

# Test Project Mobile Robotics

*COMPETITOR INFORMATION DOCUMENT*

## Warehouse Robot



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## 1. INTRODUCTION

Mobile Robots are used in a variety of applications to:

- Move between “known in advance” locations in prescribed movement patterns.
- Interact with known objects positioned in “known in advance” locations and move these known objects to “known in advance” new locations.
- Interact with known objects positioned in “unknown in advance” locations and move these known objects to “unknown in advance” locations.
- Distinguish in a group of objects between those that are objects of interest and those that are not of interest.
- Interpret and respond to specific features found in the robot’s operating environment to manage its navigation pattern and object handling system autonomously.

The role of the WorldSkills Singapore’s Mobile Robotics Task is to provide a platform which enables the Mobile Robotics Competitors to showcase their knowledge, skills and talents during the Competition Days and within the constraints of the competition space.

The ‘**Warehouse Robot**’ task concept reflects a **future** Mobile Robot application. The premise is that in the future a warehouse robot would have performance capabilities that include loading/unloading of objects at loading/unloading bay.

## 2. COMPETITOR ROBOTS

Each team is required to design/fabricate/assemble/manage (program) a competitor robot capable of moving in **autonomous mode** within the 2.25m by 4.5m Competition Performance Evaluation Court while performing the following tasks:

- a) Search for specified objects on warehouse storage shelves and transfer them to the loading/unloading bay.
- b) Transfer objects at the loading/unloading bay to their designated placement shelves in the warehouse.

All teams are required to assemble their mobile robots during Competition Day 1 and morning of Competition Day 2 using the following key components/parts from either the 2017 or 2018 WorldSkills Studica Collection Kit for the competition.

- a) Motors
- b) Motor encoders
- c) Motor driver

- d) MyRIO controller
- e) Battery
- f) Camera

Please note the above-mentioned components should come from only one Collection Kit, either the 2017 or 2018 kit.

The following constraints that will affect the design of the robot must be adhered to:

- a) The robot **MUST** be designed to include the MyRIO as the main or only processing unit.
- b) Competitors **CANNOT** purchase components as direct replacement/upgrades to the key active (powered) components in the Collection Kit. For example, teams must use the encoders/ motors in the Collection Kit.
- c) Programming **MUST** be accomplished in LabVIEW.
- d) Teams can use any additional electrical motors and servos of their choice with no restrictions on brand or number of motors and servos used.
- e) Competitors are **NOT** allowed to use commercial, off-the-shelf, straight-out-of-the-box, ready to use pre-assembled components, such as pre-assembled grippers and drive systems.
- f) All the parts for the robot **MUST** be disassembled and in their initial state (parts in the collection kit, not pre-built) when the “assemble” time starts on Competition Day1. However, this constraint does not apply to the following parts/components:
  - I. Encoder assembled on motor
  - II. Bearing force fitted in housing
  - III. Tire on wheel Hub
  - IV. Parts welded/bonded together

Teams are required to prepare and bring all the equipment/tools, software and portable computers they need for the competition.

### 3. ALLOWABLE ADDITIONAL COMPONENTS

As stated in the scope of competition, the maximum allowable amount for add-on active (powered) items is limited to S\$1000 and with each individual item not exceeding S\$400. Used active item would be based on its original purchased price.

The following parts/components/elements are examples of non-active items:

- Cables/wires
- connectors
- Switches

Team is required to submit the listing of add-on active items to the Chief Judge on Competition Day 1. This document **must** include the following information:

- Item Description
- Add-on functional capability
- Cost\* – Official receipt or published price (reputable URL must be included)

\*The judges reserve the right to adjust the listed price as they consider appropriate and, for ease of currency conversion, US\$1.0 will be fixed at S\$1.30.

## **4. MOBILITY PERFORMANCE CAPABILITY**

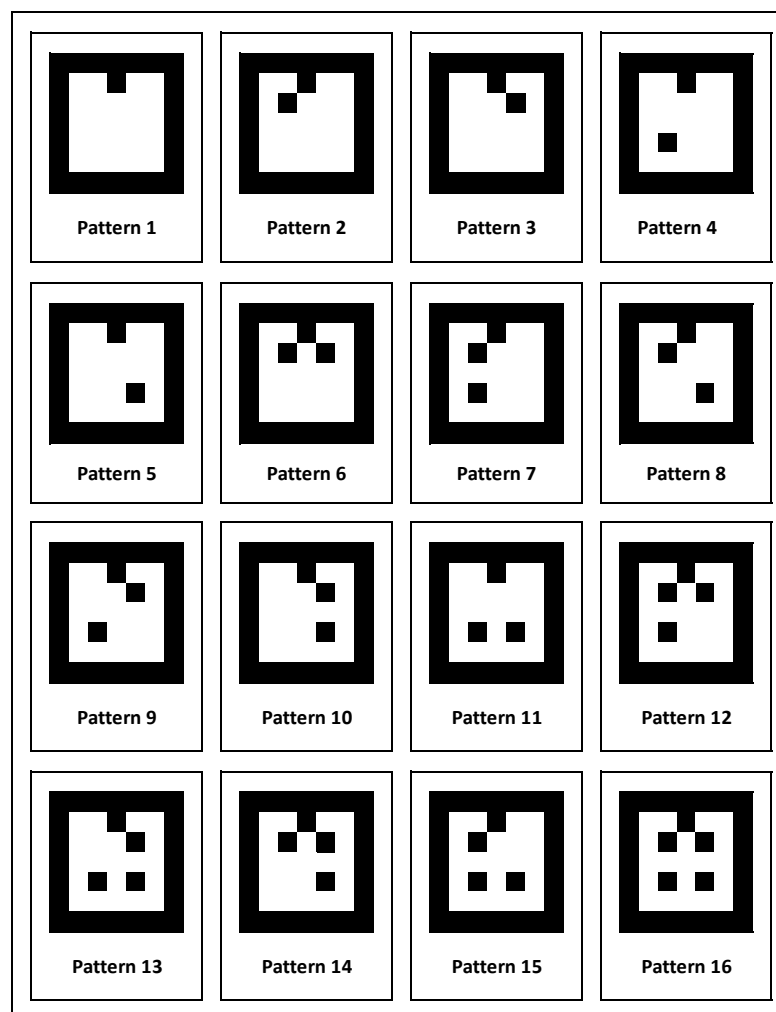
The competitor robot must be able to move in autonomous mode within the 2.25m by 4.5m Competition Performance Evaluation Court and manoeuvre along 0.7m wide passageway with a height restriction of 1.0m. The height of the surrounding wall is 80mm.

## **5. VISION PERFORMANCE CAPABILITY**

The vision system integrated on the competitor robot must be able to recognize objects and Grid Patterns (7 by 7 squares in Black and White).

The images of the full set of unique grid patterns and objects are shown in Table 1 and Table 2, respectively. Up to eight (8) objects and eight (8) grid patterns will be selected for each Full Task Performance Review. The overall size of each grid pattern is approximately 40mm by 40mm.

Table 1 – The full set of grid patterns

















## 6. OBJECT MANAGEMENT CAPABILITY

The objects to be used at the competition will be selected from the objects listed in Table 2. The weight of each object will be less than 250 grams. Competitors are required to design the Object Handling System mounted on the robot to autonomously transfer objects placed on storage shelves in the warehouse to the platforms at the loading/unloading bay and vice versa. Object from Table 2 may be randomly placed on the floor. Bonus marks will be awarded to team whose robot is able to transfer object placed on the floor to location specified by the Chief Judge at the competition.

Object to be transferred either from the storage shelf in the warehouse or platform at the loading/unloading bay will be randomly placed within a 200mm by 200mm

boundary. The competitor-built object handling system is required to place object at designated placement location within a 200mm by 200mm boundary.

Table 2 – Full set of competition objects

S/N	Approx. Size/Wt	Colour/Object	Remarks
1	70x60x30/80g	Red 	Wood
2	70x60x30/80g	Green 	Wood
3	70x60x30/80g	Blue 	Wood
4	70x60x30/80g	Black 	Wood with a single layer of transparent bubble wrap
5	60x60x60/160g	Red 	Wood
6	60x60x60/160g	Green 	Wood
7	60x60x60/160g	Blue 	Wood
8	60x60x60/160g	Yellow 	Wood with a single layer of transparent bubble wrap
9	168x30x25/58g	Mixed 	Toblerone Chocolate (50g)
10	50x50x25/100g	Mixed 	Twin pack “C” size EVEREADY Super Heavy Duty Battery
11	78x55x27/20g	Mixed 	“FairPrice” Royal Gold Luxurious Tissue Hanky (10 sheets)
12	142x80x13/52g	Mixed 	“FairPrice” Wet Tissues – Green Tea (10 Wipes)
13	160x100x28/45g	Mixed 	“CAMEL” sweet Peanuts (40g)
14	142x82x38/70g	Mixed 	“Meiji” Hello Panda (50g) Choc Biscuits with Chocolate Floured filling
15	220x165x37/175g (190x165x37- folded)	Mixed 	“Tong Garden” Salted Cocktail Nuts (160g)
16	186x110x45/235g	Mixed 	“Khong Guan” Peanut Cream Crackers (200g)

## 7. COMPETITION PERFORMANCE EVALUATION COURT

The 2.25m by 4.5m competition performance evaluation court has three sections, namely, Warehouse, Passageway and Loading/Unloading Bay.

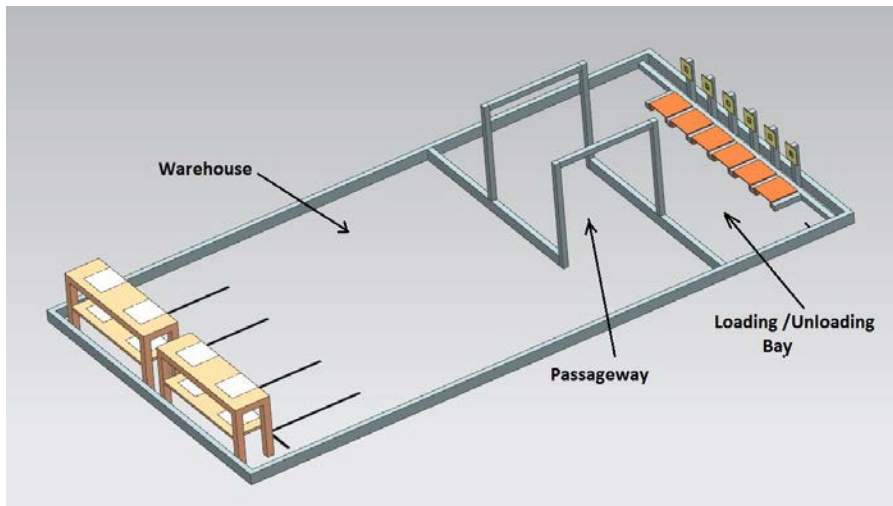


Figure 1 – Competition Performance Evaluation Court

### 7.1 WAREHOUSE

Two units of storage shelves will be placed in the warehouse. Their locations will be revealed before the start of competition evaluation run. Each storage shelf unit has two shelves and it can accommodate up to four (4) objects, two objects on each shelf. The grid pattern assigned to the object (placed or to be placed on the shelf) will be attached to the side of the shelf. There will be 20mm wide black tape lines on the floor in front of each storage shelf unit. Details on the storage shelf unit and tape lines are shown in Para 10.2.

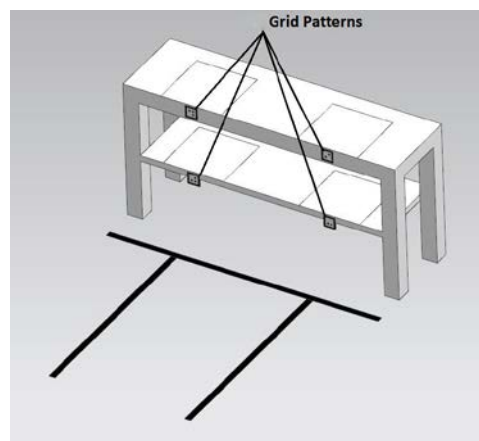


Figure 2 – Storage Shelf Unit



## 7.2 PASSAGEWAY

The passageway between the warehouse and the loading/unloading bay has a 700mm wide travel space with a maximum overhead clearance allowance of 1000mm. The width of the passageway Entrance/Exit is 700mm. The physical location of the Entrance/Exit will be known before the start of the competition task.

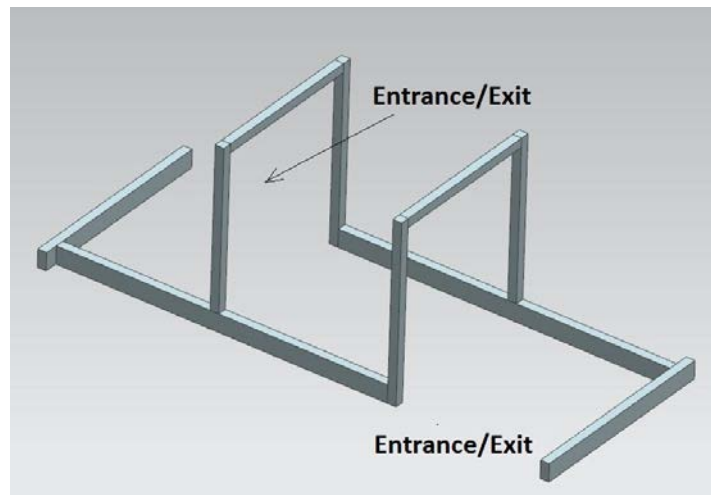


Figure 3 – Passageway

## 7.3 LOADING/UNLOADING BAY

There are six (6) 200mm by 200mm removable platforms at the loading/unloading bay. The grid pattern on the grid pattern stand immediately behind the centre of each platform is associated with the object placed or to be placed on the platform. Details on the loading/unloading bay are shown in Para 10.3.

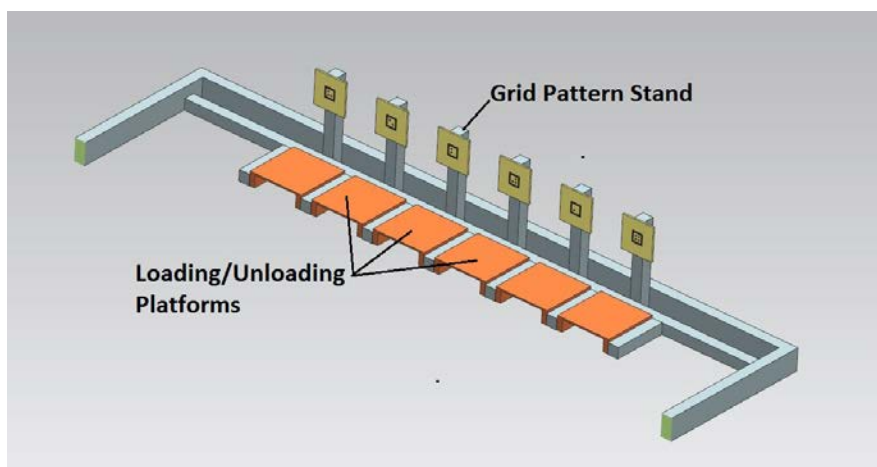


Figure 4 – Loading/Unloading Bay

## 8. COMPETITION TASKS

Competitors need to demonstrate at the competition their understanding of the mechanical, electrical and control system that they have included in their robots. They are required to dis-assemble their robots prior bringing them to the competition. Dis-assembled is defined as follows:

- All motors, sensors and electrical components must be in their “straight out of their delivery box” conditions. However crimped connector on cable is allowed and encoder can remain mounted to motor.
- All competitor-installed wiring connections to components must be removed. Wires soldered to components are allowed.
- All structural and mechanical components secured to one another by competitors by mechanical means (screws/bolts and nuts) must have these connecting elements removed resulting in the structural and mechanical components being totally separated from one another.

Competitors will be required to build/assemble and commission their robots on-site in the competition space on Competition Day 1 and the morning of Competition Day 2.

The two categories of tasks that will be evaluated at the competition are Core Programming and Full Task Performance Review.

### 8.1 CORE PROGRAMMING

The core programming task will take place during the afternoon of Competition Day 2.

The evaluation in this category is focused on those individual core programming functions likely to be included by competitors in their main programs for the full task performance review. The list of core programming tasks to be evaluated will be revealed before the start of this competition and competitors will be given time to program these tasks before the evaluation. The core programming tasks will be evaluated one at a time. You are given only one (1) chance. Below is a list of core programming examples:

- Robot moves forward
- Robot moves backward
- Robot rotates 90 degrees within a 1m by 1m space
- Robot moves from one designated location to another location within the competition performance evaluation court

- Distance sensor responds when a flat plate is brought into the sensor's field and the robot must make a pre-determined response such as reversing (Team's choosing)
- Camera recognizes a pre-selected object (out of the 16 objects) by the Chief Judge when it is brought into the camera's field of view and the robot must make a pre-determined response such as reversing (Team's choosing)
- Camera recognizes a pre-selected grid pattern when it is brought into the camera's field of view and the robot must make a pre-determined response such as reversing (Team's choosing)
- Robot picks up object from the storage shelf with the robot placed in a position of the Team's choosing
- Robot places object on the storage shelf with the robot placed in a position of the Team's choosing

Please note the above list is by no means an exhaustive list.

Before the start of development time, teams will be given a list of 6 core programming tasks. Teams have to download all the six (6) programs to the robot before the end of development time. During evaluation, each program should be started one at a time, in any sequence.

Each team will be given the following time periods for this task:

- Development time: 100 mins
- Performance evaluation: 20 mins

## **8.2 FULL TASK PERFORMANCE REVIEW**

The full task performance review will take place on Competition Day 3. There will be two (2) different tasks, one in the morning and one in the afternoon. The starting position and orientation of robot for both tasks will be made known only before the evaluation runs.

Each team will be given the following time periods for each task:

- Development time: 120 mins
- Performance evaluation: 15 mins

Teams are allowed to make as many runs as possible within the performance evaluation period. Each evaluation run must be initiated with a start button (pressed only once) on the robot. No modification nor downloading of the program is allowed during the performance evaluation period. If you are not using the FPGA, please remember to set your program as "start-up VI" so that the program is not lost when you restart your robot.

During the development time, teams can practise in the competition performance evaluation court according to a schedule.

### Task A

This Task requires teams to program their robots to transfer six (6) objects randomly placed (within 200mm by 200mm boundary) on the storage shelves to the designated platforms at the loading/unloading bay.

The selected objects and assignment of grid patterns to the objects to be transferred from the shelves to the loading/unloading bay will be made known before the start of this competition. Each assigned grid pattern will be attached to one of the grid pattern stands at the loading/unloading bay as shown in para 10.3. The locations of the assigned grid patterns at the loading/unloading bay and the two storage shelf units with objects will only be known before the evaluation run, that is, after all the teams have completed their programming. Teams are expected to program their robots to search for the selected objects and transfer them to the correct placement locations.

Example: **P1-1**: refers to Grid Pattern P1 – Object 1 pair, which means look for the storage shelf with Grid Pattern P1 **and** Object 1 in that shelf, pick the Object 1 and deposit it to the loading/unloading bay platform labelled as Grid Pattern P1. Full marks will not be given if robot picks a different object from P1 at the storage shelf.

### Task B

This Task requires teams to program their robots to transfer six (6) objects randomly placed on the six (6) platforms at the loading/unloading bay to their designated placement locations on the storage shelves in the warehouse.

The selected objects and assignment of grid patterns to them will be made known before the start of this competition. The locations of the two storage shelf units, individual object placement locations on the storage shelves and the position of individual object placed on the platform with its assigned grid pattern on the grid pattern stand will only be known before the evaluation run, that is, after all the teams have completed their programming. Teams are expected to program their robots to search for the designated object placement locations on the storage shelves.

There can be 2 objects in a Platform. But they are not stacked on each other.

Example: “**P2-8**”: refers to Grid Pattern P2 – Object 8 pair, which means look for the Platform with Pattern P2 **and** Object 8 in the loading/unloading bay, pick the Object 8 and deposit it to storage shelf labelled as Grid Pattern P2. Full marks will not be given if robot picks a different object from P2 at the Platform.

## 9. COMPETITION SCHEDULE

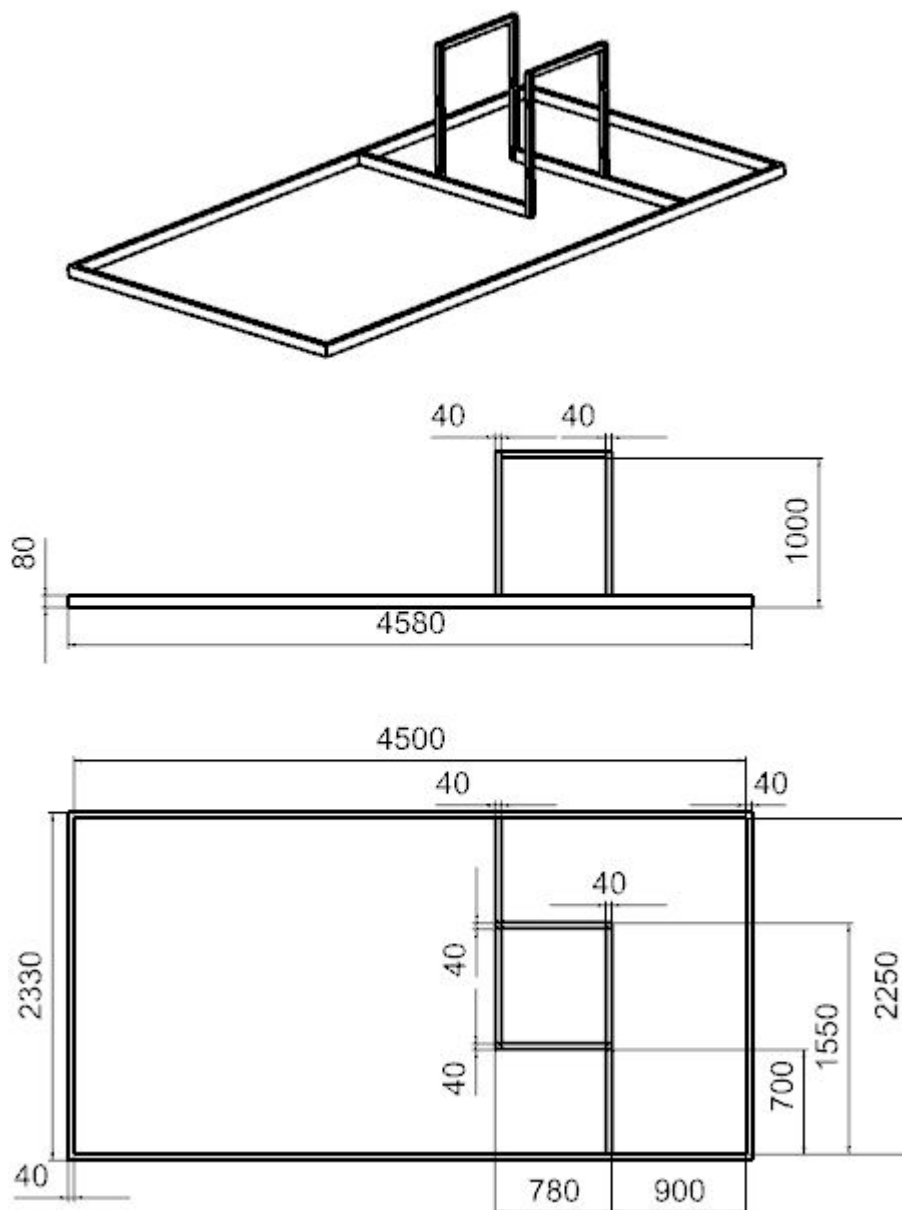
<b>C1</b>	<p><b>Competition Day 1:</b></p> <ul style="list-style-type: none"> <li>• Briefing.</li> <li>• All the parts for the robot <b>MUST</b> be disassembled and in their initial state (not pre-built) when the “assemble” time starts on Competition Day1.</li> <li>• Teams have the full competition day to build/assemble their Competition Robot.</li> <li>• Teams have access to the Competition Performance Evaluation Courts on an unscheduled and shared basis.</li> </ul>
<b>C2</b>	<p><b>Competition Day 2:</b></p> <ul style="list-style-type: none"> <li>• <b>AM:</b> Teams continue building/assembling/preparing their Competition Robot in the morning and have access to the Competition Performance Evaluation Courts on an unscheduled and shared basis.</li> <li>• <b>PM:</b> The list of core programming tasks will be given to the teams in the afternoon. Development time includes scheduled court access time for trial runs.             <ul style="list-style-type: none"> <li>○ Briefing</li> <li>○ Development time: 100 mins</li> <li>○ Performance evaluation: 20 mins</li> </ul> </li> </ul>
<b>C3</b>	<p><b>Competition Day 3:</b></p> <ul style="list-style-type: none"> <li>• <b>AM:</b> Task A or B             <ul style="list-style-type: none"> <li>○ Briefing</li> <li>○ Development time: 120 mins</li> <li>○ Performance evaluation: 15 mins</li> </ul> </li> <li>• <b>PM:</b> Task A or B             <ul style="list-style-type: none"> <li>○ Briefing</li> <li>○ Development time: 120 mins</li> <li>○ Performance evaluation: 15 mins</li> </ul> </li> <li>• Development time includes scheduled court access time for trial runs.</li> </ul>

The jury panel reserves the right to make changes without prior notice. For example, additional evaluation runs may be done.

## 10. OVERALL COMPETITION PERFORMANCE EVALUATION COURT DETAILS

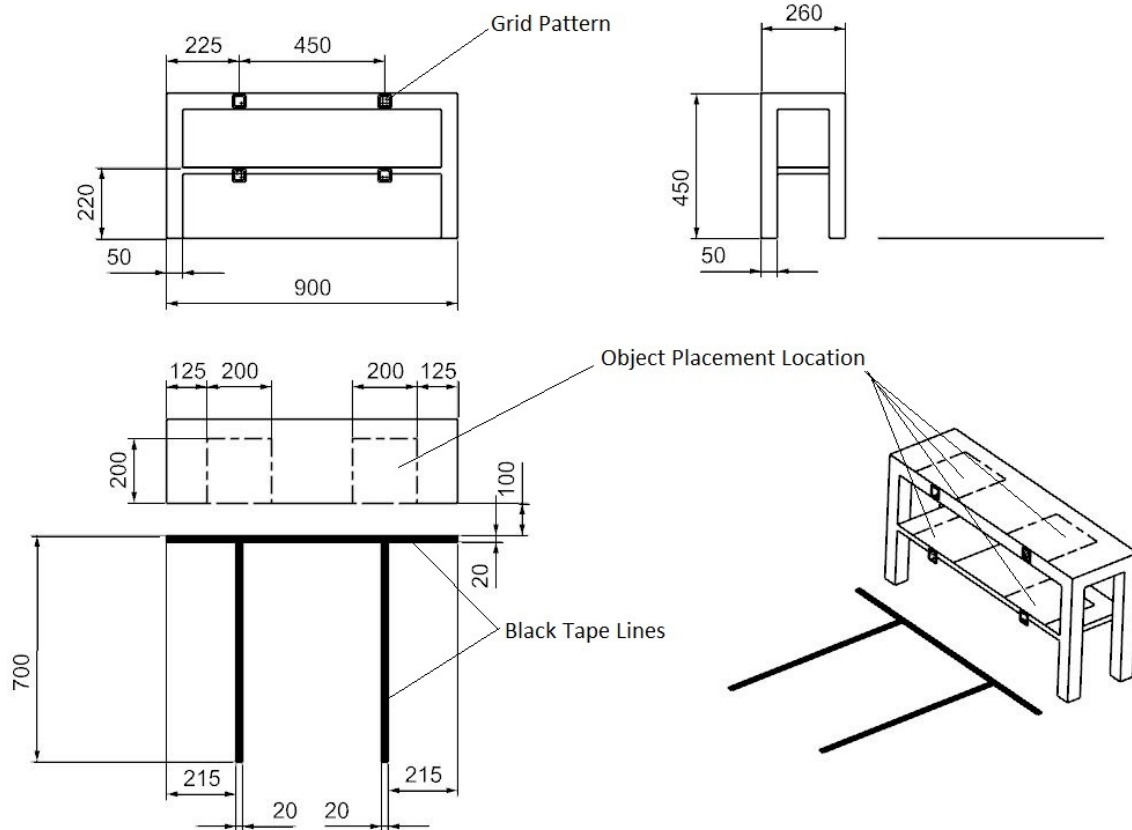
### 10.1 COMPETITION PERFORMANCE EVALUATION COURT

The 2.25m x 4.5m competition performance evaluation court is constructed using 80mm x 40mm and 40mm x 40mm aluminium profiles.



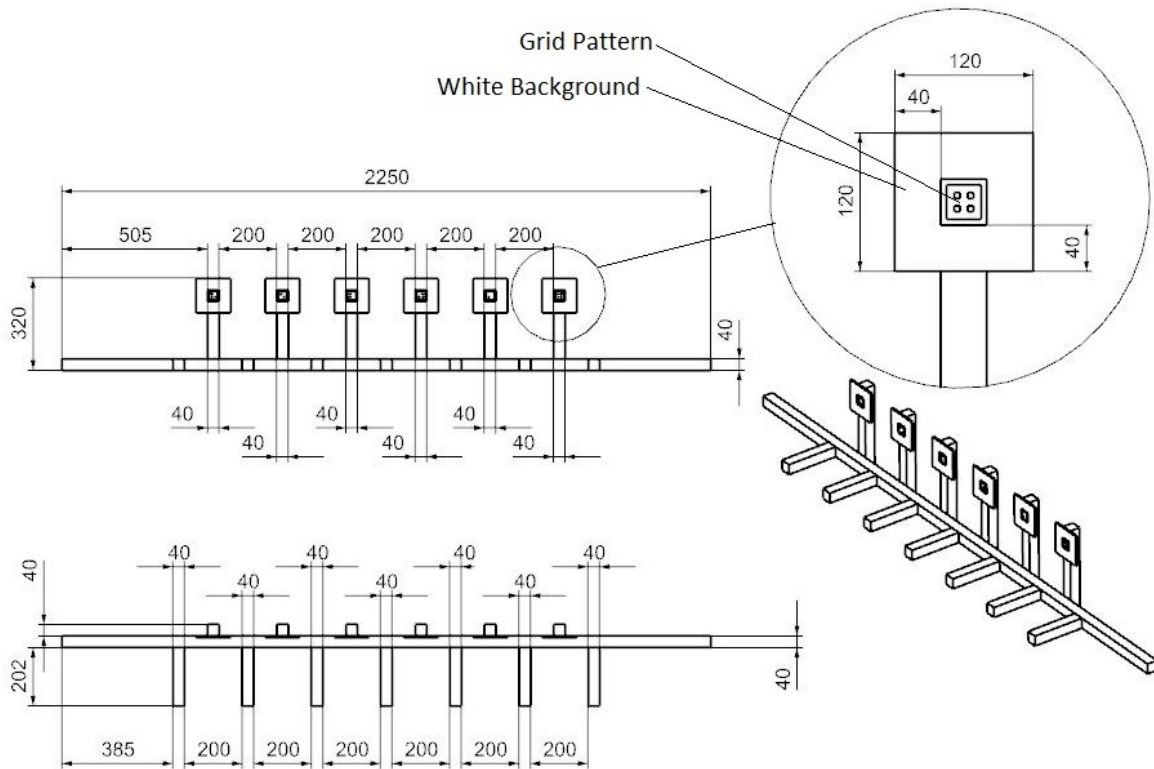
## 10.2 STORAGE SHELF UNIT

This storage shelf is white in colour. It can be purchased from IKEA (LACK TV Bench, Article Number: 103.535.67).



### 10.3 LOADING/UNLOADING BAY

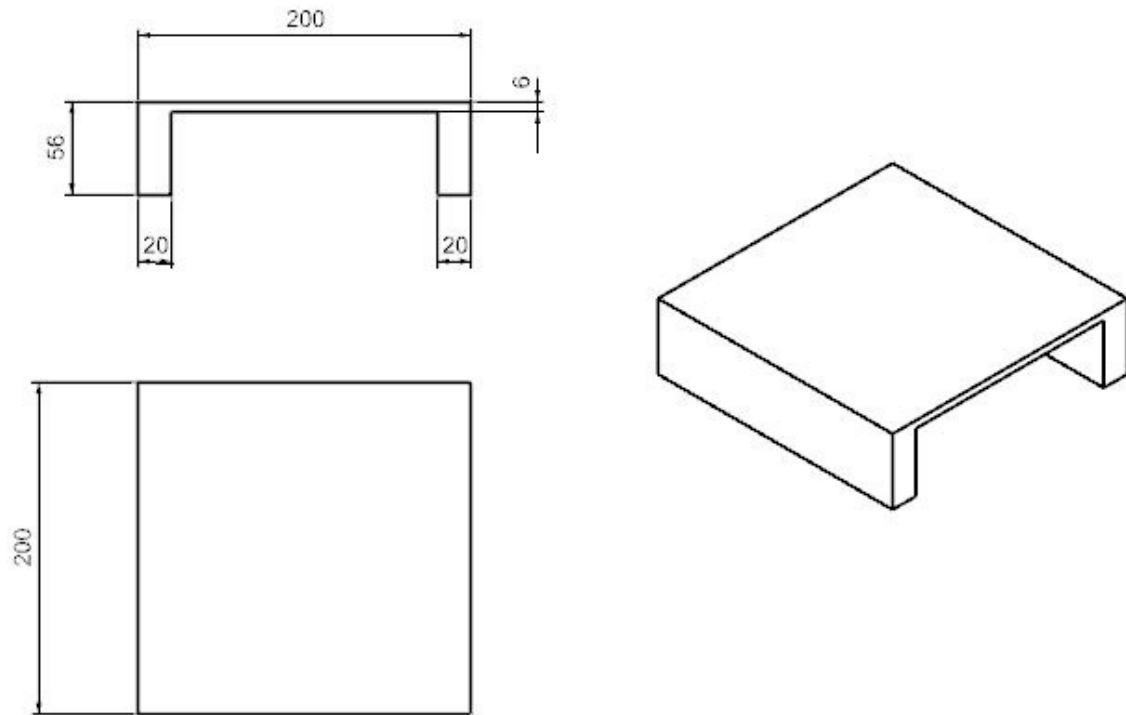
There are six (6) docking positions at the loading/unloading bay. The thin plate mounted at the top of each grid pattern stand is less than 3mm thick.





#### 10.4 LOADING/UNLOADING PLATFORM

The top surface of this platform is “beige” in colour and it is made from MDF board.



## 10.5 GRID PATTERN

The overall size of the grid pattern is approximately 40mm by 40mm. It is printed on white paper.

