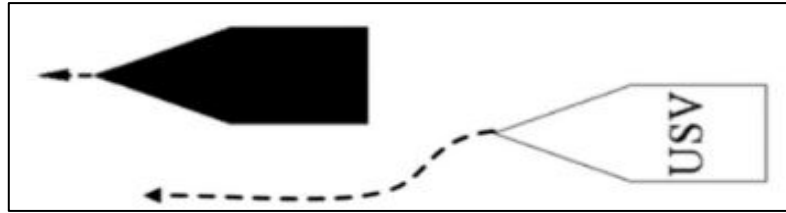


# **A COLREGs-Compliant Local Guidance System for Unmanned Surface Vehicles (USV) based on Hierarchical Task Network (HTN)**

# Unmanned Surface Vehicles (USVs)



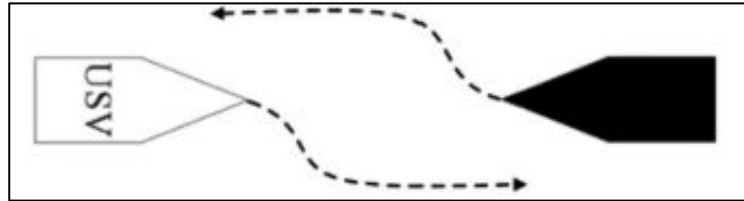
# Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs)



## Rule 13 – Overtaking:

Any vessel overtaking any other shall keep out of the way of the vessel being overtaken.

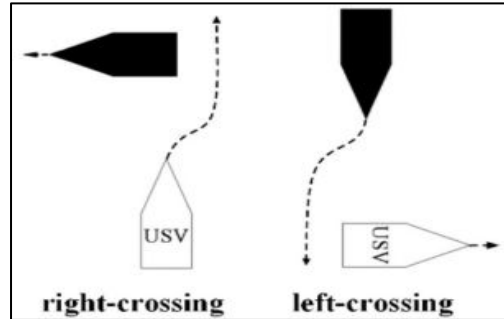
# Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs)



## Rule 14 – Head-on Situation:

When two power-driven vessels are meeting on reciprocal or nearly reciprocal courses so as to involve risk of collision, each shall alter her course to starboard so that each shall pass on the port side of the other.

# Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs)



## Rule 15 – Crossing Situation:

When two power-driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way and shall, if the circumstances of the case admit, avoid crossing ahead of the other vessel

# PROBLEM

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Reactive USV planning and acting on danger situations at sea.

# PROBLEM

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Reactive USV planning and acting on danger situations at sea.

- COLREGs non-objectiveness
  - Made by humans to humans

# HYPOTHESIS

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Modeling a USV guidance system using HTN is a effective way of deal with the COLREGs non-objectiveness.



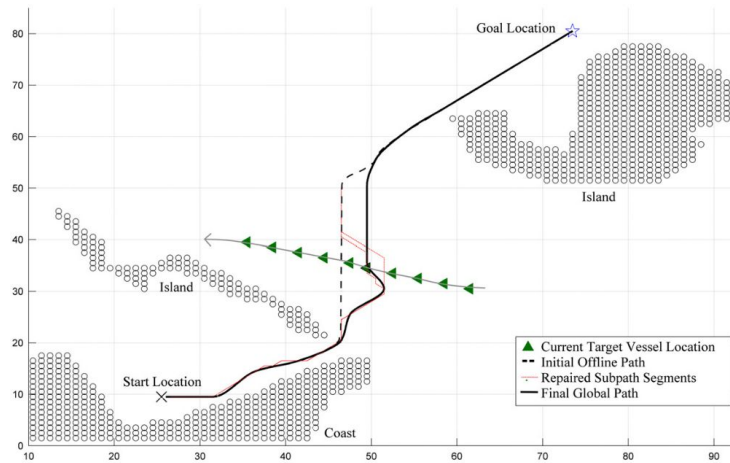
# PROPOSED WORK

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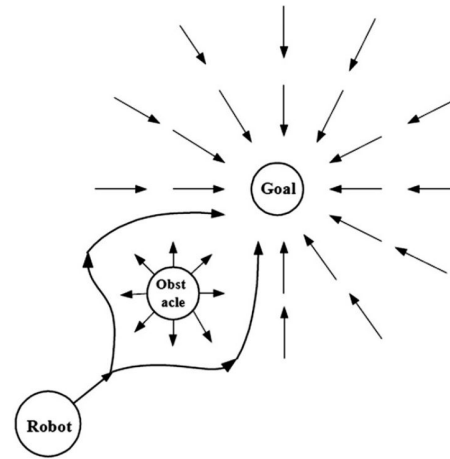
1. Guidance System for USV
  - a. Reactive to danger situation at sea
  - b. COLREGs-Compliant
  - c. HTN based

# GUIDANCE SYSTEM

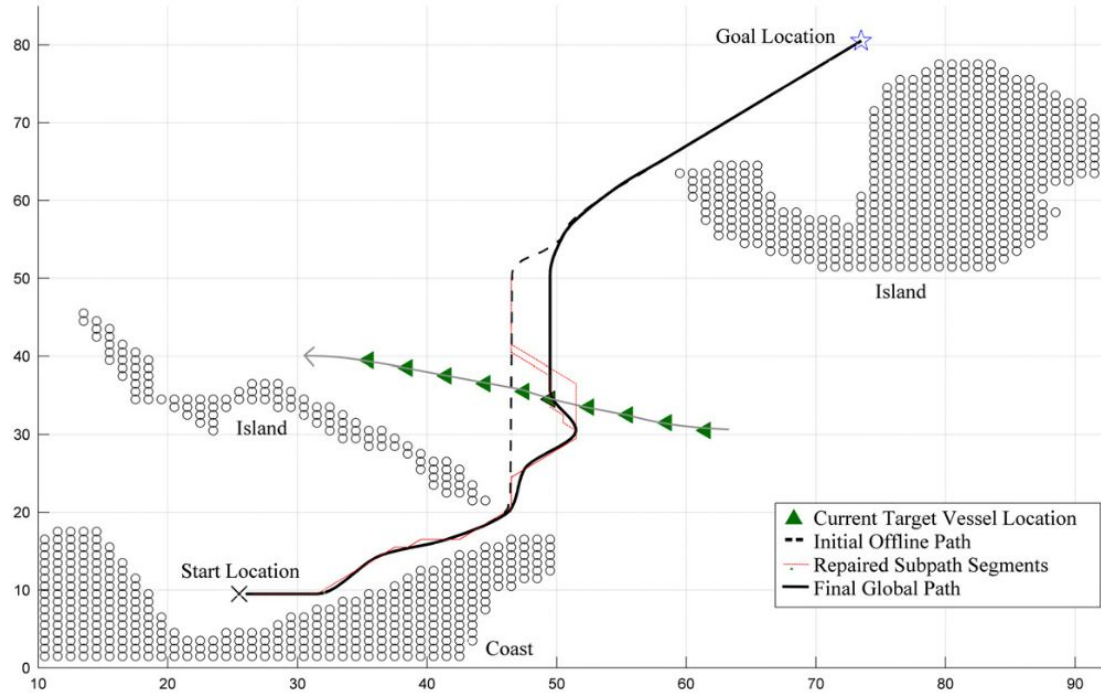
## GLOBAL



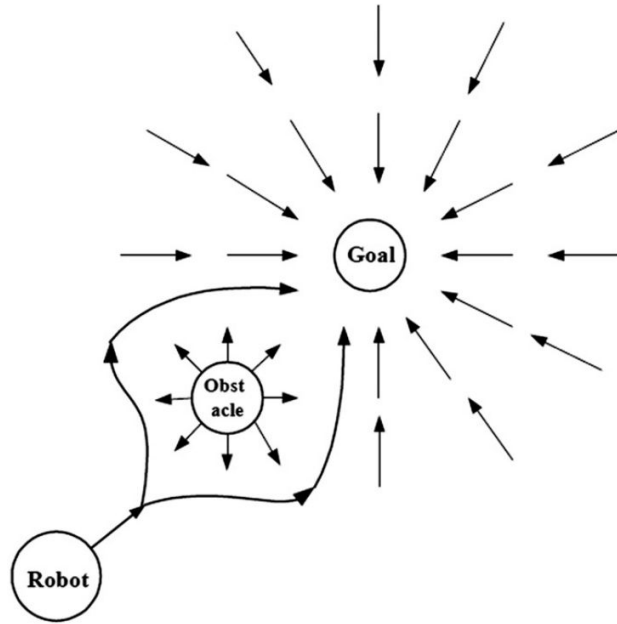
## LOCAL



# GUIDANCE SYSTEM - GLOBAL



# GUIDANCE SYSTEM - LOCAL



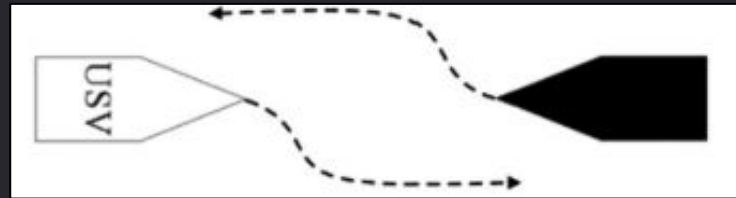
# DEVELOPED WORK

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## 1. LOCAL GUIDANCE SYSTEM

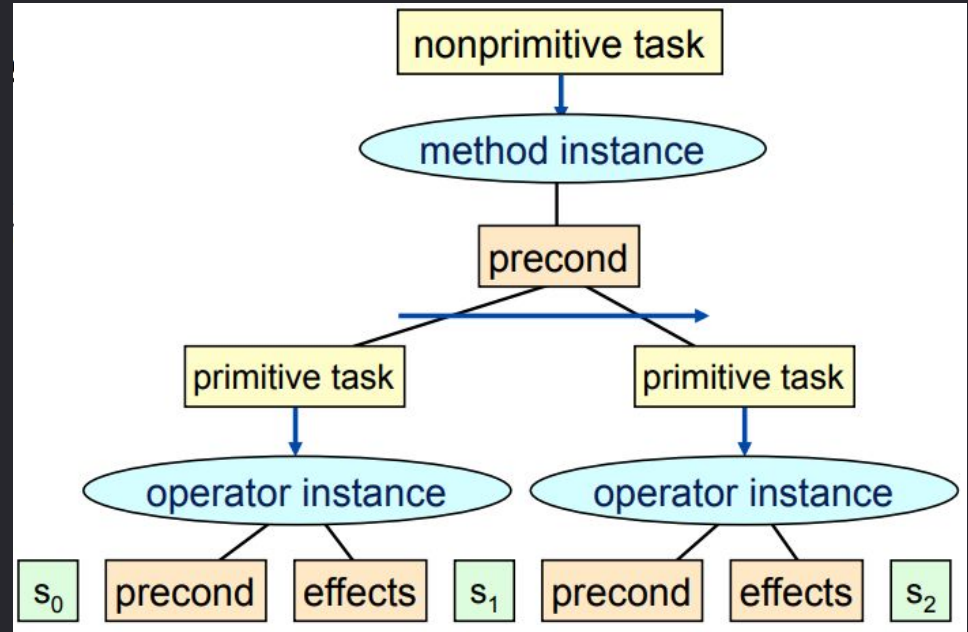
# DEVELOPED WORK

1. LOCAL GUIDANCE SYSTEM
  - a. Avoid head-on collision situations
  - b. COLREGs-Compliant



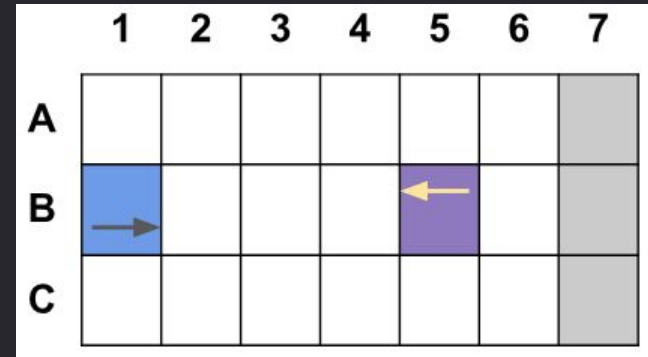
# DEVELOPED WORK

1. LOCAL GUIDANCE SYSTEM
  - a. Avoid head-on collision situations
  - b. COLREGs-Compliant
  - c. Based on HTN
    - i. Developed using JSHOP2



# DEVELOPED WORK

1. LOCAL GUIDANCE SYSTEM
  - a. Avoid head-on collision situations
  - b. COLREGs-Compliant
  - c. Based on HTN
    - i. Developed using JSHOP2
2. SIMPLE MISSION
3. GRID





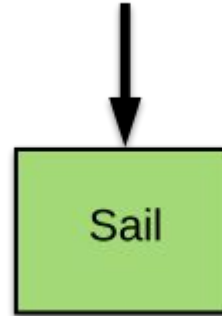
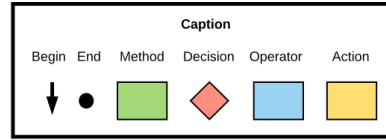
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	1	2	3	4	5	6	7
A		NW	N	NE			
B		W		E			
C		SW	S	SE			

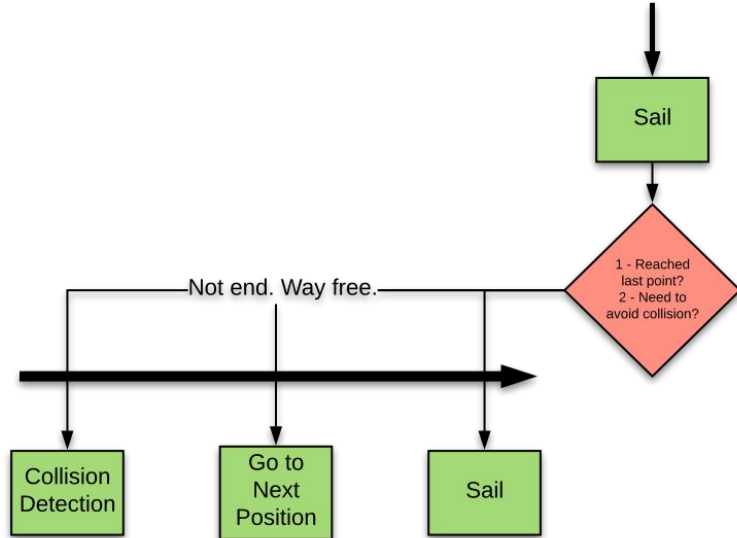
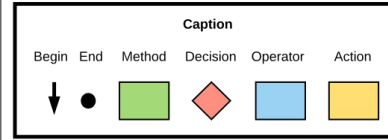
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  - c. Based on HTN
    - i. Developed using JSHOP2
2. SIMPLE MISSION
3. GRID
4. HIERARCHICAL TASK NETWORK
  - a. Sail



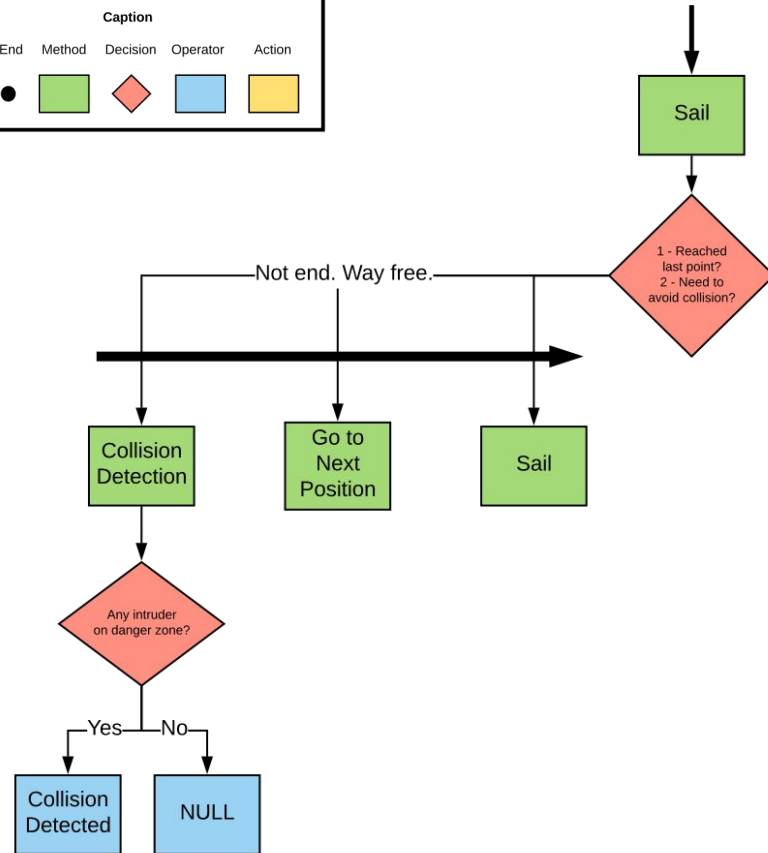
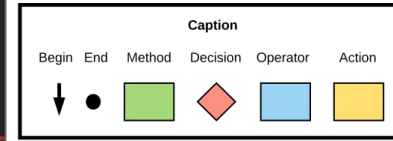
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2. SIMPLE MISSION
3. GRID
4. HIERARCHICAL TASK NETWORK
  - a. Sail
  - b. Collision Detection
  - c. Go to the next position



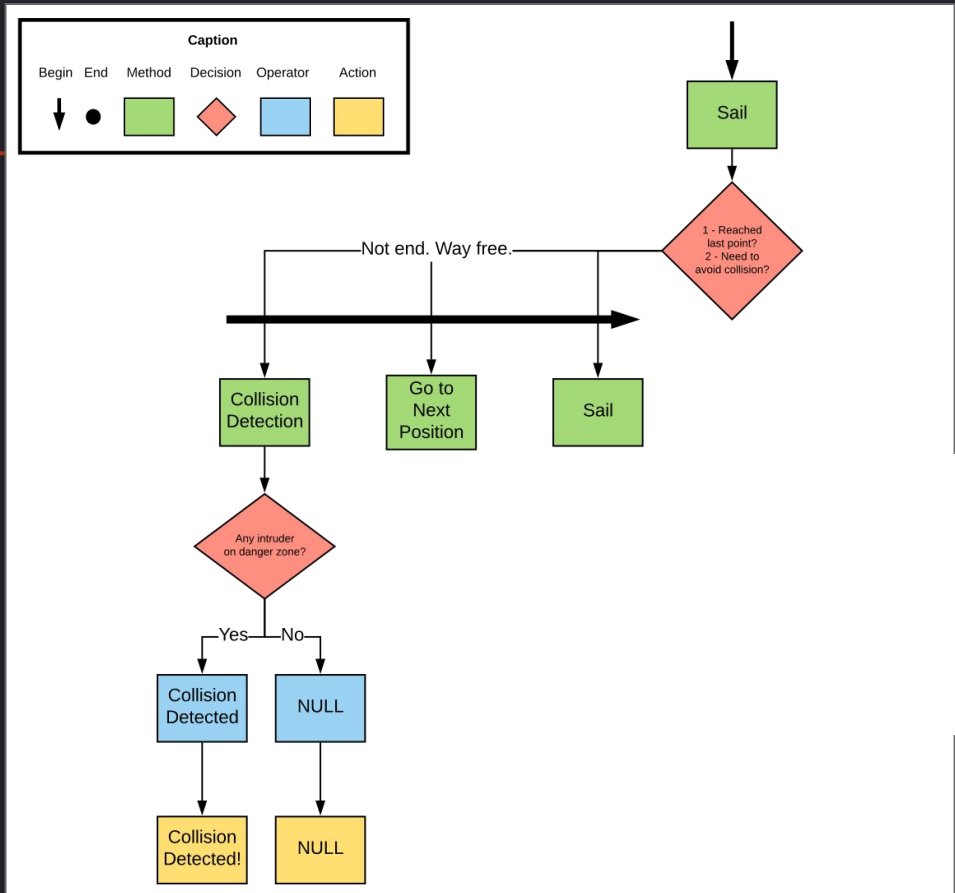
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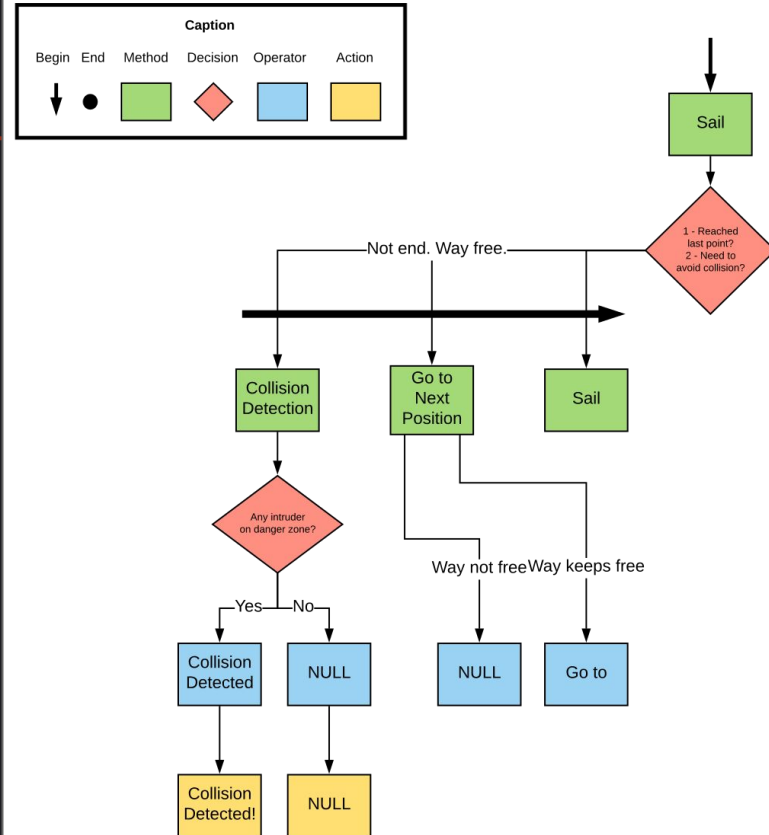
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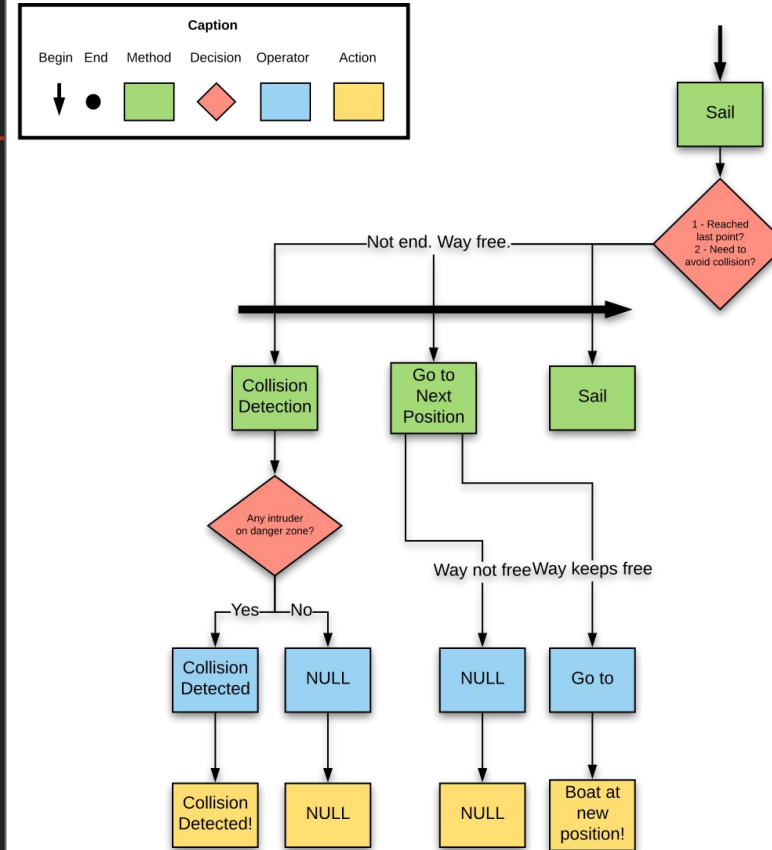
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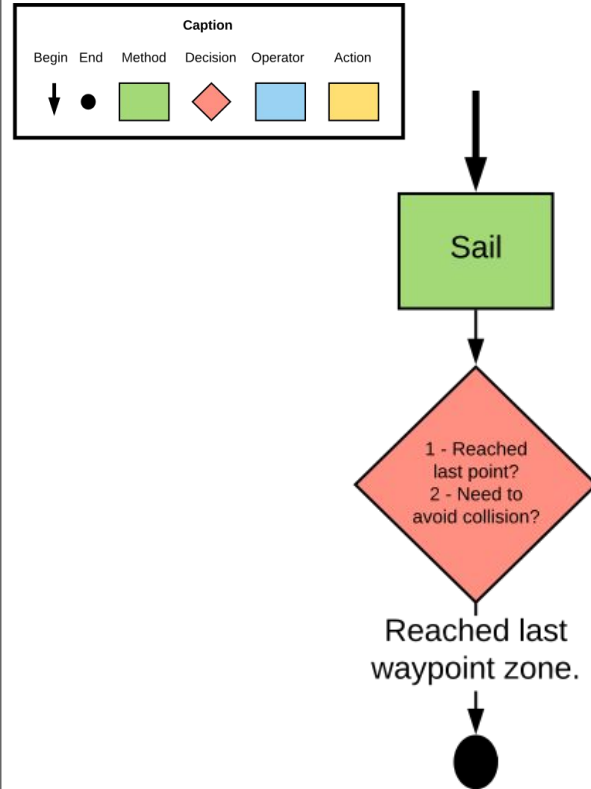
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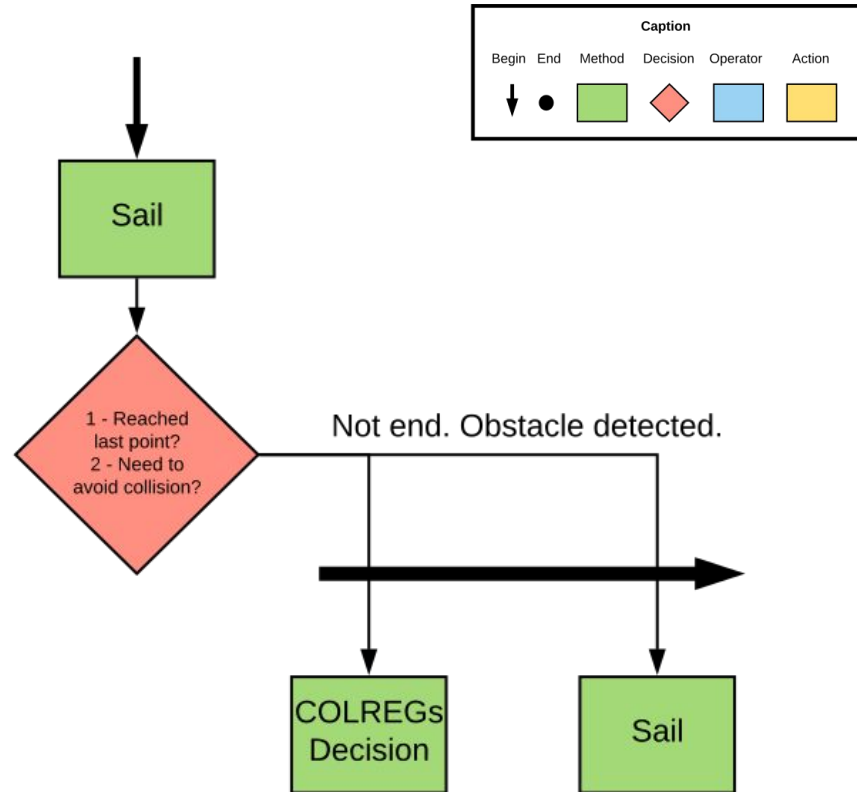
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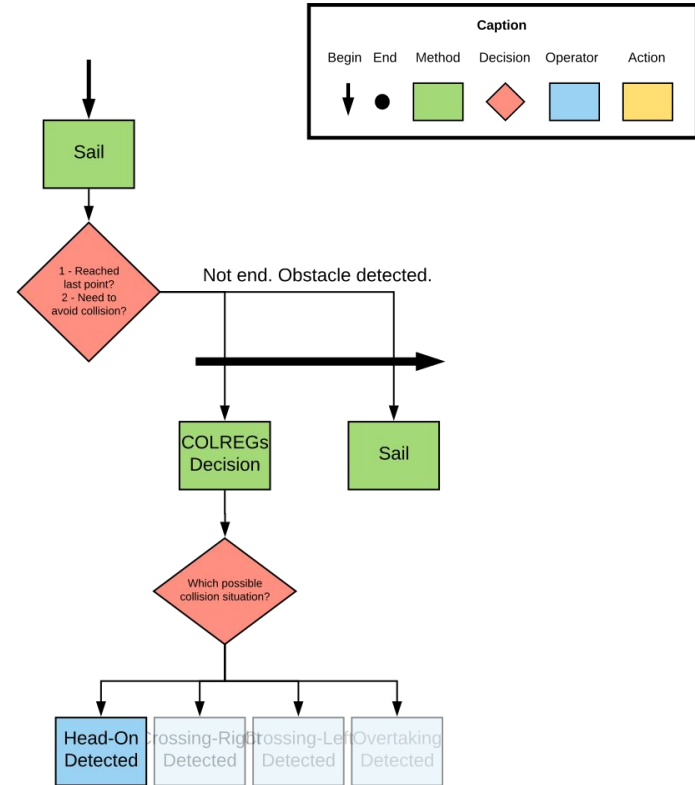
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  - a. Sail
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  - c. Go to the next position
  - d. Avoid according to the COLREGs



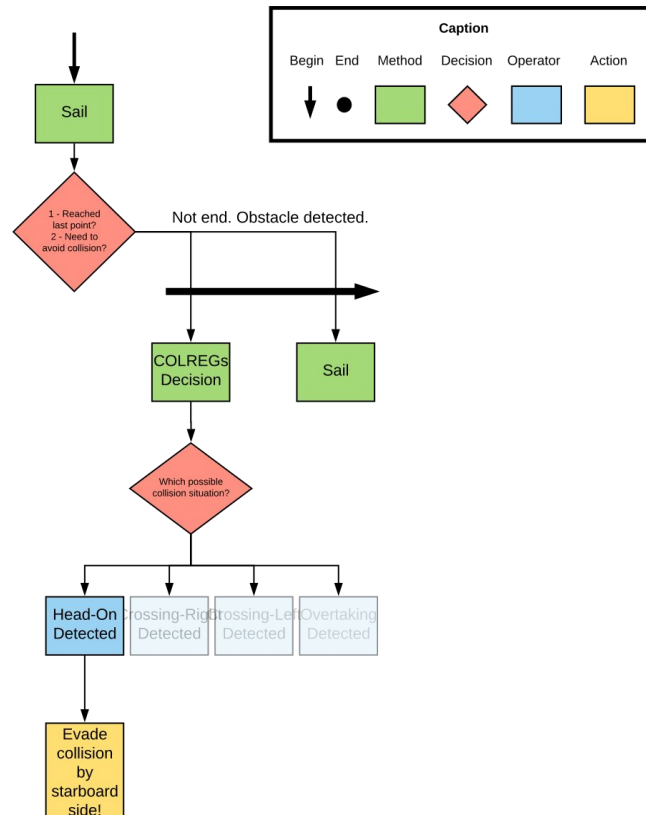
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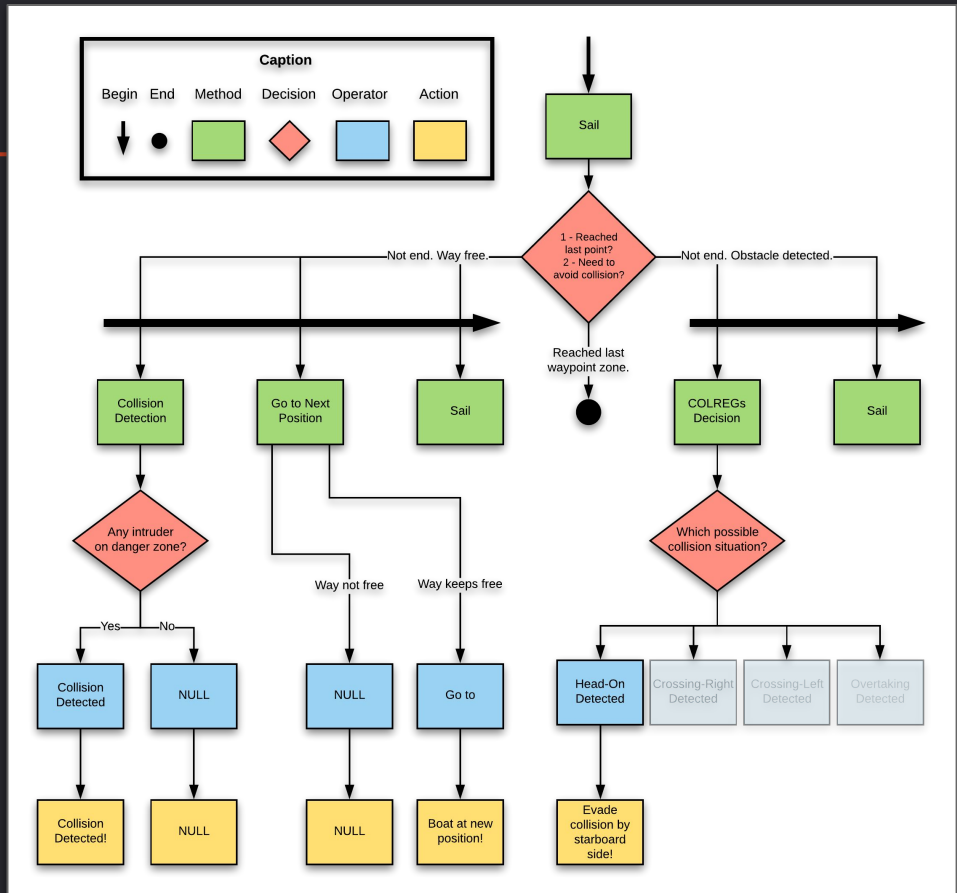
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  - b. Collision Detection
  - c. Go to the next position
  - d. Avoid according to the COLREGs



# EXPERIMENT

## SIMPLE MISSION

Go ahead and stops when reached predefined end points.

	1	2	3	4	5	6	7
A							
B							
C							

## GRID

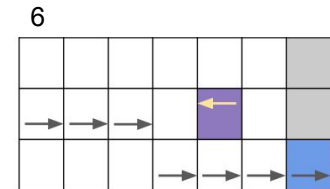
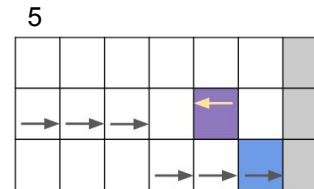
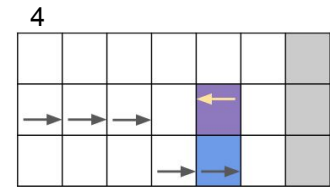
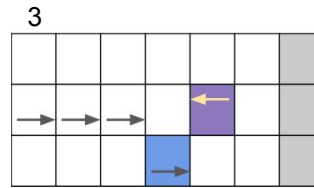
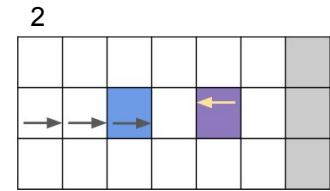
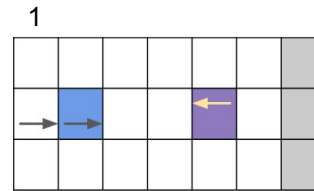
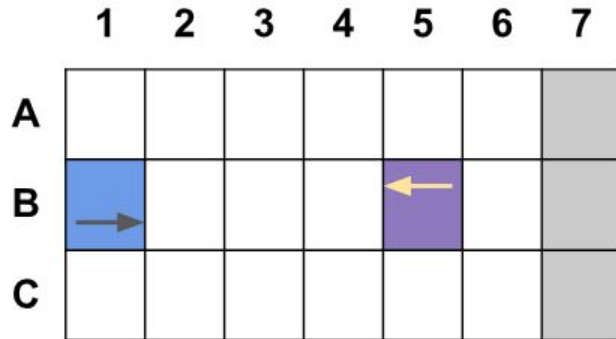
Environment modeled based on a grid representation.

	1	2	3	4	5	6	7
A		NW	N	NE			
B		W		E			
C		SW	S	SE			

# EXPERIMENT

## SIMPLE MISSION

Go ahead and stops when reached predefined end points.

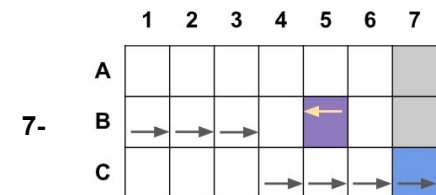
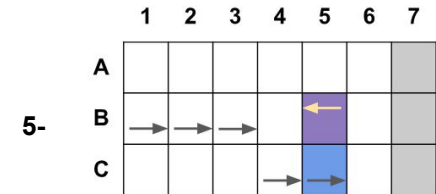
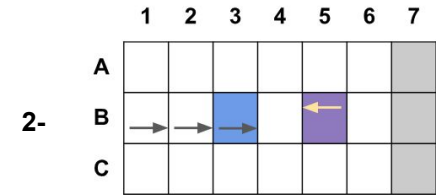
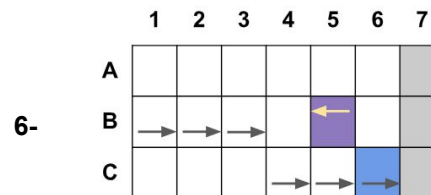
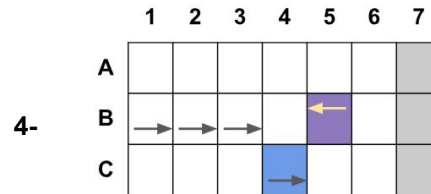
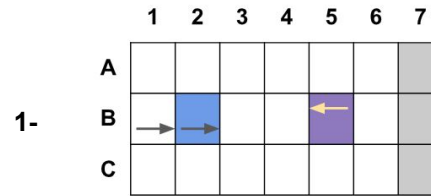


# EXPERIMENT

## JSHOP 2 Output

Defined plan.

```
1] (!goto boat1 gc_b1 gc_b2)
2] (!goto boat1 gc_b2 gc_b3)
3] (!collision-detected boat1)
4] (!head-on-detected boat1 e)
5] (!goto boat1 gc_c4 gc_c5)
6] (!goto boat1 gc_c5 gc_c6)
7] (!goto boat1 gc_c6 gc_c7)
```



# Conclusion and Future Work

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## CONCLUSION

- It was implemented a local guidance system
  - Based on HTN
  - Capable of avoid head-on collision situations
  - COLREGs-compliant for COLREGs 14 (Head-on)
  - Dealt with COLREGs non-objectiveness (in the presented scope)

## FUTURE WORK

- Implement other danger situation such as
  - Overtaking
  - Crossing
  - Encounter between different types of ships
- Experiment in more realistic and complex environment
  - Gazebo integration



# Thanks!

# Q&A

## Rule 19

### ***Conduct of vessels in restricted visibility***

(a). This Rule applies to vessels not in sight of one another when navigating in or near an area of restricted visibility.

(b). Every vessel shall proceed at a safe speed adapted to the prevailing circumstances and conditions of restricted visibility. A power-driven vessel shall have her engines ready for immediate manoeuvre.