2020 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
1.0.1	August 11, 2019	Preliminary release
1.1.1	October 11, 2019	Reduced number of pulse generators to one. - Added blue flags to end of obstacle avoidance section. - Defined bypass of Object ID Section
1.2.1	March 26, 2020	Updated competition date and deadlines

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. 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 fifteen minutes in which the robot may attempt a maximum of three runs. The robot must follow a predefined path from "Start" to "Finish" within the allotted time, performing a prescribed task along the way, 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 Eleventh Mercury Remote Robot Challenge will be held on **August 29, 2020** at the Student Union located on the Oklahoma State University campus in Stillwater, Oklahoma.

2 Field

The Field consists of several components: the track, bypasses, bridge, tunnel, the object identification and handling section, rough terrain section, and obstacle avoidance section. A general description of each component follows below. Models and dimensioned drawings of each of the field's components can be found in the 2020 Track Pack.

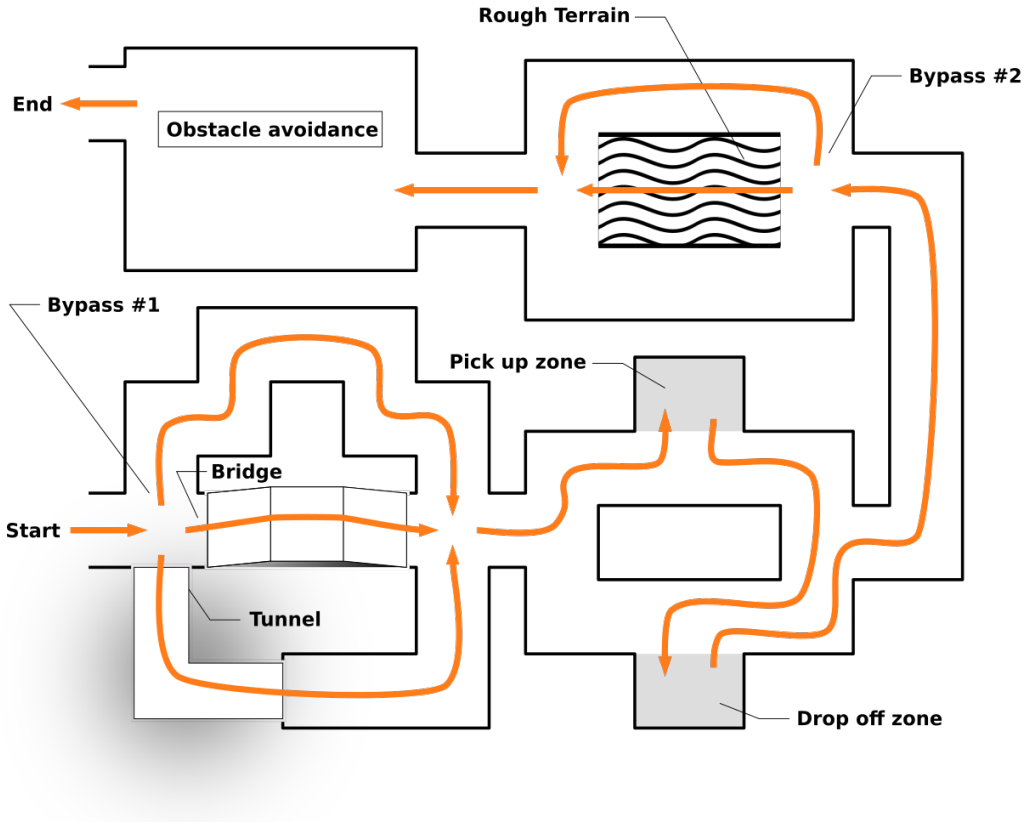

Figure 1: Field Overview

2.1 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: 0.125-inch-thick with a matte, white paper surface. The walls will be stabilized with plastic brackets that will raise them roughly one inch off the floor. The track will be laid out on a terrazzo floor.

2.2 Bypasses

The 2020 competition track includes paths that bypass most obstacles. Teams may choose to bypass any or all of the obstacles during a run. See section 3.4 for details.

2.3 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 Bridge

The bridge is 24-inches-wide with a carpeted surface and no guard walls. The climb is 30-degrees with a 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 an inclined surface.

2.5 Object Identification and Handling

2.5.1 Pick-Up Zone

There will be four bright red cubes with side lengths of 2 inches in the pick-up zone. One contains an electromagnetic coil that will generate a square wave at a frequency of approximately 10 Hz. The robot must detect which object is emitting the square wave. Once detected, the robot is tasked with securing the cube and transferring it to the drop-off zone.

2.5.2 Drop-Off Zone

There will be one bright yellow bin at the drop-off zone. It will be dimensioned as 4 inches wide by 4 inches deep by 2 inches tall. It will not have a front facing side. The robot is tasked with placing cube emitting the 10 Hz oscillating signal into the bright yellow bin.

2.6 Rough Terrain

The rough terrain section is a 3-feet-wide by 5-feet-long area covered with an array of domes aligned in a diagonal grid pattern. The domes will be 3D-printed plastic with a base diameter of 2 inches and a height of $1/2$ inch. There will be walls on the long edges of the section, with bypass paths extending another 24 inches beyond the section walls. This section tests the durability and agility of the robot.

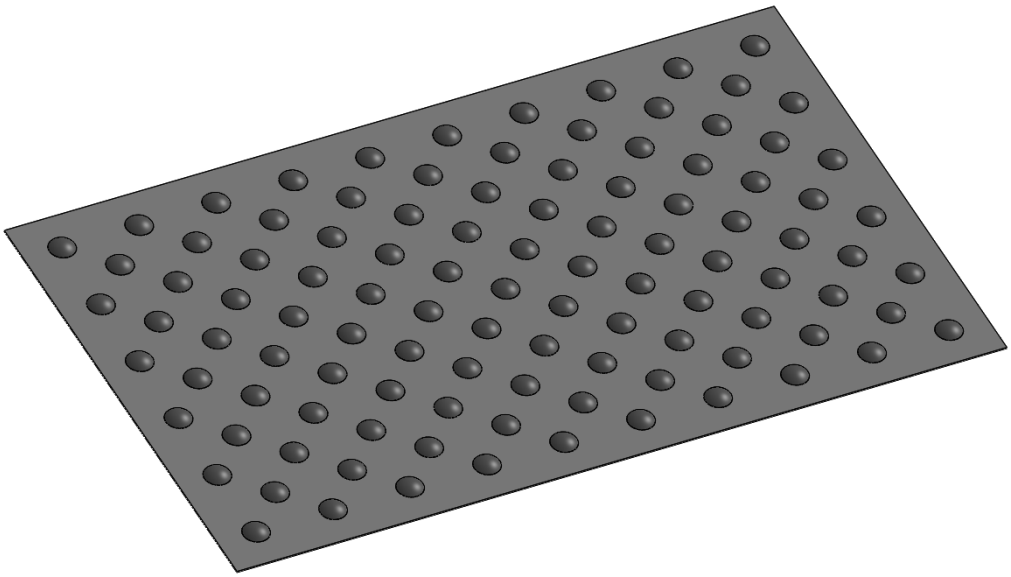

Figure 2: Example of Rough Terrain Section

2.7 Obstacle Avoidance

The obstacle avoidance section is defined as a rectangular area 6-feet-wide by 8-feet-long. The robot must navigate from the start to the finish without contacting walls or obstacles. Obstacles will consist of standard commercial 2x4 wooden boards varying in length. Note that the actual dimensions of a standard 2x4 are 1.5 inches by 3.5 inches. They will be bright orange. There will be at least one path through this section providing a minimum of 24 inches between obstacles. There will be blue flags on either side of the exit of this section. They will be visible from all points in the section.

Three different versions of this section are available; they very in the amount of robot autonomy involved. When registering for the competition, teams will be required to specify which version of the section they wish to attempt. This selection may be changed at or before registration the day of the competition. The three versions of the section are as follows:

- Manual - Known Placement

  The network will remain enabled and the operator will have full control of the robot as it navigates the section. If this option is chosen, the section will be laid out as defined below.

- Autonomous - Known Placement

  The network will be disabled and the operator will lose contact with the robot. The robot must be able to navigate the section autonomously. If this option is chosen, the section will be laid out as defined below.

- Autonomous - Unknown Placement

  The Network will be disabled and the operator will lose contact with the robot. The robot must be able to navigate the section autonomously. If this option is chosen, the layout of obstacles in the section will be unknown to teams until after the deadline to submit robots on the day of the competition.

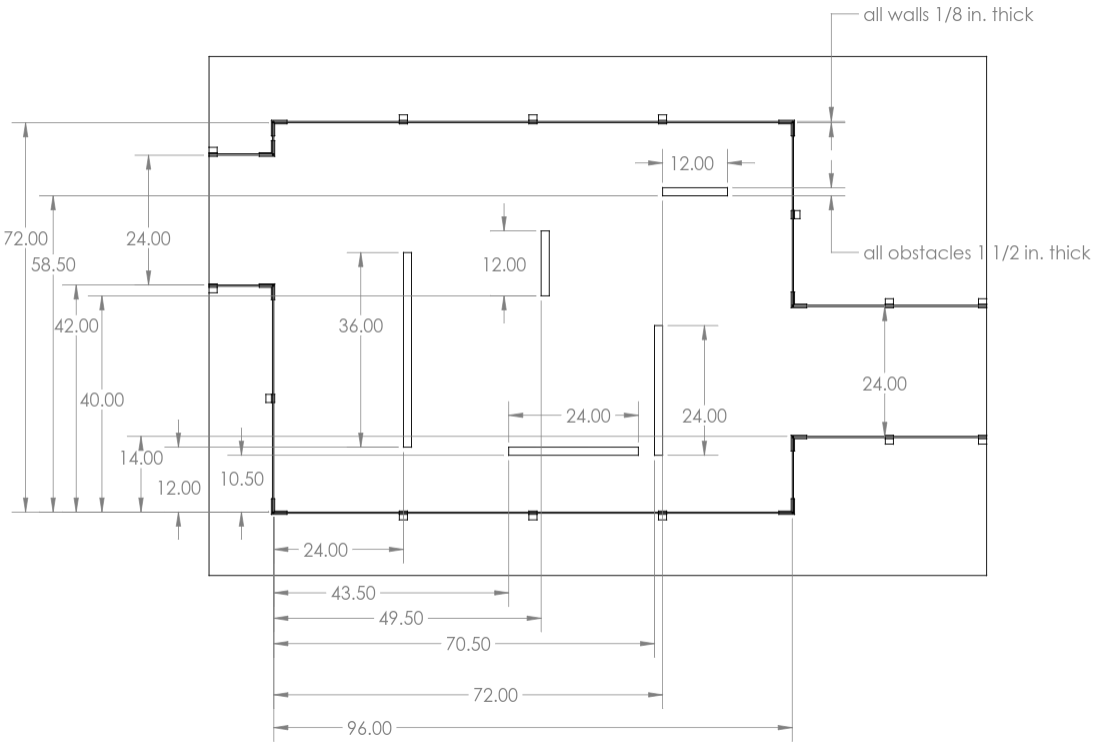

Figure 3: Known Obstacle Layout

3 The Game

The order in which robots go through 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 to navigate the entire track, which involves a variety of obstacles and prescribed tasks, letting the robot operate both autonomously and under operator control.

3.2 Run Times

Each team will be allowed a maximum of 20 minutes of operating time during the competition. The 20 minutes is divided into two sections: 5 minutes for setup and 15 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 15 minutes of run time.

The teams may attempt up to 3 runs within the 15 minute time window. At any time during the 15 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 15 minute window expires. A run in-progress will be terminated at the 15 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. Additionally, robots that obtain DNF scores will be ranked among themselves in a second, lower category. A DNF score will not be recorded for bypassing a section unless the robot is otherwise unable to complete the track.

If a robot is unable to start a run during the 20 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:

$$Score = (S_1 + S_2 + S_3(1 - \frac{C_{S_3}}{5}) + S_4(1 - \frac{C_{S_4}}{5})) + T_b(1 - \frac{T_r + 3W}{T_{tot}}) - 50R$$

3.3.1 Section 1 - Bridge/Tunnel

If the robot crosses the bridge unaided, 150 points are awarded. If the robot successfully navigates the tunnel, 90 points are awarded. If the robot takes the bypass or is otherwise aided, 0 points are awarded.

Table 1: Scoring Variables

		Values	Notes
S_1	Bridge/Tunnel	0,90,150	150 if crosses bridge, 90 if takes tunnel, else 0
S_2	Object ID/Handling	$0, 100, 200, 300$	Details below
S_3	Rough Terrain	200	Maximum points for S_3
S_4	Obstacle Avoidance	75,175,300	75 if manual, 175 if autonomous (known) 300 if autonomous (unknown)
C_{S_3}	Contact Penalty in S_3	$0 \leq C \leq 5$	Times the robot touches the inner wall in S_3
C_{S_4}	Contact Penalty in S_4	$0 \leq C \leq 5$	Times the robot touches an obstacle in S_4
W	Wall Contacts	$0 \leq W$	Times the robot touches a wall
T_r	Run Time	$0 \leq T_r \leq T_{tot}$	Run Time in seconds, including contact penalties
T_{tot}	Total Time	900	Total available run time in seconds
T_b	Time Bonus	300	Maximum time bonus
R	Reset Penalty	$0 \leq R$	Number of times the handler touches robot

3.3.2 Section 2 - Object Identification and Handling

Robots that identify and place the 10 Hz oscillator in the bright yellow bin will be awarded 300 points. 200 points are awarded for identifying and securing the 10 Hz oscillator. 100 points are awarded for securing any other cube. 100 points are awarded for placing any cube in the yellow bin. Only the first cube to be secured will be scored.

3.3.3 Section 3 - Rough Terrain

A maximum of 200 points are available for completing the rough terrain section. 40 points are deducted for each contact with the inner walls of the section. Extended contacts may be recorded as multiple penalties at the judges' discretion. Completion is defined as the robot navigating from start to finish without more than half of the robot crossing the section boundaries.

C_{S_3} represents the number of times the robot contacts the inner walls of the section.

3.3.4 Section 4 - Obstacle Avoidance

S_4 represents the maximum possible points available for the obstacle avoidance section. These maximums are as follows:

- Manual - 75 points
- Autonomous (Known placement of obstacles) - 175 points
- Autonomous (Unknown placement of obstacles) - 300 points

C_{S_4} represents the number of times the robot contacts obstacles in the section. Teams will be given 1 free contact, after which C_{S_4} will increment by one per contact. Extended contacts may incur multiple penalties at the judges' discretion. Note that C_{S_4} is not affected by contacts with course boundaries, which are defined in Section 3.4.

3.3.5 Time Bonus

T_b represents the maximum possible time bonus. To qualify for the time bonus, the robot must both finish the track and use no more than two bypass routes.

Note that the robot is considered to have bypassed the Object ID Section (S_2) if it traverses the section without attempting to complete the assigned task.

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 50 points and the robot will be put where it left the track or anywhere it has previously traveled. 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?"
- **Wall Contact** – If the robot comes into contact with the track walls or crosses over track boundaries a penalty of 3 seconds will be added to the robot's run time. 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 while one that drives while touching the wall might receive a series of penalties at the judge's discretion.
- **Bypassing an Obstacle** – There are bypass routes available for most sections. If a robot bypasses a section, the team will receive no points for that section. There will be no additional penalties assessed for bypassing the section. However, the robot may incur other penalties during the route.

4 The Robot

4.1 General Robot Requirements

All work on the robot shall be completed by **8:30 AM August 29, 2020**, 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 twenty minute operating time. Violation of this requirement will result in a warning, penalty, or disqualification at the judge's discretion.

4.2 Safety

All teams must 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. The following are required:

- 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 voltage cut-off systems have been implemented. Low voltage cut-off systems must include an integrated protection circuit that disconnects the battery from all robot systems.
- Switches: At minimum, teams must implement two switches. The first must disconnect the batteries from all robot systems. The second must disable the drive system. Both switches must be clearly identified in the technical documentation and easy to identify and reach on the robot.
- 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 at 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 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 **August 1, 2020**. 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 three 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.
10. If the team chooses to attempt an autonomous version of the obstacle avoidance section, the network will be disabled when the robot reaches the beginning of that section. The robot is still required to indicate a loss-of-signal event. The indicator must be described in the technical documentation such that competition judges can easily identify the state of the robot's wireless connection. If the robot continues through the obstacle avoidance section without indicating a loss-of-signal event, it will be scored as if it is controlled manually.

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: **August 28, 2020** during the evening Practice period and during regular testing the morning of **August 29, 2020**.

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.
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 **May 30, 2020**. 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. Unlike previous years, the operator is no longer required to be 50 miles (80km) away from the competition site. There will be a room provided at the competition venue for the operator to guide the robot. If the operator is located on the OSU campus, he or she must control the robot from the provided room. There is no other restriction on the location of the operator.
- 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 **August 28, 2020 at 5 pm** at the competition venue. During the setup period teams will be allowed to test their robots on the track as it is being assembled. 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 **July 18, 2020**. 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 including both electrical (batteries, sensors, relays, etc.) and mechanical systems (drive train, motors, belts, gears, etc.)
- Safety systems (battery protection (fuses, protection circuit), kill switch, etc.)
- 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
- Parts list/Bill of materials
- A general description of any autonomous and logical subsystems
- 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. While videos may be humorous, please refrain from including profanity of any kind. Videos found to contain profanity will be disqualified from the "Best Design" award and will not be featured on the Mercury web page.

5.3.3 Robot and Team Picture

Teams are required to submit a reasonably high-resolution picture of the robot (300 dpi) and a 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

A panel of OSU Mercury Robotics officers and OSU professors will be responsible for judging the performance of the robot during the competition (penalties, starting time, etc.). The judges will also be in charge of scoring the video presentation, the robot design, and interviewing 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: "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	May 30, 2020
Documentation Submission Deadline	July 18, 2020
Deadline to Update Network Information	August 1, 2020
Practice, Early LOS Testing	August 28, 2020
Competition	August 29, 2020

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 2020 Mercury Remote Robot Challenge