

2019 TECH THEME: LIVABLE CITIES

TECH TEAMS ARE CHALLENGED TO BUILD ROBOTS THAT TRANSPORT PUBLIC INFRASTRUCTURE, ASSIST AT JOB TRAINING CENTERS AND MANAGE CITY WASTE.

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TECH LEAGUE 2019 CHALLENGE REVIEW

GRADES: 4 – 8 AGE: 11 – 15 YEARS

ROBOT KIT: VEX IQ SUPER KIT

INTRODUCTION

As individuals looking for social mobility move from rural areas to cities, there is an increase of unemployment, lack of education, informal economy, and poverty. When these are added to poor city planning and politics, slums eventually form. That's when your team comes in - TECH teams are tasked to design and build robots to solve two important challenges rising from urbanization: urban development and waste management.

TERMINOLOGY

Urban Development is a comprehensive term we've used for creating cities that plan for efficient land-use, promotes the conservation of agriculture land, invests in public services infrastructure and support economic development initiatives. In this challenge, robots execute the city land-use & zoning plan and help train employees at a vertical farming center.

Waste management is the collection, transportation, and disposal of garbage, sewage and other waste products. Cities without proper waste management usually experience a high rate of disease and slum formation. Team robots are tasked to execute the city's waste management plan.

CAREERS

Urban planning is a difficult and complex challenge which requires expertise from many fields working together: designers, architect, engineers, sanitary and health workers, law makers and other public service personnel.

TECH LEAGUE GAME OVERVIEW

In the level-one tabletop, Tech teams are tasked to build robots that autonomously execute the city's land-use & zoning plan and aid in the vertical farming job training center. The more tasks the robot accomplishes the more points the teams earns.

This year PARC has introduced a two-level playing field. The robot must use the elevator to travel to the level-two tabletop where students use their remote control to guide the robot in executing the city's waste management plan. This includes separating the waste from the recyclables and transporting each to their assigned locations.

LEVEL 1: URBAN DEVELOPMENT

Objective 1: Move the infrastructures (hospital) from the construction site to the appropriate installation zones in the city

Objective 2: Pickup and plant crops on the designated space on the vertical farm at the job training center

LEVEL 2: WASTE MANAGEMENT

Objective 3: Sort the garbage, waste vs plastic recyclables

Objective 4: Transport trash to the Waste Management Facility

Objective 5: Transport plastic to the Recycling Center

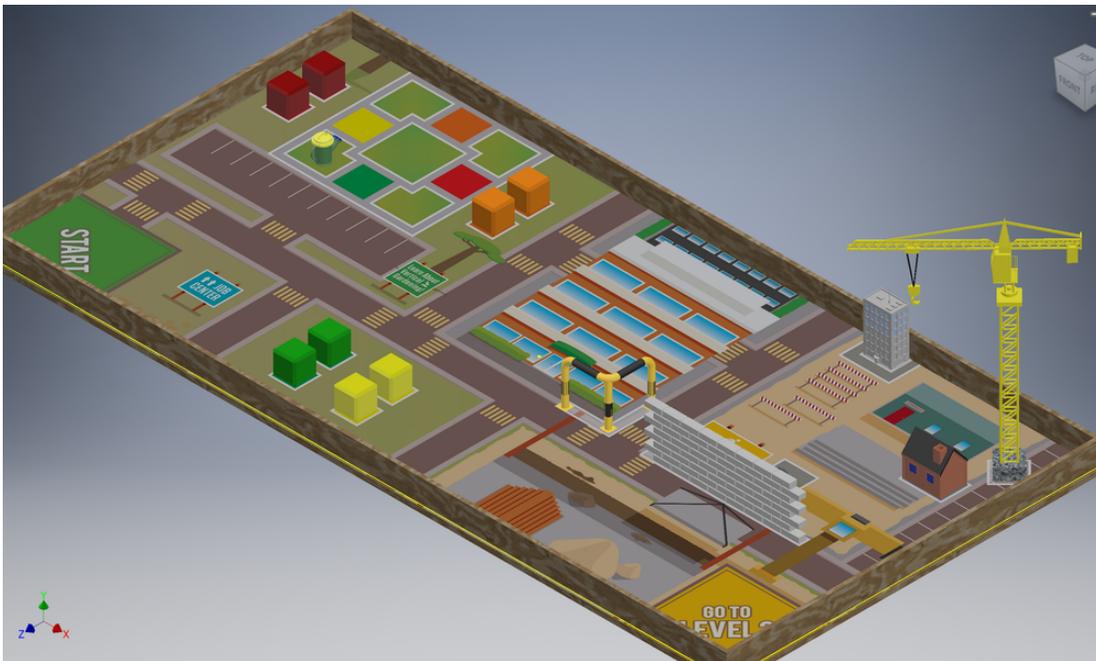
LEVEL 1: URBAN DEVELOPMENT SCORING

Objective 1: Robots are tasked with autonomously transporting infrastructure from a predefined area on the playing field and placing them into its assigned location.

- The hospital placed in the correct location - 25pts

Objective 2: Robots are tasked with autonomously picking up crops (colored cubes) from the predefined area on the playing field and placing them onto the vertical garden, making sure to match the correct colors.

- There is no limit on the number of crops a robot can carry at one time.
- There is no minimum or maximum number of crops that must be placed on vertical garden.
- Each crop placed on the vertical garden - 25pts
- Teams receive an extra 100 points for successfully placing and matching all crops onto the vertical garden.

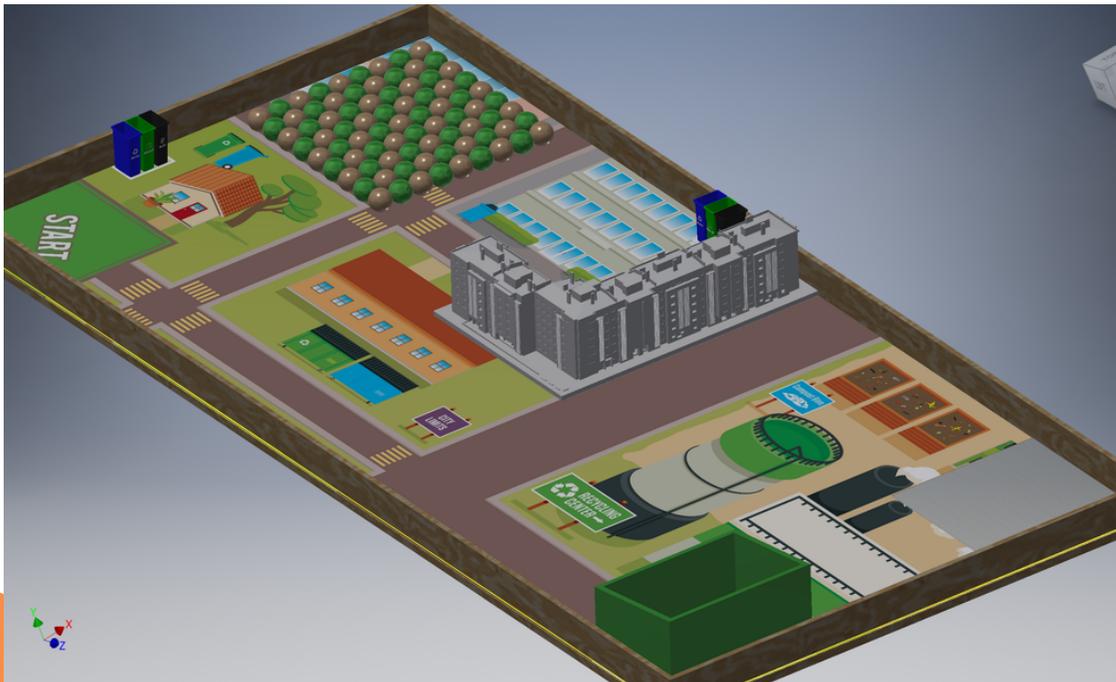


Level-one playing field

LEVEL 2: WASTE MANAGEMENT SCORING

Objectives 3, 4, 5: Teams must guide their robot using a remote control to sort waste from the landfill and transport them to their appropriate locations.

- Waste pieces (trash & recyclables) must be picked up from predefined area in playing field.
- Depending on color, waste pieces must be sorted into the green recycling container or into the waste management zone which is a hole in the corner of the playing field with a net at the bottom to catch the waste pieces.
- There is no limit on the number of waste pieces a robot can carry at one time.
- There is no minimum or maximum number of waste pieces that must be placed in their appropriate locations.
- Total number of waste pieces is 30 combined.
- Each trash piece transported to the Waste Management zone is worth 10 pts
- Each recyclable piece transported to the Recycling Center bin is worth 15 pts



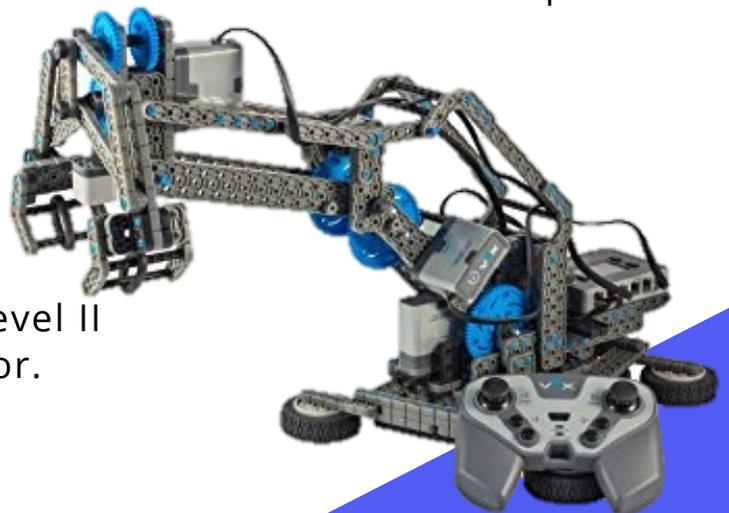
Level-two Playing Field

GAME PLAY

- Level I is autonomous
- Level II is remote controlled
- Robot must start in the Start Box
- All objectives can be carried out in any order
- Once on level II, robot cannot be brought back to level 1
- The total length (all levels combined) of the game is 2.5 minutes
- Each team will have two trials, the best of the two trials will be counted as final score. In the case of a tie, first trial scores will be used.

GENERAL RULES

- Starting robot configuration must be within a 30x30x30cm box but can extend outside of that after the start of the match.
- No part of the robot can extend outside the starting box before the match begins.
- Robot must be completely inside and stopped on the orange elevator area in order to move on to the next level.
- 10 point penalty for touching your robot outside of the starting zone or elevator, penalty increases by 5 points for each additional touch.
- No penalty for touching robot while it is in starting base or on the elevator.
- There is no limit on the number of times a robot goes back and forth from the starting base to start over. The time does not pause.
- You can change attachments on robot while in starting base or elevator.
- Once on elevator, teams can pick-up robots to place them on the level II starting base.
- 25 point penalty for moving to Level II while robot is outside the elevator.



TECH LEAGUE GAME DEFINITIONS

TECH GAME DEFINITIONS

Level Field - 4 x 8 feet
(~1.2 x 2.4 meters)

Start box - Base from where robot starts

Orange box - Elevator to next Level

Red Crop - Tomato,
3 x 3 in (~7.6 x 7.6 cm)

Yellow Crop - Corn,
3 x 3 in (~7.6 x 7.6 cm)

Orange Crop - Carrot,
3 x 3 in (~7.6 x 7.6 cm)

Green Crop - Lettuce,
3 x 3 in (~7.6 x 7.6 cm)

Green Sphere - Plastic waste, 2 in (~5 cm) in diameter

Brown Sphere - Other trash waste, 2 in (~5 cm) in diameter

Large green bin - Recycling Center

Brown square - Waste Management Zone

VEX IQ Super Kit: \$330 USD
Provided by PARC.

Level table (optional): ~ \$50 USD
Not provided by PARC.

Teams can make any variations of Robot however must only use pieces in the VEX IQ Super Kit.

Robot kits are shipped to teams by PARC free of charge. Teams may print and construct their own practice playing field. Level mats and game elements can be downloaded online from PARC website.

Teams may use any programming language to code robot, VEX & MathWorks are provided for free.



2019 STARS THEME: RESILIENT CITIES

STAR TEAMS ARE CHALLENGED TO BUILD A ROBOT THAT ASSEMBLES THE CITY PIPELINE, THEN TRANSFER WATER TO THE DRAIN TO BE SENT TO THE PUMP STATION.

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STARS LEAGUE 2019 CHALLENGE REVIEW

GRADES: 9 – 12 AGE: 15 – 19 YEARS

ROBOT KIT: VEX V5 SUPER KIT

INTRODUCTION

Resilience is about surviving and thriving, regardless of the challenges. 100 Resilient Cities—Pioneered by The Rockefeller Foundation (100RC) is dedicated to helping cities around the world become more resilient to the physical, social and economic challenges that are a growing part of the 21st century. One such challenge is flooding. African cities are often scenes of large scale flooding which have devastating impact on city mobility, health, and economy.

STAR teams are tasked to build robots to prevent and manage flooding in African Cities.

TERMINOLOGY

Flood management and prevention is a term we've used to describe the efforts of reducing, mitigating, and ideally eliminating, excess flooding. There are numerous techniques used to prevent and manage flooding including the use of pipelines, drains and pump stations to redirect water. Successful flood management practices helps to protect lives, property, and contributes to a prosperous, resilient city.

CAREERS

There are many personnel involved in the prevention and management of flooding including public officials that invest in prevention equipment and disaster relief, the scientist and engineers that build the infrastructure and technology, weather experts, emergency responders, restoration specialists, and more.

STAR LEAGUE GAME OVERVIEW

Star teams are tasked with building remote controlled robots that help manage and prevent flooding.

In the first task, robots must work together to complete the city pipeline. Pipes are color coordinator and teams may only work with their assigned color. Robots must pick up and transport the pipes from the pipe holder into their assigned troughs to assemble the pipeline.

In the second task, city workers release water droplets and the robots play against each other to bring the water droplets to the city workers. Water droplets are colored and teams may only work with their assigned color. Water droplet that has been delivered to the city worker from the floor goal line will be available to be thrown by city workers into the pump station.

GAME OBJECTIVES

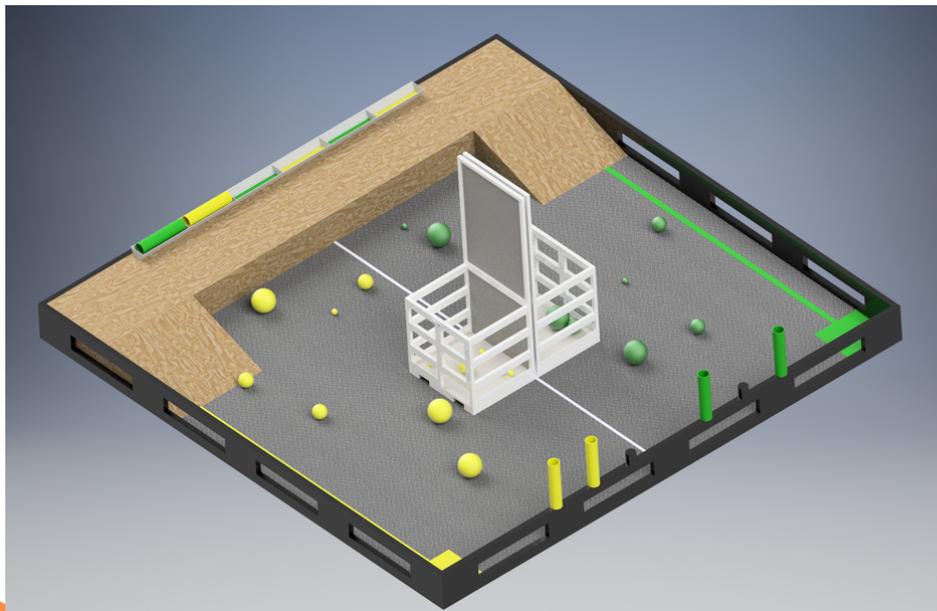
Objective 1: Transport and assemble PVC pipeline for redirecting rainwater to city canals and flood ways.

Objective 2: Drain floodwater from the city to be transferred by city workers into the pump stations.



FIELD SPECIFICATIONS

- Teams may print and construct their own practice playing field.
- PVC pipe sections: 18in (~46cm) long and have a 4in (~10cm) outer diameter and 3.5in (~8cm) dia inner diameter
- Field Perimeter: 16ft (~5m) long, 16ft (~5m) wide, 1ft (~0.3m) tall. The entire playing field is resting on a stage that is 2ft (~0.6m)
- Floor Material: Short pile carpet.
- Pipe Holder: 4in (~10cm) cylinder that is 3in (~7.6cm) in diameter that stick up from the playing field that holds the pipe sections in the beginning of the game.
- Flood Water Releases: Square where students can place flood water on the field from a bucket
- Troughs: 22in (~56cm) trough, 1ft (~0.30m) off the ground that extends across the field for robots to place and assemble the pipeline.
- Floor Goal line: 6in (~15cm) away from the field perimeter.
- Pump Station: 3ft (~1m) tall x 3.5ft (~1m) wide x 4ft (~1.2m) long with a backboard
- Stage: 16ft (~5m) long, 30in (~76cm) wide, 1ft (~0.3m) tall.
- Ramp: 3ft (~0.9m) long, 33in (~84cm) wide, 1ft (~0.3m) tall.



PIPELINE ASSEMBLY SCORING

- The premise of this challenge is for robots to assemble a pipeline.
- Robots must transport their pipe section into the correct colored trough to receive points.
- The penalty for placing a pipe in your opponents trough is that your opponent receives the points.
- 1st Pipe Section – 50pts, 2nd Pipe Section – 100pts, 3rd Pipe Section – 150pts. Points are cumulative, 300 pts available.
- Robots may carry only one pipe section at a time.
- Teams are responsible for 3 pipe sections each, for a total of 6.
- If all pipe sections are delivered correctly, both teams receive a 1.25pts multiplier to their individual scores, which is then rounded to the nearest whole number.

FLOOD WATER CLEAN-UP SCORING

- The premise of this challenge is for robots to drop water droplets (sphere balls) into their assigned drain so that the city workers (students) can pick up the drops and toss them into the pump station located in the middle of the field.
- Points are only received if the water droplets are successfully tossed into the pump station by the city worker.
- Penalty for robot crossing the floor goal line to toss the water droplet out of the field perimeter: team loses 15% of their final score. Additional 2% is lost every time it happens.
- Penalty for robot tossing an opponent's water droplet outside the field perimeter is: your opponent receives the points.
- Penalty for scoring a water droplet in your opponent's pumping station is: your opponent receives the points.
- 2in (~5cm) diameter Water droplet ball (40 possible per team) – 5pts
- 5in (~13cm) diameter Water droplet ball (25 possible per team) – 8pts
- 8in (~20cm) diameter Water droplet ball (10 possible per team) – 10pts
- There no limitations on the number of water droplets (balls) that a teams can carry and control.
- The water droplets can be released by city workers at any time even if the pipeline is not assembled.

GAME PLAN

- The pipeline assembly and flood water clean-up happens in the same match, and each match lasts 2 minutes.
- Each match has 2 teams playing at the same time.
- Teams will have 5 matches playing against different teams.
- Robot must start by touching the field wall and its corresponding colored box, and fit within a 50x50x50 cm box at the beginning of the game, but can expand after.
- After the start of the match teams work to score as many point as possible by completing as many of the tasks as possible.
- Contact between robots is allowed however intentionally damaging another robot is not allowed. This distinction is left to the referee. The penalty is disqualification.
- A teams overall ranking is determined by the average score throughout these matches.

GENERAL RULES

- Robots must be constructed out of the kit materials provided.
- Robots must fit inside a 18in (~46cm) cube to start the match.
- Robots must be constructed with safety in mind; no sharp edges, no dangerous components, nothing designed to intentionally damage other robots or field elements.
- There can be up to 6 students on the field at a time: **1-2 drivers** – driving the robot, **1 strategist** – giving strategy information to the driver(s), **1-3 city workers** – releasing the water droplet balls, tossing the droplet balls into the pump stations.
- If teams do not follow the rules, they are disqualified from the game.

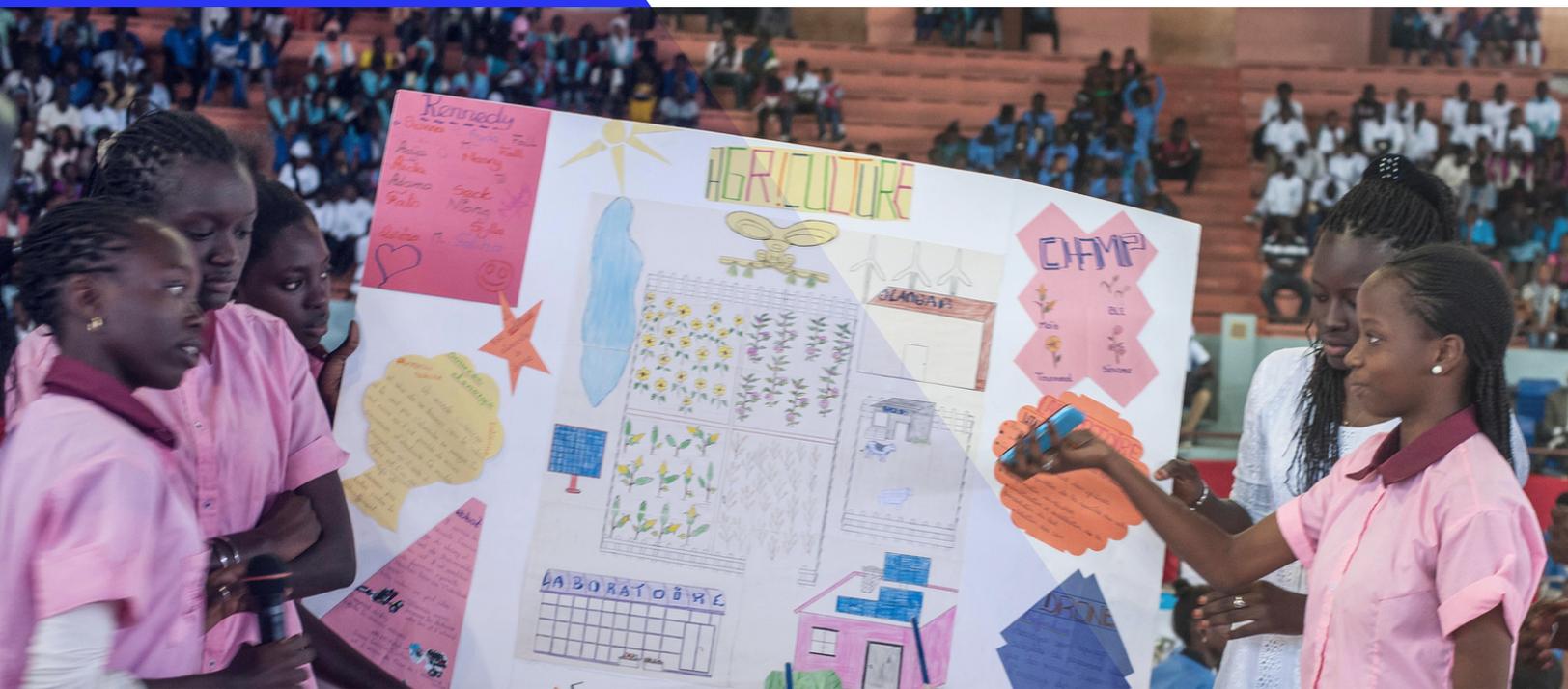
Robot kits are shipped to teams by PARC free of charge. Teams may use any programming language to code robot, VEX & MathWorks are provided for free.

2019 MAKERS THEME: HEALTHY CITIES

MAKERS TEAMS ARE CHALLENGED TO DESIGN, BUILD & PRESENT A TABLE-TOP SCALE MODEL OF A "HEALTHY CITY" THAT IMPROVES THE HEALTH AND WELL-BEING OF CITY DWELLERS.

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MAKERS LEAGUE 2019 CHALLENGE REVIEW

GRADES: 9 – 12

AGE: 15 – 19 YEARS

OPEN CHALLENGE

INTRODUCTION

Urban health in African cities is increasingly challenging. Cities often put human health at risk from air pollution, water contamination and other health hazards. Lack of access to health care services and problems related to cities' sedentary lifestyle such as obesity are also problematic. Future African cities must be designed with people at the forefront - offering places where we can live well and be healthy.

MAKERS teams are challenged to use their technical skills and imagination to conceptualize and build a tabletop scale model of a "Healthy City". Their model must be a solution that elevate the well-being of city dwellers through improved living conditions or better health services. Along with developing skills in researching, brainstorming and problem solving - teams learn to deliver clear, concise and effective oral and visual presentations.

2019 MAKERS CHALLENGE

This is an open-ended competition challenge, teams are invited to imagine the impossible today. Makers teams are encouraged to imagine the ideal city to live, work, and play. Think of some of the major factors which significantly influence our health such as air pollution, water supply, sanitation, nutrition, food safety, health services, housing conditions, working conditions, education, and lifestyles. Then design a city which solve one or more of these challenges.

Teams who chose to program a device as part of their model have the option of using the MathWorks sponsored software for free.

COMPETITION DELIVERABLES

- Design and build a tabletop scale model
- Create a poster (French or English)
- Deliver a 5-7 min presentation (French or English)
- Document your work into a portfolio using the Design Thinking Process (French or English)

Each team will be assigned a booth at the competition site in Accra, Ghana. Teams should be prepared present their project and answer questions from the judges.

DESIGN & BUILD A MODEL

Makers teams are tasked to build a model around their idea of a "Healthy City". The model is an artistic representation of the team's idea. The model does not have to be on all aspects of proposed solution, but could be on specific sub-components, e.g., low-carbon building, sewage network, digital connected health system, environmental protection, medical supply chain, drone delivery of healthcare, clean air, pollution, healthy air circulation, drinking water, street food vendors, noise, natural & green spaces, wetlands, river pollution, physical activity, senior care, obesity, stress, etc.

Teams must bring their model to the competition; therefore, make plans on how to transport your model on plane/car to PARC.

The model has some parameters that teams will need to follow.

- Model cannot be larger than 1.22 m in width, 2.44 m in length and 1.22 m in height.
- Model material cannot cost more than \$200 USD. Teams must provide a material expense list. Teams must estimate the value of any scrap and donated materials used.
- No restriction on materials used to build model, which could include electronics and moving parts.

Models cannot include any hazardous or illegal materials.

CREATE A POSTER

Makers teams will have the opportunity to show off their hard work and creativity by developing a poster. It is recommended to use a tri-fold poster but teams can use a standard poster board. Content of the poster can include information on:

- Team members
- Home country and/or city
- Your Future Healthy City Idea/Proposal
- Problems faced during the development of model
- Other items that the team wants to share

GIVE A PRESENTATION

Makers teams must deliver a 5-7 minutes presentation about their project. All team members are encouraged to have a speaking part during the presentation. Team members can use items such as their model or poster during the presentation. This is the team's moment to shine in front of hundreds of spectators and supporters... be creative and make the presentation exciting!



SUBMIT A PORTFOLIO

This year, Makers League must use the human-centered, design thinking process to solve their 2019 Challenge. Design Thinking is a structured problem solving process that will allow Maker teams to find an effective and meaningful solution to improve the health of city dwellers.

Teams must go through each phase of the Design Thinking Process (Empathy, Define, Ideate, Prototype, Test/Feedback) then create a summary portfolio.

Teams must submit an electronic copy of their portfolio to parcrobotics@senecole.com by June 15 and bring a physical copy to PARC. Every day that the submission is late, the team loses 1 point per day from their score.

Each phase of the Design Thinking Phase will receive a score of (5)- Exemplary, (4)- Competent, (3)- Developing, (2)- Marginal, (1)- Needs Major Support.

The portfolio should include an expense sheet documenting all costs related to the model. Expenses may not exceed \$200 USD. Teams should be prepared to answer questions about their portfolio from the judges.

HOW WILL TEAMS BE JUDGED?

Teams will be judged in each of the areas on a scale of 0-10:

- Model (idea, imagination, creativity, aesthetics, workmanship, within budget)
- Poster (content, aesthetic/organization)
- Presentation (content, clarity, team work)
- The Portfolio will be scored based on the Design Thinking Judging Rubric.

PORTFOLIO JUDGING RUBRIC

Maker Teams portfolio should include:

- Title of Project
- Team Member Names
- Summary of each phase in the Design Thinking Process (Empathy, Define, Ideate, Model, Test/Feedback)
- Reports must use a 12-point font, double spaced.
- Reports may be submitted in French or English.

Empathize	Define	Ideate	Table-Top Model	Test/Feedback
<p>Prompt: Learn about the audience whom you are designing.</p> <p>The team must explain their research technique (interviews, experiencing, observing, etc) to identify and define the emotions and concerns of the primary stakeholder(s). Team should display a deep understanding of the various viewpoints of the primary stakeholder(s).</p>	<p>Prompt: Construct a point of view that is based on user needs & insights.</p> <p>The team must analyze the information gathered in the Empathy phase and create a problem statement that defines the target user and their true need.</p>	<p>Prompt: Brainstorm and come up with creative solutions.</p> <p>The team must generate a high volume of ideas, teams may compare and group possible solutions. List of ideas should include innovative and non-traditional ideas. The final chosen design solution must be well justified and highly likely viable.</p>	<p>Prompt: Build a representation of one or more of your ideas to show to others.</p> <p>The team must clearly and fully describe their table-top model, with enough detail to assure that the problem statement identified in the Define phase has been addressed. The model should show great display of imagination, creativity, aesthetics and workmanship.</p>	<p>Prompt: Return to your original user group to test your ideas for feedback.</p> <p>The team must create a logical, well-developed plan to test the potential effectiveness of their design solution if they were to implement it in society.</p>

Each phase will be scored using the following rubric:

Score	Description
5 Points Exemplary	Strong evidence of meeting or exceeding the objectives. Strong evidence of meeting or exceeding expected effort. Response is compelling and specific, responding effectively to all parts of the prompt. Response is enriched by critical thinking, creativity, and insight.
4 Points Competent	Evidence suggests adequate meeting of objectives. Response is detailed and specific, responding to all parts of the prompt. Shows critical thinking, and/or creativity. Evidence suggests appropriate effort has been applied to this task.
3 Points Developing	Evidence suggests some objectives are met. Responds to all parts of the prompt but response lacks 1-2 important details. Shows some critical thinking and/or creativity. Evidence suggests some effort has been applied, but greater effort would have improved the response.
2 Points Marginal	Evidence suggests some partially met objectives. Responds to only part of the prompt. Response lacks detail. Minimal evidence of critical thinking and/or creativity. Evidence suggests minimal effort has been applied to this task.
1 Point Needs Major Support	Evidence suggests failure to meet desired objectives. Response is off topic or largely incomplete. No critical thinking or creativity evident. Evidence suggests no serious effort has been applied to this task.

2019 ENGINEERS THEME: MOBILE CITIES

ENGINEER TEAMS ARE CHALLENGED TO DESIGN, BUILD & PRESENT A FUNCTIONING PROTOTYPE OF A 4IR ENABLED SYSTEM THAT IMPROVES MOBILITY IN URBAN CITIES.

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ENGINEERS LEAGUE 2019 CHALLENGE REVIEW

GRADES: COLLEGE UNDERGRADUATES
OPEN CHALLENGE

INTRODUCTION

As cities grow and urban population rises, the transportation of good and people has become extremely complicated. In African cities- traffic congestion, road accidents, overcrowded buses, and lack of sidewalks, significantly hinder the mobility of goods and people. The Fourth Industrial Revolution (4IR) is changing the way in which cities provide services to their residents. 4IR is characterized by a fusion of technologies that is blurring the lines between the physical, digital / AI, and biological spheres, collectively referred to as cyber-physical systems.

ENGINEER Teams are challenged to use their engineering skills to design and prototype a 4IR enabled technology that provides the efficient mobility of people and good in African cities.

2019 CHALLENGE

PARC 2019 challenges Engineer teams to use their engineering skills to design and build a 4IR enabled system, device, machine, or software to improve the mobility of good and people in an urban environment. Think transit system and scheduling, public transportation, on-demand shuttles, driver-less vehicle, shared cars/bikes, flying cars, tunnel transport (e.g., Hyper-loop), smart traffic intersection lights, parking, electrical vehicle and bikes, pedestrian sidewalks, bike lanes, etc.. Then come up with a novel and innovative 4IR-Enabled solution. Remember to think BOLD.

COMPETITION DELIVERABLES

- Fully working prototype of solution
- 10 minute power-point presentation and an on-stage demonstration of prototype (French or English)
- Quad Chart Poster (French or English, template provided)
- Project Report: 15 - 20 pages (French or English)

Each team will be assigned a booth at the competition site in Accra, Ghana. Teams should be prepared to present their project and answer questions from the judges.

PROTOTYPE PARAMETERS

- Solution cannot be entirely off-the-shelf product; at minimum 50-60% of solution must be developed by team (e.g., 50-60% of effort needed for the development of solution).
- Prototype must be functioning and teams must give a demonstration.
- No limit on size or money spent to develop solution/prototype. Do keep in mind however that prototype needs to be transported to competition site in Accra, Ghana.
- Prototype must be safe to users and audience.
- On a scale of 0 -10, prototypes will be judged based on:
 - A. Solution/Product Need
 - B. Functionality
 - C. Innovation & Novelty
 - D. Aesthetic (note that this applies to both hardware and software if applicable)

Teams may use any programming language to code, the MathWorks sponsored software is provided for free.

POWER-POINT PRESENTATION

- Powerpoint presentations should be 10 minutes which includes time for question and answer.
- Suggestion is 8 minute presentation and 2 minutes of Q&A.
- Power-point presentations should include at minimum:
 - A. Introduction of team members
 - B. Background of problem
 - C. Explanation of team solution
 - D. On-stage demonstration of prototype
 - E. Explanation of the impact solution will have in the city
 - F. Explanation of how the solution is inspired by the 4IR

QUAD-CHART POSTER

- The Quad-Chart Poster serves as a summary of the team project.
- Teams should be prepared to bring their poster to the competition to be displayed at their team booth.
- Teams must use the following template to organize their poster:

	Engineering League Name of team members University or Organization	LOGO of Team
<u>Title of Solution / Project</u> Use graphic images or photographs to describe the problem and proposed solution / prototype. Use labels or descriptive text as needed for clarification.	<u>Operation & Implementation</u> Tell how solution works, explain how solution would be implemented in real-world application. Use images, graphics, and/or schematics for clarification.	
<u>Technical Approach</u> Specifically, describe the technologies used in developing the solution. Use bullet points if appropriate.	<u>Innovation</u> What's unique about the proposed solution?	

PROJECT REPORT

- Final Project report will be judged based on both style (i.e., writing, presentation, drawings) and content.
- Reports must be 15-20 pages long including the title page, images, graphs, and appendices if applicable.
- Reports must use a 12-point font, double spaced.
- Reports may be submitted in French or English.
- Teams must email an electronic copy of the report to parcrobotics@senecole.com by June 15, 2019 and bring a physical copy to PARC. For each day that the report is late, teams lose one point from their total score.
- Teams are encouraged to follow the following guideline for their report. (Descriptions of each guideline attached.)
- Scoring for the report will be based off the following:
 - A. Presentation and Justification of the Problem
 - B. Documentation and Analysis of Prior Solutions Attempts
 - C. Presentation and Justification of Solution Design Requirements
 - D. Design Concept Generation, Analysis, and Selection
 - E. Application of Engineering Principles and Practices
 - F. Consideration of Design Validity
 - G. Construction of a Testable Prototype
 - H. Prototype Testing and Data Collection Plan
 - I. Testing Data Collection and Analysis
 - J. Documentation of External Evaluation
 - K. Report is emailed to parcorbotics@senecole.com by due date

PROJECT REPORT JUDGING RUBRIC

Preview of the Judging Rubric - available for download at parcrobotics.org:

Element	5 Exemplary	4 Proficient	3 Competent	2 Apprentice	1 Novice	Score
A. Presentation and justification of the problem	The problem is clearly and objectively identified and defined with considerable detail; the justification of the problem highlights the concerns of primary stakeholders and is based on comprehensive, timely, and credible sources; it offers detail from which multiple measurable design requirements can be determined.	The problem is clearly and objectively identified and defined with some detail; the justification of the problem highlights the concerns of some primary stakeholders and is based on various timely and generally credible sources; it offers generally objective detail from which multiple measurable design requirements can be determined.	The problem is somewhat clear and objective; sometimes has detail though some information included as elaboration may be imprecise or general; justification of the problem highlights the concerns of a few primary stakeholders based on a few sources that are timely and credible; justification allow at least a few measurable design requirements to be determined.	The problem is somewhat clear and/or objectively defined with somewhat superficial and/or minimal detail; justification of the problem highlights concerns of only 1-2 primary stakeholders based on sources that are insufficient, outdated or of dubious credibility; enough detail to allow a few design requirements to be determined; however, they may not be measurable.	The identification and/or definition of the problem is unclear, unelaborated, and/or clearly subjective; any intended justification of the problem does not highlight the concerns of primary stakeholders and/or is based on sources that are overly general, outdated, and/or of dubious credibility; insufficient information for the determination of measurable design requirements.	
B. Documentation and analysis of prior solution attempts	Documentation of plausible prior attempts to solve the problem and/or related problems is drawn from a wide array of clearly identified and consistently credible sources; the analysis of past and current attempts to solve the problem—including both strengths and shortcomings—is consistently clear, detailed, and supported by relevant data.	Documentation of existing attempts to solve the problem and/or related problems is drawn from a variety of clearly identified and consistently credible sources; the analysis of past and current attempts to solve the problem—including both strengths and shortcomings—is clear and is generally detailed and supported by relevant data.	Documentation of existing attempts to solve the problem and/or related problems is drawn from several—but not varied—clearly identified and generally credible sources; the analysis of past and current attempts to solve the problem—including both strengths and shortcomings—is generally clear and contains some detail and relevant data.	Documentation of existing attempts to solve the problem and/or related problems is drawn from a limited number of sources; some may not be clearly identified and/or credible; the analysis of past and current attempts to solve the problem—including strengths and shortcomings—is overly general containing little detail relevant data.	Documentation of existing attempts to solve the problem and/or related problems is drawn from only 1-2 sources that may not be clearly identified and/or credible; the analysis of past and current attempts to solve the problem—including strengths and/or shortcomings—is vague and missing relevant details and/or supporting data.	
C. Presentation and justification of solution design requirements	Design requirements are listed and prioritized with clarity and detail; they are consistently objective, measurable, and would highly likely lead to a tangible and viable solution to the problem identified; there is evidence that requirements represent the needs of, and have been validated by, many if not all primary stakeholder groups.	Design requirements are listed and prioritized, generally clear and detailed, nearly always objective and measurable, and would likely lead to a tangible and viable solution to the problem identified; there is evidence that requirements represent the needs of, and have been validated by, several primary stakeholder groups.	Design requirements are listed and prioritized, generally clear and somewhat detailed; generally objective and measurable with the potential to lead to a tangible and viable solution to the problem identified; there is evidence that requirements represent the needs of, and have been validated by, at least a few primary stakeholder groups.	Design requirements are listed and prioritized, some/all may be incomplete and/or lack specificity; they are sometimes objective and/or measurable, it is not clear it will lead to a tangible and viable solution; there is evidence that the requirements represent the needs / have been validated by only one primary stakeholder group.	An attempt is made to list, format, and prioritize requirements, but these may be partial and/or overly general, making them insufficiently measurable to support a viable solution to the problem identified; there is no evidence that the requirements represent the needs of, or have been validated by, any primary stakeholder groups.	
D. Design concept generation, analysis, and selection	The process for generating and comparing possible design solutions was comprehensive, iterative and consistently defensible; design solution is highly likely viable, well justified with attention to all design requirements; plan of action has considerable merit, easily supporting the repetition and testing for effectiveness by others.	The process for generating and comparing possible design solutions was thorough, iterative, and generally defensible; design solution is likely viable; justified with attention to most if not all design requirements; the plan of action would support repetition and testing for effectiveness by others.	The process for generating and comparing possible design solutions was adequate and generally iterative and defensible; design solution is possibly viable explained with reference to at least some design requirements; the plan of action might not clearly or fully support repetition and testing for effectiveness by others.	The process for generating a possible design solution was partial or overly general and only somewhat iterative and/or defensible; design solution has issues with viability and was not sufficiently explained with reference to design requirements; there is insufficient detail to allow for testing for replication of results.	The process for generating a possible design solution was incomplete and was only minimally iterative and/or defensible; any attempted explanation for the design solution chosen lacked support related to design requirements and cannot be tested.	
E. Application of STEM principles and practices	The proposed solution is well-substantiated with STEM principles and practices applicable to nearly/all design requirements and functional claims; there is substantial evidence that the application has been reviewed by two or more experts or project mentors providing verification or detail necessary to inform a corrective response.	The proposed solution is generally substantiated with STEM principles and practices applicable to some design requirements and functional claims; there is some evidence that the application has been reviewed by at least two experts or project mentors providing verification or some detail necessary to inform a corrective response.	The proposed solution is partially substantiated with STEM principles and practices applicable to a few design requirements and functional claims; there is some evidence that the application has been reviewed by at least one expert or project mentor but there is no clear verification to inform a corrective response.	The proposed solution is minimally substantiated with STEM principles and practices applicable to a few design requirements and functional claims; there is minimal evidence that the application has been reviewed by at least one expert or project mentor but there is no evidence of verification to inform a corrective response.	The proposed solution is minimally substantiated with STEM principles or practices applicable to a few design requirements and functional claims; however, there is no evidence that the application has been reviewed by an expert qualified consultant or project mentor.	
F. Consideration of design viability	The proposed design was carefully reviewed based on several relevant extra-functional considerations; a judgment about design viability based on those considerations—the capacity of the proposed solution to address the problem—is clearly realistic and well supported with credible evidence.	The proposed design was adequately reviewed based on several relevant extra-functional considerations; a judgment about design viability based on those considerations—the capacity of the proposed solution to address the problem—is generally realistic and adequately supported with credible evidence.	The proposed design was partially reviewed based on one or two relevant extra-functional considerations; a judgment about design viability based on those considerations—the capacity of the proposed solution to address the problem—is only somewhat/sometimes realistic, partially supported with credible evidence.	The proposed design was superficially reviewed based on one or two relevant extra-functional considerations; a judgment about design viability based on those considerations—the capacity of the proposed solution to address the problem—is generally unrealistic and/or inadequately supported with credible evidence.	The proposed design was superficially reviewed based on one or two extra-functional considerations of marginal relevance; a judgment about design viability based on those considerations—the capacity of the proposed solution to address the problem—is generally unrealistic and/or not supported with any credible evidence.	
G. Construction of a testable prototype	The final prototype iteration is clearly and fully explained, with enough detail to assure that objective data on nearly/all design requirements could be determined; all attributes of the unique solution that can be tested or modeled mathematically are addressed; a well-supported justification is provided for items that require expert review.	The final prototype iteration is clearly and adequately explained, with enough detail to assure that objective data on many design requirements could be determined; most attributes of the unique solution that can be tested or modeled mathematically are addressed; general justification is provided for items that require expert review.	The final prototype iteration is clearly and adequately explained, with enough detail to assure that objective data on some design requirements could be determined; some attributes of the unique solution that can be tested or modeled mathematically are addressed; adequate justification is provided for items that require expert review.	The final prototype iteration is explained only somewhat clearly/ completely, with enough detail to assure that objective data on a few design requirements could be determined; few attributes of the solution can be tested or modeled mathematically are addressed; insufficient justification for items that require expert review.	The final prototype iteration is only minimally explained, with enough detail to assure that objective data on at least one design requirements could be determined; no more than one attribute of the solution that can be tested or modeled mathematically is addressed; justification for items that require expert review is missing.	
H. Prototype testing and data collection plan	The testing plan addresses nearly/ all of the high priority design requirements by effectively describing the conduct (physical and/or mathematical modeling) feasibility and providing a logical, well-developed explanation confirmed by one or more field experts of how testing would yield objective data regarding effectiveness of the design.	The testing plan addresses many of the high priority design requirements by generally describing the conduct (physical and/or mathematical modeling) feasibility and providing a logical, generally developed explanation confirmed by one or more field experts of how testing would yield objective data regarding effectiveness of the design.	The testing plan addresses some of the high priority design requirements by adequately describing the conduct (physical and/or mathematical modeling) feasibility and providing a logical, adequately developed explanation confirmed by one or more field experts of how testing would yield objective data regarding effectiveness of the design.	The testing plan addresses a few of the high priority design requirements by partially describing the conduct (physical and/or mathematical modeling) feasibility and providing a somewhat logical, partially developed explanation confirmed by one field expert of how testing would yield objective data regarding effectiveness of the design.	The testing plan addresses one of the high priority design requirements by describing at least minimally the conduct (physical and/or mathematical modeling) feasibility and/or providing a general logical and/or partially developed explanation (no expert input) of how testing would yield objective data regarding effectiveness of the design.	
I. Testing, data collection and analysis	Through the conduct of several tests for high priority requirements that are reasonable, physical or mathematical modeling; considerable understanding of testing procedure, including the gathering and analysis of resultant data; the analysis of the effectiveness with which the design met stated goals; consistently detailed explanation of the data from each portion of the testing procedure and from expert reviews, generally supported by pictures, graphs, charts and other visuals; overall summary of the implications of all data for proceeding with the design and solving the problem.	Through the conduct of several tests for high priority requirements that are reasonable, physical or mathematical modeling; ample understanding of testing procedure, including the gathering and analysis of resultant data; the analysis of the effectiveness with which the design met stated goals; generally detailed explanation of the data from each portion of the testing procedure and from expert reviews, generally supported by pictures, graphs, charts and other visuals; overall summary of the implications of most if not all of the data for proceeding with the design and solving the problem.	Through the conduct of a few tests for high priority requirements that are reasonable, physical or mathematical modeling; adequate understanding of testing procedure, including the gathering and analysis of resultant data; the analysis of the effectiveness with which the design met stated goals; somewhat detailed explanation of the data from each portion of the testing procedure and from expert reviews, somewhat supported by pictures, graphs, charts and other visuals; summary of the implications of at least some of the data for proceeding with the design and solving the problem.	Through the conduct of one or two tests for high priority requirements that are reasonable, physical or mathematical modeling; partial or overly general understanding of testing procedure, including the gathering and analysis of resultant data; the analysis of the effectiveness with which the design met stated goals includes a partial explanation of the data (partially complete and/or partially correct), minimally supported by pictures, graphs, charts and other visuals; the analysis includes a partial and/or overly general summary of the implications of at least some of the data for proceeding with the design and solving the problem.	Through the conduct of one or two tests for requirements (which may or may not be high priority) that are reasonable physical or mathematical modeling; minimal understanding of testing procedure, including the gathering and analysis of resultant data; the analysis of the effectiveness with which the design met stated goals includes an attempted explanation of the data but may not be supported by any pictures, graphs, charts or other visuals; the analysis may be missing even a partial and/or overly general summary of the implications of all of the data for proceeding with the design and solving the problem.	
J. Documentation of external evaluation	Documentation of project evaluation by multiple, demonstrably qualified stakeholders and field experts is presented and is synthesized in a consistently specific, detailed, and thorough way; documentation is sufficient in two or more categories to yield meaningful analysis of that evaluation data; the synthesis of evaluations consistently addresses evaluators' specific questions, concerns, and opinions related to design requirements.	Documentation of project evaluation by two or more demonstrably qualified stakeholders and field experts is presented and is synthesized in a generally specific, detailed, and thorough way; documentation is sufficient in at least one category to yield a meaningful analysis of that evaluation data; the synthesis of evaluations generally addresses evaluators' specific questions, concerns, and opinions related to design requirements.	Documentation of project evaluation by three or four demonstrably qualified stakeholders and/or field experts is presented and is synthesized in a somewhat specific and detailed way, but may not be thorough; documentation may not be sufficient in any category to yield a meaningful analysis of that evaluation data; the synthesis of evaluations addresses at least some of evaluators' specific questions, concerns, and opinions related to design requirements.	Documentation of project evaluation by two or three representatives of stakeholders and/or field experts (some of whom may not be demonstrably qualified) is presented and is synthesized in a somewhat specific and/or detailed but incomplete or overly general way; the synthesis of evaluations addresses at least a few of evaluators' specific questions, concerns, and/or opinions related to design requirements.	Documentation of project evaluation by one or two representatives of stakeholders and/or field experts is presented but synthesis is sparse, with few specific details; the synthesis of evaluations addresses only one or two of an evaluator's questions, concerns, and/or opinions related to design requirements.	