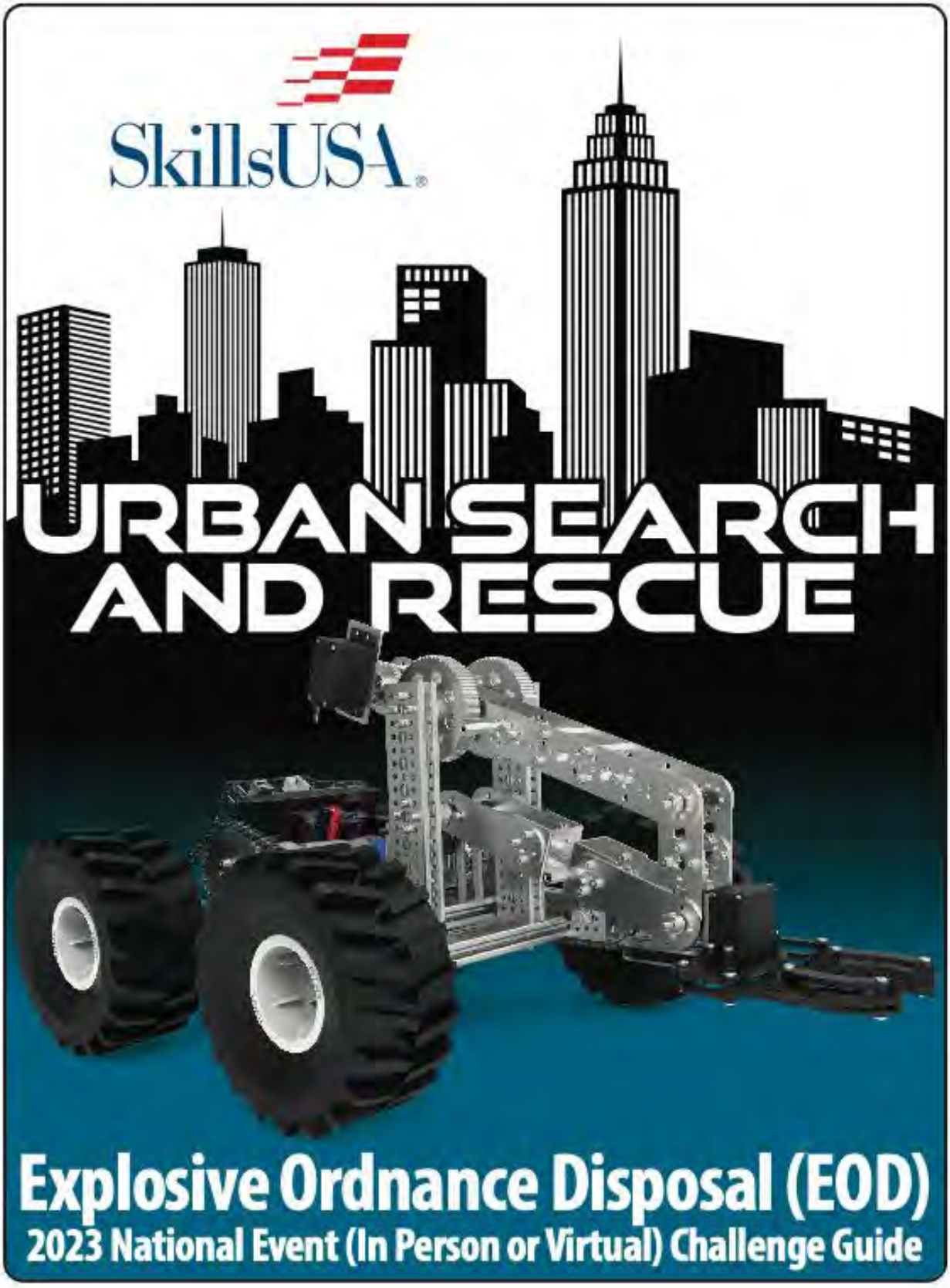

(Version: November 17th, 2022)

Note: *Event rules/regulations are subject to revision prior to competition.*

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Explosive Ordnance Disposal Robot, Springfield (MO) Fire Department

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Event

This document has been written to the SkillsUSA® Championships Technical Standards with the intent that individual states have the autonomy to change, modify, or abbreviate any or all the standards as outlined.

The 2023 Robotics: Urban Search & Rescue Challenge: Explosive Ordnance Disposal (EOD) enables students to create a mobile robot like those employed by emergency service personnel (fire, police, and military). The robot is designed to secure an area by locating, neutralizing, moving, and disposing of explosive materials. The demand for designers, skilled technicians, and manufacturing workers who are fluent in mechanical design and electrical systems and highly skilled in troubleshooting and maintenance of robotic systems is projected to continue to grow. The current generation of students is expected to take artificial intelligence and robotics into the evolving world of emergency services, finding new ways to help trained personnel react more quickly and effectively. Therefore, it is imperative that our future labor force be on the leading edge of current and emerging technologies and possess the technical and team skills necessary to maintain industry leadership in design, manufacture, maintenance, and operation of life-saving robotic equipment.

Purpose

- To evaluate team members' skills and preparation for employment in fields related to and including robotics, engineering, automation, manufacturing, electronics, and emergency services.
- To recognize outstanding performance by participants in scenarios that require problem-solving and teamwork in a real-world situation.
- To foster participant and spectator excitement and interest in careers focused on robotics, engineering, automation, manufacturing, electronics, and emergency services.

Clothing Requirement

Official SkillsUSA white polo is required. Safety glasses are required when contestants are in the pit area working on their robots. Scoring deductions may be given and/or disqualification of contestant only if clothing safety standards are not met. For complete details, visit www.skillsusastore.org. If you have questions about clothing or logo attire, call 800-401-1560 or 703-956-3723.

Eligibility (Team of 2)

Open to active SkillsUSA members enrolled in programs with robotics, engineering, automation, manufacturing, electronics, and emergency services as the occupational objectives.

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Equipment and Materials

Supplied by Technical Committee

- Challenge field: 30' x 40' simulated neighborhood (See Appendix for state-level recommended modifications).
- Field elements:
    - Challenge Field Test: Components of an urban area and obstacles to traverse, open, and manipulate in order to locate and dispose of simulated explosive ordnances. (See Challenge Field Test examples in Appendix.)
    - Skills Challenge: Individual components needed to test unique skills typically used in Urban Search and Rescue events. (See Challenge Skills Test examples in Appendix.)
- A command center area equipped with a table, a driver chair, spotter area, a video monitor, and two-way communication equipment for driver and spotter. (See "Command Center" specifications in Appendix.)
- General workspace for each team designated as a "pit" area, including one table, two chairs, and access to a 120-volt electrical supply.

Supplied by Competing Team

Note: The first five bulleted items following apply to virtual competitions.

- Computer with high-speed Internet capability and camera to use applications such as Zoom or Teams. The minimum recommended Internet bandwidth speeds for joining Zoom meetings, accessing on-demand curriculum, and other online operations is 2.0 Mbps up and down. You can test your current Internet speeds by following this link: www.speedtest.net. Allow the page to load and click **Go**. Note that computer is for technical purposes only, not for robot operation.
- A secondary camera(s) may be required to provide judges with the ability to view contestants from different angles. Additional camera requirements will be located on the SkillsUSA website at http://updates.skillsusa.org.
- A contest proctor will be required to be on-site to assist judges. A local industry expert is preferred to serve as the proctor and shall not be an individual who has been involved with the training of the contestants. The proctor will serve as the on-site "hands and eyes" for the judges. The proctor will follow instructions from the judges for safety and operations related to the competition. The proctor may be asked by judges to perform several tasks such as operating a portable camera to show specific components or steps, measure parts, or do any task that will provide judges with information needed to assist in accurate scoring of the contestant's work or presentation. However, the proctor shall not serve as a judge nor have any influence on contestant scores.
- The contestant's instructor or adviser shall be on-site to observe all competition activities to ensure a safe and healthy competition experience for all participants. That instructor or adviser will not be allowed to interact or interfere with the competitor unless a safety issue arises that requires interaction. Any other support or interaction between the contestant and the instructor/adviser will result in disqualification.

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- All competitors must create a one-page résumé and submit an electronic copy to the technical committee chair at least seven (7) days in advance of the competition. Failure to do so will result in a 10-point penalty. Instructions for submission of the electronic résumé copy will be provided on the SkillsUSA website at http://updates.skillsusa.org.
- Safety equipment – Eye protection is required when contestants are in the pit area working on their robot.
- Fully assembled, tested, and operational ordnance disposal robot conforming to the guidelines and parts restrictions listed in this document. (See "Urban Search & Rescue Challenge Set Bill of Materials" in Appendix.)
- Team number affixed to robot
- Presentation software for oral presentation to judges (optional)
- CAD/CAM software for blueprint design (optional)
- Completed Engineering Notebook (**Note:** Technical drawing/blueprint of robot drive chassis must be included in notebook.)
- Pens, pencils, and paper
- Tools (suggested):
    - Allen wrench set (English)
    - Clamping vise
    - Metal tin snips
    - Power strip
    - Calculator
    - Tape measure
    - Hammer
    - Metal file
    - Flat-head and Phillips-head screwdrivers
    - Wire strippers (one set)
    - Wire cutters/snips (one set)
    - Roll of electrical tape
    - 4" nylon wire ties (25-Pack)
    - Multimeter
    - Multi-nut pliers
    - Metal-cutting hacksaw (manual)
    - Cordless drill with charger
    - Set of standard drill bits
    - Pliers (needle nose or regular)
    - Set of box wrenches

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Event Overview

A two-member team builds its robot and arm mechanism prior to the competition. Then, during the competition, there will be two separate but related challenges. The first will be a demonstration of proficiency in five specific skill test challenges. The second is a simulated urban search and rescue mission to traverse a course and locate, secure, and properly dispose of ordnances. Both challenges will require teams to demonstrate proficiencies such as remotely operating the robot via camera, navigating, manipulating the arm mechanism to collect simulated ordnances, traversing various types of terrain, and communicating between driver and spotter. Each team will perform one round of the five skill trials and one round of the simulated mission to locate and dispose of two ordnances. In both challenges, teams will be under time constraints to complete the objective. Challenge breakdown is as follows. **Note:** See Appendix for technical details of each skill challenge.

The five identified skills challenge areas are:

- **Arm Mechanism Skill Challenge:**
  - Teams will demonstrate how effective they can open mailboxes and remove ordnance at three levels of increasing difficulty.
- **Navigation Skill Challenge:**
  - Teams will demonstrate basic navigation skills while controlling an ordnance by driving to specified areas of the field.
- **Drive Chassis Skill Challenge:**
  - Teams will navigate multilevel terrain challenges to test the engineering of their chassis and overall robot design. (Examples might be driving up smooth ramps, or rough ramps, a teeter totter, or a debris field, and so on.)
- **Camera POV Skill Challenge:**
  - Teams will demonstrate their Tele-Op/remote control driving proficiency using only POV (point of view) information transmitted from an onboard camera by navigating through a complex tunnel.
- **Communication and Collaboration Skill Challenge:**
  - Teams will demonstrate communication and collaboration skills by navigating a course using only direction from a spotter. This simulates a potential hardware failure on a robot where the driver must depend only on information from the spotter for successful completion of the challenge.

Each skill area will have a unique simplified field area from the overall Urban Search and Rescue field set up. (This is not to say that specific aspects of the overall field might not or could not be used for an individual skill area.) For example, the end effector manipulation skills challenge might be three mailboxes lined up next to each other with different levels of difficulty to open and remove the ordnance for each one.

Because each skill challenge will be consistent for all participants, the element of a time bonus can be implemented. There will be a maximum time limit that, if exceeded, will cost participants points; there will also be a proficiency time target that will provide bonus points if participants complete the challenge before the target time.

Because skill areas 1-3 are impacted more by robot design and function rather than remote driver skill, the driver shall have clear visual view of the robot and test courses during the skill challenge. The driver will be restricted to an area clearly defined by test organizer adjacent to the course at the time of the skill challenge field.

Skill areas 4 and 5 are a direct test of remote driver ability and communication between driver and spotter. Therefore, the driver shall not have direct visual view of the robot and skill challenge courses. This causes the driver to rely on information from the robot's camera or spotter teammate. The driver will be restricted to a driver station with no

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direct view of the skill challenge course during the test. The participant can use a supplied digital output (monitor/TV) or a device of their own.

Urban Search and Rescue Field Challenge
For the simulated urban search and rescue mission, a total of two ordnances will be placed. One of the ordnances will be placed in a specified location. The other ordnance will be placed in a random location determined by the event chairperson. The random location will likely change from one run to the next. For the known ordnance location, there will be two obvious routes. One route will be higher risk but with potential time savings. The other route will be lower risk but could potentially take longer. These routes will be determined by the event chairperson. Teams should strategize when determining their route to the known ordnance.

Contest Field

- 30' x 40' simulated urban area (See Appendix for state-level recommended modifications.)
- Features of neighborhood:
    - Starting point from which robot deploys
    - Containment boundaries marking the 30' x 40' challenge area
    - Objects often found in urban settings: home, street, grass, and mailboxes

Note: Ordnances are randomly and strategically positioned on the challenge course in locations that require a robot to open doors and reach for and grab items to deliver them to a safe disposal site. Some ordnances may be located outside a direct line of sight from the command center. Each team will operate its mobile robot and navigate by first-person POV through the video feed from an onboard wireless camera.

Command Center

The command center will be within view of the playing field. The designated driver must remain seated at the command center while the designated spotter remains in the defined spotting area while competing. (See "Command Center" specifications in Appendix.)

Pit Area

A pit area where teams modify their robots and arm mechanisms will be provided. Each team will have a conference table, two chairs, and access to a 120-volt electrical outlet. **Note:** Robot cameras must remain *off* while in the pit area to minimize the chance of interference for the team actively driving the course.

Recommended Content for Urban Search & Rescue Challenge Set

The Urban Search & Rescue EOD robot may be built using only components that comprise the Urban Search & Rescue Challenge Set and/or other approved parts listed in the Appendix. Each set contains everything necessary to construct a basic robot for the Urban Search & Rescue Challenge competition.

Upon registering for the event, if needed, teams may purchase an Urban Search & Rescue Challenge Set and other approved robotics supplies necessary to compete from Pitsco Education at www.pitsco.com.

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Notes: Any off-the-shelf robotics building platform may be used for this event, as long as the robot complies with all part restrictions (see page 13) and is operated by remote control; **autonomously controlled robots will be disqualified.** Any wireless camera system that can be mounted to the robot with output to video display will meet contest requirements. A video monitor/TV with RCA inputs will be supplied by the technical committee for the purpose of displaying the team's video feed in the command center. A bill of materials for the Urban Search & Rescue Challenge Kit and a list of approved optional parts and raw materials can be found in the Appendix.

Challenge Checklist

- ☐ Purchase robot challenge kit.
- ☐ Design and build robot and arm mechanism within specifications that is capable of grabbing, holding, and moving objects. Document process and blueprints in Engineering Notebook.
- ☐ Practice driving robot on various types of terrain while looking at a video monitor displaying the feed from the onboard camera.
- ☐ Review basic mechanical, robotics, and electrical knowledge in preparation for written test.
- ☐ Plan, prepare, and practice presentation.
- ☐ Attend local, regional, state, and national Urban Search & Rescue Challenge competitions.

Sample Event Agenda

Following is a sample agenda for an Urban Search & Rescue Challenge event.

1. **Orientation and Written Test:** Teams will bring robots for inspection and Engineering Notebooks for judging. The written test will be administered (30-minute limit for written test).
2. Robot and Engineering Notebook **inspection** by judges (items then returned to teams)
3. The following can be done simultaneously if the number of event personnel permits:
    - Teams complete **technical presentation** (oral and physical) over robot, Engineering Notebook, and arm mechanism. (Following presentation, items will remain in judges' possession until challenge field competition.)
    - Final robot and arm mechanism **inspection** by judges
4. Skills Challenges conducted
5. **Lunch**
6. Urban Search and Rescue Field Challenge **competition** conducted

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Contest Guidelines/Rules

Note for Virtual Competitions: Contestants may not be required to perform all the standards and competencies listed in this and the following sections. However, contestants should be prepared to perform competencies in all areas. Prior to the competition, the technical committee may determine which standards and competencies contestants will perform for the virtual contests. The technical committee will determine if additional information is needed for contestants prior to the competition. These changes will be posted on the SkillsUSA Championships contest update website at http://updates.skillsusa.org.

Note: Guidelines and rules are subject to change.

- Each **team** must be composed of two members. If a team member is absent, the lone team member will be allowed to compete, but a 30-point penalty will be applied to the overall score.
- Each robot must have an **identification label** with the team's number listed.
- Each **technical presentation** should last a maximum of five minutes and should be primarily oral, with supporting materials of printed or electronic media and physical models. Students should be prepared to discuss the roles they played, their robot design, and the functions of their robot. (**Note:** The technical committee will **not** provide projector, screen, or other presentation equipment.)
- **Before attending** the competition, team members should design, build, and experiment with robots constructed from the SkillsUSA Urban Search & Rescue Challenge Kit. Additional TETRIX® or other approved parts and raw materials (see Appendix) may also be used. The prebuilt robot and arm mechanism will be required to grab, hold, and move objects during the mission.
- The robot's arm mechanism must be capable of opening a standard-size mailbox and reaching **into the box up to five (5) inches**, grabbing the simulated ordnance, and pulling it out of the mailbox. The arm mechanism must be capable of reaching items positioned **up to nine (9) inches above the floor**.
- The simulated ordnances (wooden block image, left) are not included in the competition kit and are **approximately 2.7 inches cubed** and **weigh 4.3 ounces**. The handles on doors and mailboxes (right) are **3.3 inches long and 0.41 inch wide**.

Ordnance (wooden block)

Mailbox handle

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- **Part Restrictions:**
    - Limit of **eight** motors/servos per competing robot
    - Maximum of **one** transmitter/remote
    - **One** rechargeable battery pack for drivetrain motor power, maximum 12V 3,000 mAh.
    - **Wireless camera system** that must be mounted on robot
    - Robot must fit into an **18" x 18" x 18"** space when starting **but may be expanded to a larger size during the challenge**.

- Each team must provide in its Engineering Notebook a **technical drawing or blueprint** detailing the construction of its robot drive chassis and additional drawings/blueprints for its associated arm mechanism.

- The robot and arm mechanism must be **assembled by the team prior to the competition**.

- All robots will be required to **pass inspection** (see page 16) by judges to determine if all the parts used are from the list of allowed parts. Any team whose robot fails inspection will be disqualified if proper modifications have not been made by at least two hours prior to competing.

- Robots with an arm mechanism that poses a **danger** to competitors or could cause potential damage to the challenge field will not be allowed to compete.

- Accuracy of the robot's **construction matching the blueprint** will be considered during scoring. All necessary parts and tools for construction must be brought to the competition site.

- Team members will be required to follow proper safety procedures and use eye protection.

- Teams may bring a **laptop computer and blueprint drawings** of their robot and arm mechanism designs to the contest building area. A description of the assembly process is required to be within the Engineering Notebook. The designs also may be printed or hand-drawn copies.

- Teams **may view the challenge course** prior to the beginning of competition and may watch other competing teams during the challenge event.

Engineering Notebook

The Engineering Notebook will be submitted for judging at check-in. Required elements:

- Overall neat and professional appearance

- A complete bill of materials for the robot drive chassis and arm mechanism designed and used in competition at the event

- A detailed description of the assembly process for the robot drive chassis and arm mechanism

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- Illustrations, sketches, photos, and written log entries accurately documenting the design and prototyping iterations detailing the evolution and logical progression of the robot's design

- Explanations noting how testing was conducted, why modifications were made, what skills were learned, and how robot might further be modified to improve performance and achieve desired objectives if no restrictions were in place

Skill & Challenge Course Rules

Note: All teams will be expected to adhere to the official rules for the Urban Search & Rescue Challenge competition and compete in a positive and professional manner.

- All teams will be required to compete in all five Skill Challenges prior to the Urban Search and Rescue Field Challenge.
- At the competition site, the **simulated urban area** will be provided and maintained by the technical committee. During competition, the course will be reset to its original state before each team competes. The ordnance pieces will be randomly placed before each team competes.

- The Urban Search & Rescue Field Challenge: Explosive Ordnance Disposal event will consist of **a single timed mission** for each team. During the mission, the robot has up to six minutes to navigate the course, complete the challenge, and return to home base.

- Each team will **operate its mobile robot** and navigate by line of sight and by the video feed from an onboard wireless camera. The command center will be within view of the playing field. The driver must remain seated at the command center and the spotter must stay within the boundaries of the spotter station while competing.

- An official will be in charge of placing the team's robot at the starting point on the challenge course. (**Reminder:** The robot must fit within an 18**"** x 18**"** x 18**"** space at the start but **may expand to any size after it enters the neighborhood**.)

- After a "clear" signal is issued by a challenge course official, **time will begin** as soon as the robot moves. Following completion of a mission, **time will stop** upon successful return to home base following disposal of two simulated explosive ordnances or time limit expires.

- Robots should remain on roads and paths within the urban area in order to avoid property damage. Shortcuts are not allowed and will result in penalties.

- The Urban Search & Rescue Field Challenge will be a **maximum of six minutes**.

- Team members are **not allowed to touch** their robot at any time while a Skill Challenge or Urban Search and Rescue Field Challenge is in progress, unless instructed to do so by a judge.

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- The **containment unit** where the ordnance pieces are placed by the robot after removal from the course must remain outside of the field of play and as close to the starting position as possible. Any team that deliberately moves the containment unit from its starting point may be disqualified.
- An official will award points for the team's mission based on the official **"Urban Search and Rescue Skills and Field Challenges" rubric**.

Penalties

- A deduction (see rubric in Appendix) will be assessed each time an ordnance is dropped.
- Each time the **robot stalls or becomes hung up** and has to be freed by an official, a deduction will be assessed. An official will free a robot only at the request of a team member, but a deduction will be assessed.
- A deduction will be assessed whenever a robot goes off the designated path within the neighborhood or **outside of the course boundaries**. **Shortcuts are not allowed**.

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Robot Inspection Checklist

Inspector: _____ **Team Number:** _____

Time of Inspection: _____ **Pass/Fail:** _____

Inspection Type: ____ **Initial** ____ **Mandated** ____ **Random**

Pass	Fail	Rules/Guidelines	Notes
		Robot fits in size limitation of 18" L x 18" W x 18" H.	
		Team name/number is attached and visible on robot.	
		Robot does NOT contain components that will intentionally detach on playing field.	
		Robot does NOT contain any components that could damage the playing field.	
		Robot does NOT contain any parts that are sharp, jagged, or pointed.	
		Robot poses NO obvious unnecessary risk of entanglement with any element on the playing field.	
		Robot contains a total of no more than eight DC motors, servo motors, or a combination thereof.	
		Robot contains only ONE transmitter/controller and receiver.	
		Robot contains only ONE 12V 3,000 mAh battery for drive train.	
		Robot wiring MUST be secured to chassis, free and clear of any moving parts to avoid entanglement while competing.	
		Robot battery pack(s) MUST be securely fastened to robot's chassis away from sharp edges, corners, screws, and moving parts.	
		Robot MUST contain a securely fastened wireless camera.	
		Robots using chain and sprocket or tank treads MUST have sufficient slack in the chain and/or tank treads.	
		Robot is built ONLY from approved materials listed in Appendix A of the current Urban Search & Rescue Technical Standards.	

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Scoring Rubrics

Urban Search & Rescue Challenge – Possible Points: 100
These skill challenge scores will be subject based on judge's opinion – points shown are to be guidelines and awarded points might fall between levels shown.

Bonus:
Robot can successfully traverse all the field obstacles and return to starting point under time proficiency target.

Team: _____

Skill Challenge #1: Drive Chassis

Objective	Points Performance Level					Points
	0	**5**	**8**	**12**	**15**	
Skill challenge of design, construction, and durability of power drive-system assembly (gears, chain, sprocket, wheels, treads).	Drive-system assembly is poorly designed or constructed and lacks durability.	Drive-system assembly demonstrates adequate design, construction, and durability.	Drive-system assembly demonstrates average design, construction, and durability.	Drive-system assembly demonstrates above-average design, construction, and durability.	Drive-system assembly demonstrates excellent design, construction, and durability.	
Skill challenge of electrical components installation and wire management.	Poor effort given to wire routing and safety management.	Minimal effort given to wire routing and safety management.	Average effort given to wire routing and safety management.	Above-average effort given to wire routing and safety management.	Excellent effort given to wire routing and safety management.	
Skill challenge of basic driving performance test (FWD, REV, turn right, turn left).	Robot chassis does not function in any capacity when demonstrated.	Robot chassis powers up but performs only one basic control function.	Robot chassis powers up but performs only two basic control functions.	Robot chassis powers up but performs only three basic control functions.	Robot chassis powers up and performs all four basic control functions.	

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	0	**10**	**20**	**30**		
Challenge goals achieved. (Challenge goals are all or nothing – if you achieve a level, you get full score for that level.)	Robot is unable to traverse any of the field obstacles before time expires.	Robot is able to successfully traverse the field of debris but unable to traverse either of the ramps before time expires.	Robot is able to successfully traverse the field of debris and one of the ramps before time expires.	Robot is able to successfully traverse all of the field obstacles and return to starting point before time expires.		
					Bonus (25-point max)	
					Total:	
Judge's comments:						

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Urban Search & Rescue Challenge – Possible Points: 100
Skill challenge scores will be subject based on judge's opinion – points shown are to be guidelines and awarded points might fall between levels shown.

Bonus:
Successfully picked up ordnance, completed four field targets, and exited the field under time proficiency target.

Team: _____

Skill Challenge #2: Navigation

Objective	Points Performance Level					Points
	0	**5**	**8**	**12**	**15**	
Skill Challenge of ordnance control	Driver unable to pick up ordnance.	Driver is able to pick up the ordnance after multiple tries and drops the ordnance multiple times as they complete the course.	Driver can pick up the ordnance but drops the ordnance once as they complete the course.	Driver can pick up ordnance and maintain control through the whole course.	Driver able to pick up ordnance efficiently and maintain obvious control through the whole course.	
Skill Challenge of driver control and efficiency	Driver is unable to navigate to any of field targets.	Driver struggles to navigate to any of the field targets and has to make multiple attempts and corrections to avoid field obstacles.	Driver is able to navigate to field targets but demonstrates average proficiency when addressing field targets and avoiding field obstacles.	Driver is able to navigate to field targets and demonstrates above average proficiency when addressing field targets and avoiding field obstacles.	Driver is able to navigate to all field targets efficiently and demonstrates superior proficiency when addressing field targets and avoiding field obstacles.	
	0	**10**	**20**	**30**	**45**	

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Challenge goals achieved. (Challenge goals are all or nothing – if you achieve a level, you get full score for that level.)	Unable to pick up ordnance and complete any of field targets before time limit expired.	Successfully picked up ordnance and completed one field target before time limit expired.	Successfully picked up ordnance and completed two field targets before time limit expired.	Successfully picked up ordnance and completed three field targets before time limit expired.	Successfully picked up ordnance, completed four field targets, and exited the field before time limit expired.	
					Bonus (25-point max)	
					Total:	
Judge's comments:						

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Urban Search & Rescue Challenge – Possible Points: 100
Skill challenge scores will be subject based on judge's opinion – points shown are to be guidelines and awarded points might fall between levels shown.

Bonus:
The robot can find, enter, navigate through, exit the enclosed space, turn around, and return back through the space to the original starting point under time proficiency target to complete with correct critical mission data.

Team: _____

Skill Challenge #3: Camera POV

Objective	Points Performance Level					Points
	0	**5**	**8**	**12**	**15**	
Performance skill challenge of POV camera system	Camera system powers on but cannot connect to output device to successfully transmit image.	Camera system powers on and connects to output device but signal is unreliable and intermittent.	Camera system powers on, connects to output device, and provides adequate enough image quality to allow the robot to complete the course.	Camera system powers on, connects to output device, and provides good image quality allowing the robot to complete the course and collect at least some mission critical data.	Camera system powers on, connects to output device, and provides superior image quality allowing the robot to complete the course and collect all of the mission critical data.	
	0	**15**	**30**	**45**	**60**	
Challenge goals achieved. (Challenge goals are all or nothing – if you achieve a level, you get full score for that level.)	The robot is unable to find and enter into the enclosed space before time expires.	The robot is able to find and enter into the enclosed space but can't find the exit before time expires.	The robot is able to find, enter, navigate through, and exit the enclosed space in one direction before the time expires.	The robot is able to find, enter, navigate through, exit the enclosed space, turn around, and return back through the space to the original starting point before time expires.	The robot is able to find, enter, navigate through, exit the enclosed space, turn around, and return back through the space to the original starting point before time expires to complete	

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					with correct critical mission data.	
					Bonus (25-point max)	
					Total:	
Judge's comments:						

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Urban Search & Rescue Challenge – Possible Points: 100
Skill Challenge scores will be subject based on judge's opinion – points shown are to be guidelines and awarded points might fall between levels shown.

Bonus:
The robot is successful at traversing the full course, including collecting and disposing of the ordnance without going outside of the marked boundaries or impacting the obstacles under the time proficiency target.

Team: _____

Skill Challenge #4:
Communication & Collaboration

Objective	Points Performance Level					Points
	0	**5**	**8**	**12**	**15**	
Skill challenge of Spotter verbal/communication skills	Spotter fails to provide effective information that allows the driver to achieve any of the critical objectives of the course.	Spotter provides poor or inadequate information that inhibits the driver from effectively completing the course objectives.	Spotter provides average, adequate information that allows the driver to complete the course, but not without numerous corrections and attempts on critical objectives.	Spotter provides above average information that allows the driver to complete all the critical objectives of the course.	Spotter provides superior, concise, comprehensive, and effective information that allows the driver to efficiently complete all the critical objectives of the course with minimal corrections and no wasted motion.	
Skill challenge of Driver listening/comprehensive skills	Driver fails to receive or react to Spotter information resulting in failure to complete any of the critical course objectives.	Driver demonstrates poor ability to receive and react to Spotter information, necessitating multiple attempts and ultimate	Driver demonstrates average ability to receive and react to Spotter information, allowing for completion of all of the critical	Driver demonstrates above average ability to receive and react to Spotter information, allowing for effective completion of all of the	Driver demonstrates a superior ability to receive and react in highly responsive actions to Spotter information, allowing	

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		failure to complete critical course objectives.	course objectives after several attempts.	critical course objectives.	for a superior level of proficiency in completion of critical course objectives.	
	0	**15**	**30**	**45**		
Challenge goals achieved (Challenge goals are all or nothing – if you achieve a level, you get full score for that level.)	The robot is unsuccessful at avoiding the obstacles and reaching the beginning of the T-junction before time expires.	The robot is successful at traversing the course up to tagging the mailbox before time expires (at this level it does not matter if robot goes outside of marked boundaries or impacts the obstacles).	The robot is successful at traversing the full course, including collecting and disposing of the ordnance before time expires (at this level it does not matter if robot goes outside of marked boundaries or impacts the obstacles).	The robot is successful at traversing the full course, including collecting and disposing of the ordnance before time expires and without going outside of the marked boundaries or impacting the obstacles.		
					Bonus (25-point max)	
					Total:	
Judge's comments:						

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Urban Search & Rescue Challenge – Possible Points: 100
Skill challenge scores will be subject based on judge's opinion – points shown are to be guidelines and awarded points might fall between levels shown.

Bonus: **Team:** _____

Successfully opened all mailboxes and removed all ordnances under time proficiency target.

Skill Challenge #5:
Arm Mechanism

Objective	Points Performance Level					Points
	0	**5**	**8**	**12**	**15**	
Performance skill challenge of arm mechanism	Arm mechanism does not function in any capacity.	Arm mechanism functions unreliably and is poorly engineered.	Arm mechanism functions satisfactorily but lacks engineering efficiency.	Arm mechanism functions well and is moderately engineered.	Arm mechanism functions reliably and is well-constructed and engineered.	
Performance skill challenge of gripper	Gripper is ineffective and cannot maintain hold on ordnance.	Gripper functions unreliably and is poorly engineered.	Gripper functions satisfactorily but lacks engineering efficiency.	Gripper functions well and is moderately engineered.	Gripper functions reliably and is well-constructed and engineered.	
Overall performance of arm and gripper assembly	Assembly does not allow for transport and disposal of ordnance.	Assembly is unreliable and is poorly engineered.	Assembly functions satisfactorily but lacks engineering efficiency.	Assembly functions well and is moderately engineered.	Assembly functions reliably and is well-constructed and engineered.	
	0	**10**	**20**	**30**		
Challenge goal achieved. (Challenge goals are all or	Unable to open any mailboxes or remove	Successfully opened one mailbox and removed	Successfully opened two mailboxes and	Successfully opened all mailboxes and		

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nothing – if you achieve a level, you get full score for that level.)	any ordnances before time limit expired.	one ordnance before time limit expired.	removed two ordnances before time limit expired.	removed all ordnances before time limit expired.		
					Bonus 25-point max	
					Total:	
Judge's comments:						

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Urban Search & Rescue Challenge – Possible Points: 125 **Team: _____**

Engineering Technician Notebook

Objective	Points Performance Level					Points
	5	10	15	20	25	
Overall content format and appearance	Notebook did not follow mission format/guidelines or demonstrate understanding of task.	Notebook adequately follows some, but not all, of the mission format/guidelines and demonstrates understanding of task.	Notebook adequately follows mission format/guidelines and demonstrates understanding of task.	Notebook meets the mission format/guidelines and demonstrates understanding of task.	Notebook is outstanding and goes above and beyond format/guidelines and demonstrates understanding of task.	
Logical structure and documentation	Team did not document the project in a satisfactory manner.	Team adequately documents project but lacks logical flow and structure of project from start to finish.	Team completed documentation, flow, and structure in an average manner, but more could have been done.	Team documented the project "journey" with good flow and structure from beginning to end.	Team's documentation of project demonstrates an effort that goes above and beyond.	
Technical accuracy and bill of materials	Technical content (descriptions, sketches, drawings, tables, and figures) does not match robot project build.	Technical content (descriptions, sketches, drawings, tables, and figures) only vaguely resembles robot project build.	About half of the technical content (descriptions, sketches, drawings, tables, and figures) matches robot project build.	About three-quarters of the technical content (descriptions, sketches, drawings, tables, and figures) matches robot project build.	Technical content (descriptions, sketches, drawings, tables, and figures) matches robot project build with outstanding detail and clarity.	
Technical drawing quality (if no drawing provided, score is 0)	Drawing detail and quality are inferior.	Drawing detail and quality are adequate.	Drawing detail and quality are average.	Drawing detail and quality are above average.	Drawing detail and quality are excellent.	

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Accuracy of technical drawing to assembled drive train	Technical drawing does not match assembled drive train.	Technical drawing matches few components of the assembled drive train.	Technical drawing matches major components of the assembled drive train.	Technical drawing matches all major and most minor components of the assembled drive train.	Technical drawing matches all major and all minor components of the assembled drive train.	
					Total:	
Judge's comments:						

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Urban Search & Rescue Challenge – Possible Points: 75 **Team: _____**

Technical Presentation

Objective	Points Performance Level					Points
	5	**10**	**15**	**20**	**25**	
Explanation of mechanical and electrical systems within the robot	Did not explain mechanical and electrical parts and their functions.	Demonstrates minimal knowledge of mechanical and electrical parts and their functions.	Demonstrates adequate knowledge of mechanical and electrical parts and their functions.	Demonstrates a working knowledge of mechanical and electrical parts and their functions within the mechanical system.	Demonstrates a thorough knowledge of mechanical and electrical parts and their functions within the mechanical system.	
Description of design challenges and solutions implemented for the robot	Did not explain design challenges faced or solutions implemented.	Demonstrates minimal knowledge of design challenges faced and solutions implemented.	Demonstrates adequate knowledge of design challenges faced and solutions implemented.	Demonstrates a working knowledge of design challenges faced and solutions implemented.	Demonstrates a thorough knowledge of design challenges faced and solutions implemented.	
Overall presentation quality	Teammates did not equally share responsibilities and presentation quality was poor.	Teammates did not equally share responsibilities or demonstrate adequate presentation skills.	Teammates somewhat shared responsibilities and demonstrated adequate presentation skills.	Teammates mostly shared responsibilities and demonstrated good presentation skills.	Teammates shared responsibilities and demonstrated polished presentation skills.	
					Total:	

Judge's comments:

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Urban Search & Rescue Challenge – Possible Points: 200 **Team:** _____

Urban Search and Rescue Field Challenge

Objective	Points Performance Level								Points
	0	**50**	**100**	**125**	**150**	**170**	**200**	**Time**	
Challenge Course Mission: Ordnance retrieval and containment	Robot became disabled on the course and could not continue.	Robot did not find any of the ordnances.	Robot found at least one of the ordnances but was unable to retrieve and dispose of it.	Robot was able to find both of the ordnances but not dispose of either within the allotted time.	Robot was able to retrieve and dispose of one of the ordnances.	Robot was able to retrieve but not dispose of the second ordnance within the allotted time.	Robot was able to retrieve and dispose of both of the ordnances within the allotted time.		

Point Deduction Worksheet

Infraction	Number of Incidents	Points to Deduct
Loss of ordnance (5 points per incident)		
Vehicle stalled; official asked to help (5 points per incident)		
Robot intentionally outside of boundaries (25 points per incident)		
Deduction Total (insert into main scoring rubric)		

Total Time	
Field Challenge Points (subtotal)	
Deduction Total (from Point Deduction Worksheet)	
Field Challenge Point Total	

Judge's comments:

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Urban Search & Rescue Challenge – Possible Points: 100

Team: _____

Written Test

	Number of Questions	Points Possible per Question	Points Possible	Points Scored
	25	**4**	**100**	

Judge's comments:

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Team: _____

Urban Search & Rescue Challenge **Total Possible Points: 1,000**

Category	Possible Points	Points Scored	Judge's Comments
Arm Mechanism Skill Challenge	100		
Navigation Skill Challenge	100		
Drive Chassis Skill Challenge	100		
Camera POV Skill Challenge	100		
Communication & Collaboration Skill Challenge	100		
Engineering Technician Notebook	125		
Technical Presentation	75		
Urban Search & Rescue Field Challenge	200		
Written Test	100		
Team Total:	**1,000**		
No résumé (deduction)	- 10		
Team member absent (deduction)	- 30		
Team Total (minus deductions):			

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Appendix

(A) TETRIX® MAX Urban Search & Rescue Challenge Kit

TETRIX® MAX Urban Search & Rescue Challenge Kit Bill of Materials	
Item	**Quantity**
4" Wheel	6
16T Sprocket	4
24T Sprocket	6
32T Sprocket	2
Chain w/Link	1
Chain Breaker	1
Gear Hub Spacer	10
100 mm Axle	12
DC Drive Motor	2
Motor Mount	2
Axle Set Collar	12
288 mm Channel	6
160 mm Channel	4
96 mm Channel	4
32 mm Channel	6
L Bracket	6
Flat Building Plate	2
Flat Bracket	6
2" Standoff Post	12
1" Standoff Post	12
180 Servo	2
Single Servo Bracket	2
Bronze Bushing	24
Axle Hub	12
Motor Hub	2
1/8" Axle Spacer	24
3/8" Axle Spacer	6
Motor Power Cable	2
On/Off Switch	1
12-volt TETRIX Battery	1
Motor Speed Controller	1
1/2" Socket Head Cap Screw	200
Hex Keys	1
Zip Tie Pack	20
Kep Nut	200
3/8" Button Head Cap Screw	50
NiMH Battery Charger	1
288 mm Flat Bar	4
Servo Pivot w/Bearing	1
80T Gear	2
40T Gear	2
Electronics Deck	1
Lid	1
Top Card	1
Side Label Sticker	1
TorqueNADO Motor	2
Gripper Kit	1
On/Off Switch	1

Control System Options	
Item	**Quantity**
2.4 GHz 6ch R/C Controller	1
PRIZM Controller with Tele-Op	1

Additional parts and raw materials legal for use:

- TETRIX Building System parts (https://www.pitsco.com/SearchAll/?keywords=urban_search_and_rescue&type=0#24&1, 800-835-0686, or competitions@pitsco.com)
- Other robot parts similar in size and design to Urban Search & Rescue Challenge Kit materials
- (1) 12" x 24" sheet of acrylic plastic, maximum thickness of 0.250"
- (1) 12" x 24" sheet of aluminum, maximum thickness of .080"
- 3-D-printed parts of original design
- Raw material used for fabricating custom robot parts

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(B) Command Center

- (1) Six-foot table or equivalent positioned **in close proximity to the field with driver view of the field blocked.**
- (1) Chair for driver
- Designated spotter area within communication range of driver
- (1) Video monitor
- (1) Assistive communication system to aide communication between driver and spotter
- Access to a 120-volt electrical outlet

Urban Search & Rescue Command Center

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(C) Example Challenge Field

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(D) Technical Outline Skill Challenges

Skill #1 – **Arm Mechanism Skill Challenge**

- Time limit – 3 minutes
- Proficiency time target – 1.5 minutes
- Available bonus points – 10 points
- Setup configuration
    - Three mailboxes fastened securely to a board that measures approximately 3/8" x 24" x 48". The board will be securely fixed to the ground with gaffer's tape or hook-and-loop fastener.
    - Each mailbox will be equipped with a handle on the exterior of door to afford a point of contact for the arm mechanism of the robot in addition to the original features inherent to the supplied/recommended mailboxes. (See Figure 1.)
    - Additional modifications to the mailboxes to make it more difficult to open the doors will not be allowed.
    - There will be at a minimum of 12" of separation between each mailbox.
    - First mailbox will be mounted such that the interior bottom of the mailbox will be at least 4" but not more than 5" from the ground. The ordnance will be fixed to the inside door of the mailbox with hook-and-loop fastener. The hook-and-loop fastener should not exceed 1" x 1" surface area. (Recommendation is 1" hook-and-loop tape cut to 1" lengths.) (See Figure 2.)
    - Second mailbox will be mounted such that the interior bottom of the mailbox will be at least 6" but not more than 7" from the ground. The ordnance will be placed inside the mailbox at least 1" but not more than 2" from the opening of the mailbox. The ordnance should not be fastened or affixed to the mailbox in any way that would inhibit removal. (See Figure 2.)
    - Third mailbox will be mounted such that the interior bottom of the mailbox will be at least 6" but not more than 7" from the ground. The ordnance should be attached to a smaller target object such as an empty thread spool via a tether at least 6" but not more than 8" long. The smaller target shall be suspended from the roof of the mailbox approximately 2" in from the entrance and the top of the target should not be more than 9" from the ground. The string that suspends the smaller target should be securely attached to the roof of the mailbox but have hook-and-loop fastener at the bottom that is used to attach to the smaller target. The ordnance will be placed inside the mailbox at the end of the tether, so that the robot will have to grab the smaller target first, pull it loose from the hook-and-loop fastener at the bottom of the string, and use it to drag the ordnance close enough to the entrance of the mailbox so the robot can release the smaller target and grab the ordnance itself to remove it from the mailbox and successfully set it on the ground. (See Figure 3.) Using the smaller target to drag the ordnance completely from the mailbox by only engaging the smaller target will not be considered a successful removal. For a successful removal from this mailbox, the ordnance itself must be engaged by the robot arm mechanism and in a controlled motion be removed and set on the ground. The smaller target and tether should only be used to drag the ordnance from deeper in the mailbox and position it so it can be engaged directly by the robot arm mechanism.
- Starting point for the participant robot will be 2' in front of and center of the mailbox setup.
- Robots can address and attempt to open the mailboxes in whatever order they wish.
- Successful removal of the ordnance will be considered if the robot can successfully open the door of the mailbox, engage the ordnance with the arm mechanism, and in a controlled action set the ordnance on the ground next to the mailbox. Knocking the ordnance off the mailbox door or dropping

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the ordnance from the arm mechanism before it is set on the ground will not count as a successful removal.

- Time will begin when the official gives a “Start” command and will end either when the last ordnance is successfully set on the ground or when the maximum time limit is reached.

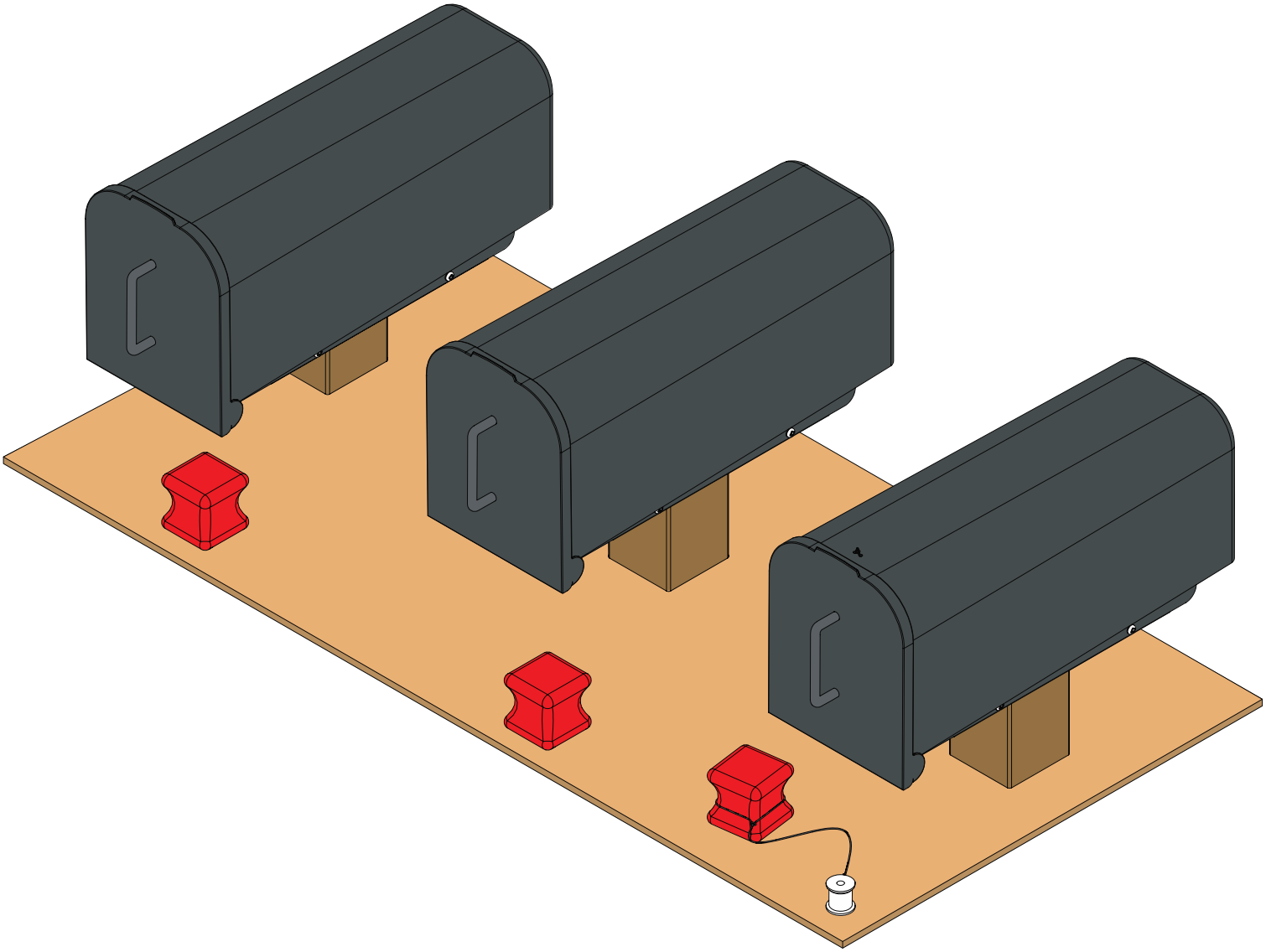

Figure 1

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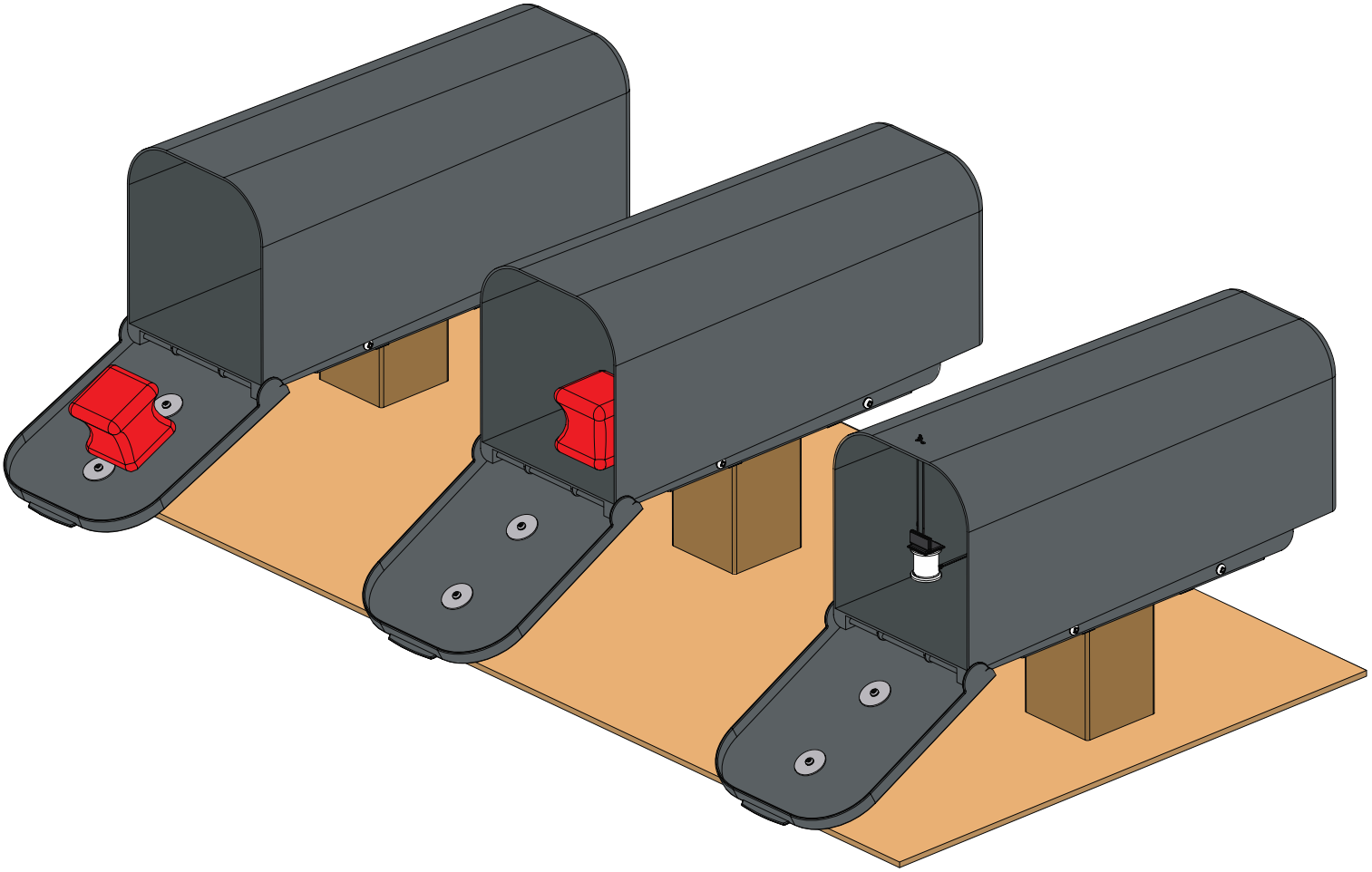

Figure 2

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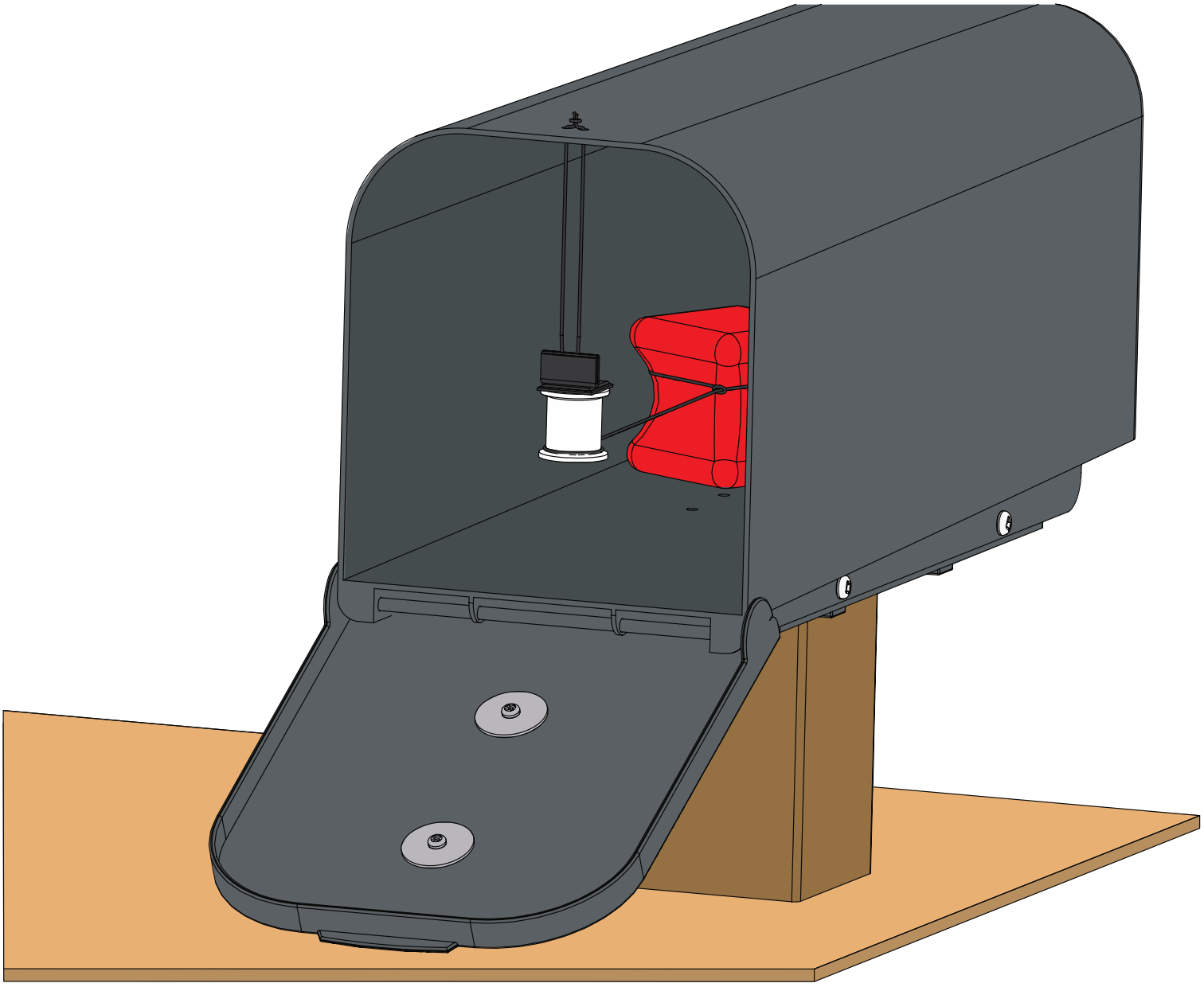

Figure 3

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Skill #2 – **Navigation Skill Challenge**

- Time limit – 3 minutes
- Proficiency time target – 2 minutes
- Available bonus points – 10 points
- Setup/Configuration
    - Using a 30' x 40’ field configuration, each of the four corners will have a defined marked area at least 2' x 2' square.
    - In the corner of each defined area furthest away from the center of the field there will be a “target” that should be at least 6" but not more than 8" in diameter and elevated at least 4" but not more than 5" from the ground. This target will be further identified by being a contrasting color from the marked/defined area.
    - Between each corner there shall be at least one but not more than two obstacles that prohibit a direct route from one corner to the next.
    - A single ordnance will be placed on the ground 2' from the normal starting position of the field.
    - See the following diagram.
- The participating robot must drive to the ordnance from the starting position, pick it up, and proceed to the first corner of their choice.
- The robot must drive to the target in the corner and touch the ordnance down to the top of the target without releasing the ordnance. Only after a successful “touch” to the target will the corner be considered complete.
- The corners can be completed in any order the participant decides best fits their strategy for a fast and successful time.
- Successful completion of the skills test challenge will be considered if the robot can pick up the ordnance and maintain control of the ordnance while driving and completing each of the four corners of the field and then exiting the field from the starting position.
- Points will be deducted if at any time during the attempted run, the ordnance is out of the robot’s control or is dropped.
- Time will begin when the official gives a “Start” command and will end when the robot exits the field or when the maximum time limit is reached.

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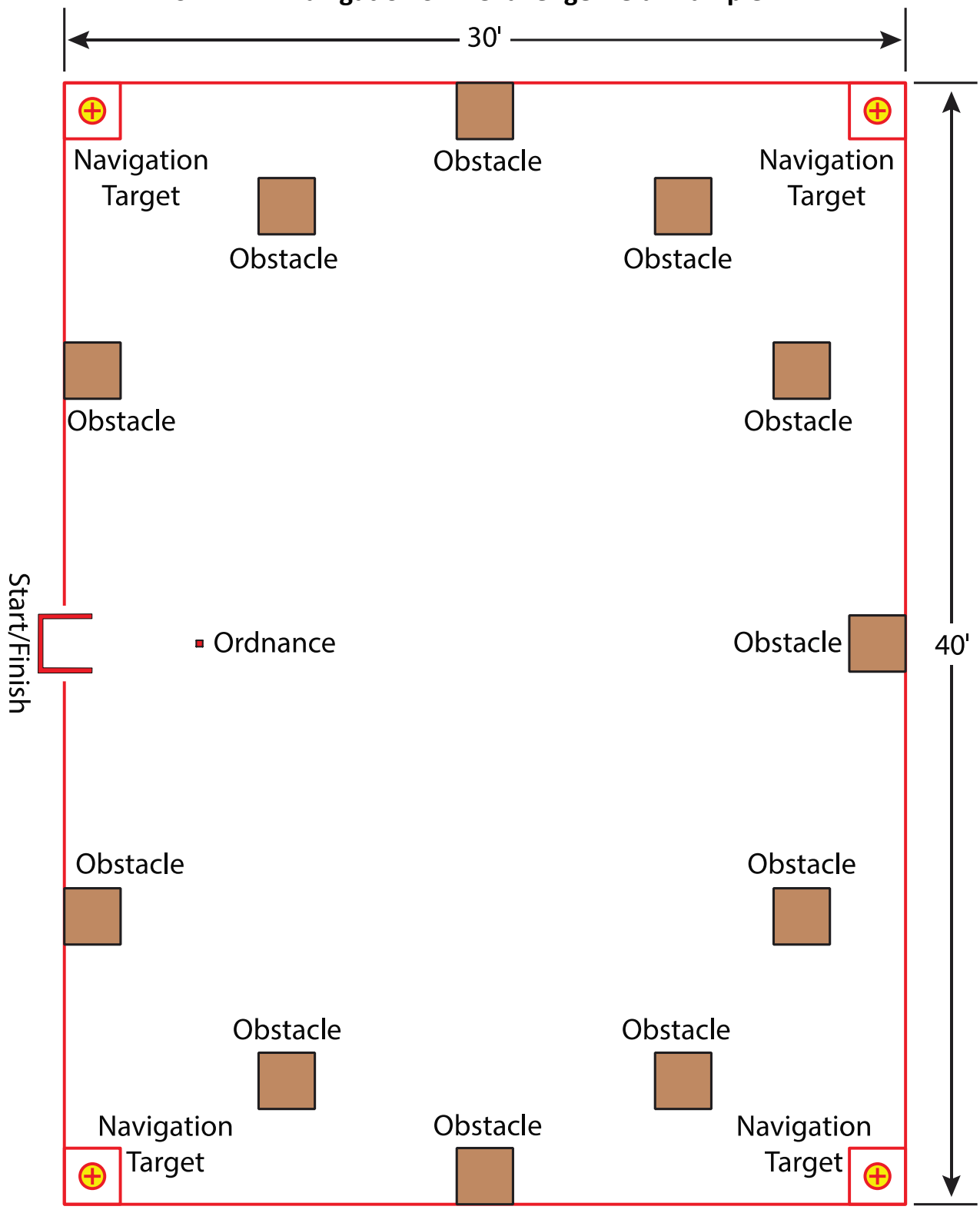
Skill #2 – Navigation Skill Challenge Field Example



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Skill #3 – **Drive Chassis Skill Challenge**

- Time limit – 2 minutes
- Proficiency time target – 1.5 minutes
- Available bonus points – 10 points
- Setup/Configuration
    - The test course shall consist of three types of obstacles: a debris field, a smooth ramp, and a rough ramp connected by a raised 2' x 4' platform.
    - The debris field should consist of a 2' x 6' strip of indoor/outdoor carpet/rug laid over four 24" lengths of 1" PVC pipe, and should be laid out as follows: the first end of the carpet should be taped to the ground using gaffer's or duct tape. The first length of 1" PVC pipe should be placed 10" from the end of the carpet, parallel to the end of the carpet. The second length of 1" PVC pipe should be placed diagonally to the length of the carpet with the end of the pipe 10" from the first parallel length of pipe. The third length of 1" PVC pipe should be placed parallel to the second diagonal pipe with approximately 10" of space between them. The fourth length of 1" PVC pipe should be placed parallel to the ends of the carpet and 10" from the end of the diagonal length of pipe. The basic layout of the 1" PVC pipe lengths under the carpet should create the outline of a Z, with the diagonal pipes doubled up and parallel to each other. The final end of the carpet should also be taped to the ground using gaffer's or duct tape.
    - The smooth ramp should be a surface 24" wide x 72" long set at least at a 10° but not more than a 12° incline. (With one end of the ramp resting on the ground and the other end elevated 18.5" from the surface of the ground, the ramp should be setting at roughly a 12° incline.) The surface of the ramp should either be covered by indoor/outdoor carpet or have strips of gaffer's tape or something similar adhered across the surface to create friction and keep the surface from being too slick for robots to ascend.
    - The rough ramp should be a surface 24" wide x 48" long set at least at a 20° but not more than a 22° incline. (With one end of the ramp resting on the ground and the other end elevated 18.5" from the surface of the ground, the ramp should be setting at roughly a 22° incline.) The surface of the ramp should be indoor/outdoor carpet laid over four 24" lengths of 1" PVC pipe. The PVC pipe should be fastened diagonally across the inclined surface to form the shape of a W, with the center peak of the W aligned with the center of the inclined surface. The indoor/outdoor carpet should be fastened securely to the inclined surface with either staples or glue so it creates a stable surface and will not slip. See the following image.
    - There should be a 24" x 48" platform elevated 18.5" from the ground that connects the two ramps. The ramps should be attached to opposite sides of the platform at each end, perpendicular to the length of the ramp.
    - The layout for the obstacles should be as follows: with the debris field parallel to the length of the connecting platform between the smooth and rough ramp. The robot should have to turn right or left when exiting or entering the debris field to access one of the ramps leading to the connecting platform.
- The starting position for the robot will be approximately centered between the ramp obstacles.
- Time will begin when the official gives a "Start" command and will end when the robot returns to the original starting position or when the maximum time limit is reached.
- Participants will have the choice to enter the course from one of two possible directions, either entering the debris field first and exiting from the steep/rough ramp or entering via the steep/rough ramp first and exiting through the debris field.

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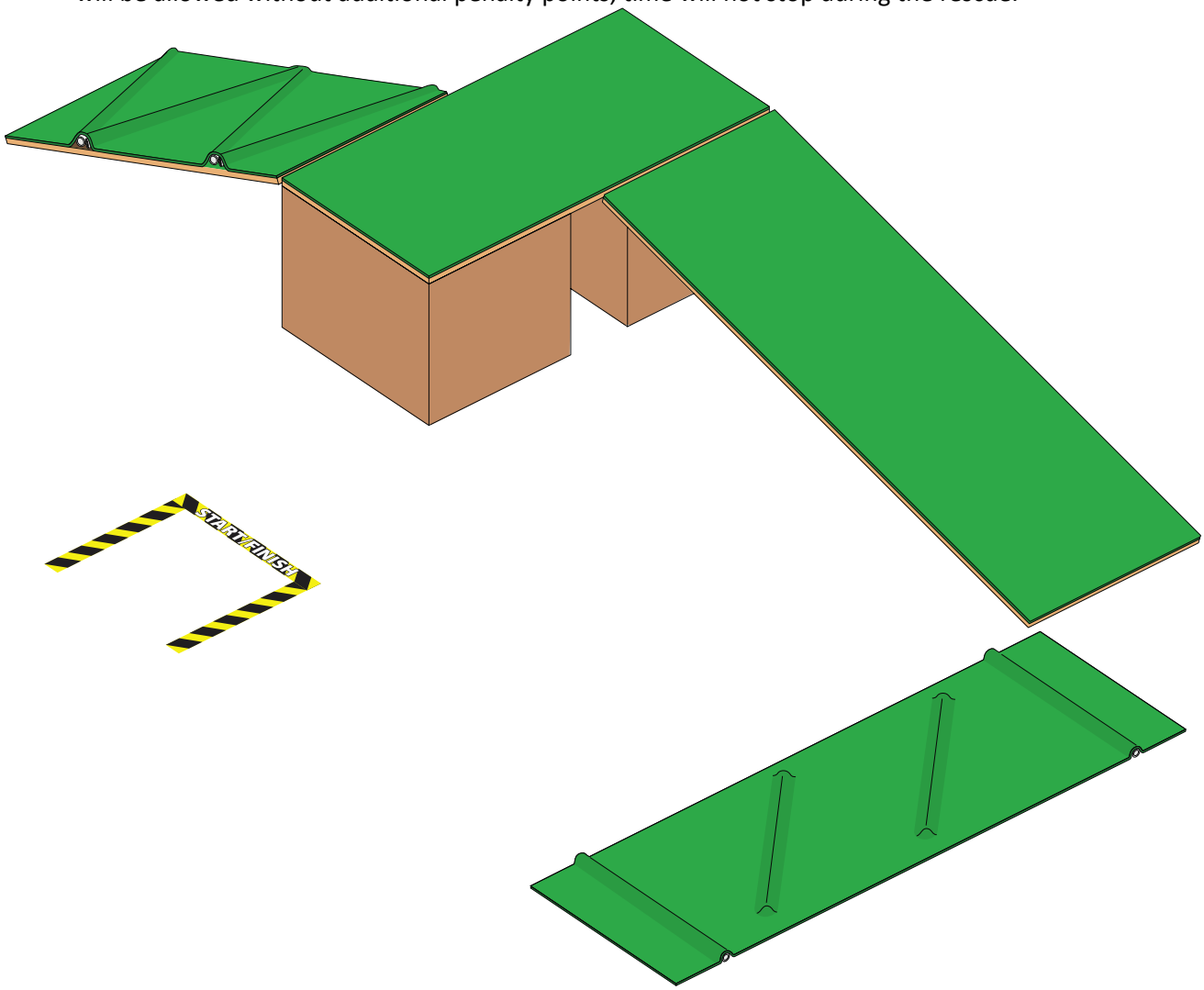
- Successful completion of the course will be considered when the robot has traversed all three obstacles and returned to the original starting point.
- A robot that falls from either of the ramps or the connecting platform can be rescued by the non-driving team member but will have to start the course over from the original start point. While a rescue will be allowed without additional penalty points, time will not stop during the rescue.



Skill #4 – **Camera POV Skill Challenge**

- Time limit – 2.5 minutes
- Proficiency time target – 1.5 minutes
- Available bonus points – 10 points
- Setup/Configuration
    - The test shall be an enclosed space simulating either a tunnel/crawl space/or HVAC duct work. The robot must be remotely driven through via POV (point of view) information provided by an onboard camera system and outputted to remote monitor out of view of the test course.
    - The tunnel/crawl space/HVAC duct work must have at least 24" W x 20" H internal clearance throughout the length of the structure.

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    - The layout of the space shall consist of at least two 90° corners that must be navigated and be no longer than 12' from entrance to exit. (See Figure 1.) Structure for the space can easily be made with cardboard boxes that are at least 24" x 20" x 18". One box that is easy to source that meets or exceeds that size is the Model# XLBX Extra-Large Moving Box with Handles from Home Depot.
    - Additional external openings beyond the entrance and exit should exist to let in enough external light so it is possible for a robot to traverse the length of the space without needing onboard external lights. Floor or wall vents can work well for this. (See Figure 2.) The goal is to reproduce a low light/low visibility condition, not a totally dark condition. Robots that are equipped with external lights can use said lights without penalty.
- The starting position for the robot will be approximately 4' from the entrance to the tunnel and offset to one side. (It does not matter which side as long as the robot is not directly in front of the entrance – see Figure 3.)
- Time will begin when the official gives a "Start" command and will end when the robot returns to the original starting position or when the maximum time limit is reached.
- Successful completion of the course will be considered when the robot has traversed through the space in one direction and completely exited the space (all parts of the robot must be outside of the tunnel/crawl space/HVAC duct), and then re-enter via the opening it just exited and traverse back through the space to return to the original starting point.

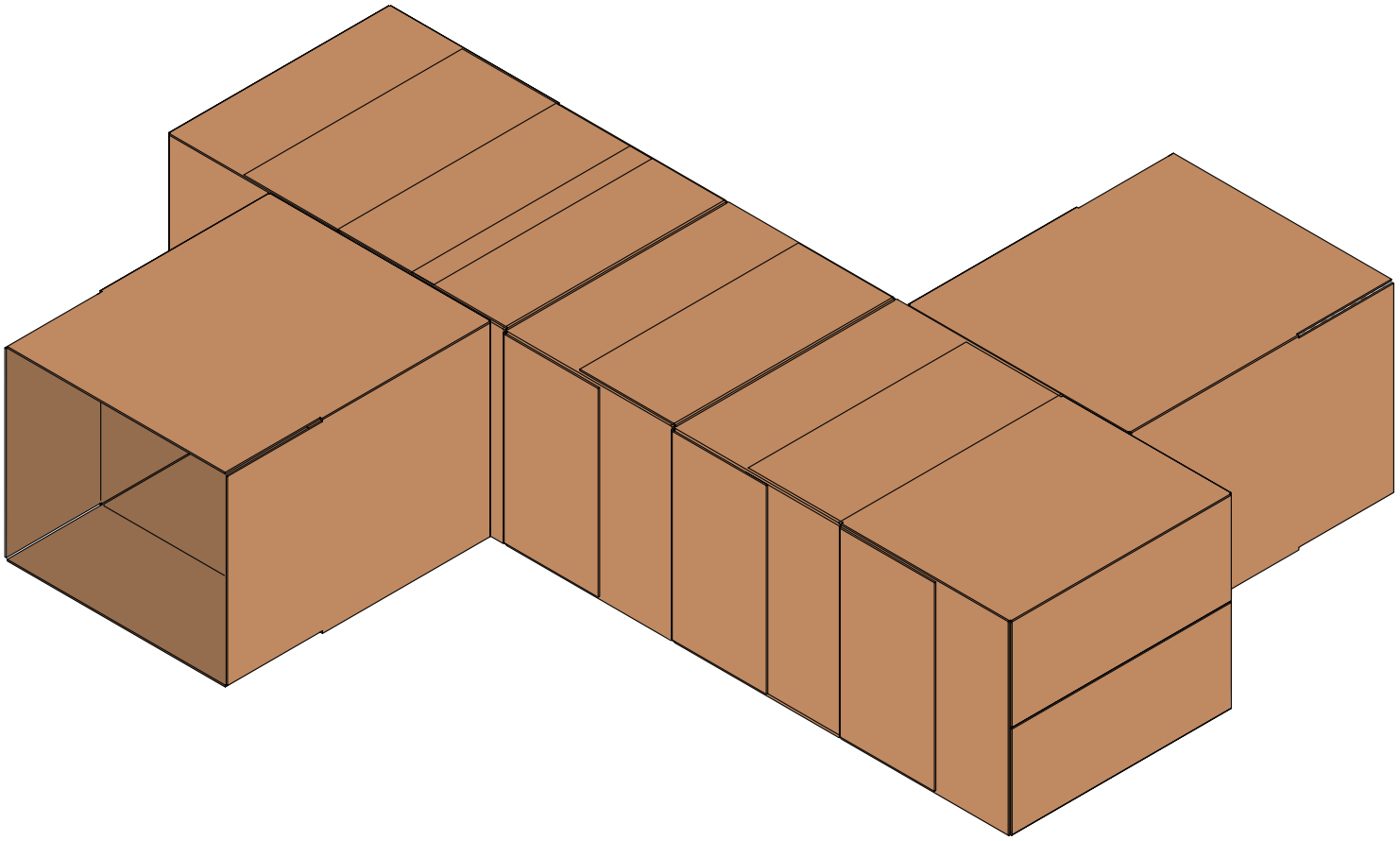

Figure 1

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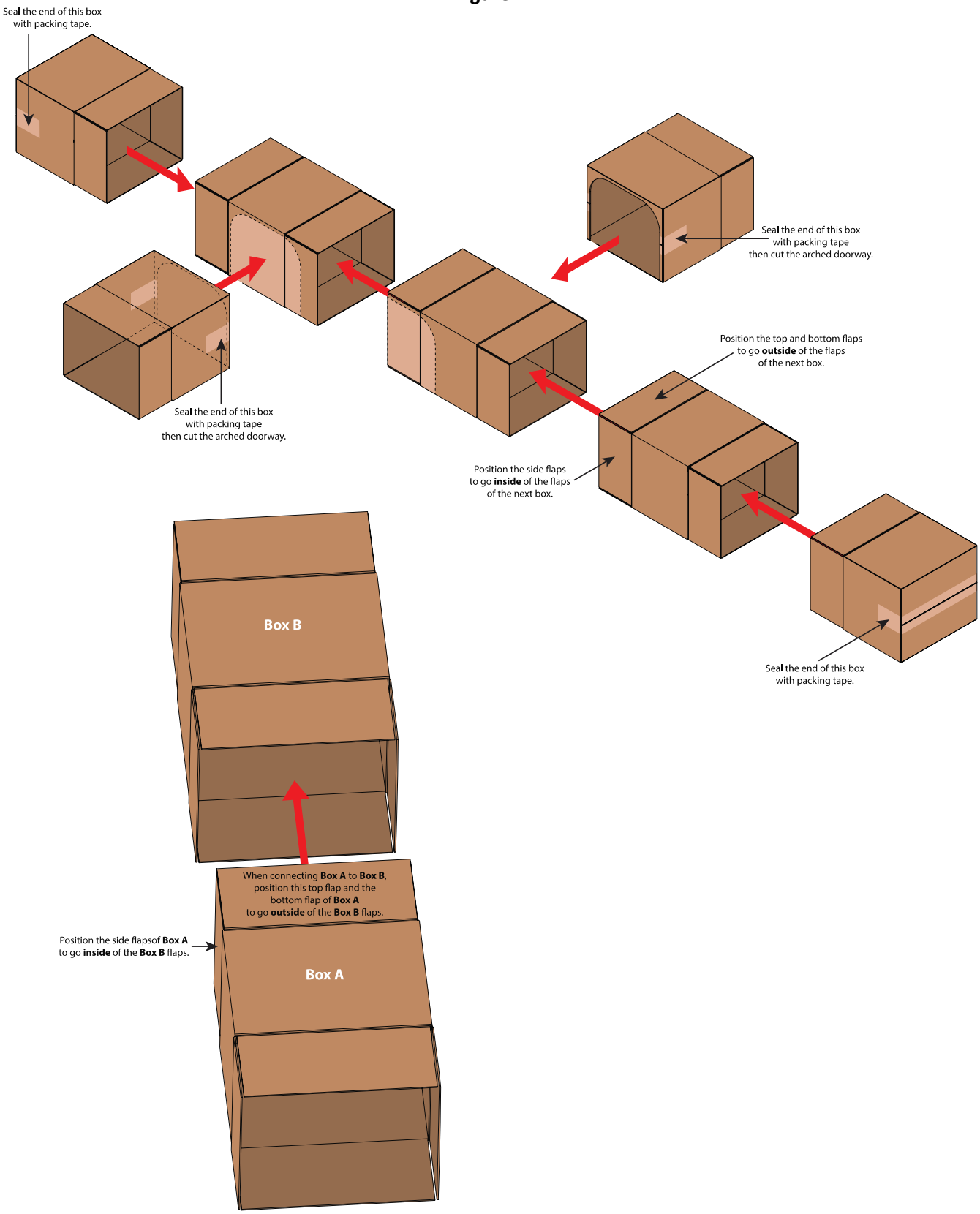
Figure 2



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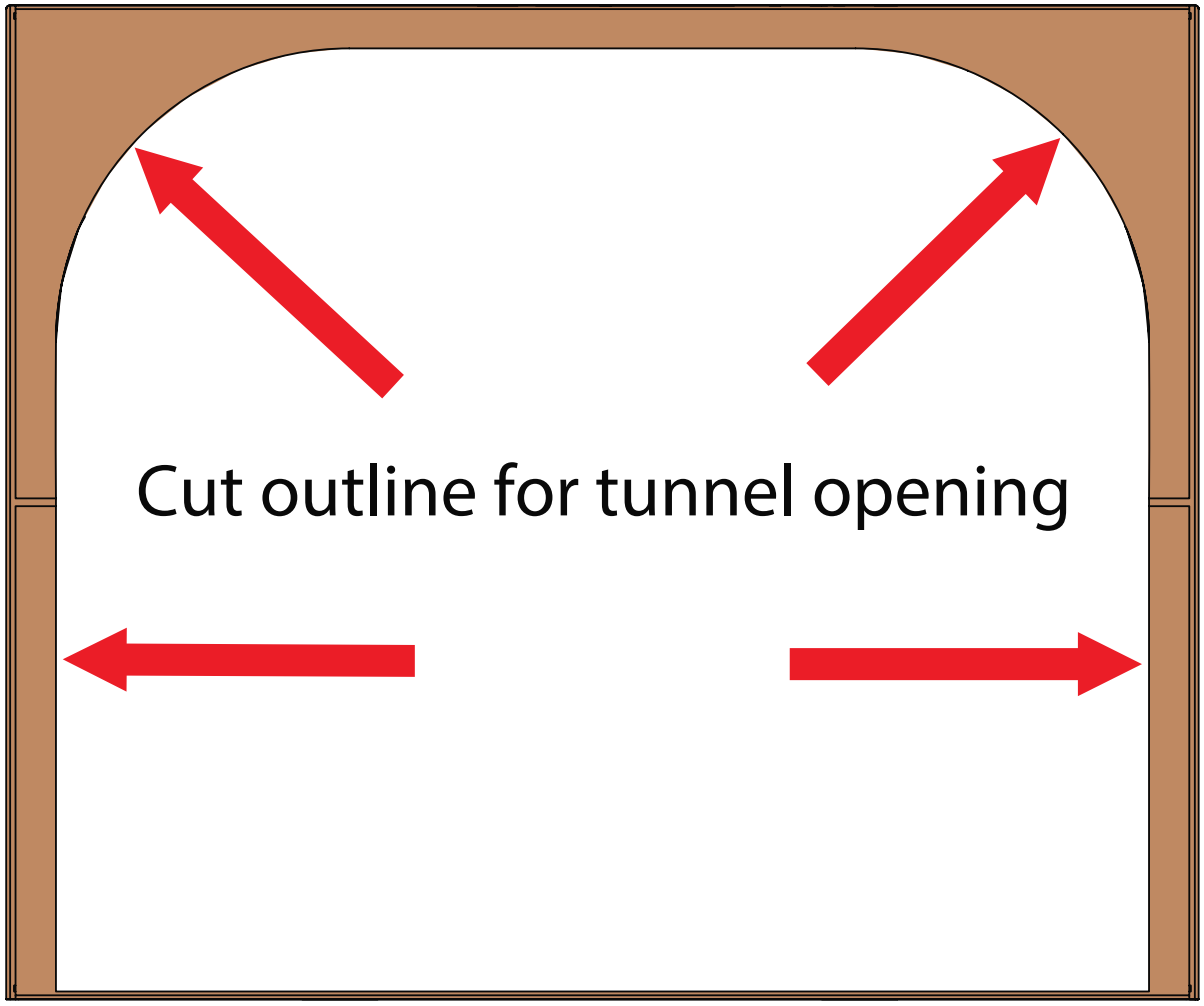

Figure 3

Skill #5 – **Communication and Collaboration Skill Challenge**

- Time limit – 3 minutes
- Proficiency time target – 2 minutes
- Available bonus points – 10 points
- Setup/Configuration
    - This is a test of the level of proficiency of communication and collaboration between the driver and spotter teammates. The spotter will have full view of the course while the driver will not, such that the driver must be fully dependent on verbal communication from the spotter to drive the course.
    - The driver should be sitting in a chair next to the start position of the robot facing away from the course, while the spotter should be able to freely walk along the boundaries of the course. There should be a visual barrier behind the driver chair that will prohibit the driver from seeing the course even if they inadvertently turn and face the course during the test. The spotter in no way can physically touch or interact with the robot for the duration of the test. The driver must not be able to view the test course or robot for the duration of the test, but they must be able to hear the directions from the spotter.

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    - The course should be laid out in a simple T shape with a straight section approximately 6' long x 40" wide leading to a T-junction. The T-junction should be approximately 6' long and 3' wide, with a mailbox placed at one end. The mailbox should be placed facing such that it would open back toward the center of the course. On the opposite end will be the ordnance disposal container. In the middle of the T-junction should be a single ordnance. The ordnance should be on the ground and 6" from the back line that defines the course. The course should be defined or laid out with painter tape on the floor/ground.
    - The mailbox must be mounted so the top of the door does not exceed 12" from the ground and the face of the door should be marked with a red piece of tape that creates a target. The middle of the red tape target should not be more than 9" from the ground. See the following image.
    - There should be two obstacles placed down the straight section, such that the robot must make a slalom action between and around each in order to reach the T-junction. The first obstacle should be set 20" inside the entrance to the course and 16" from the outside edge. The second obstacle should be set 20" before the entrance to the T-junction and 16" from the opposite outside edge of the first obstacle. The obstacles must not be wider than 8" so there is at least 20" of clearance around the open side. They should be secured in place on the ground using gaffer's tape.
- The starting position for the robot should be 2' in front of the entrance to the straight section.
- The spotter must verbally direct the driver so that the robot traverses the straight section avoiding the obstacles, reaches the T-junction, and turns left or right and approaches the first mailbox. The robot must use its end manipulator to reach up and touch (tag) the red tape target. It must then turn around and address the ordnance placed in the T-junction. The robot must pick up the ordnance and make its way to the disposal container and deposit the ordnance in the container.
- Time will begin when the official gives a "Start" command and will end when the robot successfully deposits the ordnance in the disposal container.
- Successful completion of the course will be if the robot can traverse the course, avoid the obstacles, "tag" the mailbox, and collect and dispose of the ordnance without going outside the taped boundaries.
- Going outside of the taped boundaries will result in a point deduction. Each instance will count as a 5-point deduction from the final overall score for this test.

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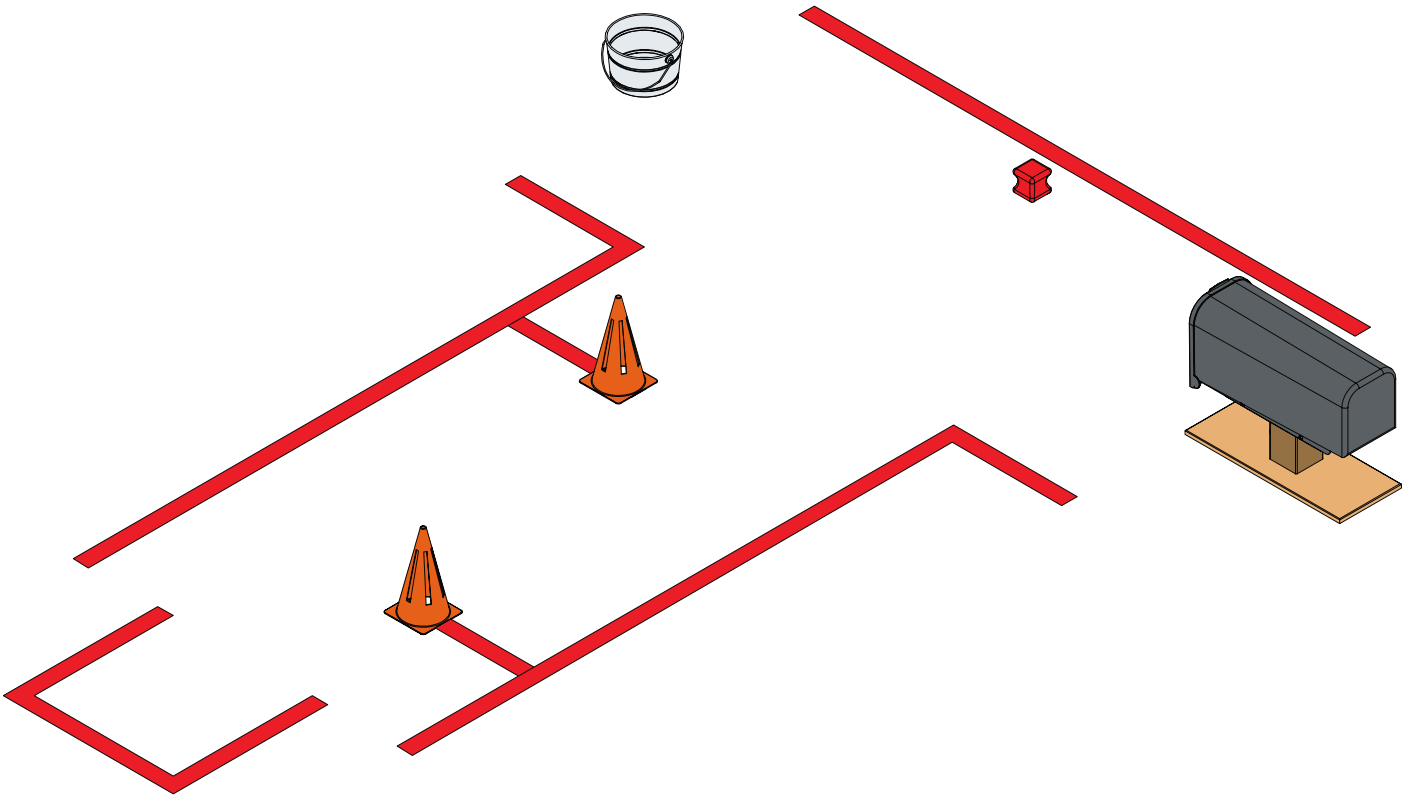

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(E) Standards, Competencies, and Academic Skills

Standards and Competencies

- **RR 1.0 Demonstrate knowledge in safety rules and practices**
- 1.1 Maintain a safe work area.
- 1.2 Demonstrate safe and correct use of hand tools.
- 1.3 Follow safety rules during robotic assembly.
- 1.4 Demonstrate safe operation of robotic equipment in tele-op mode.

- **RR 2.0 Produce technical documentation**
- 2.1 Keep an engineering notebook detailing design discussions, design details, design changes, and troubleshooting notes.
- 2.2 Develop a technical drawing of the final competitive robot design.
- 2.3 Produce a bill of materials for the final competitive robot design.
- 2.4 Explain design choices and changes made within the engineering design process.

- **RR 3.0 Demonstrate knowledge of robot parts**
- 3.1 Identify mechanical and electrical parts of the final robot design.
- 3.2 Demonstrate understanding of the mechanical and electrical functions of the parts of the final robot design.

- **RR 4.0 Demonstrate understanding of robot mechanical systems**
- 4.1 Identify mechanical systems within the final robot design.
- 4.2 Demonstrate the function of control systems of the final robot design.
- 4.3 Demonstrate and explain the functioning of the drivetrain of the robot.
- 4.4 Demonstrate and explain the functioning of the package delivery system of the robot.

- **RR 5.0 Demonstrate understanding of robot electrical systems**
- 5.1 Identify electrical/electronic systems within the final robot design.
- 5.2 Demonstrate and explain the function of electrical control systems of the final robot design.

- **RR 6.0 Demonstrate tele-op skills and real-time problem solving**
- 6.1 Demonstrate ability to safely and quickly maneuver the robot through rough and unknown terrain via tele-op.
- 6.2 Demonstrate ability to overcome challenging areas of course terrain via tele-op.
- 6.3 Demonstrate ability to locate objects through remote robotic manipulation via tele-op.
- 6.4 Demonstrate ability to transport objects via tele-op.

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- **RR 7.0 Demonstrate ability to present and explain technical information**
- 7.1 Demonstrate correct and effective use of oral, written, and technological tools to present technical information regarding engineering design process, robot construction, and robotic tele-op control.
- 7.2 Demonstrate knowledge of design choices and implementations during the engineering design process.
- 7.3 Demonstrate knowledge of team processes and individual team member contributions.

Committee-Identified Academic Skills

Math Skills

- Students use fractions in contextual applications to solve problems.
- Students use percentages in contextual applications to solve problems.
- Students solve problems through the contextual application of proportions.
- Students measure time, distance, and angles within contextual problem-solving applications.
- Students simplify numeric expressions.
- Students use comparisons, predictions, and inferences in analyzing data to solve a problem.
- Students utilize modeling techniques to solve problems.
- Students write and solve algebraic expressions in one or more variables.
- Students use derived measurements to solve problems.

Science Skills

- Students apply the scientific method to plan and conduct experiments.
- Students apply knowledge of heat, sound, mechanical, chemical, electrical, and light energy within contextual problem-solving applications.
- Students apply knowledge of kinetic and potential energy in contextual applications to solve problems.
- Students apply knowledge of Newton's laws of motion to solve problems.
- Students apply knowledge of simple and compound machines to solve problems.
- Students apply knowledge of gears, motors, and linkages to solve problems within contextual applications.
- Students use formulas to solve problems.
- Students apply scientific knowledge within the engineering design process.
- Students apply knowledge of force and motion concepts in contextual problem-solving.

Engineering Skills

- Students apply the engineering design process to solve a contextual problem.
- Students apply the principles of circuit analysis.
- Students apply the elements of circuit design and construction.

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- Students understand and apply energy and power types, sources, and conversions.
- Students apply methods of maintaining, servicing, troubleshooting, and repairing systems.
- Students apply skills and techniques related to building, repairing, and maintaining robotic mechanisms.
- Students apply techniques and technologies related to the production of technical drawings.
- Students apply basic mechanical skills related to robotic design, construction, and troubleshooting.
- Students understand and apply knowledge of safety during construction and use of equipment.
- Students apply problem-solving and engineering-design processes to solve unforeseen challenges.

Language Arts Skills

- Students make effective use of spoken, written, and visual communications with team members within the problem-solving and engineering-design processes.
- Students make effective use of spoken, written, and visual communications with a variety of audiences.
- Students use appropriate information resources within the research-and-design process.
- Students organize and synthesize information for use in research-and-design processes and in formal presentations.
- Students demonstrate the ability to correctly read and interpret rules, instructions, and specifications within the robotic challenge.
- Students demonstrate the proper use of language, both written and verbal.

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