MILESTONE 6: Targets

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Introduction

Targets and metrics are vital in determining the end goal that a design needs to accomplish. The targets and metrics are mainly derived by the functions found in the functional decomposition. The mechanical engineering RoboBoat team is merging with the electrical engineering RoboBoat team, and they will have the final say on the power requirements.

A target is a specific value to design a product to meet. The metric is what method will be used to validate the function from the functional decomposition. There are a couple different types of measures; Performance, Physiological, Subjective, and Objective.

Performance measures are directly quantifiable and reproducible; such as a length, temperature, or pressure. This is easy to confirm, and some performance methods of the RoboBoat would include the weight, size.

Physiological measures are more difficult to measure, they include things that deal with the end user such as comfort, ease of use and mental workload. For the RoboBoat the physiological measures consisted of style.

Subjective measures are performance measurements measured by an end user (preferably a professional). The RoboBoat is not in the stage where subjective measurements can be determined.

Objective measurements are similar to performance but are typically measured with instrumentation. The RoboBoat objective measurements could include motor speed (rpm), thrust and GPS positional accuracy.

Derivation of Targets and Metrics

The functional decomposition was made by taking customer needs and forming them into distinct functions and subfunctions. The functional decomposition is then used to derive the targets and metrics for each function. The values for the targets and metrics were found via component specification sheets, goals based on previous competition performances, the electrical engineering senior design team, and advisor recommendations. The critical were determined as what was needed to have the bare minimum for a boat to compete.

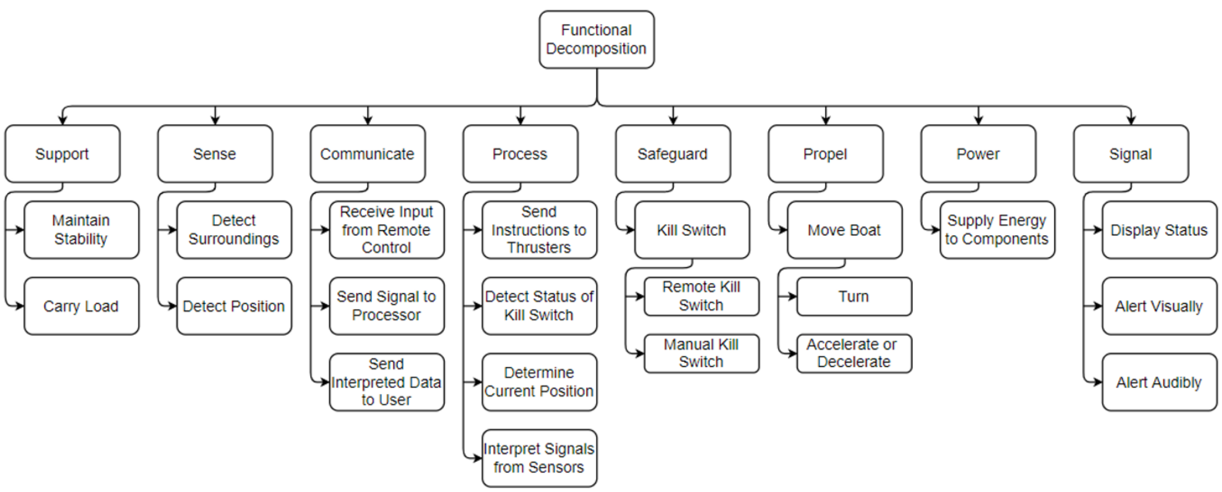


Figure 1: Functional Decomposition

Explanation of Targets and Metrics

The list below explains the functions and their relation to the targets and metrics

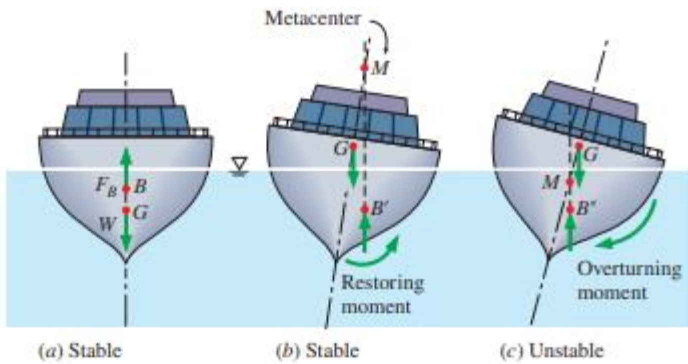


Figure 2: Stability of Boats in regards to Center of Gravity vs Center of Buoyancy

- **Maintain Stability:** A seen in Figure 2, to properly maintain stability the RoboBoat should have a center of gravity below the center of buoyancy, and as the boat rocks the metacentric height GM, which is the distance between the center of gravity G and the metacenter M, will self correct the boats stability. If the center of gravity is above the center of buoyancy then the boat's metacentric height will cause an overturning moment, capsizing the boat. Thus the team aims to have a boat that is bottom-heavy.
- **Carry Load:** The boat hull will contain/support the electrical workings, battery, sensors, processing unit, status indicators, and objects for delivery. The weight distribution and total weight will affect the center of gravity, and therefore directly affects maintaining stability. The target is to be under the weight limit (less than 140 lbs), with stable object placement.
- **Detect Surroundings:** The boat will be equipped with sensors capable of detecting the surroundings of the RoboBoat. Our goal is to detect objects up to 20 feet away.

- **Detect Position:** The boat will be equipped with some sort of GPS system capable of detecting the position of the RoboBoat. The position of the boat will be measured in GPS coordinates. The target is to have a GPS system that provides location within ____ range.
- **Communication:** The three sub functions under communication are “Receive Input from Remote Control”, “Send Signal to Processor”, and “Send Interpreted Data to User”. All of these will be measured in hertz, however each has a different target for the speed at which it needs to be communicated. “Receive Input from Remote Control” and “Send Signal to Processor” should both be at a high hertz rate because it is important that messages are sent to components of the RoboBoat fairly quickly. It is less important that the user see the interpreted data as quickly.
- **Process:** The targets and metrics for Process are similar to Communication. “Send Instructions to Thrusters” and “Interpret Signals from Sensors” should both be receiving information faster than the other sub functions. “Determine Current Position” should be the next fastest, with “Detect Status of Kill Switch” being the slowest. All of these will be measured in hertz.
- **Safeguard:** The safeguard function's target is to cut off the power to the boat, the metric would see if the boat loses power when the kill switches are activated.
- **Move Boat:** The RoboBoat needs to move by generating thrust, the thrust needs to be powerful enough to overcome the weight of the boat and frictional forces between the boat and water. Desired thrust was found by giving a tolerance to the average thrust from the 2019 competition. This will be measured using the same strain-gauge method that the official RoboBoat competition uses.

- **Power:** The RoboBoat will be equipped with a cordless energy source and the energy supplied will be measured in volts.
- **Signal:** The RoboBoat will be capable of both an audible alarm as well as a visual signal to display whether or not the boat is in autonomous or remote-controlled mode. The visual signal will most likely be a set of different color LED lights, with the different colors signifying specific control modes.
- **Other Targets and Metrics:**
    1) Low drag in water, with a metric of testing hull designs in software or an air tunnel and seeing how the flow acts on the design.
    2) Low amount of time needed to reach ideal velocity from rest. This can be tested by using a stopwatch in tandem with on-board programming controlling thrusters.
    3) Low amount of time to have the RoboBoat powered and ready to run the course. Tested by using a stopwatch to check how long the startup time takes.

Critical Targets and Metrics

Function	Metric	Target
Maintain Stability	Buoyancy	Positive buoyancy for >= 30 minutes
	Weight Distribution	Center of Gravity below Center of Buoyancy
Detect Surroundings	Sensor Range	6 meters
	Sensing Speed	Value from spec sheet
Process	Object Detection	Same as Sensing Speed
Move Boat	Thrust	13-18 lbs

Table 1. Critical Targets and Metrics

Our critical targets and metrics are determined by examining our customer needs and our functional decomposition. The critical functions are Stability, Detection, Process, and Propulsion, since without these key functions we are unable to meet the requirements set by the RoboBoat standards. The boat will need stability to maintain buoyancy and to keep from capsizing. The boat will also need to move itself by generating thrust, and to detect its surroundings and determine how to maneuver around any detected obstacles. While all of the listed functions in the Functional Decomposition are needed to make a functional final design, these are the most critical to the project.

Methods of Validation

Stability test

A floating object is considered stable when it has the ability to return to its initial upright position after being disturbed by an outside force. The stability of the boat will be tested by placing it in a lake during various environmental states (rain,wind, waves ect) and observing to see if it will remain or return upright.

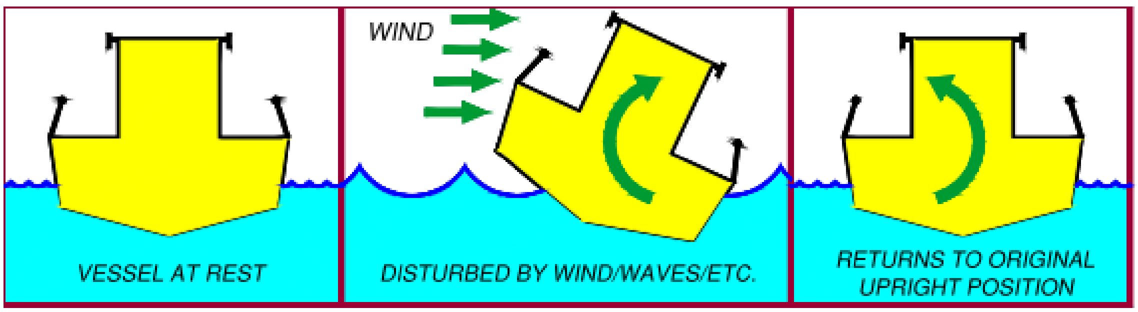


Figure 3a. Stable

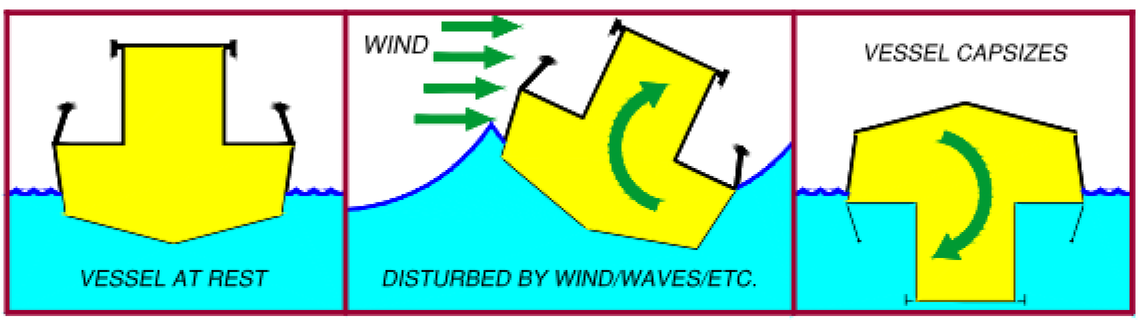


FIgure 3b. Unstable

Detection Test

A majority of the competition tasks will require the boat to navigate through and around various obstacles. In order to accomplish this, the boat must be able to detect its surroundings as well as the positions of targets. Detection tests will be conducted by placing several buoys in a water setup similar to Figure 5. The boat's lidar and gps system will be used to locate specific buoys so that it may travel through or around them. Each trial run will be timed.

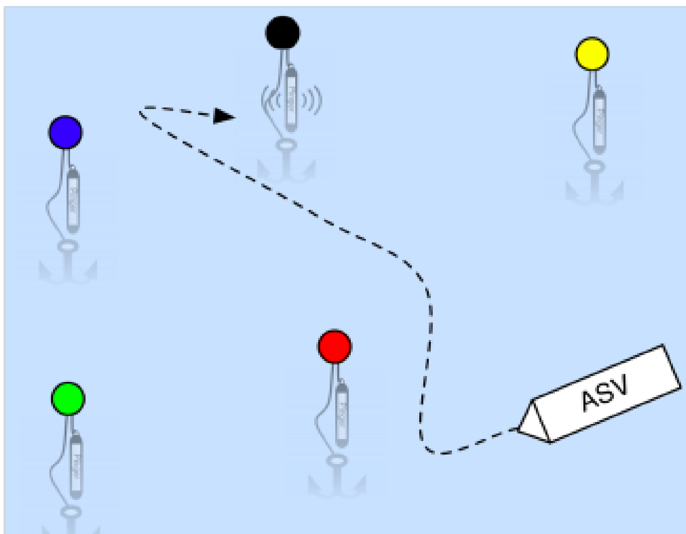


Figure 4. Buoy Set-Up

Thrust Test

Thrust is a static measurement that determines how powerful a motor is. At the beginning of the competition, the boat will have both weight and thrust measurements taken. The thrust of the boat will be measured by attaching it to a thrust measurement system that is similar to the one shown in Figure 6. The boat will then generate as much thrust as possible for 10 seconds. This task can be accomplished in a manned manner (i.e remote, laptop or buttons on the boat to start/stop this task). A similar strain gauge system will be replicated by our team for the practice trials.

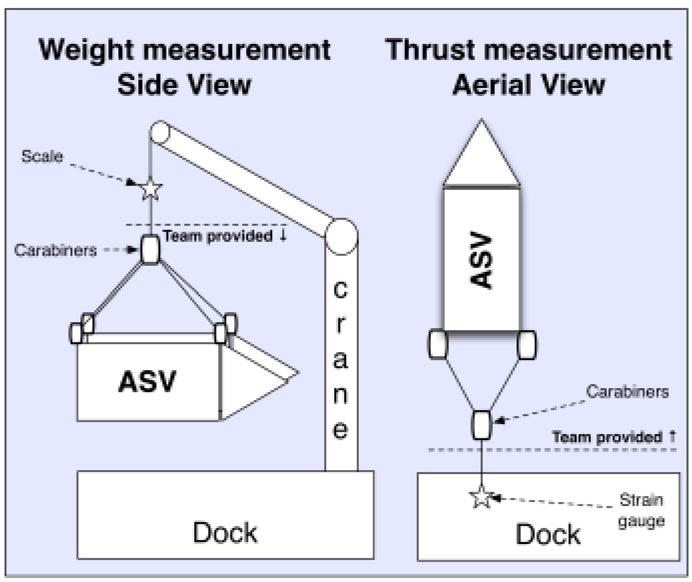


Figure 5. Weight and Thrust measurement Systems

Discussion of Measurements

The tools that we will need to utilize in order to validate our design are water, lidar/GPS, propellers, a stopwatch, strain-gauge system, weight measurement system (like a scale), and tools for measurements (measuring tape, yard stick, meter stick, etc.). We will need to use a body of water in order to conduct a stability test during the following weather conditions: rain, wind, waves. Conducting this test will allow us to observe what the best boat design is going to be in unknown weather. The next tool we will need to test is a lidar and GPS system. This will help us be able to navigate through and around various buoys. We will execute a detection test in order to implement what lidar and GPS system performs the best. We will also use a GPS verification system so that we can make sure our GPS reads right. The next tool we will need to validate our design is a propulsion system (thruster/propeller). Using a thrust test will tell us how powerful the motor is. The next tool that will help us with the design process is a strain gauge. This will be used to measure the deformation of where the propellers are connected to the boat. With the deformation recorded the thrust will be calculated from this device. Next we will use a weight measurement system. This will help us ensure that our boat will stay under 140 pounds once all the parts are placed into order. Lastly, we will use a measurement tool (such as a tape measure, ruler, yardstick, meter stick, etc.) to make sure our boat will fit within the prescribed dimensions. We will conduct tests prior to competition in order to find and implement the best equipment relative to our needs and competition.

Summary

The targets and metrics were derived using a number of resources including component specification sheets, goals based on previous competition performances, the electrical engineering senior design team, and advisor recommendations. Metrics were created as something to measure a specific function by, and then targets were created based on these metrics. This was done using each function of the functional decomposition to be sure that all targets and metrics were covered. It was decided that the critical targets were Maintain Stability, Detect Surroundings, Process, and Move Boat. Table 2 describes all of the targets and metrics with their corresponding functions.

Function	Metric	Target
Maintain Stability	Buoyancy	Positive buoyancy for >= 30 minutes
	Weight Distribution	Center of Gravity below Center of Buoyancy
Detect Surroundings	Sensor Range	6 meters
	Sensor Speed	Value from spec sheet
Detect Position	Sensor Accuracy	Within 14 cm
	Sensor Speed	Value from spec sheet
Communicate	Receive Input from Remote Control	Same as Sensor Speed
	Send Signal to Processor	Same as Sensor Speed

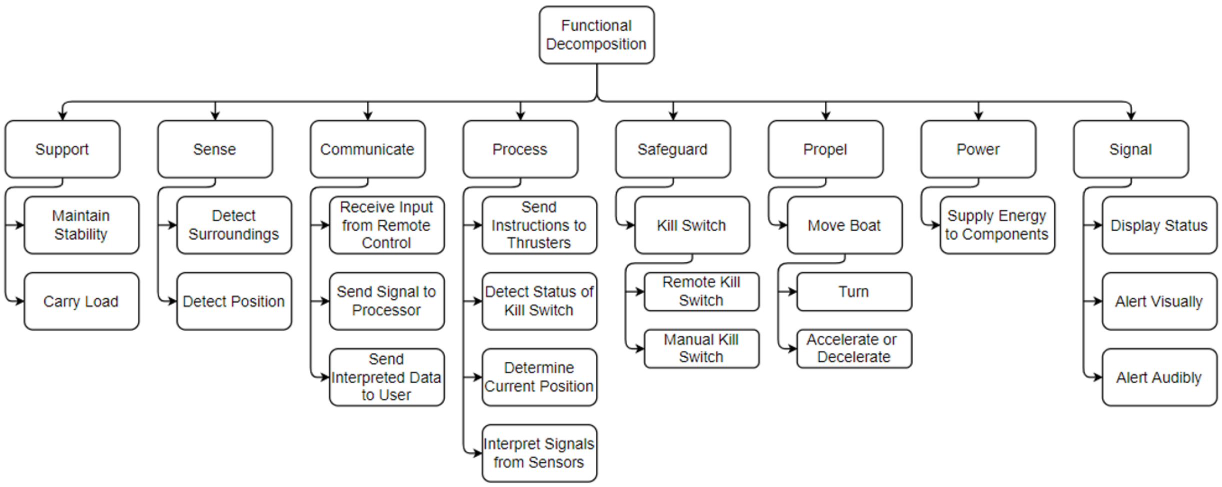
	Send Interpreted Data to User	Same as Sensor Speed
Process	Object Detection	Same as Sensor Speed
	Send Instructions to Thrusters	Same as Sensor Speed
	Interpret Signals from Sensors	Same as Sensor Speed
	Determine Current Position	Same as Sensor Speed
	Detect Status of Kill Switch	Same as Sensor Speed
Safeguard	Kill Switch	If the kill switch is activated, then the boat loses power.
Move Boat	Thrust	13-18 lbs.
Power	Energy Supplied	Up to 60 Volts (decided by the electrical group)
Visual Signal	Colored LED Lights	One color signifies autonomous mode, one color signifies remote-controlled mode.
N/A	Test hull designs in software or air tunnel and see how the flow acts on the design.	Low Drag in Water
N/A	Use a stopwatch in tandem with on-board programming controlling thrusters.	Low amount of time to reach operating velocity from rest.

N/A	Use a stopwatch to check how long the startup time takes.	Low start-up time.

Table 2. Summary of Targets and Metrics

Appendix

Figure 1: Functional Decomposition



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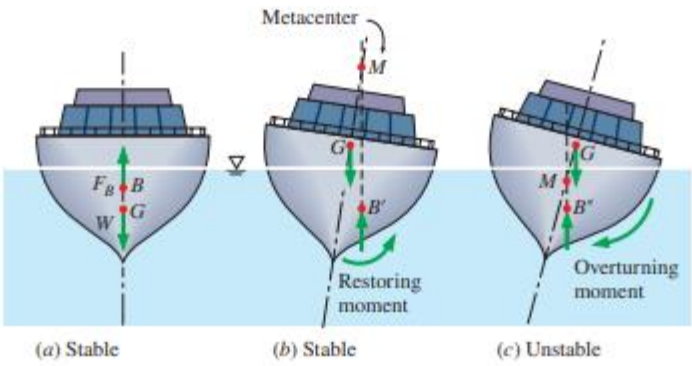

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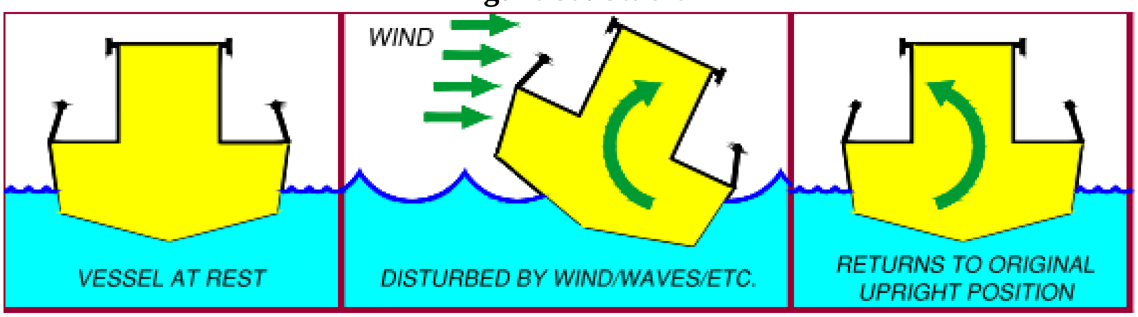
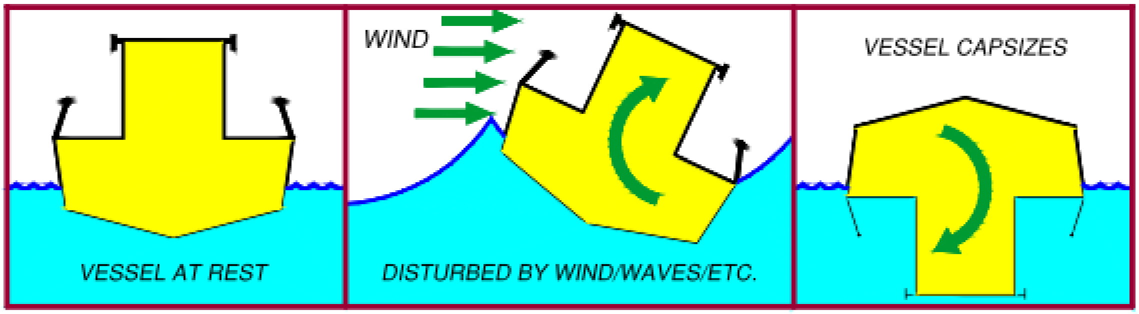


Figure 3b. Unstable



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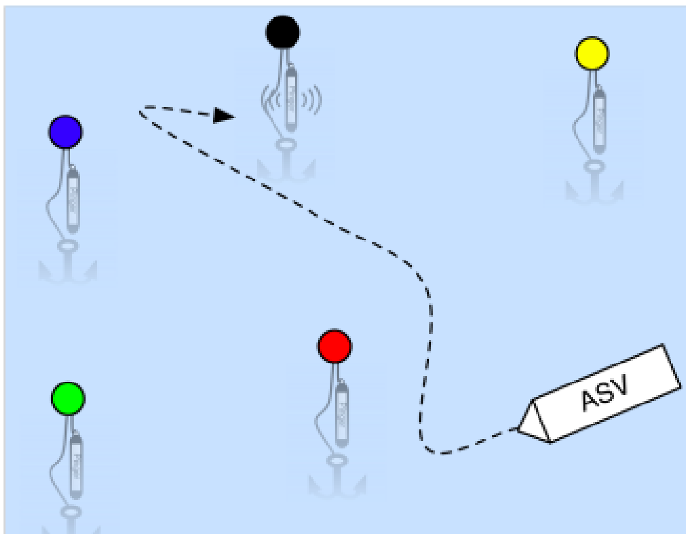

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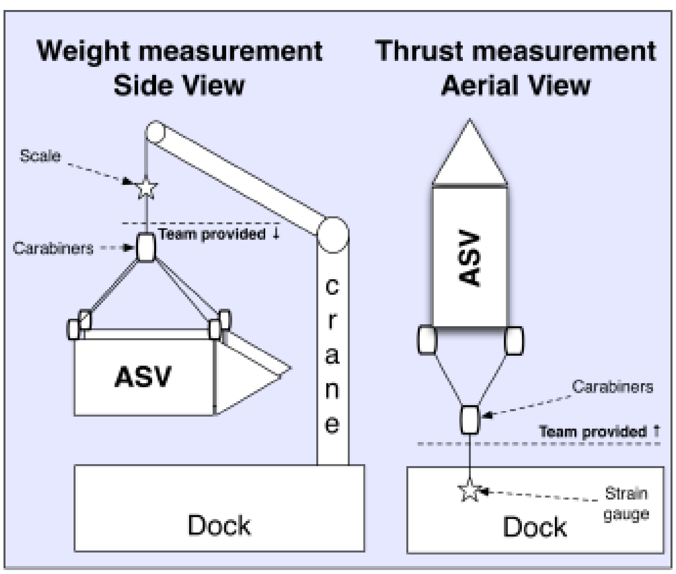

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References

RoboNation (2020). *RoboBoat Rules and Task Description*. (version 1). Daytona, FL: Retrieved from roboboat.org