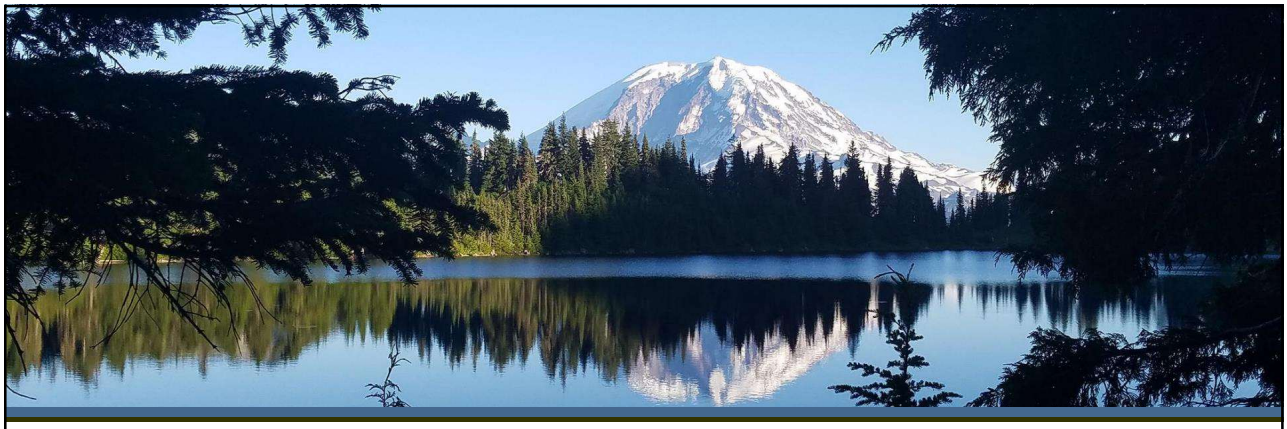

Vessel Encounter Module

Modeling Team

JD Ross Leahy (Presenter), Adam Byrd, Alex Suchar

DEPARTMENT OF ECOLOGY
State of Washington

Today's outline

1. **Background**
2. **Movement Module Update**
3. **Encounter Module Review**
4. **Encounter Module Selection Process and Next Steps**
5. **Questions and Comments**

Today's discussion topics

- Current status of our work on the Vessel Movement Module
- Current status of our work on the Vessel Encounter Module
- Next steps for the Vessel Encounter Module

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Legislative background

- ESHB 1578 was passed in 2019 to reduce the risk of oil spills, and protect Southern Resident Killer Whales
- Ecology's Spills Program tasked to undertake or assist with multiple policy initiatives in the bill, including the development of an oil spill risk model

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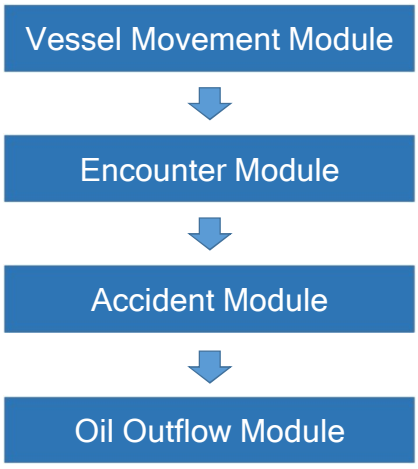
Modeling Approach



Vessels move in the system according to their empirical distribution

Measures and evaluates relationship of each vessel to the shore and other vessels

Evaluates situations for their potential to lead to accidents

Estimates the size of oil spills that result from accidents

Vessel Movement Module

Purpose:

- Simulate vessel activity and potential changes in traffic volume with AIS driven model

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Vessel Movement Module Review

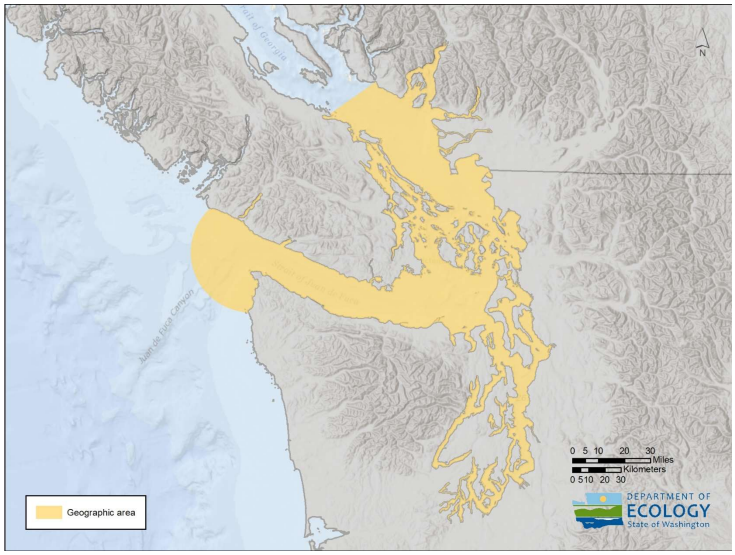
Identify vessel tracks

Collect tracks into routes

Statistical analysis of factors that could affect vessel distribution on tracks

Simulate vessels on tracks based on distribution

Simulate additional rules and non route based vessels



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Vessel Movement Module: Components

Vessel Movement Module

- Geographic Area
- Track Selection Factors
- AIS Messages
- External Rules
- Track Identification
- Dependent Vessels
- Route Identification
- Non-AIS Vessels

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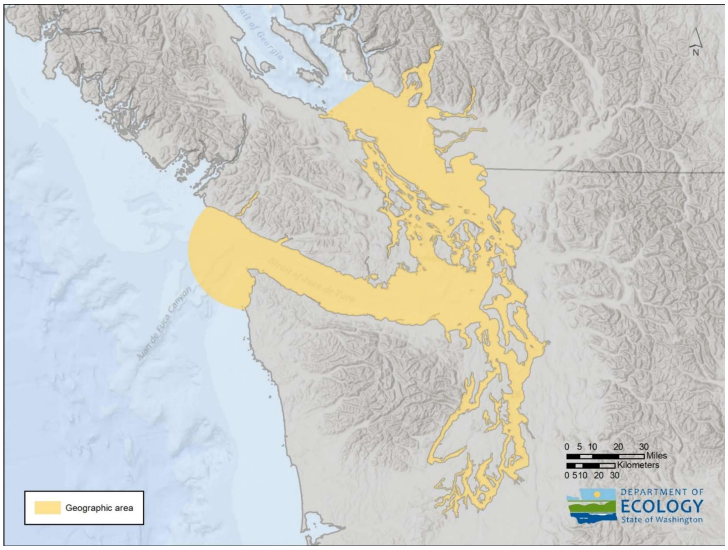
Vessel Journey and Journey Network

Vessel Journey starts when a vessel enters the system, and ends upon departure

Vessel Journey Network is a collection of linked route segments

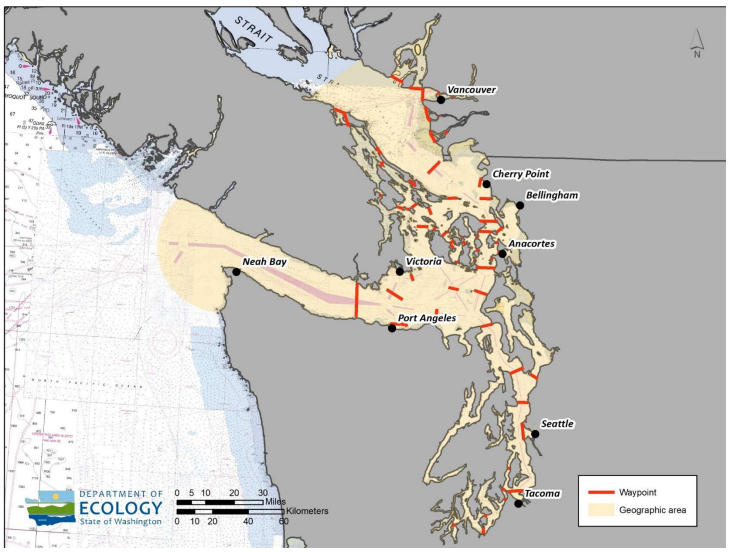
Time at anchor or facility is incorporated as a unique part of vessel journey



Identify Route Waypoints

Waypoints are intersection lines along a route

These intersection lines are now included in our list of origins and destinations

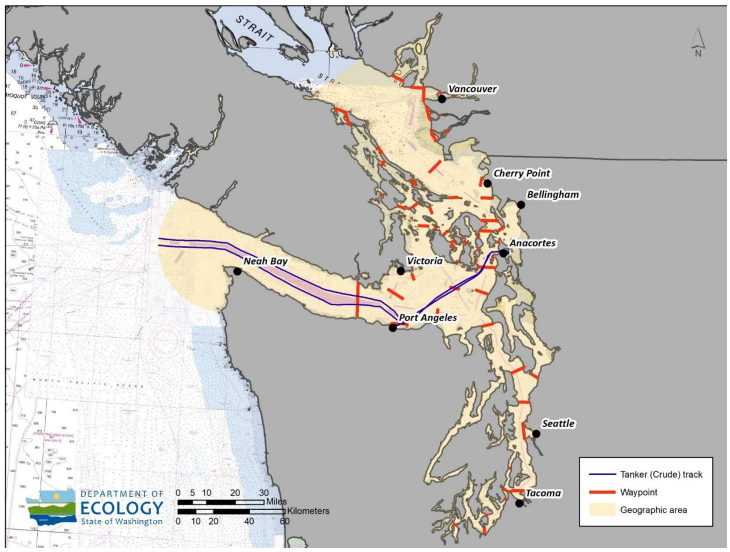


Simulating Vessel Movements

Small test case based on one month of tanker movements

Vessels enter the simulation based on the distribution in the test data

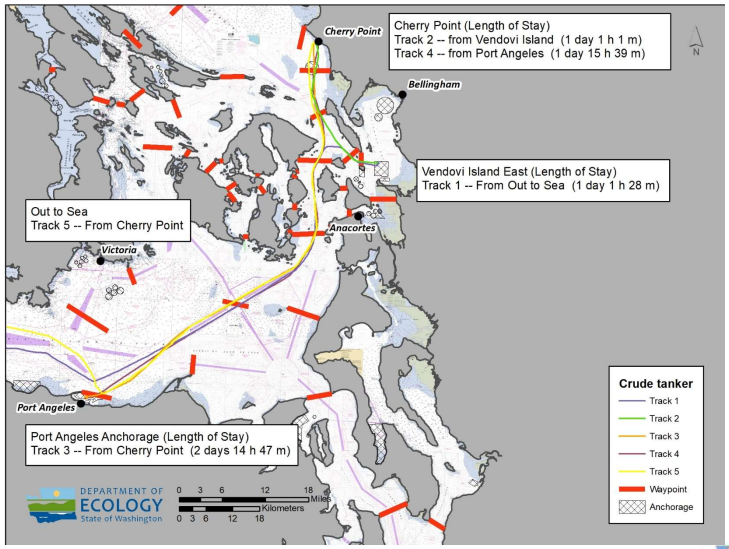
Vessels select their next waypoint based on distribution of waypoint selection in the test data



"Look Back" for Next Waypoint Selection

Actual vessel movements include repetition

Vessels select their next waypoint based on distribution of waypoint selection in the test data – *based on previous two or more waypoints visited*

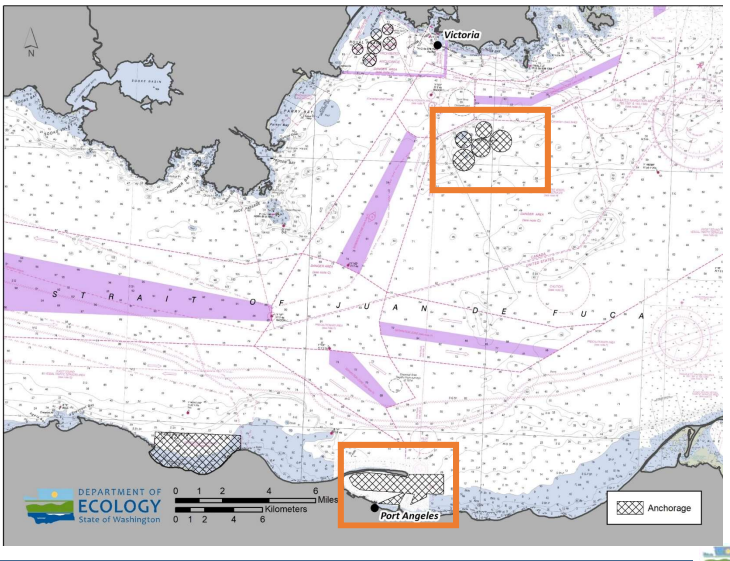


Location Within an Anchorage Area

Many anchorages in US waters have a capacity for more than one vessel

We break down anchorages into subsections based on VTS reported capacity

Simulated vessels select anchorage subsection based on distribution in the data



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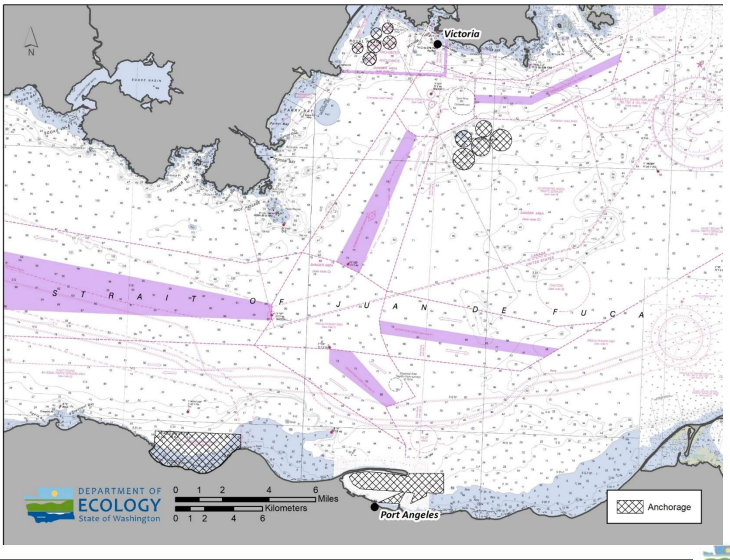
Time at Anchor and Location While Anchored

Vessels select anchorage duration based on distribution in the data

We will not be representing vessel swing while at anchor.

Vessel location data while at anchor will be based on the last point of their arrival track.



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Movement Module: Next Steps

Near Term:

- Review and validation of vessel routes
- Adding more vessel data to our test set
- Continued testing of simulation algorithm

Longer Term:

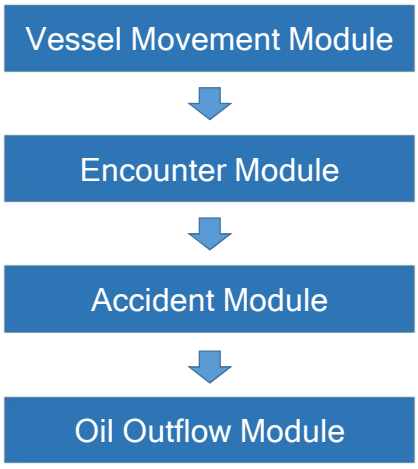
- Non-AIS based vessels (sport fishing, whale watching, tribal fishing)
- Dependent vessels (pilot boats, escort and assist tugs)
- Module Description Document

Vessel Encounter Module

Purpose:

- To identify if a vessel or obstacle is nearby enough to represent the possibility of a collision or a powered grounding

Modeling Approach



Vessels move in the system according to their empirical distribution

Measures and evaluates relationship of each vessel to the shore and other vessels

Evaluates situations for their potential to lead to accidents

Estimates the size of oil spills that result from accidents

Role of the Encounter Module

Identify locations and potentialities of collisions

- A collision requires at least two vessels
- Excludes from accident calculation areas and moments where collisions can't occur

Identify locations and potentialities of powered groundings

- A powered grounding requires a shoreline or underwater hazard
- Excludes from accident calculation areas and moments where collisions can't occur

Selecting an Encounter Model

Defining an encounter
- The simultaneous presence of a vessel and an obstacle in a finite area (Goerlandt et al. 2015)

How nearby is nearby enough
- No consensus on proximity measure and threshold

Many models
- Closest Point of Approach
- Ship Domain

Selecting an Encounter Model

Selection criteria
- Appropriate for restricted waters, a variety of vessels, and simulated data
- Computational efficiency

Selection process
- Select candidates
- Test and compare

Encounter model criteria

Variety of vessels	• Includes ship length and width
Transits and approaches to port	• Includes ship speed
Okay for simulated data	• Does not require detailed maneuvering data
Computational efficiency	• Relatively simple, well documented and reproducible
Restricted waters	• Ship Domain model

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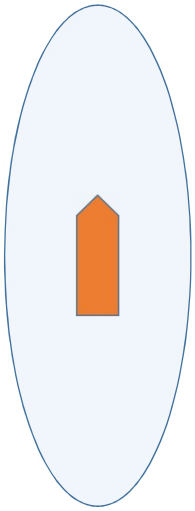
A Ship Domain Based Approach

Definition of Ship Domain

- Area around the ship that should be free of other vessels or fixed objects

Suitability of Ship Domain Approach

- Relative ship domains are a function of the dimensions of the vessel
- Better suited for restricted waters
- Can incorporate speed
- Does not require detailed maneuvering data



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Different Types of Ship Domains

Empirical

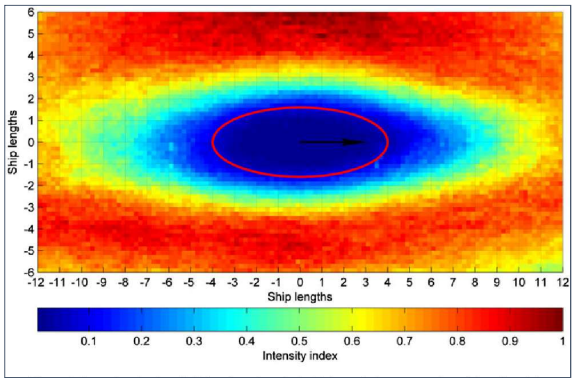
- Based on AIS data and representing area kept clear by actual navigators

Analytical

- Based on the properties of the ships, including size and maneuverability

Knowledge-Based

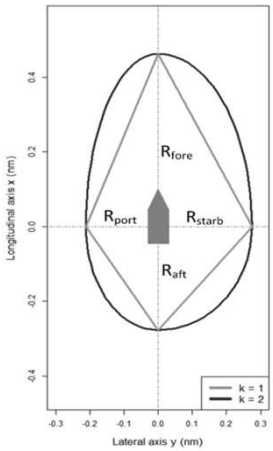
- Based on expert opinion, survey, or simulations



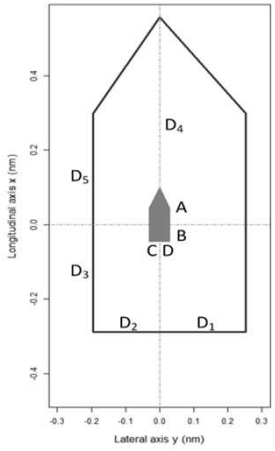
Hansen et al. (2013).

Two Analytical Ship Domain Options

Quaternion Ship Domain (QSD) (Wang 2010)



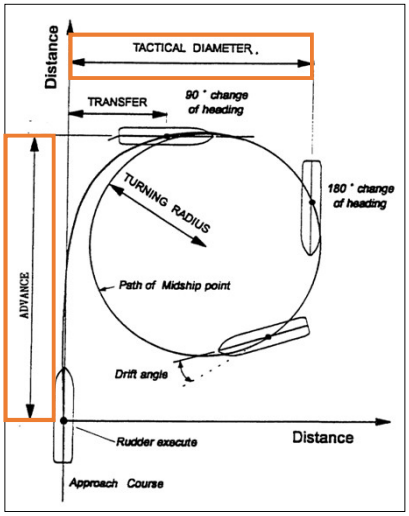
Pentagonal QSD (Bakdi 2019)



Variables for QSD and Pentagonal QSD

Ship Characteristics
- Length
- Beam
- Speed

Calculated Maneuverability Data
- Advance
- Tactical Diameter

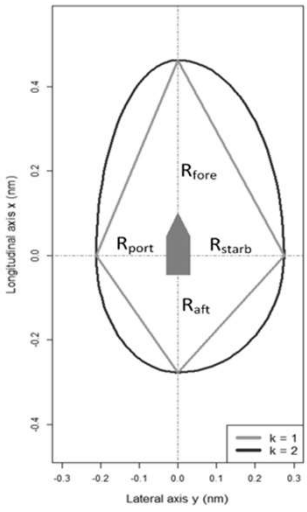


IMO MSC/Circ.1053

Strengths and Challenges for QSD and Pentagonal QSD

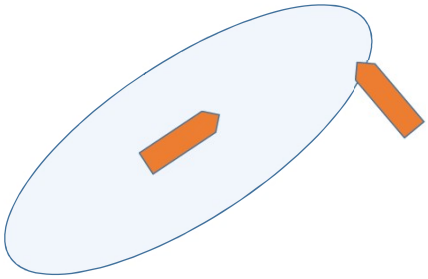
Strengths
- Suitable for restricted waters
- Includes vessel maneuverability
- Well specified
- Computationally efficient
- Used in a number of recent papers

Challenges
- Maneuverability data points based on formula
- No discussion of towing vessels
- No discussion of smaller vessels

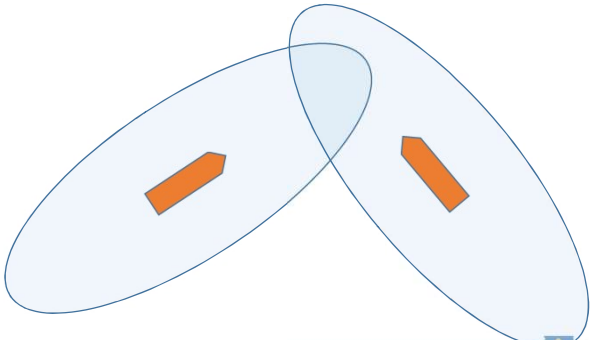


Encounter Criteria

Vessel Enters Domain of Another Vessel



Vessel Domain Overlaps Another Vessel Domain



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Inputs and Outputs

Vessel Movement Module

- Vessel details
- Locations/times
- Speed and course

Encounter Criteria

- Vessel details
- Locations and times
- Course

Encounter Analysis

Encounter Analysis

- Location → **Accident Module**
- Type → **Outflow Module**

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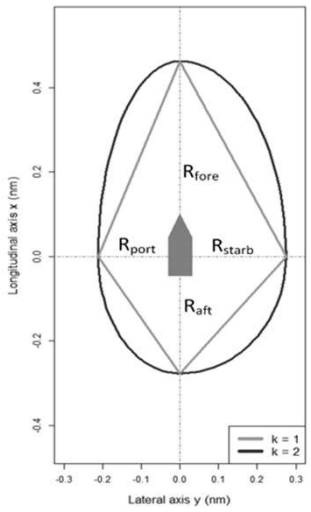
Areas for Further Discussion

Intentional Encounters
- Escort and Assist Tugs, Crew/Pilot Boats
- Bunkering

Tugs Towing Astern
- Length of tow/length of barge

Ship Domains for Small Vessels
- Formula is derived from large vessel data

Grounding Encounters
- Representing the possibility of a collision or a powered grounding



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Encounter Module: Next Steps

Near Term:
- Test Four Approaches (2 Ship Domains and 2 Sets of Criteria)

Longer Term:
- Validate encounter model results for simulated data against AIS data

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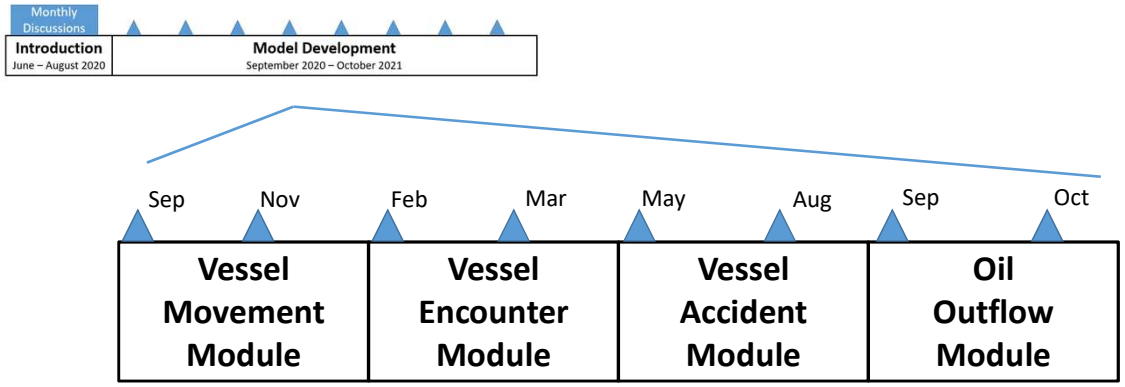
Webinars and Technical Discussions

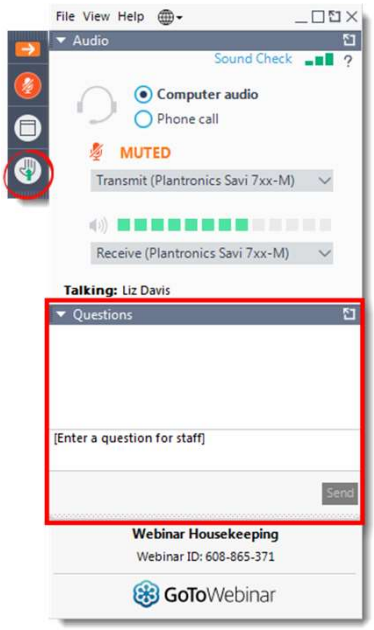


Upcoming events

March 17th, 2021 -- 1 pm to 3 pm
- Technical Discussion: Ship domain examples

March 23rd, 2021 -- 1 pm to 3 pm
- Vessel Encounter Module Updates and Follow Up

Discussion logistics



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Today's discussion topics

- Current status of our work on the vessel movement module
- Current status of our work on the vessel encounter module
- Next steps for the vessel encounter module

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Contact Info

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References

Bakdi, A., I. K. Glad, E. Vanem, and Ø. Engelhardtsen. 2019. AIS-Based Multiple Vessel Collision and Grounding Risk Identification based on Adaptive Safety Domain. Journal of Marine Science and Engineering 8:5.

Hansen, M., Jensen, T.K., Lehn-Schiøler, T., Melchild, K., Rasmussen, F., & Ennemark, F. (2013). Empirical Ship Domain based on AIS Data. Journal of Navigation, 66, 931-940.

Goerlandt, F., J. Montewka, V. Kuzmin, and P. Kujala. 2015. A risk-informed ship collision alert system: Framework and application. Safety Science 77:182–204.

Wang, N. 2010. An Intelligent Spatial Collision Risk Based on the Quaternion Ship Domain. Journal of Navigation 63:733–749