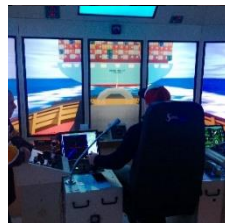
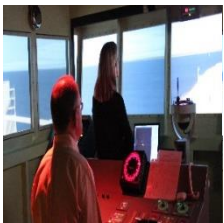
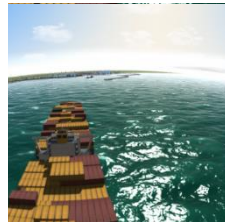
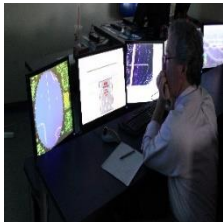
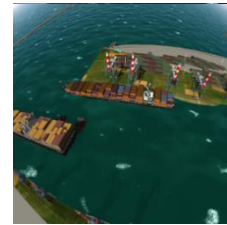


# Marine Operations Research: Modeling & Simulation



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***Merging highly experienced marine operators,  
innovative researchers and our pioneering legacy  
with the latest generation maritime simulation technologies  
to mitigate your most complex marine operations risks.***

## What makes USMRC different?

### Our Perspective - Mariner in the Loop

Our well tested and innovative approach to marine operations research continues to yield highly regarded outcomes and practical solutions for research sponsors and stakeholders. We achieve this by integrating the human-machine interface through real-time “mariner in the loop” simulations led by our team of marine operations technical experts. This methodology effectively incorporates the human factor with more realistic results.

### Specialized, niche focus

USMRC’s research project engagements concentrate on addressing highly complex and demanding problem sets for clients who have top tier operational standards of excellence and a low tolerance for risk. Our particular research specialty involves the integration of ship bridge teams, marine pilots and tug masters with the vessel and geographic area models and interactive simulations to create a truly accurate representation of the environment that has proven to very closely replicate real world operations.

### Why we do it? - It’s our passion!

We want the results of our marine operations research simulation projects to provide the client with tangible solutions to their marine operations problem set that advance safety, efficiency and environmental stewardship. We especially excel at the most challenging projects that require innovative thinking and original approaches.

### Independent and unbiased

As an independent nonprofit, USMRC brings an element of impartiality and objectivity to our work vice being influenced by owners, shareholders or special interests who may seek to direct the results of the research work. We allow the facts to determine the outcome.

### Help Empower USMRC to Achieve More for Maritime

Since USMRC is a maritime nonprofit, 100% of the net proceeds from all of our work get reinvested in our programs which support one or more of our many diverse activities including:

- Making marine operations safer and better for the environment;
- Promoting the growth of a strong, resilient and vibrant maritime sector that contributes to the wellbeing of all; and
- Transforming the lives of young persons of all backgrounds in being able to have the opportunity to pursue careers in the maritime industry and provide for their families.

## Service Principles

**Flexible** - schedule, operating hours, work scope - all scalable to the needs of the client

**Responsive** - quickly adapt to evolving requirements and challenges presented in a project

**Innovative** - often recognized for presenting unique and original solutions to challenging operational problems

**High Quality Results** - combining our marine operations technical expertise with our proven, thorough research approach and detailed methodology yield precise data outcomes

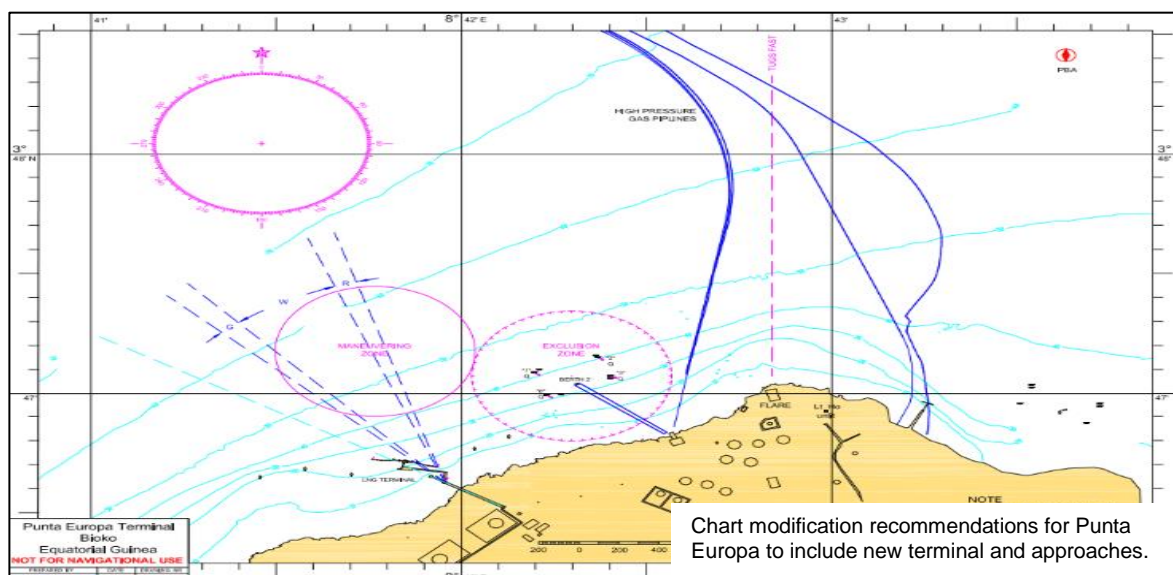
## Experience

Possessing a strong heritage spanning more than four decades of employing simulation technologies, USMRC is arguably one of the most recognized pioneers in marine operations research. The Center's simulation studies are highly acclaimed for their practical, solutions to a wide-range of design, operational and environmental aspects of marine operations projects.

## Effective Collaboration with Diverse Stakeholders

USMRC is particularly well known for working on simulation projects on behalf of energy majors and super majors with participation in the maritime simulation work from large, diverse groups of stakeholders and interests including Front-End Engineering and Design (FEED) contractors, marine facility construction firms, terminal operators, port authorities, marine operations consultants, ship pilots and tug masters, ship owners/operators/charterers, Non-Governmental Organizations (NGOs), regulatory bodies and others.

USMRC has acquired substantial experience in and become particularly adept at effectively managing the input from and relating the details and value of the maritime simulation process, analysis and outcomes to this same diverse group of stakeholders.



## About USMRC

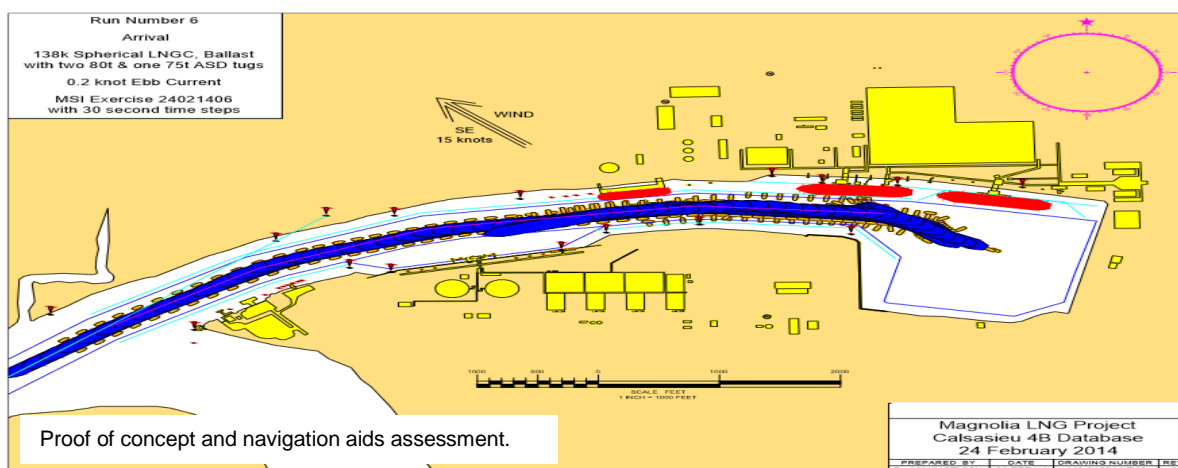
The United States Maritime Resource Center (USMRC) is an independent, nonprofit marine operations and maritime risk research center. USMRC's programs focus on navigation safety, risk mitigation, human capital development, raising awareness of international shipping and maritime trade, and contributing to environmental stewardship. USMRC employs various maritime simulation technologies in support of these programs as a tool for both traditional and emerging applications.

USMRC's marine operations and maritime risk research integrates industry practitioner expertise and analysis with modeling and simulation tools for risk assessment and proof of concept R&D work. The findings of our research support the development of risk mitigation strategies and best practices as well as serve as the foundation for specialized maritime education and training programs.

## Simulation Philosophy

Traditional use of navigation simulation software and technologies in marine operations research covers a wide range of applications including terminal design evaluation and proof of operational concepts, new ship design trials, navigation safety assessments, port and waterway design studies, human factors, dredging plan validations, etc. Outcomes from this research have been used to inform and drive maritime education and training activities such as advanced shiphandling and navigation training, bridge resource management and mariner assessments.

USMRC has found, through several decades of conducting marine operations and maritime risk research, that employing real-time, mariner in the loop, full mission bridge simulations tend to yield the most realistic, reliable and practical results. For certain research applications with more defined and limited scope, USMRC has also incorporated the use of desktop simulation workstations into the project with great success. Examples include passing ship effects, turning basin design and location, assist and escort tug requirements. This has proven to be a cost effective way to investigate specific concerns and determine if further, more extensive, studies are required.



## Applications for Simulation-based Marine Operations Research

In the past decade alone, USMRC has conducted over 50 highly specialized real-time, man in the loop, full mission bridge and desktop simulator evaluations involving Liquefied Natural Gas (LNG) export/import, tanker, dry bulk and container terminals and marine facilities.

The list below is a representative sample of proven applications for simulation-based marine operations research, but many more possibilities exist depending on the customer's specific needs and operational requirements:

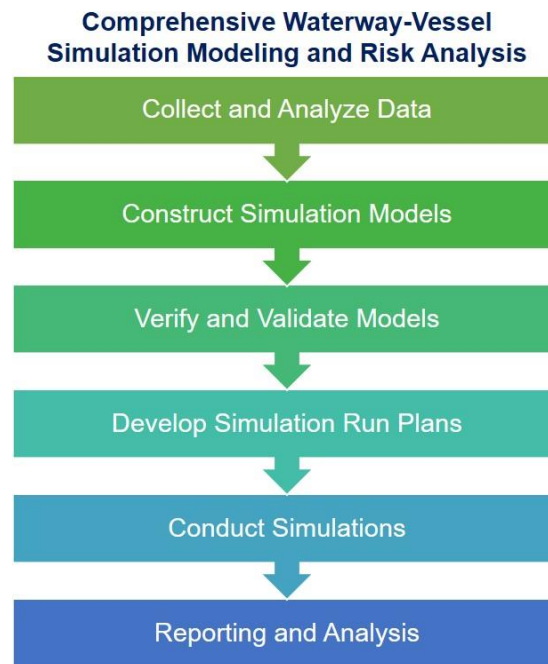
- Marine terminal design evaluation and proof of concept
- Dredging plan, turning basin and channel design studies
- Port, terminal, waterway and navigation assessments
- Evaluations of proposed berthing layout options
- Simulation studies and new ship design trials
- Accident re-creation and investigation
- Establish environmental operating limits
- Testing and validation of standard operating and emergency procedures
- Bridge team ergonomics and mariner-machine interface
- Determine ship assist and tethered escort tug power requirements
- Environmental efficiency optimization for ship transits and maneuvering in port areas



## Research Approach

The key for any maritime research center and its ability to produce high quality outcomes is having a well-defined and thoroughly tested process in place, combined with the technical expertise to employ both simulation tools and research participants in a manner that optimizes the final outcomes. This includes critical process components such as: clearly articulating the problem set, research objectives and assumptions; a robust data collection effort that forms the basis of the precision hydrodynamic and visual modeling work; a comprehensive internal verification and external validation of the vessel(s) and port area models by experienced in-house staff experts and outside marine professionals; fully understanding the capabilities and limitations of the modeling and simulation technologies; and post simulation processing and technical analysis of simulation output data.

## Research Process



**Collect and Analyze Data** - This step is critical in creating realistic and precise models. Critical data about the waterway, the environment and waterway users from a variety of key sources will be consolidated and analyzed to determine the relevancy of the data for the modeling and simulations. USMRC will use the existing nautical charts as the footprint for developing accurate geographic area database models. Other notable input data USMRC proposes to utilize and incorporate in the models includes, but is not limited to, the following:

- Topographical information
- Metocean data for the local area, specifically historical wind data and tidal current information

- Channel, turning basin, anchorage area, dredging and navigation aid plans
- Satellite imagery of other significant natural and man-made features and other objects the pilot would use for navigation decision making
- Coast Pilot, Notices to Mariners, interviews with waterway users (e.g. pilots), etc.
- Forecasted and expected vessel traffic
- Any other information that is deemed necessary to accurately model the area

Following collection of the data, the quality and relevancy of the data will be assessed and a determination made as to which elements of the data will be incorporated into the models.

**Construct Simulation Models** - This effort involves the actual creation of navigation simulation models which accurately depict the waterway system, navigation aids, environmental and marine terminal infrastructure to include present day conditions as well as future conditions (e.g., deeper and wider channels, with/without barge shelves, with associated navigation aids and new terminal infrastructure).

**Geographic Area Database** - This database will accurately reflect the effects of water movement and interaction between vessels to include: bank effects, water depths, tidal currents and wave characteristics. The will also be capable of producing RADAR and other electronic navigation displays (e.g., ECDIS, AIS, fathometer, etc.) that would typically be used by the mariner.

**Ship and Tug Models** - This effort involves collaboration with the customer to determine if a ship and/or tug models from our existing library are suitable for the project. If not, relevant vessel data will be required in order to produce any number of ship/tug models for use in the simulations. Vessel data would include, but not be limited to, General Arrangement, Body Plan and Lines drawings (AutoCAD preferred), engine and auxiliary propulsion systems specifics, detailed performance (actual sea trial results or theoretical if a new ship), photographs and any stability data. Accurate model performance is considered critical to the success of a project and the ensuing results.

**Verify and Validate Models** - The completed models then are put through a rigorous Internal Verification procedure using expert, in-house marine personnel. This is followed by an External Validation process using local area marine pilots and/or other experts to ensure the models meet the highest quality standards. This extensive in-house test by an USMRC facilitator will be performed on a desktop simulator at USMRC to verify that the database models accurately match the data from which they are developed and produce expected ship behavior under varying conditions. After the database models have been verified by USMRC staff we normally request local pilots participate in the validation process. This validation process will identify any refinements or corrections to the models. Inaccuracies identified during either the verification or validation processes will be corrected prior to proceeding with the simulations.

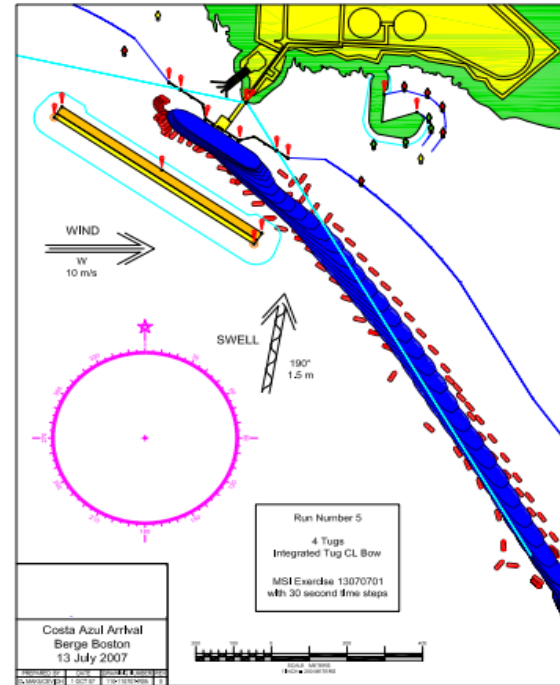
**Develop Simulation Run Plans** - In collaboration with the research sponsor, USMRC will develop simulation run plans to create a comprehensive matrix of simulation runs using current



and forecasted marine traffic that will produce the desired data set and outcomes for risk and other analysis. These plans will be developed in a manner that ensures a proper data sampling for the study and will be vetted by local area pilots and local area harbor tug operators.

**Conduct Simulations** - A series of simulations would be conducted using ship's bridge navigation simulators appropriate to the clients project (see Simulation Tools). USMRC expert mariners will control the simulations consistent with local area pilot and industry best practices.

**Reporting and Analysis** - Following the simulations, the final step in the process will be to perform Reporting and Analysis. This step will include aggregating all of the simulation output data and analyzing the information to address the key Scope of Work requirements. USMRC will utilize its proven evaluation process for assessing waterway suitability for safe navigation acquired through over 50 waterway and marine operations simulation projects in the past decade.



Proof of Concept and Tug Use Analysis.

**Quality Assurance/Quality Control** - All proposed work performed by USMRC will be in keeping with the highest standards of workmanship and industry expectations. The USMRC/MSI also employs a Quality Management System (QMS) that is certified by Nippon Kaiji Kyokai (ClassNK) Registration No. 16-756 as conforming to ISO 9001:2008 standards. This QMS and the certification specifically governs USMRC's principal activities in conducting operations research, modeling and simulation, education and training, and technical and risk assessment for the maritime sector.

## Research Team / SMEs

USMRC's marine simulation research team is comprised of a diverse group of mariner backgrounds from master mariners and pilots who lead all USMRC's projects to research analysts who possess both marine operations and varied analytical experience and simulation operators with marine operations experience. This in house expertise is augmented by a network of subject matter experts from across the maritime industry to include: pilots, masters of various vessel types, tug masters and terminal construction experts. Here at USMRC we also look to leverage local knowledge of the region in which a marine simulation project is being conducted to ensure that our simulation results provide the customer with the most accurate information from which to make decisions.



### [The AES Corp / BP - Terminal Maneuvering Study, Caucedo, Dominican Republic](#)

The model was used to validate the size of ships capable of accessing the port. Additionally, the size of assist tug was determined based on the forces required to maneuver vessels to and from berths.

### [Mediterranean Pilot Group - Ultra Large Container Ship \(ULCS\) mooring proof of concept, Mediterranean Sea region](#)

Despite the operating restrictions identified in the research; the pilots were able to determine that it was possible to bring a 400 meter ULCS into the port. The result of the simulation research allowed the pilots to identify the necessary operating conditions for mooring a ULCS, as well as identify port efficiency constraints that would result from mooring such a ship.

### [Magnolia LNG - Port of Lake Charles LNG Terminal, Lake Charles, Louisiana, USA](#)

The simulation research identified the optimal placement, arrangement and type of navigation aids for supporting the safe arrivals and departures of LNGCs from the proposed LNG export berths along the Industrial Canal waterway.

### [Cerrejón - Puerto Bolívar Coal Terminal, Columbia](#)

The initial purpose of both sessions of simulation runs was to provide the Puerto Bolívar pilots with advanced, ship handling training for pilots focusing on scenarios incorporating challenging wind and current conditions, shipboard mechanical failures, assist tug failures and emergency maneuvers. Additionally, the Puerto Bolívar pilots also were able to evaluate navigation issues related to an ongoing dredging project at the Cerrejón facility, the introduction of a new type of ship assist tug, as well as the plan to bring larger tonnage ships into the terminal.

### [Portland Pipeline Corporation - South Portland Crude Oil Terminal, Maine, USA](#)

The benefits of conducting the Portland Pipe Line towing exercise using simulation proved to be:

- Liability reduction by not having to perform emergency towing exercises using loaded oil tankers off the Maine Coast.
- Chance to involve all members of the pilot organization and towing companies in these maneuvers rather than just a select few.
- Ability to perform these maneuvers within the modeled confines of the harbor and not just 5 - 8 miles off the environmentally sensitive coast.
- Completed night time and bad weather/poor visibility simulations.
- As a test platform for new types of tugs or ships that may visit the terminal.

### [Multinational Energy Companies - Specialized liquid bulk carrier, Ship to Ship \(STS\) transfer operations at anchor and underway maneuvers](#)

Upon successfully proving the concept of operation for this dynamic maneuver; key stakeholders requested USMRC also provide training to ship masters and chief officers as well as mooring masters in this maneuver, which was completed over the course of several training sessions.

### Sempra LNG - Energía Costa Azul LNG, Mexico

USMRC integrated its full mission ship bridge simulator using an in-house built 210,000 m<sup>3</sup> LNGC ship model as well as other smaller size LNGC ship models combined with its specialized, purpose-built 360° ASD tug simulator and model to conduct fully integrated LNGC and tug assist operations. Even though the focus of the simulation trials was on evaluating night time operations at the Energía Costa Azul LNG terminal, the SMBC took the opportunity to provide training to the participating SMBC tug masters.

### Fluor Transworld Services / Petrixo Oil and Gas, Fujairah, UAE

USMRC conducted 29 simulation runs under a variety of operational scenarios and environmental conditions and rated each of the proposed berth layouts in terms of their suitability from a navigation safety perspective.

### Marathon E.G. Production Limited, Punta Europa, Equatorial Guinea

This simulation provided the pilots with human in the loop simulation and allowed them to collect additional ship, tug and towline data. This data was integral to the pilot's emergency preparedness assessment and they submitted chart modification to the British Admiralty to be incorporated on the Punta Europa charts as result of the training. In the coming years the intent is for local national Equatorial Guinea pilots to receive this training as they are integrated into the pilotage service.

### Chevron Energy Technology Company, Wheatstone LNG, Curtis Island, Australia

USMRC provided a comprehensive array of data outputs from the trials to Chevron for further analysis and determination of critical project elements such as environmental operating limits and tug performance requirements.

### Hutchison Port Holdings - Terminal Maneuvering Studies, Balboa, Panama

USMRC was able to provide HPH and their subsidiary Panama Ports Company with operational impacts of the Neo-Panamax vessels transiting to the new locks as well as mooring at a new container terminal location in the vicinity of the locks. Both of these simulation studies were timely in providing HPH with an understanding of how the opening of the new Panama Locks would impact their container terminal operations.



For additional information on simulation research solutions, please contact:

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