moffatt & nichol

REAL TIME VESSEL SIMULATION INCORPORATING COASTAL NUMERICAL MODELING

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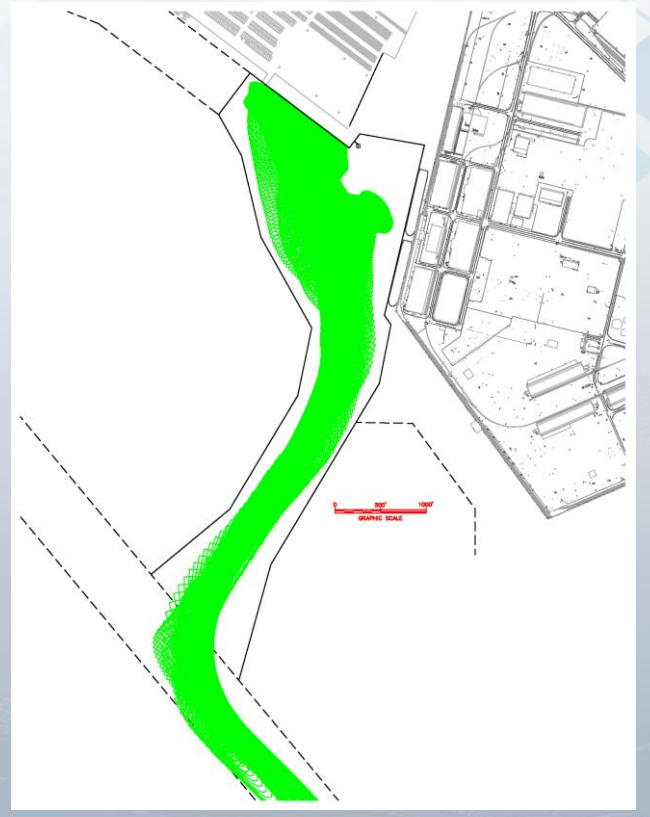
Outline

- **Real Time Vessel Simulation in Engineering Design**
- **Preparation of Coastal Engineering Model Data for Simulators**
- **Translate Coastal Numerical Models into Real Time Simulators**
  1. Tidal Currents
  2. Tsunamis
  3. Waves
- **Future Advancements**



REAL TIME VESSEL SIMULATION IN ENGINEERING DESIGN

Ship Simulation in Engineering Design

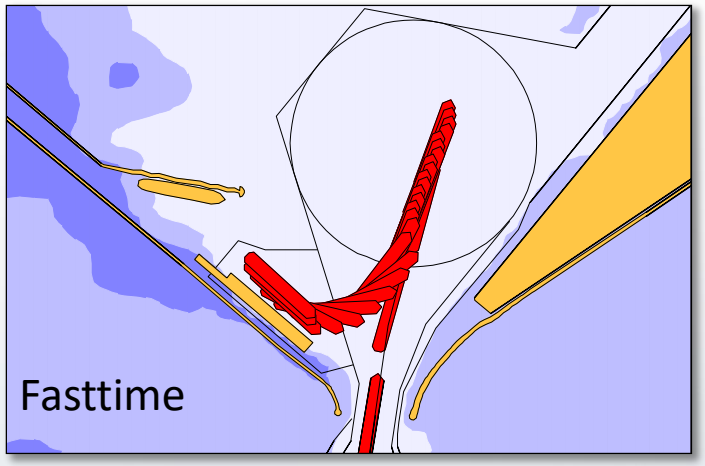
- **International guidelines provide formula for preliminary selection of channel and basin widths:**
  - USACE EM 1110-2-1613 *Hydraulic Design of Deep-Draft Navigation*
  - PIANC 121-2014 *Harbour Approach Channels Design Guidelines*
  - Spanish ROM 3.1-99
  - ASCE *Ship Channel Design and Operation*
- **All recommend final design incorporate vessel simulation studies**

PIANC WG 171

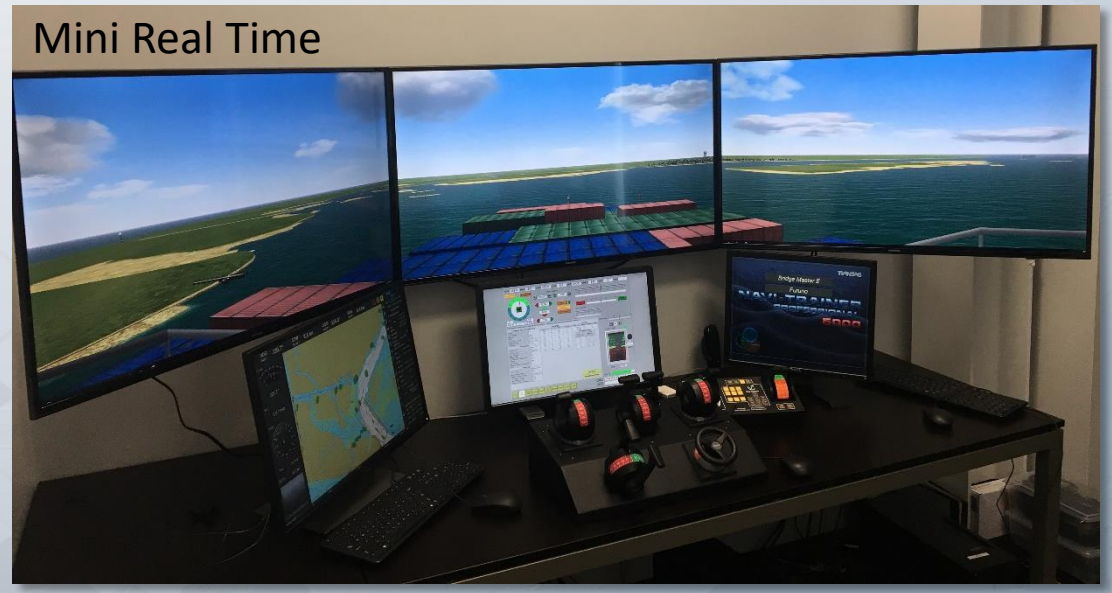
Shiphandling Simulation Dedicated to Channel and Harbour Design

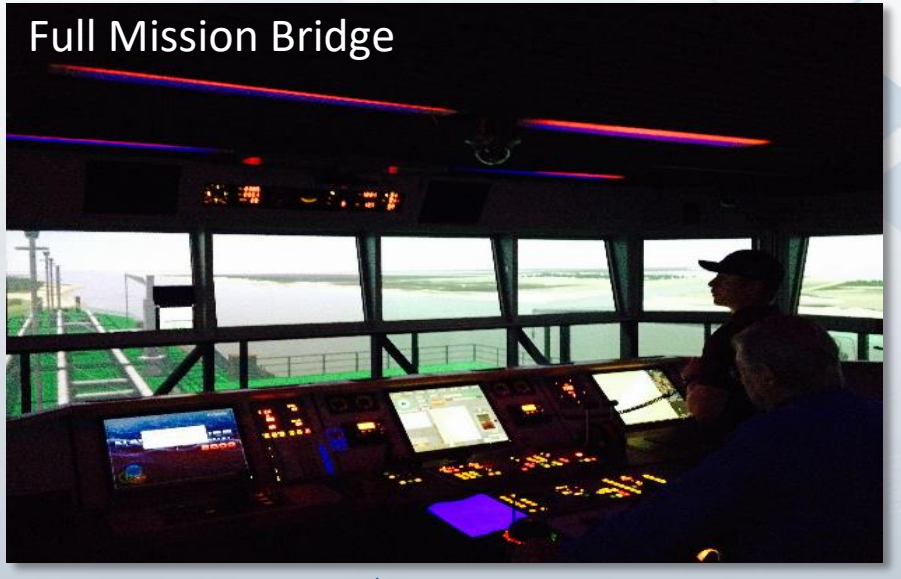
- Update to WG 20 – 1992
- Guidance for the application of simulation studies:
  - Types of simulators
  - Preparation of simulation
  - Vessel Hydrodynamic models and environmental influences
  - Definition and execution of simulator programs
  - Reporting and analysis
- Estimated publication 2019

Vessel Simulators



Increasing Realism



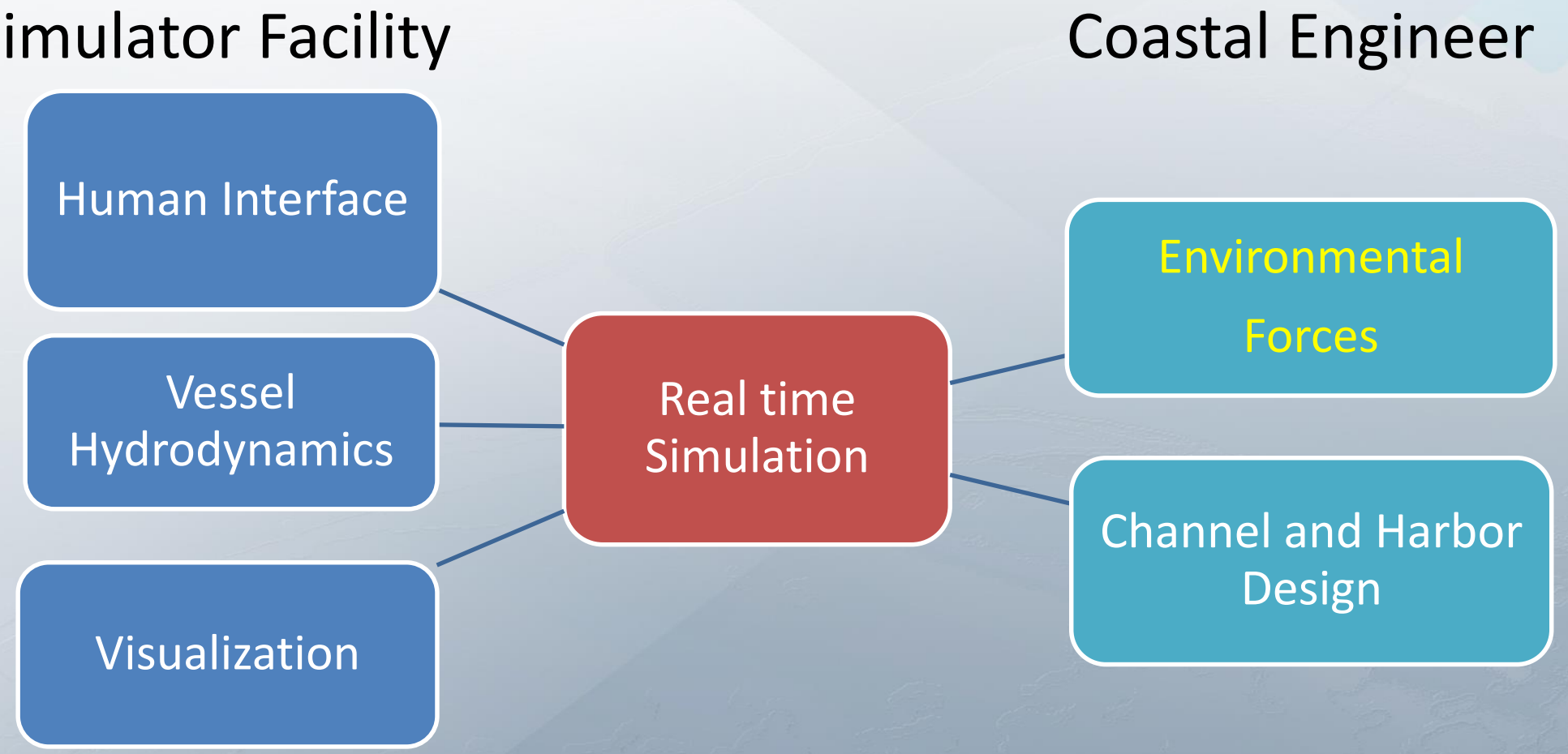


Real Time Simulation in Channel and Harbor Design

- **Allow input from pilots and stakeholders**
- **Optimize design and layout of channel and navigation aids**
- **Develop operational limits – wind, waves, and currents**
- **Identify tug requirements**
- **Full mission bridge facilities**
  - Typically focused on training
  - May use a number of different software systems
  - Many times use a local facility for pilotage

PREPARATION OF DATA FOR REAL TIME SIMULATION

Preparation of Data for Design Real Time Simulation



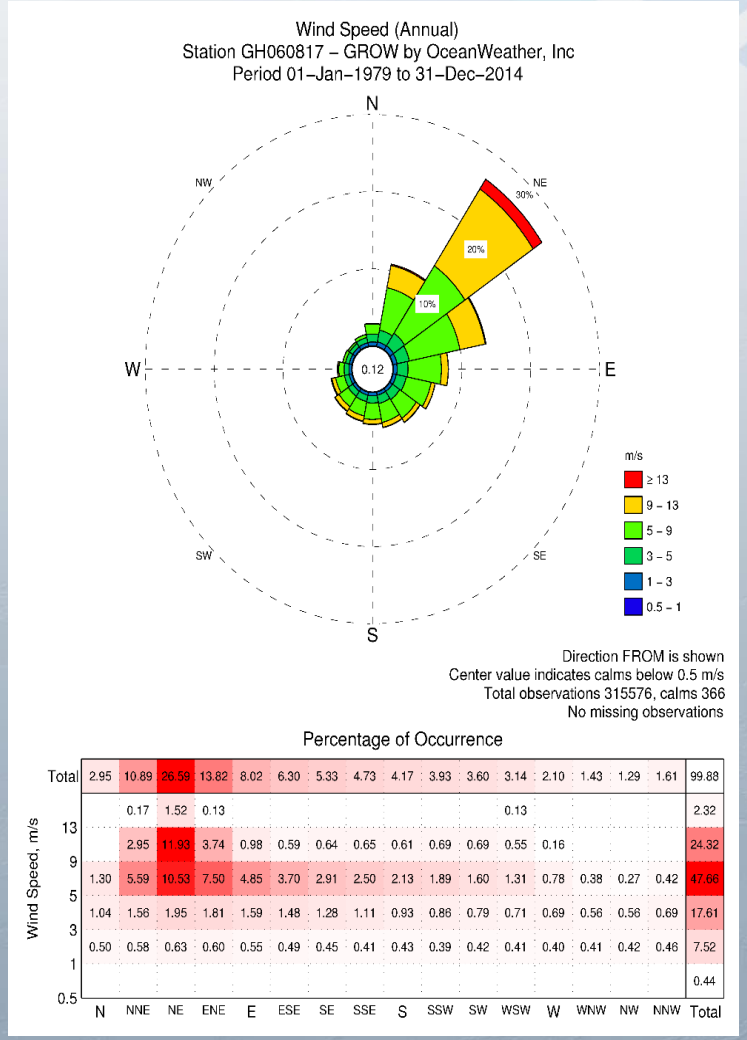
Simulation Facility Considerations

- Vary in capabilities and software
- Generally focused on training – visualization and vessel response
- Environmental forces often based on generalized local data or pilot experience
- Simulations must run in real time with no response delays, hesitation, or stops due to numerical processing
- Improvements in computing allow fields of time-varying currents, water levels

COASTAL MODELING AND DATA PREPARATION

Wind Effects in Full Mission Bridge Simulations

- **Uniform Field or Multiple Areas**
- **Steady or Gusting**
  - Wind gusts may be exaggerated
  - Gusts best controlled with a times series of wind speed and direction
- **Wind shielding**

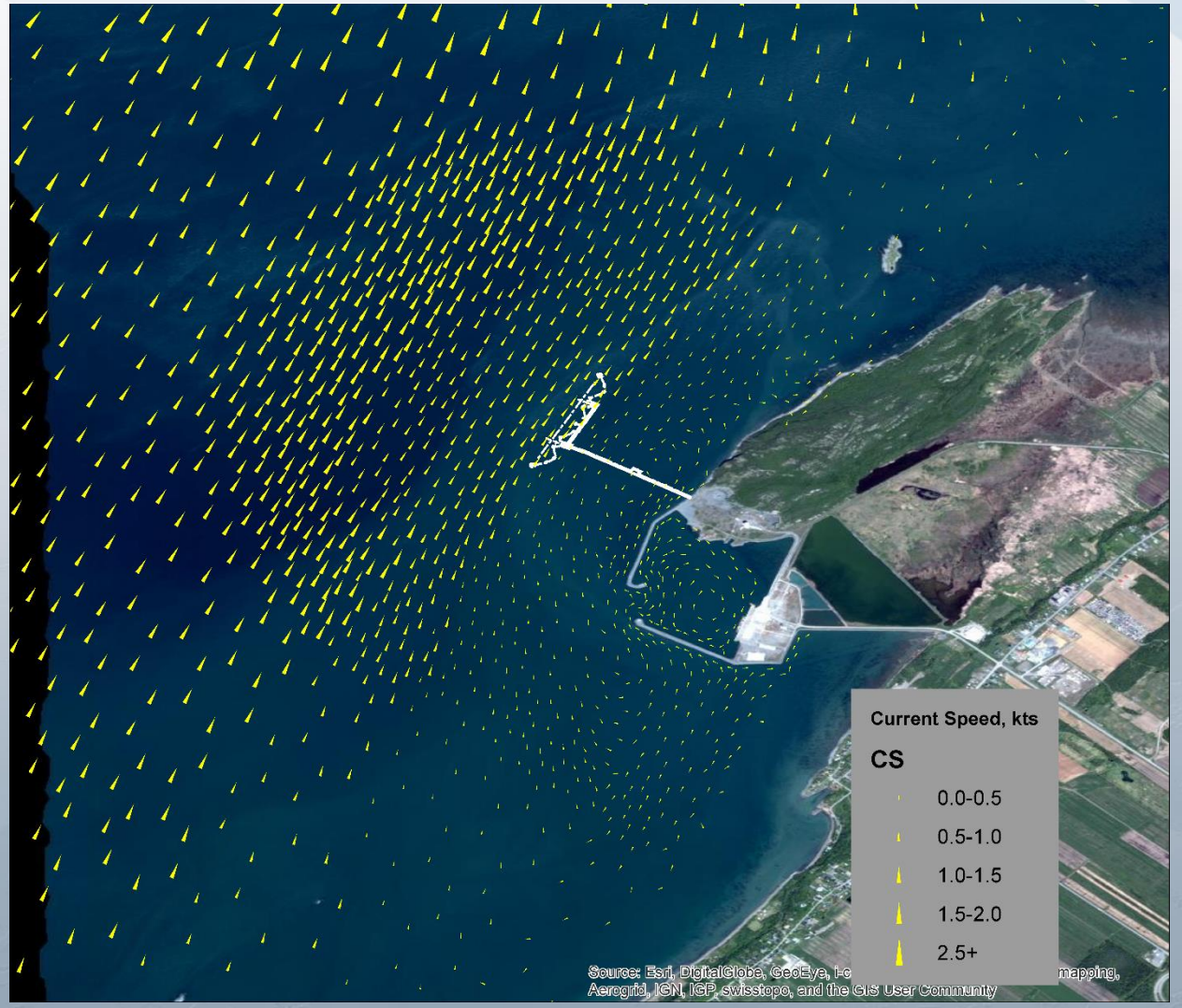


Hydrodynamic Tidal Current Preparation

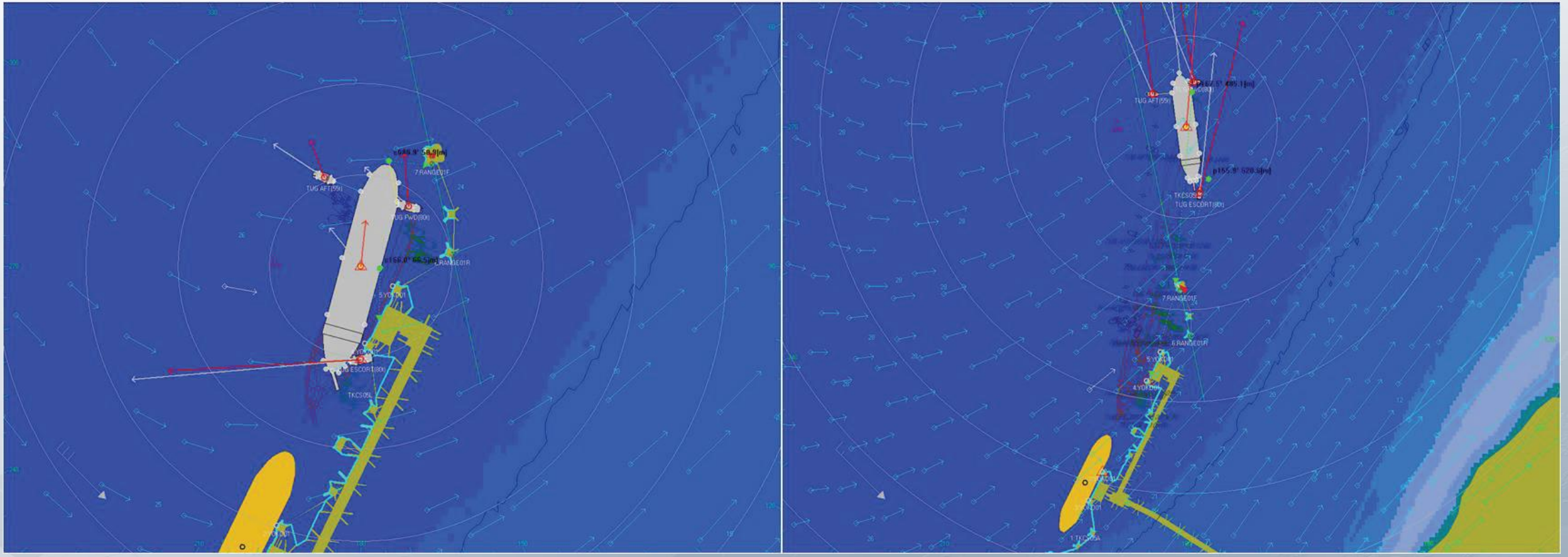
- Coastal hydrodynamic model may have much higher resolution than required for vessel simulation
- Recommend a 24-hour cycle of spring tides
- Spatial resolution 4-5 vectors per vessel length
- Time step depends on variability of currents and data capacity of simulator
- Optimize spatial and temporal resolution to maintain real time processing speed
- Current vectors only required at navigable water depths or over navigation channels

Tidal Eddy Currents

- Marine terminal approach and departure
- Time step one hour
- Resolution ~ 100 meter
- Peak Flood/Ebb Strongest
- Critical condition occurs near slack prior to ebb tide



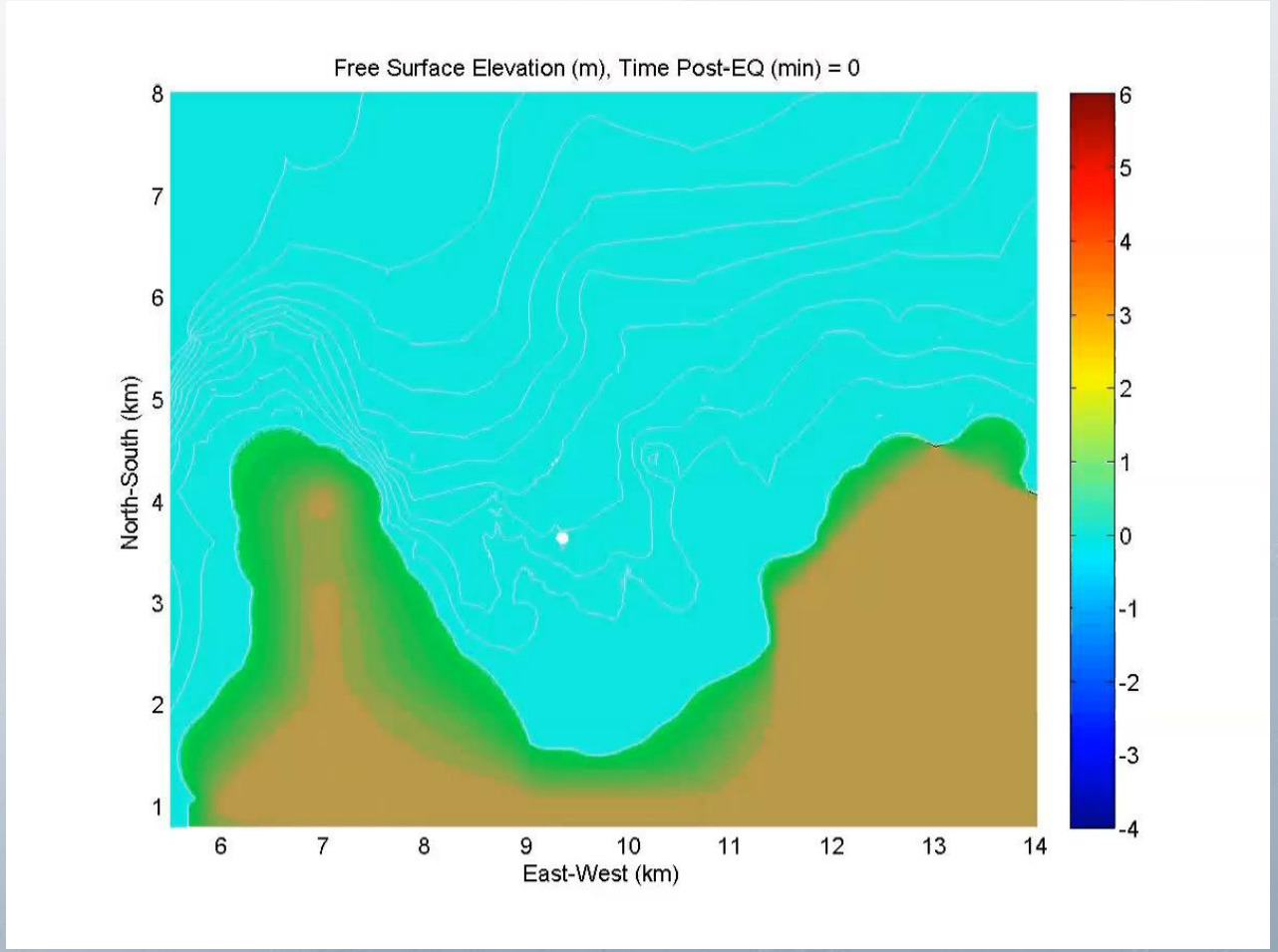
Departure from Dock in Eddy Conditions



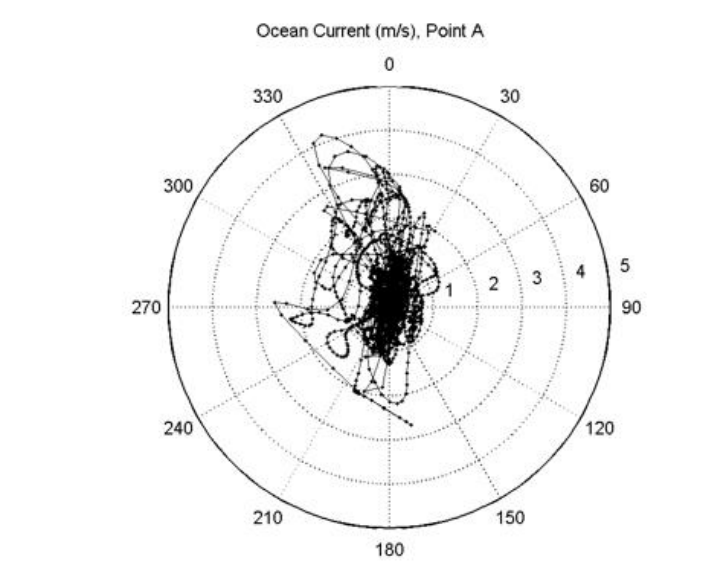
Extreme Event Tsunami Current Preparation

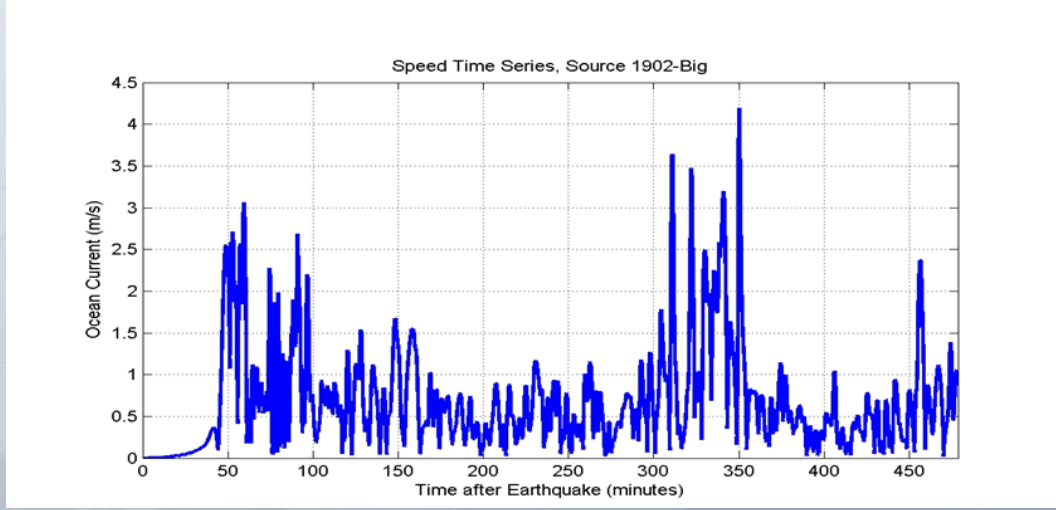
- Tsunami impact simulations may be need for long term moorings or other circumstance where a vessel may have to evacuate
- Short warning 15-30 minutes where timing is critical
- Short duration event (e.g. 2-3 hours)
- Temporal resolution higher – 1-minute time step to capture rapid changes in current direction, speed and water level

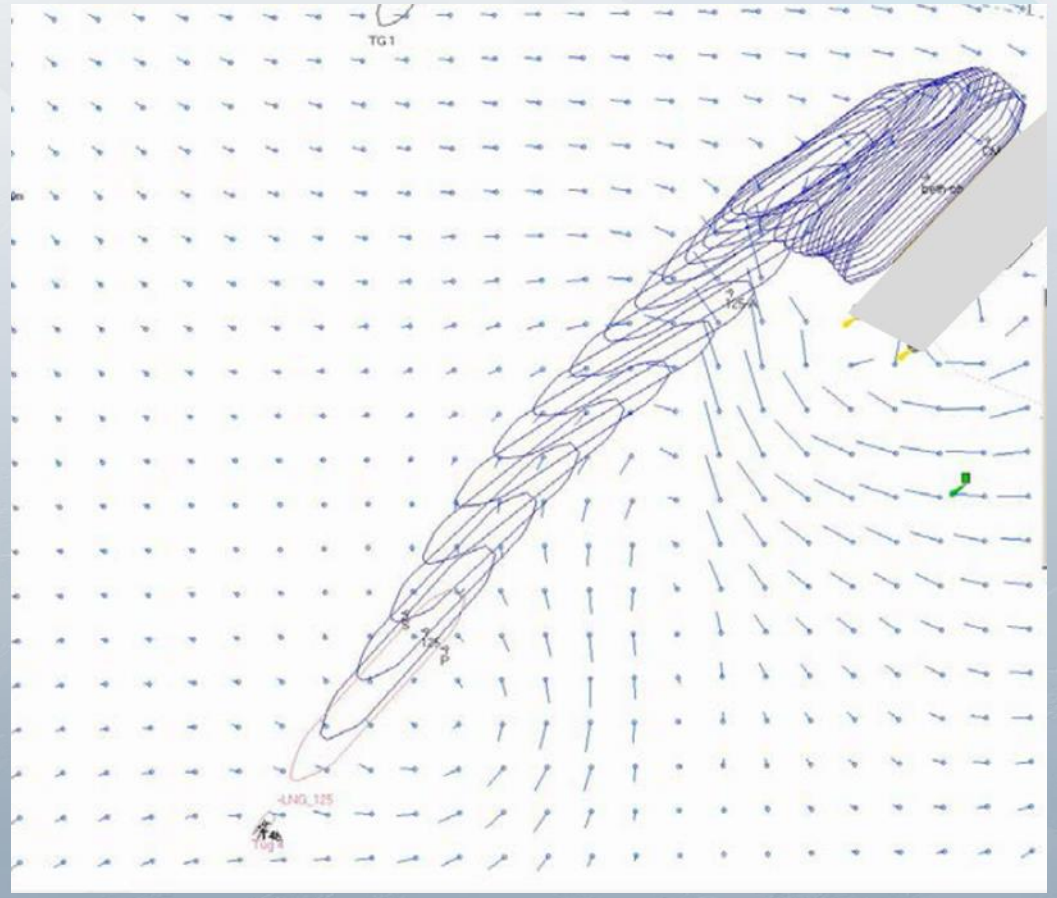
Coastal Tsunami Model



Departure from Dock in Tsunami Event

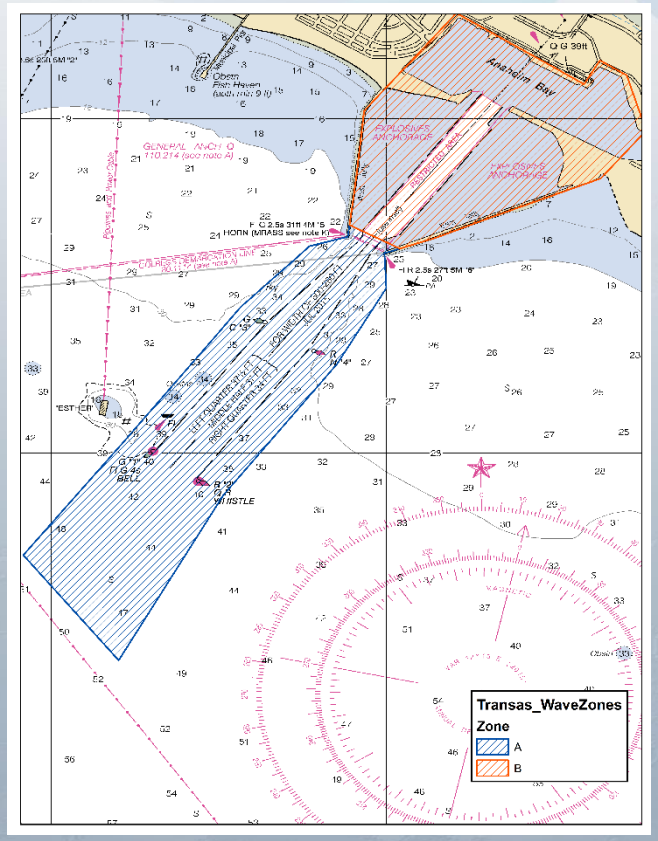




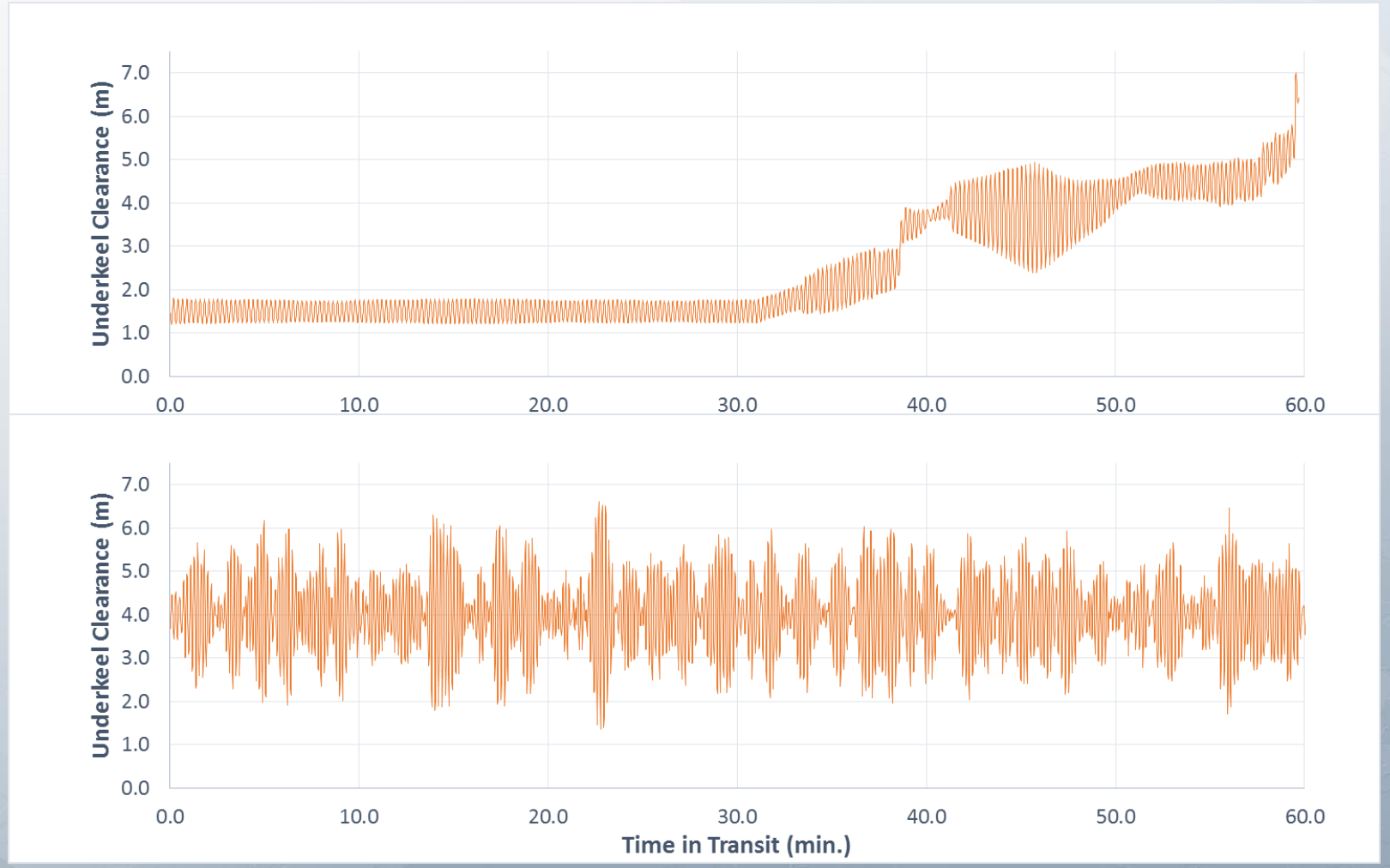


Wave Representation in Real Time Ship Simulation Software

- **Typically defined a wave condition over an area, not spatial grid**
- **Does not include wave dispersion for computational efficiency:**
  - Constant wave height and period or
  - Spectral derived time series
- **Simulator wave characteristics to be used with caution.**
  - May not include shallow water effects
  - May use simplified definition of wave spectra
  - Period-wave length relationship may be skewed
- **Coastal engineer must be familiar with how waves are treated within the simulator software and adapt input**



Simulated Underkeel Clearance with Regular and Spectral Waves



6 DOF Vessel in Waves with Tugs

Future Advances in Real Time Simulation of Coastal Processes

- **Faster simulators and GPUs for processing may lead to improved fidelity for coastal models:**
  - Three-dimensional currents
  - Wave dispersion, diffraction
  - Real time ship-to-ship interaction

Summary

- Real time vessel simulation necessary component of channel and harbor design
- Coastal engineering models improve the realism and design output of simulations
- Coastal engineers should have an understanding of the limitations and basis for the facility being used and adapt data preparation accordingly
- Real time simulators must strike a balance between complexity and efficiency, but advancements should continue

THANK YOU