MERCURY
REMOTE ROBOT CHALLENGE
2018 Competition Handbook

Oklahoma State University
Stillwater, Oklahoma

Revision History

Please note that only the latest version of this document is considered authoritative. The most recent version is available at http://mercury.okstate.edu/. Major changes to the Handbook will be described on this page.

Revision	Date	Notes
3	8/28/2017	Links updated, Track Pack updated
2	8/18/2017	Links pointing to Track Pack updated
1	8/8/2017	First publication
0	7/20/2017	Preliminary version

Contents

1   Competition Overview

The Mercury Remote Robot Challenge is an international, interscholastic competition that involves the design and implementation of a robot that is capable of completing a variety of tasks while under the control of an Operator who is located at least 50 miles from the site of the competition. Any communication between the robot and Operator must be carried out over the onsite communications channel. Additionally, the Operator may only receive information provided by the robot. This means that any source of information, such as live streaming video, that originates from a source other than the robot and/or does not utilize the onsite communications channel cannot be used as a reference by the Operator.

Each game begins with a five minute setup time followed by ten minutes in which the robot may attempt a maximum of three runs. The robot must follow a predefined path from "Start" to "Finish" and perform the Pickup, Transport and Delivery of the Payload in the allotted time while attempting to avoid striking obstacles. Striking and/or knocking over obstacles will carry penalties. Nothing may be dropped on the course and any robot that is likely to cause damage to persons or property will be deemed ineligible to compete. It is understood that minor damage due to robots bumping the track walls may occur. While the robot must be guided by the actions of the Operator at the remote location, it may utilize onboard intelligence as well.

The Ninth Mercury Remote Robot Challenge will be held on **Saturday April 21, 2018** at the Nobel Research Center on the Oklahoma State University Stillwater campus.

2 The Field

The Field consists of several components; the Track, Pickup and Deposit zones, three Obstacles, and the Sprint. A general description of each component follows below. Models and dimensioned drawings of each of the Field's components can be found in the 2018 Track Pack.

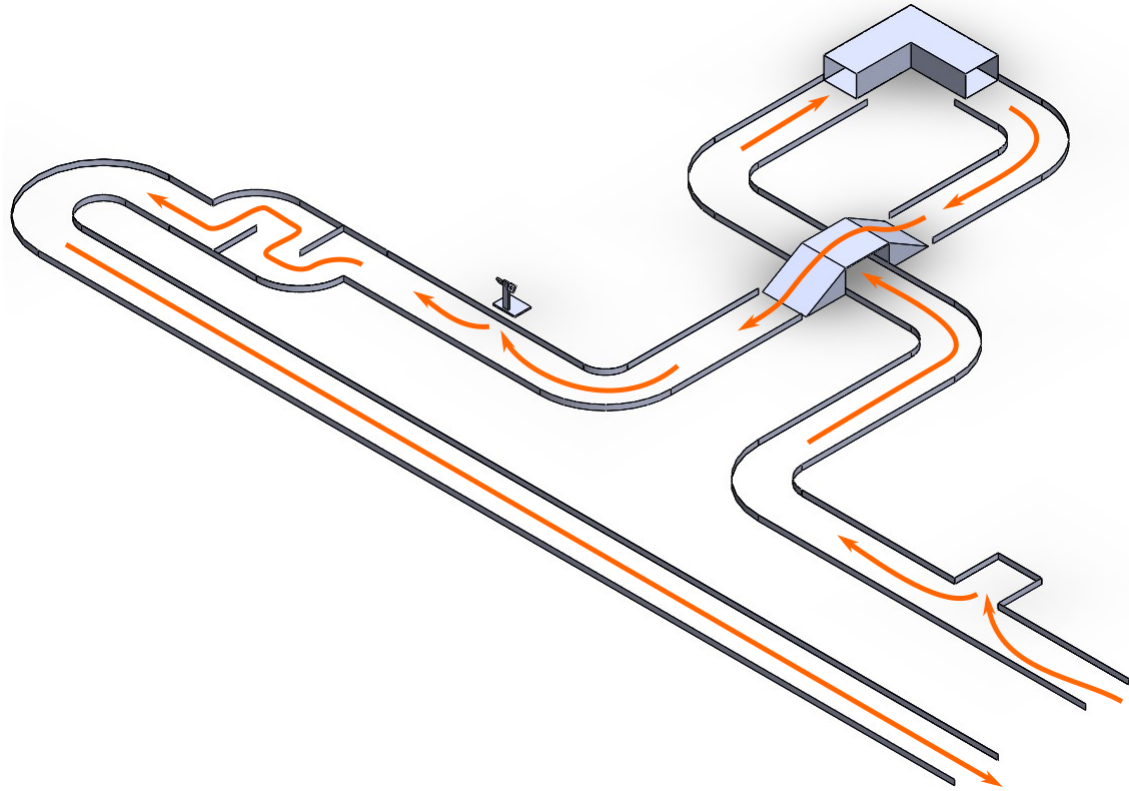Figure 1: Field Overview

2.1 The Track

The Track is defined as a 24 inch wide path that is bounded on either side by 3 inch high walls. The walls used at the Competition will be constructed from foam board of the type that is easily obtainable from craft stores; 1/8 inch thick with a matte white paper surface. The track floor will be short pile carpet.

2.2 Pickup Zone

This area is defined as a 24 inch square, dead end section of track that will hold the Payload for pickup by the robot. The team is allowed to choose the placement and orientation of the Payload within the Pickup Zone prior to the start of a run. The robot and Payload are the only objects permitted in the Pickup Zone at any time during a run.

2.3   Delivery Zone

The Delivery Zone is a freestanding object placed just outside the Track boundary that the Payload is Delivered to. It will be placed at approximately the location indicated in figure 1. The Delivery Zone has three openings of two types to accommodate either Payload; two square and one circular. Please refer to the 2018 Track Pack for models and a dimensioned drawing of this object.

2.4   Obstacles

Although the 2018 Competition Track does not include any paths that bypass the Obstacles, a team may choose to bypass any or all of the obstacles during a run. See section 3.4 for details.

2.4.1   Tunnel

The Tunnel is an L-shaped wooden structure with openings on either end that are 12 inches high by 18 inches wide. The interior is dark. This Obstacle tests the maneuverability of the robot in a confined space with limited visibility.

2.4.2   Bridge

The Bridge is 24 inches wide with a smooth wooden surface and no guard walls. The climb is 30 degrees with 12 inch rise, followed by a 24 inch span and a 30 degree descent. This Obstacle tests the robot's ability to move in a controlled manner on low friction inclined surfaces.

2.4.3   Slalom

To receive points for this task the robot must negotiate the path determined by the walls in the Slalom area with as few wall contacts as possible.

2.5   The Sprint

The final section of the Track is a 40 foot long straight run timed by infrared tripwires at both ends. This portion of the Field will test the speed and straight line control of the robot. The points earned in this section will be a multiplier for the total points acquired in a run by the robot.

3 The Game

The order in which robots take the track will be determined by lottery and may be reordered at the discretion of the event organizers.

3.1 Objective

The Objective of the Game this year is the Pickup and Delivery of one of two wooden objects (the Payload). Teams score points based on their robot's performance in carrying out the Objective and navigating the Field.

3.1.1 The Payload

The Payload will be constructed from wood according to the dimensions in figure 2. The official Payload objects for use in the Competition will be provided by the event organizers at the venue. Teams will select and place a Payload in the Pickup Zone prior to each run. The Payload can be different from one run to the next.
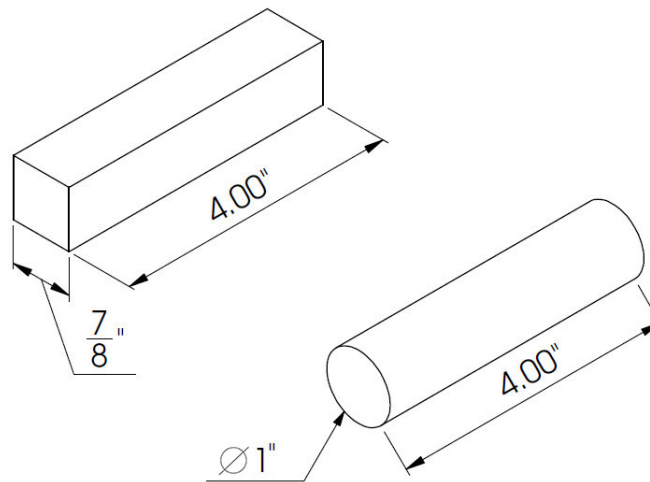

Figure 2: Square and Circular Payload Dimensions

3.2 Run Times

Each team will be allowed a maximum of 15 minutes of operating time during the competition. The 15 minutes is divided into two sections; 5 minutes for setup and 10 minutes to run the track. The setup time ends when the robot begins operating. If the team uses more than 5 minutes for setup, it will cut into the 10 minutes of run time.

The teams may attempt up to 3 runs as the 10 minute time window will allow. At any time during the 10 minute run time, a team may choose to terminate the run and restart the Track. A team may not restart after starting its third and final run. When the final run is started, it must be completed before the 10 minute window expires. A run in progress will be terminated at the 10 minute mark, and the score for that run recorded at that time.

If a robot cannot complete the track in the allotted time, or if it runs out of time during a run, then "Did Not Finish" (DNF) is recorded along with the score for that run. A DNF score cannot be considered for the purpose of selecting a champion.

If a robot is unable to start a run during the 15 minute operating period, it is recorded as "Did Not Start" (DNS).

In the event that the site communication link fails, the clock may be stopped or reset at the judges' discretion.

3.3   Scoring

For the score of a particular run to be considered valid for the purpose of selecting a Champion, the robot must perform a complete run of the track.

The score for each run is calculated using the following formula:

$$Score = (P + (30 - T) + B + (30 - S) + D_b \cdot D_m) \cdot (1.375 - 0.0075 \cdot t_{sprint}) - (5W + 10R)$$

Table 1: Scoring Variables

		Values	Notes
P	Payload Pickup	0,30	30 if pickup successful, else 0
T	Tunnel	0,15,30	Increments with each impact
B	Bridge	0,30	30 if crossing is successful, else 0
S	Slalom	0,10,20,30	Increments with each impact
D_b	Delivery Base Score	15,20,25	See figure 3
D_m	Delivery Multiplier	0,1,2	Fail is 0, halfway is 1, fully through is 2
t_{sprint}	Sprint Time	$0 \leq t_{sprint} \leq 50$	Time in seconds to complete sprint
W	Contact Penalty	$0 \leq W$	Number of times robot touches wall
R	Reset Penalty	$0 \leq R$	Number of times Handler resets/touches robot

3.3.1   Payload Pickup

The Payload Pickup is considered successful if the robot is able to retrieve the Payload from the Pickup Zone unaided by the Handler. P is assigned thirty points for a successful pickup. Otherwise no points are awarded. A Reset Penalty is assessed any time the Handler places the Payload in the robot's carrying device. No points are deducted if the robot drops and recovers the Payload on its own.

3.3.2   Delivery

The Delivery score is divided into two parts, the Delivery Base Score and the Delivery Multiplier.

- **Delivery Base Score** D_b depends on which Payload object the team selects for a particular run. See figure 3 for the points awarded for each deposit.

- **Delivery Multiplier** A multiplier of one is assigned to D_m if the robot places the Payload in an opening so that it remains suspended and does not fall through. A multiplier of two is assigned if the robot inserts the Payload into an opening so that it clears it completely and falls through the other side. Failure to place the Payload through any opening, or the Payload falling back out once the robot has placed it, will result in a multiplier of zero.
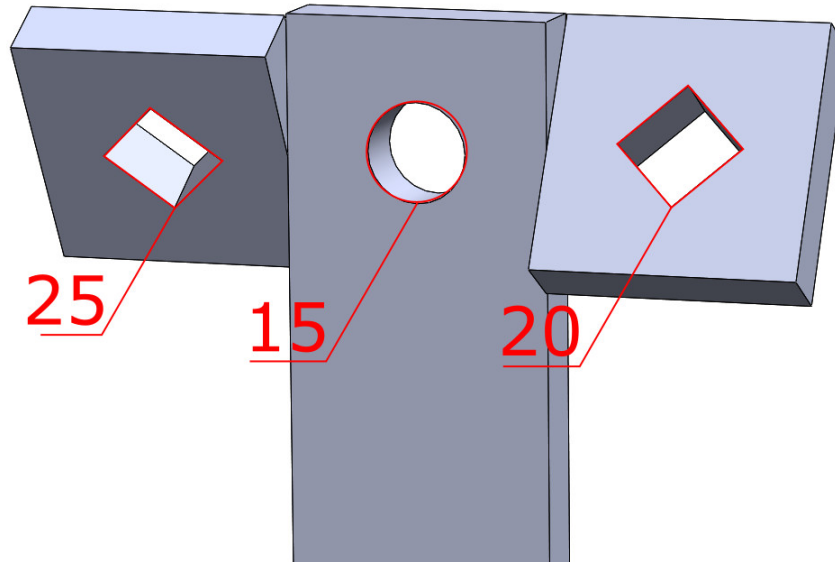

Figure 3: Delivery Zone Point Values

3.3.3 Tunnel

The variable T is initially zero and increments by fifteen points for each of the first two times the robot makes contact with the Tunnel. Further impacts with the Tunnel do not result in T increasing beyond 30, and do not count as Contact Penalties.

3.3.4 Bridge

If the robot is able to cross the Bridge unaided and without falling off, B is assigned thirty points. Otherwise no points are awarded. The team can choose to take a Reset Penalty and reattempt the crossing for the for the full thirty points should the robot fall off while crossing.

3.3.5 Slalom

The variable S is initially zero and increments by ten points for each of the first three times the robot makes contact with the Slalom walls. Further impacts with the Slalom do not result in S increasing beyond 30, and do not count as Contact Penalties.

3.3.6 Sprint

Any time the robot has not completed the Sprint, or the time taken to complete the sprint is greater than fifty seconds, t_{sprint} is assigned a value of 50.

3.4 Penalties

- **Robot Reset** – If the Robot Handler has to touch the robot during the run it will result in a score penalty of 10 points and the robot will be put where it left the track or anywhere prior to that point. If any other team member touches the robot during the run, the current run will be disqualified and therefore not scored.

- **Excessive Communication** – If the judge rules that any team member at the competition site is providing directions to the Operator during a run, the team may be issued a warning, penalty or be disqualified depending on the extent of the infraction. The only communications recommended between the Operator and the Robot Handler are "Start when ready" and "Terminate this run?"

- **Touching track boundaries** – If the robot comes into contact with the track walls or crosses over the area above marked track boundaries a penalty of 5 points will be deducted from the final score. The penalty will be assessed each time the robot comes into contact with the boundaries. Extended contact can be assessed multiple penalties if it lasts longer than three seconds and the robot remains in motion. For example, a robot that stops while touching the boundary will only receive one penalty but one that drives while touching the wall might receive more than one at the judge's discretion.

- **Bypassing an Obstacle** To bypass an Obstacle the Robot Handler may pick up the robot at that Obstacle's entry point and place the robot just after the exit point for a Reset Penalty.

3.5 Scoring Examples

$$Score = (P + (30 - T) + B + (30 - S) + D_b \cdot D_m) \cdot (1.375 - 0.0075 \cdot t_{sprint}) - (5W + 10R)$$

Robot 1 performs it's final run flawlessly; it incurs no penalties, scores maximum points for the Delivery, and executes the Sprint in 10 seconds.

Table 2: Total Score for Robot 1

Score	P	T	B	S	D_b	D_m	t_{sprint}	W	R	DNF
221	30	0	30	0	25	2	10	0	0	False

Robot 2 successfully performs the Pickup, but scores no points in the Tunnel due to impacts. It makes three attempts at the Bridge, crossing successfully on the third try. It is able to score Maximum points for the Delivery but impacts the walls of the Slalom several times and runs out of time during the Sprint.

Table 3: Total Score for Robot 2

Score	P	T	B	S	D_b	D_m	t_{sprint}	W	R	DNF
65	30	30	30	30	25	2	50	5	2	True

Robot 3 is able to successfully perform the Pickup, but incurs a Contact Penalty while passing under the Bridge. It contacts the inside of the Tunnel once and is able to cross the Bridge on the first attempt. While getting into position to Deliver the Payload it makes two additional wall contacts. The robot places the circular Payload in the Delivery Zone. With less than a minute left, the team opts to take a Reset Penalty to bypass the Slalom. The Sprint is completed in 5 seconds.

Table 4: Total Score for Robot 3

Score	P	T	B	S	D_b	D_m	t_{sprint}	W	R	DNF
95.375	30	15	30	30	15	1	5	3	1	False

4 The Robot

4.1 General Robot Requirements

All work on the robot shall be completed by **8:30 AM the day of the Competition**, at which time all competing robots are to be turned off and put on display. Minor adjustments, such as the tightening of screws or the replacement of components that have fallen off, are permissible only during a team's fifteen minute run time.

4.2 Safety

We strongly encourage all teams to consider the safety of their fellow participants, the public and the venue when designing their robot. We reserve the right to disqualify any team whose robot is considered to fall short of safety standards. Consider the following:

- Batteries: You may use NiCad, NiMH, SLA batteries or other "safe" batteries. Li-ion batteries may be used only if the team can demonstrate that proper charging and low cut-off systems have been implemented.

- Rocket motors, Medieval flails, Nuclear devices (that includes both fusion and fission) and any components that have a tendency to combust, explode, or jump start the apocalypse are strictly prohibited.

4.3 Communications

The Competition provides an 802.11b/g/n Wi-Fi network on the venue. All communications between the driver and the robot must use this network. The driver must establish a two-way communication with the robot. At the very least, the robot must send a heartbeat signal back to the driver.

The following are the details of the wireless network and regulations of its use during the competition:

1. The Competition Wi-Fi network will have the ESSID "MERCURY" and *no security protection*. This ESSID will not be broadcast. Please ensure that your system can connect to a Wi-Fi network without the ESSID broadcast.

2. The Wi-Fi router providing this network will have a public IP address that will be disclosed to the team on the day of the Competition.

3. Each team is allowed to have at most **three** networked hosts using the Wi-Fi network. For example, an IP camera and a Wi-Fi device will count as two hosts. A Wi-Fi device with a non-IP camera attached only counts as one host (for example, a smartphone providing video feed and control channel will only count as one host, but it must use the Wi-Fi network).

4. The team will have to provide information about their networked devices on the online registration form. The team may change this information on the form any number of times up until **Friday April 13, 2018 at 11:59:59 PM CST**. This information includes a brief description of each device, the MAC addresses, and the ports each device will use if an inbound connection is required.

5. The networked devices will have to use DHCP to obtain an IP address. Static IP addresses are not allowed and will result in the team's disqualification if used. IP addresses are assigned based on the MAC addresses of the networked devices provided by the team on the registration form.

6. If the team requires an inbound connection to a networked device, the team is allowed to have at most three forwarded ports. The information provided on the registration form will be used and the team will be notified of the external ports assigned to the team a week before the competition.

7. During a team's run, only that team's robot and its associated devices will have access to the Wi-Fi network. **_All other robots and devices that access the Competition router must be completely turned off._** Failure to do so will result in the team being issued a warning, a penalty or disqualified.

8. A base station to provide non-Wi-Fi wireless link between the robot and the official router is allowed to be used on-site. This wireless link must not use the 802.11 standard. The base station must use the competition Wi-Fi network to gain Internet access and the base station will count towards the two maximum networked devices.

9. Independent Wi-Fi repeaters, bridges, ad-hoc Wi-Fi networks, and access points are not allowed. The only 802.11b/g network each device may use is the official wireless network.

4.3.1 Loss-of-Signal Test

The team must pass a "Loss-of-Signal" (LOS) test to be eligible as the Competition champion. Teams will have two opportunities to demonstrate LOS handling: **Friday April 20, 2018** during the evening Practice period and during regular testing the morning of **Saturday April 21, 2018**.

The test will be performed as follows:

1. The team clearly demonstrates that the driver can control the robot,

2. The official router technician will then shut down the router and the robot must be able to clearly indicate that it is now experiencing a loss-of-signal situation and stop,

3. After the official router is restarted, the team must be able to demonstrate that the driver can re-establish connection to the robot without the team personnel manipulating the robot. The robot must show that connection is re-established by turning off the Loss-of-Signal indicator, and resume normal operation as in point 1.

5 The Tournament

5.1 Registration

Registration forms can be found online at http://mercury.okstate.edu under the Mercury Challenge tab. Registration information should be submitted no later than **Saturday February 24, 2018 at 11:59:59PM CST**. The registration forms provide information that is needed to organize the competition, generate name tags, and for preparing refreshments. Please contact us if you have special dietary needs.

The competition is open to teams of any size though only four members may hold active positions at the competition. The active positions and their responsibilities are:

- Team Leader – The team leader is the contact point between the competition organizers and the team. The team leader is encouraged to be at the venue or to have a representative standing in during the day of the competition and may act as the robot handler or a technical assistant.

- Operator – During the competition only the Operator may guide the robot. Note that the Operator must be at least 50 miles (80km) away from the competition site at all times during the team's run.

- Robot Handler – During the competition only the Robot Handler may touch the robot during a run. Permitted contact includes any technical support or maintenance.

- Technical Assistant – During the competition the technical assistant may only handle the robot whenever a "run" is not in progress. The technical assistant is to provide aid with technical issues that may arise with the robot.

Teams are encouraged to come up with a unique team name that will be used for keeping score and for announcements at the competition.

5.2 Practice Runs

Track setup will begin **Friday April 20, 2018 after 5pm** at the Competition venue. During the setup period teams will be allowed to test their robots on the Track as it is constructed. The Competition router will also be available for testing. Additionally, robots can undergo LOS testing at this time. Teams are encouraged to contact us ahead of time so that staff is available to assist them when they arrive.

5.3 Documentation

In order to participate in the competition, each team is required to provide a documentation package that is to be submitted via email to okstate.mercury.robotics@gmail.com no later than **Saturday March 17, 2018 at 11:59:59 PM CST**. This section describes all submission items that comprise the documentation package.

5.3.1 Technical Document

The technical document describes the robot and the design decisions that go into the robot. There is a 10 page limit to this document NOT including appendices. This document will be used by the competition officials to survey the technology and engineering methods used by the team to improve subsequent competitions.

At the minimum, please ensure that the document addresses the following topics:

- A high-level block diagram of the robot
- Communication systems used (TCP or UDP sockets, applications, etc.)
- The main controller used for the robot (single-board computers, Arduino, custom made, etc.)
- Video feedback system (if the robot has it)
- The driver interface of the robot
- The robot's drive configuration (number of motors, wheels, etc.)
- Sensors and other intelligent subsystems used on the robot
- Power subsystem

This document is a factor for the "Best Design" award. Please submit this document in PDF format.

5.3.2 Video Presentation

Each team is required to submit a 2 to 5 minute video for the competition. This video will be used for promotional materials for the competition and will be played during the competition itself for the audience, so please tailor the contents of the video accordingly and ensure that the robot is actually featured! The video is a factor for the "Best Presentation" award. Please upload your team's video to a video hosting service, preferably YouTube or Vimeo, and include a link to it with your documentation package submission.

5.3.3 Robot and Team Picture

Teams are required to submit a reasonably high-resolution picture of the robot (300 dpi) and a smaller picture of the team personnel. These pictures will be featured in promotional materials and miscellaneous items in the competition such as team member badges, posters, displays, etc. The picture must be in JPEG or PNG format. Please submit the picture with your documentation package submission.

5.4 Judging

The Jury consists of professors from OSU. The head judge will be responsible for judging the performance of the robot during the competition (penalties, starting time, etc.). The remaining judges will be in charge of scoring the video presentation, the robot design, and interview the participants to determine the winners for Judges' Choice awards. Any subject not considered in this document will be left to the discretion of the Judges.

5.5 Awards

The awards will be given to the three highest scores computed during the competition, resulting in the 1st, 2nd, and 3rd place respectively. Other Awards will include: the "Best Presentation" (submitted video presentation), "Best Design" and "Judge's Choice". Note that it is possible for one team to win multiple awards. Awards, except the ones based on the team's score, will be given at the discretion of the Judges. They may base awards on personal preference or by examining the general consensus of teams, volunteers, and spectators.

6   Appendix

6.1   Important Dates

Please note that the cutoff time for each deadline below is 11:59:59 PM CST.

Registration Deadline	Saturday February 24, 2018
Documentation Submission Deadline	Saturday March 17, 2018
Deadline to Update Network Information	Friday April 13, 2018
Practice, Early LOS Testing	Friday April 20, 2018 Starting at 5pm
Competition	Saturday April 21, 2018

6.2   Contact Information

If you have any questions regarding the information in this document or in relation to the Competition, visit our website at http://mercury.okstate.edu or contact us via email at okstate.mercury.robotics@gmail.com.

We look forward to seeing you at the 2018 Mercury Remote Robot Challenge