ROBOT DRONE LEAGUE

PRESENTED BY STREAMWORKS

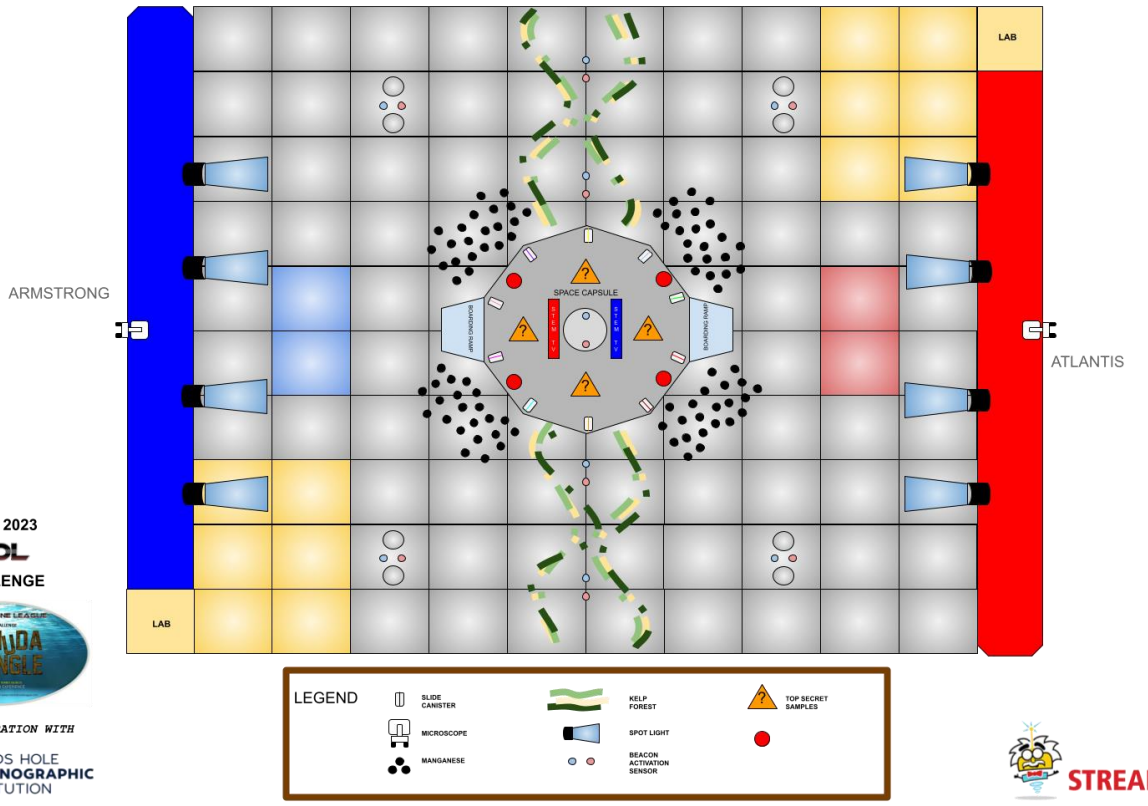
2022 Official Challenge Manual

STREAMWORKS

2022 Official RDL Field

ROBOT DRONE LEAGUE

BERMUDA TRIANGLE



2022 / 2023

RDL

CHALLENGE

IN COLLABORATION WITH

WOODS HOLE OCEANOGRAPHIC INSTITUTION

STREAMWORKS

hree Laws of Robotics

1. *A robot may not injure a human being or, through inaction, allow a human being to come to harm.*

2. *A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.*

3. *A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.*

~Isaac Asimov

And one more….

4. *A robot may not intentionally injure another robot unless the action or inaction conflicts with the First, Second or Third Laws. ~ Scooter Willis (Creator of RDL)*

To the men and women of Woods Hole Oceanographic Institution who passionately lead the world in ocean discovery and exploration, ~ Thank You ~

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Introduction

Creativity and innovation are key elements to advancing the fields of science, technology, engineering and mathematics (STEM) into the future. Robot Drone League (RDL) has been designed to provide students with open-ended challenges that allow for creation and innovation by engaging in hands-on design, engineering, and programming of interactive robots and drones. Students are presented with the opportunity to develop real-world connections to classroom learning. Working with robots in a collaborative game format can be a very powerful tool to engage students and enhance math and science skills through hands-on, student-centered learning. Through participation in RDL, students can develop the essential life skills of teamwork and collaboration, as well as critical thinking, project management, and communication required to become the next generation of innovators and problem-solvers in our global society. The 2022 RDL "Bermuda Triangle" 2022 Challenge, presented by STREAMWORKS, is designed to inspire students to develop a lifelong passion for learning and pursuing educational and career opportunities in STEM fields by implementing real-world STEM-related problems that require innovative and critical thinking to find solutions.

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ROBOT DRONE LEAGUE

Challenge Overview

RDL 2022 Challenge: Bermuda Triangle

The Bermuda Triangle Challenge includes an exciting Robot Drone League (RDL) game, centered around real-world aspects of undersea technology. Machine design and collaboration are key to scoring maximum points.

In the 2021 RDL Dragonfly mission, teams retrieved samples from Saturn's largest moon, Titan. As a result of completing tasks and collecting samples, some unique, never-before-seen samples were found on Titan's surface. These samples, extremely time-sensitive, were rushed back to Earth for observation. While the returning space craft was in descent through Earth's atmosphere, just over the Bermuda Triangle, all signals and controls were lost, which led it straight to a splashdown in the middle of the Atlantic Ocean.

Teams, partnering with Woods Hole Oceanographic Institute (WHOI), are assigned with the mission of retrieving this crucial sample from the bottom of the ocean floor. While retrieving the sample boxes, WHOI has asked teams to maintain connection with Underwater Acoustic Transponders (UAT) and to collect manganese.

The RDL Bermuda Triangle Challenge provides an opportunity for students, with the unassisted guidance of mentors, to build a robot to solve exciting engineering challenges. Students collaborate in a teamwork format to strategically collect scoring elements and solve math and science questions.

RDL emphasizes the importance of programming through drone technology. In this year's challenge, drones maintain continuous connection with beacons through RFID chips and solve STEM questions via broadcasting live video back to the driver stations for student developed solutions. Students need to work together to write the code for the drone to successfully complete these tasks.

RDL implements Next Generation Science Standards (NGSS) through the completion of grade-appropriate science and math questions.

Game Rules

Object of the Game

The object of the game is to successfully complete as many of these tasks as possible within a ten-minute match, with the first sixty seconds under autonomous conditions. RDL Bermuda Triangle is played on a 7.3 m by 11.0 m indoor enclosed field, surrounded and separated into equal halves by a combination of game elements designed for the current RDL challenge, Bermuda Triangle. Two teams compete against each other as either red or blue alliances. The two alliance field sides are mirror images of each other. There is a potential of 50 manganese game elements per alliance that teams may retrieve and transport to the alliance player labs. The object of the game is to retrieve the various samples and top-secret samples located in assigned spaces within the space capsule. Once the samples are collected and received in the human player lab, the contents in the sample boxes can be removed and then analyzed for identification. The biological samples are prepared slides that must be observed through a microscope within the alliance driver station.

Teams are tasked with collecting the deep-sea element manganese which are represented by 100 dark purple sphere-shaped game pieces which are 72 mm in diameter.

Teams must also secure and maintain a connection with seven (7) Underwater Locator Beacons (ULB) by flying over each beacon and activating the sensors that will illuminate with the appropriate color.

Drones are responsible for providing images of the screen on the opposing side, which displays the STEM questions for students to answer and also maintains a connection with the underwater locator beacon.

Matches

Teams will compete in three scoring matches in which teams are randomly assigned to an alliance and will compete for the highest score on the field. The first minute requires robots and drones to be operated autonomously. This is followed by a 9-minute teleop period of robots and drones operated under the control of the humans.

Lab Stations

For each alliance side, there is a designated area for interaction between human players and robots called the lab station. The lab floor is identified by the yellow mats both in the lab and adjacent to the perimeter of the lab. Each alliance needs to assign a lab technician who is responsible for accepting elements and identifying samples. Robots and drones either deploy from or bring collected elements to the lab station, where the lab technician can then accept or attach game items. The lab technician may retrieve these capsules to identify the samples

located inside the container. The lab technician is only permitted to touch the robot or drone when in the neutral and non-moving configuration and fully in the yellow safety zone.

Space Capsule

The RDL field has a space capsule in the center of the field. This capsule houses the slide canisters and the secret slide canisters. In order to gain entry to the capsule, teams must first depressurize the cabin by hitting a red button and activating the depressurization stage and opening of the doors. Once entry is gained, teams can go inside and begin collecting the slide canisters and the secret slide canisters and gain access to the opposing alliance side.

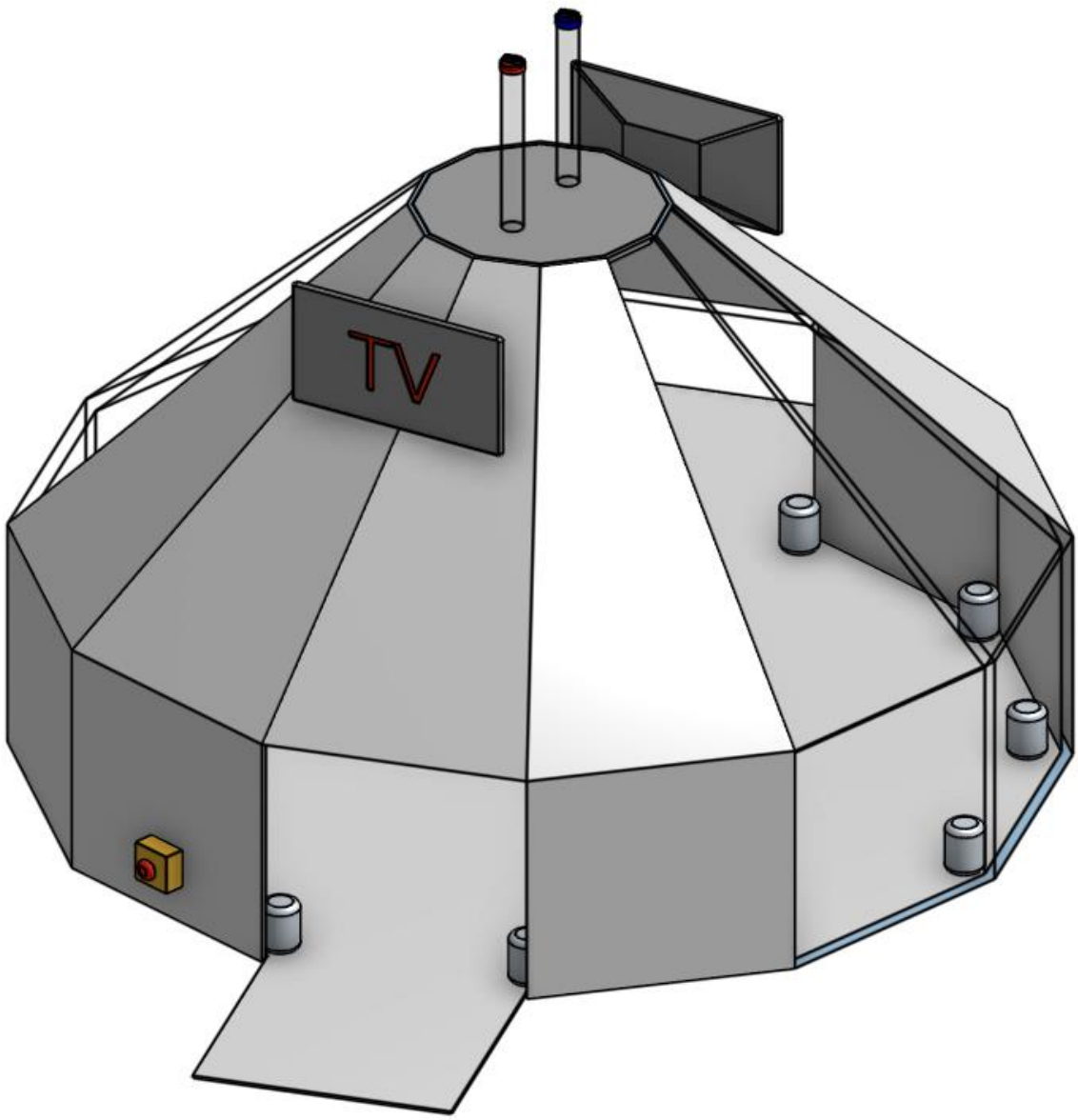

Figure 1: Space Capsule

Starting Position

Robots and drones need to be placed in the ROV Garage prior to beginning the match. The starting position is marked by two adjacent 61.0 cm by 61.0 cm squares, colored to correspond with the alliance. Robots and drones may start with a scoring element or sensor preloaded at the base. Human players can also load sensors at the lab station. Alignment tools and devices are allowed onto the playing field as long as the tools do not interfere with the ability of the opposing alliance to retrieve game elements and score points.

STEM Questions

Each team is given the opportunity to earn points by solving one (1) STEM-based question that appears after the match has started. During a 10-minute match, there are a maximum of four (4) additional questions to be gained by each alliance. Questions are displayed on screens on the opposing side of the capsule. Teams must use the drone or robot camera feed to view the questions in order to solve them. Teams will receive a maximum of five (5) STEM questions per scoring match.

STEM questions are aligned with NGSS, Common Core, ISTE, and P21 Standards and directly correlated to what students learn in the classroom. Question difficulties are dependent on a team's division *(see League Overview)*, which are arranged and aligned with the appropriate grade level to each division, either DIV I, II, or III. Teams must correctly answer the question and receive points from the RDL official prior to advancing to the next STEM question.

Acoustic Transponder

The acoustic transponder needs to be activated to properly collect data. To activate the acoustic transponder, a drone must fly over the Underwater Locator Beacons, which are situated in locations on the playing field. The beacon illuminates with the alliance color when the transponder has been activated. Teams must battle the other alliance in maintaining uplink with the acoustic transponder by attempting to keep all the beacons illuminated with their alliance's color.

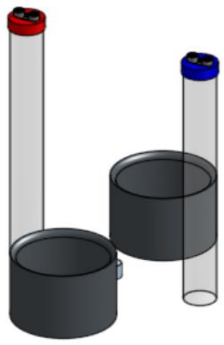

Figure 2: Underwater Locator Beacons

Element Retrieval

Located on the perimeter of the capsule, teams will find fifty (50) manganese. Manganese must be obtained from the team's own alliance side and returned to the human lab. Teams can then exchange five (5) manganese for a battery, which can be deployed into the power cell deposit.

Power Cell Deposit

On the field, there are four (4) power cell reservoirs located with each set of beacons. Teams may trade in five (5) manganese game elements for one Power Cell game piece, The battery cell may be obtained from a RDL drive station official at each drive station.

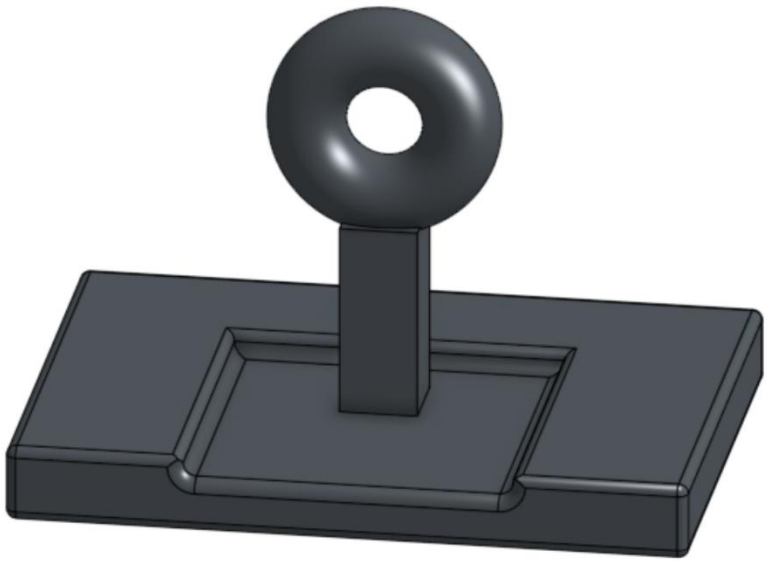

Figure 3: Power Cell

Slide Canister

Inside the capsule, there are ten (10) slide canisters measuring 128.0 mm in length and 91.0 mm in diameter with various bacteria slides located inside the canister. Teams must collect the canisters and return them to the human lab to analyze them through a microscope. Teams will have a microbiological catalog at the driver station to aid in the identification of the bacteria type and points are awarded upon successful completion of the microbiological identification task.

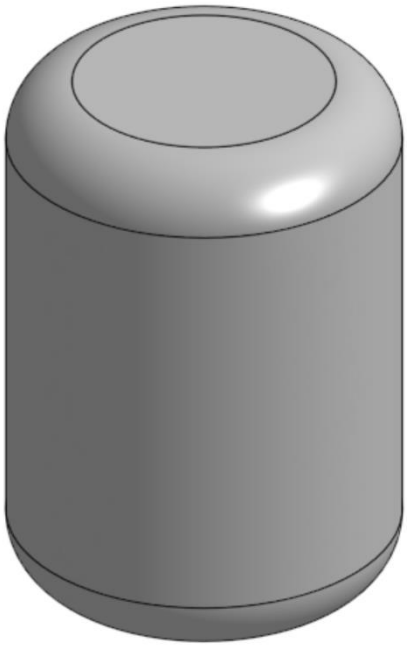

Figure 4: Slide Canister

Turbulent Undersea Conditions

During the first 30 seconds of the autonomous period, there will be deep sea turbulent conditions and sea fog on the surface of the water. In the first 15 seconds, the playing field becomes very hazy, causing robots and drones to navigate through a visually limited atmosphere. In the following 15 seconds, robots and drones will have to navigate through deep sea turbulent current conditions.

Autonomous Period

At the beginning of a 10-minute match, the first 60 seconds is considered the autonomous period. Human control of the robot or drone is not allowed. Teams are awarded points for autonomous movement of the robot or drone as depicted in the scoring table below. Drones and robots may score autonomous points by initiating movement, activating the space craft entry ramp, and AUV, as well as image recognition. Completing these tasks autonomously results in double points.

Autonomous – 01:00 minute	**Action**	**Element**	**Robot/Drone/ Lab**	**Points Each**
	Movement beyond the starting block area	Field	Robot / Drone	***100***
	Space capsule door release mechanism activation	Spacecraft Access Door / Ramp	Robot / Drone	***100***
	STEM question	#1	Robot / Drone	***250***
	Acoustic beacon activation	Acoustic Beacon	Drone	***100***
	Collect manganese sample	Manganese Sphere	Robot / Drone	***50***
	Collect slide canister	Slide Canister	Robot	***100***
	Identify microbiological sample	Microbiological slide	Lab (microscope)	***150***
	Deposit Power Cell	Power Cell Reservoir	Robot / Drone	***200***

Table 1

Teleop Period

Upon completion of the 60-second autonomous period, the remaining 9 minutes are considered a teleop (human control) period. Autonomous functions are not restricted during the teleop period; however, human operators must maintain hands-on control of the robot or drone during the 9-minute period. If autonomous functionality is used within the 9-minute teleop period, doubled points are not awarded.

Teleop – 09:00 minute	**Action**	**Element**	**Robot/Drone/ Lab**	**Points Each**
	Movement beyond the starting block area	Field	Robot / Drone	***50***
	Space capsule door release mechanism activation	Spacecraft Access Door / Ramp	Robot / Drone	***50***
	STEM question	#1, #2, #3	Robot / Drone	***125***
	Acoustic beacon activation	Acoustic Beacon	Drone	***50***
	Collect manganese sample	Manganese Sphere	Robot / Drone	***25***
	Collect slide canister	Slide Canister	Robot	***50***
	Identify microbiological sample	Microbiological slide	Lab (microscope)	***75***
	Deposit Power Cell	Power Cell Reservoir	Robot / Drone	***100***
	Collect top secret canister	Top Secret Canister	Robot	***300***
	Identify top secret microbiological sample	Top Secret microbiological slide	Lab (microscope)	***150***

Table 2

League Guidelines

League Overview

The Robot Drone League season runs from early September through January. RDL is a multi-week game where a percentage of scoring elements are changed each year, and point values are adjusted to meet the requirements of the game. Teams should benefit from the guidance of teachers or mentors, with the constraint that only the students are the only ones allowed to build the robot and drone and compete. When faced with a challenging problem, students appreciate guidance on different methods the problems can be solved or solutions to improve upon an existing student-driven design.

Divisions

Teams will be categorized by grade level. RDL consists of three divisions: Division I, Division II, and Division III.

Division I - Grades 9th – 12th

Division II - Grades 6th – 8th

Division III - Grades 1st – 5th

Keep in mind that teams in different divisions may still compete against each other, but the STEM questions will differ in difficulty based on division and based upon standards-aligned within each grade level.

Team Organization

Teams may consist of an unlimited number of members; however, RDL recommends ten to fifteen members per team. There is a limit of six players allowed in the driver's station. There is a designated pit area where team members not in the driver's station may stay to encourage teammates during competition.

RDL Team Showcase

On RDL competition day, teams will have an assigned showcase time. A maximum of ten minutes is allocated to allow the team to showcase to a panel of three judges. For the first five to seven minutes, teams have the freedom to uniquely present the engineering and design of the robot, as well as the programming of the drone. Teams are not limited in presentation style. The only requirements are that all team members are present and speak, and the team's robot must be present. After the team has finished the five to seven-minute presentation, the judges are given the opportunity to present the team members with questions for the remaining time. The RDL Team Showcase is designed to award teams with an opportunity to discuss the STEM

ideas behind the teams' robots, as well as how teams are impacting communities by setting the STEM example to others. As an option, teams are allowed to include technical documents (less than 10 pages), reports, posters, and published materials to aid the RDL Team Showcase in support of the team's presentation to the judging panel.

Engineering Notebook

An engineer's notebook is a book in which an engineer will formally document, in chronological order, all of his/her work that is associated with a specific design project. For RDL, the engineering notebook serves a unique purpose in recording the teams' actions and discoveries throughout the RDL season. Although the engineering notebook is not required to officially compete or to participate in the RDL Team Showcase presentation (which is required), teams should know that the engineering notebook is strongly recommended for teams competing for all award categories.

The engineering notebook should have your team number and school name on the front cover. Engineering notebooks may contain other pertinent information such as community outreach, budgets, sponsorships, mentor notes, goals, and lessons learned. Each team session should be recorded with accurate dates and times of meetings. Team members contributing engineering notebook entries must initial all entries responsible for inclusion.

Illustrations and CAD diagrams are highly suggested.

Only one notebook per team shall be submitted. Teams will leave notebooks with the judges' panel and must retrieve them prior to the end of the competition day.

Driver Station

The primary concern during any event is safety. To ensure the safety of all participants and observers, safety restrictions within the driver station must be followed at all times. The number of team members allowed in the driver station during a match is limited to four to six. Mentors are never allowed at the driver's stations during match play. All players in the driver's station must be wearing closed-toe shoes, as well as safety glasses. Long hair must be pulled back and secured. No loose clothing or dangling jewelry is permitted.

Safety Check

The game has numerous scoring strategies which impact the design and construction of the team robots and the programming of the drones. Following the Four Laws of Robotics, safety is the primary concern for humans, robots, and drones related to inspection. Each robot and drone are required to successfully pass a safety check before competing in the tournament. To pass a safety check, robots and drones need to successfully meet the specifications defined below. If a robot or drone is not deemed safe, it is not allowed to compete. After a robot and drone has passed safety checks, teams will be given a safety card that is required to bring on

deck and present to the alliance official when competing in scoring matches. **Please note that when practicing for or competing in an event, safety should always be the priority. Unsafe operations of both robots and drones can result in serious injuries in the occurrence of misuse or malfunctions.**

Robot Specifications

Robots must be under 61.0 cm wide and 61.0 cm high in the starting configuration. A 20-amp fuse in line with the circuit is required. Robots are limited to using 30 or fewer amps. Wires should be attached to the frame of the robot and organized in a safe configuration. Robots must have no exposed wires. Robots must use batteries of 12V or less. Teams can use any control hub as long as it is inside the manufacturer's amperage limit. RDL does not allow the use of hydraulic systems; however, pneumatics may be used. For pneumatics, there is a limit of 50 PSI, and robots using pneumatics are required to have a pressure relief valve. Robots may not have any sharp edges or properties that would allow the robot to intentionally disregard any of the Four Laws of Robotics. All robots must have an ON/OFF control switch which is properly marked on the ECP and depicted in the ECP systems integrated diagram (SID). Any robot exceeding the limits will not pass the safety check.

Drone Specifications

Teams may use any drone within the size limitations. Drones must be no larger than 46.0 cm long, 46.0 cm wide, and 46.0 cm high. Drones will be measured from the tip of the propeller to the tip of the opposing propeller extended to its fullest. Teams can use any means of programming the drone. Drone propellers must be shrouded with protective devices. When not in use or during transportation, it is advised to remove propellers to ensure safety. Any drone exceeding the limit will not pass the safety check.

Team Match Participation

Team Members

During a match, a team cannot use other participants outside of the driver station to guide robots or drones. If the team is viewed as using external participants to gain an advantage, a red card can be issued. Team members are not allowed on the field during a match and must remain in the driver station or pit at all times, with the exception of the lab technician, who is in the lab station. **Under no circumstances shall a team member reach past the net and onto the field.** The only human interaction with robots is to be from the lab technician and is limited to the safety zone (yellow mats). If the robot or drone is not working, an RDL official will place the robot or drone outside the playing field for the team to work on. Team members who violate the field access rules are awarded a penalty card at the discretion of the RDL official.

Match Setup

Before each match, teams have five minutes to set up the robot and drone. Teams also have a five-minute breakdown period after each match.

Match Scoring

Each team needs to designate a scoring captain. The scoring captain is responsible for keeping track of the team's points during the match. If a scoring captain sees a possible error after an RDL official has calculated the final scores for both teams, the scoring captain may bring up the issue with two different RDL officials. The two RDL officials will reconsider the team's score. Scoring captains need to present evidence for any scores to be reconsidered, including, but not limited to, video evidence.

Field Reset

After each match, RDL officials will reset the field. This reset period lasts approximately five minutes. During this time, teams are required to remove their robots and drones from the field.

Penalties

Definitions

Yellow cards serve as warnings to teams. Red cards result in a fifty (50) point deduction from a team's score. A driver or pilot issued a red card is required to sit out the following match.

1. Following the intent of the Four Laws of Robotics, a robot may not purposely harm another robot, unless that somehow violates the First Law related to the safety of a human. The field is large, and it is expected that robots from

each team will come in close proximity to each other. Robots should not intentionally contact another robot to play defense or prevent the other robot from accomplishing a task.

2. Purposely blocking a robot with another robot to prevent scoring or movement of the robot results in a yellow card.
3. Drones that intentionally crash into a robot as a way to prevent scoring result in a red card for the offending drone pilot. Drones that crash into an opposing robot are not eligible to be rescued during the match.
4. If a drone collision occurs, pilots are awarded a yellow card. If, in the opinion of a referee, a drone was intentionally crashed into another drone or did not show clear intent to avoid a collision, a red card can be issued for the offending drone's pilot.

Yellow Card

A yellow card serves as a warning for robot or drone behavior that is not in the spirit of the Robot Drone League. Any yellow card that is issued can be reviewed by league officials at the end of the match to determine if the actions of the robot under the control of the driver were intentional to gain an advantage and disregard of rules. If the league officials determine that the rule violation was intentional, it can become a red card.

Red Card

A red card issued for poor robot or drone behavior will result in the designated driver's absence in the next match, as well as a fifty (50) point deduction from the offending team's final score. The driver is allowed in the driver's station during the next match. A drone that is awarded a red card requires that the pilot of the drone sit out the following match.

Excessive Mentorship

During an RDL event, if mentors, parents, or any adults are seen by an RDL Official or Judge actively working on a team's robot, this will result in the team's disqualification from competition matches and the withdrawal from any awards related to the competition matches or design of the robots. Additionally, if judges/officials have suspicion of excessive mentorship which has affected the outcome of the design of the robot, the judges/officials have the right to conduct an investigation into a more thorough understanding of the team's knowledge of their own robot.

Video Replay

If video-captured evidence, by RDL, clearly shows that a yellow card or red card should not have been issued, a team can appeal to the head referee to have the penalty overturned. If in the opinion of RDL officials, the video shows clear evidence that the penalty should not have been awarded, the penalty is removed. If RDL officials conclude the appeal had no merit and the video does not provide any evidence that the penalty should be reversed, an additional yellow card can be issued.

The 2022 Bermuda Triangle game is designed to be a challenging and fun game. In the interest of fairness and clarity, rules may need clarification or additional rules added during the season.

Awards

World / Regional Champion – Awarded to the top team that encompasses the overall best in competition, both on and off the challenge field. The following factors are taken into consideration for this prestigious award:

Challenge field scores

Team Showcase presentation

Community Outreach

Tournament Professionalism

Collaborative Spirit

Top Score Award – Awarded to the 1st, 2nd, and 3rd place teams based solely on scores finalized at the end of challenge field play.

Professors Award – Awarded to the team demonstrating the best of community outreach that helps to promote STEM learning in their community. Submission for this award is optional and must include a team essay not to exceed 500 words. Pictures, articles, and letters of appreciation or acknowledgement are recommended for serious consideration of award. Submissions be submitted no later than midnight on December 1st, 2021.

Engineering Award – Awarded to the team that best demonstrates innovation in design and provides best evidence of documented engineering practices to panel of SME professionals. An engineering notebook is required for award consideration.

Judges Award* – Awarded to the team that best demonstrates team grit and tenacity no matter the scoreboard. *Note* (This award is optional and awarded at the discretion of the Head Judge).*

Top Dog Award – Awarded to the team demonstrating the highest competition autonomous scores.

Top Rookie Award – Awarded to the best of the best Rookie team competing in their first RDL season.

Sample STEM Questions

Division I

1) Calculate the amount, in g, of Copper Sulphate produced when 5g of Copper Oxide is reacted with 20ml of 0.5M of Sulphuric acid.
   $CuO + H_2SO4 \dashrightarrow CuSO_4 + H2O$

2) Fluid pressure is always directed?

   a. Up
   b. Down
   c. Sideways
   d. In All Directions

3) It costs $\$\mathbf{2.5}$ MUSD to make each AUV and $\$\mathbf{1.75}$ MUSD to make each drone for exploration on Titan. Which equation represents the cost, $\boldsymbol{C}$, of making $\boldsymbol{x}$ AUV's and $\boldsymbol{y}$ drones?

   A $C = 1.75x - 2.50y$
   B $C = 1.75x + 2.50y$
   C $C = 2.50x - 1.75y$
   D $C = 2.50x + 1.75y$

4) Which best describes an angle?

   A two distinct rays that originate from a common point
   B two parallel lines on a plane
   C the set of all points equidistant from a particular point
   D a line with a starting point that extends to infinity

Sample STEM Questions cont.

Division II

1) A magazine reports that a robot sent to Mars drilled on the surface to collect rock samples. What kind of technological instrument is the robot?

   A satellite
   B space observatory
   C space probe
   D spectroscope

2) How do greenhouse gases in Earth's atmosphere interact with heat from the Sun?

   A Greenhouse gases block heat from the Sun by forming clouds.
   B Greenhouse gases use heat from the Sun to generate light.
   C Greenhouse gases decrease the amount of heat created from the Sun.
   D Greenhouse gases trap some of the heat from the Sun.

3) What is the product of $\mathbf{14.7} \times \mathbf{5.32}$?

   A 7.8204
   B 78.204
   C 782.04
   D 7,820.4

4) What is the value of 63 − 12p when p = 2?

   A 12
   B 24
   C 192
   D 202