

## 2017 IEEE R5 Conference

### Student Robotics Competition Rules

This document contains the rules of the 2017 R5 Robotics Competition. The competition is open to teams of no more than 5 and no less than 2 undergraduate students who are enrolled in a College or University within the IEEE Region 5 boundaries. The competition encourages a multidisciplinary approach to robot development and recognizes the participation of students who may already be members of SAE, ASME, EEGS, etc. Therefore, only one team member will be required to be a current IEEE Student Member.

#### **Competition Motivation**

The objective of the competition is to demonstrate the use of an autonomous robot on the surface to map a tunnel and investigate “buried caches” at the tunnel endpoints. The game field simulates a tunnel containing infrastructure such as steel cables or rails for material transport and electrical conductors for lighting or communications. Surface obstacles and anomalies represent typical operational challenges.

This year’s competition may require sensors to detect the tunnel, guidance navigation and control to execute search patterns, tunnel mapping, obstacle avoidance and a manipulator.

#### **Venue**

The 2017 Region 5 Robotics Competition will be held at the Rocky Mountain Event Center (RMEC) in the Denver Marriott Tech Center located at 4900 S. Syracuse Street, Denver, CO 80237. Four (4) game fields will be available starting Friday, March 31, 2017. The competition will be held on Saturday, April 1, 2017. Detailed schedule information will be posted on the Robotics Competition page of the Region 5 website.

Wireless internet will be available for teams in the RMEC on Friday and Saturday. A workspace station will be available for each team. Each station will have 2 adjoining tables, 6 chairs and a single 120 VAC 15 amp outlet.

Four (4) competition fields will be used for practice on Friday and for the competition on Saturday. They will be placed (one each) in the corners of the RMEC. A “Quarantine Area” will be centrally-located in the RMEC and have a numbered grid corresponding to team numbers assigned at robot registration.

#### **Events and Prizes**

Team registration is required for area game field entry and badges. The competition will conclude with an awards banquet on Saturday evening. Cash prizes and certificates will be awarded at the banquet. Specific award details will be provided on the Robotics Competition page of the Region 5 website. The general public may view the competition; however, guests must register and pay to attend the banquet.

#### **Playing Field**

The Game Field base is ½” x 8’ x 8’ MDF panels. Centered on top of the MDF is a 3/16” x 7’ x 7’ pegboard. Forty-nine 2”x1’x1’ “grid blocks” cut from sheets of Extruded Polystyrene (XPS) insulation are

arranged in a 7 x 7 grid on the pegboard. One ¼" x 3' x 7' clear acrylic sheet and one ¼" x 4' x 7' clear acrylic sheet will create a surface over the grid blocks. The robot will navigate on the acrylic surface. Acrylic is employed to enhance audience viewing. To minimize the sole use of vision for subsurface mapping, sheets of paper will be interspersed between the grid blocks and acrylic. Any component may vary in color or physical properties. Examples may include, but are not limited to, 3D-printed parts while the make and model of XPS insulation may exhibit slight color variations from grid block to grid block. The MDF base and acrylic surface are pulled together by ¼ – 20 x 2-1/2 inch flat Phillips head machine screws and T-nuts. A Computer-Aided Design (CAD) package including a Bill of Materials (BOM) and Assembly Instructions will be published on the Robotics Competition page of the Region 5 website.

A minimum of seven contiguous grid blocks under the Game Field surface will be removed to form the tunnel. The endpoints will NOT be located on the same side of the Game Field. Infrastructure emulating winch cables and power lines will run inside the tunnel from endpoint to endpoint. The winch cables are emulated by 16-Gauge galvanized steel wire. The power cables will be emulated by a plastic shield incandescent trouble light connected to a 25' 16/3 extension cord connected to the RMEC 120V 60Hz . No portion of the trouble light assembly will be inside the tunnel but it will be turned ON and contain a 25-Watt incandescent A19 soft white light bulb. The steel wire and extension cord will be held above the pegboard with supports located within +/- 2" of the tunnel's horizontal centerline. The CAD package and BOM will include the details. The entire tunnel containing infrastructure from endpoint to endpoint is the Objective Tunnel (OT). New tunnels can be configured by adding and/or removing blocks. Points are awarded for correctly mapping the OT.

Additional grid blocks may be removed to form "dead ends" connected to the OT. A dead end will not contain infrastructure. Bonus points will be awarded for correctly mapping dead ends.

"Buried" caches with a removable lid are located in the Game Field perimeter. Each of the two tunnel endpoints will include a cache. A single white die with black points (Cache Die) will be located in the bottom of each OT endpoint cache. Points are awarded for correctly identifying the points showing upward on the Cache Die in either of the OT endpoint caches. It is not required to replace a cache lid. Cache system drawings and die description are included in Appendix B. Monitor the Robotics Competition page of the Region 5 website for any changes.

One or more obstructions will be placed on the surface to emulate operational challenges. These surface obstructions will consist of grid blocks removed to form tunnels. Only one grid block will be used per obstruction.

Every one of the 49 grid locations will be referenced by column and row. Columns will be labeled A-G and rows will be labeled 1-7. See Figure 1 below.

	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							

Figure 1: Field Grid Location Reference

The robot START/STOP location will always occupy grid location A7 and serve as a geographic reference for displaying and judging a map. A7 will not contain any portion of the OT or a dead end and it will not contain a buried cache.

The 24 grid locations on the Game Field perimeter will only contain grid blocks, the robot START/STOP location, two (2) empty OT endpoints and buried caches.

### **Robot Requirements**

1. Autonomous Operation - No communication with the robot after placement in the Quarantine Area. Communication may begin after the robot is removed from the Game Field after a Round.
2. Size – While occupying the START/STOP location (A7) the robot must fit inside a 12” square cube. All inner cube edges are 12 (+/-0.25)” and all angles are 90 (+/-1) degree.
3. Weight – Must weigh 30.0 pounds or less as measured by a “DYMO by Pelouze Heavy-Duty Electronic Utility Scale Model 4010” (Competition Scale). The Competition Scale used for judging will be available at the Head Judge table during practice and competition. Robots over 30.0 pounds may, at the discretion of the Head Judge, be disqualified without appeal.
4. Chemicals or explosives – Explosives and volatile liquids are not permitted. Chemical batteries are allowed but only if used correctly and with appropriate safety and handling. See <http://www.icharger.co.nz/articles/ArticleId/3/Lipo-Lithium-Battery-Safety-Guide.aspx> for guidance.
5. Mapping Display (MD) Requirement - an 8x8 RGB LED pixel array firmly attached to the uppermost horizontal surface of the robot. A Scoring Judge must have a clear and unobstructed view of the MD from above without having to touch the robot.
6. Die Point Display (DPD) Requirement - a red 7-segment single digit display firmly attached to the uppermost horizontal surface of the robot and adjacent to the MD. A Scoring Judge must have a clear and unobstructed view of the DPD from above without having to touch the robot.
7. The robot must have a Red “STOP” button and Green “GO” button easily accessible on the uppermost horizontal surface of the robot. Each button will be labeled STOP or GO using Arial Font, Regular Style, Size 20 or larger.
8. A single corner LED on the MD will be designated as the Yellow “Robot Ready” Light. This LED will also map START/STOP grid location A7. The OT map must be correctly referenced to the START/STOP grid location A7. For this reason, the Yellow “Robot Ready” Light must remain continuously lit until the Scoring Judge asks the robot to be removed from the Game Field.

### **Gameplay**

Rounds will proceed as follows:

1. T-20 minutes - Twenty (20) minutes prior to the start of a Round, teams will have 5 minutes to deliver their robot to the Quarantine Area.
2. T-15 minutes – Fifteen (15) minutes prior to the start of a Round, all robots are required to be in the Quarantine Area. The Quarantine Area will be closed. A Judge will have an opportunity to assess the robot field for rule infractions.
3. T-15 minutes – Configuration of the game fields by Judges and assistants will begin.
4. T-0 minutes – The fields are ready to begin the Round.
5. The A/V Screen at the Head Judge table will display the order of competition for each game field.
6. The public address system will call the first flight of robots to their respective game fields.

7. Upon entry to the Game Field Area (defined as inside the area surrounded by stanchions), the student designated as the Team Lead will be announced to the Scoring and Timing Judges.
8. Team Lead will place their robot fully within the START/STOP location on grid location A7 and take whatever actions are necessary to illuminate the Yellow "Robot Ready" Light. The robot will have no more than 60 seconds after being placed on the START/STOP location to illuminate the Yellow "Robot Ready Light". During the 60 second interval, all of the team members present, except the Team Lead are required to sit in the team chairs situated around the field within the Game Field Area to facilitate audience viewing.
9. After the Yellow "Robot Ready" Light is illuminated or 60 seconds has elapsed, the Timing Judge will begin a countdown from 5 to GO. The countdown will be 5-4-3-2-1-GO.
10. The Yellow "Robot Ready" Light must remain continuously lit until the Scoring Judge asks to have the robot removed from the Game Field.
11. Upon saying GO – the Timing Judge will start the Field Clock and the Team Lead is expected to press the Green "GO" button on their robot. The Team Lead is the only person authorized to touch the robot to complete a Round. See End of Round Conditions.
12. Robot will execute the mapping and die point identification tasks for the round of play and return to the START/STOP location.
13. Upon completely entering the START/STOP grid location A7 AND coming to a complete stop, the Team Lead will activate the robot's Red "STOP" button. The Timing Judge will stop the Field Clock when the Red "STOP" Button is pressed.
14. If the robot has not completely entered the START/STOP location within 6 minutes of starting the Field Clock", the Timing judge will ask the Team Lead to stop the robot by pressing the Red "STOP" button.
15. Elapsed Time starts when the Timing Judge says "GO" and starts the Field Clock. Elapsed Time ends when any one of the End of Round Conditions occurs.
16. The robot must remain in the spot where the Red "STOP" button was pressed until the Scoring Judge asks the Team Lead to remove it from the game field.
17. The Scoring Judge will record the tunnel map displayed on the Mapping Display (MD).
18. The Scoring Judge will record the number of die points displayed on the Die Point Display (DPD).
19. The Scoring Judge will ask the Team Lead to remove the robot from the Game Field and the remaining team members will leave their seats and exit the Game Field area.
20. Steps 1-5 will be repeated prior to each competition round.
21. Steps 6-17 will be repeated within each round until all robots in the Quarantine Area are given an opportunity to compete.

### **End of Round Conditions**

1. A team member touches the robot or activates the Red "STOP" button.
2. Six (6) minutes have elapsed on the Field Clock.
3. Robot falls off the Game Field. This condition is indicated by any part of the robot touching the ½" MDF base or touching the RMEC floor.

### **Competition Rounds**

- Round 1 Field Complexity – single tunnel, no dead ends, no more than two (2) 90-degree turns.
- Round 2 Field Complexity – single tunnel, possible dead ends, no more than three (3) 90-degree turns.

- Round 3 Field Complexity – single tunnel, possible dead ends, no more than three (3) 90-degree turns, one or more surface obstructions.

All four (4) Game Fields in each Round will have identical objective tunnels, dead ends and die points showing. See example tunnels for each round in Appendix A.

### Scoring per Round

- OT Map: Ten (10) Points for each correctly mapped OT grid location as displayed on the MD with Red LEDs. OT grid locations under surface obstructions are mapped for points. The map must be correctly referenced to the START/STOP location in grid location A7.
- Die Points: Thirty (30) Points for correctly displaying on the DPD the number of points showing on the Cache Die in either OT end point cache. A maximum of 30 points will be awarded.
- Return: Twenty (20) Points for completely entering the START/STOP grid location A7 AND coming to a complete stop. Awarded only if the robot has completely exited A7 during the Round. Completely entering A7 is defined as all parts of the robot are within the boundaries of A7. A complete stop is defined as no relative motion of the MD with respect to the Game Field.

### Bonus Scoring per Round – Available ONLY if the entire OT is mapped correctly

- Dead End Map: Forty (40) Points for correctly mapping all of the dead end grid locations. The grid locations of a dead end will be displayed on the MD with Blue LEDs.
- Correct OT Map: Forty (40) points for correctly mapping all of the OT grid locations as displayed on the MD with Red LEDs. OT grid locations under surface obstructions are mapped for points. The map must be correctly referenced to the START/STOP location in grid location A7.

### Scoring Penalties per Round

- Incorrect Map: Ten (10) Points will be subtracted for each incorrectly mapped OT grid location. Ten (10) Points will be subtracted for each incorrectly mapped dead end grid location.
- Obstacle Movement: Fifty (50) Points will be subtracted from the round score if a robot or team member moves a surface obstacle. Temporary Reference Marks will surround the surface obstacle at a distance not to exceed  $\frac{1}{2}$ ". If the Scoring Judge determines a robot has moved a surface obstacle into contact with the inside edge of the temporary reference mark or beyond, a penalty will be assessed. Only one (1) Obstacle Movement penalty assessed per surface obstacle.
- Game Field Damage: A robot will be disqualified from the round if a robot or team member damages any part of a Game Field. Any Game Field component that requires replacement to continue the Round is considered damage. The Head Judge will make this determination. Only one penalty per replaceable component. No limit on the number of damage penalties.

### Final Competition Score

- The total sum of all points, bonuses and penalties from Rounds 1-3 on a per robot basis.
- No Round score will be less than zero (0).

## **Award Determination**

- The highest robot point total from all three rounds will be awarded First Place.
- The second highest robot point total from all three rounds will be awarded Second Place.
- The third highest robot point total from all three rounds will be awarded Third Place.
- The fourth highest robot point total from all three rounds will be awarded Fourth Place.
- The fifth highest robot point total from all three rounds will be awarded Fifth Place.
- A tie will be decided by the Tie Breakers below.
- If the head judge determines a team has communicated with their robot during the interval defined in Autonomous Operation on page 3 they risk forfeiting one or more awards.

## **Tie Breakers**

- First tie breaker – Total number of correct OT Maps summed over three (3) rounds
- Second tie breaker – Robot with lowest weight as measured by the Competition Scale

## **Round Disqualification**

- When a robot falls off the Game Field it will be disqualified from that Round and awarded zero (0) points for the Round. Falling is judged by any part of the robot touching the ½” MDF base or touching the RMEC floor

## **Game Restrictions**

1. Flash photography is prohibited during the competition.
2. No light sources external to the robots may be used by teams during the competition.
3. No airborne robots.

## **Field Design Data Provided to Teams on the Robot Competition page of the IEEE R5 website**

Game Field Bill of Materials  
Game Field Assembly Instructions  
Game Field CAD Files and Drawings (various file formats)

## **A Q&A Forum and Change Log will be available on the Robot Competition page of the IEEE R5 website**

## **Glossary of Key Terms and Abbreviations**

ASME – American Society of Mechanical Engineers  
A/V Screen – Audio Visual display system  
BOM – Bill of Materials required to build a Game Field  
Cache – Enclosure with a removable lid along the Game Field perimeter which hold a Cache Die  
Cache Die – A single white die with black points  
CAD – Computer Aided Design. A set of drawings required to build a Game Field  
Competition Scale - “DYMO by Pelouze Heavy-Duty Electronic Utility Scale Model 4010”  
Dead End – Grid Locations with no Grid Block AND no Infrastructure  
DPD – Die Point Display – a red 7-segment single digit display mount adjacent to the MD  
EEGS – Environmental and Engineering Geophysical Society

Elapsed Time – The time interval between the Timing Judge saying “GO” and the moment when any End of Round Condition occurs.

Field Clock – The timing device controlled by the Timing Judge

Game Area – The entire area enclosed by stanchions placed around the Game Field

Game Field – all of the components situated upon and including the ½” x 8’ x 8’ base

Grid Block – 2” x 1’ x 1’ blocks cut from sheets of XPS insulation

Grid Locations – The forty-nine (49) 1’ x 1’ locations centered on the Game Field and referenced by columns A-G and rows 1-7

Head Judge – A Denver Section Robot Committee Member who makes all final rule decisions and award determination

Infrastructure – Wire and cable placed inside a tunnel

MD – Mapping Display. An 8x8 RGB LED pixel array on the uppermost horizontal surface of the robot

MDF – Medium Density Fiberboard

OT – Objective Tunnel. The entire tunnel containing infrastructure

Quarantine Area – Numbered grid location where robots are placed prior to each Round

RMEC - Rocky Mountain Event Center – location of robot competition in the Marriott Tech Center

Round – A judged and timed opportunity to collect points

SAE – Society of Automotive Engineers

Scoring Judge – Records and reports all points and penalties

START/STOP – The surface contained within Grid Location A7

Team Lead – A student designated at the start of each Round to handle the Team robot

Temporary Reference Marks – marks placed on the Game Field surface surrounding a surface obstacle

Timing Judge – Controls and reports elapsed time

Tunnel – Grid Locations where contiguous Grid Blocks have been removed from under the Game Field surface

Tunnel Map – Red LEDs representing the Objective Tunnel on the Mapping Display and the Blue LEDs representing Dead Ends on the Mapping Display

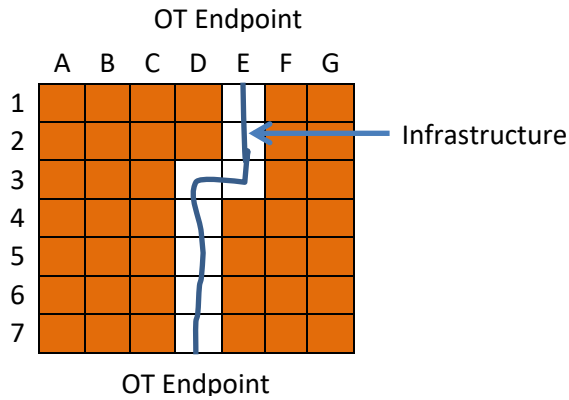
VAC – Volts Alternating Current

XPS – Extruded Polystyrene

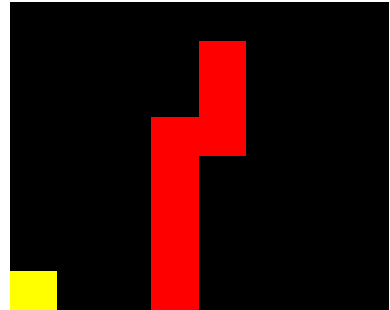
# Appendix A – Tunnel Examples

## Round 1 Tunnel Example

Game Field Layout



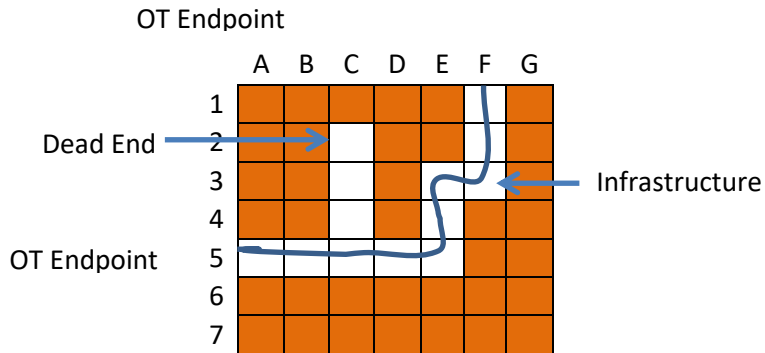
Map Display (MD)



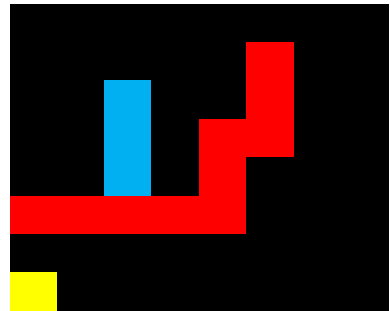
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## Round 2 Tunnel Example:

Game Field Layout



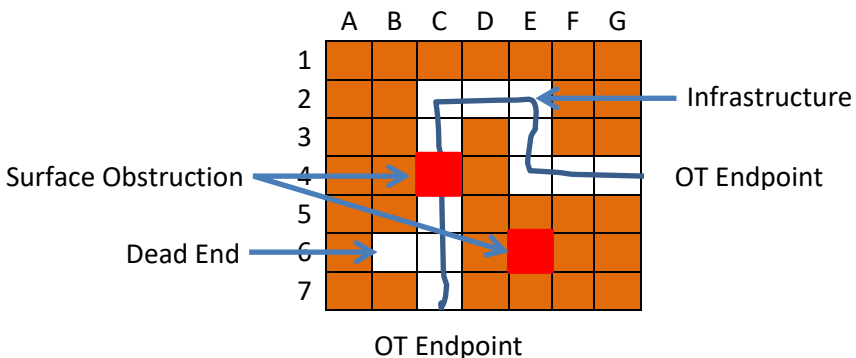
Map Display (MD)



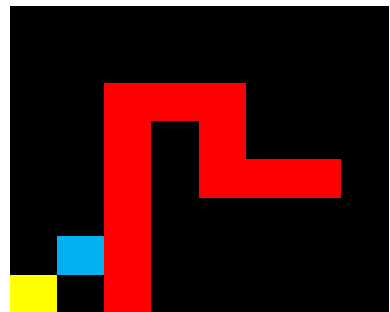
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## Round 3 Tunnel Example:

Game Field Layout

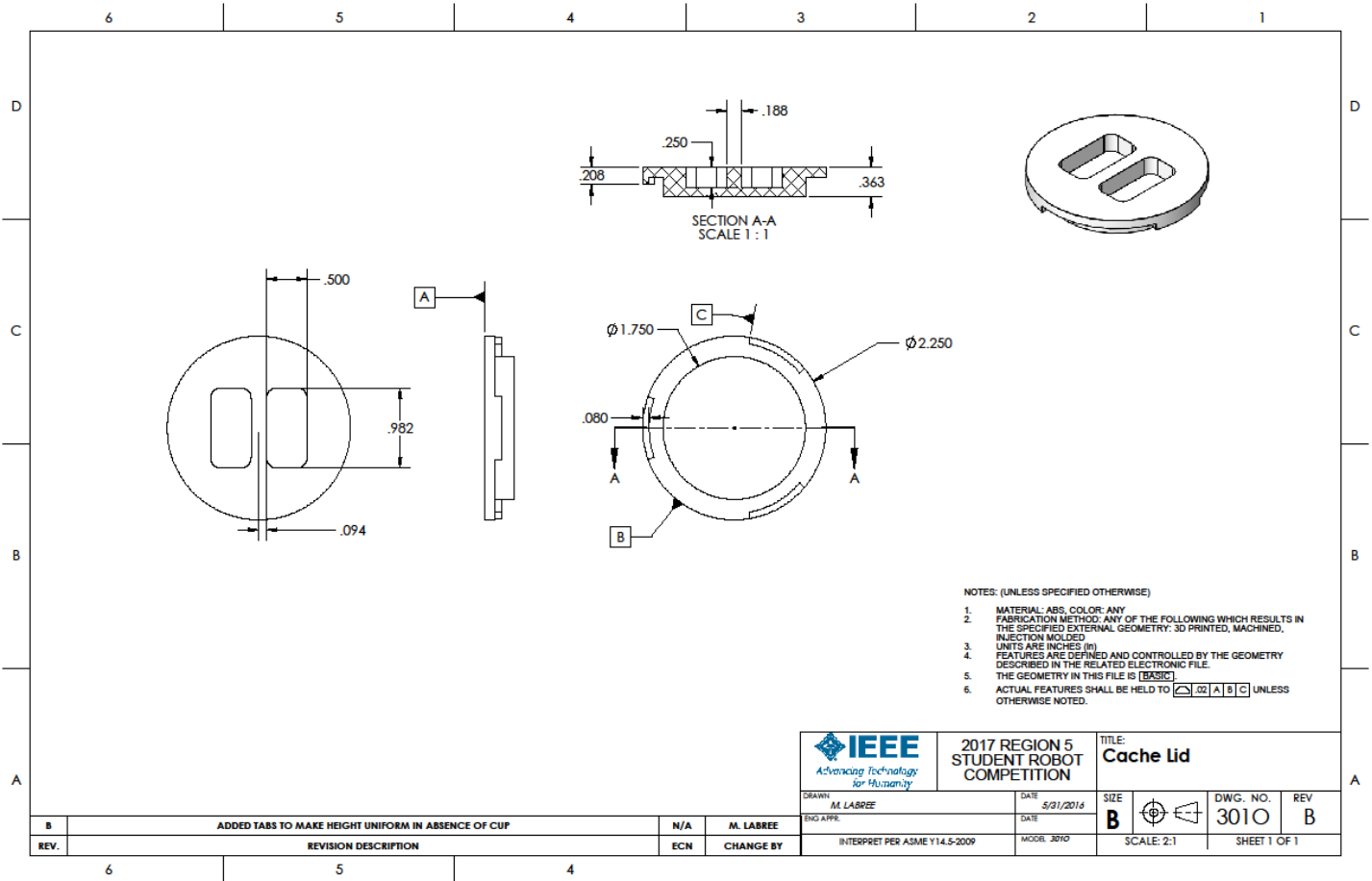


Map Display (MD)





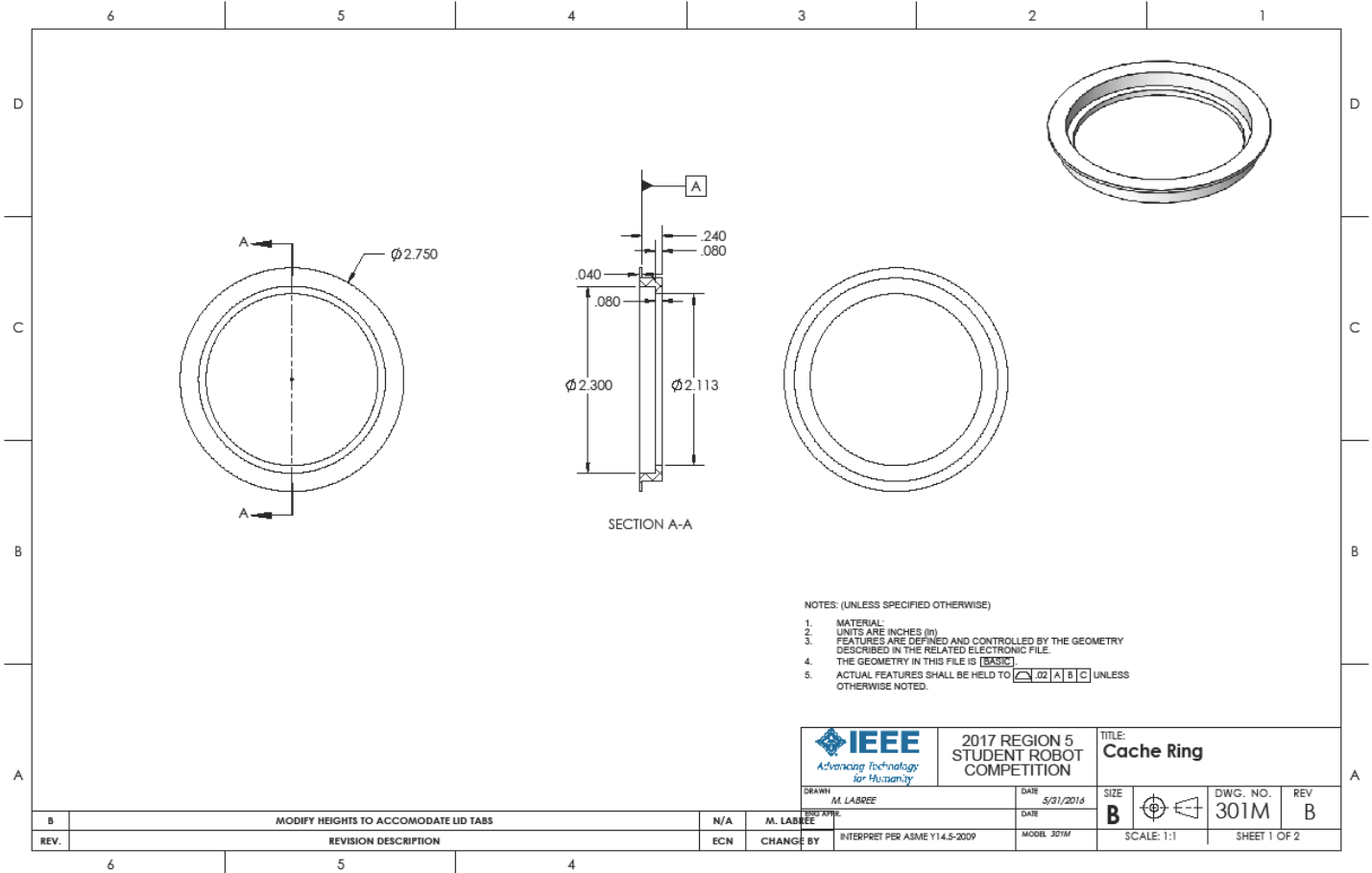
## Appendix B – Key Buried Cache Information



- NOTES: (UNLESS SPECIFIED OTHERWISE)
1. MATERIAL: ABS, COLOR: ANY
  2. FABRICATION METHOD: ANY OF THE FOLLOWING WHICH RESULTS IN THE SPECIFIED EXTERNAL GEOMETRY: 3D PRINTED, MACHINED, INJECTION MOLDED
  3. UNITS ARE INCHES (in)
  4. FEATURES ARE DEFINED AND CONTROLLED BY THE GEOMETRY DESCRIBED IN THE RELATED ELECTRONIC FILE.
  5. THE GEOMETRY IN THIS FILE IS [BASIC]
  6. ACTUAL FEATURES SHALL BE HELD TO  $\square \square \square \square \square \square$  UNLESS OTHERWISE NOTED.

 <small>Advancing Technology for Humanity</small>	<b>2017 REGION 5 STUDENT ROBOT COMPETITION</b>	<b>TITLE:</b> <b>Cache Lid</b>			
	DRAWN: <b>M. LABREE</b> END APPR:	DATE: <b>5/31/2016</b> DATE:	SIZE: <b>B</b>	DWG. NO.: <b>3010</b>	REV: <b>B</b>
INTERPRET PER ASME Y14.5-2009		MODEL: <b>3070</b>	SCALE: 2:1      SHEET 1 OF 1		

B	ADDED TABS TO MAKE HEIGHT UNIFORM IN ABSENCE OF CUP	N/A	M. LABREE	
REV.	REVISION DESCRIPTION	ECN	CHANGE BY	



**Cache Die – Typical Manufacturer, Model and Sources of Supply**

Manufacturer: Chessex Manufacturing

Model: 25601 16mm d6 White/Black Dice Block™

Sources of Supply:

<http://www.chessex.com/Dice/Opaque%20Dice/25401.htm>

<http://www.amazon.com/Chessex-Manufacturing-25601-Opaque-White/dp/B00OU6PK64>

<https://www.neweggbusiness.com/product/product.aspx?item=9siv06w2gd2852>



