Waste Management Autonomous Robot Challenge

for the
WorldSkills Mobile Robotics National and Regional Competitions

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1. Introduction

“The WorldSkills Waste Management Autonomous Robot Challenge requires a team of two students / competitors to design and build a robot that will efficiently collect and deliver materials from homes to the Waste Management Center. The robot must be built to function autonomously.

Many elements can be introduced or removed to make this challenge more difficult or easier, such as; introducing traffic, adding construction, reducing the size of the road, etc.”

This challenge is inspired by and based on the WorldSkills Russia and WorldSkills Russia Junior 2019 National Competition by Damira Ramazanova, the WorldSkills Mobile Robotics Expert for Russia.

2. Purpose of this document

To assist in developing a common understanding regarding the skill set WorldSkills competitors require to support success at WorldSkills Europe Sankt Petersburg 2023.
To support WorldSkills Regional and National Technical Committees to develop Test Projects that are suitable to their specific needs while at the same time have a connection to what is happening in other regions and countries.

3. Benefits connected with participating in the challenge

It is expected when students / competitors are building and programming a robot for this challenge they will:

a) Gain an understanding of robotic technology through design, mechanical and electronic systems, controls and programming. Students build a complete system designed to accomplish a task. The fundamentals of problem-solving, program design, algorithms, and programming using a high-level language are central to the challenge.

b) Learn the skills sets required for the development of an Intelligent Mobile Robot using autonomous navigation.

c) Learn the engineering aspects of designing and building a robot frame and structure, drivetrain, mechanisms and manipulators. Mechanics, materials engineering and manufacturing are central to understanding how robotics works.

d) Learn the electrical systems that control the mechanical structure of the robot as it performs its tasks. Particularly for the electronics, embedded systems, control theory and low-level programming. The control of a robot involves three distinct phases – perception, processing, and action. Sensors give information about the

environment or the robot itself (e.g. the position of its joints or its end effector). This information is then processed to be stored or transmitted and to calculate the appropriate signals to the actuators (motors) which move the mechanical.

e) Understand the Computing technology that is a crucial part of robotics, This aspect deals with the motion planning, computer vision and machine learning aspects of robot creation. This can include artificial intelligence and software design.

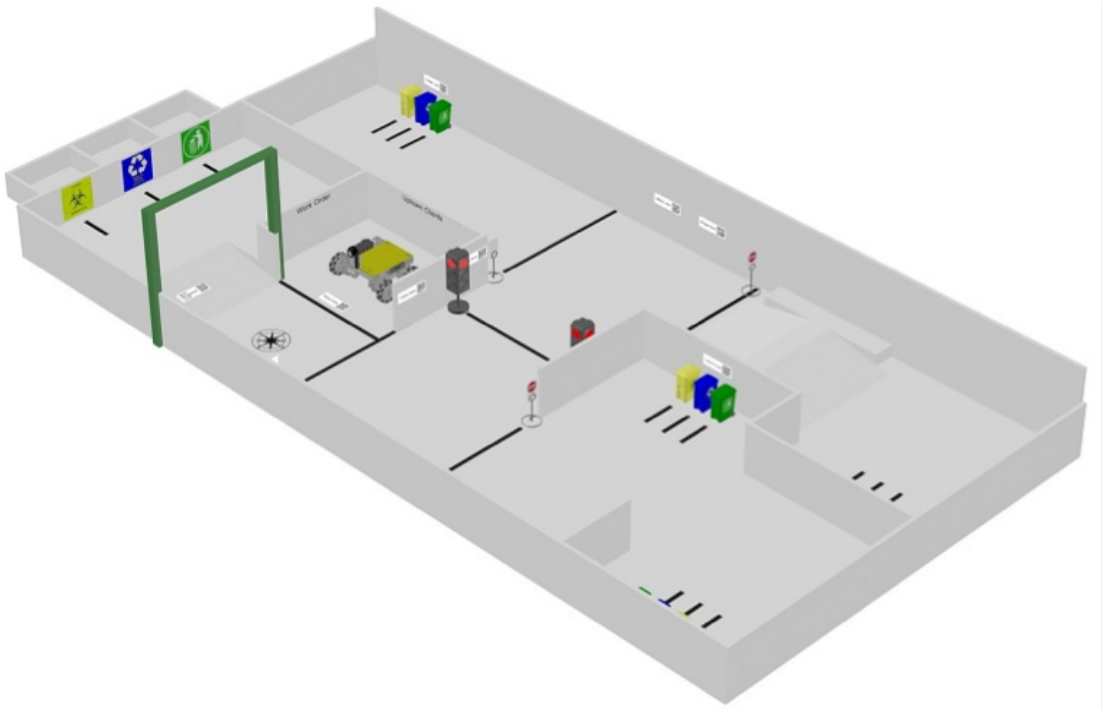
f) Understanding these five major parts of a career in robotics is crucial to becoming a robotics technician/engineer. The challenge allows for the opportunity to put knowledge into practice

g) Gain an understanding of robotics technology through design, the mechanical and electronics application, programming, and the application in the challenge.

4. Participation Requirements:

To build, program and test a Waste Management robot requires:

a) The WorldSkills Mobile Robotics Collection
b) The Studica Waste Management Autonomous Robot kit
c) The WorldSkills Mobile Robotics Official Court

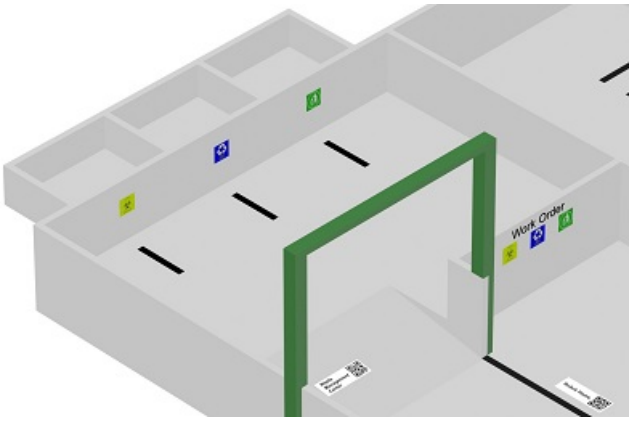


5. The WorldSkills Mobile Robotics Official Court

The Waste Management Court Layout presents a community in which competitor's Mobile Robots / Autonomous Vehicles work in support of a Waste Management Center.
This will require the robot to be able to:

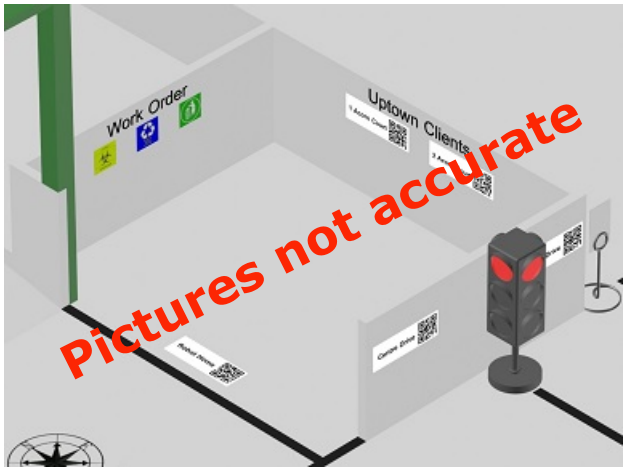
a) Navigate the community streets remaining in compliance with traffic signs
b) Manage 1 to 3 same size but different colour recycling bins at up to 4 different client locations
c) Take temporary possession of the bins (individually or collectively)
NOTE: Robots cannot remove bins from the client areas
d) Retrieve the collection of objects (golf balls) from the bins in client areas
e) Ensure that the different types of objects are always kept separate when they are in the possession of the robot
f) Deliver the sorted recycle objects (coloured golf balls) into each of the 3 designated bins in the recycling center
g) The control panel provided with the robot gives them a Start button, Reset Button, Stop Button and an Emergency stop.
h) The autonomous programs will be started by a competitor pushing the start button on the robot then immediately departing the court area.
i) The local computer will not be used for any processing or 2-way communication during an autonomous test project run. It can however show feedback from the various sensors and actuators on a robot.

The primary elements of the community layout include:



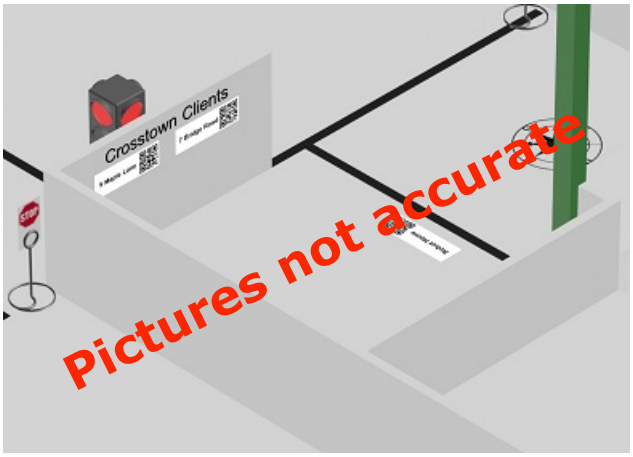
1. The Waste Management Center

a. 1200 by 800 mm Open Area raised 57 mm higher than the general court floor,
b. The Entry Ramp Slope is 10degrees
c. The Entry Archway provides a 600 mm wide and 600 mm tall travel space
d. There are Three 308 by 210 by 100 mm Storage Bins along the outside of the1200 mm Back Wall
e. Each of these Bins has an image of the Bin Label they support and a Black Tape Line leading to the center of the bin



2. The Robot's Home: Start / End Space

a. Is a 705 by 600 mm open space
b. Has a 600 mm wide entry / exit
c. The daily work order, displayed on each wall, defines which Material Types the Robot is to manage together with the respective client.
d. If a client name is not present, then that client is not included in the current work order.



e. The Robot is required to 'Read' the work order display to determine the specific task it must complete.
f. The order in which the robot completes the task(s) can be chosen autonomously by the robot itself.

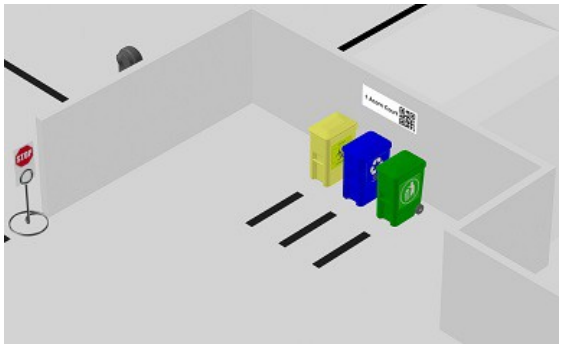
g. The robot will send a text report back to the control center (competitor laptop) that shows a summary of the current work order and client pickup schedule before the robot leaves the Start / End Home Space.

h. The Center of ALL Signs (Home Area Material Signs, Client Address Signs as well as Street Signs, Stop Signs and Client Home Area Signs) will be 170 mm above the court floor.

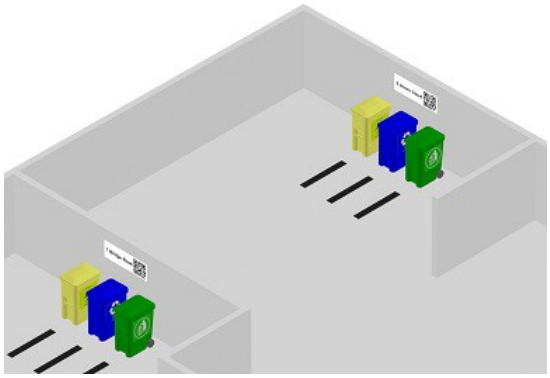
i. The Work Order Wall material and client signs are 170 by 110 mm.

j. The Black Tape Lines at the Home Area Entrance as well as at Stop Signs and Traffic Lights are 19 mm (3/4-inch Gaffers Tape)

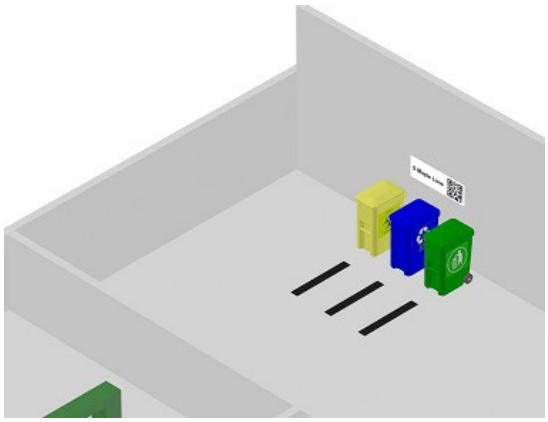
k. At the start of an Evaluated Test Project Run the robot will be positioned as follows:
- The center of the robot will be aligned with the center of the home area space
- Teams must identify the front of their robot
- The front of their robot and the robot's camera must be facing directly towards the Home Area Exit Opening



1 Acorn Court



2 Acorn Court



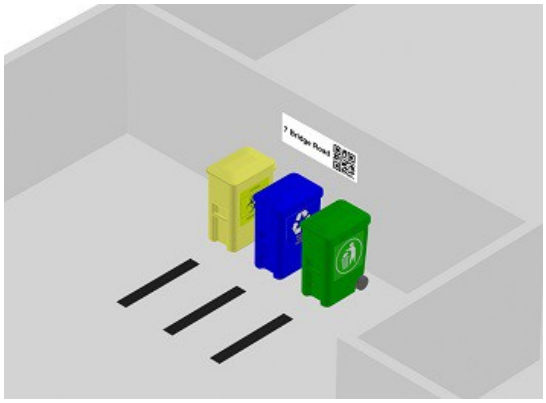
5 Maple Lane

3. There are Four Clients in the community requiring service.

The Four Clients have agreed to:

a. Always place the Blue Bin in the Center with the Green Bin to the Right and the Yellow Bin to the Left
b. Each Bin will have a 150 by 19 mm Black Tape Line leading to the Center of the Bin
c. The Center of the Blue Bin will be 400 mm to the Right or Left of the nearest wall
d. Use the same 125 by 87 by 57 mm Yellow, Blue and Green Bins
e. Provide a minimum of 668 by 800 mm Open Space in front of the set of bins
f. Empty Bins weigh 58 grams
g. Solid Golf Balls weigh 44 grams
h. Whiffle Golf Balls weigh 3 grams
i. Robots must retrieve the contents of the Bins in the Client Spaces and deliver these contents to the appropriate receptacle in the Recycling Center.
j. Robots must ensure that the various elements
(Golf Balls of different colors / type) are never in contact with one another during either the collection / delivery process or in the Recycling Center's Final Destination Bins

Robots **CANNOT** remove any Bins from the Client's Space at any time.



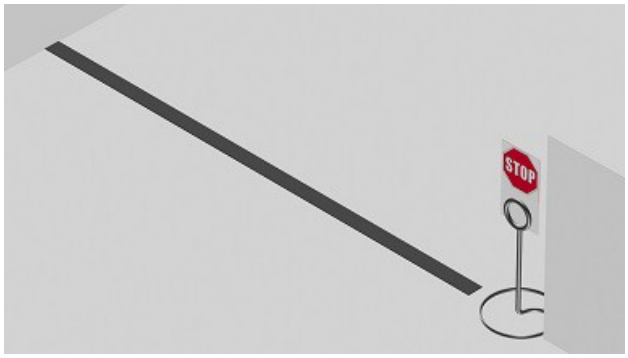
7 Bridge Road

The court Tape Lines will be created using 3M 1755 Cotton Friction Tape – 3⁄4” (or similar)

4. Waste Management Center Materials

The Colored Whiffle and Solid Golf Balls are used to represent materials delivered to the Recycle Centre

a. Bio-hazardous Materials – Yellow Bins – Yellow Whiffle Balls
b. Reduce / Reuse / Recycle Materials – Blue Bins – Blue Whiffle Balls
c. Waste Materials – Green Bins – Green Solid Balls



5. Traffic Signs

When moving on the community space streets the Mobile Robot / Autonomous Vehicle must comply with ALL Traffic Controls.

When approaching a Stop Sign from the Front the Robot / Autonomous Vehicle **MUST STOP BEFORE** reaching the Black Tape Line.

When approaching a Stop Sign from the Back the Robot / Autonomous Vehicle MUST NOT STOP and MUST Continue traveling PAST the Black Tape Line

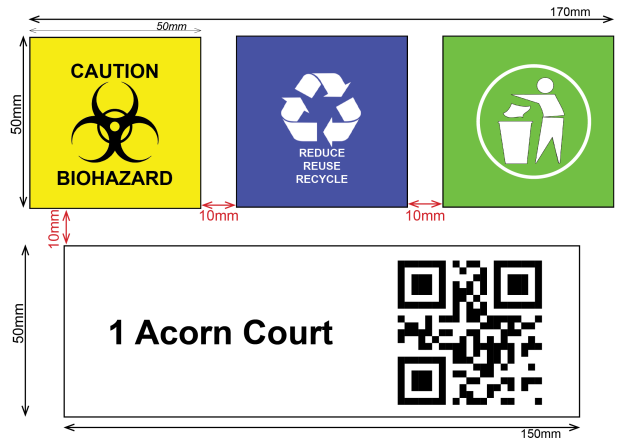
Note: The Black Tape Lines associated with Stop Signs and Traffic Lights are intended to serve as reference points for those 'Judging / Marking' the Robot's actions in 'Real Time'. When Stopping is the expected behaviour, then the Robot MUST Stop BEFORE reaching the Tape Line.

5.1. Work Order / Client Management

…is conducted using Material and Client Address Signs. Material signs are
170 x 50 mm, materials to be picked up are 50 x 50 mm in according colour scheme.
It is expected Competitors will use the VISION utility as a Primary Robot Management Tool.

- **Work Orders** can be displayed on either Wall of the Robot's Home Space and used to inform the Robot exactly what work the robot must complete with which client
- Robots will send a 'Text Message' to the competitor's Laptop identifying what the robot sees.
- The robot **identifies** the **clients** requiring service by viewing the Walls of the Robot's Home Area. Clients are identified by Text Name and QR, displayed 10 mm above the work order icons.

The following Work Orders are offered as samples only and should not be viewed as being the only work order options available



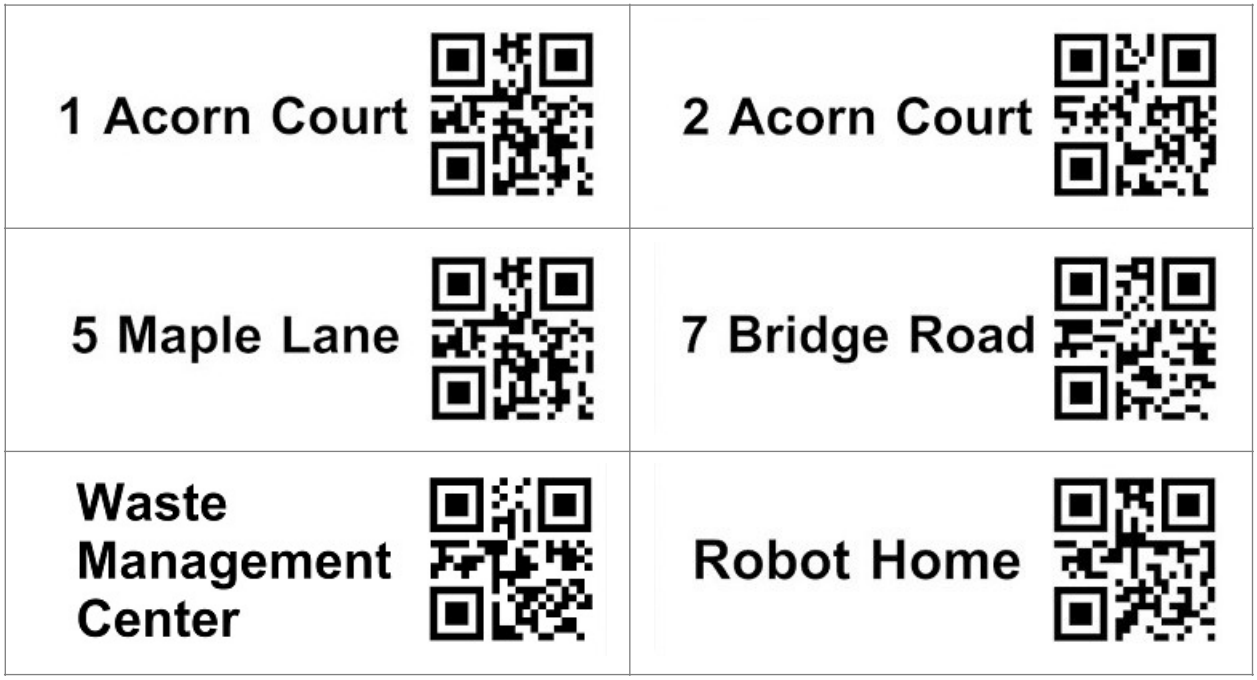
1 Acorn Court servicing ALL Bin Types
(example w/ measurements)

7 Bridge Road servicing Waste - and Reduce / Reuse / Recycle Materials
(in-game example)

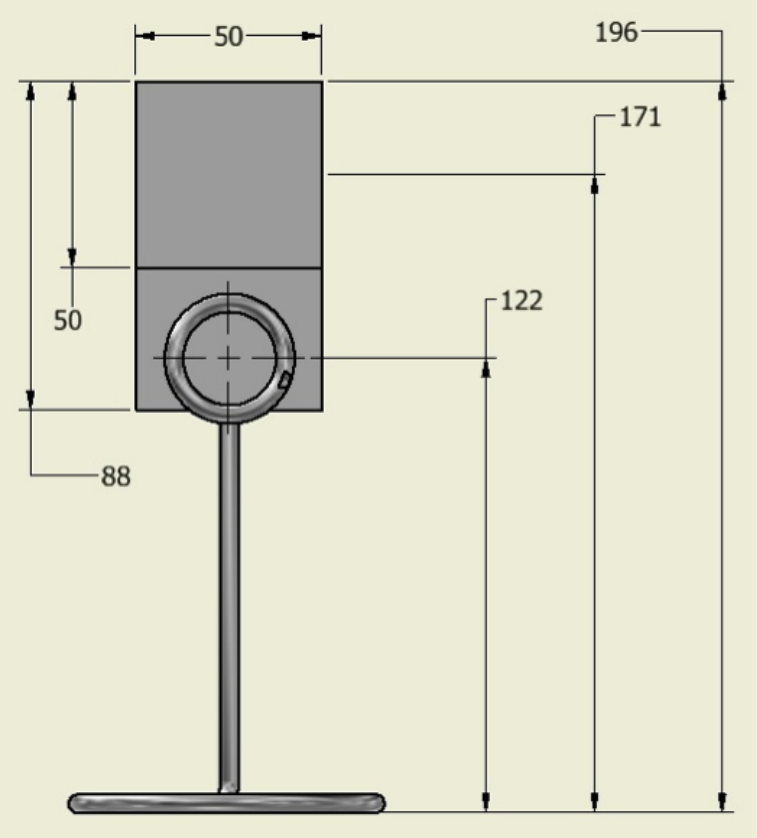
5.7. Location and Street Signs

All signs are available for download in digital form under https://luxskills22.makeit.lu.
Street and Location signs are:

a. 150 by 50 mm
b. Have a Text section and a QR Code
c. Are Black and White
d. The Center of these signs will be 170 mm above the court floor



Stop Sign Details



5.8. Procedure for Managing Evaluated Test Project Runs

a. Competitors are required to have their robot positioned in the court and prepared to start BEFORE the Work Order Information is put in place on the walls of the robot's home space.
b. To maintain Fairness and keep the Work Order Information Unknown In Advance the following procedure's recommended:
    1. Pre-set the number of Evaluated Test Project Runs each team will have in a single Competition Day
    2. Create a Table displaying the Full Set of competition Work Orders (see example below) that will be used during a Single competition day. Do NOT share this table with the competitors.
    3. Set the Work Order using a 'Random Process' (Draw Numbers from a Hat / Roll a Die).
c. An Overall Equal Level of Difficulty for ALL Competitors will be maintained by:
    1. Recording the Specific Work Order #'s each team attempts
    2. Providing Teams with Only a Single Attempt at each Work Order#

A companion document will present how the Waste Management Challenge Test Project can run in a manner that is compatible with WorldSkills CIS.

5.9. Managing Test Project Difficulty Level

Teams will use the layout presented in this document for 'Competition Preparation / Practice Purposes Only' and require the robots to perform in an environment that is completely unknown in advance. In this situation robots would need to 'Interpret and Respond to their Environment' to a greater degree than when they are programmed to follow prescribed in detail in advance routes.
If an alternative 'Community Court Layout' is used I recommend that the following be considered:
The Layout will be presented to the competitors the morning of the competition

a) Competitors would be allowed to view the New Community Court Layout
b) Competitors would NOT be allowed to take any measurements
c) Competitors would be provided with images of all relevant signs / features in the court environment which their robot would be expected to observe / interpret and respond appropriately
d) If the layout supports more than one route to destinations, then the additional variable of 'Construction Detour' can be added requiring the robot to respond to an environment change.
e) The base layout provides a travel space that is approximately 600 mm wide. An alternate layout could be created with a smaller travel space width (450 or 500 mm wide for example).

Note: I will create alternate layouts for Regional Competitions wishing to utilise one and forward the replacement layout to an individual identified by the Regional Competition Expert Jury Panel prior to the competition date.

Note: Additional means of modifying the Test Project could include:

a) Introduction of a completely new performance requirement at the competition site
b) Provision of the 'Unknown in Advance' hardware required to address this new performance element
c) Requiring competitors to integrate the new hardware into their robot and utilise it in addressing the needs of the test project

5.10. WorldSkills Mobile Robotics Collection 2021

The WorldSkills Mobile Robotics Collection 2021 described at **https://www.studica.com/worldskills-mobile-robotics-workshop-kit-2021** is expected to serve as the core equipment source for competitors attempting this Test Project.

5.11. Additional Components Restrictions

WorldSkills Regional and National Expert Jury Panels are encouraged to set appropriate additional components restrictions based on their local circumstances.

Additional purchased components may not have more than one degree of freedom.
The following Chart based on WorldSkills Kazan 2019 is offered as a reference.

All components / elements / parts that are structural in nature, their contribution is to hold / secure in place functional elements of the robot do NOT need to be accounted for in the listing of additional money spent to enhance the robot's performance capabilities.

Example: Neither a purchased nor a competitor fabricated bracket with the functional purpose of holding a Linear Actuator in position needs to be accounted for in the listing of additional $ spent to enhance the robot's performance capabilities.

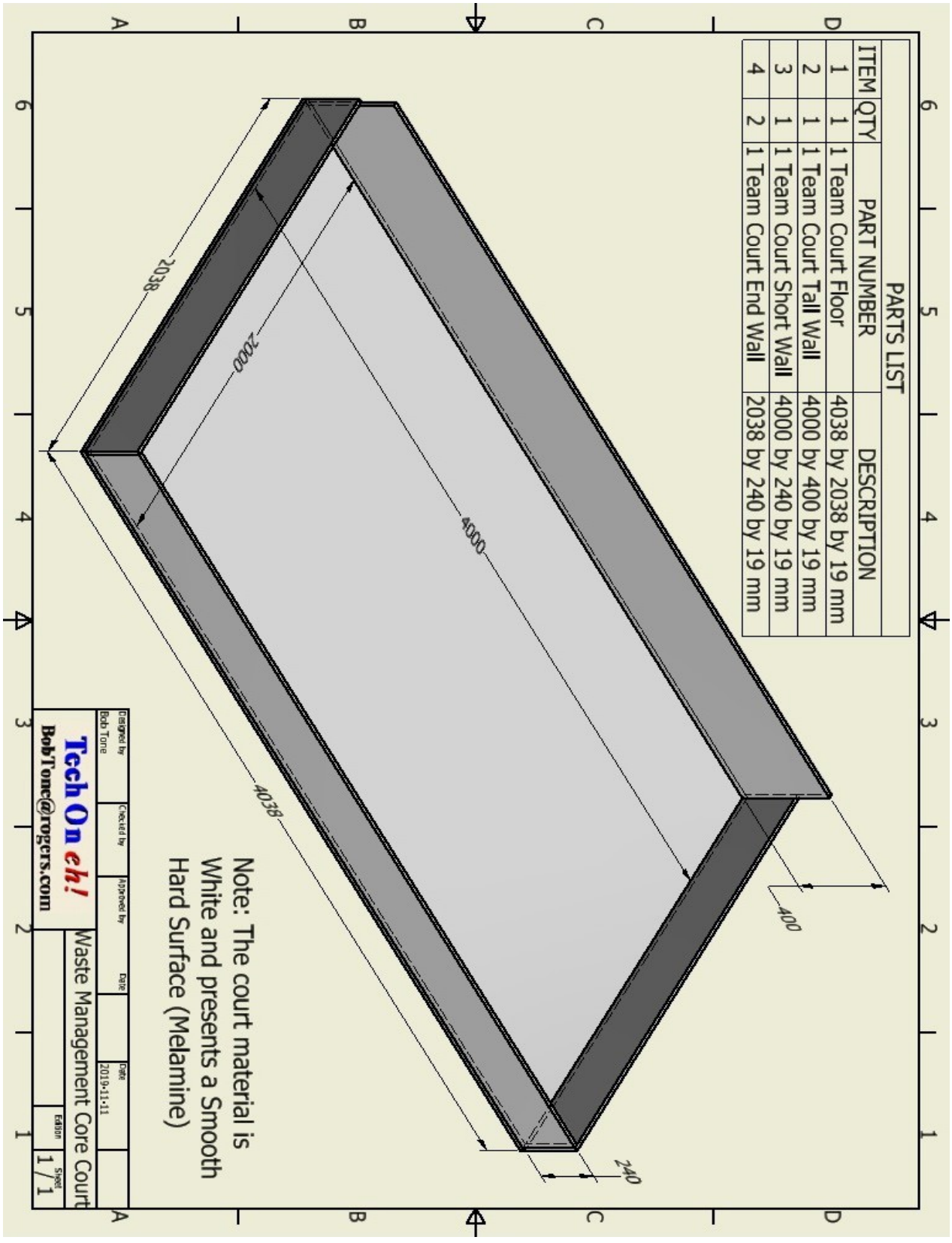
The following are considered performance related **NOT** structural Items and must be included in the 500€				
Motor and Servo Controllers	Additional Batteries	Linear Actuators	Signal Modifiers	Speed Controls
Micro Controllers	Single Board Computers	Additional Sensors	Additional Motors	Gripper
The following items will **NOT** be counted in the 500€ spending limit:				
Cables, Wires, and Connectors	Safety Switch	Voltage Regulators	Electrical Connectors	Relays
Switches	Electronics Mounts	Breadboards	Competitor manufactured items	Lead Screws
Wheels	Competitor manufactured Sensor Interface Board			

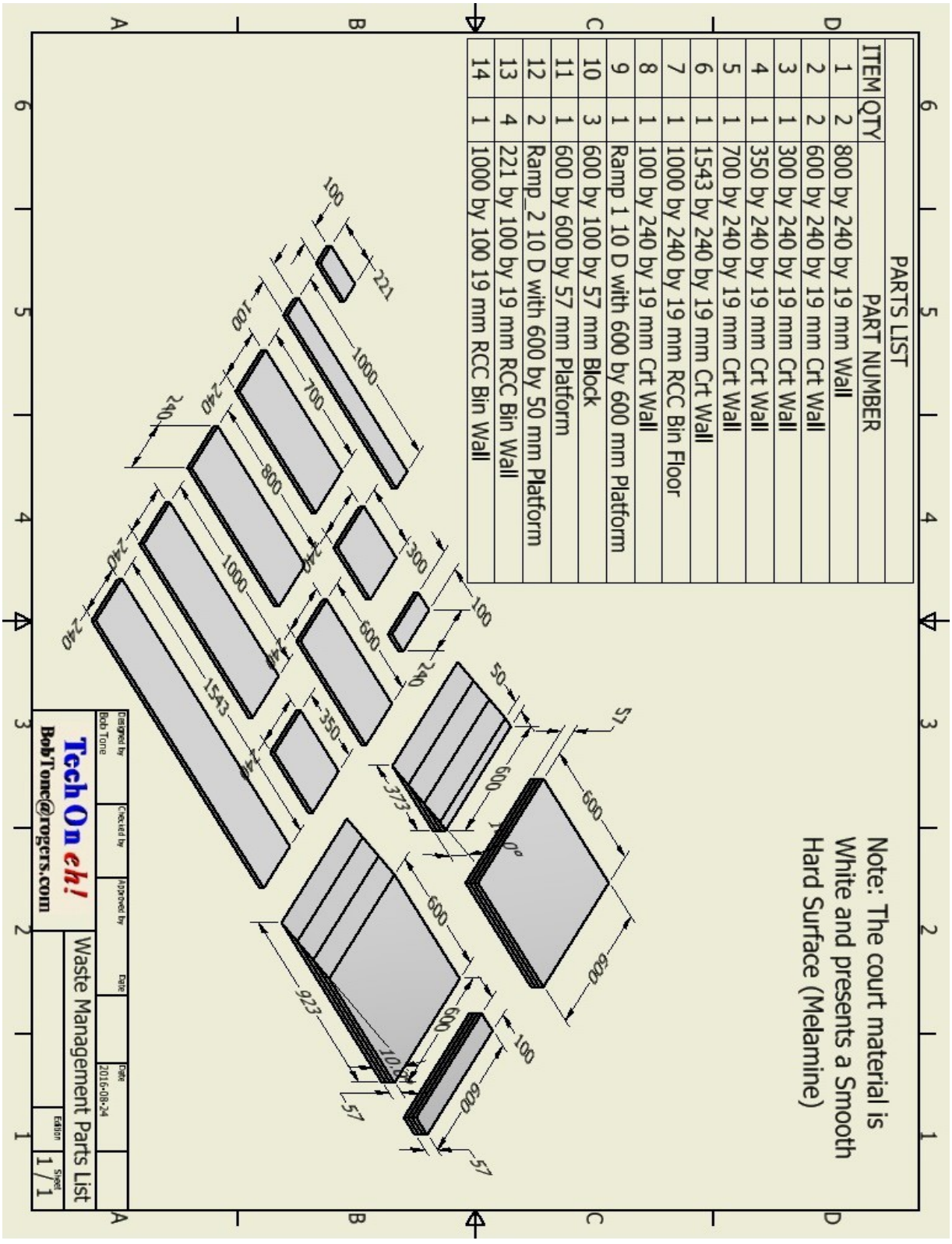
5.12. Robot Budget's Role in Evaluation

a) The Overall Competitor Experience is based on reflecting the relationship between a Service Provider (The Competitor Team) and an End User Client (The Recycling Centre).
b) The core budget is the 2021 WorldSkills Mobile Robotics Collection. The Client's expectation is the project will 'Come in ON Budget'.
c) Teams may utilise items beyond those in the provided Component Collection. The tables and information points above display examples of items that:
    - Will be considered 'No Cost Items' and will NOT be viewed as the Team going over budget
    - Will be considered 'Cost Items' and WILL be viewed as the Team going over budget.

Marking applied when Teams go 'Over Budget' is addressed in the accompanying Waste Management Challenge WorldSkills CIS document.

6. Court plans





PARTS LIST

ITEM	QTY	PART NUMBER
1	2	800 by 240 by 19 mm Wall
2	2	600 by 240 by 19 mm Crt Wall
3	1	300 by 240 by 19 mm Crt Wall
4	1	350 by 240 by 19 mm Crt Wall
5	1	700 by 240 by 19 mm Crt Wall
6	1	1543 by 240 by 19 mm Crt Wall
7	1	1000 by 240 by 19 mm RCC Bin Floor
8	1	100 by 240 by 19 mm Crt Wall
9	1	Ramp 1 10 D with 600 by 600 mm Platform
10	3	600 by 100 by 57 mm Block
11	1	600 by 600 by 57 mm Platform
12	2	Ramp_2 10 D with 600 by 50 mm Platform
13	4	221 by 100 by 19 mm RCC Bin Wall
14	1	1000 by 100 19 mm RCC Bin Wall

Note: The court material is
White and presents a Smooth
Hard Surface (Melamine)

Designed by: Bob Tome
Checked by:
Approved by:
Date:
Tech On eh!
BobTome@rogers.com
Waste Management Parts List
Date: 2016-08-24
Edition:
Sheet: 1/1