Vessel Accident Module

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Model Development Team

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Today's outline

1. **Background**
2. **Hazard Identification**
3. **Break for 1st Discussion**
4. **Establishing Probabilities**
5. **Next Steps and 2nd Discussion**

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

Describing oil spill risk

Scenarios

- Hazard identification: collision, allision, grounding, etc.

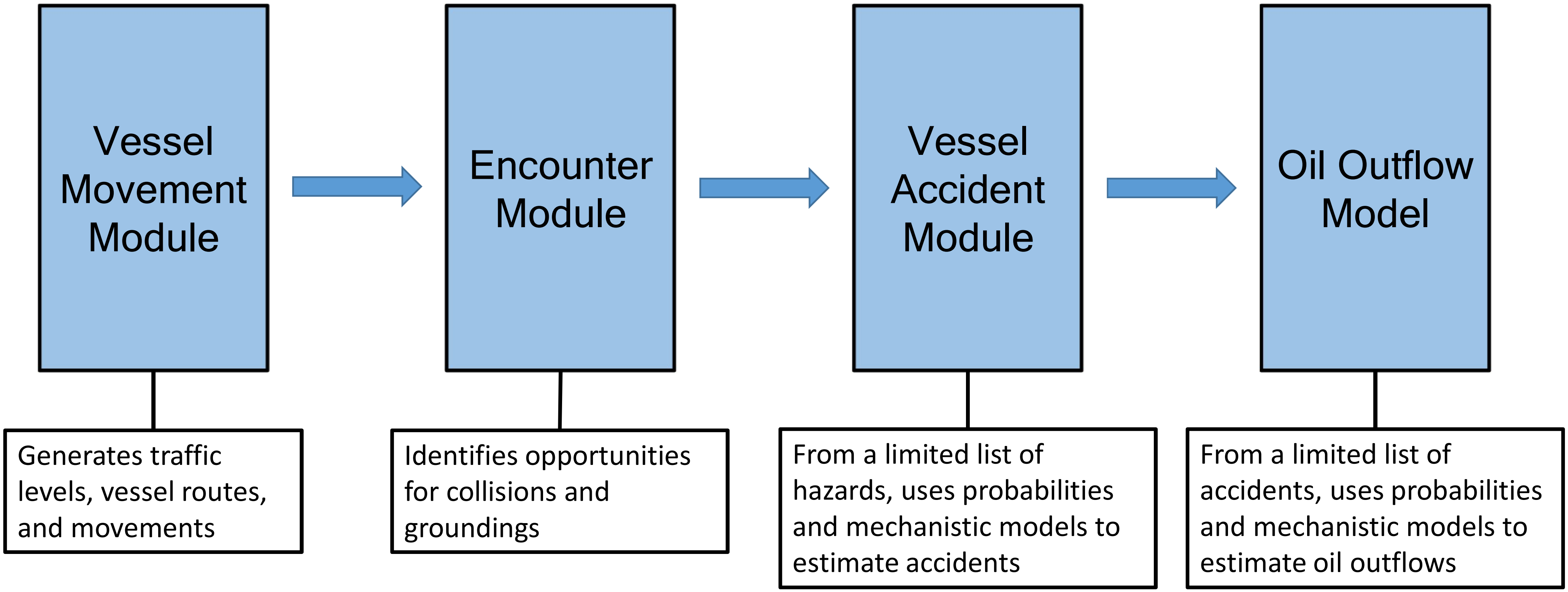
Probability

- How likely is each hazard?

Consequences

- If an accident happens, how likely is that an oil spill occurs, where will it occur, and what volume and type of oil will be released?

Modeling Approach



Hazard Identification

Existing Approaches

- Not comprehensive
- Based on accident databases
- Lack of consensus in the literature

Mechanistic Approach

- Starting with four ways to have a maritime oil spill:
  - Hull damage
  - Submergence
  - Transfer Spill
  - Deck/Mechanical Spill

Initial List of Hazards

Model Hazards

- Allision
- Capsize
- Collision
- Deck Spill
- Grounding
- Sinking
- Transfer Spill

What further detail are we interested in?

- Scenarios that lead to hazards
- Additional specification of hazards

Hazard Identification – Scenarios that lead to hazards

Indirect Model Hazards
- Loss of Propulsion
- Loss of Steering
- Anchor Dragging

Direct Model Hazards
- Allision
- Capsize
- Collision
- Deck Spill
- Grounding
- Sinking
- Transfer Spill

Hazard Identification – Additional specification

Collision
- Vessel to Vessel Collision
- Tug to Barge Collision

Allision
- Navigational Allision
- Berth Allision

Other
- Catch-all category that includes, for example:
  - Fire/Explosion
  - Metal fatigue/cracking
  - Spills of unknown/unreported cause

Hazard Identification and Probability

Combined List of Model Hazards

Powered grounding
Tug to barge collision
Vessel to vessel collision
Navigational allision
Berth allision
Sinking
Capsizing
Deck spill
Transfer spill
Other spill

For each:

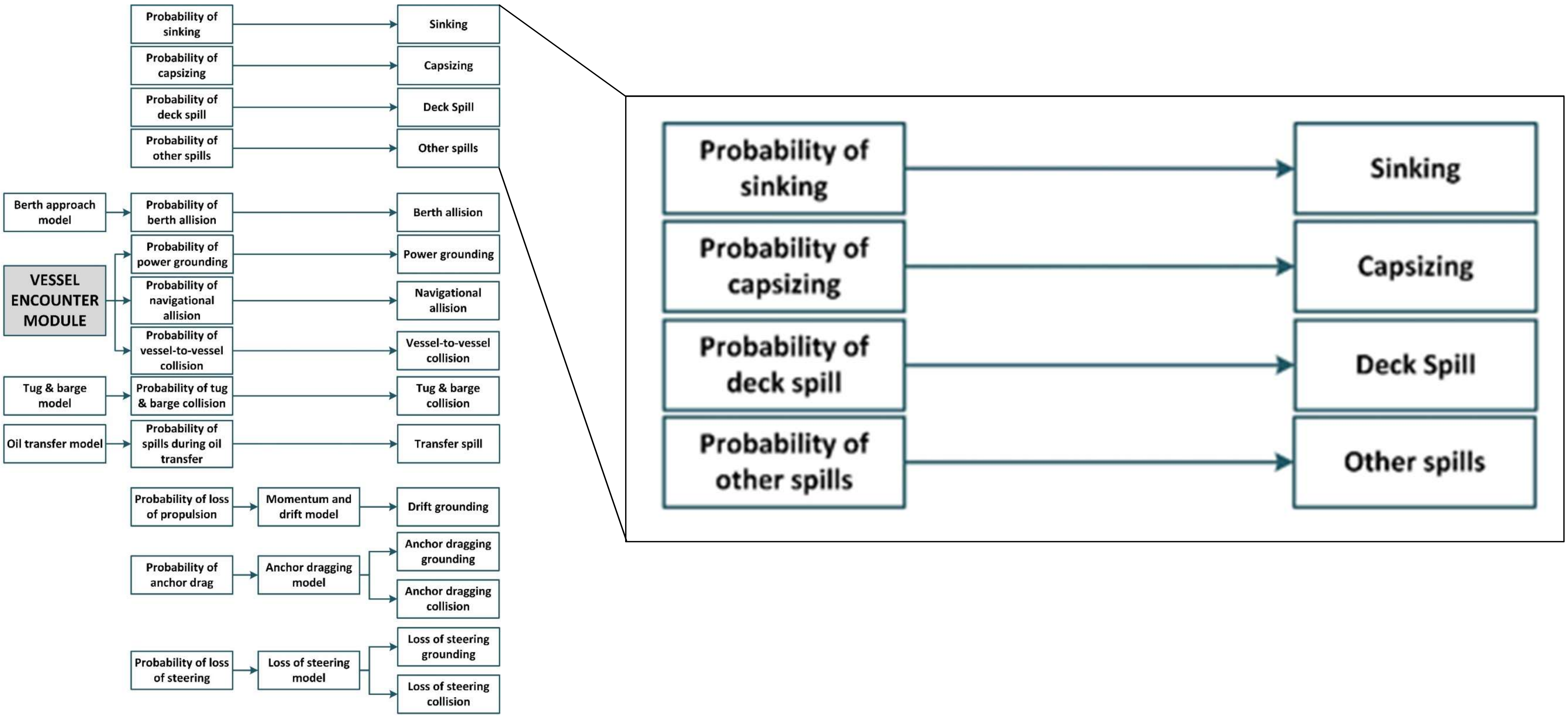
- we must identify a probability

Loss of propulsion grounding
Anchor dragging grounding
Loss of steering grounding
Anchor dragging collision
Loss of steering collision

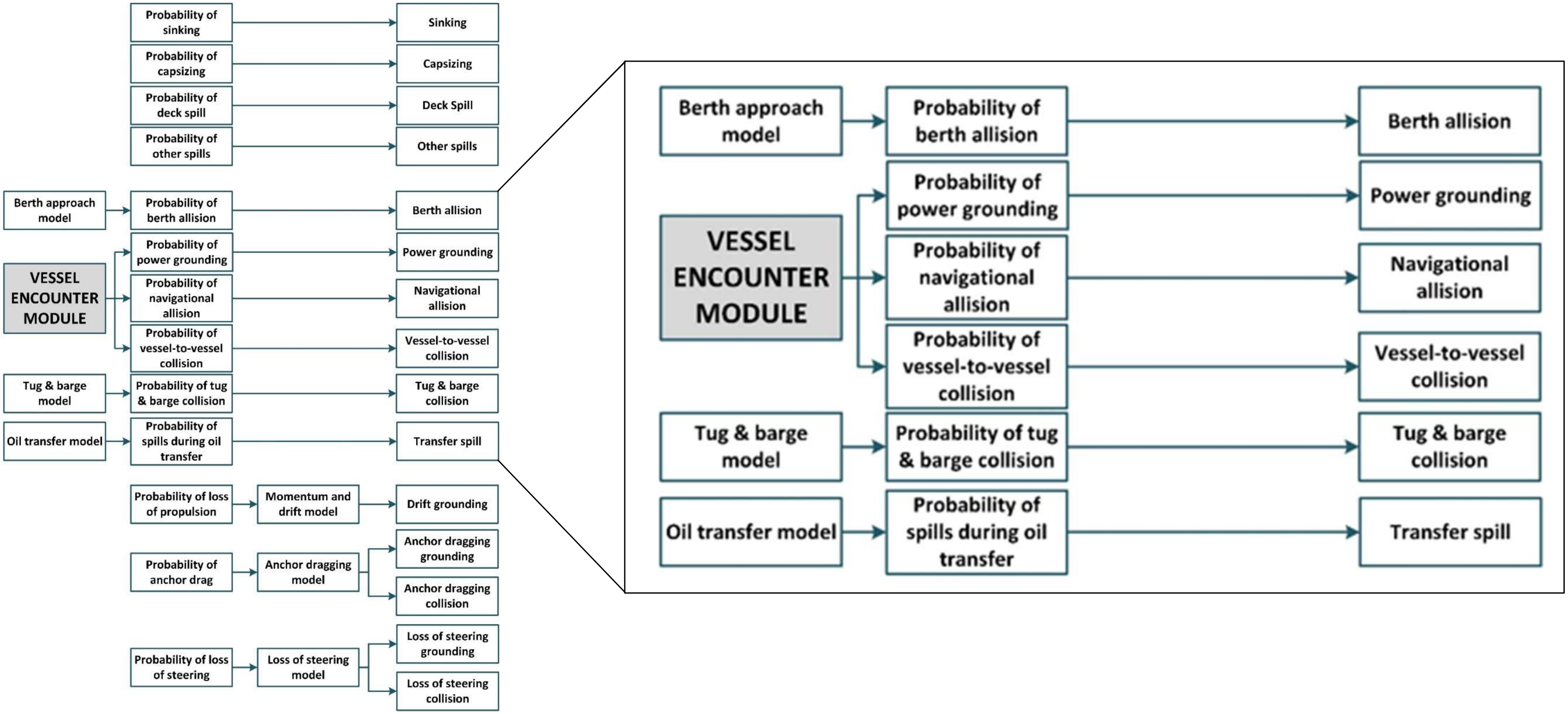
For each:

- we must identify a probability and a mechanism

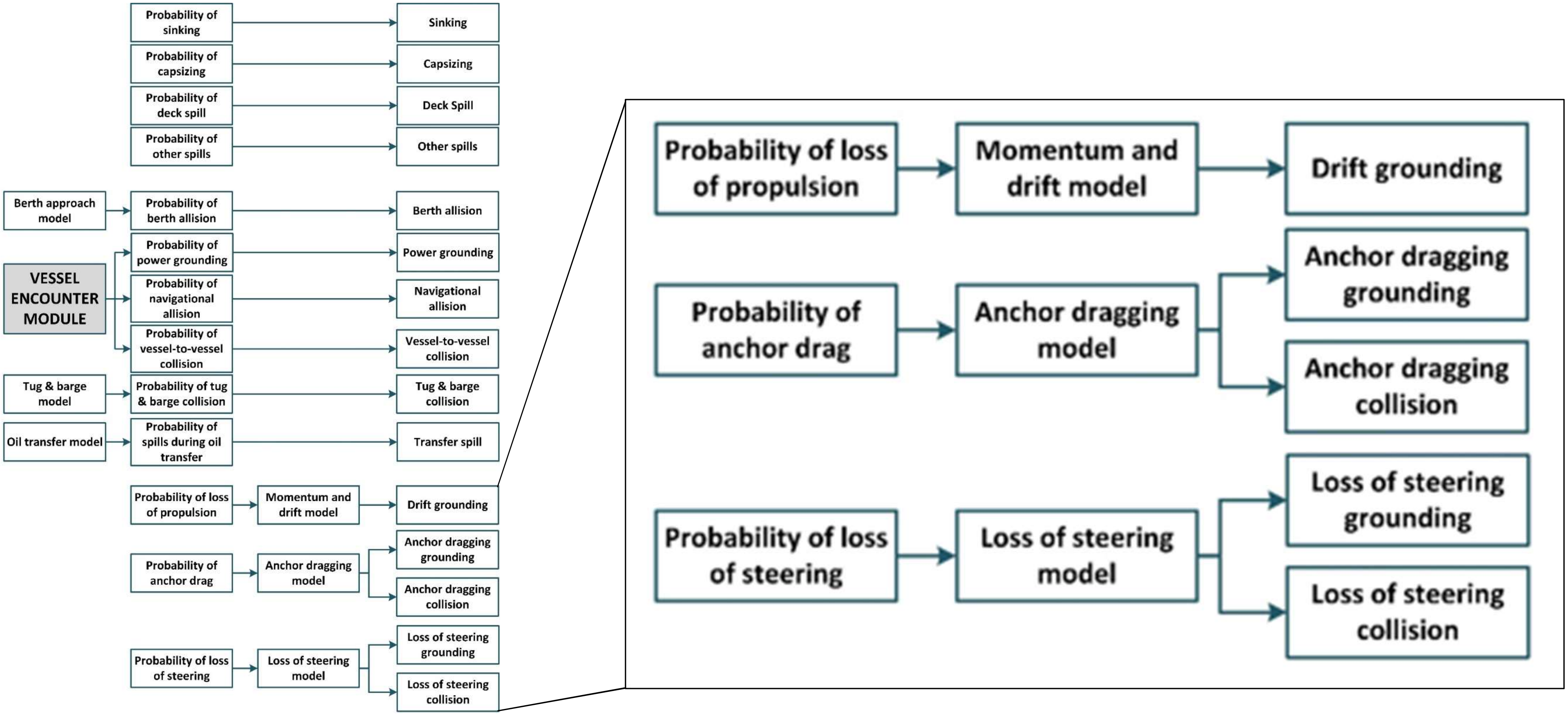
Hazard Identification – Probabilistic Approach



Hazard Identification – Probabilistic Approach



Hazard Identification – Mechanistic Approach



Strengths and weakness

Probabilistic Approach

Vs

Mechanistic Approach

Probabilistic Approach

Strengths

- Based on data, to the extent possible
- Best chance at evidence based probability

Weaknesses

- Most prevention strategies cannot be evaluated for these hazards
- Only very limited scenarios can be tested

Probabilistic Approach

What can we estimate?

- Oil spill risk from a listed hazard
  - E.g. What portion of oil spill risk is from vessels sinking?

What can we estimate, if sufficient data exists?

- Effect on spill risk for a listed hazard for factors like weather, ship age, flag…
  - E.g. How would a change in ship age affect the risk from vessels sinking?

What can't we estimate?

- Oil spill risk from a non-listed hazard
- Effect of training, crewing levels, or other human factors based interventions on spill risk
- Effect of maintenance, onboard equipment or lack thereof, on spill risk

Mechanistic Approach

Strengths

- Allow us to test tug interventions associated with loss of propulsion, loss of steering, and anchor dragging events.

Weaknesses

- Mechanistic model is a simplification
- Outputs not linked to historical data

Mechanistic Approach

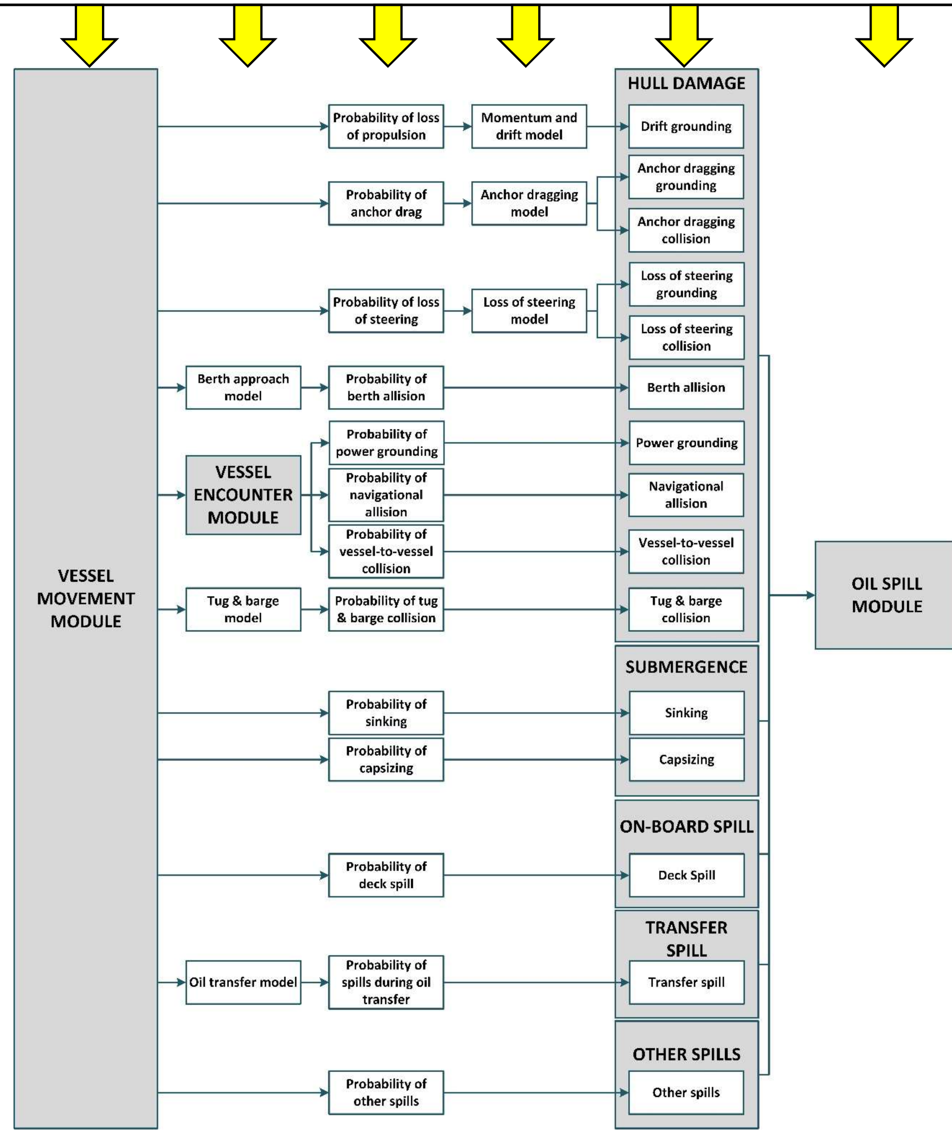
What can we estimate?

- Oil spill risk from a listed hazard
- Ability of a tug to physically intervene prior to a drift grounding, or collision associated with a loss of steering or anchor dragging event.
  - E.g. What proportion of drift groundings can be averted by stationing an ERTV in a given area?

What can't we estimate?

- Effect of training, crewing levels, or other human factors based interventions on spill risk for these hazards
- Effect of any risk intervention not specifically linked to a tug's ability to physically intervene in the accident chain for these hazards
  - E.g How would additional escort training affect oil spill risk from loss of steering events?

How it fits together



Why this combined approach?

Why not take probabilistic path for all hazards?

- Tug intervention questions could not be evaluated

Why not take mechanistic path for all hazards?

- How most indirect hazards lead to accidents is not specifiable due to a lack of data
  - The mechanistic path between loss of propulsion and drift grounding is uniquely transparent
- Other hazards do not offer such transparency:
  - E.g. The accident chain between water ingress and sinking

End of Part 1: Questions and comments

Is this list of hazards sufficient?

- Suggested additions or reorganization?

Does this model structure allow us to answer the questions we are interested in?

- In the near term?
- In the long term?

Part 2: Establishing likelihood

Scenarios

- Hazard identification: collision, allision, grounding, etc.

Probability

- How likely is each hazard?

Consequences

- If an accident happens, how likely is that an oil spill occurs, where will it occur, and what volume and type of oil will be released?

What makes a probability?

A probability consist of two parts:

- **The number of occurrences**
  - E.g. the number of accidents of a particular type

- **A measurement of opportunities**
  - E.g. the number of encounters, ship-years, operation hours, or nautical miles sailed
  - The “exposure variable”

Some examples:

- 0.00232 serious collisions per ship year
- 0.0000000386 serious collisions per nautical mile sailed

$$\textbf{Probability} = \frac{0.0000000386 \text{ serious collisions}}{1 \text{ nautical mile sailed}}$$

Establishing a Probability – Standard Method

Standard Methodology

- Define a "population of interest"
- Count occurrences within that population
- Count opportunities within that population

Population of interest: Covered vessels in a geographic area during a time period

Occurrences: Number of groundings in that area, during that time period

Opportunities: Number of transits in that area, during that time period

Establishing a Probability – Standard Method

1) Find a population of interest

- A time period with similar trends as today
- An geographic area with similar trends as the study area

2) Count occurrences

- Representative examples
- Must be of sufficient number

3) Count opportunities

- Need an exposure variable
- The unit of measure for the probability denominator

Establishing a Probability – Standard Method

Challenges

- No easy way to identify the right population of interest
- Relatively small number of occurrences
- Database challenges

Establishing a Probability – Alternative Method

Zero-Failure Approaches

- Estimates probability with few to no occurrences
- A wide variety of ways to do this
- Lots of uncertainty in the different approaches

How?

- Estimate based on number of opportunities
- The number of opportunities could be larger or smaller, depending on your approach

Establishing a Probability – Expert Elicitation

An alternative to data: expert elicitation

- Other risk analysis projects have used expert elicitation as a way to produce quantifiable information on human error or other factors with sparse data available

Many challenges with this approach

- Complex process aimed at eliminating biases from the expert's interest in the value of the parameter
- Extremely difficult to provide a probability with a meaningful level of precision

How will we calculate a probability?

When there are occurrences, the probability is the number of occurrences divided by the number of opportunities.

When there are no occurrences, the probability is a function of the number of opportunities.

$$\hat{p} = \begin{cases} f(n), & when\ x = 0 \\ \dfrac{x}{n}, & when\ x > 0 \end{cases}$$

Multiple Probability Approach

There are strengths and weaknesses to every approach

- No one way is identifiably the best

Proposed path forward

- Multiple methodologies for calculating probabilities
- Each methodology is a comprehensive, standalone approach to calculating probabilities
- Model will produce unique outputs for each methodology
- Model results will be characterized as a range based on the different outputs

Multiple probability approach

Helps communicate uncertainty

- Different methods yield different results

Improves model transparency

- How much difference do different accident probabilities make?

Allows multiple viewpoints to be included

- A more inclusive approach may help us find common ground

Multiple probability approach

One potential structure for this approach:

	Probability Set A	Probability Set B	Probability Set C
Geographic Area	Narrow	Medium	Broad
Time Period	Shorter	Medium	Longer

The narrower our scope:

- More likely to end up using the zero failure method
- Less likely to be able to identify factors that influence probabilities

The broader our scope:

- Higher potential that we are capturing trends that don't match trends in study area
- Less able to use AIS information for calculation of exposure variables

Consideration for Parameters

For each Probability Set, we need

- A temporal scope – how far back in time?
- A geographic scope – how wide an area?

Temporal Scope

<u>We want a time period that mirrors today</u>

What factors might drive changes in accident trends?

- Regulatory changes
- Industry practices
- Other factors

Other considerations

- Reporting practices – formal and informal
- Database quality/changes over time

Geographic Scope

We want a geographic area that mirrors our study area

What factors might drive geographic differences in accident trends?

- Different rules and regulations
- Waterway characteristics
- Traffic separation schemes
- Vessel Traffic Services
- Pilotage

Other considerations

- Reporting practices – formal and informal
- Database quality/changes between jurisdictions

Next Steps for Vessel Accident Module

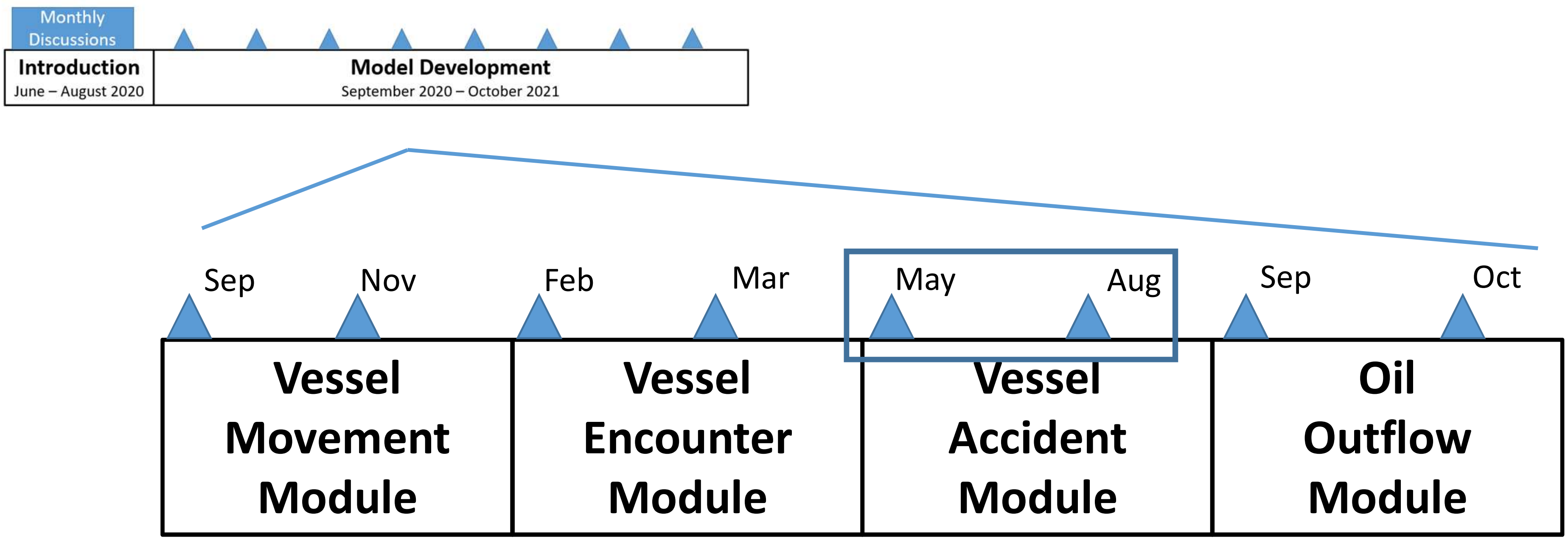
Mechanistic models

- Drift and momentum model
- Anchor dragging model
- Loss of steering model
- Discuss at next accident module webinar

Probability sets

- Work on parameters (geographic scope, temporal scope, etc)
- Discuss at public technical discussion sessions

Webinars and Technical Discussions



Upcoming events

June 30th, 2021 -- 1 pm to 3 pm
- Model 101 review session

July 14th, 2021 -- 1 pm to 3 pm
- Technical Discussion Session: Modeling vessels and anchorages

July 28th, 2021 -- 1 pm to 3 pm
- Technical Discussion Session: Probability

Upcoming events

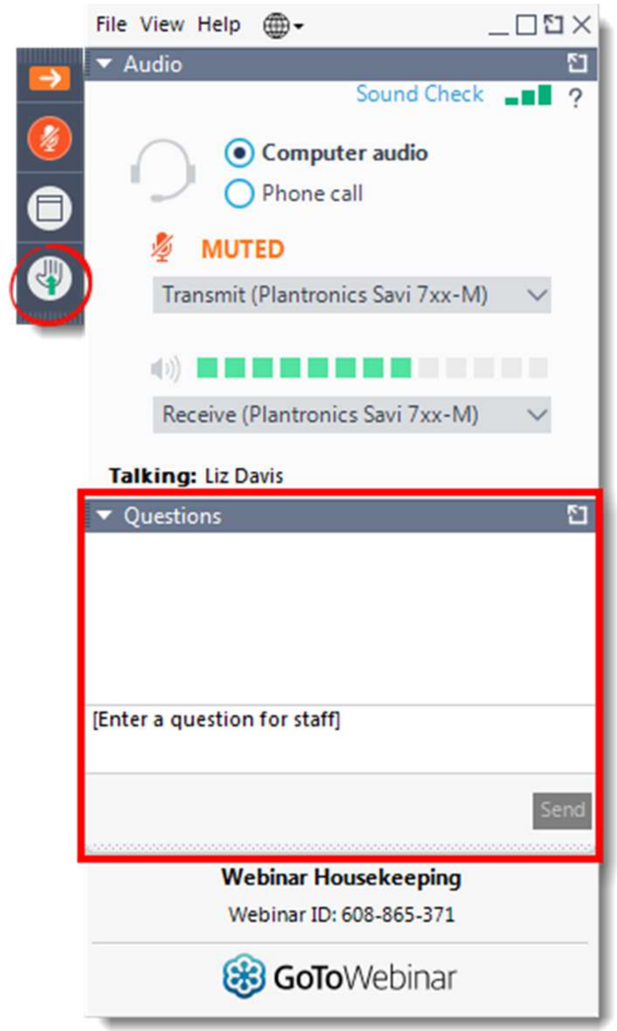
August 18th, 2021 -- 1 pm to 3 pm

- Vessel Accident Module Outstanding Topics and Follow Up

Today's discussion topics

- Our proposed multiple probability approach
- Your initial thoughts on probability parameters
    - What factors do you feel are most important?

Discussion logistics



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