feasibility Level Ship Simulation (FLSS) study using the ERDC Ship/Tow Simulator. These lower-resolution databases from the FLSS study were used as a foundation to complete a more robust navigation study in 2020 to test the proposed modifications to Mobile Harbor. During this study, three main areas were focused on: a bend easing, a passing lane, and a turning basin. Testing of the proposed design was evaluated over the course of 2 weeks with eight pilots. Assessment of the proposed modifications was accomplished through analysis of ship simulations completed by experienced local pilots, discussions, track plots, run sheets, and final pilot surveys.

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Preface

This study was conducted for the US Army Corps of Engineers (USACE), Mobile District (SAM), under General Investigations, “Mobile Harbor PED,” MIPR W31XNJ00581919. The technical leads at SAM were Ms. Elizabeth Godsey and Mr. Richard Allen. The project manager was Mr. David Newell.

The ship simulation portion of this project was completed by the US Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL), Navigation Branch of the Navigation Division. The numerical modeling portion of this project was completed by the ERDC, CHL, Coastal Processes Branch of the Flood and Storm Protection Division. At the time of publication of this report, Mr. Ben Burnham was Chief of the Navigation Branch, Mr. Victor Gonzalez Nieves was Acting Chief of the Coastal Processes Branch, Ms. Ashley Frey was Chief of the Navigation Division, and Dr. Cary A. Talbot was Chief of the Flood and Storm Protection Division.

At the time of publication of this report, the Deputy Director of CHL was Mr. Keith Flowers, and the Director was Dr. Ty V. Wamsley.

COL Theresa A. Schlosser was the Commander of ERDC, and the Director of ERDC was Dr. David. W. Pittman.

1 Introduction

Background

Mobile Bay is a large estuary located in the southwest corner of Alabama, which connects to the Gulf of Mexico. Mobile Harbor contains the only port in the state that supports ocean-going vessels. Mobile Bay spans approximately 413 mi².¹ The Gulf of Mexico side of the bay is confined by Dauphin Island on the west and Morgan Peninsula on the east. The Mobile and Tensaw Rivers drain into the northern section of the bay. The Gulf Intracoastal Waterway can be accessed through the southern part of the bay. The current federal navigation channel accounts for only a small piece of the entire bay (Figure 1). Within the federal channel, authorized depths range from 47 to 40 ft, but the average depth of the bay is 10 ft.

Figure 1. Mobile Bay.

¹ For a full list of the spelled-out forms of the units of measure used in this document, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office 2016), 248-52, <https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf>.

Mobile Harbor contains facilities that process foreign and domestic cargo. Many different types of imports and exports are handled through the port. The Alabama State Port Authority is the largest facility operator in Mobile Bay with 41 total berths. Near the Choctaw Pass Turning Basin, there are three terminals: APM (A. P. Moller-Maersk), Pinto Island, and McDuffie Coal Terminal (Figure 2).

Figure 2. Terminals near Choctaw Pass Turning Basin.

Purpose

The port of Mobile has continued to expand with new facilities such as the APM Terminal and Pinto Island Terminal. The addition of these new facilities has increased vessel traffic and vessel size. Based on current channel dimensions, some of the larger vessels calling on the port experience inefficiencies due to delays. Some of the larger vessels restrict the channel to be only one-way, which reduces traffic volume. Additionally, some vessels must wait for ideal conditions to transit, such as limited current or during daylight. The current depth of the channel also limits the cargo capacity of larger vessels calling on the port. As the shipping industry continues to expand, it is expected that these inefficiencies will increase based on the current channel dimensions. A

navigation improvement study was conducted for Mobile Harbor to determine what modifications would be necessary to better utilize the harbor and reduce these concerns.

Objective

The Mobile District (CESAM) has proposed several modifications to the federally maintained channels in Mobile Bay, which include (1) deepening the Bar, Bay, and a small section of the River Channel, (2) minor bend easings in the northern section of the Bar Channel, (3) increased width for a 3 mi passing lane in the lower Bay Channel, and (4) an expansion to the Choctaw Pass Turning Basin. A ship simulation study was conducted to ensure that these modifications would not create adverse navigation conditions in the Bar or Bay Channel.

Approach

Ship simulations for Mobile Harbor were conducted with 10 pilots over multiple testing periods at the US Army Engineer Research and Development Center (ERDC) Ship/Tow Simulator (STS). Validation of simulator databases occurred on March 11–12, 2020, and July 21, 2020. Testing occurred during July 21–24, 2020, and July 28–31, 2020. Table 1 is a list of attendees for all testing sessions. The large gap between the initial and final validation sessions was due to the COVID-19 pandemic. Although CESAM did not participate in person during the testing sessions, they were able to participate virtually through a webcast of the ship simulations, debrief phone calls, and frequent updates. The validity of the proposed changes was analyzed through a series of ship simulation exercises, track plots (Appendix A), discussions following simulations, written pilot comments (Appendix A), final wrap-up discussions, and final pilot questionnaires (Appendix B).

Table 1. List of attendees for simulation testing.

Name	Pilot ID #	Session: Dates Attended
Captain Patrick Wilson	1	Validation: March 11-12, 2020
Captain Kirk Barrett	2	Validation: March 11-12, 2020
Mr. Richard Allen – CESAM		Validation: March 11-12, 2020
Captain Billy Bixler	3	Validation: July 21, 2020 Testing: July 22, 2020

Name	Pilot ID #	Session: Dates Attended
Captain Jay Miller	4	Validation: July 21, 2020 Testing: July 22, 2020
Captain Jason Comer	5	Testing: July 23-July 24, 2020
Captain Pete Burns	6	Testing: July 23-July 24, 2020
Captain Chris Brock	7	Testing: July 28 -July 29, 2020
Captain Curtis Wilson	8	Testing: July 28 -July 29, 2020
Captain Reid Key	9	Testing: July 30 -July 31, 2020
Captain David Berault	10	Testing: July 30 -July 31, 2020

Simulator description

Since the 1980s, the ERDC STS has served as a vital modeling tool for navigation projects for the US Army Corps of Engineers (USACE). The ERDC STS has three full mission bridges, each having a 240 deg field of view. Each mission bridge can operate independently or can be linked together. Simulations occur in real time, which means transits take the same amount of time that they would in real life. A virtual database is created for existing and proposed conditions for each unique project location. A virtual database includes input such as wind, waves, currents, bathymetry, navigational markers, and a visual scene. Figure 3 shows a captain piloting the STS for the Mobile Bay project.

Figure 3. Captain piloting the STS during testing.

2 Reconnaissance Trip

A reconnaissance visit to Mobile Harbor was conducted August 22–26, 2016, as preparation for the initial Feasibility Level Ship Simulation (FLSS) study. The site visit allowed ERDC personnel to observe navigation conditions in Mobile Harbor and gain a more thorough understanding of port operations. During the site visit, ERDC personnel along with CESAM design team members rode on several transiting vessels in Mobile Harbor (Figure 4). During these transits, USACE personnel observed Mobile Bar Pilots transverse the Mobile Navigation Channel, took digital imagery, and discussed current operations with the pilots. Digital images that were taken along these transits were subsequently used to create the visual scene necessary for the STS.

Figure 4. Image taken aboard a transiting vessel during the reconnaissance trip.

3 Feasibility Level Ship Simulation (FLSS) Study

An FLSS study was previously completed during May 2017. The purpose of an FLSS study is to screen proposed alternatives using lower-resolution databases to limit monetary and time commitments while still providing vital insight of the proposed alternatives moving forward. The lower-resolution databases are quicker and less costly to develop. Additionally, the databases are easier to manipulate during the course of testing. This method allows for discussion after the completion of each simulated run, necessary modifications to be implemented, and then allows the same simulation to be re-run. By allowing for quick manipulation, the suggested adjustments can be made during the testing week and then tested with the same group of pilots.

Testing during the FLSS study focused on screening channel depths, widths, passing lane dimensions, and turning basin alternatives using a lower-resolution database. Testing occurred from May 23–26, 2017, with two Mobile Bar pilots. This study determined that the originally proposed turning basin design (deepened only) was insufficient in size and would have to be further refined. Several different passing combinations were also screened for the passing lanes. The databases created for the FLSS study were then subsequently used as a foundation for this study. Further description regarding the FLSS study can be found in the letter report¹ that was furnished to CESAM following the study.

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¹ Johnston, M. 2017. *Mobile Bay Deepening and Widening Feasibility Ship Simulation Study (FLSSP) Data Report*. Vicksburg, MS: US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory. NOTE: Unpublished letter report.

4 Proposed Modifications

From the Mobile Harbor Feasibility Study, a recommended plan was determined (Figure 5). This plan includes the following features:

- Deepening the Bar, Bay, and River Channel (south of station 226+16) to project depths of 52, 50, and 50 ft, respectively
- Moderately easing the bends near buoy #18 and buoy #21
- Widening the Bay Channel by 100 ft for 3 nautical miles for a two-way traffic passing lane (total width of 500 ft)
- Enlarging the Choctaw Pass Turning Basin by 250 ft.

Figure 5 shows the recommended plan in its entirety with four areas of interest identified. Figure 6 – Figure 9 show the details of those four areas of interest.

Figure 5. Recommended plan (USACE SAM 2019).

Figure 6. Bend easing near buoy #18 (USACE SAM 2019).

Figure 7. Bend easing near buoy #21 and passing lane start (USACE SAM 2019).

Figure 8. End of passing lane (USACE SAM 2019).

Figure 9. Turning basin expansion (USACE SAM 2019).

5 Ship Simulator Support Hydrodynamic Modeling

The hydrodynamic model simulations were expanded to support the Ship Simulation¹ utilizing the Advanced Circulation (ADCIRC) model. Grids for existing conditions utilized the 174,954-node grid used in the previous study. Figure 10 through Figure 12 depict the whole domain, the Mobile Bay and vicinity, and the Mobile Harbor and vicinity, respectively. These show the resolution transgression from offshore to the focus area including the navigation channel and the Harbor. The grid nodes and bathymetry were rearranged to represent existing and project conditions (Figure 13).

Figure 10. The 174,954 node ADCIRC model grid.

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¹ Bunch, B., E. Hayter, S. C. Kim, E. Godsey, and R. Chapman. 2021. *Three Dimensional Hydrodynamic, Water Quality, and Sediment Transport Modeling of Mobile Bay*. ERDC/EL LR-21-3. Vicksburg, MS: US Army Engineer Research and Development Center. NOTE: Unpublished letter report.

Figure 11. The Mobile Bay and vicinity from the ADCIRC model grid.

Figure 12. The Upper Mobile Bay and the entrance to the Mobile River portion of the ADCIRC grid.

Figure 13. ADCIRC Grid and bathymetry for (a) existing and (b) project conditions.

The astronomical tides in the ADCIRC model are forced by eight dominant tidal constituents—M2, S2, N2, N1, O1, Q1, P1, and K2. A diurnal tide is dominant in the Mobile Bay. Combinations of a constant wind speed of 20 kn (10.2 m/s), wind directions of north (N), east (E), and southeast (SE) (Table 2) with low flow (LQ) conditions of 9,000 ft³/s and high flow of 60,000 ft³/s (Table 3) were specified for both the existing and with project conditions. The high-flow (HQ) conditions are typical values. To approximate the vessel blockage effect, sensitivity had to be examined.

For sensitivity tests, the high-flow conditions were amplified by 65%, 75%, and 85%, respectively. Both the maximum spring tide flood and ebb tide conditions are archived to provide flow for ship simulation. A list of ship simulation hydrodynamic forcing is provided in Table 4.

Table 2. Wind conditions.

Wind Direction	Wind Speed
No Wind	0 kn
N	20 kn
E	20 kn
SE	20 kn

Table 3. Mobile River flow conditions.

Flow Conditions	Symbol	Discharge
Low flow	LQ	9,000 cfs
High flow	HQ	60,000 cfs
High flow increased by 65%	HQ65	99,000 cfs
High flow increased by 75%	HQ75	105,000 cfs
High flow increased by 85%	HQ85	111,000 cfs

Table 4. Archived hydrodynamic conditions for ship simulation.

	LQ	HQ	HQ65	HQ75	HQ85
No wind	Flood	Ebb			
N		Ebb	Ebb	Ebb	Ebb
E	Flood				
SE	Flood				

Hourly output of currents and water levels from each ADCIRC model simulation run is archived over the global domain. From the archived global variables, the local values at the corresponding nodes in the ship simulation domains are extracted, and the currents for the maximum ebb and/or the maximum flood conditions are generated in ship simulation format. Figure 14 – Figure 17 show the maximum ebb flows generated for ship simulation for existing conditions from northerly wind with HQ, HQ65, HQ75, and HQ85, respectively. The current patterns remain similar through varying river flow conditions. Magnitudes increase with increased river flows. Figure 18 – Figure 21 show the similar forcing conditions for with project conditions. The responses to varying river flows are similar to

the ones in existing conditions. However, the increased currents are shown on the downstream side of the turning basin, compared to existing conditions. Figure 22 and Figure 23 show currents along the passing lane for the maximum ebb with N wind and high river discharge with existing and project conditions, respectively. The differences in current magnitudes and directions are not much different between existing and with project conditions. Figure 24 and Figure 25 show the maximum flood currents along the passing lane with E wind and high river discharge with existing and project conditions, respectively. Figure 26 and Figure 27 show the maximum flood currents along the passing lane with SE wind and high river discharge with existing and with project conditions, respectively. The differences between existing and project conditions are indistinguishable.

Figure 14. Simulated maximum ebb flows (m/s) from N wind HQ flows for existing conditions.

Figure 15. Simulated maximum ebb flows (m/s) from N wind HQ65 flows for existing conditions.

Figure 16. Simulated maximum ebb flows (m/s) from N wind HQ75 flows for existing conditions.

Figure 17. Simulated maximum ebb flows (m/s) from N wind HQ85 flows for existing conditions.

Figure 18. Simulated maximum ebb flows (m/s) from N wind HQ flows for project conditions.

Figure 19. Simulated maximum ebb flows (m/s) from N wind HQ65 flows for project conditions.

Figure 20. Simulated maximum ebb flows (m/s) from N wind HQ75 flows for project conditions.

Figure 21. Simulated maximum ebb flows (m/s) from N wind HQ85 flows for project conditions.

Figure 22. Simulated maximum ebb flows (m/s) along the passing lane from N wind HQ flows for existing conditions.

Figure 23. Simulated maximum ebb flows (m/s) along the passing lane from N wind HQ flows for project conditions.

Figure 24. Simulated maximum flood flows (m/s) along the passing lane from E wind LQ flows for existing conditions.

Figure 25. Simulated maximum flood flows (m/s) along the passing lane from E wind LQ flows for project conditions.

Figure 26. Simulated maximum flood flows (m/s) along the passing lane from SE wind LQ flows for existing conditions.

Figure 27. Simulated maximum flood flows (m/s) along the passing lane from SE wind LQ flows for project conditions.

6 Database Development

During a simulation, there are a variety of environmental forces which act upon the vessel during a transit. Some of these forces include wind, waves, currents, bathymetry, and ship-to-ship interaction. Virtual databases are developed as input into the ship simulator for the area of interest for existing conditions first. The existing conditions databases are validated with experienced mariners and then modified to replicate proposed future conditions. Testing of the proposed future conditions are referred to as production runs.

Design vessels

Two design vessels were selected for testing:

1. *Maersk Guayaquil* (CNTNR49): containership that is 1,105.6 ft long, 158.5 ft wide, and drafts 47.0 ft.
2. *Regina Oldendorff* (BULKC19): bulk coal carrier that is 853 ft long, 141.2 ft wide, and drafts 47.0 ft.

Additional vessel information, in the form of pilot cards, can be found in Appendix C. These design vessels were tested for simulations involving the turning basin, one-way traffic, and one-way traffic in the bend easings.

Passing vessels

In addition to the two design vessels listed above, two passing scenarios were selected for testing:

1. Aframax tanker passing with a Tanker Panamax.
2. Post Panamax Containership Generation II (PPXGN2) passing with a Panamax Bulk Carrier.

Four vessels were selected to represent those vessel categories:

1. Aframax tanker – *Vicksburg Spirt* (TANK21X): tanker that is 820.9 ft long, 145.0 ft wide, and drafts 36.0 ft.
2. Tanker Panamax – *MT Danita* (TANK10L): tanker that is 750.0 ft long, 105.8 ft wide, and drafts 45.9 ft.

3. Post Panamax Generation II – *Konway I* (CNTNR41): containership that is 1,102.4 ft long, 137.8 ft wide, and drafts 45.9 ft.
4. Panamax Bulk Carrier – *MS Magnitogorsk* (BULKCo6L): bulker that is 706.7 ft long, 104.3 ft wide, and drafts 37.7 ft.

These four vessels were utilized for passing simulations only, but some simulations did feature testing the bends as well. Additional vessel information, in the form of a pilot card, can be found in Appendix C.

Visual database

A visual database was developed for Mobile Harbor from the entrance channel to just past the Choctaw Pass Turning Basin (Figure 28). Digital pictures taken of the area during the reconnaissance trip were used as a guideline to create the visual scene. The radar was also created for the area.

Figure 28. Extents of the ship simulation database.

Environmental database

An environmental database was created for Mobile Bay that included current, bathymetric, and wind data. Bathymetric survey data from late 2016 was incorporated into the ship simulator and the numerical model. Proposed channel lines were provided from the district along with channel slope, which were used to modify the survey data to create the proposed condition database.

Wind

Wind was paired with the currents. There were four total environmental conditions selected for testing (Table 5). For the turning basin, 20 kn of wind from the north was paired with increased ebb current. For the passing lane and bend easing, three conditions were selected for testing. The primary focus was 20 kn of wind from the southeast with flood current. The secondary focus was 20 kn of wind from the north with ebb current. The last condition selected for testing of the passing lane was 20 kn of wind from the east with flood current.

Currents

Currents for the project were developed using the ADCIRC model. Table 5 lists the currents that were utilized for each testing area. Further description of the current development can be found in the Ship Simulator Support Hydrodynamic Modeling section of this report.

Table 5. Currents used in each testing area.

Testing Area	Mobile River Condition	Tide	Wind
Turning Basin	High Mobile River flow increased by 75%	Ebb	20 kn, N
Passing Lane	Low Mobile River flow	Flood	20 kn, SE
	Low Mobile River flow	Flood	20 kn, E
	High Mobile River flow	Ebb	20 kn, N
Bend Easing	Low Mobile River flow	Flood	20 kn, SE
	Low Mobile River flow	Flood	20 kn, E
	High Mobile River flow	Ebb	20 kn, N

Visibility

In addition to clear-day simulations, limited-visibility conditions, either foggy or nighttime, were selected for testing. For the turning basin, nighttime simulations were selected, as pilots expressed that they would not attempt to turn these larger vessels during foggy conditions. Even if the fog set in quickly after they had already committed to docking, they would dock the vessel head up as opposed to using the turning basin under the extreme conditions. Passing lane and bend easing runs were simulated

under foggy conditions as well as clear day. Although it was originally understood that pilots would operate during these conditions in real life, it was determined during the end of testing that they would avoid transiting during foggy conditions. Pilots would not attempt to bring in a vessel during heavy fog as tugs may not operate during these extreme conditions. Due to this, the ship simulations that tested foggy conditions would be considered unlikely unless fog quickly set in without notice.

7 Validation

During validation, the existing condition database is thoroughly assessed to ensure any necessary modifications are identified. Alterations that may need to be addressed could include visual adjustments, vessel model modifications, current issues, bathymetry problems, or bank effects. Initial validation was completed March 11–12, 2020, with two Mobile Bar Pilots who tested preliminary vessel assessment, currents, and the overall database. Remaining validation regarding ship-to-ship interaction and bank effect occurred on July 21, 2020 with two different Mobile Bar Pilots.

Vessel assessment

For this project, two new vessel models were constructed to represent the two design vessels that were selected. Neither vessel had been tested by pilots yet, so an important piece of validation for this project was properly vetting them. Initial simulations were completed with no environmental conditions (slack water, no wind) with both design vessels. Pilots identified a few minor modifications that would be required to adequately represent the two design vessels. These modifications were implemented and then re-tested during the initial validation session. Once the vessels were modified, pilots considered both vessels to be realistic representations.

Turning basin currents

When a large vessel turns in the Choctaw Pass Turning Basin during ebb tide, the vessel blocks a large percentage of the Mobile River flow (Figure 29). This blockage causes the currents to intensify as more of the vessel is exposed to the river flow. In the current conditions, the vessel will send its tugs to the stern starboard quarter (see tug in position in Figure 29) to attempt to hold the stern in place while the bow falls due to the strong ebb current. The simulator uses pre-calculated current information that cannot update based on a vessel impacting it. Real-time recalculation of currents to account for ship blockage is beyond the ability of present-day ship simulation modeling. To account for this increased effect of currents, the Mobile River flow was increased in the hydrodynamic simulations until pilots felt the currents could adequately represent this phenomenon. While this method was used during the FLSS study, it was not fine tuned. An existing condition vessel (CNTNR44x: 965 ft × 106 ft × 43 ft) was

selected to test existing condition currents in the turning basin. After initial simulations were completed in slack water, currents were added. During validation, the starting condition was a Mobile River flow that was increased by 75% from base (see Table 3 for Mobile River conditions simulated). After testing +65%, +75%, and +85%, both pilots concurred that +75% was the most representative. This same +75% was used to develop the proposed turning basin currents.

Figure 29. Turning vessel that dams majority of the Mobile River flow during ebb conditions.

Bank effect and ship-to-ship interaction

During the remaining validation that occurred in July 2020, a full day was devoted on further refining bank effect and ship-to-ship interaction. Pilots began in existing conditions with the four vessels that were selected for passing scenarios. These two pilots tested the bank effect first. After determining they were too weak to be representative, a bank file was used in the simulator. The bank file replaces the depth in the specified location with values that are provided by the operator. While the specified depths were shallower than actual proposed depths, this allowed the vessel to experience a more accurate bank effect. Additionally, a bank-effect factor unique to each vessel was increased based on pilot feedback. Once these factors were determined for each vessel, a passing scenario was simulated in the proposed conditions to also test ship-to-ship interaction. During this testing, it was determined that the bank-effect factors on each vessel were increased slightly too much, so they were reduced. Typically, the bank effect a vessel feels in this area is minimal until the vessel gets close to the bank, which normally does not happen unless the vessel is passing another or if it is out of position. Inherently, the ship-to-ship and bank-effect interactions are linked, and it is difficult to isolate how much interaction is caused by the bank versus the passing vessel. Note that the bank effect and ship-to-ship interactions are difficult to precisely and accurately replicate in the simulator. In general, all pilots who participated in testing felt these passing effects were representative. At times, pilots experienced an effect that they considered too extreme, but further discussion regarding these effects are presented in the Results and Production Runs Additional Discussion section.

Pilots agreed that the overall existing-condition database was a realistic approximation of the current operations in Mobile Harbor. Once the existing-condition model was validated, production runs, or simulations of the proposed modifications, could begin.

8 Understanding of Passing Simulations

Since a large portion of this project was analysis of passing simulations, a brief discussion on passing is included in this section. To understand passing simulations, one must have a basic understanding of the forces that can impact the vessel's path and must understand how time can be extracted from track plots to illustrate a more complete passing interpretation.

Passing interaction

During a head-on vessel encounter, there are many forces that interact on the vessel. Figure 30 provides a quick snapshot of the phenomena. In the first phase of the process, vessels approach, and their bow waves interact. During this interaction, their bows are pushed apart. During the second or meeting phase, if the vessels are close enough, they will feel an attraction that will pull them closer together. During the final phase, the sterns of the vessels are pulled together. The strength of these passing effects depends on many factors such as speed of the vessels, distances between vessels, size disparities between vessels, and depth under the keel.

Figure 30. Forces felt during a passing maneuver (Brčić et al. 2017).

In addition to the forces experienced during passing, there are other forces that can affect the vessel and impact its path as well. A moving vessel can experience squat, where the vessel sits lower in the water column than if stagnant. Additionally, a vessel can experience forces related to the bank. If a vessel gets close to the bank, the vessel can experience a bow shear away from and stern suction to the bank that can cause the vessel to shear

to port away from the bank. Furthermore, there is interaction from the environmental conditions on the vessel, such as currents or wind.

All of these forces and more combine to influence how a vessel is able to transit during a meeting. Ultimately, this leads to a complex interaction of forces that the pilots must counteract to have a successful passing scenario.

Time component of passing

To adequately understand how a passing occurred, time must be captured to identify the approach, the meeting, and the recovery. Figure 31 shows an example passing trackplot where time has not been identified. When analyzing this trackplot, it is not clear where the approach, meeting, or recovery exist between the two vessels. To properly capture these events, a snapshot of time was extracted from the track plots. When the two vessels were approximately mid-ship-to-mid-ship, the vessel shapes have been colored red. Knowing where the two vessels were at that specific passing moment allows for the approach and recovery to also be understood. When the track plots are processed, they create a ship shape every 30 sec. Once the meeting location has been identified, the previous vessel shape represents the approximate approach of the vessel, and the vessel shape located after the meeting location represents the approximate recovery. Figure 32 further demonstrates understanding the time component based on knowing the meeting location. The approach, meeting, and recovery ship shapes are shown in green, red, and purple respectively. Note that while only one vessel shape for each transiting vessel is tagged as the recovery instance, the actual recovery experienced by a vessel is often longer than just 30 sec past the initial meeting location. For ease of understanding, only one vessel shape was tagged. This logic also applies to the tagged approach vessels.

Figure 31. Basic passing trackplot without time identified.

Figure 32. Example of understanding the time component of a passing simulation trackplot.

9 Results

This section presents results for the proposed condition simulations. Following each simulation, the pilots were asked to fill out a runsheet with their comments about the run and to provide a pilot score for run difficulty and run safety. Pilot scores are ranked from 1 to 5, with low scores indicating a safer and less difficult transit. Pilot scores are listed for each area in the following sections. Results are presented in the form of track plots (Appendix A), information sheet with pilot comments filled out after each run (Appendix A), and final pilot questionnaires (Appendix B). Several pilot comments were summarized or paraphrased in each section, but the entirety of pilot comments can be found in Appendix A following each plate.

Turning basin production runs

Table 6 lists all of the proposed turning basin simulations that were completed during testing. The leftmost column contains the plate number in Appendix A that contains the corresponding track plot that is immediately followed by a combined information sheet for each simulation. Table 7 lists the average pilot scores for the turning basin simulations. Conditions simulated in each run can be determined by comparing back to the run number listed in Table 6. In all turning basin simulations, the same environmental condition, increased ebb current with 20 kn of wind from the N, was used. The runs are presented first during the daytime and then followed by the same run completed during nighttime. For most of the nighttime runs, pilots scored lower in run difficulty than the paired clear-day simulation. This was probably due to familiarity rather than the lighting condition. Several clear-day turning basin simulations were completed by each pilot set before moving to nighttime simulations.

Table 6. Proposed turning basin simulations completed.

Plate # in Appendix A	Heading	Vessel	Current	Wind	Visibility	Pilots Completed	Run #
1	Inbound	CNTNR49	Ebb+75%	20 kn, N	Clear	3,6,7,9,10,10	1
2	Inbound	CNTNR49	Ebb+75%	20 kn, N	Night	3,5,7,7,10	2
3	Composite of all inbound CNTNR49 TB Simulations						
4	Outbound	CNTNR49	Ebb+75%	20 kn, N	Clear	4,5,8,10	3
5	Outbound	CNTNR49	Ebb+75%	20 kn, N	Night	5,6,7,8,9,10	4
6	Composite of all outbound CNTNR49 TB Simulations						
7	Inbound	BULK19	Ebb+75%	20 kn, N	Clear	4,5,6,7,8,9,9	5
8	Inbound	BULK19	Ebb+75%	20 kn, N	Night	4,6,8,9	6
9	Composite of all BULK19 TB Simulations						

Table 7. Pilot score breakdown for turning basin simulations.
Lower scores equate to safer, less difficult transits.

Turning Basin Averages - Breakdown by Run		
Run Number	Run Difficulty	Run Safety
1	3.7	2.7
2	3.0	2.2
3	3.3	2.0
4	2.3	2.2
5	2.6	1.9
6	2.8	2.5
Turning Basin Averages - Breakdown by Simulation Type		
Simulations	Run Difficulty	Run Safety
CNTNR49	3.0	2.3
BULK19	2.6	2.1
Clear Day	3.1	2.2
Nighttime	2.7	2.3
All TB	2.9	2.2

During turning basin simulations, a representative vessel was placed at all of the docks except where the transiting vessel was assigned. This configuration exhibits a worst-case scenario in terms of vessel traffic (Figure 33 and Figure 34). For simulations involving the CNTNR49, the vessel either simulated docking at (inbound) or leaving from (outbound)

the northern berth of the APM Terminal (see red dashed rectangle in Figure 33). For simulations involving the BULK19, the vessel simulated docking at Berth #2 at the McDuffie Coal Terminal (see red dashed rectangle in Figure 34). Once the pilot felt like the simulation was a docking maneuver and they were no longer testing the turning basin design, the simulation was ended. Simulations were not completed for both inbound and outbound BULK19 transits as the use of the turning basin from Berth #2 would essentially be the same regardless of the heading. The track plots in Appendix A show CNTNR49 transits in pink and BULK19 transits in blue. For all turning basin track plots presented, the condition tested is listed in the bottom right corner along with a scale, the transiting vessel(s) are shown in the bottom left corner, and the docked vessel dimensions are shown in the table located on the left side of the plate. Following each combined turning basin track plot in Appendix A, there is an informational sheet for each run. This includes conditions tested, pilot scores, pilot comments, and the initial location of the tugs. Turning basin simulations were performed with either three or four tugs, which was determined by the pilot. These tug forces were controlled by the operator based on pilot commands throughout the simulation.

Figure 33. Starting/ending location for CNTNR49 turning basin simulations with docked vessels.

Figure 34. Ending location for BULK19 turning basin simulations with docked vessels.

Plate 1 – Plate 6 show track plots from simulations that were completed with the CNTNR49.

In Plate 1, a composite of six simulations is shown that were completed with the vessel headed inbound going to dock at the northern berth of the container terminal during a clear day. During all of these simulations, pilots used three tugs for the turning maneuver. Two of the pilots commented that they felt a fourth tug would be required for this size vessel under these conditions in real life. One of the track plots in this plate shows a vessel intersecting with the TANK21X. The pilot felt this was partially due to pilot error of turning too fast and waiting too long to move his tugs to control the vessel's swing to starboard. The pilot also commented that a fourth tug would have likely helped control the swing of the vessel when turning. In one of these simulations, the pilot started his turn in the turning basin too high and clipped TANK21x at the southern berth during his entrance into the turning basin. This trackplot was

removed in the composite plot shown in Plate 3 as the grounding happened during the approach to the turning basin. This simulation was stopped, and the run was restarted with the same pilot. While the trackplot of the repeated run did not show a failure, the pilot felt he was not going to be able to catch the vessel's swing to starboard, so the simulation was ended early. This same pilot repeated the simulation at night (shown in Plate 2) with four tugs and was successful. Although two of the tracks traversed very close to the edge of the turning basin entrance (approximately 15 ft or less), neither exceeded the channel limits. The remaining three track plots shown on Plate 1 were successful.

In Plate 2, a composite of track plots from five simulations is shown that were completed with the vessel headed inbound going to dock at the northern berth of the container terminal at nighttime. Pilots used four tugs for this turning maneuver during all but one of these simulations (pilot 5 used three tugs). In one of the track plots, a vessel is shown to have clipped both the northern and southern limits of the turning basin. During this simulation, the pilot used four tugs but was unable to turn the vessel. Upon further review of the simulator output, this appeared to be a simulator issue as the tug force for the tugs was shown as zero for the entire simulation. This track plot was removed in the composite plot shown in Plate 3 as the grounding appears to be a simulator issue as opposed to a channel deficiency. The same pilot repeated this run again and was successful the second time. During one of the simulations, there was a miscommunication about the maneuver; the pilot completed the turn and then headed outbound instead of heading towards the terminal. Although this was not the desired maneuver, it was successful. During one of the simulations, the vessel entered the berthing area of the Pinto Island terminal but stayed within the federal channel for the remainder of the transit. Two of the tracks traversed very close to the edge of the turning basin entrance (approximately 30 ft or less).

Plate 3 shows a composite of all inbound turning basin simulations completed using CNTNR49 except for two simulations that were removed either due to simulator or pilot error.

In Plate 4, a composite of four simulations is shown that were completed with the vessel headed outbound from the northern berth of the container terminal during a clear day. Half of these simulations were completed with three tugs, and the other half were completed using four tugs. Track plots

for these simulations all remained well within the federal channel. For this set of simulations, the closest any of the CNTNR49 vessels got to the vessel docked at the southern APM berth was approximately 105 ft.

A composite of track plots from six simulations completed with CNTNR49 headed outbound from the northern berth of the container terminal at nighttime is shown in Plate 5. Two simulations were completed using four tugs; the remaining four simulations were completed with three tugs. Two of the pilots who utilized only three tugs in the maneuver commented that a fourth tug was likely necessary. During one simulation, the vessel clipped the GASO4 docked at the northern most McDuffie Coal Terminal when exiting the turning basin. The pilot felt he could have used a fourth tug to complete the maneuver but felt the turning basin was adequate. Three of the track plots slightly entered the southern berthing area of the container terminal, but all transiting vessels maintained a distance of at least 50 ft from the docked TANK21X.

Plate 6 shows a composite of all outbound turning basin simulations completed using CNTNR49.

Plate 7 – Plate 9 show simulations that were completed with the BULKC19.

In Plate 7, a composite of the track plots from seven simulations is shown that were completed with the BULKC19 headed inbound going to dock at Berth #2 at the McDuffie Coal Terminal. During all of these simulations, pilots used three tugs for the turning maneuver. There was a miscommunication about the maneuver during one of the simulations; the pilot completed the turn, and then headed towards the container terminal instead of heading back towards McDuffie. Although this simulation was successful and the vessel stayed within the confines of the channel, it was removed from the composite on Plate 9 as this was not representative of the outbound maneuver required. In one simulation, the pilot turned his vessel much lower in the basin than any other turning basin maneuver and did not fully utilize the turning basin. While the vessel did not exceed the federal channel except in the berthing area, it did collide with the GASO4L in the northern berth of the McDuffie Coal Terminal when exiting the turning basin. The same pilot repeated this simulation with an approach that utilized the basin more and this repeated simulation was successful. The remaining track plots remained within the federal channel; however, several

pilots expressed concern regarding the amount of backing power required by this vessel under the conditions tested, and it was suggested that a fourth tug may be required to increase safety.

Plate 8 shows a total of four tracks that were completed in simulations featuring an inbound BULKC19 docking at Berth #2 at the McDuffie Coal Terminal during nighttime. Three tugs were utilized in all of these simulations. One of these tracks features a vessel that entered into the southern berthing area of the container terminal, but it maintained a distance of approximately 40 ft from TANK21X. The remaining track plots all stayed within the confines of the federal channel. Multiple pilots commented that the additional room in the turning basin was a requirement to make this maneuver feasible.

Plate 9 shows a composite of all BULKC19 turning basin simulations except for one simulation that was removed due to a miscommunication about where to dock.

Passing lane production runs

Each passing lane track plot is presented individually in Appendix A so that the meeting could be more easily analyzed. Figure 35 shows an example passing lane plate. These plates feature a zoomed-in inset shown as a red, blue, or green box so that the meeting can be better visualized. The red ship shapes represent an approximate meeting location. Due to how the tracks are processed (every 30 sec), this meeting location may not always capture an exact beam-to-beam meeting, but knowing how the tracks are tied together allows for better analysis and understanding. The approach and recovery vessels have not been individually tagged so as to not to muddle the plates. However, using the red vessels to determine a meeting time snapshot, an approach and recovery may be inferred using the logic presented in Figure 32. The channel center line is shown as the blue line throughout the channel so that it may be visualized if a vessel is out of position.

Figure 35. Example plate for a passing lane simulation.

Table 8 lists all of the proposed passing lane simulations that were completed during testing. The inbound vessel was selected as the vessel that was drafting more in the meeting scenario as the harder transit would include making the bends and then having to meet an outbound vessel. This combination was considered more difficult than the inverse combination. The leftmost column in Table 8 contains the plate number in Appendix A. For the passing scenarios, plates are presented individually so that they may be more easily evaluated. If the plate number prefix is the same, then the conditions tested are also the same. For example, Plates 10A–10D were tested using the same conditions. Following the last plate for each condition, in this case, Plate 10D, a combined informational sheet with pilot comments is presented.

Table 9 lists the average pilot scores for the passing lane simulations. Conditions simulated in each run can be determined by comparing back to the run number listed in Table 8. For the passing simulations, the inbound pilot was selected to provide the pilot score as it was expected that they would have the more difficult exercise as they had to maneuver the bends prior to meeting. After analyzing the simulations, often the outbound pilot had a more difficult passing maneuver as it was sometimes overwhelmed by the larger vessel during passing, especially during the containership and bulkier meetings. Any disparity that existed between the inbound vs. outbound pilot scores during a passing was not captured as only the inbound pilot typically provided a score. Run 18 was rated as the least safe and one of the most difficult, which is the simulation that featured the most groundings. In general, the pilots ranked the tanker meeting simulations as safer and less difficult than the containership and bulkier meetings. While pilots did not score the foggy condition runs as more difficult, they did score them less safe than clear day simulations.

Table 8. Proposed passing lane simulations completed.

Plate # in Appendix A	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility	Pilots Completed	Run #
10A - 10D	TANK10L	TANK21X	Flood	20 kn, SE	Clear	3/4, 5/6, 7/8, 10/9	9
11A - 11B	TANK10L	TANK21X	Flood	20 kn, E	Clear	9/10, 10/9	11
12A - 12D	TANK10L	TANK21X	Ebb	20 kn, N	Clear	4/3, 6/5, 8/7, 10/9	13
13	Composite of Tanker Clear Day Passing Simulations - 10 Simulations Shown						
14A - 14E	CNTNR41	BULKC06L	Flood	20 kn, SE	Clear	4/3, 6/5, 6/5, 8/7, 9/10	10
15A - 15B	CNTNR41	BULKC06L	Flood	20 kn, E	Clear	9/10, 10/9	12
16A - 16C	CNTNR41	BULKC06L	Ebb	20 kn, N	Clear	3/4, 5/6 ¹ , 7/8, 10/9	14
17	Composite of CNTNR/BULK Clear Day Passing Simulations - 8 Simulations Shown						
18A - 18C	TANK10L	TANK21X	Flood	20 kn, SE	Foggy	5/6 ⁴ , 6/5, 8/7, 9/10	15
19A - 19D	TANK10L	TANK21X	Flood	20 kn, E	Foggy	6/5, 6/5, 7/8, 9/10	17
20A - 20D	TANK10L	TANK21X	Ebb	20 kn, N	Foggy	6/5, 6/5, 7/8, 9/10	19
21	Composite of Tanker Foggy Passing Simulations - 9 Simulations Shown						
22A - 22C	CNTNR41	BULKC06L	Flood	20 kn, SE	Foggy	5/6, 7/8, 10/9	16
23A - 23F	CNTNR41	BULKC06L	Flood	20 kn, E	Foggy	3/4, 6/5, 6/5, 6/5, 8/7, 9/10 ⁴ , 10/9 ⁴ , 10/9	18
24A - 24C	CNTNR41	BULKC06L	Ebb	20 kn, N	Foggy	5/6, 8/7, 9/10	20
25	Composite of CNTNR/BULK Foggy Passing Simulations- 9 Simulations Shown						

¹ Data were corrupted and lost. No trackplot is presented.

Table 9. Pilot score breakdown for passing simulations. Lower scores equate to safer, less difficult transits.

Passing Lane Averages - Breakdown by Run		
Run Number	Run Difficulty	Run Safety
9	2.5	2.5
10	2.4	2.0
11	2.0	2.0
12	2.0	2.5
13	2.5	2.8
14	2.8	2.0
15	2.3	2.3
16	3.0	2.0
17	2.0	2.0
18	2.9	3.5
19	2.3	2.0
20	2.3	2.3
Passing Lane Averages - Breakdown by Simulation Type		
Simulations	Run Difficulty	Run Safety
Tankers	2.3	2.3
CNTNR/BULK	2.6	2.6
Clear Day	2.5	2.3
Foggy	2.5	2.6
Flood, E Wind	2.5	2.9
Flood, SE Wind	2.5	2.2
Ebb, N Wind	2.5	2.3
All Passing	2.5	2.5

Clear day

Plate 10 – Plate 13 show track plots from simulations that were completed with the TANK10L (inbound) meeting the TANK21X (outbound) on a clear day.

Track plots from four simulations are presented individually that were completed with flood tide and SE wind in Plates 10A –10D. In Plate 10A, the outbound pilot traveled close to the channel edge during the meeting but stayed within the channel confines. In Plate 10B, the inbound pilot

slightly exceeded the channel toe during the recovery phase of the meeting, but this did not result in a grounding as this vessel is lighter loaded. The outbound vessel was slightly over the channel center line during the meeting. The meeting occurred slightly lower in Plate 10C than the previous Plate 10B, but minimal difficulty was shown in these tracks. While Plate 10D presented a track that featured good spacing between vessels, there is a slight wiggle that can be seen in the inbound track following the meeting. This was probably due to the large speed disparity between vessels (12.1 kn outbound vessel speed vs. 8.8 kn inbound vessel speed), which made the inbound vessel more susceptible to ship-to-ship effects. This pronounced ship-to-ship interaction was also discussed in the pilots' comments for this simulation.

Plates 11A – 11B present two simulations individually that were completed with flood tide and E wind. A model track plot is shown in Plate 11A, which displays good space between the vessels (approximately 140 ft during meeting), minimal recovery effects, and good position by both vessels. The track plots in Plate 11B are similar to Plate 11A, except the vessels were closer together during the meeting (approximately 90 ft apart) and transiting at slightly lower speeds, which resulted in more ship-to-ship interaction; however, the transit was still successful.

Four simulations are individually presented, which were completed with ebb tide and north wind, in Plates 12A – 12D. Plates 12A, 12C, and 12D show tracks from simulations that included large speed disparities (3.1 kn in 12A, 2.1 kn in 12C, and 2.8 kn in 12D) between the inbound and outbound vessels during the meeting. The variations in these track plots can be explained by comparing the meeting distances between vessels, the ship speeds, and position in the channel. Plate 12A and Plate 12C feature tracks that include a large recovery path for the smaller inbound vessel due to the increased ship-to-ship interaction. The meeting distances between vessels were approximately 110 ft and 120 ft for Plate 12A and Plate 12C, respectively. Both plates feature the outbound vessel hugging the centerline during meeting. Although Plate 12D features a transit that still included a large speed disparity between vessels, this track plot shows a less pronounced ship-to-ship interaction. This is probably due to the vessel being in a more ideal position in the channel and maintaining an approximate distance of 150 ft between vessels during meeting. Although Plate 12B features a track plot of the outbound vessel hugging the

centerline, the track plot shows a meeting that went well due to vessel speeds that were more ideal at approximately 9 kn for both vessels.

Plate 13 shows a slightly zoomed-in composite of all clear-day passing simulations with the two tankers. The meeting location ship shapes have been removed for clarity. No groundings occurred in these simulations.

Plate 14 – Plate 17 show track plots from simulations that were completed with the CNTNR41 (inbound) meeting the BULKCo6L (outbound) on a clear day.

Five simulations are presented individually that were completed with flood tide and southeast wind in Plates 14A – 14E. In Plate 14A, the outbound pilot traveled close to the channel edge during the recovery but stayed within the channel confines. A grounding of the outbound vessel is shown in Plate 14B. This grounding is probably due to the inbound vessel hugging the channel centerline during the meeting, the high speeds of the inbound vessel during meeting (approximately 14.5 kn), and the speed disparity between the vessels (approximately 4.6 kn). This track shows the outbound vessel's bow being shoved to starboard during the meeting from the strong bow wave of the larger inbound vessel. The simulation was repeated by the same pilots, and the tracks are shown in Plate 14C. In this simulation, the inbound vessel again hugged the centerline, but the speed of the inbound vessel was much lower (approximately 10.7 kn) and there was minimal speed disparity between the transiting vessels. The outbound vessel still experienced some recovery effects, but they were much less severe and could be managed, which resulted in a successful run. Plate 14D featured a successful passing; however, the inbound pilot commented that he had difficulty managing the flood tide and the bends, and he felt that this vessel combination was at the limit of what could be attempted during good conditions. A lower meeting location is shown in Plate 14E. This meeting was successful with both transiting vessels staying within the channel confines for the duration of the simulation.

Plates 15A – 15B present two individual simulations that were completed with flood tide and E wind. Plate 15A shows that the outbound vessel grounded during the meeting/recovery. This grounding is probably due to the inbound vessel hugging the channel centerline during the meeting, the high speeds of the inbound vessel during meeting (approximately 12.6 kn), and the speed disparity between the vessels (approximately 2.2 kn). This

track plot shows that the outbound vessel experienced a large shear towards the bank that was not manageable. The same pilots repeated this run in Plate 15B without a grounding, but the tracks still showed difficulty. In this simulation, the inbound vessel again hugged the centerline, but the speed of the inbound vessel was lower (approximately 11.5 kn) and the speed disparity between the transiting vessels was much less (approximately 0.8 kn). The outbound vessel went slightly outside the channel toe during the recovery.

Although four runs were completed with ebb tide and N wind, one dataset was corrupted so only three track plots are shown in Plates 16A–16C. For each of the three simulations, these track plots represent, the vessels were transiting faster than ideal (more than 12 kn), and the vessels were out of position for meeting. While none of these simulations resulted in grounding, all three resulted in the lighter-loaded outbound vessel slightly exceeding the channel toe during the recovery phase.

Plate 17 shows a slightly zoomed-in composite of all clear-day passing simulations with the containership and bulker. The meeting location ship shapes have been removed for clarity. Two groundings are shown in this set of conditions.

Foggy conditions

Although it was originally understood that pilots would pass during foggy conditions in real life, it was later determined during testing that they would avoid transiting during these conditions. Due to this, the ship simulations that tested foggy conditions would be considered unlikely to be performed in real life unless fog quickly set in without notice. Therefore, these simulations represent a true worst-case scenario that would be avoided in real life.

Plate 18 – Plate 21 show track plots from simulations that were completed with the TANK10L (inbound) meeting the TANK21X (outbound) under foggy conditions.

Although four runs were completed with flood tide and SE wind, one dataset was corrupted, so only three track plots are shown in Plates 18A–18C. While the meeting shown in Plate 18A was successful, the inbound vessel grounded above buoy #30 (outside the plate footprint). This grounding was due to pilot distraction at the end of the run rather than a

channel issue. The same set of pilots repeated this run in the track plot that is not shown. It did not result in a grounding. In Plate 18B, the outbound vessel shows a meandering track plot that suggests the pilot had issues controlling the vessel. The speed the vessel was going probably contributed to this effect (approximately 8 kn during meeting). The outbound vessel hugged the centerline in the track shown in Plate 18C, but both vessels stayed within the channel confines during the simulation.

Plates 19A – 19D present four individual simulations that were completed with flood tide and E wind. Plate 19A shows the outbound vessel's stern exceeded the channel toe during the meeting and then grounded during the recovery. This grounding is probably due to the outbound vessel being too far over prior to the meeting (approximate 18 ft to the channel toe from the bow of the vessel), and vessel speed disparity (outbound vessel speed of 9.8 kn vs. inbound vessel speed of 12.3 kn). Although the outbound vessel's displacement tonnage is greater than the inbound vessel, the displacement tonnages are similar. Because the outbound vessel was so close to the bank prior to meeting, the ship-to-ship interaction was probably enough to cause the vessel to exceed the channel toe, the pilot to lose control of the vessel, and the vessel to run to the other side of the channel and ground. This simulation was repeated with the same pilot set, and the track plot is shown in Plate 19B. In this simulation, the outbound vessel hugged the centerline during meeting, the vessels were traveling at comparable speeds (outbound vessel speed of 10.7 kn vs. inbound vessel speed of 11.1 kn), and the meeting was successful. In Plate 19C, the inbound vessel approached the channel limits near buoy #21 but was able to recover from the bend in time for the meeting with approximately 140 ft distance between vessels. Although the outbound vessel hugged the channel centerline in the tracks shown in Plate 19D, the meeting was successful, and both vessels stayed within the channel limits.

Plates 20A – 20D present track plots from four individual simulations that were completed with ebb tide and north wind. The track plots displayed in Plate 20A show the inbound vessel grounding during the meeting and recovery phase. This was due to pilot error as the wrong set of rudders was used during this vital time, which caused the vessel to run aground. This simulation was repeated by the same pilot set and was successful on this second attempt as shown by the track plots on Plate 20B. Plate 20C presents tracks from a successful meeting and recovery where both vessels stayed within the channel limits, but a large recovery from the inbound

vessel can be observed. The inbound pilot expressed that he experienced a large suction that almost caused him to ground. The inbound vessel grounded in the tracks shown in Plate 20D. By analyzing the time component of these tracks, an odd phenomenon is shown. During the meeting tag, shown as the red vessel shapes, the vessels appear to be set up for a successful pass. However, during the recovery phase, after the outbound vessel had already traveled well past the inbound vessel, the inbound vessel shears hard to starboard. While the shear could be expected based on the outbound vessel traveling on the centerline and a large speed disparity (outbound vessel speed of 12.6 kn vs. inbound vessel speed of 8.8 kn), the timing or location of the shear is different than most other track plots observed. Typically, this shear has occurred just prior to or during the meeting, not during the recovery phase. There could be some stern suction experienced due to the outbound vessel, but the effect appears extreme. The inbound pilot commented that he did not understand what happened during this simulation.

Plate 21 shows a slightly zoomed-in composite of all foggy condition passing simulations with the tankers. The meeting location ship shapes have been removed for clarity. This set of simulations contained four groundings, but two of those groundings were considered pilot error.

Plate 22 – Plate 25 show track plots from simulations that were completed with the CNTNR41 (inbound) meeting the BULKCo6L (outbound) under foggy conditions.

Plates 22A – 22C present track plots from three individual simulations that were completed with flood tide and SE wind. In Plate 22A, the outbound vessel track plot meanders down the channel, and the inbound vessel travels down the centerline during the meeting, but both vessels stayed within the channel limits throughout the simulation. In Plate 22B, the outbound pilot slightly exceeded the channel toe during the recovery phase of the meeting, but this did not result in a grounding as this vessel is lighter loaded. The outbound vessel probably left the channel due to the vessel speed disparity (outbound vessel speed of 9.7 kn vs. inbound vessel speed of 13 kn). The outbound vessel actually grounded below buoy #23, but this was because there was a miscommunication about the simulation ending, so the pilot was no longer controlling the vessel at that time. Since no one was controlling the vessel at the time of the grounding, it was deemed a successful run and not labeled as a grounding. While the

meeting shown in Plate 22C did not result in a grounding, the trackplot shows difficulties for the outbound vessel. The outbound vessel exceeded the channel limits and exhibited a long recovery period following the meeting. After the meeting, the outbound vessel traveled from one bank to the other trying to control the vessel after the effects from the meeting. The outbound vessel exceeded the channel probably due to the vessels being out of position for the meet and the inbound vessel traveling at higher than ideal speed, approximately 12.4 kn.

Although eight simulations were completed with flood tide and E wind, two datasets were corrupted, so only six track plots are shown in Plates 23A – 23F. This set of simulations presented by far the most trouble for the different pilot sets with six out of the total eight simulations resulting in groundings. The track plots shown in Plates 23A – 23C resulted in groundings. These three simulations contained high vessel speeds (greater than 11.8 kn), large speed disparities between vessels (greater than 2.6 kn), and the vessels being out of position. In Plate 23A, the outbound vessel was essentially on the bank prior to meeting, so the large ship-to-ship interaction was enough to push the vessel outside the channel and ground. The most extreme ship-to-ship interaction is presented in Plate 23B, where both vessels grounded following the meeting. This violent shear away from each other was probably caused by the extreme vessel speed of the larger inbound vessel (outbound vessel speed of 9.6 kn vs. inbound vessel speed of 17 kn). This same pilot set repeated this simulation in the track plots shown in Plate 23C. However, the inbound vessel speed was still too high (outbound vessel speed of 10.3 kn vs. inbound vessel speed of 13.1 kn), and the inbound vessel grounded again. The same pilot set repeated this simulation for a third time, and these tracks are presented in Plate 23D. While the inbound vessel still hugged the centerline during meeting, the inbound vessel speed was much lower (10.4 kn), and there was only a minor speed disparity between vessels. This meeting was successful with both vessels staying within the channel limits for the simulation. In Plate 23E, the outbound vessel grounded during the recovery phase. The outbound pilot orally commented that he did not get the expected effect from the vessel being pulled off the bank when passing, so the vessel grounded in the channel. The last pilot set simulated these conditions three times. Data from two of these simulations were corrupted, so they could not be presented or analyzed. Of those two simulations, one was successful, and the other resulted in a grounding. Plate 23F presents the track plots from the simulation that did not

experience data corruption. In this simulation, the outbound vessel grounded during meeting. This grounding was probably due to the inbound vessel traveling close to the centerline and the outbound vessel already committing very close to the channel edge prior to meeting.

Track plots from three simulations that featured ebb tide with N wind are shown individually in Plates 24A – 24C. Although the lighter-loaded outbound vessel slightly exceeded the channel limit during the recovery phase as shown in the track plots presented in Plate 24A, this simulation did not result in a grounding. The outbound vessel was traveling at a higher than ideal speed at 12 kn, and the inbound vessel was close to the centerline during the meeting. In Plate 24B, the meeting and recovery shown in the track plots went smoothly. In Plate 24C, the tracks show that the inbound vessel actually exceeded the channel just prior to meeting the outbound vessel and then grounded during the meeting.

Plate 25 shows a slightly zoomed-in composite of all foggy condition passing simulations with the containership and the bulker without the meeting location ship shapes identified. This set of simulations contained seven groundings with one that is not shown due to data corruption.

Bend easing production runs

Table 10 lists of all the proposed bend easing simulations that were completed during testing. The leftmost column contains the plate number in Appendix A that contains the corresponding track plot, which is immediately followed by a combined information sheet that contains pilot comments for each simulation. Table 11 lists the average pilot scores for the bend easing simulations. Conditions simulated in each run can be determined by comparing back to run number listed in Table 8.

Table 10. Proposed bend easing simulations completed.

Plate # in Appendix A	Heading	Vessel	Current	Wind	Visibility	Pilots Completed	Run #
26	Inbound	CNTNR49	Flood	20 kn, SE	Foggy	4, 7, 7, 9	27
27	Inbound	CNTNR49	Flood	20 kn, E	Foggy	5, 6, 10	30
28	Inbound	CNTNR49	Ebb	20 kn, N	Foggy	5, 8, 10, 10	28
29	Inbound	BULKC19	Flood	20 kn, SE	Foggy	3, 7, 7, 9	25
30	Inbound	BULKC19	Flood	20 kn, E	Foggy	5, 6, 9	31
31	Inbound	BULKC19	Ebb	20 kn, N	Foggy	6, 8, 10	26
32	Composite of All Inbound Bend Easing Runs (BulkC19 and CNTRN49)						
33	Outbound	BULKC19	Flood	20 kn, E	Foggy	5, 7, 7, 8, 9	32
34	Outbound	CNTNR49	Flood	20 kn, E	Foggy	6, 8, 10	33
35	Composite of All Outbound Bend Easing Runs (BulkC19 and CNTRN49)						
36	Composite of All Passing Runs that Featured the Bend Easing Area for TANK21X and TANK10L						
37	Composite of All Passing Runs that Featured the Bend Easing Area for CNTNR41 and BULKC06L						

Table 11. Pilot score breakdown for bend easing simulations. Lower scores equate to safer, less difficult transits.

Bend Easing Averages - Breakdown by Run		
Run Number	Run Difficulty	Run Safety
25	2.8	3.0
26	2.0	1.7
27	2.8	2.0
28	2.8	2.5
30	3.0	2.0
31	1.3	1.0
32	2.5	1.8
33	2.0	2.3
Bend Easing Averages - Breakdown by Simulation Type		
Simulations	Run Difficulty	Run Safety
CNTNR49	2.7	2.1
BULKC19	2.1	2.1
Flood, E Wind	2.2	1.8
Flood, SE Wind	2.8	2.5
Ebb, N Wind	2.4	2.1
All Bend Easings	2.4	2.1

For all track plots presented for the bend easing, the condition tested is listed in the bottom right corner, a scale is located on the bottom left corner, and the transiting vessel is listed on the left-hand side of the plate. All simulations devoted to the bend easing were completed under foggy conditions, and the runs are presented first for inbound and then outbound headings. Foggy visibility was selected for these simulations as a time savings. It was expected that if simulations could be successful under foggy visibility, then they would be successful under clear conditions. Based on how the port currently operates, an inbound vessel would likely not start a transit under foggy conditions. Therefore, the foggy conditions tested for the bend easings would likely restrict inbound traffic unless fog showed up quickly after a vessel had already begun its transit toward Mobile Harbor. This represents a truly worst-case scenario for the bends. Note, these one-way bend transits were typically the first simulations that a new set of pilots began testing on. While this was not ideal, the tight schedule did not allow for individual warm-up runs to be completed by pilots as their first runs. Due to the typical spin-up required to become accustomed to a ship simulator, sometimes these initial simulations ended in groundings. These simulations have been tagged as such in the further discussion below.

Plate 26 – Plate 28 show track plots from simulations that were completed inbound with CNTNR49 under foggy conditions.

In Plate 26, a composite of the track plots from four simulations that were completed with flood tide and southeast wind is shown. One of these simulations ended in a grounding near buoy #20. Based on the other tracks, it appears the pilot probably started his turn slightly too late. This pilot repeated the simulation with slower speeds and started the turn earlier. During the second attempt, the simulation was successful. The remaining three track plots shown on Plate 26 were successful.

In Plate 27, a composite of the track plots from three simulations that were completed with flood tide and east wind is shown. All vessels stayed within the channel limits during these simulations. Pilot 10 experienced a soft grounding due to vessel squat, but this was due to extreme speed, approximately 18 kn, not a channel width issue.

Plate 28 contains a composite of track plots from four simulations that were completed with an ebb tide and north wind. One of these simulations

was a pilot's first run completed on the simulator, and it ended in a grounding below buoy #19. This pilot repeated the simulation and during the second attempt, the simulation was successful. The remaining track plots shown on Plate 28 were successful.

Plate 29 – Plate 31 show track plots from simulations that were completed inbound with BULK19 under foggy conditions.

In Plate 29, a composite of the track plots from four simulations that were completed with flood tide and SE wind is shown. One of these simulations was a pilot's first run completed on the simulator, and it ended in a grounding just above buoy #19. This pilot repeated the simulation, and during the second attempt, the simulation was successful. The remaining three track plots shown on Plate 29 were successful.

Plate 30 features a composite of tracks from three successful runs, which show minor difficulties. Conditions tested for these simulations were flood tide with E wind. Pilots commented that the simulations felt realistic and they did not experience issues.

In Plate 31, a composite of the track plots from three simulations is shown that were completed with ebb tide and N wind. In one of these simulations, the rudder was not activated, which probably caused the vessel to slightly exceed the channel between buoy #14 and buoy #16. The remainder of the simulation showed little difficulties once the rudder was activated. One of these simulations was the first run completed on the simulator by one of the pilots, and although it did not end in grounding, the track excessively weaves around channel.

Plate 32 shows a composite of all inbound foggy condition bend easing simulations with the CNTNR49 and BULK19. This set of simulations contained three groundings, but two of those groundings were the pilot's first run on the simulator, and both of those pilots were successful during a repeated run.

Plate 33 shows track plots from five simulations that were completed outbound with BULK19 under foggy conditions with flood tide and E wind. Of these five simulations, two simulations resulted in groundings. Both of these groundings were experienced by the same pilot and were a result of an unrealistic sluggish response of the vessel. None of the other

pilots experienced this extreme lack of rudder response, which suggests this may have been a simulator issue. The remaining track plots shown on Plate 33 were successful.

Plate 34 shows track plots from three simulations that were completed outbound with CNTNR49 under foggy conditions with flood tide and east wind. While none of these simulations ended in grounding, one of the vessels did slightly exceed the channel near buoy #18. The other vessels stayed within the channel limits for these simulations.

Plate 35 shows a composite of all outbound bend easing simulations with the CNTNR49 and BULKC19. This set of simulations contained two groundings, but these groundings appeared to be related to a simulator issue, not a channel concern.

Plate 36 and Plate 37 show track plots from all the simulations that were completed for the passing scenarios that traversed through the bends for TANK21X/TANK10L and CNTNR41/BULKCO6L, respectively. A few of these simulations featured tracks that exceeded the channel near the bends, but none of these simulations resulted in a grounding in the bends.

10 Production Runs Additional Discussion

After simulations were completed, there were two areas that required additional review: the entrance into the turning basin and the passing lane.

Entrance to turning basin

During testing, safety concerns regarding transiting by the docked vessels at the McDuffie Coal Terminal were raised. Since the docked vessels at McDuffie are close to the federal channel, the transiting vessel must slow down to ensure it does not disturb the docked vessel(s). If the transiting vessel goes by too fast, the vessel(s) could be pulled off the dock, and damage to the terminal could occur. However, the transiting vessel must maintain an adequate amount of speed as they can lose steerage if traveling too slow, which can also result in safety concerns.

Docked vessels are typically placed in the simulator as a target, which means no hydrodynamic effects are associated with the target and it only acts as a visual cue. Since the docked vessels were represented as targets for all of the Mobile ship simulations, no information can be determined about speed or distance threshold that may cause an unstable condition to the docked vessels. However, the track plots were analyzed after the simulations were completed to pull out approximate distances and vessel speeds for each run (Table 12 and Table 13). Since there are known historic events that have caused damage, it is recommended that this effect be analyzed further as larger vessels will be calling on the port based on the proposed modifications. Larger, or deeper-drafting, vessels will cause more water to be pushed when transiting by these docked vessels, so this concern will likely increase and should be further evaluated.

Table 12. Approximate CNTNR49 transiting speeds and distances to the McDuffie Coal Terminal for turning basin simulations.

Run #	Pilot ID #	Mid Berth		Northern Berth	
		Speed (kn)	Shorted Distance to Docked Vessel (ft)	Speed (kn)	Shortest Distance to Docked Vessel (ft)
1	3	3.5	190	3.3	260
1	6	3.0	190	2.0	210
1	7	2.9	160	4.0	170
1	9	3.1	165	2.0	160
1	10	3.8	180	3.9	200
1	10	3.1	180	3.7	230
2	3	3.6	200	3.6	240
2	5	2.0	190	2.3	220
2	7	2.6	185	4.0	230
2	7	N/A	N/A	2.5	185
2	10	2.6	190	2.6	180
3	4	N/A	N/A	N/A	N/A
3	5	N/A	N/A	3.0	200
3	8	5.0	230	3.5	210
3	10	N/A	N/A	5.3	240
4	5	N/A	N/A	4.4	0
4	6	6.0	130	4.2	80
4	7	6.4	150	5.1	70
4	8	5.1	180	3.5	150
4	9	6.1	170	5.8	130
4	10	6.0	220	5.6	180

Table 13. Approximate BULK19 transiting speeds and distances to the McDuffie Coal Terminal for turning basin simulations.

Run #	Pilot ID #	Mid Berth		Northern Berth			
		Inbound Speed (kn)	Outbound Speed (kn)	Inbound Speed (kn)	Inbound Shortest Distance to Docked Vessel (ft)	Outbound Speed (kn)	Outbound Shortest Distance to Docked Vessel (ft)
5	4	5	4	3.2	N/A	3.4	N/A
5	5	5	5	2.8	3.4	1.9	3.0
5	6	5	6	2.8	N/A	2.7	N/A
5	7	5	7	3.2	6.6	3.5	2.7
5	8	5	8	3.0	1.4	2.3	2.4
5	9	5	9	3.0	N/A	2.0	2.2
5	9	5	9	N/A	1.7	3.1	2.6
6	4	6	4	3.0	N/A	2.7	N/A
6	6	6	6	2.9	5.1	2.9	4.3
6	8	6	8	3.0	4.8	3.1	3.5
6	9	6	9	3.0	N/A	2.0	N/A

Following ship simulations, a discussion with the pilots who participated in the simulations occurred to propose a turning basin entrance expansion. Figure 36 provides an approximation of this proposed expansion to the turning basin to reduce concerns of pulling vessels off the McDuffie Coal Terminal Dock and causing damage. This approximation is based on pilot input only. No simulations were completed to determine if the proposed expansion would be adequate or excessive.

Figure 36. Approximate proposed turning basin entrance expansion.

Passing lane

Groundings

The passing lane simulations, in general, featured a larger-than-expected number of groundings. These groundings can be partially attributed to the aggressive testing plan that was selected. A typical simulation study has a group of pilots available for four full days of testing. Additionally, several different pilot sets participate over the course of several weeks (length depending on the complexity of the project). For this study, each pilot set (five sets for a total of ten pilots) was only at ERDC for a 2-day session. The aggressive testing plan was a result of the COVID-19 pandemic delaying the initial testing by several months and pilot availability. During each 2-day session, pilots had to quickly get accustomed to the ship simulator and new channel dimensions with little to no practice simulations. Pilots were often not able to repeat runs and modify their approach based on their new understanding of the proposed channel.

Due to the frequency of groundings that occurred, an additional analysis was preformed to better understand the root cause. First, the conditions themselves were analyzed to determine if any trends existed. A total of 47 passing simulations were performed with 13 of those featuring groundings. Two of the groundings were determined to be caused by pilot errors that did not have to do with channel concerns. For the additional analysis, these two groundings and simulations were removed. Table 14 features a breakdown of the passing scenarios completed by the tankers. Table 15 features a breakdown of the passing scenarios completed by the containership and bulker. In general, the passing scenarios completed by the tankers featured a much higher success rate than the containership and bulker simulations (90% vs. 64%). The run condition that was clearly the least successful was Run 18 (CNTR41/BULKCo6L, flood tide, E wind, foggy conditions) at only a 25% success rate. Table 16 features a breakdown of all of the passing scenarios. By reviewing this total breakdown information, it is clear that foggy conditions featured a lower success rate (63% foggy vs. 90% clear-day success rate) and flood tide with E wind is the most difficult environmental condition (50% E wind vs. 93% SE wind vs. 86% N wind success rate). While pilots did not feel that the E wind had a large negative impact on their transits, the simulation breakdown by conditions suggests otherwise.

Table 14. Tanker passing simulations breakdown by conditions.

Run #	Total Runs	Total Successful	Total Groundings	Success Rate
9	4	4	0	100%
11	2	2	0	100%
13	4	4	0	100%
15	3	3	0	100%
17	4	3	1	75%
19	3	2	1	67%
Summary of Tanker Meetings				
Condition	Total Runs	Total Successful	Total Groundings	Success Rate
All	20	18	2	90%
Clear day	10	10	0	100%
Foggy	10	8	2	80%
Flood, E Wind	6	5	1	83%
Flood, SE Wind	7	7	0	100%
Ebb, N Wind	7	6	1	86%

Table 15. Containership and bulker passing simulations breakdown by conditions.

Run #	Total Runs	Total Successful	Total Groundings	Success Rate
10	5	4	1	80%
12	2	1	1	50%
14	4	4	0	100%
16	3	3	0	100%
18	8	2	6	25%
20	3	2	1	67%
Summary of Containership/Bulker Meetings				
Condition	Total Runs	Total Successful	Total Groundings	Success Rate
All	25	16	9	64%
Clear day	11	9	2	82%
Foggy	14	7	7	50%
Flood, E Wind	10	3	7	30%
Flood, SE Wind	8	7	1	88%
Ebb, N Wind	7	6	1	86%

Table 16. All passing simulations breakdown by conditions (modified from Johnston and Godsey 2021).

Condition	Total Runs	Total Successful	Total Groundings	Success Rate
All	45	34	11	76%
Clear day	21	19	2	90%
Foggy	24	15	9	63%
Flood, E Wind	16	8	8	50%
Flood, SE Wind	15	14	1	93%
Ebb, N Wind	14	12	2	86%

Based on the initial condition breakdown analysis, two conditions were identified as causing the most difficulty: reduced visibility by fog and flood tide with E wind. Further analysis was performed by inspecting tracks for similarities. During this analysis, three additional factors were determined that increased the likelihood of a grounding to occur during the simulation. These factors included high transiting speeds, large speed disparities between vessels, and transiting vessels being out of position during or prior to the meeting. Table 17 lists these factors and how they were determined to be true or applicable for a simulation.

During debrief sessions, the ideal speed of the vessels during meeting was discussed. Pilots considered that a speed close to 10 kn for both vessels would probably be the ideal meeting speed so that the vessels would maintain steerage but would also not be going overly fast. During simulations, pilots often felt that the bow wave experienced by the smaller vessel from the larger vessel was extreme. This effect can also be noticed in some of the tracks where a large shear is shown during or after passing. While the magnitude of effect may have been exaggerated by the simulator, the effect itself is accurate. The larger vessel will create a bow wave as it moves through the water that will impact the smaller vessel as it passes. This effect becomes more pronounced if the larger vessel is transiting much faster than the smaller vessel. The larger vessel was determined by comparing the displacement tons on the pilot cards of the vessels. TANK21x accounts for approximately 15% more displacement tons than TANK10L. CNTNR41 accounts for approximately 122% more displacement tons than BULKCo6L. Based on this assessment, the vessel size disparity is much larger between the containership and bulkier than the two tankers. This large vessel disparity may help account for the greater number of difficulties the pilots had with the containership and

bulker meetings. The larger containership often overwhelmed the bulker during the meetings.

While pilots did not specify an ideal distance from the bank for passing scenarios, an estimate of ideal bank distance was determined by reviewing the track plots. If the vessel was less than 20 ft from the bank prior to the meeting, that vessel often experienced a bow wave that was enough to cause it to go outside of the channel. If the vessel's distance to the bank was large, then that vessel was likely not in its designated section of the channel, and more ship-to-ship effects were likely felt. Note that these ideal metrics were approximately appropriate to determine difficulties in these simulations but are by no means a rule for other passing scenarios in other areas.

Table 17. Grounding factors for passing simulations (modified from Johnston and Godsey 2021).

Factor Description	Controlled by	True Determination
Adverse visibility	Conditions tested	If the simulation tested foggy conditions
Adverse wind	Conditions tested	If the simulation tested east wind conditions
High transiting speeds	Pilots	If the speed of either transiting vessel was >11.5 kn during the meeting
Large speed disparity	Pilots	If the larger vessel was traveling >2 kn more than the smaller vessel during the meeting
Transiting vessels are out of position	Pilots	If the transiting vessel's beam is approximately 105 ft and the distance to the bank is <20 ft or >110 ft just prior to meeting If the transiting vessel's beam is approximately 140 ft and the distance to the bank is <20 ft or >80 ft just prior to meeting

Table 18 and Table 19 break down the passing simulations by these identified factors (Table 17) for the tanker/tanker and containership/bulker meeting simulations, respectively. If the row has been grey filled, those data were lost, so a factor determination was not possible. If the row is yellow filled, that simulation was designated as a pilot error, so its factors were ignored when analyzing. While five factors were identified for analysis, these factors are inherently linked. For example, higher transit speeds are often paired with large speed disparities. Additionally, some of the conditions themselves may more

frequently cause additional factors to occur. For example, simulations that feature a N wind may experience larger vessel speeds on the outbound vessel, or simulations with an E wind may more often experience vessels being out of position during meeting. While magnitude was not considered in this factor analysis, it does matter in some cases. For example, in the first Run 18, performed by pilots 6 and 5, the larger vessel was transiting at a speed of 17 kn during the meeting, which accounted for a speed disparity of 7.4 kn. While this run ended up with a factor score of 5, it probably would have ended in a grounding based on the speeds alone.

Table 18. Tanker passing simulations breakdown by factors.

Run #	Pilot ID # (Inbound/Outbound)	Adverse Visibility ?	Adverse Wind?	High Speeds?	Speed Disparity?	Out of Position?	Total Factors	Pilot Error ?	Grounding?
9	3/4	No	No	No	No	No	0		
9	5/6	No	No	No	No	Yes	1		
9	7/8	No	No	No	No	No	0		
9	10/9	No	No	Yes	Yes	No	2		
11	9/10	No	Yes	No	No	No	1		
11	10/9	No	Yes	No	No	Yes	2		
13	4/3	No	No	No	Yes	Yes	2		
13	6/5	No	No	No	No	Yes	1		
13	8/7	No	No	No	Yes	Yes	2		
13	10/9	No	No	Yes	Yes	No	2		
15	5/6	Yes	No	Data corrupted, these factors are unknown					
15	6/5	Yes	No	No	No	No	1	Yes	Yes
15	8/7	Yes	No	No	No	No	1		
15	9/10	Yes	No	No	No	Yes	2		
17	6/5	Yes	Yes	Yes	No	Yes	4		Yes
17	6/5	Yes	Yes	No	No	Yes	3		
17	7/8	Yes	Yes	No	No	No	2		
17	9/10	Yes	Yes	No	No	Yes	3		
19	6/5	Yes	No	No	No	No	1	Yes	Yes
19	6/5	Yes	No	No	No	Yes	2		
19	7/8	Yes	No	No	No	No	1		
19	9/10	Yes	No	Yes	Yes	Yes	4		Yes

Table 19. Containership and bulkier passing simulations breakdown by factors.

Run #	Pilot ID # (Inbound/Outbound)	Adverse Visibility ?	Adverse Wind?	High Speeds?	Speed Disparity?	Out of Position ?	Total Factors	Grounding?
10	4/3	No	No	Yes	No	No	1	
10	6/5	No	No	Yes	Yes	Yes	3	Yes
10	6/5	No	No	No	No	Yes	1	
10	8/7	No	No	No	No	No	0	
10	9/10	No	No	Yes	No	No	1	
12	9/10	No	Yes	Yes	Yes	Yes	4	Yes
12	10/9	No	Yes	No	No	Yes	2	
14	3/4	No	No	Yes	No	Yes	2	
14	5/6	No	No	Data corrupted, these factors are unknown				
14	7/8	No	No	Yes	No	Yes	2	
14	10/9	No	No	Yes	No	Yes	2	
16	5/6	Yes	No	No	No	Yes	2	
16	7/8	Yes	No	Yes	Yes	No	3	
16	10/9	Yes	No	Yes	No	Yes	3	
18	3/4	Yes	Yes	Yes	Yes	Yes	5	Yes
18	6/5	Yes	Yes	Yes	Yes	Yes	5	Yes
18	6/5	Yes	Yes	Yes	Yes	Yes	5	Yes
18	6/5	Yes	Yes	No	No	Yes	3	
18	8/7	Yes	Yes	No	No	Yes	3	Yes
18	9/10	Yes	Yes	Data corrupted, these factors are unknown				
18	10/9	Yes	Yes	Data corrupted, these factors are unknown				Yes
18	10/9	Yes	Yes	No	No	Yes	3	Yes
20	5/6	Yes	No	Yes	No	Yes	3	
20	8/7	Yes	No	Yes	No	No	2	
20	9/10	Yes	No	Yes	No	Yes	3	Yes

Table 20 combines the individual simulation factor analysis from Tanker/Tanker and Containership/Bulker meeting simulations presented in Table 18 and Table 19. The simulations that included corrupted data (grey-filled rows) or pilot error (yellow-filled rows) were removed in this combined table. Based on these factors, it is clear that the higher the number of factors exhibited, the more probable a grounding occurred. When considering the initial condition analysis, certain simulations, like Run 18, start with a base factor score (in this case, 2) that is higher than others. With the runs that featured foggy conditions and E wind, any additional pilot error was more probable to end in a grounding. Simulations that featured a lower base factor score were more easily able to overcome high speeds, speed disparity, or being out of position. Based on the frequencies of groundings that occurred, it is expected that the channel will probably require restrictions of when certain passing scenarios can occur. For example, passing during foggy conditions or during strong flood tide with strong E wind should not occur based on ship simulation results. Typically, once the channel is constructed, conditions and scenarios should be attempted gradually. As pilots become more accustomed to the channel, restrictions may be able to be reduced.

Table 20. Summary of total grounding factors present in passing simulations (modified from Johnston and Godsey 2021).

# of Factors	# of Occurrences	# of Groundings	% of Groundings
0	3	0	0%
1	8	0	0%
2	14	0	0%
3	10	4	40%
4	3	3	100%
5	3	3	100%

Logistics

The actual timing of vessels meeting in the passing lane was largely ignored during simulations since the two vessels were placed in somewhat ideal starting locations to meet in the passing lane. It is expected that in some starting locations, an inbound vessel may not be able to appropriately meet an outbound vessel in the proposed two-way traffic area. Testing this in the ship simulator would not have provided much insight other than to highlight that logistics will be an important piece of fully utilizing the

passing lane. Although the length of the passing lane was determined to be adequate for the passing itself, it should be acknowledged that the limited length of the passing lane will reduce its effectiveness. Challenging logistics and cooperation between pilots will be necessary to accurately time meeting in the proposed 3 mi passing location; however, it is feasible.

11 Final Recommendations

Overall conclusions and recommendations are based on track plots (Appendix A), informational sheets with pilot comments (Appendix A), final pilot surveys (Appendix B), discussions after each simulation, final wrap-up meetings completed at the end of each testing week, and the final pilot letter (Appendix D).

The turning basin expansion was found to be acceptable for the vessels tested under the extreme ebb condition. Adequate tug power would be required to make this maneuver feasible for the larger transiting vessels maneuvering by the docked vessels. There is a safety concern regarding the interaction between a transiting vessel and docked vessels at the McDuffie Coal Terminal. It is recommended that a further investigation be performed to determine the turning basin entrance expansion that may be required to reduce the safety concerns.

Generally, the ship simulations featured a larger-than-expected number of groundings especially in the passing area. These groundings likely occurred due to an aggressive testing schedule and difficult environmental conditions. The passing lane width was deemed adequate for the two vessel combinations tested with the understanding that it will require some restrictions. Passing should not occur during foggy conditions or during strong flood tide with strong east wind based on ship simulation results. The passing lane length is deemed adequate, but the short length will limit how often it can be used. Logistically, the length will be challenging, but the use of it is feasible.

Pilots experienced little difficulty with the proposed bend easings. The bend easings allowed pilots to more easily navigate the bends, especially for the larger vessels or when preparing for a meeting scenario. Groundings that occurred in this area were primarily due to initial pilot unfamiliarity with the simulator. The bend easings are recommended as proposed.

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Acronyms and Abbreviations

ADCIRC	Advanced Circulation
APM	A. P. Moller-Maersk
CESAM	Mobile District
E	east
ERDC	US Army Engineer Research and Development Center
FLSS	Feasibility Level Ship Simulation
HQ	high flow
LQ	low flow
N	north
SE	southeast
STS	Ship/Tow Simulator
USACE	US Army Corps of Engineers

Appendix A: Track Plots and Pilot Comments

Informational Sheet Plate 1

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
1	Inbound	CNTNR49	Ebb+75%	20 knots N	Clear

Individual simulation information:

Pilot #	Initial location of Tugs	Pilot Comments	Pilot Scores	
			Run Difficulty	Run Safety
3	3 - Port Shoulder, 2 Starboard Quarter	Maneuver would be done with four tugs due to current and wind with a ship this size.	3	2
6	3 - Port Shoulder, Starboard Quarter, Starboard Shoulder	Ship and tug boats handled well. Added room in turning basin was needed and welcome for this ship!	2	2
7	3 - Port Shoulder, 2 Starboard Quarter	Ship was sluggish at slow speed. Three tugs seemed like enough to turn but probably needed fourth tug to help check swing when turning around.	3	1
9	3 - Port Shoulder, 2 Starboard Quarter	More than 100 ft from the docked vessel. Heavy ship and extra room at the south end of the basin was very nice and allowed plenty of time to accomplish turn.	4	1
10	3 - Port Shoulder, Port Quarter, Starboard Shoulder	Came into turning basin a little faster than I would do normally. Had difficult time slowing down.	5	5
10	3 - Port Shoulder, Port Quarter, Starboard Shoulder	Vessel began turning to starboard in an unrealistic way immediately. After turning, vessel continued to turn to starboard unchecked with tugs applying force in the opposite direction.	5	5

Informational Sheet Plate 2

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
2	Inbound	CNTNR49	Ebb+75%	20 knots N	Night

Individual simulation information:

Pilot #	Initial location of Tugs	Pilot Comments	Pilot Scores	
			Run Difficulty	Run Safety
3	4 - Port Shoulder, 3 Starboard Quarter	There is a lot of current effect on this run. Four tugs made it easier than the first time with three tugs.	3	2
5	3 - Port Shoulder, Starboard Quarter, Starboard Shoulder	Very realistic simulation. Good room to turn the ship.	3	2
7	4 - Port Shoulder, 2 Starboard Quarter, Center Lead Aft	Ordered four tugs this time but couldn't turn ship in the basin.	3	3
7	4 - Port Shoulder, 3 Starboard Quarter	The tug definitely helped expedite the turn. Plenty of room in the basin.	2	2
10	4 - Port Bow, 2 Starboard Quarter, 1 Aft/Starboard Quarter	Vessel began swinging to starboard immediately. Had to first check her up. Once checked up, simulation went well. Turning basin had ample room for turning. Had to back bow tug full and between full to port to check swing but it worked.	4	2

Informational Sheet Plate 4

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
3	Outbound	CNTNR49	Ebb+75%	20 knots N	Clear

Individual simulation information:

Pilot #	Initial location of Tugs	Pilot Comments	Pilot Scores	
			Run Difficulty	Run Safety
4	3 - Port Shoulder, Port Quarter, Starboard Shoulder	There is much more room to run out into the basin. I turned low with ebb and there was still plenty of room. The ship seemed a little sluggish to shed headway but once checked handled like what I would expect. Huge benefit to the extra room.	3	1
5	3 - Port Bow, 2 Starboard Quarter	Simulation was realistic. Vessel behaved as expected.	4	2
8	4 - 2 Port Shoulder, 2 Starboard Quarter	This exercise clearly showed the need for the extended turning basin. This maneuver with this LOA ship and another vessel at the south end of MCT is not feasible in ebb current conditions unless using 5-6 tug boats. Even then, close-quarter turns in this scenario are guaranteed to happen and not ideal for safety.	4	4
10	4 - Port Bow, 3 Starboard Quarter	Success! Needed three 65t tugs on starboard quarter to make the turn.	2	1

Informational Sheet Plate 5

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
4	Outbound	CNTNR49	Ebb+75%	20 knots N	Night

Individual simulation information:

Pilot #	Initial location of Tugs	Pilot Comments	Pilot Scores	
			Run Difficulty	Run Safety
5	3 - Port Shoulder, 2 Starboard Quarter	Good simulation. Very real. Basin design is good. Probably could have used a fourth tug.	3	2
6	3 - 2 Port Shoulder, Starboard Quarter	The extra areas to the east side of the turning allowed this ship to turn with a vessel at the lower container dock. This is something I would not attempt with the area we now have.	1	1
7	3 - Port Shoulder, 2 Starboard Quarter	Ship turned fine but have to drive on it to steady up to pass three large vessels at Coal dock. Need four tugs.	2	2
8	3 - Port Shoulder, 2 Starboard Quarter	Existing basin not adequate for turning with three tugs (under these conditions). Expanded basin made it possible for bow to swing clear.	4	4
9	4 - Port Bow, 3 Starboard Quarter	No issues. Speed past McDuffie probably a bit excessive.	2	2
10	4 - Port Bow, Port Quarter, 2 Starboard Quarter	Good, safe turn. Needed three tugs pushing on starboard quarter to life the stern. Everything seemed to work well.	2	2

Informational Sheet Plate 7

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
5	Inbound	BULK19	Ebb+75%	20 knots N	Clear

Individual simulation information:

Pilot #	Initial location of Tugs	Pilot Comments	Pilot Scores	
			Run Difficulty	Run Safety
4	3 - Port Shoulder, Starboard Quarter, Starboard Shoulder	Trying to slow down a loaded bulker is a handful. When you come astern on the ship you can lose the bow (swing to starboard). Having that extra room in the basin is incredibly handy. It's good that there's not only more room in the basin but also on the west corner of the island.	3	1
5	3 - Port Shoulder, Starboard Quarter, Starboard Shoulder	Ship simulation was very realistic.	3	2
6	3 - Port Shoulder, Starboard Quarter, Starboard Shoulder	Ship handled as a loaded, underpowered ship would. Too many engine orders were required, as high current conditions would.	2	2
7	3 - Port Shoulder, 2 Starboard Quarter	Ship didn't have good backing power. Probably needed fourth tug. Plenty of room to turn.	1	1
8	3 - Port Shoulder, Starboard Quarter, Starboard Shoulder	Executed maneuver with three tugs but not feasible. Had to use ship's engine full astern for entire turn and it still nearly didn't hold. Bow would have hit bottom in existing basin.	3	4
9	3 - Port Shoulder, 2 Starboard Quarter	Turning low in basin is possible but must shape up quickly before continuing south due to strong set.	3	1
9	3 - Port Shoulder, 2 Starboard Quarter	Higher turn in basin leaving additional room for "error margin" worked well. Still strong set to west.	3	2

Informational Sheet Plate 8

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
6	Inbound	BULK19	Ebb+75%	20 knots N	Night

Individual simulation information:

Pilot #	Initial location of Tugs	Pilot Comments	Pilot Scores	
			Run Difficulty	Run Safety
4	3 - Port Shoulder, Starboard Quarter, Starboard Shoulder	I had to drive away from the ship on the south end of the container dock. Went into the turn with way too much headway. With the extra room in the basin, I was able to salvage the maneuver. Love the extra room.	3	2
6	3 - Port Shoulder, Starboard Quarter, Starboard Shoulder	I used the least amount of tug power and the ship's engine while turning this ship. The extra room allowed this ship to turn safely.	1	1
8	3 - Port Shoulder, Starboard Quarter, Starboard Shoulder	Executing this maneuver in the existing basin with three tugs required very aggressive turn. The ability to use extended area on bow would allow reasonable and much safer execution.	3	4
9	3 - Port Shoulder, 2 Starboard Quarter	Extra room in the basin was necessary while waiting on bow to come around.	4	3

Informational Sheet Plate 10

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
9	TANK10L	TANK21X	Flood	20 knots SE	Clear

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
3/4	144	Ship's rudder didn't react as good as normal. Other than that all OK.	2	2
5/6	134	Did not feel as much bank cushion/suction as I would have expected but realistic simulation.	3	2
7/8	106	Ship got squirrely when passing the other ship but recovered. Comfortable passing.	3	3
10/9	143	Met the ships a little further north. Meeting went fine, lots of bow interaction and a little difficulty recovering the swing.	2	3

Informational Sheet Plate 11

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
11	TANK10L	TANK21X	Flood	20 knots E	Clear

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
9/10	135	Success!	2	2
10/9	93	Lots of swing of the ships heading and interaction between the bows. A little unrealistic in interaction but recoverable.	Not Recorded	Not Recorded

Informational Sheet Plate 12

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
13	TANK10L	TANK21X	Ebb	20 knots N	Clear

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
4/3	110	Inbound Pilot: Simulator started with my ship swinging hard to starboard. I was able to catch the swing and finish the turn at 17/18 on the green side. With the extra channel at the turns it proved to be beneficial. The added width/depth was very beneficial. Outbound Pilot: Bends will be easier to maneuver with the cut outs being made.	3/1	2/1
6/5	94	This new channel width allowed these ships to safely meet, with much more room, both between them and from the ship to the bank.	1	1
8/7	117	Both ships met with slow, controlled speed. My ship (inbound ship) still felt significant shear off other ship when bows met. There was enough room to get by but pushing the edge of channel meeting a ship that wide.	2	4
10/9	148	Timing is critical due to slower speed of inbound vessel. Meeting was executed further south than anticipated, leaving little time to recover and position for turn at 21/22. Excessive speed and/or reduction < 10 kts causes awkward handling characteristics when meeting.	4	4

Informational Sheet Plate 14

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
10	CNTNR41	BULKCO6L	Flood	20 knots SE	Clear

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
4/3	145	The extra room is very beneficial. The extra 100 ft of the channel is good but the extra water under-keel is great.	2	1
6/5	178	The ship pretty much handled as expected. Effect of flood tide might be a bit too much. For the wider bends and channel seems like more than enough room. Ship interaction seemed stronger than normal. Overall realistic.	3	2
6/5	88	With lower speeds on inbound ship, both ships were allowed to move away from the centerline. The widened channel allows meeting of wider, deeper ships in this area.	1	1
8/7	125	Very strong flood effect. Vessel was difficult to steer while slowing down to make turns. These two ships are pushing the limit to what we could do in good conditions.	3	3
9/10	142	Inbound Pilot: Timing is paramount. Couldn't initially get desired speed out of vessel, creating meeting situation further south than desirable. More time to negotiate meeting position would be nice but maneuver went well. Outbound Pilot: Passing at this draft no problem. Also ship size made it somewhat easier. Used bend easement. Had plenty of time to get over being the outbound pilot.	3/1	3/1

Informational Sheet Plate 15

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
12	CNTNR41	BULKCO6L	Flood	20 knots E	Clear

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
9/10	120	These two vessels do not like to meet. Vessel meeting container ship is severely influenced by bow pressure.	3	4
10/9	117	Flood tide again made turns at 17/18 and 21/22 a little difficult but manageable. Meeting went fine from my side. Outbound pilot had difficulty recovering after getting too far over for meeting. No issues or concerns from my end.	1	1

Informational Sheet Plate 16

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
14	CNTNR41	BULKCO6L	Ebb	20 knots N	Clear

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
3/4	159	This run was the most realistic run so far. Environmentalists were very noticeable.	2	2
5/6	166	Realistic simulation. Good room to meet wide beam.	2	1
7/8	133	Inbound Pilot: Ship handled well. Was able to turn at 21/22 and line up in plenty of time to pass a comfortable distance. Outbound Pilot: Vessel handled well enough to give inbound wide beam room to pass. Bow cushion effect when meeting felt far too strong and resulted in max rudder use to stay in the channel. Channel width however does seem adequate.	3/2	2/2
10/9	171	I timed the meeting from when I turned 21/22 and it was 8 minutes to turn, get in the center, then meet in the passing lane. It worked and is workable, provided we are able to accurately have both ships at the starting points shown in the simulation. Challenging but doable.	4	3

Informational Sheet Plate 18

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
15	TANK10L	TANK21X	Flood	20 knots SE	Foggy

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
6/5	165	This vessel didn't seem to run away from the bank as hard (if at all) as I thought it should given its draft and size.	2	2
5/6	*	Good simulation. Good room to pass both vessels safely. Definitely felt ship effects but manageable.	3	2
8/7	145	Vessel handled well enough in low visibility to give outbound enough room for passing. Close quarters but doable.	2	3
9/10	142	Ship of this size with flood tide the use of new "eased" turn is necessary to prevent being pushed to reds at middle ground.	Not Recorded	Not Recorded

* Data not available

Informational Sheet Plate 19

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
17	TANK10L	TANK21X	Flood	20 knots E	Foggy

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
6/5	186	The wider channel at 21/22 allowed more room to set up for meeting and allowed time for the inbound ship to settle down after the turn.	Not Recorded	Not Recorded
6/5	111	The fact that we have more room in turns and straight reaches really allows more time and distance to set both inbound and outbound ships for meeting.	2	2
7/8	137	Inbound Pilot: Sluggish to react when passing but able to recover and reposition in middle of the channel. Outbound Pilot: Passing lane allowed enough room for ships to pass. Hulls still close enough to experience significant suction effect but not so much to make unsafe.	2/2	2/2
9/10	152	Good run with no problems as long as two vessels coordinate to meet in the passing lane.	2	2

Informational Sheet Plate 20

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
19	TANK10L	TANK21X	Ebb	20 knots N	Foggy

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
6/5	164	Pilot used wrong steering control.	2	1
6/5	111	On the last run, pilots fault! Was attempting to steer with wrong control on rerun. Both ships used the wider channel with room between both ships to spare. The wider lanes allow ships to stay in deeper water for a longer time when meeting.	2	1
7/8	137	Was fine until abeam of outbound. Suction was enough to almost make the ship run aground.	3	3
9/10	152	I have no idea!	2	3

Informational Sheet Plate 22

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
16	CNTNR41	BULKCO6L	Flood	20 knots SE	Foggy

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
5/6	129	Ship simulation was realistic.	3	2
7/8	155	Seemed fine. Ship handled well.	2	2
10/9	156	Flood tide with fog made turn at 17/18 difficult. Recovered from turn and was able to meet outbound ship without problem. Felt like I had enough room to get over and meet smaller ship with ease.	4	2

Informational Sheet Plate 23

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
18	CNTNR41	BULKCO6L	Flood	20 knots E	Foggy

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
3/4	181	This was a very realistic run. This is when the widened passing lane will be most utilized.	2	3
6/5	114	See second repetition comment (below).	3	4
6/5	105	Too much speed on inbound container ship. Wider channel allowed both ships to move over more, but the inbound ship's speed took steering ability away from the outbound ship.	3	4
6/5	81	Less speed and ships meeting closer together allowed both to safely meet in these conditions. The wider channel will give us more time to get ships (like these) set up better to meet.	1	2
8/7	152	Containership with flood tide required me to run on dead slow in order to reduce speed. This made the ship handle poorly, which in turn made it more difficult to get over to meet outbound ship. Speed still resulted in causing significant cushion effect while passing.	3	3
9/10	120	Berault on bulk carrier on this run. Moving over for passing - no problem. Keeping ship over for meeting - no problem. Bow interaction very strong. This ship swings fairly energetically just as/after meeting large container.	4	4
10/9	*	Had to slow ship down immediately with flood tide to make turns and be at slow enough speed to meet inbound ship. Still had plenty of interaction between ships. Outbound pilot had trouble meeting ship of the size I was on and recovering.	3	3
10/9	178	Introduction between ships when meeting is dramatic with deep loaded inbound has speeds ≥ 10.5 knots. Maneuver is only accomplished with application of initial rudder toward bow of inbound vessel and then quick counter rudder to combat tendency of ship to dive back to port.	4	5

* Data not available

Informational Sheet Plate 24

Conditions tested:

Run #	Inbound Vessel	Outbound Vessel	Current	Wind	Visibility
20	CNTNR41	BULKCO6L	Ebb	20 knots N	Foggy

Individual simulation information:

Inbound / Outbound Pilot #	Meeting Distance (ft)	Pilot Comments (Inbound pilot unless stated otherwise)	Inbound Pilot Scores	
			Run Difficulty	Run Safety
5/6	183	Good simulation and ship effects. Good room to pass.	3	2
8/7	155	Inbound Pilot: Inbound vessel turns OK. Definitely used all of widener to get containership over to meet outbound ship. All OK. Outbound Pilot: Passing was fine. Able to recover and get in position to make outbound turns.	2	2
9/10	168	Need plenty of time to come out of turn at 21/22 to get set up in passing lane for meeting other vessel.	2	3

Informational Sheet Plate 26

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
27	Inbound	CNTNR49	Flood	20 knots SE	Foggy

Individual simulation information:

Pilot #	Pilot Comments	Pilot Scores	
		Run Difficulty	Run Safety
4	Nice to have the extra room and water to ease around the turns.	2	2
7	Thought I started the turn early enough with the flood but still was set up on the red side coming out of the turn.	3	2
7	Used bend easing on green side at 17/18 to help compensate for flood tide. Made turn at 22 no problem.	3	2
9	Found easing of turn helpful while trying to maintain a speed > 13 knots. Approach and execution of turn typically ≤ 12 knots but the extra room to start turn early was nice.	3	2

Informational Sheet Plate 27

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
30	Inbound	CNTNR49	Flood	20 knots E	Foggy

Individual simulation information:

Pilot #	Pilot Comments	Pilot Scores	
		Run Difficulty	Run Safety
5	Ship handled well within confines of channel. Good simulation.	3	1
6	Conditions seem to affect the ship as it would in real life. I think the ship would handle as this one did.	4	3
10	Wanted to see, at full ahead and flood tide, how much set to the NE would be represented in first turn. Did not feel as much set as I would have expected. Speed a little too much through 2 nd turn but nice with widener.	2	2

Informational Sheet Plate 28

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
28	Inbound	CNTNR49	Ebb	20 knots N	Foggy

Individual simulation information:

Pilot #	Pilot Comments	Pilot Scores	
		Run Difficulty	Run Safety
5	Realistic simulation.	2	1
8	Vessel handled realistically with environmental effects in place. Bend easing allows for more forgiveness in bad visibility on ships this size, but this would not be ideal and more times than not unsafe for even one-way traffic.	3	3
10	Trying to get acclimated in the fog was difficult. Using my PPU hindered this. The difference between my PPU and ECDIS (and other data) was great. Would recommend getting adjusted to using simulator in good vision.	5	5
10	Bend easing did not affect how I made the turns in the channel. Did not see remarkable difference.	1	1

Informational Sheet Plate 29

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
25	Inbound	BULK19	Flood	20 knots SE	Foggy

Individual simulation information:

Pilot #	Pilot Comments	Pilot Scores	
		Run Difficulty	Run Safety
3	I would never say it is safe to run in the fog. We do not start ships in foggy conditions. The only time we do this is when it gets foggy during transit.	1	2
7	Flood realistic turning Mobile Point but ship hard to answer coming out of that turn.	4	4
7	Made turns fine but the ship is very sluggish. Don't think I would want to meet another deep draft of any size in the passing lane because by the time I could get ship settled out I was almost back to the 400 ft channel.	4	4
9	Certainly a pronounced increase in current after swinging turn with the flood tide. Vessel wants to be set to reds.	2	2

Informational Sheet Plate 30

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
31	Inbound	BULK19	Flood	20 knots E	Foggy

Individual simulation information:

Pilot #	Pilot Comments	Pilot Scores	
		Run Difficulty	Run Safety
5	Realistic simulation. Ship handled well.	2	1
6	Wider turns at buoys 17/18 allow for an easy set up to turn at 21/22. Best turns I've seen yet.	1	1
9	No problems. Simulation went well. Vessel will handle better at slower speeds.	1	1

Informational Sheet Plate 31

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
26	Inbound	BULK19	Ebb	20 knots N	Foggy

Individual simulation information:

Pilot #	Pilot Comments	Pilot Scores	
		Run Difficulty	Run Safety
6	Run seemed very real. Ship was slow to respond but very close for these conditions. Winder bends seem to give a good bit more "forgiveness."	4	3
8	First simulation. Low visibility. All well and vessel behaved properly. Bend easing apparent for turning in low visibility.	1	1
10	Tried to use bend easements. Definitely can "sense" wider channel but difficult to gauge with fog on display.	1	1

Informational Sheet Plate 33

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
32	Outbound	BULK19	Flood	20 knots E	Foggy

Individual simulation information:

Pilot #	Pilot Comments	Pilot Scores	
		Run Difficulty	Run Safety
5	Realistic simulation. Ship handled well in confines of channel.	3	1
7	Flood seemed realistic but ship didn't handle well.	3	2
7	Ship was very hard to steer against the flood tide.	Not Recorded	Not Recorded
8	Vessel handles realistically in given conditions. The bend easing is helpful in bad visibility.	2	2
9	Turn is easier to negotiate with about ~ 5° of rudder as opposed to 10° which is normal for that particular turn. Easings seem to all for > speed and < rudder.	2	2

Informational Sheet Plate 34

Conditions tested:

Run #	Heading	Vessel	Current	Wind	Visibility
33	Outbound	CNTNR49	Flood	20 knots E	Foggy

Individual simulation information:

Pilot #	Pilot Comments	Pilot Scores	
		Run Difficulty	Run Safety
6	With these conditions and the wider turns, this ship made a good run. The wider turns will not take long to get used to!	1	1
8	Strong flood tide on a ship this size makes turning at buoys 17/18 much slower and vulnerable to NE set. Low visibility compounds difficulty considerably. The ship's steering felt too slow to react on the simulator, but set was realistic.	3	4
10	Good simulation in fog. Needed to use a lot of rudder to check swing. Used easement in channel bend at 17/18.	2	2

Appendix B: Final Pilot Questionnaires

Final Pilot Questionnaires

Question 1: Please comment on your experience of using the ERDC Ship-Tow Simulator this week for testing.			
Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
This was a good learning experience. The crew here was great to deal with.	Great experience.	Great experience! Very nice facility and simulator.	This simulator was the best I have ever worked with.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
Everything seemed realistic for the most part.	Simulators worked well and had realistic display/effects during use.	I thought the simulator was very realistic in nearly every scenario.	The overall experience of using ERDC's Ship simulator was good. The equipment worked well. Communications with simulator operators was good. I thought the simulator worked in a way that it should - to be realistic.

Question 2: Do you feel the environmental conditions and visuals provided a reasonable representation of the Mobile Harbor under which pilots would navigate the channel?			
Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
Yes, they do.	Yes.	Yes.	Yes! Whoever set this up really did their homework.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
Yes.	Yes, all major landmarks/navigation aids were present and easy to identify. Conditions were realistic too.	Yes.	Yes, the visuals were a good representation of the ship channel. The environmental conditions seemed to be stronger (current) than that which I would experience in real life. Some modifications of the environmentals would be helpful. Maybe the ability to "tone down" the current quickly if it felt a little too strong.

Question 3:

Please comment on the behavior of the two design vessels (Maersk Guayaquil – Containership: 1105.6- x 158.5- x 47-ft) and Regina Oldendorff – Bulk "coal" carrier: 853- x 141.2- x 47-ft). Do you feel the design vessels were an adequate representation of a real life vessel?

Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
I do feel like they were a good representation.	The container ship's rudder seemed much more sluggish than you would normally see. Making the turns at 17:10-21:22 usually doesn't require that much rudder to make those turns.	Yes, the vessel designs were very realistic and true to handling.	Both vessels were as real as it gets.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
The bulk carrier inbound requires almost entire passing lane to stabilize after turning northbound. I wouldn't want to pass it. If it was outbound I don't see an issue. Bulk carrier maybe a little too slow to react as far as steering.	The containership steered a little sluggish but was otherwise adequate. The Oldendorff experienced unusual shear effects while meeting in the channel.	They did not like each other at all. Speed of container vessel needs to be ≤ 10.5 to allow for a safe meeting situation.	The containership (<i>Maersk Guayaquil</i>) seemed a bit "heavy" and not as responsive as I have felt in real life, but maybe just a little bit more than normal. The <i>Regina Oldendorff</i> felt realistic for a bulk carrier.

Question 4:

Please comment on the response of other vessel models tested (passing lane), both ships and tugs (turning basin). Do you feel the other vessels were an adequate representation of real life vessels?

Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
Aside from rudder response they were good.	Fairly accurate.	Yes, ship effects seemed true to real life and behaved as would expect.	All the test vessels handled as real ships would in that class.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
Deep loaded tankers/bulk carriers meeting presented more of a challenge due to draft and engine and rudder power. Definitely a doable maneuver but absolutely no room for error. Turning basin and tugs good.	Yes, the tankers and other containership were adequate.	Yes, all other vessels seemed accurate with exception of bulkier turning in the basin. She really struggled to back up river.	The response overall was fairly representative of what I have experienced in real life. However, there were times (on the bulk carriers and tankers) where the bow interaction seemed to be ridiculously strong. I have never had the bow of my ship sheer away from the bow of the other ship like was shown in simulation. The bank effect, on the other hand, appeared to be accurate. The response of the ships in the turning basin was much more accurate. The tugs also were very representative of real life.

Question 5: Did you consider the 3 mile, 500 ft , 52/50 ft channel adequate for passing in the following situations: a) Aframax (Vicksburg Spirit: 821- x 145- 36.0-ft) vs Tanker Panamax (MT Danita: 750- x 106- x 46-ft) b) PPXGN2 (Konway I: 1102- x 138 x 46-ft) vs Bulk04 (MS Magnitogorsk: 707- x 104- x 38-ft) Why or why not?			
Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
Yes for both a and b.	Yes, physically I think it will work. Logistically I think it will be hard at times to choreograph meeting points.	Yes, in these simulations there seemed to be adequate room for the vessels to pass.	Adequate for both a and b. We learned that the speed of the larger container ship controls what happens to the ship it is meeting.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
Yes on both. The room is there under the right conditions. As stated in question 4, you've got to be pretty precise on getting over and maintaining position. Also for bank effect and ship suction once passed.	Yes for both a and b. The 3-mile length will take logistical familiarization to properly use.	Yes for both a and b. All of these vessels, given slower speeds, seemed to meet safety in that area.	a. Yes, these two would appear to be able to meet in the widened channel. However, given only three (3) miles to make adjustments the timing of meeting these two vessels could make it very difficult to meet. Also, I'm not 100% sure we were able to accurately simulate meeting of these drafts with bank suction. b. Yes, I believe these vessels could meet in the widened channel. Similar reasonings for concerns in (A).

Question 6: Based upon the simulator runs, what possible limits or restrictions MIGHT be considered by the Mobile Bar Pilots for two-way traffic in the passing zone?			
Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
That will need to be discussed after more pilots have come and participated.	Extreme environmental.	Things to consider will be environmental conditions and type of ships meeting. Example, (1) Can inbound vessel make adequate speed to meet at widener, (2) Car carriers may "crab" too much with certain wind conditions, etc.	Might be a weather restriction/limit.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
Visibility, wind, combined length and draft.	Low visibility and extreme weather. Also potentially combined length and/or draft could dictate one-way traffic if two ships are too large.	To be discussed.	It is very difficult to be specific about new, LOA/BEAM limitations to be implemented considering the widened passing lane. Whatever new passing requirements are developed will give consideration especially to strong Ebb/Flood currents and the possibility that ships won't actually be able to make it into the passing lane at the same time. I'm very hopeful that 143' beam ships will be able to make the "old" panamax ships of 106' beam. Drafts will still play a factor and it may take actually using the passing lane with real ships to become comfortable with the adjustments to new, more liberal, restrictions.

Question 7: Did the bend easings improve safety and the setup for meeting of the large vessels in the passing lane?			
Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
Yes, they did. Less aggressive turns are easier to control.	The bend easings make the turns much less severe, making it easier to steady up on a course.	Yes, it makes the turns a little more forgiving.	Yes.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
Yes, can swing turns wider and line up earlier.	Yes.	Yes.	The bend easing wasn't significant in my opinion. The bend easing at 17/18 isn't really a bend easing as much as it is a buoy adjustment. There is plenty of deep water in the west side of this turn. The bend easing at 21/22 is more significant, but need to be longer in taper to make this helpful. I would rather see any funds directed towards bend easing used somewhere else - like elongating the passing lane.

Question 8: Was the deepened and expanded turning basin adequate (please include comments concerning docked ships) for turning the following vessels: a) Maersk Guayaquil – Containership: 1105.6- x 158.5- x 47-ft b) Regina Oldendorff – Bulk “coal” carrier: 853- x 141.2- x 47-ft Why or why not?			
Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
Yes for both a and b. This is my favorite part.	Love the turning basin. As long as the proper tugboats are available I believe it is adequate.	Yes, definitely more room in the basin. Turning off of ships alongside will always be a concern and make it more challenging. Ship and tug wheel can have effects on docked ships so it's just not about room. However, being able to get further off is good.	Yes, the deepened basin allows us to use the east side and still have room to back out and get the ship underway.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
With sufficient tug power, both are doable.	a. Yes. Very crucial and necessary in ebb current conditions. b. Yes. Bulk carriers handle less reliably and the added room will be used.	Yes, however a tapering of the "basin to channel" transition is a bit dramatic. A more gradual introduction to channel would be nice.	Yes for both a and b. The containership of that length with most certainly use the expanded and deepened turning basin - especially in the winter months where we need more north/south area for turning. Bulk carriers are notoriously less maneuverable than containerships so this sized bulk carrier will definitely enjoy an expanded turning basin. Also we will have large containerships on the south end of APM terminal so this extra room will make it much safer.

Question 9:

Do you consider the proposed channel adequate for the two design vessels (Maersk Guayaquil – Containership: 1105.6- x 158.5- x 47-ft and Regina Oldendorff – Bulk “coal” carrier: 853- x 141.2- x 47-ft) in one-way traffic?

Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
Yes, I do think they would be fine with one-way traffic.	No, it would need to be deepened.	Yes.	Yes.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
Just going by the simulation, if bulk carrier was outbound yes, inbound no. See question 3.	Yes.	Yes.	One-way traffic for these two vessels is certainly adequate for the two mentioned vessels.

Question 10:

Were the simulations representative of real-life piloting operations?

Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
Yes, they were.	Yes, mostly.	Yes.	Yes. Very real.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
For the most part yes.	Yes, some bank cushion/suction effects were a little extreme but otherwise it was realistic.	The meeting of the vessels and their introduction with each other was fairly accurate. In the simulations, the vessels were always initiated at distances and locations in the channel that breed the meeting situations to happen in the designated passing area. This isn't realistic.	The simulations were very representative of real life piloting operations. Minus having an actual, trained helmsman. It was a little difficult to recreate the fact that we are not normally really steering the ships. The simulator operators where very good in communication.

Question 11:

Do you think there were any additional testing runs that should have been completed that were not tested this week?

Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
We did not complete all of the runs due to limited time.	N/A	No, I feel it was adequate testing for the design.	No, I think everything was touched on.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
Pretty much covered all scenarios. Maybe a car carrier and bulk carrier or containership. New car terminal being built so expect to see after more of those type ships.	No.	I think that a trust test of the practiced nature of the new passing lane should probably include scenarios that don't guarantee both vessels will meet in the passing lane.	I would have liked to turn containerships to port as well as starboard to experience the expanded turning basin and currents in this maneuver. I'm curious as to the efficiency of the turning in this manner as compared to the way we do it in real life - almost always to starboard. This means we lift the stern against the strongest part of the current. With the expanded turning basin we might have more success (with less tugs) by turning to port. Time didn't allow for this experiment but it would be good to try another time.

Question 12:			
Any Additional Comments?			
Pilot 3 (Capt. Billy Bixler)	Pilot 4 (Capt. Jay Miller)	Pilot 5 (Capt. Jason Comer)	Pilot 6 (Capt. Pete Burns)
Keep up the good work!	Thank you for the help/input.	Thank you for your time and improving our channel!	No.
Pilot 7 (Capt. Chris Brock)	Pilot 8 (Capt. Curtis Wilson)	Pilot 9 (Capt. Reid Key)	Pilots 10 (Capt. David Berault)
No.	Working PPU hookups on simulator is helpful. All else OK.	No.	Thank you to Morgan, Mary Claire, Keith, Shannon and Kiara for being gracious hosts and conducting a very professional simulation time with Captain Key and myself. We (the Mobile Bar Pilots) appreciate your hard work!

Appendix C: Pilot Cards

PILOT CARD

CNTNR49V1

Version 1

Ship's name Maersk Guayaquil
Call Sign VROS8 Deadweight 119359 tonnes Year built 2015
Draught aft 14.33 m / 47 ft 0 in Forward 14.33 m / 47 ft 0 in Displacement 155190 tonnes

SHIP'S PARTICULARS

Length overall 337 m Anchor chain: Port 13.0 shackles Starboard 13.0 shackles
Breadth 48.3 m
Bulbous bow Yes (1 shackle = 27.432 m = 15 fathoms)

PROPULSION PARTICULARS

Type of engine Diesel Maximum power 58118 kW (79019 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	PLoaded
Full sea speed	1	81.0	N/A	N/A	23.0
Full Ahead	0.8	54.0	N/A	N/A	15.6
Half Ahead	0.5	40.0	N/A	N/A	11.5
Slow Ahead	0.25	28.0	N/A	N/A	8.0
Dead Slow Ahead	0.125	21.0	N/A	N/A	6.0
Dead Slow Astern	-0.125	-21.0	N/A		
Slow Astern	-0.25	-28.0	N/A		
Half Astern	-0.5	-40.0	N/A		
Full Astern	-1	-54.0	N/A		

STEERING PARTICULARS

Type of rudder _____ Normal _____ Maximum angle _____ 35 _____ °
Hard-over to hard-over _____ 11.3 _____ s
Rudder angle for neutral effect _____ 0 _____ °

Thruster: Bow _____ 2410 _____ kW (_____ 3277 _____ hp) Stern _____ N/A _____ kW (_____ N/A _____ hp)

CHECKED IF ABOARD AND READY

Anchors

Indicators:

Whistle

Rudder

Radar

3 cm

10 cm

Rpm/pitch

ARPA

Rate of turn

Speed log

Doppler:

Yes / No

Compass system

Water speed

Constant gyro error ±

°

Ground speed

VHF

Dual-axis

Elec. pos. fix. system

Engine telegraphs

Type

_____

Steering gear

Number of power units operating

OTHER INFORMATION:

PILOT CARD

BULKC19V2

Version 2

Ship's name Regina Oldendorff
Call Sign CQIB2 Deadweight 118863 tonnes Year built 2011
Draught aft 14.33 m / 47 ft 0 in Forward 14.33 m / 47 ft 0 in Displacement 131735 tonnes

SHIP'S PARTICULARS

Length overall 260 m Anchor chain: Port 11.5 shackles Starboard 11.5 shackles
Breadth 43.04 m
Bulbous bow Yes (1 shackle = 27.432 m = 15 fathoms)

PROPULSION PARTICULARS

Type of engine Diesel Maximum power 13558 kW (18433 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	1	99.5	N/A	14.5	N/A
Full Ahead	0.8	86.0	N/A	12.6	N/A
Half Ahead	0.5	66.0	N/A	9.6	N/A
Slow Ahead	0.25	44.0	N/A	6.3	N/A
Dead Slow Ahead	0.125	30.0	N/A	4.2	N/A
Dead Slow Astern	-0.125	-30.0	N/A		
Slow Astern	-0.25	-44.0	N/A		
Half Astern	-0.5	-66.0	N/A		
Full Astern	-1	-86.0	N/A		

STEERING PARTICULARS

Type of rudder _____ Normal _____ Maximum angle _____ 35 _____ °
Hard-over to hard-over _____ 13.5 _____ s
Rudder angle for neutral effect _____ 0 _____ °

Thruster: Bow _____ N/A _____ kW (_____ N/A _____ hp) Stern _____ N/A _____ kW (_____ N/A _____ hp)

CHECKED IF ABOARD AND READY

Anchors

Indicators:

Whistle

Rudder

Radar

3 cm

10 cm

Rpm/pitch

ARPA

Rate of turn

Speed log

Doppler:

Yes / No

Compass system

Water speed

Constant gyro error ±

°

Ground speed

VHF

Dual-axis

Elec. pos. fix. system

Engine telegraphs

Type

_____

Steering gear

Number of power units operating

OTHER INFORMATION:

PILOT CARD

TANK21 Version 1

Ship's name VICKSBURG SPIRIT Date _____
 Call Sign C6FY5 Deadweight 79660 tonnes Year built 2004
 Draught aft 10.97 m / 35 ft 12 in Forward 10.97 m / 35 ft 12 in Displacement 95400 tonnes

SHIP'S PARTICULARS

Length overall 250.2 m Anchor chain: Port 26.0 shackles Starboard 26.0 shackles
 Breadth 44.2 m Stern _____ shackles
 Bulbous bow Yes (1 shackle = 27.432 m = 15 fathoms)

PROPULSION PARTICULARS

Type of engine Diesel Maximum power 12711 kW (17046 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	P Loaded
Full sea speed	1	105.0			16.3
Full Ahead	0.8	87.0			13.7
Half Ahead	0.5	70.0			11.0
Slow Ahead	0.25	53.0			8.3
Dead Slow Ahead	0.125	34.0			5.2
Dead Slow Astern	-0.125	-34.0			
Slow Astern	-0.25	-53.0		Time limit astern _____ min:sec	
Half Astern	-0.5	-70.0		Full ahead to full astern _____ min:sec	
Full Astern	-1	-87.0		Max. No. of consecutive starts _____	
				Minimum RPM _____ knots	
				Astern power _____ % ahead	

STEERING PARTICULARS

Type of rudder	Normal	Maximum angle	35 °
Hard-over to hard-over	19.9	s	
Rudder angle for neutral effect	0	°	
Thruster:	Bow	kW (hp)	Stern kW (hp)

CHECKED IF ABOARD AND READY

Anchors	____	Indicators:	____	
Whistle	____	Rudder	____	
Radar	____ 3 cm	Rpm/pitch	____	
ARPA	____	Rate of turn	____	
Speed log	____ Doppler:	Compass system	____	
Water speed	____	Constant gyro error ±	____	°
Ground speed	____	VHF	____	
Dual-axis	____	Elec. pos. fix. system	____	
Engine telegraphs	____	Type	____	
Steering gear	____			
Number of power units operating	____			

OTHER INFORMATION:

PILOT CARD

TANK10L Version 7

Ship's name M/T Danita II Date _____
 Call Sign _____ Deadweight 0 tonnes Year built _____
 Draught aft 14 m / 45 ft 11 in Forward 14 m / 45 ft 11 in Displacement 82970 tonnes

SHIP'S PARTICULARS

Length overall	<u>228.6</u>	m	Anchor chain: Port	<u>26.1</u>	shackles	Starboard	<u>26.1</u>	shackles
Breadth	<u>32.24</u>	m	Stern		shackles			
Bulbous bow	<u>No</u>							(1 shackle = 27,432 m = 15 fathoms)

PROPULSION PARTICULARS

Type of engine Diesel Maximum power 7000 kW (9518 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	<u>1</u>	84.0		13.9	
Full Ahead	<u>0.8</u>	72.0		11.9	
Half Ahead	<u>0.5</u>	54.0		8.9	
Slow Ahead	<u>0.25</u>	39.1		6.4	
Dead Slow Ahead	<u>0.125</u>	27.1		4.5	
Dead Slow Astern	<u>-0.125</u>	-27.1			
Slow Astern	<u>-0.25</u>	-36.0		Time limit astern _____ min:sec	
Half Astern	<u>-0.5</u>	-47.0		Full ahead to full astern _____ min:sec	
Full Astern	<u>-1</u>	-58.8		Max. No. of consecutive starts _____	
				Minimum RPM _____ knots	
				Astern power _____ % ahead	

STEERING PARTICULARS

Type of rudder	Normal	Maximum angle	35	°
Hard-over to hard-over	15.6	s		
Rudder angle for neutral effect	0.2	°		
Thruster:	Bow	kW (	hp)	Stern
				kW (
				hp)

CHECKED IF ABOARD AND READY

Anchors		Indicators:	
Whistle		Rudder	
Radar		Rpm/pitch	
ARPA		Rate of turn	
Speed log		Compass system	
	Doppler:	Constant gyro error ±	°
Water speed		VHF	
Ground speed		Elec. pos. fix. system	
Dual-axis		Type	
Engine telegraphs			
Steering gear			
Number of power units operating			

OTHER INFORMATION:

PILOT CARD

CNTNR41
Version 0

Ship's name Konway 1 Date _____
Call Sign XXUJ2 Deadweight 103691 tonnes Year built 2006
Draught aft 14 m / 45 ft 11 in Forward 14 m / 45 ft 11 in Displacement 135296 tonnes

SHIP'S PARTICULARS

Length overall	<u>336</u>	m	Anchor chain: Port	<u>25.8</u>	shackles	Starboard	<u>25.8</u>	shackles
Breadth	<u>43</u>	m	Stern		shackles			
Bulbous bow	<u>Yes</u>							(1 shackle = 27,432 m = 15 fathoms)

PROPULSION PARTICULARS

Type of engine Diesel Maximum power 68632 kW (93313 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	<u>1</u>	104.0		25.2	
Full Ahead	<u>0.8</u>	68.0		17.3	
Half Ahead	<u>0.5</u>	52.0		13.2	
Slow Ahead	<u>0.25</u>	42.0		10.6	
Dead Slow Ahead	<u>0.125</u>	32.0		8.0	
Dead Slow Astern	<u>-0.125</u>	-32.0			
Slow Astern	<u>-0.25</u>	-42.0		Time limit astern _____ min:sec	
Half Astern	<u>-0.5</u>	-52.0		Full ahead to full astern _____ min:sec	
Full Astern	<u>-1</u>	-68.0		Max. No. of consecutive starts _____	
				Minimum RPM _____ knots	
				Astern power _____ % ahead	

STEERING PARTICULARS

Type of rudder	Normal	Maximum angle	35	°						
Hard-over to hard-over	12.7	s								
Rudder angle for neutral effect	0	°								
Thruster:	Bow	2500	kW (	3399	hp)	Stern		kW (		hp)

CHECKED IF ABOARD AND READY

Anchors		Indicators:	
Whistle		Rudder	
Radar		Rpm/pitch	
ARPA		Rate of turn	
Speed log		Compass system	
	Doppler:	Constant gyro error ±	°
Water speed		VHF	
Ground speed		Elec. pos. fix. system	
Dual-axis		Type	
Engine telegraphs			
Steering gear			
Number of power units operating			

OTHER INFORMATION:

PILOT CARD

BULKC06L
Version 15

Ship's name M/S Magnitogorsk Date _____
Call Sign A8IS3 Deadweight 22691 tonnes Year built 1976
Draught aft 11.5 m / 37 ft 9 in Forward 11.5 m / 37 ft 9 in Displacement 60920 tonnes

SHIP'S PARTICULARS

Length overall	<u>215.4</u>	m	Anchor chain: Port	<u>10.9</u>	shackles	Starboard	<u>10.9</u>	shackles
Breadth	<u>31.8</u>	m	Stern	<u></u>	shackles	(1 shackle = 27,432 m = 15 fathoms)		
Bulbous bow	<u>No</u>							

PROPULSION PARTICULARS

Type of engine Diesel Maximum power 9180 kW (12481 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	<u>1</u>	120.0		16.0	
Full Ahead	<u>0.8</u>	108.6		14.9	
Half Ahead	<u>0.5</u>	96.0		13.6	
Slow Ahead	<u>0.25</u>	76.2		11.1	
Dead Slow Ahead	<u>0.125</u>	45.0		6.6	
Dead Slow Astern	<u>-0.125</u>	-45.0			
Slow Astern	<u>-0.25</u>	-70.2		Time limit astern _____ min:sec	
Half Astern	<u>-0.5</u>	-89.4		Full ahead to full astern _____ min:sec	
Full Astern	<u>-1</u>	-96.0		Max. No. of consecutive starts _____	
				Minimum RPM _____ knots	
				Astern power _____ % ahead	

STEERING PARTICULARS

Type of rudder	Normal	Maximum angle	35	°
Hard-over to hard-over	15.6	s		
Rudder angle for neutral effect	0.2	°		
Thruster:	Bow	kW (		hp)
	Stern	kW (		hp)

CHECKED IF ABOARD AND READY

Anchors		Indicators:	
Whistle		Rudder	
Radar		Rpm/pitch	
ARPA		Rate of turn	
Speed log		Compass system	
	Doppler:	Constant gyro error ±	°
Water speed		VHF	
Ground speed		Elec. pos. fix. system	
Dual-axis		Type	
Engine telegraphs			
Steering gear			
Number of power units operating			

OTHER INFORMATION:

PILOT CARD

CNTNR44V1
Version 1

Ship's name Zim Piraeus Date _____
Call Sign VRGA5 Deadweight 62740 tonnes Year built 2004
Draught aft 13.11 m / 43 ft 0 in Forward 13.11 m / 43 ft 0 in Displacement 77567 tonnes

SHIP'S PARTICULARS

Length overall	<u>294.1</u>	m	Anchor chain: Port	<u>13.0</u>	shackles	Starboard	<u>13.0</u>	shackles
Breadth	<u>32.2</u>	m						
Bulbous bow	<u>Yes</u>	(1 shackle = 27.432 m = 15 fathoms)						

PROPULSION PARTICULARS

Type of engine Diesel Maximum power 41083 kW (55858 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	<u>1</u>	104.0	N/A	24.0	N/A
Full Ahead	<u>0.8</u>	78.0	N/A	18.4	N/A
Half Ahead	<u>0.5</u>	66.0	N/A	15.6	N/A
Slow Ahead	<u>0.25</u>	54.0	N/A	12.7	N/A
Dead Slow Ahead	<u>0.125</u>	36.0	N/A	8.4	N/A
Dead Slow Astern	<u>-0.125</u>	-36.0	N/A		
Slow Astern	<u>-0.25</u>	-54.0	N/A		
Half Astern	<u>-0.5</u>	-66.0	N/A		
Full Astern	<u>-1</u>	-78.0	N/A		

STEERING PARTICULARS

Type of rudder	Normal	Maximum angle	35	°						
Hard-over to hard-over	12.5	s								
Rudder angle for neutral effect	0	°								
Thruster:	Bow	1800	kW (	2447	hp)	Stern	N/A	kW (	N/A	hp)

CHECKED IF ABOARD AND READY

Anchors		Indicators:	
Whistle		Rudder	
Radar		Rpm/pitch	
ARPA		Rate of turn	
Speed log		Compass system	
	Doppler:	Constant gyro error ±	°
Water speed		VHF	
Ground speed		Elec. pos. fix. system	
Dual-axis		Type	
Engine telegraphs			
Steering gear			
Number of power units operating			

OTHER INFORMATION:

Appendix D: Letter from Mobile Bar Pilots

OFFICE OF
MOBILE BAR PILOTS, LLC

201 NORTH JACKSON STREET
MOBILE, ALABAMA 36603

August 18, 2020

Elizabeth S. Godsey, P.E.
United States Army Corps of Engineers
Mobile District Office
P.O. Box 2288
Mobile, AL 36628-0001

Cc: David Newell, PE, Project Manager
U.S. Army Corps of Engineers

Via email

Dear Elizabeth,

Thank you and everyone with the US Army Corps of Engineers for inviting the Mobile Bar Pilots to participate in the simulation of the proposed changes to Mobile Harbor and Mobile Ship Channel. I believe all of the pilots who participated now have a good sense of the possibilities because of these simulations and discussions.

I would like to summarize our observations and opinions on each of the three (3) areas of change in the harbor and channel:

1. Expanded Turning Basin: The additional 250 feet of turning basin to the south will be a huge addition to the turning basin. Earlier this year we experienced river currents that made turning large ships, on a daily basis, extremely challenging with no north-south ability to "fall" while turning. This required an extraordinary amount of tug power to "hold" the stern of the ship up against the current so that the bow could safely swing within the limits of the turning basin and off Little Sand Island. Container lines are already inquiring about 1,200 foot vessels coming to APM Terminal. With both north and south berths at APM occupied with "wide beam" vessels - the additional 250 feet will be a great plus for turning ships safely.

Additionally, we believe that a channel widener congruent with the new turning basin, tapering to the south past McDuffie Coal Terminal (approximately beacon "82"), would give great safety benefits for ships completing a turn in the turning basin and successfully negotiating the passing of McDuffie. Due to the displacement of very large containerships passing very large bulk ships at McDuffie, there is a great amount of interaction between these ships and the result is unwanted movement of ships secured to McDuffie. Worst case

scenarios include ships breaking free from the berth at McDuffie and damage to ship or berth/loading equipment. Widening the channel in this tapered fashion would allow container ships (and all ships) to navigate further away from McDuffie, thus decreasing the interaction between ships. Please contact us if further explanation is needed. Also, attached to this letter is a very rudimentary drawing of the taper (highlighted).

2. Three Mile Passing Lane: The three (3) mile passing lane in the lower reach of the Mobile Ship Channel will allow for the passing of Panamax vessels with wide beam vessels. The simulation proved that the timing of the passing vessels will be critical to making this passing lane usable. Three miles, with two meeting vessels each making 10 knots, allows for approximately nine (9) minutes of maneuvering vessels out of the way of each other to successfully pass. This nine minutes, in a 30 mile ship channel, could prove to be very challenging at times but not impossible. The Mobile Bar Pilots will certainly be looking at the particular conditions inclusive of wind and current to decide whether or not meeting in the passing lane is safe. The drafts of the two vessels will certainly play a component of safely meeting in the passing lane.
3. Bend Easements at Middle Ground: The bend easements, in simulation, proved to be very helpful in negotiating the turns at Buoys 17/18 and Buoys 21/22 of the Mobile Ship Channel. The pilots felt that any widened area in these bends, specifically for large container vessels, will be beneficial. Additionally, the bend easement at Buoys 21 and 22 will assist in setting up to meet in the passing lane.

Again, we greatly appreciate the opportunity to take part in the discussion regarding the proposed changes to the harbor and ship channel. We look forward to any developments and are happy to continue any dialogue that can make the ship channel more efficient and safe.

Please call or email with any further questions regarding this letter or other topics not mentioned.

Sincerely,

Captain David M. Berault
President
Mobile Bar Pilots, LLC

octaw Pt

uffie
nd
2 w Or
Priv

Upper Bay
Basin

FI 4s 20ft 3M "A"

Subm
piling

Ruins

Piles
Subm
piling

Little
Sand
Subm
ruins

15 ft rep
1998

rep 1998

44 FT 2012-2013
42 1/2 FT 2012-2013

FI R
Ra Ret

17ft 3M "8"

Unit Conversion Factors

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
degrees (angle)	0.01745329	radians
feet	0.3048	meters
horsepower (550 foot-pounds force per second)	745.6999	watts
knots	0.5144444	meters per second
miles (US statute)	1,609.347	meters

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14. ABSTRACT Mobile Bay is a large estuary located in the southwest corner of Alabama, which connects to the Gulf of Mexico. Mobile Harbor contains the only port in the state that supports ocean-going vessels. Some of the larger vessels calling on the port experience transit delays and limited cargo capacity, so a study was conducted by the US Army Corps of Engineers, Mobile District (CESAM), and the Alabama State Port Authority to investigate channel improvements. In 2017, the US Army Engineer Research and Development Center (ERDC) assisted CESAM in screening proposed deepening and widening alternatives in Mobile Bay by completing a Feasibility Level Ship Simulation (FLSS) study using the ERDC Ship/Tow Simulator. These lower-resolution databases from the FLSS study were used as a foundation to complete a more robust navigation study in 2020 to test the proposed modifications to Mobile Harbor. During this study, three main areas were focused on: a bend easing, a passing lane, and a turning basin. Testing of the proposed design was evaluated over the course of 2 weeks with eight pilots. Assessment of the proposed modifications was accomplished through analysis of ship simulations completed by experienced local pilots, discussions, track plots, run sheets, and final pilot surveys.						
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