Vessel Accident Module Updates

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Model Development Team

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State of Washington

Today's outline

1. Background
2. Updates
3. Momentum and Drift Model
4. Other Models For Indirect Hazards
5. Next Steps and 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.

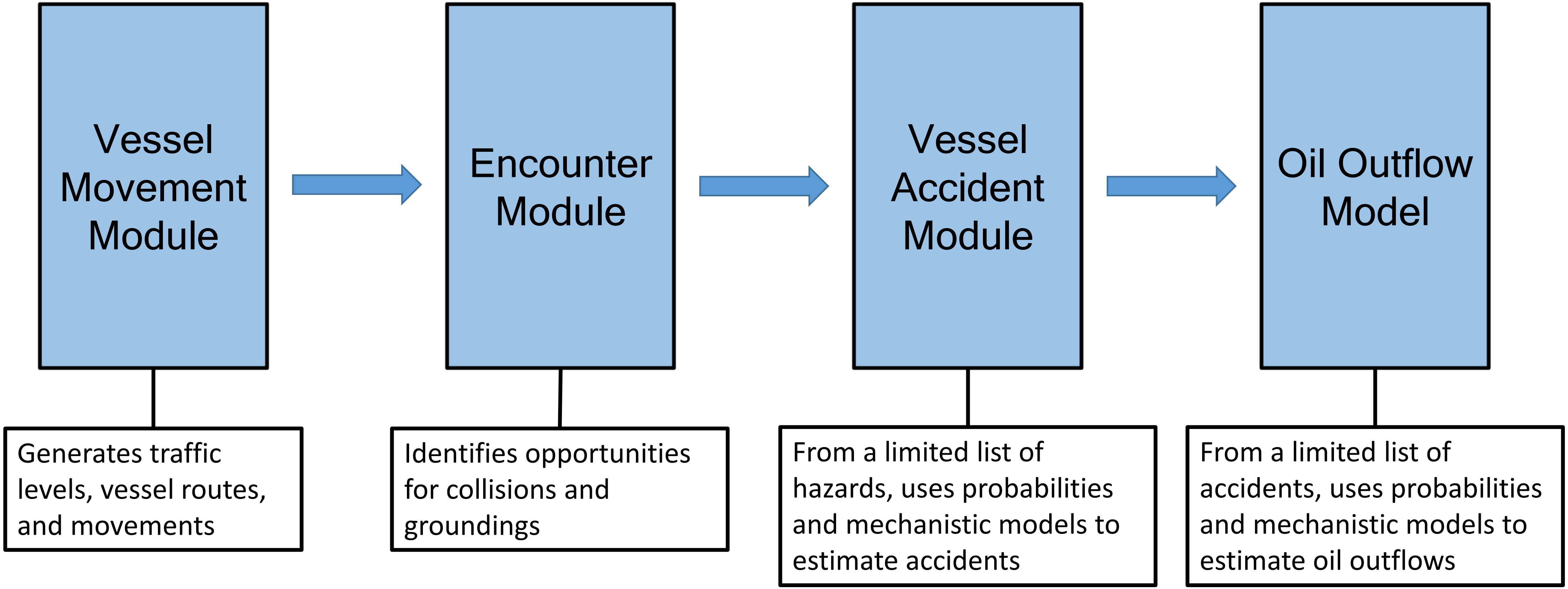
Probability

- 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



Updates since last presentation

Changes to Hazard Definitions

- Machinery Spill
  - "An oil spill to water from machinery or equipment onboard a covered vessel. Excludes spills related to overwater oil transfers."

- Vessel to Vessel Collision
  - "A collision between a covered vessel and another vessel, while both vessels are underway, **or while one is underway and one is anchored."**

Updates since last presentation

Adjustments to Anchorages

- Added additional anchorage area near Cherry Pt

Revisions to anchorage alternatives

- Changed alternatives for Yukon Harbor
    - Elliot Bay East and West replaced Smith Cove East and West
- Removed alternatives for the two explosives anchorages.

Adjustments to Model Area

Momentum and Drift Model

Model Hazards

Direct Model Hazards

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

Probabilistic Approach

Indirect Model Hazards

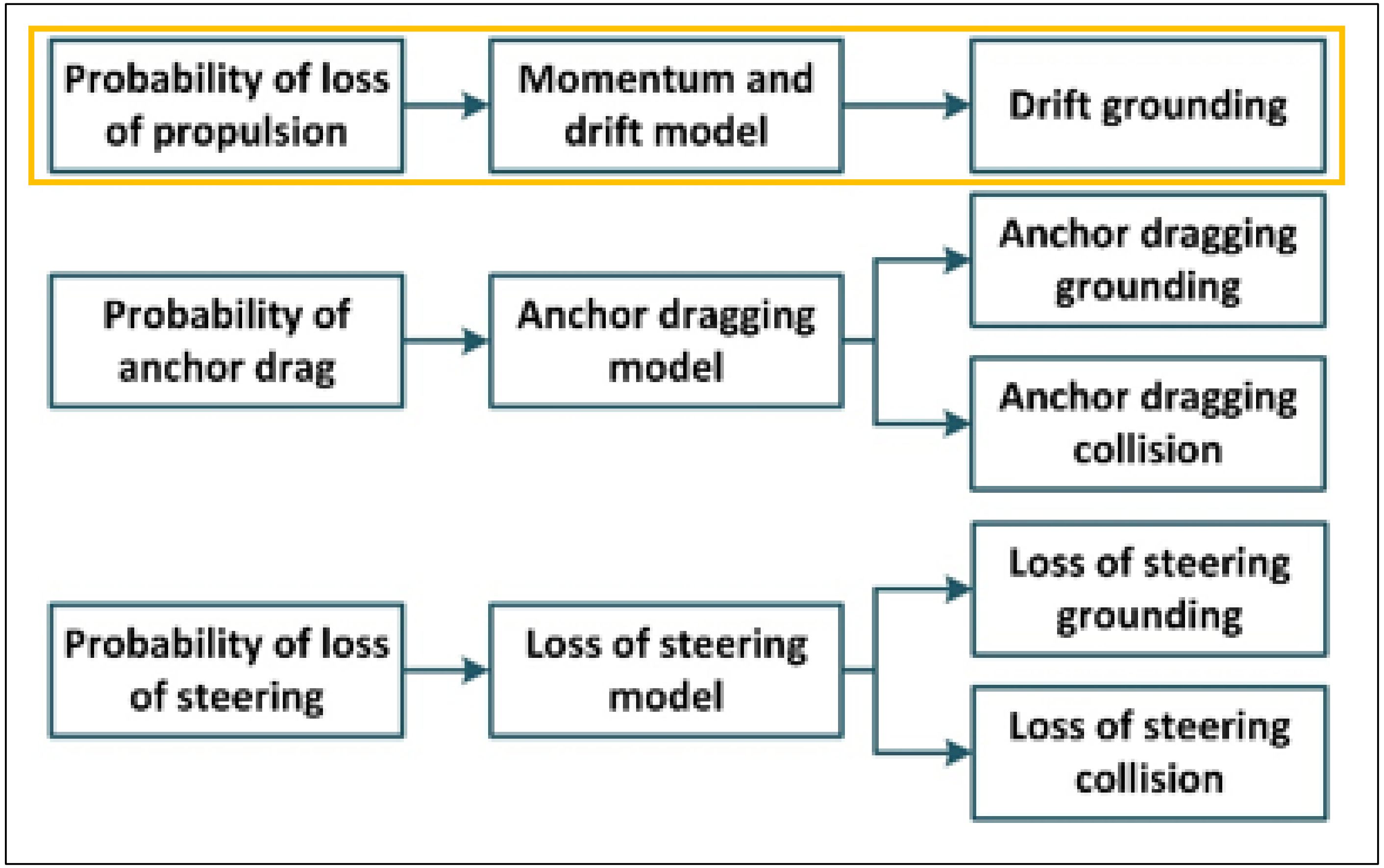
- Loss of Propulsion
- Loss of Steering
- Anchor Dragging

Mechanistic Approach

Modeling Indirect Hazards

Indirect Model Hazards

- Loss of Propulsion
- Loss of Steering
- Anchor Dragging



Momentum and Drift Model

Purpose:

- Simulate ship movement after a total loss of propulsion while underway

Key Considerations:

- Inshore Study Area

Components of Momentum and Drift Model

Loss of Propulsion	Crew Actions	Velocity Vector	Self Repair	Drift Grounding
Estimate of LOP Probability	Immediate course change using remaining momentum	Ship trajectory	Duration of the LOP, prior to regaining control	Overlap between ship draft and grounding contour

Velocity Vector

Ship's Momentum → ← External Forces and Drag

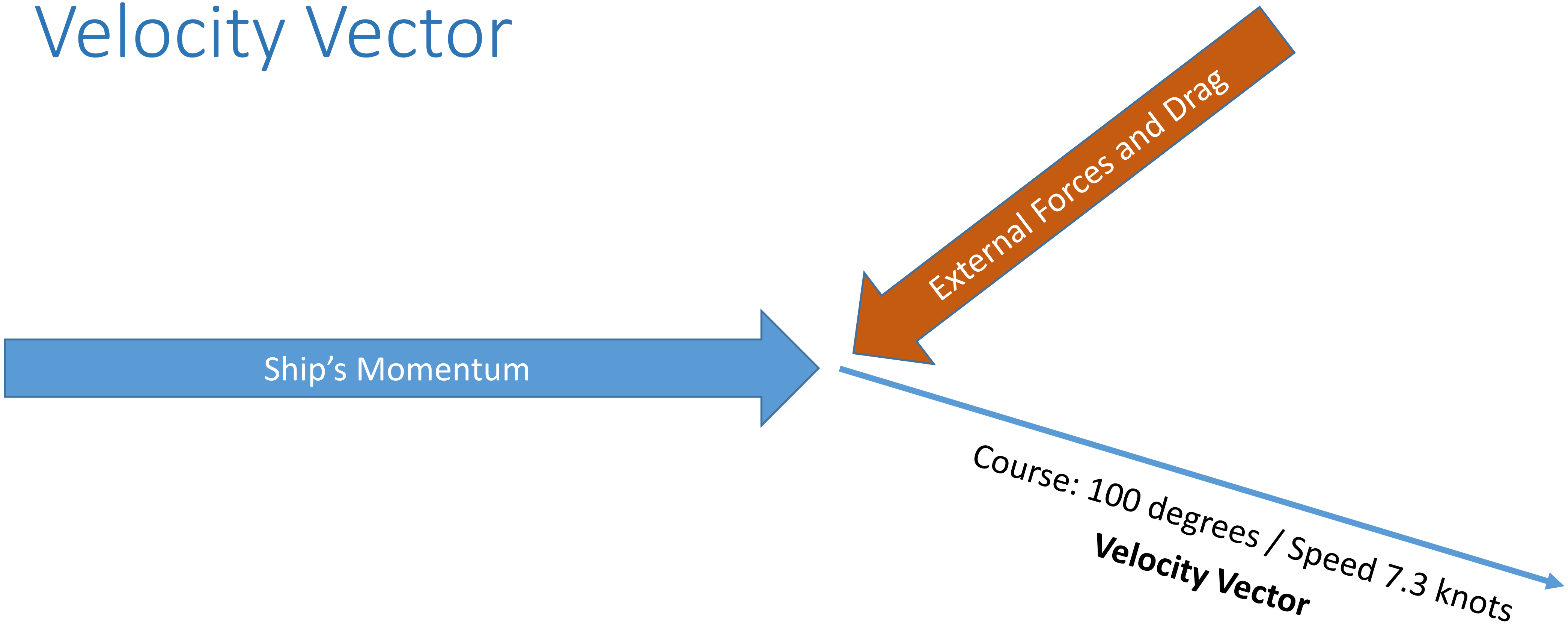
Ship's Momentum
- Ship's mass
- Added mass
- Ship's speed

External Forces
- Wind
- Current
- Waves

Ship Drag
- Drag Coefficients
- Wind/water exposed areas
- Wind/water densities

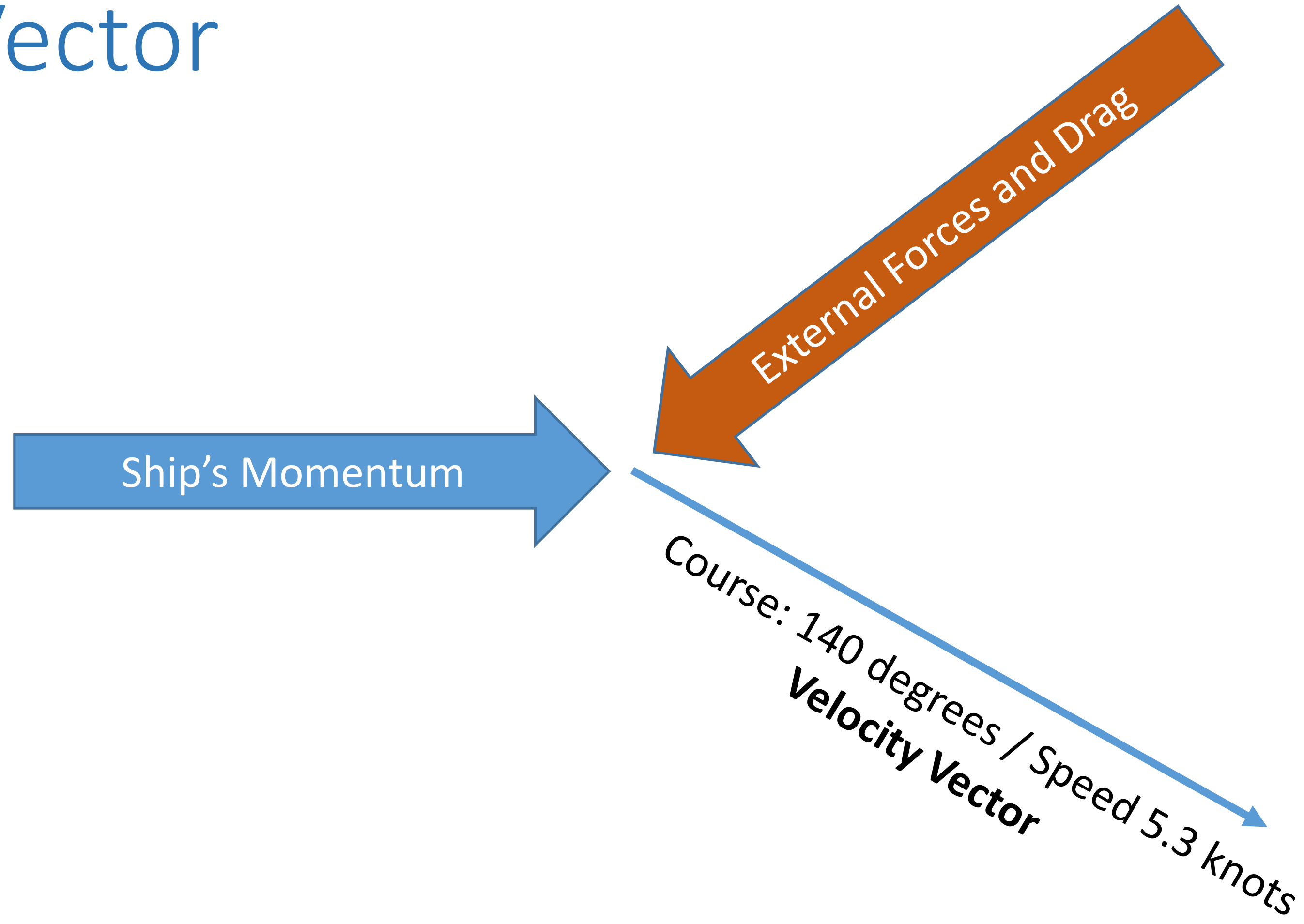
$$(m + m')\frac{dv}{dt} = F_{wind} + F_{current} + F_{wave}$$

Velocity Vector



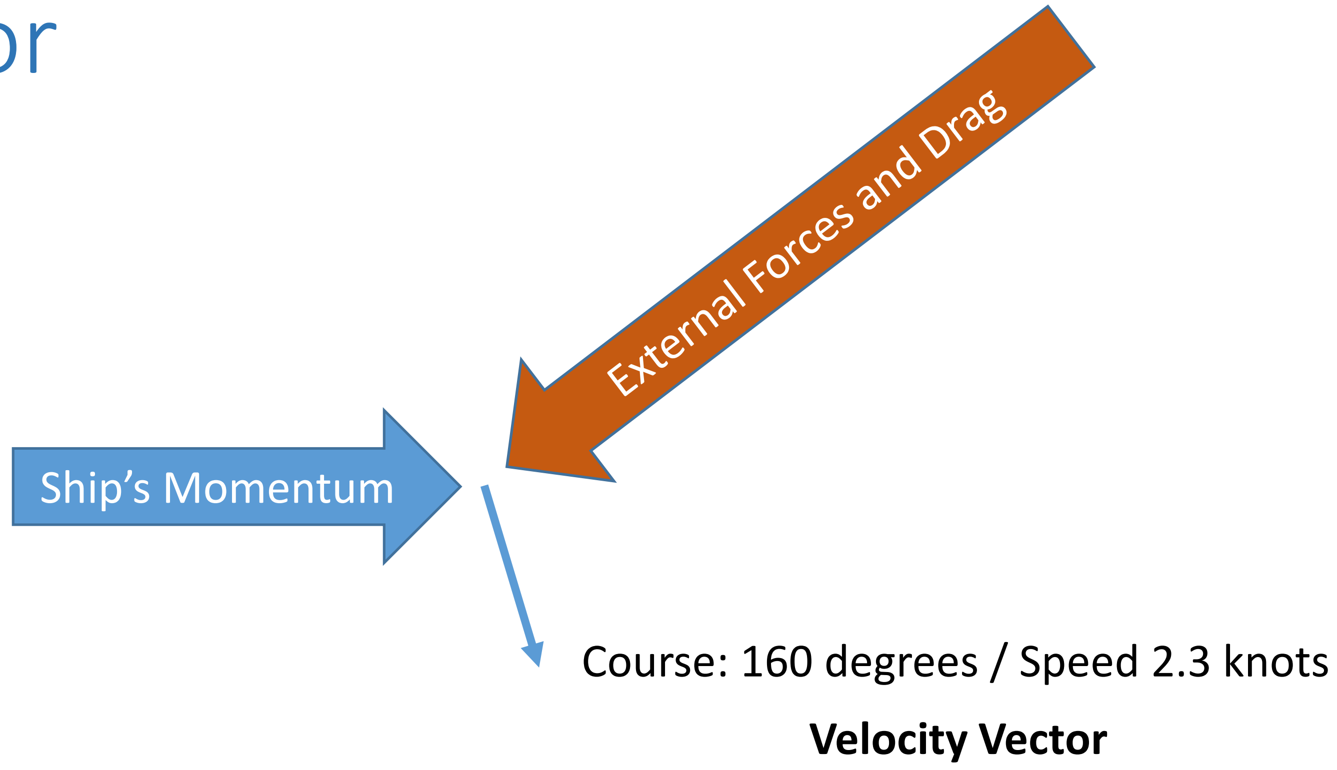
Calculated every 60 seconds

Velocity Vector



As the momentum drops, the external forces have a larger affect

Velocity Vector



Eventually, the ship’s momentum is expended, and the external forces and drag forces are responsible for the course and speed of the ship

Why This Approach

Strengths

- Allows incorporation of ship course and speed at time of LOP (aka "ship's momentum")
- Allows crew actions to be included, in form of course changes at moment of LOP
- Physics based model

Weaknesses

- Requires the identification of many parameters
- Not based on experimental or observed drift patterns
- Challenging to validate

Required Parameters

To be calculated with data from Salish Sea Model, IHS Markit, and Model outputs:

- Vessel Mass
- Vessel Length at Waterline
- Relative Air Speed
- Relative Water Speed

To be pulled from existing data:

- Air density
- Water density
- Wave amplitude
- Gravitational acceleration

Required Parameters

Need additional investigation to finalize calculation approach:

- Air dragging coefficient → Dependent on vessel type and angle of attack
- Water dragging coefficient → Dependent on vessel type and angle of attack
- Wave dragging coefficient → Dependent on vessel type and angle of attack
- Wind-exposed vessel area → $5 \times \text{or} \frac{1}{5} \times \text{water exposed area}$
- Water-exposed vessel area → $\text{Length} * \text{Draft} \;\&\; \text{Beam} * \text{Draft}$
- Added mass → 1/4 - 1/3 of vessel mass

Weather Data for External Forces

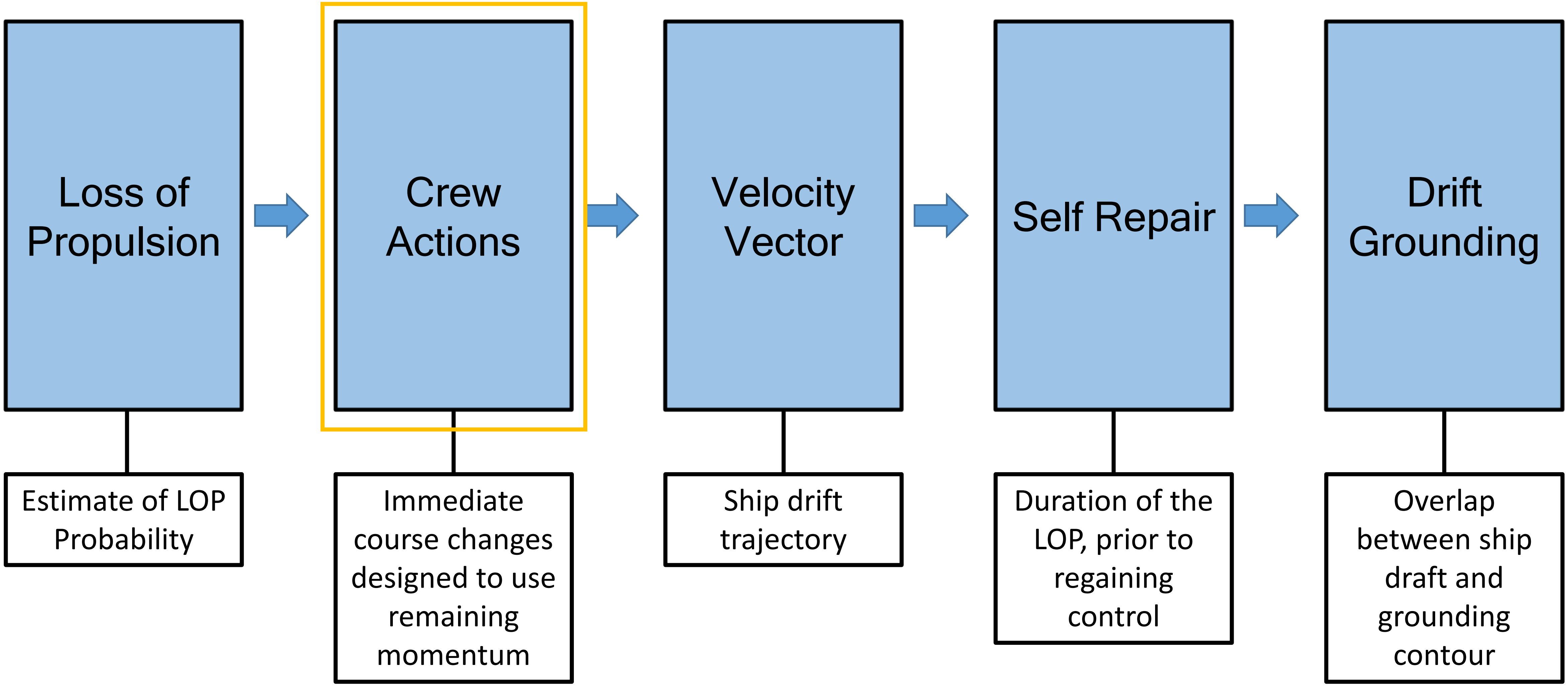
Salish Sea Model

- Developed by Pacific Northwest National Laboratory (PNNL) in collaboration with scientists from Department of Ecology

- Simulates hydrodynamic data based on inputs from river, streams, and point sources throughout the region

- Model development will rely on data from 2014, but we will add additional years of data for model analysis.

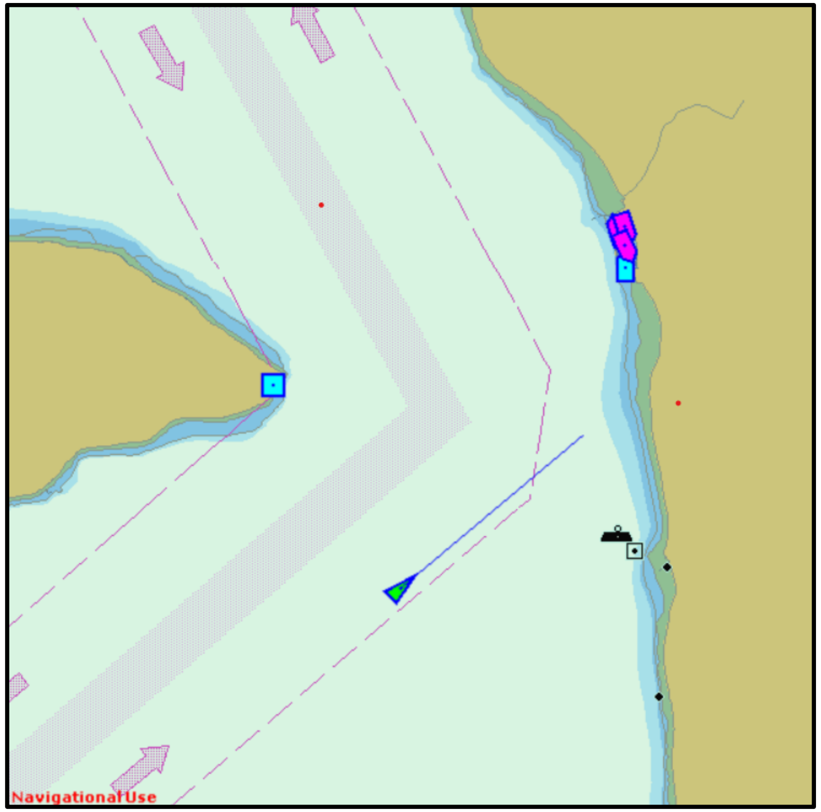
Components of Momentum and Drift Model



Crew Actions

What Happens Immediately Following a LOP?

- Momentum allows the crew some ability to control the vessel's heading.
- As momentum decreases ability to control the ship's heading is drastically reduced, and quickly resolves to a total lack of control



Why Does This Matter?

- Restricted waters
- Crew ability to avoid immediate grounding hazards

Our Approach to Crew Actions

Existing Approaches

- None found

Review of LOP incident reports

- Reviewed 133 local LOP events that fit our criteria (2007-2021)
- Identified 25 reports that include immediate crew actions

Crew Actions Identified in Historical Data

- Helm Offshore
- Maintain Heading

Helm Offshore

- "I put left rudder on to steer away from browns point"
- "I turned ship to the north to increase distance from ediz hook"

Maintain Heading

- "The helmsman was able to maintain a 046 Degrees True Heading"
- "Was able to keep vessel close to appropriate heading"

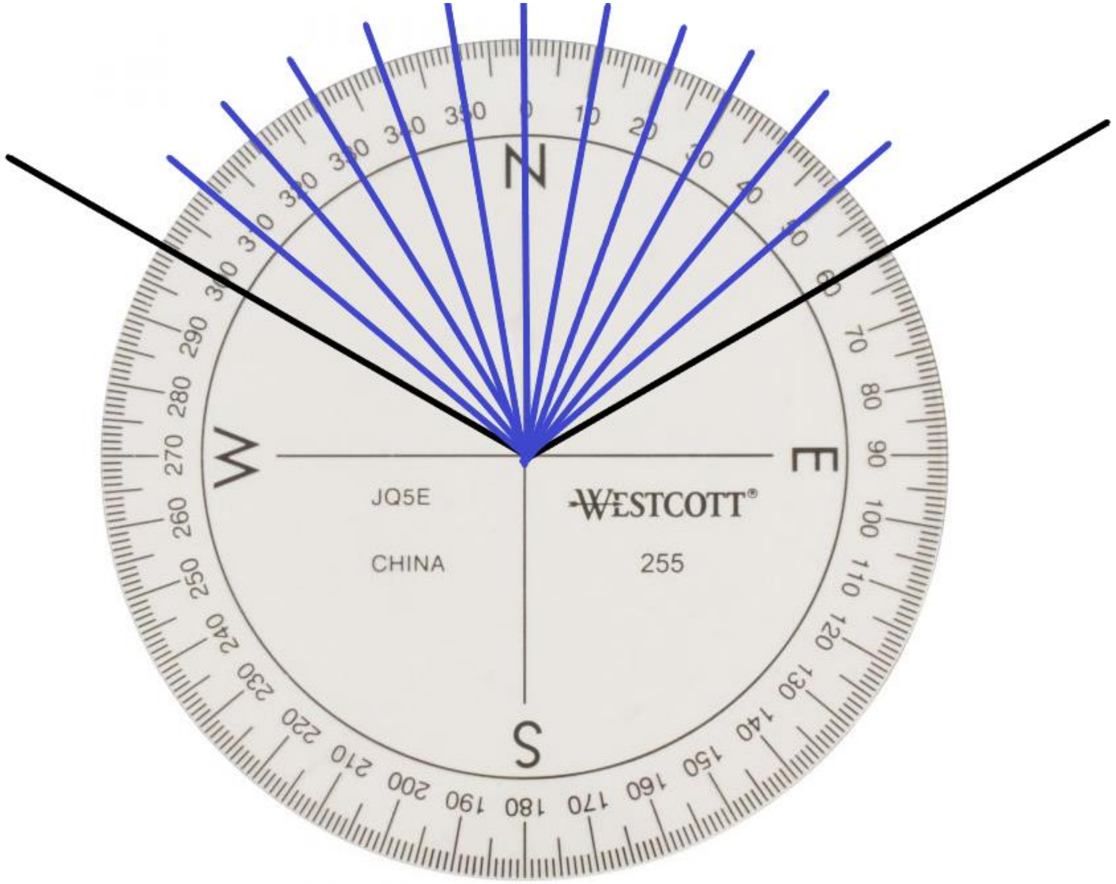
Our Approach to Crew Actions

Model Crew Actions:

- Ship may alter course at most 60 degrees to port or 60 degrees starboard.
- Ship prioritizes maintaining original heading, unless danger is close aboard.

Simulation Approach

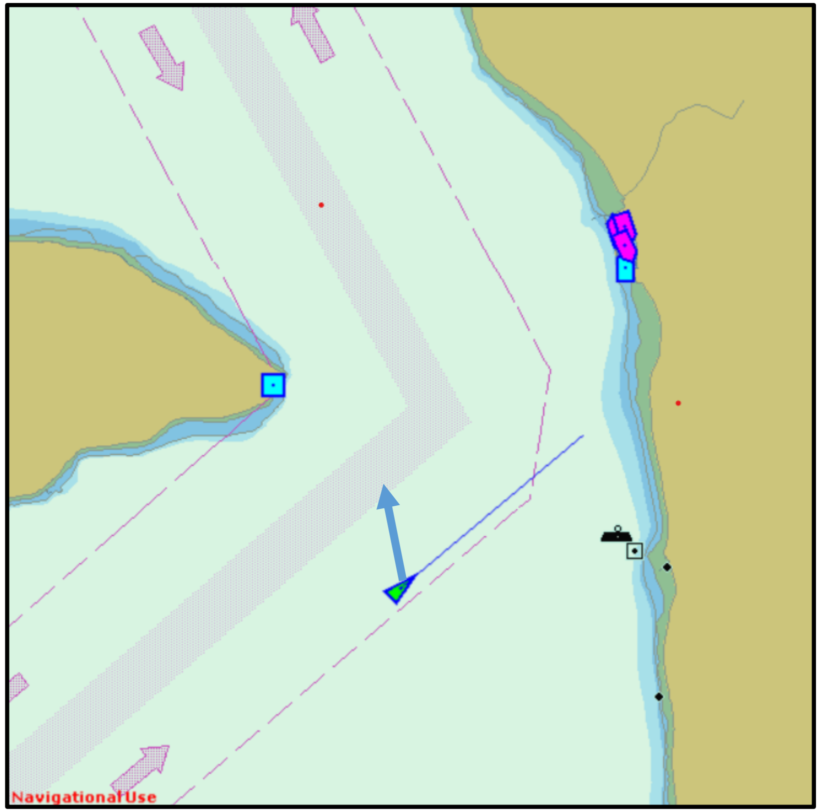
- Ship evaluates 10 degree “wedges” in a 120 degree forward arc.
- The ship chooses a course within a hazardless wedge
- Ship maintains original heading, unless danger is close aboard.



Rationale for our Approach

Why 120 degree arc?

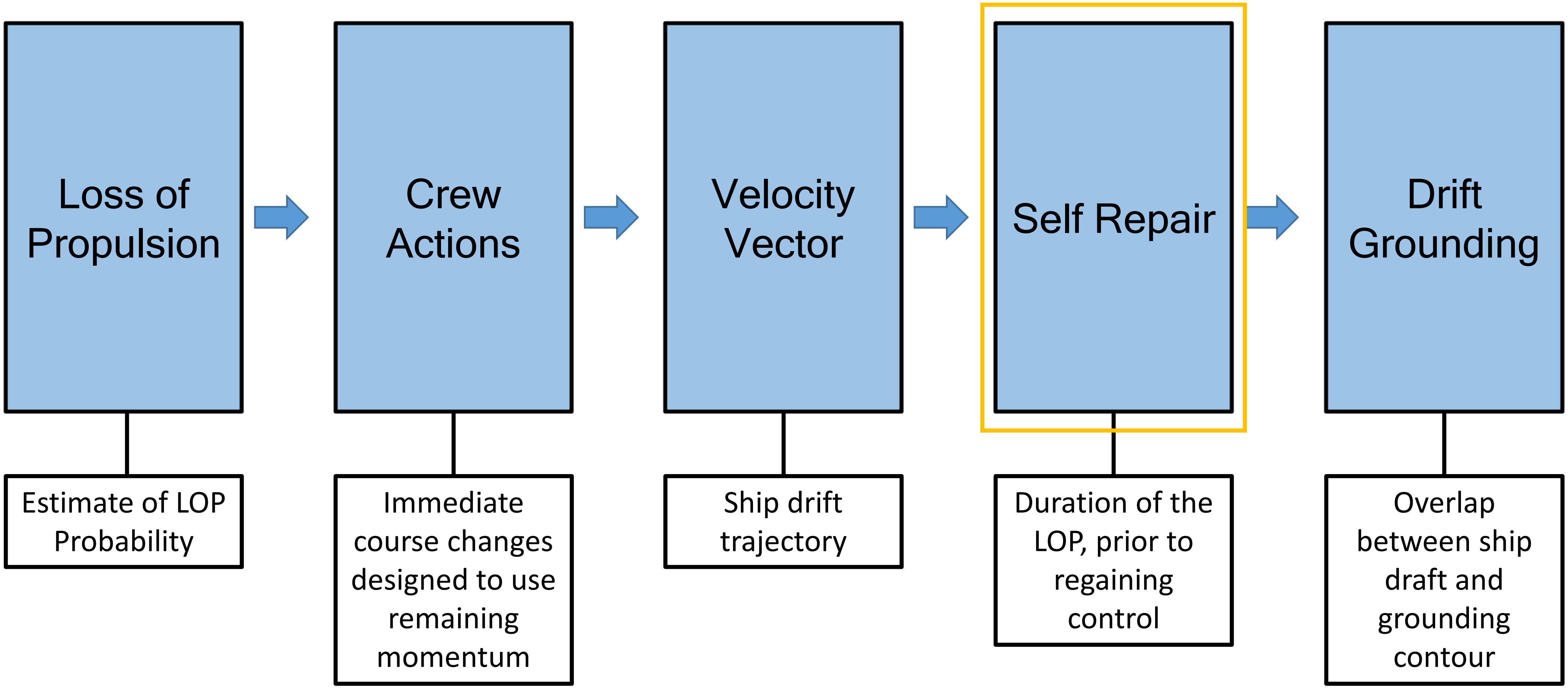
- 60 degrees to port or starboard allows a ship to avoid immediate danger resulting from operating in restricted waters
- This allows simulated ships that have suffered an LOP to lose momentum and begin drifting



Why Course Change?

- Our model only represents courses, not headings, so we are unable to evaluate ship's movements in terms of heading change

Components of Momentum and Drift Model



Time to Self Repair

What happens during an LOP event?

- When ships unexpectedly lose propulsion, crew works to recover propulsion
- The amount of time it takes to recover propulsion varies substantially
- For our modeling effort, we need a distribution of propulsion recovery times

Our Approach to Establishing a Time to Self Repair

Existing Approaches

- Either based on expert elicitation, or very small datasets

Review of LOP Incident Reports

- Reviewed 133 local LOP events that fit our criteria (2007-2021)
- Identified 31 reports that include timing information

Proof of Concept

- Sufficient data exists for us to produce a distribution of self repair times

Next Steps for Momentum and Drift Model

Velocity Vector

- Parameter Identification

Self Repair

- Identification of additional datasets that might inform the time to self repair distribution

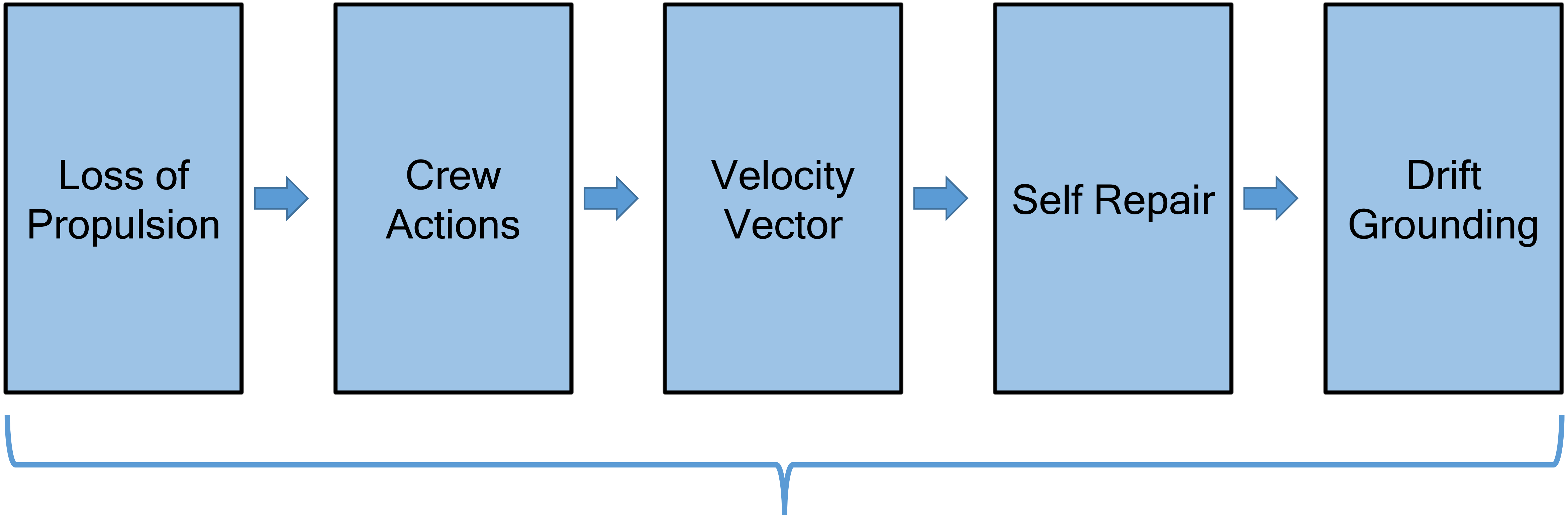
Crew Actions

- Review initial momentum and drift model outputs to determine if crew action module is working as designed

Drift Grounding Criteria

- Determine criteria for groundings

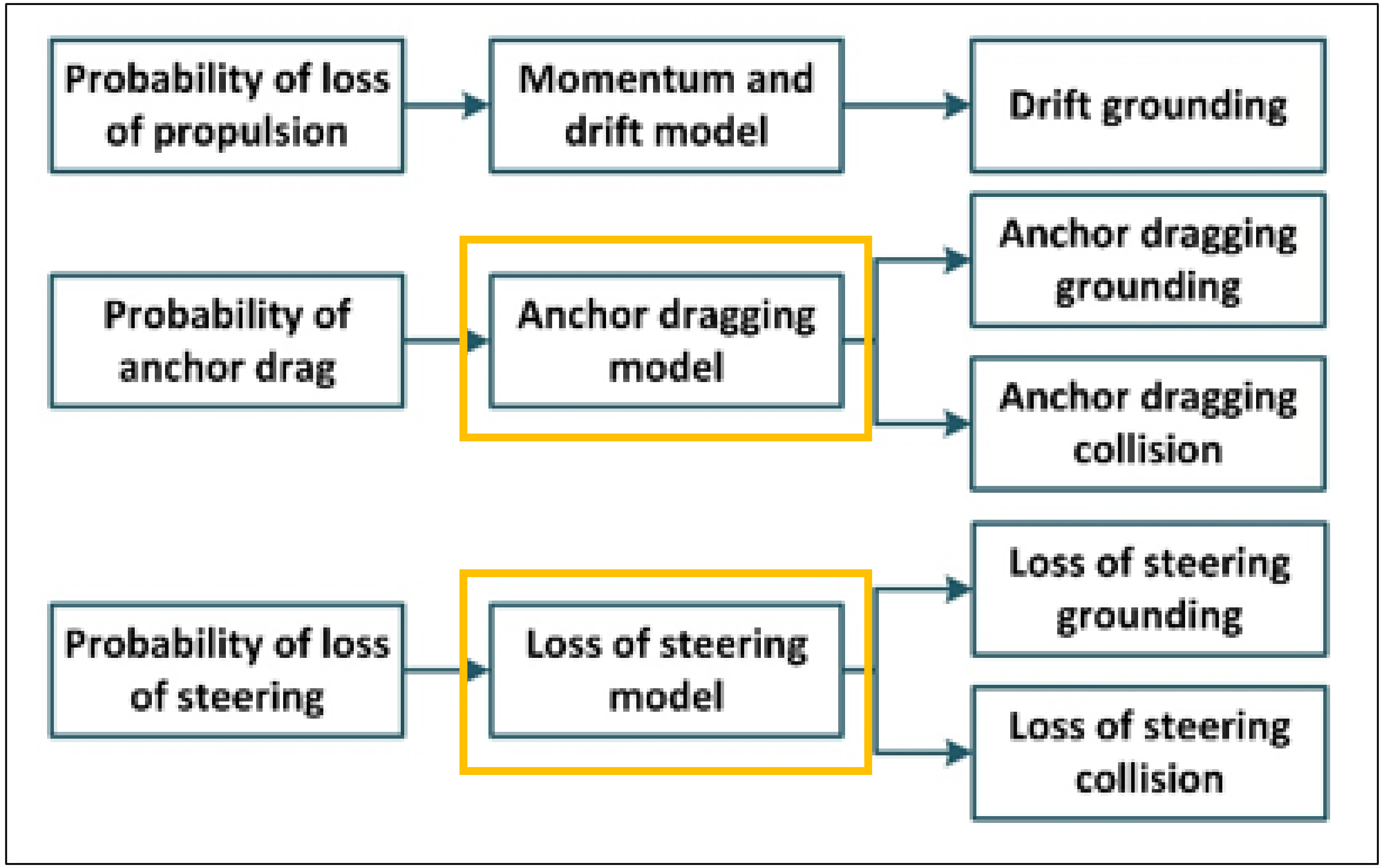
Components of Momentum and Drift Model



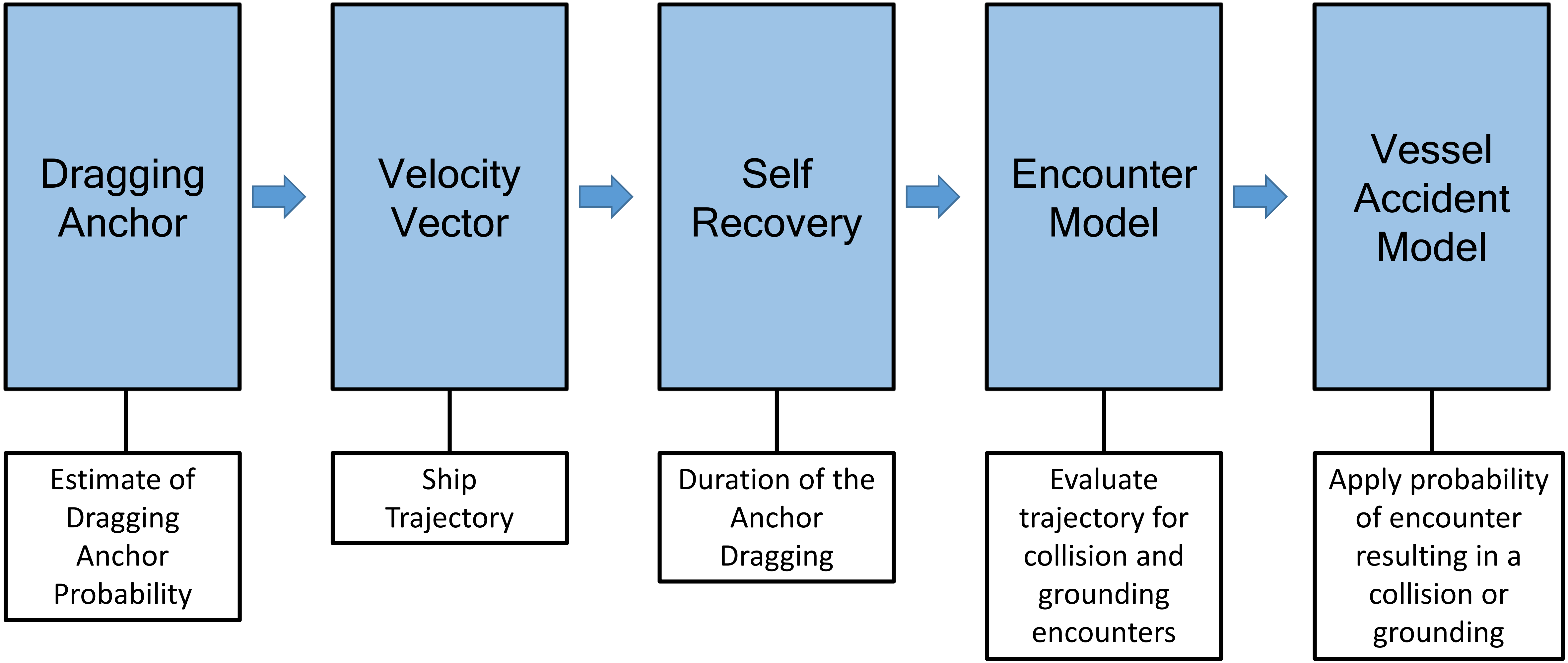
Interventions

Tug Intervention
Emergency Anchoring

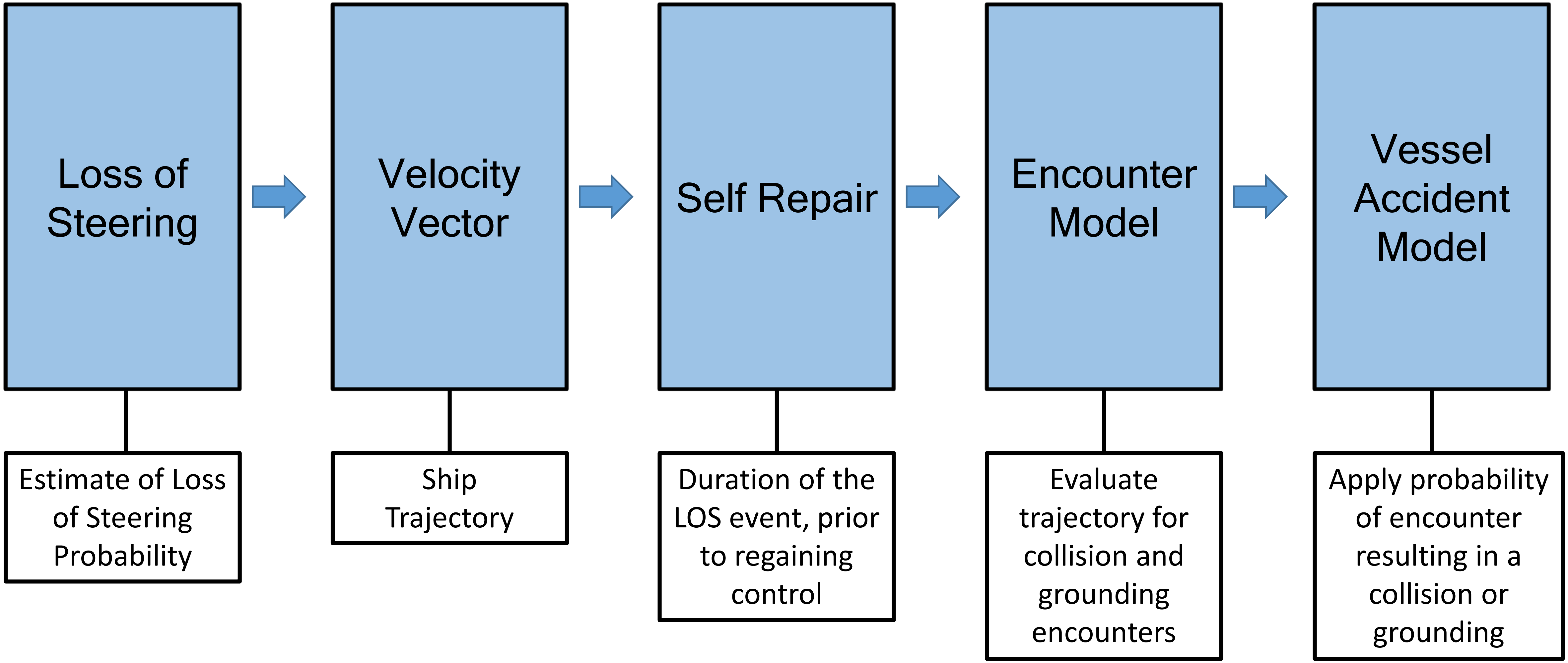
Remaining Indirect Models



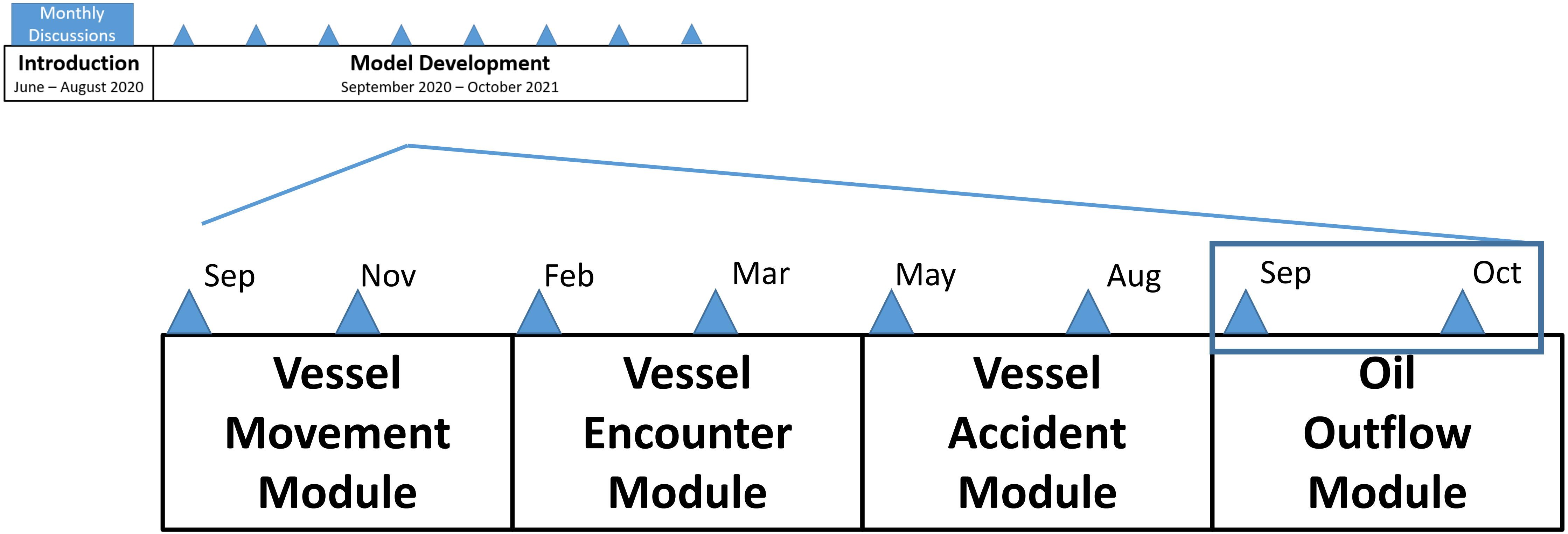
Potential Components of Anchor Dragging Model



Potential Components of Loss of Steering Model



Webinars and Technical Discussions



Upcoming events

September 22nd, 2021 -- 1 pm to 3 pm

- Oil Outflow Module

Analysis Updates

Tug Escort Analysis Draft Scope of Work

- Analysis objectives and high level research questions
- Will be shared via email on August 31

ERTV Analysis Draft Scope of Work

- Analysis objectives and high level research questions
- Will be shared via email on August 31

Questions and comments welcome

Next Steps for Analysis Projects

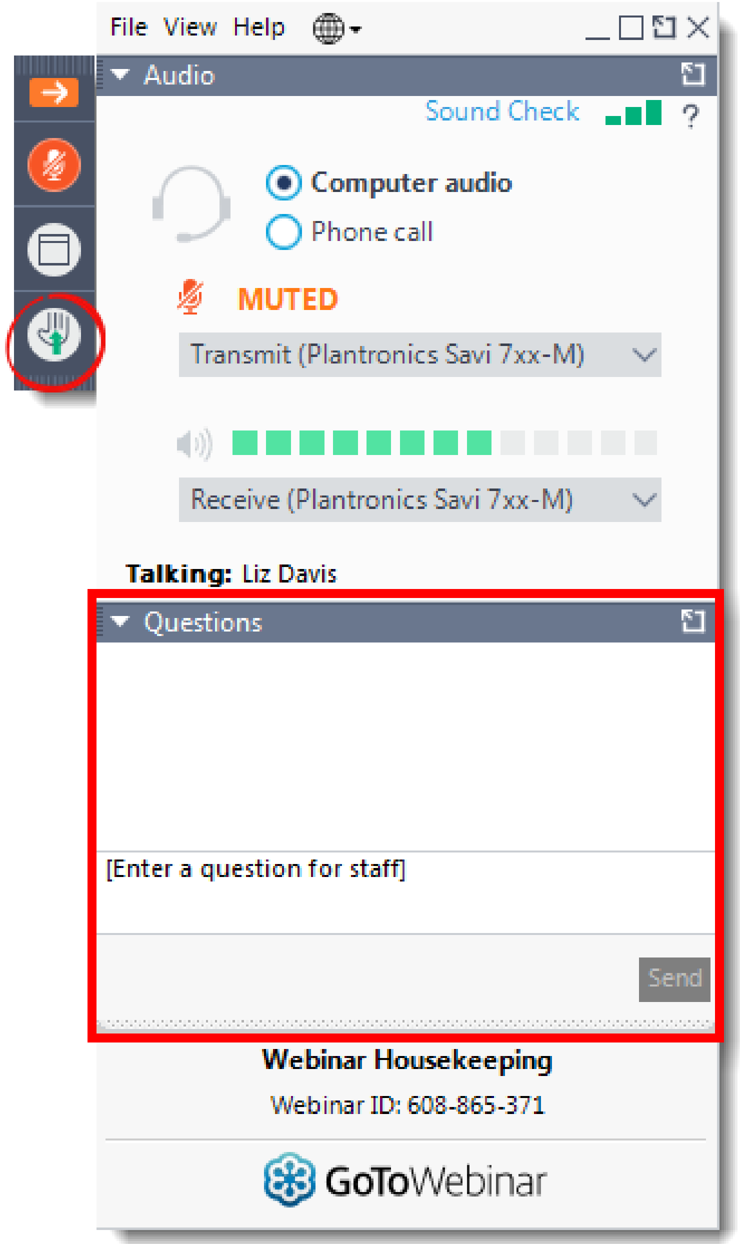
Tug Escort Analysis

- Review of comments received on draft scope
- Presenting draft scope to Board of Pilotage Commissioners
- Outreach kickoff in early 2022

ERTV Analysis Draft Scope of Work

- Review of comments received on draft scope
- Outreach kickoff in early 2022

Discussion logistics



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