2015 SKILLSUSA CHAMPIONSHIP
MOBILE ROBOTICS COMPETITION

TEAM GUIDE
# Contents

2015 SKILLSUSA CHAMPIONSHIP ................................................................. 1
Acknowledgments ....................................................................................... 3
Mobile Robotics Technical Committee ........................................................ 4
Judges ............................................................................................................ 4
National Educational Technical Committee ............................................... 5
Awards ......................................................................................................... 5
2015 SkillsUSA Mobile Robotics Competition .............................................. 6
1: Contest Overview .................................................................................. 7
1.1: Clients Needs and Team Goals ......................................................... 7
1.2: Specific Problem Instructions ......................................................... 8
1.3: Project Guidelines ............................................................................. 9
1.4: Kit of Parts ........................................................................................ 10
1.5: Team Rules & Guidelines ............................................................... 10
1.6: Group Organizational Goal ............................................................. 13
1.7: Judged Scoring ............................................................................... 16
1.8: Required Materials ....................................................................... 17
2: Safety .................................................................................................. 19
3: Documentation ...................................................................................... 20
Judging Form 2015 .................................................................................. 21
Appendix A – SkillsUSA VEX Robotics Kit Bill of Materials ..................... 22
Appendix B – Field Information ............................................................... 24
Appendix C – State Competitions ............................................................. 30
Acknowledgments

The success of the competition is the result of the motivated contestants and their instructors, the determined efforts of the National and State Technical Committees, and the generosity of companies donating equipment. The following companies have contributed resources and support.

Intelitek, Inc.
AZTECH Educational Resources
Solidworks
VEX Robotics, Inc.
Robotics Education and Competition Foundation
Honeywell
Visual Edge Inc.
Mobile Robotics Technical Committee

The following individuals contributed their time and energy to the Technical Committee:

**Dan Larochelle**
Robotics Education and Competition Foundation

**Rick Knisely**
AZTECH Educational Resources

**John V-Neun**
VEX Robotics, Inc

**Dan Ward**
Visual Edge Inc.

**Isaac Onigman**
Intelitek Inc.

**Trevor Pope**
Intelitek Inc.

Judges

The following individuals contributed their time and energy as Judges for the competition:

**Tom Hand**
Honeywell

**James Lula**
Honeywell

**Sandra Lula**
Honeywell
National Educational Technical Committee

The following individuals contributed their time and energy to the National Educational Technical Committee.

Roger Osgood, National Education Chair
John E. Dwyer Technology Academy

Awards

The following companies have supplied awards:

Intelitek, Inc.
Solidworks
VEX Robotics, Inc.
2015 SkillsUSA Mobile Robotics Competition

The Game
In this year’s challenge, teams are tasked with moving red and blue cubes into color-coded scoring zones during a two-minute autonomous and operator control round.

The Field
The 12’ x 12’ field contains 36 cubes; 18 are blue and 18 are red. The field contains a total of four posts that are approximately two feet tall. Two are in the blue scoring zone and two are in the red scoring zone. There are a total of nine yellow tower sections mounted to collars along the perimeter of the field. One tower base is placed in each scoring zone of the field. The field contains white tape lines that form a pattern on the inside of the field.

The Round
A team’s robot is located completely inside the starting square at the beginning of the round. For the first 60 seconds of the round, the robot operates completely autonomously. Using sensors and pre-programmed instructions, the robot must attempt to strategically move the cubes across the playing field and into the scoring area. During the next 60 seconds of the round, drivers take control of the robot. Teams score points for each cube placed completely inside the corresponding color floor tiles or on a two foot post. Teams may also build a “multiplying tower” by placing yellow tower sections into the yellow bases and then placing the appropriate colored cube onto the tower.

Scoring
Red Cube placed completely on a red tile: one point
Blue Cube placed completely on blue tile: one point
Red cube placed completely on blue tile: zero points
Any stacked cubes of the same color are awarded an additional point value based on the elevation. For example a red cube stacked on top of a red cube located inside the red scoring zone is worth two points.
Any matching color cubes placed on two foot posts will be considered a multiplier value and additional cubes placed will increase the value. For Example, one cube on the two foot post = 2x multiplier; two cubes = 3x, three cubes = 4x, four cubes = 5x

End of round bonus
Any yellow tower pieces assembled with a matching colored cube placed on the tower will multiply the “end-of-round” total score by the number of cubes that are placed on the tower.
1: Contest Overview

A Need for Cutting-edge Technology

Many believe that in the future, robotics will encompass every part of life. Even today, robots do the jobs that 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.

In current and future robotics design and engineering challenges, individuals with diverse skills no longer may have all the answers. Therefore, teamworking experience will be necessary and is advantageous to a successful robotics industry.

Your Team

Success in industry and in this 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.

1.1: The Client’s Needs and the Team Goal

1.1.1: The Client’s Needs

Today’s warehouse acts as the hub of the integrated supply chain (ISC) by combining accounting, order and shipping software systems with RF (radio frequency) and barcode scanning hardware to create automated warehouse systems. These automation systems boost productivity, reduce costs, shorten order fulfillment times, increase customer satisfaction and deliver a rapid return on investment (ROI). The ROI is achieved through order accuracy, on-time shipping, minimization of inventory carrying costs and a decrease in labor costs. Today’s warehouse managers are consistently finding that two to five percent improvement across various performance metrics can mean hundreds of thousands of dollars in bottom-line returns to the business. By using automated robots in a warehouse, companies are able to eliminate manual package handling and improve the picking and receiving functions, enabling the warehouse to process more orders at a much higher level of accuracy. The client is requesting this type of system from the Mobile Robotics Team.

1.1.2: The Team Goal

The AmaZone Shipping and Receiving Company (The Client) is looking to improve their warehouse productivity. The client is processing more orders resulting in a need for more accurate and efficient workflow. During the overnight operation, the Client is asking that the robot move autonomously around the warehouse gathering packages to be processed. During the day AmaZone employees will use the robots to transfer the remaining cubes to the shipment processing areas. Therefore, as a Mobile robotic development team, your Goal is create a robot that can fulfill the shipping and receiving process autonomously and while AmaZone employees are controlling it.

The shipment processing storage containers are the red and blue tiles located on the floor of the warehouse used for ground shipment methods. Two storage posts are available in both the red and blue shipping areas for packages that are processed as overnight shipments. One yellow tower base in each shipping area is available for any shipment that should be shipped by “AmaZone drone”. It is your Goal to transfer the red and blue packages into their respective shipping areas. A productivity bonus will be awarded for packages that
are shipped overnight and a second efficiency bonus will be awarded for construction of the drone launch tower including packages that are successfully prepared for shipment.

### 1.2: Specific Project Instructions

#### 1.2.1: Initial Design

The Client is a shipping and receiving company that is looking for an automated way to collect packages throughout the warehouse and place them in the appropriate shipping locations. AmaZone has provided a layout of the warehouse property; along with these general robot operating requirements. 1). the robot must autonomously move packages into the processing areas, 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 C code program for the robot.

After your prototype has been designed, programmed, assembled, and documented your Team will test the robot in a simulation of the Client’s facility at the Mobile Robotics Competition event.
1.2.2: 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 cube packages or storage 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.

1.3: Project Guidelines

1.3.1: 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. All team members are responsible for double-checking each other’s work. Thus, they shall both assist with build and quality control.

6. At the competition, the robot must be constructed from only the materials supplied by the technical committee.

7. During an oral presentation session, each team will have 10 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.

8. After teams have completed the first 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.

9. At all times, team members are required to adhere to industrial safety standards, such as wearing of eye, ear, and hand protection where appropriate.

10. All engineering notebooks, forms, documentation, and programs must be turned in to the technical committee members during orientation session.

11. All team members, advisors, and judges are required to attend a debriefing session after the competition has concluded.

1.4: Kit of Parts

1.4.1: Kit of Parts Overview

Your robot may only be made of components listed on the SkillsUSA kit of parts. A full list is available in Appendix A.

1.5: Team Rules and Guidelines

1.5.1: Competition Rules

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

1.5.1.1: Definitions

- **Autonomous Period**: A 60-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.

- **Operator-Control Period**: A 60-second period in which robots are operated by team members through the use of a wireless transmitter and receiver.

- **Cube**: A hollow plastic item on the field weighing 1.12 lbs +/- 10%. Cubes can be either red or blue.

- **Yellow Base**: A yellow plastic base bolted to the foam tile floor. There are two bases on each playing field, one in each scoring area. Bases are intended to hold stacked Yellow Tower Pieces.
• Tower Piece – A yellow plastic piece mounted to the side wall of the playing field. Each tower piece may be picked up by the robot and maneuvered around the playing field. Tower pieces may also be stacked in the yellow base and inside each other.

• Collar – A ring mounted to the side wall of the playing field which is used to hold Posts and Tower Pieces.

• Post – A two foot tall plastic post mounted to the field walls. There are four posts on each playing field, two are in the blue scoring area and two are in the red scoring area

• Colored Foam Tile - A foam floor tile colored gray, blue or red.

1.5.1.2: Field Setup

• The field is 12' by 12', enclosed by an 11.5" tall field border.

• The surface of the field is comprised of grey, blue and red foam tiles.

• There are 36 hollow cubes placed on the field. Of these, 18 are blue and 18 are red.

• There are a total of four grey posts mounted to the field walls using an upper and lower collar. Two of these posts are considered to be in the red scoring zone and two of these posts are considered to be in the blue scoring zone. Each post is two feet from the corner of the playing field and two feet tall.

• There are two yellow bases mounted four feet from the scoring edge of the field and two feet from the corresponding side wall.

• There are nine yellow posts mounted along the perimeter of the playing field. Five of these posts are on the back wall, two are on the left wall and two are on the right wall.

• Two blue colored tiles and two red colored tiles are located on the field. See Appendix B for additional information on the field layout.

1.5.1.3: Scoring

• Cubes must be completely inside the corresponding colored tiles to be considered “scored”.

• A red cube on a blue tile is worth zero points.

• A blue cube on a red tile is worth zero points.

• A red cube on a red tile is worth one point.

• A red cube stacked on top of another red cube is worth two points.

• A red cube stacked on top of two red cubes is worth three points.

• A blue cube on a blue tile is worth one point.

• A blue cube stacked on top of another blue cube is worth two points.

• A blue cube stacked on top of two blue cubes (three cubes high) is worth three points.

• A colored cube placed on one of the two foot tall posts will multiply your total score by one plus the number of cubes placed. For example if two cubes are placed on the two foot posts then your total score will be multiplied by three.
• A colored cube placed on an assembled yellow tower will multiply your final score above by one plus the number of cubes placed. For example if one cube is placed on one assembled tower section then your total score will be multiplied by two.

See section 1.5.3 for a detailed explanation of scoring.

1.5.1.4: Match Sequence

• Autonomous Period: 0-60 Seconds (Night Shift shipping and receiving operations).
• Operator Control Period: 60-120 Seconds (Day Shift shipping and receiving operations).

1.5.1.5: Competition Match Rules

• Each round will be two minutes long and will feature only ONE robot.
• Any cube that leaves the field will NOT be returned to the field.
• During a round, robots may be remotely controlled only by the drivers and by software running on the control system. If any team member touches his or her team's robot at any time during a round, the robot will be disabled and the team disqualified from that round.
• Scores will be calculated at the end of the 120 seconds after all robots and field elements come to rest. 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 tiles adjacent to the blue and red scoring floor tiles.

1.5.1.6: Robot Rules

• Robots must have a starting size of no larger than 18" by 18” by 18” at the start of a round but they may expand to any size once the round has begun. If the robot exceeds the starting size, it will not be allowed to compete. The size of the robot may be checked by the judges at any time during the competition if they feel that the robots is over the size limit.
• Robots may only be constructed from the same type and quantity of parts found in the SkillsUSA VEX Robot Kit or additional, approved non-VEX materials, and only after the challenge has been released to teams. See Appendix A for a list of parts found in the SkillsUSA VEX Robotics Kit.
• No robot may have mechanisms that could potentially damage the scoring objects, playing 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 disqualification. Minor pieces that unintentionally become detached from the robot, or are the result of improper design/construction will not cause a disqualification.
• Teams may not modify any part of the control system or any motor or servo.
• Robots are allowed only the following non-VEX components:
  o Any parts which are identical to legal VEX parts, such as screws, zip ties etc.
  o Any non-functional decorations that do not affect robot performance.

Commercial threadlocker may NOT be used.
1.5.2: Field Malfunctions

IN THE CASE OF A FIELD FAILURE: The team leader will communicate the problem to a representative of the Technical Committee. The representative will then notify the Project Manager. If it is determined that it is in fact a field problem, the round will be replayed. In the case of a replayed round, the previous score will not be counted and the team’s new round score will count, regardless of whether the team scores more or less points. If no field failure is determined the score for that round will stand as is.

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. **NOTE: EasyC V4 for Cortex or EasyC V5 for IQ / Cortex will be the only supported software platforms.**

1.5.3 Scoring

8 red cubes completely inside the red tiles = 8 points

1 red cube completely inside the blue tiles = 0 points

4 red cube completely inside the red tiles (layer 1) = 4 points
4 red cubes stacked (layer 2) = 8 points (2 cubes x 2 points each)

Total Points = 12 points
3 red cubes completely inside the red tiles (layer 1) = 3 points
2 red cubes stacked (layer 2) = 4 points (2 cubes × 2 points each)
1 red cube stacked (layer 3) = 3 points (1 cube × 3 points each)

Total Points = 10 points

1 red cube on red multiplier post = 2x total = 20 points

3 red cubes completely inside the red tiles (layer 1) = 3 points
2 red cubes stacked (layer 2) = 4 points (2 cubes × 2 points each)
1 red cube stacked (layer 3) = 3 points (1 cube × 3 points each)

Total Points = 10 points

2 red cubes on red multiplier post = 3x total = 30 points

3 red cubes completely inside the red tiles (layer 1) = 3 points
2 red cubes stacked (layer 2) = 4 points (2 cubes × 2 points each)
1 red cube stacked (layer 3) = 3 points (1 cube × 3 points each)

Total Points = 10 points

4 red cube on red multiplier post = 5x total = 50 points

3 red cubes completely inside the red tiles (layer 1) = 3 points
2 red cubes stacked (layer 2) = 4 points (2 cubes × 2 points each)
1 red cube stacked (layer 3) = 3 points (1 cube × 3 points each)

Total Points = 10 points

4 red cube on red multiplier post = 5x total = 50 points

1 red cube on 1 piece of multiplier tower = 2x total = 100 points
1.6: Group Organizational Goal

1.6.1: 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.

1.6.2: 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.

1.7: Judged Scoring

1.7.1: Oral Presentation and supporting Material (200 points available)

Each team will have ten minutes to orally present their final solution to the Judges (“Client’’). They may bring additional support materials such as posters, sales brochures, lab notebooks, and the prototype robot to share with the judges.

Presentation Quality
A successful oral presentation will demonstrate that:

• Both team members participate in presentation.
• Problem description - What does the customer want or specify?
• Inspiration for robotic device design - What prompted the design?
• Evolution of design - What design changes were necessary?
• Problems - What significant problems were encountered & resolved?
• What are the advantages of the design being presented?
• Summary - What are the final design features?
• Subject matter is well organized.
• Objective of presentation is clear to customer.

Support Materials
A successful oral presentation also has the following attributes:

• Slides or View graphs which are clear, concise and easily understood.
• Bill of Materials that lists the cost & materials for the prototype.
• Programming documentation that includes a program flow chart for review.

Note: A projector and screen will be available but teams must supply their own laptops for their presentation. Bring power cords and any cables you might need to plug into “typical” projector.

1.7.2: Engineering Notebook attributes (200 points available)

Note: The Engineering Notebook will be submitted for judging prior to the assembly portion of the event. Bring your engineering notebooks to the Orientation session prior to the contest.

Overall Appearance and Professionalism:
The Engineering Notebook will be judged on format, organization, and presentation. For information on formatting and content of an engineering notebook, visit http://www.bookfactory.com/special_info/engr_notebook_guidelines.html.
**Bill of Materials:**
Each team will be required to list all of the materials used on their robot. The type, quantity and cost of each part should be provided.

**Assembly Instructions:**
Teams are encouraged to create detailed assembly instructions for their robot prior to arriving at the competition.

**Illustrations of Design Process:**
Teams are encouraged to include pictures and sketches of their design process in their Engineering Notebook.

**Printed Program for Robot:**
Teams should print their code and include it in the Engineering Notebook. This program should follow the team’s flow chart. This does not need to be the final robot program; however, teams are encouraged to make their program as complete as possible ahead of time to maximize their score.

**Program Flow Chart:**
Teams are encouraged to include a flow-chart of their robot’s program. This chart does not require actual portions of code, but should be a general overview of how the program flows. For more information on proper flow-chart technique, visit [http://en.wikipedia.org/wiki/Flow_chart](http://en.wikipedia.org/wiki/Flow_chart).

### 1.8: Required Materials

#### 1.8.1: Required Components and Supplies

Teams require the following materials to complete the competition.

**1.8.1.1: Technical Committee-Provided Components**

The Technical Committee will provide:
1. Design Challenge competition field and scoring objects.
2. General workspace for teams to cut materials along with a vise and hacksaw.
3. One eight foot conference table.
4. One standard 120V electrical outlet.
5. The description of the Mobile Robotic Design challenge.
5. A printer.

**1.8.2: Team Provided Components**

Teams may bring a small tool box along with the following components:
1. Engineering Notebook.
2. Safety glasses and work gloves.
3. Dremel (or similar) rotary tool with appropriate attachments.
4. Drill and drill bits.
5. Allen wrench set (English).
6. Aircraft metal snippers for cutting VEX metal.
7. A laptop equipped with licensed VEX programming software (for the Cortex microcontroller) and suitable presentation software (such as Microsoft’s PowerPoint). An additional tablet device is allowed for presentations.
8. Power strip and extension cord.
9. Calculator (standard, scientific or graphing).
10. Tape measure and/or ruler.
11. Hammer.
13. Metal File.
15. Graph paper, pens, pencils, tape, electrical tape, markers and scissors.
17. Replacement batteries and chargers - All 7.2V robot batteries must be made by VEX Robotics. 9V and AAA can be manufactured by any vendor.
18. Grease or graphite (non-aerosol).
19. VEX competition switch simulator.
20. Empty small parts bin or storage container.

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

2.1: 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 Mobile Robotics Competition judging to simulate a professional industrial environment.

2.2: 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 50 points deducted from their total score.

3rd Violation:
Team will be disqualified.

2.3: 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 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. Team members must wear safety glasses when they are on the playing field and while they are in their work area.

4. 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.
3.0: Documentation

3.1: Document Submission

The following documentation will be judged at the Competition.
  • Engineering Notebook
  • Math Problem
## SKILLSUSA
### Mobile Robotics
Judging Form 2014

<table>
<thead>
<tr>
<th></th>
<th>MAXIMUM POINTS</th>
<th>CHECK</th>
<th>POINTS AWARDED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oral Presentation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Presentation Quality</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Presentation Support Materials</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Presentation Subtotal</strong></td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Engineering Notebook</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Overall Appearance and Professionalism</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Bill of Materials</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Assembly Instructions</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Illustrations of Design Process</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Program Flow Chart</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Printed Program for Robot</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Engineering Notebook Subtotal</strong></td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Robotic Task Performance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Round 1 and 2 Score</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Robotic Design Challenge Performance Subtotal</strong></td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Concurrent Engineering and Area Organization</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Round 3 and 4 Score</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Area Clean and Organized</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Concurrent Engineering Performance Subtotal</strong></td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Math Problem</strong></td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety (deductions)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td>1000 pts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix A – SkillsUSA VEX Robotics Kit Bill of Materials

This year’s kit will be the VEX Classroom & Competition Super Kit P/N 276-3000

*Note: The kit comes with (1) 7.2V 3000 mAh battery and six AAA batteries as well as their respective chargers.*

Teams may bring additional batteries and chargers to the competition; however, the batteries and chargers must be made by VEX to guarantee consistency and to level the playing field.

<table>
<thead>
<tr>
<th>Logic</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)VEX Cortex Microcontroller</td>
<td>(8)Bar, 25-hole</td>
</tr>
<tr>
<td>(1)USB A-A Tether Cable</td>
<td>(2)Bar, 20-hole</td>
</tr>
<tr>
<td>(6)Motor Controller 29</td>
<td>(2)Chassis Bumper (25-hole)</td>
</tr>
<tr>
<td></td>
<td>(2)Chassis Bumper (20-hole)</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>(4)Chassis Rail (25-hole)</td>
</tr>
<tr>
<td>(1)VEXnet Joystick</td>
<td>(4)Chassis Rail (16-hole)</td>
</tr>
<tr>
<td>(2)VEXnet USB Adapter Key</td>
<td>(4)C-Channel, 1x2x1x15 hole</td>
</tr>
<tr>
<td>(1)LED Indicator Pack</td>
<td>(1)C-Channel, 1x2x1x20 hole</td>
</tr>
<tr>
<td>(3)Cable, VEX &quot;Y&quot;</td>
<td>(2)C-Channel, 1x2x1x25 holes</td>
</tr>
<tr>
<td>(3)Cable, 3-Wire Extension, 6&quot;</td>
<td>(2)C-Channel, 1x5x1x25 holes</td>
</tr>
<tr>
<td>(3)Cable, 3-Wire Extension, 12&quot;</td>
<td>(2)Plate 5x5 holes</td>
</tr>
<tr>
<td>(1)Cable, 3-Wire Extension, 24&quot;</td>
<td>(2)Plate 5x15 holes</td>
</tr>
<tr>
<td>(1)Cable, 3-Wire Extension, 36&quot;</td>
<td>(2)Plate 5x25 holes</td>
</tr>
<tr>
<td></td>
<td>(2)Angle, Slotted 30 holes Inverse</td>
</tr>
<tr>
<td><strong>Sensors</strong></td>
<td>(2)Angle, Slotted 30 holes</td>
</tr>
<tr>
<td>(2)Bumper Switch (2-pack)</td>
<td>(2)Angle, Segmented 25 holes</td>
</tr>
<tr>
<td>(2)Limit Switch (2-pack)</td>
<td>(4)Gusset, Pivot</td>
</tr>
<tr>
<td>(1)Motor 393 Integrated Motor Encoder (2-pack)</td>
<td>(4)Gusset, Angle</td>
</tr>
<tr>
<td>(1)Potentiometer (2-pack)</td>
<td>(4)Gusset, Plus</td>
</tr>
<tr>
<td>(1)Line Tracker (kit)</td>
<td>(10)Standoff 1/2in</td>
</tr>
<tr>
<td>(1)Ultrasonic Range Finder</td>
<td>(8)Standoff 1in</td>
</tr>
<tr>
<td>(1)Optical Shaft Encoder (2-pack)</td>
<td>(4)Standoff 2in</td>
</tr>
<tr>
<td></td>
<td>(4)Standoff 3in</td>
</tr>
<tr>
<td><strong>Motion</strong></td>
<td>(102)Screw, 8-32 x 1/4&quot; Long</td>
</tr>
<tr>
<td>(7)2-Wire Motor 393</td>
<td>(42)Screw, 8-32 x 1/2&quot; Long</td>
</tr>
<tr>
<td>(1)Claw Kit Assembly</td>
<td>(28)Screw 8-32 x 3/8&quot;</td>
</tr>
<tr>
<td>(4)Shaft Coupler</td>
<td>(14)Screw 8-32 x 3/4&quot;</td>
</tr>
<tr>
<td>(37)Shaft Collar</td>
<td>(3)Screw, 8-32 x 1 1/2&quot; Long</td>
</tr>
<tr>
<td>(12)Shaft, 3&quot; Long</td>
<td>(10)Screw 6-32 x 1/4in</td>
</tr>
<tr>
<td>(4)Shaft 11mm long</td>
<td>(10)Screw 6-32 x 1/2in</td>
</tr>
<tr>
<td>(4)Shaft 2&quot; long</td>
<td>(6)Locking Screw, 6-32 x 1/4&quot; Long</td>
</tr>
<tr>
<td>Part</td>
<td>Quantity</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>(2) Shaft 4&quot; long</td>
<td></td>
</tr>
<tr>
<td>(4) Shaft 12&quot; long</td>
<td></td>
</tr>
<tr>
<td>(44) Bearing Flat</td>
<td></td>
</tr>
<tr>
<td>(6) Bearing, Pillow Block</td>
<td></td>
</tr>
<tr>
<td>(4) Lock Plate, Plastic</td>
<td></td>
</tr>
<tr>
<td>(6) Spur Gear, 12-tooth</td>
<td></td>
</tr>
<tr>
<td>(4) Spur Gear, 36 tooth</td>
<td></td>
</tr>
<tr>
<td>(10) Spur Gear, 60-tooth</td>
<td></td>
</tr>
<tr>
<td>(4) Spur Gear, 84-tooth</td>
<td></td>
</tr>
<tr>
<td>(20) Rack Gear, 19-tooth</td>
<td></td>
</tr>
<tr>
<td>(4) High Strength 12-tooth Gear</td>
<td></td>
</tr>
<tr>
<td>(4) High Strength 36-tooth Gear</td>
<td></td>
</tr>
<tr>
<td>(4) High Strength 60-tooth Gear</td>
<td></td>
</tr>
<tr>
<td>(16) High Strength Square Gear Insert</td>
<td></td>
</tr>
<tr>
<td>(16) Free Spinning Gear Insert</td>
<td></td>
</tr>
<tr>
<td>(4) Intake Roller</td>
<td></td>
</tr>
<tr>
<td>(1) 2.75&quot; Wheel (4-pack)</td>
<td></td>
</tr>
<tr>
<td>(4) 4&quot; Wheel</td>
<td></td>
</tr>
<tr>
<td>(2) 4&quot; Omni-Directional Wheel (2-pack)</td>
<td></td>
</tr>
<tr>
<td>(25) Tank Tread Traction links</td>
<td></td>
</tr>
<tr>
<td>(30) Conveyor-belt Base links</td>
<td></td>
</tr>
<tr>
<td>(10) Short Conveyor-belt inserts</td>
<td></td>
</tr>
<tr>
<td>(10) Medium Conveyor-belt inserts</td>
<td></td>
</tr>
<tr>
<td>(10) Tall Conveyor-belt inserts</td>
<td></td>
</tr>
<tr>
<td>(4) High Strength 6-tooth Sprocket</td>
<td></td>
</tr>
<tr>
<td>(2) High Strength 12-tooth Sprocket</td>
<td></td>
</tr>
<tr>
<td>(2) High Strength 18-tooth Sprocket</td>
<td></td>
</tr>
<tr>
<td>(2) High Strength 24-tooth Sprocket</td>
<td></td>
</tr>
<tr>
<td>(2) High Strength 30-tooth Sprocket</td>
<td></td>
</tr>
<tr>
<td>(280) High Strength Chain Links</td>
<td></td>
</tr>
<tr>
<td>(40) Chain Attachment Links</td>
<td></td>
</tr>
<tr>
<td>(2) 12&quot; Long Linear Slide Track</td>
<td></td>
</tr>
<tr>
<td>(2) 17.5&quot; Long Linear Slide Track</td>
<td></td>
</tr>
<tr>
<td>(2) Rack Bracket</td>
<td></td>
</tr>
<tr>
<td>(4) Inner Delrin Slide Truck</td>
<td></td>
</tr>
<tr>
<td>(4) Outer Delrin Slide Truck</td>
<td></td>
</tr>
<tr>
<td>(6) Locking Screw, 6-32 x 1/2&quot; Long</td>
<td></td>
</tr>
<tr>
<td>(172) Nut, 8-32 Keps</td>
<td></td>
</tr>
<tr>
<td>(28) Nut, Nylock 8-32</td>
<td></td>
</tr>
<tr>
<td>(30) Washer, Steel</td>
<td></td>
</tr>
<tr>
<td>(26) Shaft Spacer, Thin (4.6mm)</td>
<td></td>
</tr>
<tr>
<td>(20) Shaft Spacer, Thick 8mm</td>
<td></td>
</tr>
<tr>
<td>(50) 4&quot; Tie Wraps</td>
<td></td>
</tr>
<tr>
<td>(1) Latex Tubing (10')</td>
<td></td>
</tr>
<tr>
<td>(1) Rubber Band (20-pack)</td>
<td></td>
</tr>
<tr>
<td>(1) Hinge (2-pack)</td>
<td></td>
</tr>
<tr>
<td>(1) 7.2V Robot Battery NiMH 3000mAh</td>
<td></td>
</tr>
<tr>
<td>(1) AAA NiMH Rechargeable Battery 6-pack</td>
<td></td>
</tr>
<tr>
<td>(1) Smart Charger</td>
<td></td>
</tr>
<tr>
<td>(1) Smart Charger Power Cord</td>
<td></td>
</tr>
<tr>
<td>(1) 8-Bay AA/AAA Smart Battery Charger</td>
<td></td>
</tr>
<tr>
<td>(1) VEXnet Backup Battery Holder</td>
<td></td>
</tr>
<tr>
<td>(2) Tool, Allen Wrench Small (5/64&quot;)</td>
<td></td>
</tr>
<tr>
<td>(2) Tool, Allen Wrench Large (3/32&quot;)</td>
<td></td>
</tr>
<tr>
<td>(2) Tool, VEX Open-Ended Wrench</td>
<td></td>
</tr>
</tbody>
</table>
Appendix B – Field Information

Field Pictures

- The lines are made from 3/4” wide white electrical tape.
- One vertical white line runs from the center of the blue and red scoring tiles and stretched four feet to the center of the playing field.
- An eight foot white line runs horizontally across the center of the field.
- Four vertical white lines run from the center of the two end rows of cubes to the eight foot horizontal center line.

Isometric View
The Red Cubes and Blue Cubes are placed on the field as shown prior to each match.

- There are (6x) red cubes placed in a vertical row, the center line of the cube is 24” from the left edge of the playing field.
- There are (6x) blue cubes placed in a vertical row, the center line of the cube is 24” from the right edge of the playing field.
- There are (6x) cubes placed in a vertical row, the center line of the cube is 48” from the left edge of the playing field. The three cubes closest to the back wall of the field are blue, the three cubes closest to the center of the playing field are red.
- There are (6x) cubes placed in a vertical row, the center line of the cube is 48” from the right edge of the playing field. The three cubes closest to the back wall of the field are red, the three cubes closest to the center of the playing field are blue.
- There are (6x) cubes placed in a vertical row, the center line of the cube is 7” to the left of the horizontal center line of the playing field. The cubes alternate in color starting with a blue cube closest to the back wall of the field.
- There are (6x) cubes placed in a vertical row, the center line of the cube is 7” to the right of the horizontal center line of the playing field. The cubes alternate in color starting with a red cube closest to the back wall of the field.
Game Pieces

Blue and Red Cubes

There are 36 cubes placed on the field. 18 are red and 18 are blue and dimensions may vary by as much as 1/8”. Cubes are hollow plastic and weigh approximately 1.125 pounds each.

Note: As described above, Game Objects may vary in size; teams need to accommodate this in their designs. It is always a good practice to develop mechanisms capable of adapting to this potential variance.
FIELD SETUP – Scoring Zones

The Red and Blue floor tiles are mounted to the right and left center line of the playing field. A total of four, two foot tall towers are mounted using upper and lower collars two feet from the field corner in both horizontal and vertical directions. The tower base is mounted four feet from the scoring zone wall and two feet from the horizontal wall.
A row of six red cubes are placed in a vertical row, the center line of the cube is two feet from the left edge of the playing field. A second row of six cubes (three red and three blue) are placed in a vertical row, the center line of the cube is four feet from the left edge of the playing field. A third row of six cubes (alternating in color) are placed in a vertical row, the center line of the cube is 7” from the center line of the playing field.

A row of six blue cubes are placed in a vertical row, the center line of the cube is two feet from the right edge of the playing field. A second row of six cubes (three blue and three red) are placed in a vertical row, the center line of the cube is four feet from the right edge of the playing field. A third row of six cubes (alternating in color) are placed in a vertical row, the center line of the cube is 7” from the center line of the playing field.
FIELD SETUP – Tower locations

Two tower pieces are mounted on both the right and left side walls of the playing field. Collars are mounted at the two foot collar mounting holes and five foot mounting holes measured from the corner of the field. Five tower pieces are mounted on the back wall of the playing field. Collars are mounted at the one foot, three foot, six foot, nine foot and eleven foot mounting holes (measured from the left corner).
Appendix C – State Competitions

Some State SkillsUSA competitions are held in smaller venues and are typically only four hours long. Because of this, the state director and his or her technical committee may choose to substitute or change the Mobile Robotics challenge in a variety of ways. It is up to the state to determine the how they would like to change the contest to better suit their needs. Here are some suggestions:

- Omit the math problem.
- Omit an engineering change order.
- Increase the number of rounds per team.
- Omit the assembly period (allow teams to bring pre-assembled and ready to compete robots to the event).
- Modify the competition scoring matrix or BOM to align with other changes for their state.

Please check with your SkillsUSA State Director and the associated Technical Committee for information regarding any modifications to the event as described in this document. State Competitions are allowed to modify the rules of this competition to fit their specific state requirements.

For more information on how to run or find resources for a Mobile Robotics Competition in your state, please contact the Mobile Robotics National Technical Chair, Trevor Pope at Tpope@Intelitek.com.