Over the past ten years, there has been explosive growth in the size of ships in general and containerships in particular. The ship-to-channel ratios now provide less margins of safety, and present significant challenges to port designers, pilots, tug companies, and marine operations.

Full-mission ship simulation, also known as FMSS, is gaining acceptance as a cost-effective way to evaluate whether transits are safe and under what conditions. Additionally, simulations can be of great assistance in the preliminary design process to reduce dredging costs and increase port efficiencies.

**FULL-MISSION SHIP SIMULATION**

The goal of simulation is to create a “virtual” world. Computer simulation is very useful for evaluating whether the vessel will dimensionally fit, and narrows down the number of potential port/channel designs. Full-mission ship simulation takes the next step by immersing senior captains, pilots and tug masters into a virtual world. This enhances their ability to provide accurate recommendations on designs, environmental operational limits, and mitigation strategies. Information gleaned from these studies can include:

- Feasibility of ultra large container vessel (ULCV) transits using existing waterways and the establishment of operational environmental limits (wind, current, sea state and visibility)
- Development of berthing and un-berthing evolutions
- Validation of design changes that would increase efficiencies of a waterway for ULCV transits
- Development of tug packages, for example, number, type, power, placement and use of tugs
- Creation of best practices for transits and integrated training of the ships’ captains, local pilots and tug masters
- Development of strategies for responding to unusual situations, e.g. loss of tug(s), ship steering, propulsion, severe weather, etc.

**STUDY PREPARATION**

The length and cost of the studies vary greatly depending on the desired objective. However, the following process is generally used to create high-fidelity simulation and confidence in the results. Development of the visual databases starts with the latest available electronic navigation charts. The information includes:

- Hydrographic: depth points, depth lines, depth contours, drying areas, three
dimensional (3D) channel bottom
• Landmass: 3D terrain, DEM data, coastlines, islands, pier structures, etc
• Navigation Aids: buoys, ranges and lighthouses
• Navigation Signals: color, light timing, light sector, etc

The data is loaded into proprietary simulator software that converts the charted information into a visual display. The system uses the standard reference system for GPS, WSG-84, as the base data for locating reference objects. This means virtual buoys and other structures are in same position in the simulation as they are in the chart.

Programmers overlay important navigational and visual structures of the channels, port facilities and infrastructure. Other data sources include AutoCAD drawings, Google Earth images and field videos, allowing the simulation of scenes at a specific date and time, as well as from dusk to full night. The software generates the RADAR and ECDIS conning displays during this process. Programming channel bottom contours and bottom type, whether rock, sand, or mud, greatly enhances the accuracy of the ship maneuvering behavior.

This data may come from government agencies, such as the United States Army Corps of Engineers or private surveys. This step is critical when simulating restricted channels with steep bank slopes and minimal under-keel clearances.

Another step is the programming of the hydrodynamic models of the ship and tugs to be evaluated.

The more information provided, the higher the accuracy in maneuvering behaviors. The data is gleaned from the ship’s general arrangement plans, sea trials, wheelhouse poster, engine performance tables, IMO bridge visibility diagrams, loading profiles, previous model/tank tests and other sources.

The simulator’s proprietary software, provided by Transas, creates a “virtual shipyard” that can be used by a naval architect to program the model.

WATER CURRENTS
Depending on the area, another important programming step is the water currents. In areas where currents vary significantly, using two-dimensional depth averaged water current models enhances accuracy. The algorithms calculate the average current velocity and direction for the water column from the bottom to the surface.

The spacing of the data points varies depending upon the amount of change in the current directions and velocities over a specific distance.

The water current models were critical components for modeling the vessel maneuvering behavior in the Port NY/NJ ULCV Study. Early on, the simulation study indicated that the turn after the Bayonne Bridge would be the controlling factor of the transit. The current models made this point readily apparent.

For a study in Brazil, models simulated the seasonal littoral currents. The tests led to design modifications of the breakwater entrance in order to reduce the magnitude of the counter currents.

SIMULATION TEST
The tests require the assembly of a team that includes engineering support for last minute changes, experienced shiphandlers or pilots and tug masters, a project manager and an excellent simulator operator. The runs are carefully set up based on a test matrix and adjusted as needed. Most runs are in real-time, but
focused on the specific objectives. The full-mission ship simulation tests evaluate the performance of each maneuver in terms of difficulty, safety and efficiency.

The exercises may start at the pilot station or a specific point in the transit. The runs generally cover inbound and outbound transits, and the exercises are completed when the objectives have been achieved, and conning pilot demonstrates good control of the vessel.

The Port Authority of NY/NJ sponsored simulation studies for 14,000 and 18,000 TEU ULCV transits.

The Bar Pilots, the Docking Pilots and tug operators participated using two full-mission ship simulators, used for meeting situations, integrated with two tug bridges.

The studies provided a platform for the local pilots to develop and hone their techniques for ULCV transits into Port Elizabeth and Port Jersey under a range of environmental conditions.

Properly designed and executed full-mission ship simulation studies are currently the most effective way for end users, including captains, pilots, tug masters and port operations, to validate new channel or berth designs.

In many cases, the simulation enhances the designs and reduces costs, especially for dredging. It also is essential for accurately formulating environmental operating limits and tug packages prior to arrival of the first ship.

Arguably, the most important benefit is the opportunity for local pilots, tug masters and operations personnel to develop and practice their transit plans.

Today’s ships are larger with minimal channel tolerances. A single mishap could shut down a port for a lengthy time, and cost millions of dollars. Short of practicing in the real world, full-mission ship simulation is the most accurate and efficient way to accomplish this mission.

ABOUT THE AUTHOR
Glen Paine is the Executive Director of the Maritime Institute of Technology and Graduates Studies (MITAGS)/The Maritime Conference Center (MCC) in Maryland, and the Pacific Maritime Institute, located in Seattle, Washington. Glen received his bachelor of science from the US Merchant Marine Academy (USMMA), and his master's degree from the University of Maryland University College (UMUC). Glen has been at the helm since 1999.

ABOUT THE ORGANISATION
MITAGS and PMI are among the leading maritime training and simulation centers in the United States. Founded in 1967 by the International Organization of Masters, Mates, and Pilots, the non-profit trust is dedicated to enhancing mariner professionalism through the development of internationally recognized programs in leadership, education, training and safety. MITAGS-PMI have 40 plus years of ship simulation experience, and have successfully completed hundreds of navigation feasibility studies. Its in-house engineering team provides the model programming for these projects. The MITAGS facilities include two of the world’s largest full-mission simulators (FMSS), with a 360° theater measuring nearly 12 meters in height and 24 meters wide, as well as, four assist tug bridge simulators that can be integrated into the FMSS scenarios and operated by tug masters during these studies.

ENQUIRIES
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