

TEST PROJECT - JUNIOR MOBILE ROBOTICS 2017

WSC2017_TPJMR_290717_EN

Ploughing The Field

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This Test Project proposal consists of the following documentation/files:

1. WSC2017_TPJMR_290717_EN.doc
2. WSC2017_TPJMR_290717_OP_EN.pdf (PDF One Page Game Description)
3. WSC2017_TPJMR_290717_AP_A_EN.pdf (PDF Appendix A)
4. WSC2017_TPJMR_290717_AP_B_EN.pdf (PDF Appendix B)
5. WSC2017_TPJMR_290717_AP_C_EN.pdf (PDF Appendix C)
6. WSC2017_TPJMR_290717_AP_D_EN.pdf (PDF Appendix D)



INTRODUCTION

A Need for Cutting-edge Technology

Many people believe that in the future, robotics will encompass every part of life. Even today, robots do the jobs that many people find dull, dirty, or dangerous. To compete in this evolving field of robotics, companies will be looking for individuals who are fluent in robotic design and programming, mechanical construction and electrical wiring.

Individuals rarely possess all the skills necessary to compete in current and future robotics design and engineering challenges. Therefore, team work will be necessary and advantageous to a successful robotics industry.

Your Team

Success in industry and in this Junior Mobile Robotics Competition will be realized by a teamwork approach. In the interest of emulating industry, teams should be comprised of specialists in Mechanical Design and (Mobile Robotics) Programming.

The Client's Needs and the Team Goal

The Client's Needs

In today's agriculture industry, there is the need for a better way to harvest ripened fruit and vegetables from the farmers' fields. At the same time, the Crops need to be stored correctly and in a timely manner that won't cause them to spoil. Currently, this process is performed manually, predominantly by workers in the fields and takes too much time to complete.

The Client is aware that automation systems boost productivity, reduce costs, shorten order fulfillment times, increase customer satisfaction and deliver a rapid return on investment (ROI). This ROI is achieved through faster harvests, order accuracy, and a decrease in labor costs. Today's farmers are consistently finding that a two to five percent improvement across various performance metrics can mean large increases in bottom-line returns to the business. By using automated robots in the agricultural industry, we are able to eliminate manual picking and sorting. This can improve the picking and sorting functions, enabling the farms to process larger quantities at a much higher level of accuracy and in a faster time. Any improvement in time from field-to-processing will be beneficial for all involved. The Client is requesting this type of system from the Junior Mobile Robotics Team.

The Team Goal

PBR Farming (the Client) is looking to improve their productivity. The Client is looking to increase the number of different Crops that it grows and from this, process more orders. This will result in a need for a more accurate and efficient workflow. To facilitate this the Client is looking to evaluate a Robot that can move autonomously around the Competition Field picking and sorting during a night shift. Then during the day the Client's employees will use the Robots, under direct control, to pick and sort remaining Crops. Therefore, as a Junior Mobile Robotic development team, your goal is create a Robot that can fulfill the picking and sorting process autonomously and during the time when PBR Farming's employees are controlling it.

On the Competition Field the Crops (Hexballs) are all located on the same side of the field the Robot



starts in, the Crops (Hexballs) then need to be moved over the Fence into the Processing Area using the Bridge. Once in the Processing Area, points will be awarded based on the location that the Crops (Hexballs) end in. More points will be awarded based on the location, those Crops (Hexballs) placed in the Elevated Goal will be temperature controlled and therefore Score the most points. The Low Goals are safe from damage, but not temperature controlled. Any Crops (Hexballs) in the Processing Area, but not in any other area will require further work so will Score minimal points. If Crops (Hexballs) are positioned in the correctly colored zone, this is the optimal environment and they Score double points. Any Crops (Hexballs) that remain in the Field will not be processed and Score no points.

The Robot should finish on the Bridge at the end of both periods of operation for safety. If it finishes on a Balanced Bridge then it will charge, so receives additional points, at the end of both periods of operation.

Group Organizational Goal

Team Dynamics

The Competition should run much like you would expect commercial projects to be undertaken. Group members are expected to interact professionally, respect ideas & suggestions from each other and work as a team. At a minimum, the team shall have a mechanically-oriented person to lead in mechanical design and a programmer to lead robot programming. Both team members should assist in the actual construction process.

The contest is designed to demonstrate the value of teamwork on a project. Teams should divide duties equally among all members; no individual should dominate. When necessary to achieve a particular outcome or goal, a team member will assist their partner. All team members are responsible for evaluating each other's work and contributing to the overall project's quality control.

Team Objectives

The Competition consists of developing a robotic device, at a low cost, for a customer. The device must meet specific performance requirements provided by the customer. Multiple teams will be designing a device to meet the customer's requirements, thus a Competition will be scheduled to evaluate the competing devices and select the winning proposal.

With this in mind, each team should work towards the following objectives:

- Construct a fully operational prototype robot that meets the requirements of the customer, at a low cost.
- Maintain an Engineering Notebook chronologically documenting the design evolution, materials used, and problems encountered & resolved, decisions made, and test results obtained.
- Be prepared to orally present the team's final solution to the problem, incorporating support materials such as posters, lab notebooks, prototype robot, and/or PowerPoint presentation. Each team member is expected to participate in the presentation.
- Demonstrate the functionality of the robotic device in competition.

A successful project will require the use of critical thinking and problem solving abilities, self-management skills, professional writing skills, and clear oral communication.



DESCRIPTION OF PROJECT AND TASKS

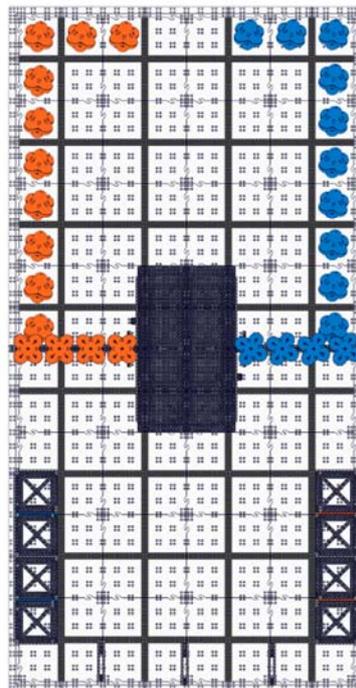
Initial Design

The Client, PBR Farming is a company that is looking for an automated way to collect various Crops throughout their farm and place them in the various processing locations. PBR Farming has provided a layout of the Fields and Processing Area; along with these general Robot operating requirements. 1). the Robot must autonomously pick up and move Crops into the Processing Areas overnight, and, 2). The next day, the Robot must transition into an operator controlled vehicle. Your team's goal is to create a Robot that can effectively and efficiently meet these requirements.

The Client also requires that each stage of the design, fabrication, and programming process be well-documented. This requires that your team provide a complete bill of materials, assembly instructions, the programming code flowchart, and a printed autonomous code for the Robot.

After your prototype Robot, has been designed, programmed, assembled, and documented your team will test the robot in a simulation of the Client's facility at the Junior Mobile Robotics Competition event.

Figure 2: Top view of Clients orchard fields and processing locations





Design Change and Concurrent Engineering

The Client will review the prototype and may require one or more changes. The team must be prepared to handle different configurations of Field layout, Crop size or processing locations that may need to be moved at different times. Having a Robot that can handle diverse challenges will make your design more appealing to the Client.

Project Guidelines

Specific Requirements

The Client's Engineering Project Manager has provided an outline of materials to begin your planning and manufacturing process. Your success on this project is based upon the following criteria:

1. Teams will be given an objective by the Technical Committee. The goal is to be fulfilled using a mobile robotic system.
2. Teams must be comprised of two members.
3. An Engineering Notebook is to be created and used by team members to chronologically document their project for the competition. It should include pictures, printed sections of code, detailed assembly instructions; design evolution with changes, problems encountered and solved, decisions made, and test results. All pages must be bound, numbered, and dated.
4. Teams may bring only their Engineering Notebook and a laptop to the Competition to be used as reference tools during the build phase. The laptop may already have programming code for the Robot.
5. It is recommended that teams use CAD software to design their robot and this virtual model can be used to support their build during the Competition. Autodesk Fusion 360 is the only CAD software that will bring marks within the Design segment of the challenge.
6. All team members are responsible for double-checking each other's work. Thus, they shall both assist with build and quality control.
7. At the competition, the Robot must be constructed from only the materials supplied by the technical committee.
8. During an oral presentation session, each team will have up to 15 minutes to share their solution with a group of judges, which should be viewed as the "Client". The presentation may incorporate support materials such as posters, lab notebooks, a prototype Robot, and/or PowerPoint presentation.
9. After teams have completed some of the Competition rounds with their Robot (designed and built for the Client), a design change may be introduced. At this time, the Competition will be repeated.
- 10. All engineering notebooks, forms, documentation, and programs must be turned in to the technical committee members for judging during a point in the Competition advised on Day One.**
11. All team members, advisors, and judges are required to attend a debriefing session after the Competition has concluded.



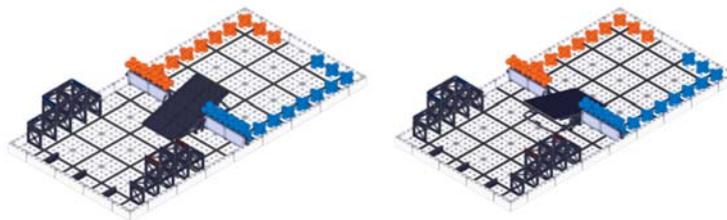
Team Rules and Guidelines

Competition Rules

Below are the official rules and guidelines for the Junior Mobile Robotics Competition. All teams will be expected to adhere to these rules.

Definitions

- **Autonomous Period:** A 90-second period in which Robots operate based only on pre-programmed instructions and sensor inputs. Team members are not allowed to interact with the Robot during this period.
- **Balanced –** A Bridge is Balanced if neither end of the Bridge is touching the Competition Field or is supported by a Hexball.
- **Bridge –** The 14" x 24" structure of VEX IQ plates that sits 3.25" high off the ground when level. The Bridge is mounted on a double hinge that allows the Bridge to tip towards either end of the Field. Teams may elect to start the Bridge tipped in either direction or to leave it Balanced. If the teams don't make a decision, it will start the Match Balanced.



An Unbalanced Bridge to either side of the Field

- **Operator-Control Period:** A 90-second period in which Robots are operated by team members through the use of a wireless transmitter and receiver.
- **Elevated Goal –** One (1) of the twelve (12), 6" wide, 6" deep volumes bounded by VEX IQ plates, where teams can Score Hexballs. Four (4) of the Elevated Goals are additionally bounded at the top by VEX IQ plates and have a height of 6.25".
- **Fence –** The 6" high pipe structure that marks the edge of the two scoring zones.
- **Field Element –** The Field perimeter, Hexballs, Fence, Goals, Bridge, and any supporting structures.
- **Processing Area –** The part of the Competition Field that is within the outer walls where the Low Goals and Elevated Goals are located.
- **Goal –** A Low Goal or an Elevated Goal.
- **Field -** The part of the Competition Field that is within the outer walls where the Game Elements begin each task.
- **Hexball –** An orange or blue plastic scoring object consisting of six (6) bumps extending from a common center, with an overall diameter of approximately 5". Each Hexball weighs approximately 0.19 lbs.
- **Low Goal –** One (1) of the eight (8), 5-6" wide, 6" deep volumes bounded by VEX IQ plates. There are two



additional Low Goals, 12 ½” wide, bounded by the field walls, and the Floor, where teams can Score Hexballs. Eight (8) of the Low Goals are additionally bounded at the top by VEX IQ plates and have a height of 6.25”.

- Parked – A Robot is Parked if it is touching the Bridge and not touching the Floor at the end of the Match.
- Scored – A Hexball is Scored if it is not touching a Robot and meets one of the following criteria.
 - 1.The Hexball is contacting the Floor within the Processing Area
 - 2.The Hexball is not being contacted by a Robot and is partially within the three dimensional volume of a Goal.
 - Note 1: If a Hexball is Scored both in the Processing Area and a Low Goal, it will only count as Scored in the Low Goal. (i.e. A Hexball cannot earn points in both the Processing Area and a Low Goal)
 - Note 2: No more than one (1) Hexball will be considered Scored in each Goal. (i.e. You cannot earn points for multiple Hexballs in a single Goal)
 - Note 3: If a Hexball is Scored in multiple Goals, it will only count as Scored in the highest point value Goal it is Scored in. (i.e. A Hexball cannot earn points in more than one Goal)
- Goal – The Processing Area, Low Goal or Elevated Goal.
- Starting Position – The designated 13” x 20” spot on the Competition Field, where Robots must start the match. Starting Positions are bounded by the outer edges of the black lines and the top most outer edge of the field wall.

Field Setup

- The Competition Field is 4' by 8', enclosed by a 2 ½” tall field border.
- The surface of the Field is comprised of white and black plastic tiles.
- There are 28 Hexballs placed on the Field.
- There are a total of three scoring zones.
 - One scoring zone is the Processing Area, over the Bridge from the Starting Position. All of the field tiles outside of the Low Goal count as the Processing Area.
 - A second scoring zone is the Low Goal, over the Bridge from the Starting Position on the opposite wall of the Field.
 - The third scoring zone is the two Elevated Goals, over the Bridge from the Starting Position.

Scoring

- A Hexball Scored in the Processing Area is worth one (1) point.
- A Hexball Scored in a Low Goal is worth three (3) points.
- A Hexball Scored in an Elevated Goal is worth five (5) points. A Hexball Scored in an Elevated Goal of the same color is worth ten (10) points
- A Robot Parked on the Bridge is worth five (5) points.
- A Robots Parked on a Balanced Bridge is worth fifteen (15) points.



Match Sequence

- Autonomous Period: 0-90 Seconds (Night Shift processing operations).
- Operator Control Period: 90-180 Seconds (Day Shift processing operations).

Competition Match Rules

- Each round will be three minutes long in total and will feature only **ONE** Robot.
- Any Hexballs that leave the Competition Field will NOT be returned to the Field.
- During a round, Robots may be remotely controlled only by the drivers and by software running autonomously on the VEX IQ Brain.
- A team may handle their robot as many times as they want during the Autonomous Period, however they must adhere to the following rules...
 - Upon handling the Robot, it must be immediately brought back to a legal Starting Position.
 - If the Robot is possessing any Hexballs when the Robot is being handled, these Hexballs will be removed from the Competition Field and can no longer be used.
 - If there are any Hexballs in the Robot Starting Position where the Robot is being placed, these Hexballs will be removed from the Competition Field and can no longer be used.
- If any team member touches his or her team's Robot at any time during the Operator Control Period, the Robot will be disabled and the team disqualified from that round – scoring zero points.
- Final Scores will be calculated at the end of the 180 seconds after all Robots and Field Elements come to rest. A note of the Robot and position in relation to the Bridge (Parked, Balanced or otherwise) will be made before the Operator Control Period. Operators are not to enter the Field or touch the Robot at the end of either round until event personnel gives permission.
- Robots must start the round completely inside the Starting Position.
- Robots start the Operator Control Period from where their Robot ends the Autonomous Control Period.

Robot Rules

- Robots must have a starting size at the beginning of a Match, each Robot must:
 - a) Only be contacting the Floor.
 - b) Fit within a 13" x 20" area, bounded by the Starting Position.
 - c) Be no taller than 15"

The size of the Robot may be checked by the judges at any time during the Competition if they feel that the Robot is over the size limit.

- During the Match, Robots may not expand beyond the 13" x 20" area they were limited to at the start of the Match. However, Robots are permitted to expand beyond the 15" height restriction they were limited to at the start of the Match.
- Robots may only be constructed from parts found in the WorldSkills VEX IQ Robot Kit. See



Appendix A for a list of parts found in the WorldSkills VEX IQ Robotics Kit.

- No Robot may have mechanisms that could potentially damage the scoring objects, Competition Field or Field Elements, or pose a safety hazard to teams or spectators.
- All parts of the Robot must remain attached to the Robot for the duration of the round. Any infraction of this rule may result in an immediate stopping of the round and a loss of points Scored. Minor pieces that unintentionally become detached from the Robot, or are the result of improper design/construction will not cause a point loss.
- Teams may not modify any part of the control system or any motor or sensor.

On-Field Malfunctions

IN THE CASE OF PROGRAMMING PROBLEMS: A Robot's program is the responsibility of the team. All software must be original copies. If your team develops a problem with the software or Robot program, the Technical Committee will work in whatever way it can to resolve the problem but no rounds will be replayed due to problems with the Robot's program. The following software platforms are recommended:

Modkit for VEX Robotics
ROBOTC for VEX Robotics

Other programming software will not be supported by the Technical Committee.

MARKING SCHEME

Please refer to Appendix B, the Score Sheet and Appendix C, the Judging Rubric.



EQUIPMENT, INSTALLATIONS AND MATERIALS REQUIRED

Kit of Parts Overview

Your Robot may only be made of components listed on the WorldSkills Junior Mobile Robotics kit of parts. This year's kit will be drawn from the VEX IQ Super Kit P/N 228-2500/3660/3670; VEX IQ Foundation Add-On Kit P/N 228-2531; VEX IQ Competition Add-On Kit P/N:228-3600

Note: The kit comes with (1) 7.2V 2000 mAh battery for the VEX IQ Brain and (1) 3.7V 800 mAh battery for the VEX IQ Controller as well as their respective chargers. These are the only batteries to be used, unless otherwise replaced by the Technical Committee.

A full list is available in Appendix A.

Required Components and Supplies

Teams require the following materials to complete the competition.

Technical Committee-Provided Components

The Technical Committee will provide:

1. Design Challenge Competition Field and Field Elements.
2. One six foot table.
3. One standard electrical outlet for the host region.
4. The description of the Junior Mobile Robotic Design challenge.
5. WorldSkills Junior Mobile Robotics Kit of Parts (VEX IQ System).

Team Provided Components

Teams are to bring the following components:

1. Engineering Notebook.
2. Safety glasses.
3. A laptop equipped with licensed VEX programming software (for the VEX IQ Brain), CAD software (Autodesk Fusion 360) and suitable presentation software (such as Microsoft's PowerPoint). An additional tablet device is allowed for presentations.
4. Power strip and extension cord.
5. Calculator (standard, scientific or graphing).
6. Tape measure and/or ruler.
7. Graph paper, pens, pencils, tape, electrical tape, markers and scissors.

Note: ONLY the above listed items will be allowed in the contest area during the competition.



Safety

Importance of Safety

In industry, it is in the best interest of both employer and employee to maintain a safe work environment. When a company's history of employee injury incidents is low, the company increases its likelihood of reduced insurance rates and Workers Compensation fees.

Safety considerations will be taken into account during the Junior Mobile Robotics Competition judging to mirror a professional industrial environment.

Safety Violations

If a team or a team member violates a safety rule, or operates their Robot in an unsafe manner, the following penalties will be levied:

1st Violation:

Team will be issued a written warning.

2nd Violation:

Team will have 5% deducted from their total score.

3rd Violation:

Team will be disqualified.

Safety Issues

1. Team members must keep their work area reasonably clean. Clean work places promote efficient and safe working conditions. Special attention should be paid to keeping the floor clean and to the elimination of tripping hazards such as uncovered or dangling power cords in of walking aisles.
2. Team members must keep their teammates and other teams aware of possible dangerous situations, such as pinch points, sharp edges, tripping hazards (power cords) and tethered or wireless enabling of Robots.
3. Tampering with or dismantling of any part of the supporting equipment (e.g., computers, printers, etc.) is a direct safety violation, and can be grounds for immediate disqualification.

Documentation

Document Submission

The following documentation will be judged at the Competition.

- Engineering Notebook