24th Annual International RoboSub Competition

Mission and Rules

23 (+1) Skidoo

Version 1, March 26, 2021

Online

March – August 2021

www.robosub.org/2021

RoboSub Mission and Rules

RoboSub 2021   *www.robosub.org*

1   Objective

RoboSub is an international student competition established to generate, cultivate, and enhance a community of innovators capable of making substantive contributions to the Autonomous Underwater Vehicles (AUV) domain.

Participants tackle fundamental challenges in the design of ocean systems capable of changing the world — while getting hands-on experience by designing, building and testing a fully autonomous vehicle. By providing a venue and mechanism to share knowledge and innovate, students are primed for jobs in developing, testing and managing state-of-the-art systems.

2   RoboSub Information and Updates

RoboSub 2021 will be hosted online. All venue, task and vehicle guidelines and descriptions included in this document are meant to guide competition submissions and will not be executed in 2021. The planning and progress made by teams in 2021 is intended to prepare them for RoboSub 2022.

2.1   Join the RoboSub Community in the Band App

In your team's registration confirmation email, you will receive a link to join the RoboSub group on the Band App. This ensures you stay up-to-date on announcements, resources and even some special deals throughout the competition season. We encourage each team member to download the Band App (available on Android and iOS) and get to know the other RoboSub teams!

2.2   RoboSub Forum

All technical questions, comments, and suggestions should be posted on the 2021 RoboSub Forum. Teams are encouraged to actively participate in the online community and monitor it for the latest news and updates regarding all things RoboSub.

2.3   Points of Contact

- Technical Director – David Novick: dnovick@robonation.org

- Competition Questions: university-competitions@robonation.org

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3   Schedule

The general competition's schedule is available on the RoboSub Website and the RoboSub group on the Band App. The schedule is subject to changes. It is the team's responsibility to check the website for the latest version of the schedule.

4   Official RoboSub Competition Website

The official competition website is www.robosub.org. The documents posted at www.robosub.org are the official documents for this competition. All documents referenced here and in other RoboSub documents are available at the official competition website. These documents are updated regularly. It is the teams' responsibility to check the website for the most recent revisions.

5   Registration Information

To participate in the competition, all teams must register through the official RoboSub 2021 website. This registration collects team contact information, an optional team bio and logo and the required registration fee.

5.1   Fees

A registration fee is required to participate in the RoboSub Competition. Check the RoboSub 2021 website for the current fee structure. Registration fees can be made through credit card, check or wire transfer.

5.2   RoboSub Website

Once RoboNation has received your registration fee, your team will be added to the RoboSub website, making you an official RoboSub 2021 team.

6   Team Deliverables (Design Documentation)

Each team must document their efforts leading up to the competition by building a website, authoring a Technical Design Report (TDR), and preparing a series of short technical videos. All elements of the competition will be conducted in English.

Once your team is officially registered for the competition, the team leader will receive further instructions and access to submitting the team deliverables. Only the team leader and RoboNation staff will have access to the teams' submissions. Detailed instructions on how to submit team deliverables will be provided in the registration portal (SUBMITTABLE). Each team leader is responsible for adhering to the instructions and deadlines listed on the RoboSub website.

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6.1 Website

Teams must maintain a website documenting their vehicle development. Layout and contents of the website are left for the teams to develop; however, the website will be scored and should include at a minimum the following information:

- Team information (name and team contact information).
- Team member information (name, picture, contact information).
- Media (pictures, video, etc.) taken during development and testing.
- List of sponsors with logos.
- Teams are encouraged to build an archive of previous vehicles and design reports.

Team websites developed for a previous competition should be updated to reflect RoboSub 2021 team information and AUV design.

6.2 Skills Videos

Each team is required to submit a skills video outlining approach and know-how of at least one (1), and not more than two (2) of the four (4) following technical topics: 1) Hull design, 2) Power Management, 3) Propulsion System or 4) Sensor Optimization. These videos will be scored and may be shared online and with the RoboNation community. The videos are meant to showcase the team's approach, decisions and challenges while evaluating ability to communicate effectively. Exceptional videos may be published as a peer-to-peer resource for future teams. Teams must follow the video instructions provided on the RoboSub website.

6.3 Technical Design Report (TDR)

Each team is required to submit a TDR that describes the design of their vehicle, as well as strategies for their approach to the tasks. The TDR should also include rationale for design choices. Teams must follow the TDR instructions provided on the RoboSub website.

7   Theme: 23 (+1) Skidoo

Due to RoboSub 2020 being conducted online, RoboSub 2021 will reflect the theme originally created for the 23rd Annual RoboSub Competition, RoboSub 2020. Therefore, RoboSub 2021's theme is 23 (+1) Skidoo.

Skidoo is an American slang phrase popularized during the early 20th century. It generally refers to leaving quickly, being forced to leave quickly by someone else, or taking advantage of a favorable opportunity to leave.

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8　Mission

The fundamental goal of the mission is for an AUV to demonstrate its autonomy by interacting with G-men or Bootleggers. Orange guide markers will help direct the vehicle to the beginning tasks. Two pingers will guide the AUV to the remaining two tasks. Along the way, there will be Badges and tommy guns the vehicle can pick up to be used in other locations. The vehicle will have these tasks:

- *Choose Your Side* (Gate)
- *Make the Grade* (Buoy)
- *Collecting* (Bins)
- *Survive the Shootout* (Torpedoes)
- *Cash or Smash* (Octagon)

9　Competition Overview

9.1　Venue

The competition will be held at the NIWC PAC TRANSDEC facility. The large facility allows us to divide the area into four sections and run full missions in every section. The mission will take place in 16ft (4.9m) of water.

Figure 1: Aerial photo of facility. The bridge structure has no piers or supports in the pond.
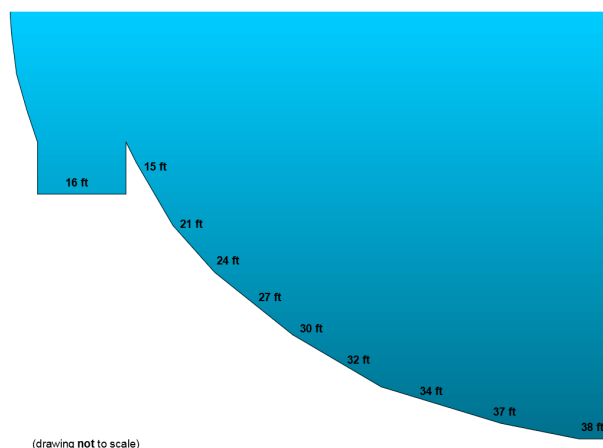

Figure 2: Cross section of facility

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9.2   Weight and Size Constraints

For the RoboSub competition, each entry must fit within a six-foot long, by three-foot wide, by three-foot high "box" (1.83m x 0.91m x 0.91m). Table 1 shows the bonuses and penalties associated with a vehicle's weight in air

Table 1: Vehicle weight in air with Bonus or Penalties

	Bonus	Penalty
AUV Weight > 125 lbs (AUV Weight > 56.7 kg)	N/A	**Disqualified**
125 lbs ≥ AUV Weight > 84 (56.7 kg ≥ AUV Weight > 38)	N/A	**Loss of** **250 + 5*(lb − 125)** **250 + 11*(kg − 56.7)**
84 lbs ≥ AUV Weight > 48.5 (38 kg ≥ AUV Weight > 22)	**Bonus of** **2*(84 - lb)** **4.4*(38 - kg)**	N/A
AUV Weight ≤ 48.5 lbs (AUV Weight ≤ 22kg)	**Bonus of** **80 + (48.5 - lb)** **80 + 2.2*(22 - kg)**	N/A

9.3   Markers

Each marker must fit within a box 2.0" square and 6" long (5.1 x 5.1 x 15.2 cm). Each must weigh no more than 2.0 lbs (0.91 kg) in air. Any marker that exceeds these limits by less than 10% will result in a 500-point penalty. Any marker that exceeds these limits by more than 10% will be disqualified. Each marker must bear the team name, color or emblem. Markers will be cleared from the arena after each run. A vehicle may carry up to two markers. A reasonable amount of time will be spent looking for lost markers, however consider them expendable and have backups.

9.4   Torpedoes

The torpedo size, weight, markings and potential "loss" are identical to the Markers. The torpedoes must travel at a "safe" speed. A "safe" speed is one that would not cause a bruise when it strikes a person underwater from close range. A vehicle may carry up to two torpedoes

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9.5 Pingers

The pingers will be Benthos ALP-365. The Benthos ALP-365 is user selectable from 25 to 40 kHz in 0.5 kHz increments. They will only be set to an integer frequency (25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39 or 40) and will be set to the maximum power. The pingers in each section will use the same frequency. For example, the two pingers in section A will both have the same frequency, and the two pingers in section B will both have the same frequency (but different from section A). There will be four different frequencies used, one for each section, and only one pinger in each section will be active at a time. The ping for each section will be deconflicted with the pings in other sections such that only one pinger will ping at a time, see Figure . As shown in **Error! Reference source not found.**, the frequencies for the sections will be: A – 30kHz, B – 40kHz, C – 25kHz, D – 35kHz.
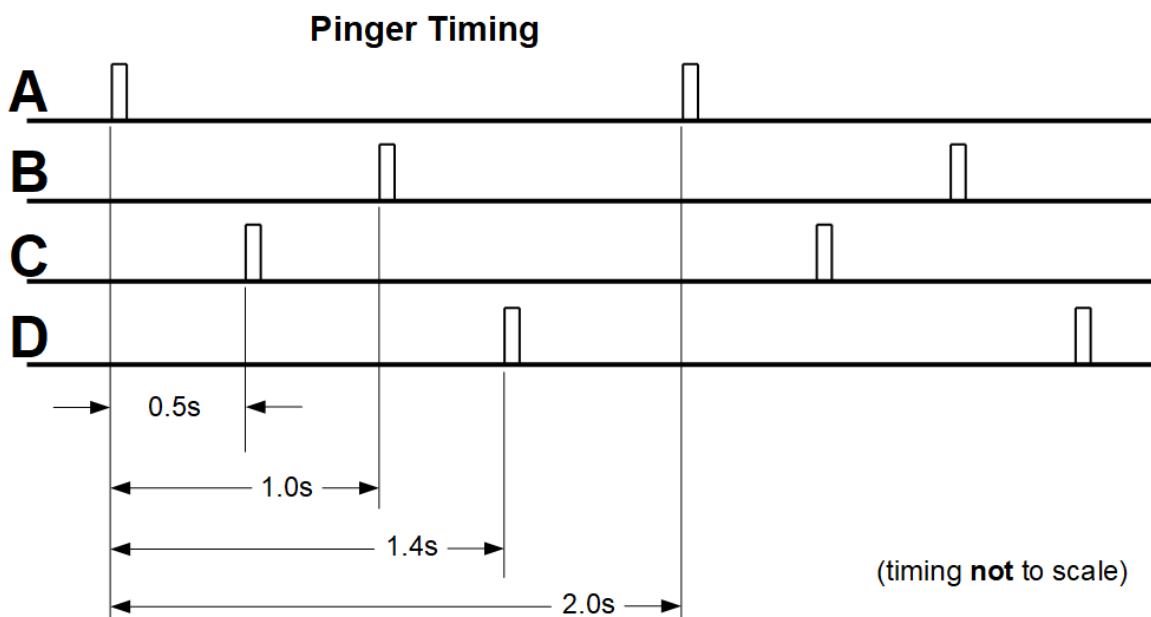

Figure 3: Pinger timer for the four sections

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10 Competition Rules

Rule 1   The official source for all information concerning rules, interpretations, and information updates for RoboSub is the World Wide Web home page at: www.robosub.org.

Rule 2   Teams may be comprised of a combination of students, faculty, industrial partners, or government partners. Interdisciplinary teams are encouraged. Members from industry, government agencies, or universities (in the case of faculty) may participate, however, full-time students must compose at least 75% of each team. Participants must be enrolled at their schools as a full-time student per quarter/semester during winter and spring to be considered "students." The student members of a team are expected to make significant contributions to the development of their vehicle.

Rule 3   Only the student component of each team is eligible for the cash awards.

Rule 4   One student member of the team must be designated as the "team lead". The team lead, and only the team lead, will speak for the team during the competition.

10.1 Onsite Expectations

The organizers have made every attempt to provide the competitors with maximum resources at the Competition site, including electrical power, test pools, Internet access, and practice time in the main pool. This event is not only open to the public, but there is a very high possibility that a potential future employer or sponsor may also be observing the event.

It is expected that ALL teams will be present during ALL days of the competition. If your team does not make it into the finals, it is expected that your team will display your vehicle and be present in the team tent during this time (ALL teams, ALL days, ALL open hours!)

10.2 Power

The United States uses a 120V 60Hz 15A electrical outlet plug. Usually 3 pins, two parallel blades (one wider than the other), and an offset semi-round pin. The wider blade is Neutral, the shorter blade is Hot/Line and the third pin is Ground.

Figure 4: US electrical outlets

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10.3 Vehicles

10.3.1 Each team may enter one or multiple vehicles into the competition. Each vehicle will be physically inspected by the competition technical staff. The technical staff may disqualify any vehicle that they deem to pose an unreasonable safety hazard to the host facility. The sponsors and the host organization, their employees and agents, as well as the organizing committee, are in no way liable for any injury or damage caused to or by any vehicle.

10.3.2 During a qualifying, semi-final or final run, each vehicle must operate autonomously during its run. While carrying out the mission, no communication is permitted between the vehicle and any person or off-board computer. Vehicles must operate solely on their ability to sense and maneuver in the arena using on-board resources. When performing a qualifying, semi-final or final run, everything attached to the vehicle must be submerged with the vehicle. Any part that breaks the surface is considered a breach. During practice days and practice runs, buoys may be used on the surface for communication.

10.3.3 The weight of each individual vehicle must be less than the maximum allowed. Note that bonus points are awarded to vehicles that are below a certain value, and penalties assessed for those that exceed it (Table 1). The entire vehicle must fit within the volume described in the section Weight and Size Constraints.

10.3.4 All vehicles must be battery powered. All batteries must be sealed to reduce the hazard from acid or caustic electrolytes. Batteries must not be charged inside of sealed vessels at any time. The open circuit voltage of any battery (or battery system) in a vehicle may not exceed 60 VDC. If a team has any questions or concerns, they are encouraged to contact the Technical Director.

10.3.5 No materials (except for the markers/torpedoes and compressed air) may be released by the vehicle into the waters of the arena.

10.3.6 For the safety of your team and those around you, no loaded torpedoes are allowed within the team tent. If you must test your launchers, test them either in the water, or in an open area pointing away from everyone and everything.

10.3.7 For the safety of your vehicle, we require it to be slung on a harness or sling of some type. Even if the vehicle is light enough to hand carry, we wouldn't want anyone to slip and destroy their vehicle. Also, we need to weigh the vehicle, and require that the vehicle be slung somehow for the measurement. Please see the document *Harnessing the Submarine* for hints and ideas on how to accomplish this.

10.3.8 All vehicles must contain a clearly marked kill switch that a diver can easily and readily activate. The switch must disconnect the batteries from all propulsion components and devices on the AUV. Note, this does not have to kill the computer. Upon reactivation, the vehicle must return to a safe state (props do not start spinning).

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10.3.9 All props must have shrouds. The shrouds must surround the prop and have at least a 2" (5.1cm) distance between the spinning disk of the prop and the edges of the shroud (front and back). If you have a guard across the opening to prevent the insertion of a finger, this distance can be minimal. Commercial thrusters qualify as is, as long as they are shrouded.

10.3.10   A vehicle will not be allowed in the water without a properly working kill switch and prop shrouds.

10.3.11   All vehicles must be positively buoyant by at least one half of one percent (0.5%) of their mass when they have been shut off via the kill switch.

10.3.12   The officials will suspend the operation of a vehicle at any time they deem that it is required by safety or security considerations. Teams may be required to submit technical descriptions of their vehicle to the officials in advance of the competition, with the goal of identifying potential safety concerns well in advance. When required, such technical information submitted to the judges will be held in confidence until the end of the competition.

10.3.13   Multiple vehicles (two total) are allowed in the competition. Each vehicle must include all the safety features mentioned above.   Along with the above requirements, these are specifications for multiple vehicles:

- The total dry volume for all the vehicles must fit within the maximum volume defined in the rules. The vehicles are not required to start joined together, nor are they required to rejoin at the completion of the run.

- Each vehicle will be weighed, and the bonuses/penalties will be calculated on a per vehicle basis.

- From the dock, each vehicle must pass through the validation gate first before heading off for its desired task.

- A team may elect to kill one vehicle and bring it back to the dock. If one (or more) vehicles are still out on the course, the competition time continues to count down (think of them as a swarm). Any vehicle that has been killed or has breached will be returned to the dock and can be redeployed at any time.

- The competition timer is only stopped when the last vehicle out on the course is under diver control and returning to the dock. The timer starts again once this last vehicle has returned to the dock, or the first vehicle leaves the dock (starting its new run).

- Teams wishing to have communication between each vehicle must post their method and frequencies on the official forum by a specified date (see forum for details).   Acoustic frequencies that are always off limits for inter-sub communication are the frequency range used by the pingers.

- Inter-vehicle communication and cueing of one vehicle by another is an advanced behavior that merits special points. If such behavior is executed, teams are encouraged to present post-run supporting documentation (e.g., vehicle logs) to the judges.
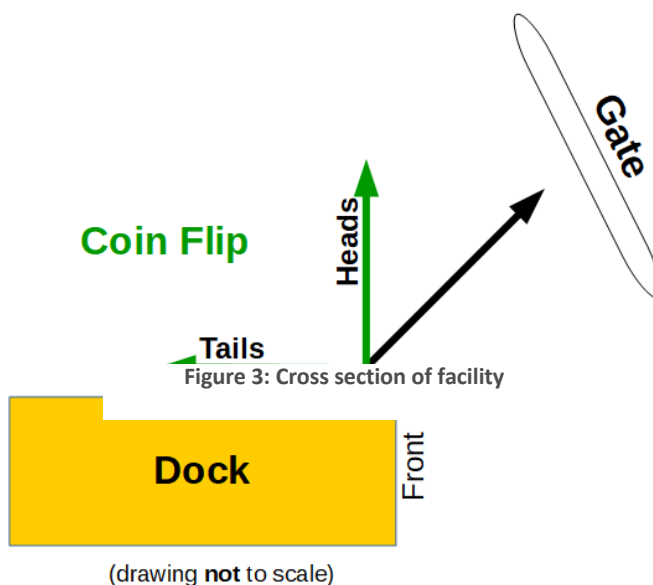
RoboSub 2021 will be hosted online. All venue, task and vehicle guidelines and descriptions included in this document are meant to guide competition submissions. The operational competition will not be executed in 2021.
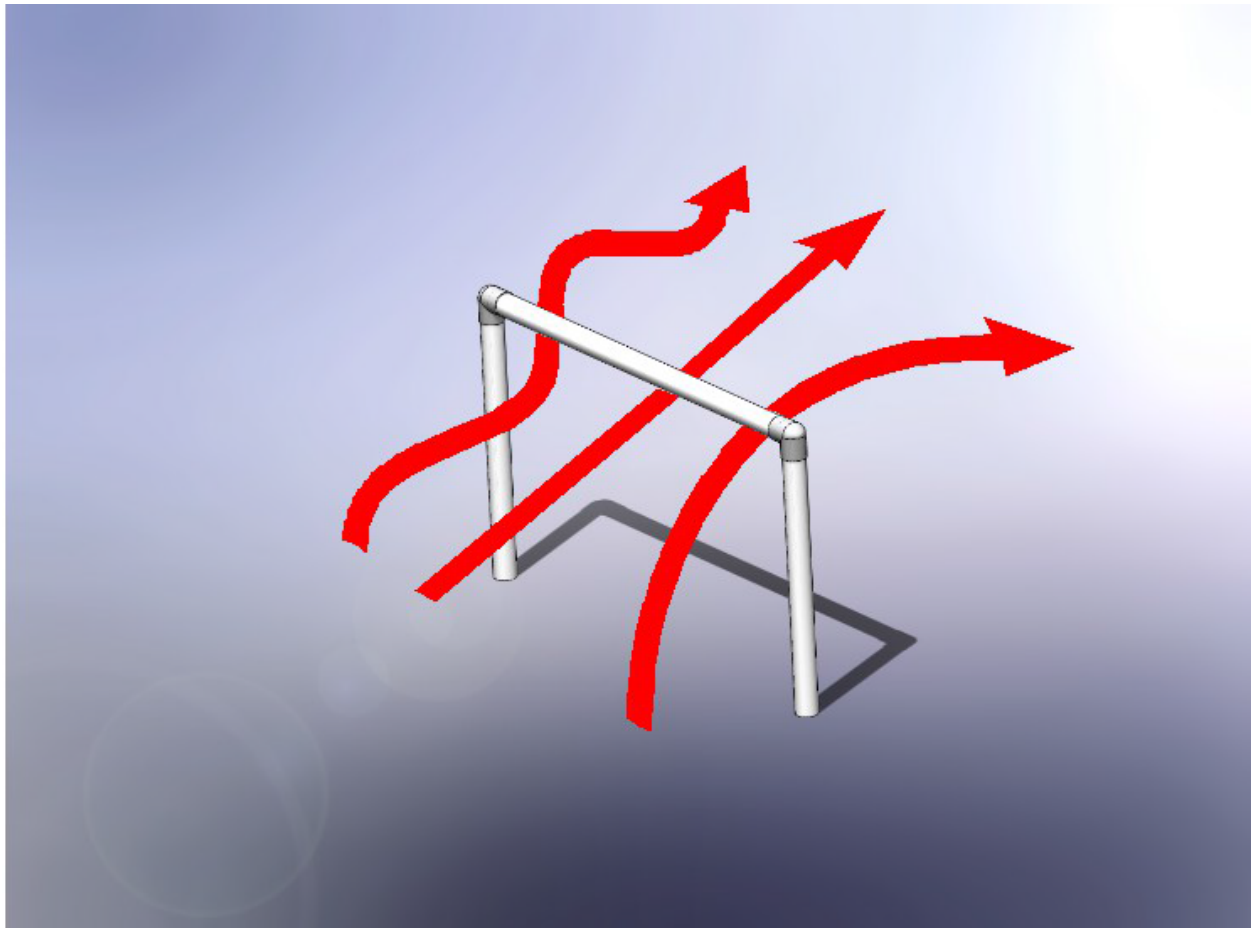
11 Competition Tasks

11.1 With Moxy

From behind the front of the starting dock, a team may point their vehicle in any direction. Before the start of a run, and for additional points, teams may request a coin flip which will determine the heading of their vehicle for the start. If the coin lands on **Heads**, the vehicle is perpendicular to the dock. If the coin lands on **Tails**, the vehicle is parallel to the dock and points away from the gate. The team member on the dock or the diver in the water may position the vehicle. **NEW:** When starting a run, the vehicle must *submerge* first and then either head toward the gate, or rotate to align with the gate and then head toward the gate.

Figure 3: Cross section of facility

Figure 5: Vehicle direction with coin flip

11.2 Choose your side (Gate)

The validation gate is made from 3-inch black PVC pipe. It will be buoyant, just below the surface and moored to the bottom. The vertical legs will be colored **ORANGE**. The vehicle can pass through the gate at any depth from the floor to just below the surface.

A 2-inch PVC pipe is used to divide the gate in half. G-man on one side, Bootlegger on the other. Choose who you will be by passing under either side.

Style points are extra points that can gained by passing through the gate with "style". For every 90° change in orientation, the vehicle increases the multiplier, up to 8x. However, returning to the last previous orientation won't count. I.e. a vehicle rolls 90° (+1 multiplier) and then back to 0° (+0 multiplier).

Figure 6: Validation gate

Figure 7: Valid ways to pass through the gate

11.3 Path

The path markers are ~4 feet (~1.2m) long by 6 inches (15cm) wide. The path will be colored **ORANGE**. Each path marker will be placed directly after the current task and point to the next task. The path markers will be in two sections. The second section will be ±45° from the first section. To obtain full points, the vehicle must follow each path segment, changing course as the path section changes.

There will be one positioned at the gate that points to the *Make the Grade* (buoy) task. Positioned near the *Make the Grade* task, the next path segment will point to the *Collecting* (bin) task. Those will be the only path segments which can be used to visually orient the vehicle to the next task.
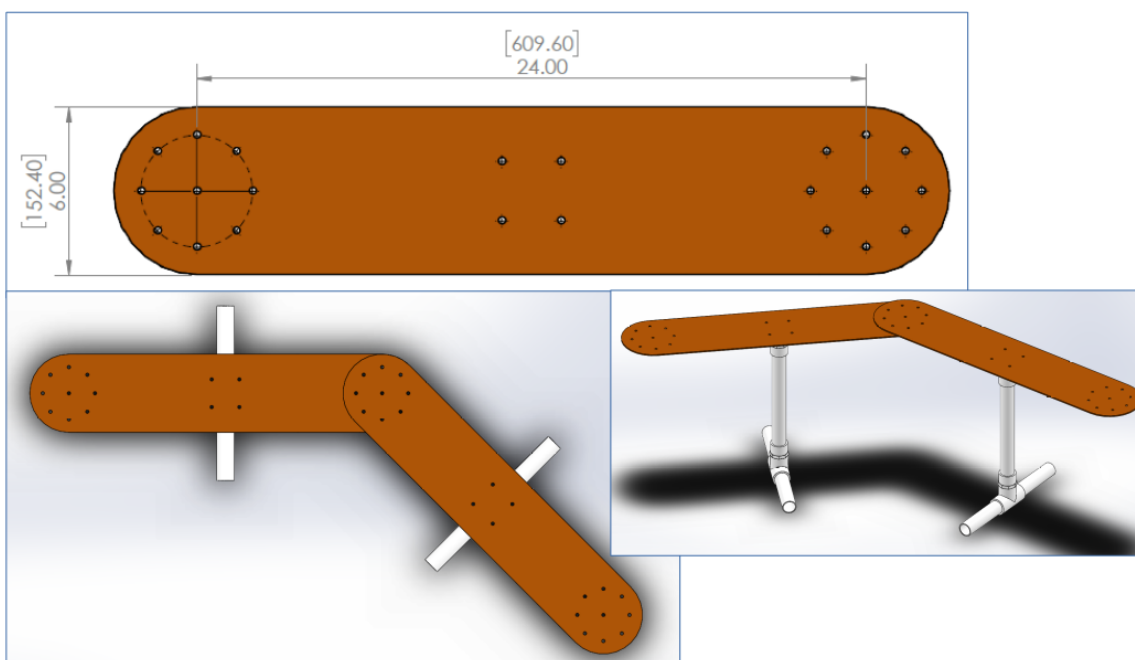
Figure 8: Path showing two sections

11.4 Make the Grade (Buoy)

There are two "buoys" that are moored to floor by line in two places. One buoy will have the image of a Badge (G-man) on both sides, and one buoy will have the image of a tommy gun (Bootlegger)

Points are awarded for touching any buoy. More points are awarded for bumping the appropriate one for you side, based on *Choose your Side* (Gate).
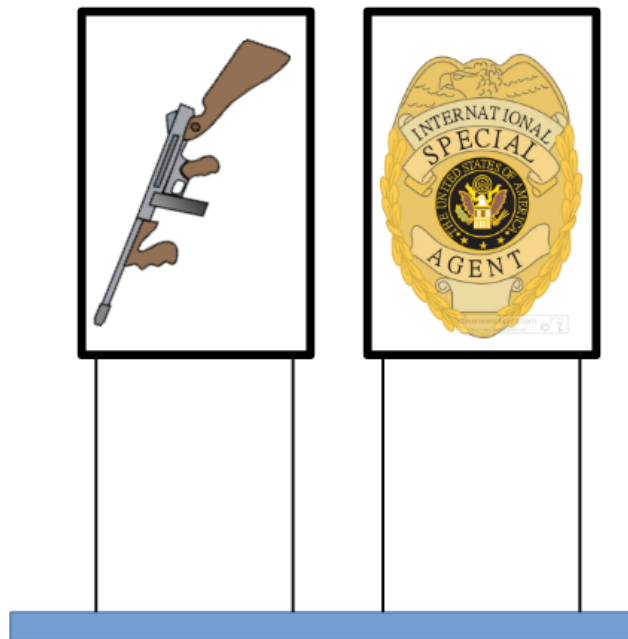

Figure 9: Make the Grade

11.5 Collecting (Bins)

This task consists of two bins. In one bin, there is an image of a whisky bottle and barrel (Bootlegger: collecting spirts), in the other bin, there is an image of a phone and note pad (G-man: collecting information). 1/3 of each bin is covered

Points are awarded for dropping markers into either bin. Points are awarded for lifting off the cover. More points are awarded for dropping markers in the appropriate bin

Figure 10: Collecting task, uncovered and covered

11.6 Survive the Shootout (Torpedoes)

An acoustic pinger will be used to guide the vehicle to this task. This task consists of a vertical board with an image on each side.   On one side is the image of the G-man, on the opposite side is the image of the Bootlegger (the same images from *Choose your Side*). There is one small and one large opening.

Points are awarded for firing torpedoes through the large opening.   More points are awarded for firing torpedoes through the small opening. Maximum points are awarded for firing torpedoes through the small opening on the appropriate side. G-men fire through the Bootlegger image and Bootleggers fire through the G-man image
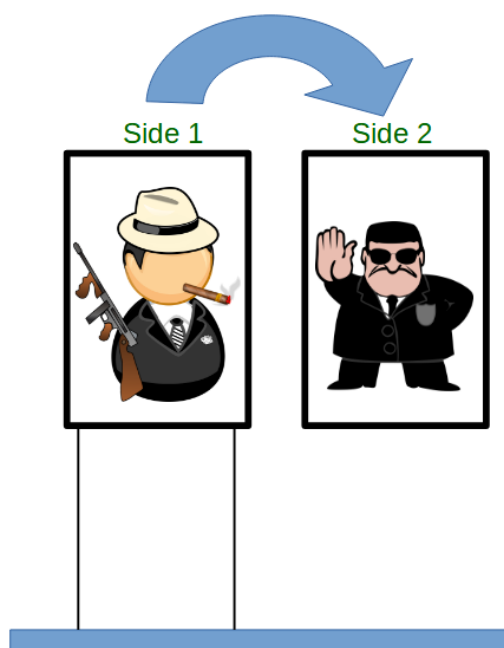

Figure 11: Survive the Shootout

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11.7 Cash or Smash (Octagon)

A 9 ft (2.7 m) diameter octagon floats on the surface and an acoustic pinger, located on the floor at the center of the octagon, will be used to guide the vehicle to this task. Located in the center of the octagon, on a platform is a collection of "bottles" (PVC structure). On one side of the octagon is a table with a dollar sign (Bootlegger), on the opposite side of the octagon is a table with an axe (G-man).

Points are awarded for surfacing inside the octagon and for surfacing with the bottles (inside the octagon). Points are awarded for moving the bottles to one of the tables. Maximum points are awarded for placing the bottles in the appropriate table.

Figure 2: Cash or Smash

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