

Competitor Information Document

Autonomous Mobile Robotics

Submitted by:
Derek Murphy/James Taylor
Independent Test Project Designer

1. Introduction	3
2. Description of project and tasks	3
2.1 Main Test Project.....	3
3. Instructions to the Competitor	4
3.1 Competition Requirement	4
3.2 Activities to be completed before the Competition	4
4. Equipment, machinery, installations, and materials required	5
4.1 Equipment provided by Competition Organizer	5
4.2 Equipment and material not permitted.....	6
4.3 Items to be provided by the teams.....	6
5. Main Test Project	7
5.1 Module A - Work Organization, Management and Communication	7
5.2 Module B – Design	8
5.3 Module C – Prototyping.....	8
5.4 Module D – Navigation and Localization	9
5.5 Module E - Vision	10
5.6 Module F – Robot Environment Interaction	11
5.7 Module G – Testing and Fault Finding	11
5.8 Module H – Performance and Commissioning	12
5.9 Mock Schedule.....	13
5.10 Test Project Summary.....	14
Appendix A - Work Organization, Management and Communication	14
Appendix B - Design	14
Appendix C - Prototyping	15
C.1 – Example List of Parts.....	15
C.2 – Example Task for Module C	15
Appendix D - Navigation and Localization.....	17
D.1 – List of Sample Robots that might be used for Module D.....	17
D.2 – Example Task for Module D.....	17
D.3 – Example Court for Module D.....	18
Appendix E –Vision.....	19
E.1 – Example set fruits or Module E.....	19
E.2 - Example Task for Module E.....	20
Appendix F - Robot Environment Interaction.....	20
F.1 – Example Task for Module F	20
Appendix G - Testing and Fault Finding.....	21
G.1 – Example Task for Module G.....	21
Appendix H - Performance Review and Commissioning	21
H.1 – Task Procedures.....	21
H.3 –Module Items	25

Note: The main changes from the previous version are identified in blue for easiness of reading.

1. Introduction

The primary focus of the WorldSkills 2024 Autonomous Mobile Robotics CID is to outline the requirements for Competitors to assemble/prepare/manage/repair robots to interpret multiple environments and tasks in various environments that will be introduced onsite at the competition. It is expected robots will take the environmental information they have gathered and use this information to manage both their overall mobility and target object handling experiences.

The agriculture sector is experiencing a surge in automation and robotics, leading to an increased demand for mobile robotic technicians and engineers who can develop and maintain robotics systems in this industry. As part of the WorldSkills 2024 Lyon competition, participants are tasked with designing, constructing, and operating a Mobile Robot that meets all performance requirements. To accomplish this, Competitors must carefully analyze the information presented in this document to identify the primary set of performance requirements for the Mobile Robot. The Mobile Robotics skill at WorldSkills 2024 in Lyon will introduce various modules that target specific skills of a Mobile Robotics Technician or Engineer.

The Robot will be able to function autonomously in in multiple environments. Sample environments and guidelines that can be used for preparation purposes are presented in the **appendixes**. As an example, the Robot will be able to manipulate objects of varying size and weight, from various locations on a course and deposit them in specified positions.

In addition, Competitors will be expected to manage their robot's mobility in an unknown environment. This experience will require the robots to demonstrate their **capability** to complete a navigation and localization task with a supplied sample robot.

2. Description of project and tasks

2.1 Main Test Project

Teams of two Competitors are required to design and build a mobile robot that will efficiently operate in custom environments that represent real-world scenarios or tasks.

The main Test Project is broken down into various modules in accordance with the WorldSkills Occupational Standards (WSOS). Competitors are expected to identify the Primary Set of Mobile Robot Performance Requirements through analysis of the information provided in this document:

1. Robots are required to move mostly autonomously throughout any performance evaluation environment,
2. Robots are required to Take control of the various target objects and move them to within in the performance environment.

Note: The Primary Task that Competitors must complete on C-2 **is to prepare the team's laptop and** complete the re-assembly of their robot in time to make it available to complete tasks as required on C1.

3. Instructions to the Competitor

3.1 Competition Requirement

Each Team will receive the following at the event:

- One WorldSkills 2024 Lyon Mobile Robotics Component Collection from Studica. Competitors are expected to develop their mobile robots using the components provided in the collection.
- In addition to the supplied collection, Competitors can 'purchase' additional Studica Robotics parts (only) to a value of up to 400 Studica's Points. Individual 'costs' and availability will be announced four months prior to the competition (C-4 months) on the official WorldSkills Discussion Forum. **Teams must select those parts in the dedicated subforum, on a first-come first-served claim within one month of the announcement. The final list will be published three months prior to the Competition (C-3 months) to ensure that they are available on site. That will be the last change allowed to the list, and any change request after will not be authorized.**

The equipment purchased by the use of the Studica's Points is mostly focused on their use by the teams in Module H, but the parts can be used during any module where the Competitors can use their robot.

Competitors will be allowed 3D printed parts and parts made from sheet stock as per the requirements specified in this document.

An assembled robot must begin any test run with the following size restrictions:

Using a measuring device, the Competitor Robot will be measured to ensure that in its unique starting (pre-match setup) configuration fits within a 600 mm x 600 mm x 600 mm requirement.

Surprise Test Project Modules or Tasks – the Surprise Test Project Modules or Tasks will be released to Competitors during meetings, and no notes may be taken at this time.

3.2 Activities to be completed before the Competition

Design, Prototyping and Testing of the Competitor Robot and manufacture of all permissible Competitor designed components needed by the team to assemble their robot for the Test Project.

Competitors could also prepare custom wiring harnessed to be used on the competition robot for the main Test Project.

Preparation of all items for Module B.

Note: Studica items/components are not to be modified in any way prior to the Competition. Subject to penalty with withdrawal of item or additional time on team or increase in item cost.

4. Equipment, machinery, installations, and materials required

4.1 Equipment provided by Competition Organizer

A WorldSkills 2024 Lyon Mobile Robotics Component Collection, [sample test elements](#), and any purchased (kiosk items) Autonomous Mobile Robotics Competition components will be provided on C-2 to all Competitors ([one kit/set per team](#)).

A **Laptop** with the core programming tools installed will be provided on C-2 to all Competitors ([two laptops per team](#)).

All equipment, tooling, and materials in the Infrastructure List – see WorldSkills Discussion Forum and Technical Description.

- All materials for any surprise Test Project as listed in the Technical Description;
- Testing equipment for fault finding module;
- Objects required for manipulation during the performance tasks and testing;
- Test court for the performance evaluation tasks;
- Test walls and objects for the navigation and localization tasks and , ranging from 500 mm to 1000 mm;
- Sample Robot with instructions for the navigation and localization tasks;
- Sample Robot with faults and instructions for the fault-finding modules;
- Parts and tools required to complete the Design and Prototyping modules.

4.1.1 VMX

For all modules except for module D ([Navigation and Localization](#)), Competitors may use any software that runs on the VMX.

For module D, the provided VMX will run the WPILib C++ and Java default configuration.

4.2.2 Competitor Computer

For all modules except for Module D, Competitors may use any software, understanding that no support will be given.

The computer will contain all the required software needed for the competition:

- [WPILib Java and C++ \(2020\)](#)
- [Local version of Studica Docs Page](#)
- [Control Station Console](#)
- [Studica Update and Config App](#)
- [NavX Utilities \(e.g. Firmware Update, navXUI, navXConfig, Magnetometer Calibration\)](#)
- [VNC Viewer](#)
- [Putty / Terra Term](#)
- [SD Card Tools \(e.g. Belena Etcher, SD Card Formatter\)](#)
- [LabVIEW \(published version of LabVIEW from the Studica Docs page\)](#)
 - [If your LabVIEW is different it will need to be loaded on C-2.](#)
- [Python](#)
- [OpenCV](#)
- [Docker-Desktop](#)
 - [Local version of CVAT](#)

- **Fusion360**

Any changes or updates to this list will be posted on the WorldSkills Forum. Experts can propose changes using the WorldSkills Discussion Forum , but such changes, if approved, will be available for all the teams.

For module D, Competitors(**Navigation and Localization**), Competitors will be provided with a password to a different user on the Competitor provided laptop with the default programming environment for WPILib C++ and Java development. A base project will also be provided on these laptops.

4.2 Equipment and material not permitted

- **Any additional** Laptop or portable computers.
- PDA's e.g. Palm, IPAQ etc.
- Memory sticks/MP3 Player/Digital Storage. **(except on C-2).**
- Walkman radio/CD Player.
- Electronic organizer/diaries.
- Wireless communication devices including a mobile phone.
- Any additional software not supplied by Competition Organizer unless approved by Experts.
- Any non-approved pre-programmed VMX controller images', teams will be required to erase any images under the supervision of an Expert during Familiarization and will then be provided with a pre-approved version.
- Purchased items modified in any way prior to the Competition.
- Equipment that is similar or operates in similar manner as supplied equipment. Example – if a metal cut-off saw is provided by Competition Organizer, then no team may provide their own metal cut-off saw.
- All raw materials, components, parts, purchased item, tools, and equipment not permitted in the Technical Description and List of Materials Allowed and Not Allowed of the skill.

Additional items could be decided as not permitted by the Skill Management Team prior or during the competition, as long as the information is provided to Competitors/Experts.

4.3 Items to be provided by the teams

Each Team must provide and wear team identification that indicate their region. These must be always worn during the Competition **and should follow overall WorldSkills regulations.**

Competitors may manufacture and create custom components for their mobile robot. Some restrictions will be enforced and checked before the Competitors may build their robot on C-2, **independently on which module(s) would those components be used or being main components or spare ones.**

1. All 3D-Printed elements must be created using ABS, PLA, Nylon, PETG, HIPS, ASA, or Carbon Fiber Filled.
2. All sheet components must be created using any polycarbonate material.
3. Competitors are allowed to bring custom cabling and electrical wires required for the robot's wiring. Custom PCBs are permitted only for custom wiring. The custom PCB may only contain headers/sockets and capacitors/resistors for any extra filtering.
4. The maximum overall weight of **3D-Printed elements, sheet components,** and assembled **PCBs** should be below 1.5kg (this is including both main components and spare ones).
5. Competitors must bring **three** cloned copy of the Micro SD Card used on the VMX. This is due to the restriction of no internet on-site, which means all packages and software must be installed beforehand.
6. Competitors must provide a USB with any software they wish to put on the computers provided to the Competitors. The USB may be used on C-2 to load the software and thereafter it will be held by the Skill Management Team (SMT) and can only be used to recover a critical failure.
7. Competitors must bring at least three Competitor manufactured baskets for module H. A spare is recommended. The weight of the baskets is not applicable to 4.3 (D).

8. Competitors will be required to bring any custom components with them to Lyon. They will not be provided on-site.
9. On C-2, Competitors' custom components will be inspected by Experts to ensure compliance with these restrictions. Any components outside the compliance must be modified before Competitors assemble their robot.
10. Personal protective equipment.

Additional, Competitors could bring:

- Electrical and electronic wiring harness components.
- Jigs, fixtures, formers and clamping devices.
- Other specific manufacturing equipment or tools required that is not in the Infrastructure List.

During the competition duration, no tools, equipment, stationary, components, part, raw materials, manuals, drawings, electrical device or digital storage device, unless approved by the **SMT** may be removed from or brought into the Competition venue. **To enter any additional items in the competition after Familiarization Day, the approval of the SMT is first necessary, and if approved, it must be checked immediately by the responsible Experts.**

5. Main Test Project

The main Test Project is broken down into various modules in accordance with the WorldSkills Occupational Standards (WSOS).

The WorldSkills 2024 Lyon Mobile Robotics Test Project requires Competitors to design, build, and operate a Mobile Robot capable of addressing ALL the performance requirements.

Competitors are expected to identify the Primary Set of Mobile Robot Performance Requirements by analyzing the information provided in this document.

Starting at WorldSkills 2024 in Lyon, the Mobile Robotics skill will introduce different modules that focus on specific skills of a Mobile Robotics Technician or Engineer.

5.1 Module A - Work Organization, Management and Communication

5.1.1 Completion Time:

The first Module is focused on addressing the sections 1 and 2 of the WSOS – “Work Organization and Management” and “Communication and Interpersonal Skills”.

Module A – **Work Organization, Management and Communication** is observed throughout the competition.

5.1.2 Assessment Criteria:

Work organization and management represents an important part of the regular tasks teams are expected to perform on a cooperative environment. Moreover, there are multiple ways for a Competitor to communicate. It is expected that a Competitor will always communicate in a professional manner.

Both criteria will be evaluated based on a system like the “Yellow / Red Cards” used in Football. Assessment is ongoing all day and it will be conducted by a team of Experts.

The following are examples of potential criteria:

- Adherence to schedules;
- Co-operative Behaviour with your Compatriot Competitor, Opponent Competitors and the Experts;
- Workspace Organization;
- Robot Assembly Completed on Time;

- Asking before leaving Competitor work area;
- Robot communication lights correctly used, to demonstrate if the robot is moving or not;

5.1.3 Module Task:

No specific task will be made for this module, as it happens during the entire competition. During C-2, warnings could be given, but no point deduction will happen.

5.2 Module B – Design

5.2.1 Completion Time:

Module B is based on an inspection of the Competitor’s Assembled Robot by a panel of three Experts as well as the completion of some simple core tasks with the focus being on the following sample areas/items.

ASPECT ID	DESCRIPTION
1	Base Robot – Structural Elements
2	Wiring Installation
3	Drive System Installation
4	Object Management Design and Wiring
5	Driving Performance
6	Accuracy
7	Maintenance Test
8	Safety
9	Operation of Object Management System

5.2.2 Assessment Criteria:

Module B is marked by the Experts during the competition, information on the specific tasks and test required will be provided to Competitors in the morning briefing.

5.2.3 Module Task:

Appendix B contains the inspection and criteria on which the Experts will mark the Competitor's robot design.

Competitors can create a 3 minute video going over the inspection list and a description of what each major part of the robot does. This video should be submitted on C-2 identified by their country code.

5.3 Module C – Prototyping

The prototyping module emphasizes the Competitor’s ability to create a prototype for a given problem. Competitors will receive a designated set of parts and must utilize them in designing their prototype. It is important to note that no components from the Competitor’s personal collection can be utilized in this module. The focus of the prototyping module lies solely on developing a mechanical solution and does not involve any programming requirements.

Competitors to complete this module. No Competitors' competition or purchased components may be used for this module. A similar list will be given to the comp Appendix C contains an example list of parts that will be provided to the etitors on the start of the module.

5.3.1 Completion Time:

Module C – Prototyping is expected to be completed in 3 **dedicated** hour time block. **After submitting their prototype, teams could use the remaining time after to continue preparing themselves for other modules, either in their workstation, or in the arenas.**

5.3.2 Assessment Criteria:

Module C is marked by a three-judge panel made up of Experts.

5.3.3 Module Task:

Competitors will be required to prototype a solution given to them given a kit of parts separate from the competition kit. Appendix C contains an example task.

5.4 Module D – Navigation and Localization

The navigation and localization module focuses on the Competitor's skill to navigate and traverse an unknown area. The module is unique as it uses a robot separate from the robot created by the Competitors. Competitors will be given a robot to use on the navigation court. The robot will be one of five known in advance robots.

The robot will only be allowed to be programmed in Java or C++. A base project template will be provided that Competitors may use. Competitors may only use libraries for the code if the code is submitted beforehand to the Skill Competition Manager **(at least C-2 months)**. This code will be shared with all teams **and announced in the WorldSkills Discussion Forum**.

5.4.1 Completion Time:

Module D – Navigation and Localization **Module** is expected to be completed **in a total 4** hour time block. **After the briefing and the robot announcement, following a random order, at least 1 hour will be given for teams to strategize about their test run, check the provided robot, modify the code, practice with the robot (outside the arena). Each team will have 15 minutes in the navigation arena to run the evaluation. If a team completes the task or preparation, they could use the remaining time to continue preparing themselves for other modules, either in their workstation, or in the arenas.**

5.4.2 Assessment Criteria:

Module D is marked objectively by a three-judge panel made up of Experts.

5.4.3 Module Task:

Appendix D contains an example task the Competitors can expect to see at the competition.

5.4.4 Specific Equipment:

Competitors will be given a preassembled robot separate from the robot they designed. **The robot will be one of five known in advance robots, or one surprise one.** Appendix D has the **list of five of the six possible robots. No building instructions will be directly provided to the teams. If instructions were previously found in public, they can be used for practice, at the team's own responsibility (as it might not be the exact ones). Prior to the event, a draw will be done in video, but this will be kept confidential until the event.**

Competitors will be given **access to a new computer or** a password to another user on their Competitor provided laptops to program the robot on **(no practical change, only being explored for logistic reasons).** That laptop **(or user)** will only have projects for Java or C++. The template projects will be provided ahead of time for Competitors to use and practice with. Should any Competitor wish to use code outside of the project, that code must be added beforehand for all Competitors to see. If Competitors do not submit any code to be added, they must memorize the code. Competitors will not be allowed to use any outside notes.

5.5 Module E - Vision

The vision module focuses on the Competitor's skill to create machine vision algorithms to detect and analyse different objects. The vision module is unique, as a robot is not required. However, Competitors may use their robots **(or parts of it)** if they wish. An example task for the vision module is in Appendix E. **task is conducted in a secure closed space to ensure equal chances to all teams. Spare cameras will be available for this module if required.**

5.5.1 Evaluation Time:

Module E – Vision is expected to be completed **in a total of a 3-hour** time block. **After the briefing, at least 1 hour will be given for teams to strategize about their test run and practice at their workbench. After that, following a random order, each team will have 15 minutes in the fault-finding room to run the evaluation. If a team completes the task or preparation, they could use the remaining time afterwards to continue preparing themselves for other modules, either in their workstation, or in the arenas.**

5.5.2 Assessment Criteria:

Module E is marked objectively by a three-judge panel made up of Experts.

5.5.3 Module Task:

Appendix E contains an example task the Competitors can expect to see at the competition.

5.5.4 Equipment:

Competitors will be given a set of unknown objects to complete the task. From the set of objects, a random sample will be chosen and used for evaluation. The set of objects used will be the same for all competitors.

For purposes of practice and getting ready for the competition there is a fruit collection that can be purchased from Studica, but the fruit in this package will not be used in Lyon for this module.

5.6 Module F – Robot Environment Interaction

A robot interacting with objects or a human part of its environment through physical contact must apply appropriate forces and torques. It must also adapt them to conditions that change with time safely and stably. For example, a robot breaking an egg must adjust its behaviour not to damage the egg inside. Similarly, a robot applying force on a human arm must be able to maintain this force while accommodating any unplanned movement. This challenge is at the core of industrial applications or human-machine interaction.

5.6.1 Evaluation Time:

Module F – Robot Environment Interaction is expected to be completed in a total 3-hour time block. After the briefing, at least 1 hour will be given for teams to strategize about their test run and prepare themselves. After that, following a random order, each team will have 15 minutes in the court to run the evaluation. If a team completes the task or preparation, they could use the remaining time after to continue preparing themselves for other modules, either in their workstation, or in the arenas.

5.6.2 Assessment Criteria:

Module F is marked objectively by a panel made up of three Experts.

5.6.3 Module Task:

Appendix F contains an example task the Competitors can expect to see at the competition.

5.6.4 Equipment:

Competitors will be given an unknown object(s) that he will need to be manipulated by or will interact with the robot. The basic size and weight requirements of these object(s) will be provided in advance via the WorldSkills Discussion Forum.

5.7 Module G – Testing and Fault Finding

The Testing and Fault-Finding module focuses on the Competitor's skill to test and find faults in given hardware. Competitors will be given faulty equipment and required to diagnose and report the fault and solutions to fixing the fault. Competitors may also be requested to fix a broken object using the provided datasheets. The documents and written brief given to all Competitors during the Fault Finding will be in English and will not have a specific translation to simulate a specific work environment where the technical documents are available. This task is a 'fault-finding' evaluation and it is conducted in closed space to ensure equal chances to all teams.

5.7.1 Completion Time:

Module G – Testing and Fault Finding is expected to be completed in a total 3-hour time block. After the briefing, at least 1 hour will be given for teams to strategize about their evaluation. After that, following a random order, each team will have 15 minutes in the fault-finding room to run the evaluation. If a team completes the task or preparation they could use the remaining time after to continue preparing themselves for other modules, either in their workstation, or in the arenas.

5.7.2 Assessment Criteria:

Module G is marked objectively by a three-judge panel made up of Experts Eperts **based on the submitted 'report' by the teams.**

5.7.3 Module Task:

Appendix G contains an example task the Competitors can expect to see at the competition.

5.7.4 Equipment:

Competitors will be provided a separate area to complete this task and will be supplied with a sample robot or components to test. It is expected that a Competitors will complete this task as scheduled at any time with the competition timeframe. **The Competitors can't bring any notes nor equipment into the fault-finding room.**

5.8 Module H – Performance and Commissioning

Module H is the main task of the **Autonomous** Mobile Robotics Skill and based on the sample task known to all competitors. Core performance tasks and test runs are completed in this module on a court that might have a dimension around 2m x 4m, 4m x 4m, 4m x 8m or 8mx8m. **For WSL2024, a the 4mx4m configuration was chosen. The court layout and test objects to be used will be made available to competitors on C1. The information on the actual requirements for the test runs will be announced during the morning briefing on C3 and C4.**

5.8.1 Completion Time:

Module H – Performance and Commissioning is expected to be completed at the end of C4 after starting the morning of C3. A total time of two full Competition days.

5.8.2 Assessment Criteria:

There are three categories to module H.

1. Individual Performance Tasks – Marked by Experts using a single pass or fail.
2. Performance Run 1 and 2 – Marked by Experts using a marking sheet at the end of a run.
3. Performance Run 3 – Marked by Experts using a marking sheet at the end of a run.

In previous editions, when a robot got stuck it was the end of the test run.

For WSL2024, competitors will be able to reset and move their robot to a known location either using tele-op or manually and starting autonomous again. However, marks will be deducted from the teams run for any adjustment. In order to simulate a real event, Tele-op adjustments will have smaller deductions manually moving the robot.

5.8.3 Module Task:

Appendix H contains an example task the Competitors can expect to see at the competition.

The task should be performed mostly Autonomous, but teams are allowed to interfere with the robot (with penalties), either using tele-operation, or manually (physically touching the robot). This will allow the Competitors to perform small adjustments to the robot, backing it up into a known stage. The details of this will be provided on the Test Project, but teams will require to announce each interaction with the Experts marking that run.

5.8.4 Equipment:

Module H is where the competitors **will take the most advantage of the robots** they designed at home. The robots will be built from the WorldSkills 2024 Lyon Collection and any additional purchased components within an allowance (Studica's Points) budget as available from Studica **and the manufactured custom components**.

For this module, the only changes applied to WorldSkills Lyon 2024 will be a new court design, a new set of main objects (instead of the grapes are currently part of the example) and colour changes to the seeds and dispensers.

Court and colour changes will be kept secret until the event. The main object specifications will be posted on the WorldSkills Discussion Forum at C-2 Months. Competitors should be aware of the changes to the main object as it may interfere with claw/gripper, and basket designs.

5.9 Mock Schedule

Competitor Schedule						
Time	C - 2	C - 1	C1	C2	C3	C4
Morning	Familiarization Day	Empty	Module C	Module E / F / G	Module F / H	Module H
Afternoon	Competitors Build Robot designed prior to competition		Module D		Module H	Module H

If Competitors finish the modules early, they may use the time to practice for other modules.

Competitors are allowed to modify (build) parts of their robot during the Competition days

5.10 Test Project Summary

Module	Days	Main Location	Equipment	Evaluation
A/B	C1 – C4	All	N/A	Judgement
C	C1	Workspace	Dedicated	Judgement
D	C1	Navigation Court	Dedicated	Measurement
E	C2	Secret Room	Any	Measurement
F	C2 – C3	Competition Arena	Any	Measurement
G	C2	Secret Room	Dedicated	Measurement
H	C3 – C4	Competition Arena	Any	Measurement

Appendix A - Work Organization, Management and Communication

No further information at this point.

Appendix B - Design

Design is marked by the Experts on how well the robot is built by the Competitors. To help the Experts with marking and understanding the robot. Competitors can create a 3 min video going over the inspection list and a description of what each major part of the robot does. This video should be submitted on C-2 identified by their country code.

Appendix C - Prototyping

C.1 – Example List of Parts

Below is an example list of parts the Competitor may receive for completing module C.

During the module no parts outside of the list provided (during the competition) will be permitted.

MODULE C EXAMPLE PARTS LIST		
288 mm U-Channel	76013	2
20 mm OD Round Groove Pulley	76235	4
Polyurethane 5 mm Round Belt 3 m length	76400	1
Rack & Pinion Set	76170	2
End Piece Plate	76143	2
30 Tooth GT2-6mm Timing Belt Pulley	76451	4
GT2-6 mm Timing Belt Clamp w/Set Screw	76456	2
GT2 Timing Belt, 2 mm Pitch, 6 mm width, 810 mm Closed	76463	2
6 mm x 96 mm D-Shaft	76161	6
U-Channel Bumper	76505	4
Rubber Foot	76506	4
32 Tooth Gear	76220	2
48 mm Square Beam	76108	1
14 mm Bronze Bushing	76301	12
Shaft Spacer 1 mm	76305	24
Shaft Spacer 2 mm	76306	24
6 mm D Shape Collar Clamp	76320	4
6 mm Shaft Hub	76284	4
M3 Kep Nut	76204	100
M3 x 10 mm Socket Head Cap Screw	76201	100
M3 x 20 mm Socket Head Cap Screw	76209	50

C.2 – Example Task for Module C

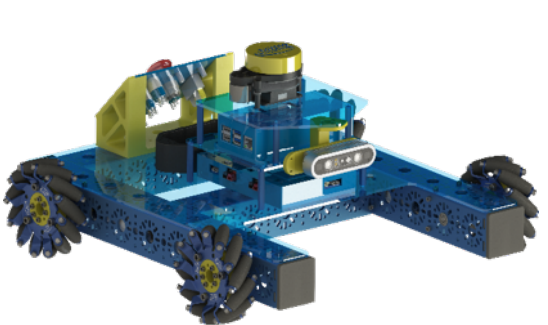
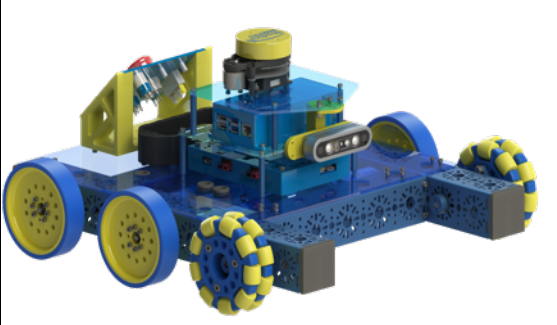
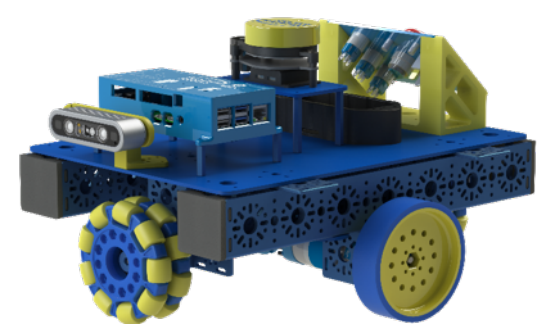

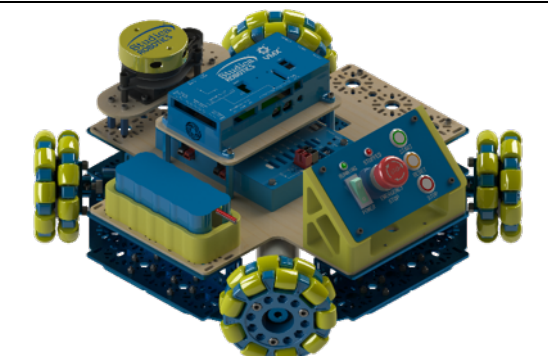

Using the list of parts in C.1, design a conveyor system to get a foam golf ball to travel 240 mm. The conveyor, once built, can be spun by hand to simulate a moving conveyor.

The example solutions below are for training purposes only (and might not be able to be built with the list above).



Appendix D - Navigation and Localization

D.1 – List of Sample Robots that might be used for Module D

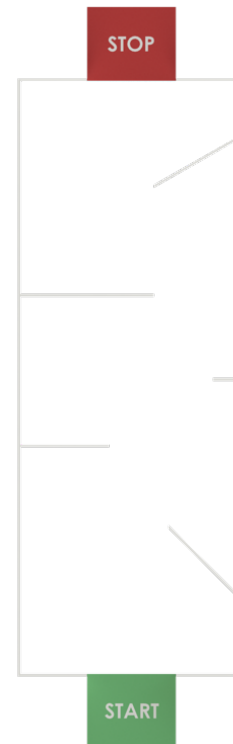
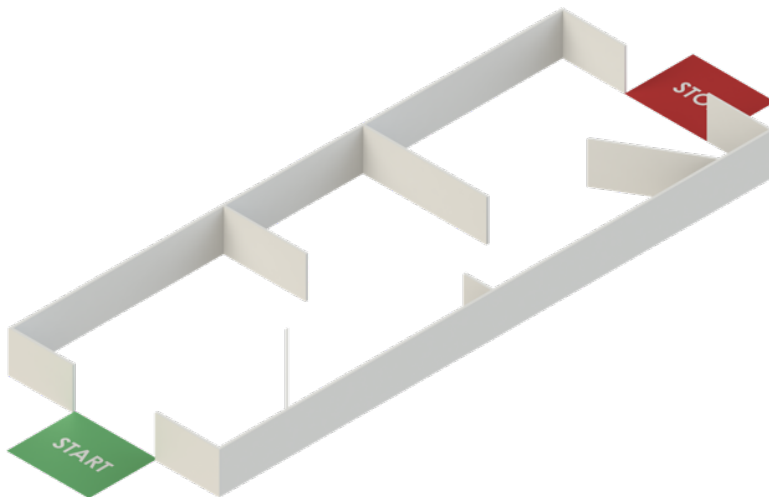
Chassis	Picture	Chassis	Picture
1 Mecanum		4 Six Wheel Drive	
2 Two Wheel Drive		5 The Stack	
3 X-Drive		6 Unknown Variation	

D.2 – Example Task for Module D

One of the robots from D.1 could be chosen for use during module D. For the below example task, **let's say the X-Drive robot** was chosen.

Competitors will be required to program the X-Drive robot in Java or C++ with the provided project template. **Competitors are not allowed access to the court except for the evaluated run. The robot must be calibrated and tested in their work area or one of the main module H courts. During an evaluation run the robot is placed in the start position and must end in the end position.** No code modification is allowed once the robot enters the test area.

D.3 – Example Court for Module D













This design isn't the one being used in WorldSkills Lyon 2024, but Competitors will be able to see the actual field during the event.

Appendix E –Vision

E.1 – Example set fruits or Module E

This set will not be used in WorldSkills Lyon 2024, it should be used as sample objects for training purposes only.

Peach	Apple	Lime
		
Garlic	Kiwi	Mangosteen
		
Chili Pepper	Banana	Orange
		
	Pomegranate	
		

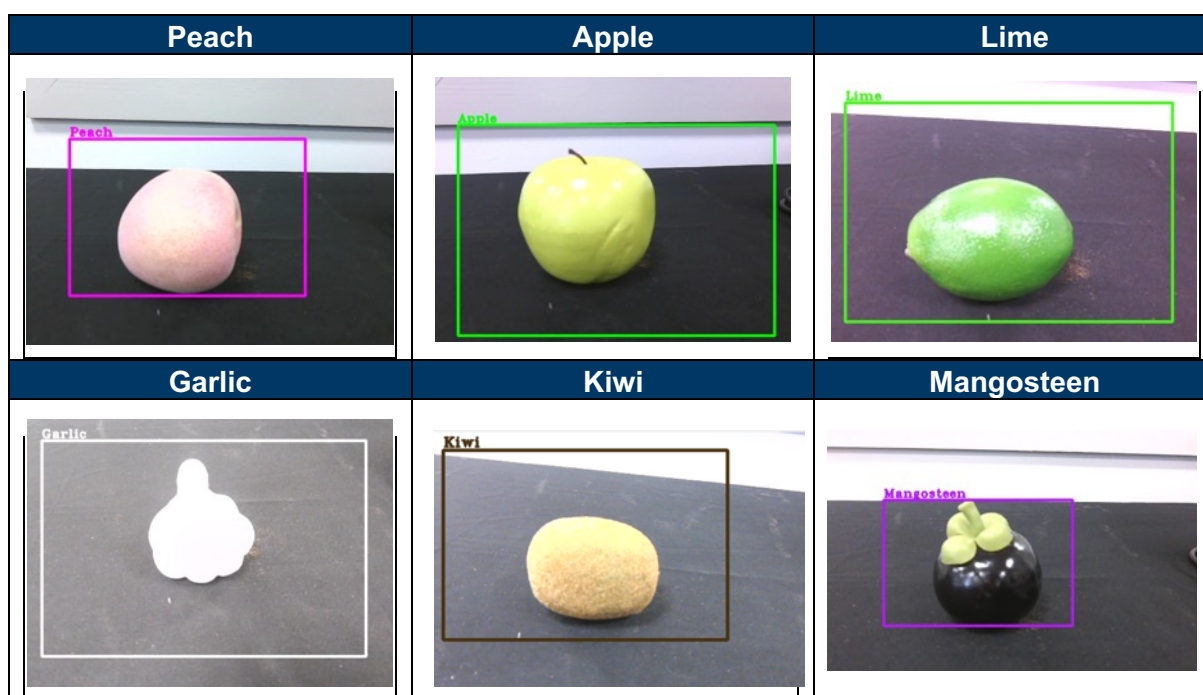
E.2 - Example Task for Module E

Five random fruits will be chosen from the fruit in E.1. The Competitors will be required to use machine vision to identify the fruit.

Competitors will be marked on a live stream video from the camera and vision program. The Expert will place the fruit in the camera's FOV (Field of View), and the vision program will either display on the camera feed or a simple print statement as to the identity of the fruit.

Fruit will only be placed one at a time in the camera FOV.

Sample results:



Appendix F - Robot Environment Interaction

F.1 – Example Task for Module F

Competitors will be given an unknown object for the Competitor robot to manipulate. **Despite the object being unknown, it has similar characteristics in terms of scale and weight with the fruit in example E.1.**

For the example task, Competitors will be given the Chilli Pepper from the Vision Module in E.1. Competitor robots are required to pick up the Chilli Pepper, drive 1m, turn around, drive back, and place the Chilli Pepper back in the same spot it was picked up from.

In this example, the height and placement of the Chilli-Pepper at the start is up to the Competitor.

The additional details will be provided during the Competition.



Appendix G - Testing and Fault Finding

G.1 – Example Task for Module G

A template is provided that shows how Module G is performed. Competitors will receive a robot or platform, that they will need to examine and follow the template as a checklist and complete. The robot or platform will have some damaged or not working parts that needs to be identified.

Appendix H - Performance Review and Commissioning

H.1 – Task Procedures

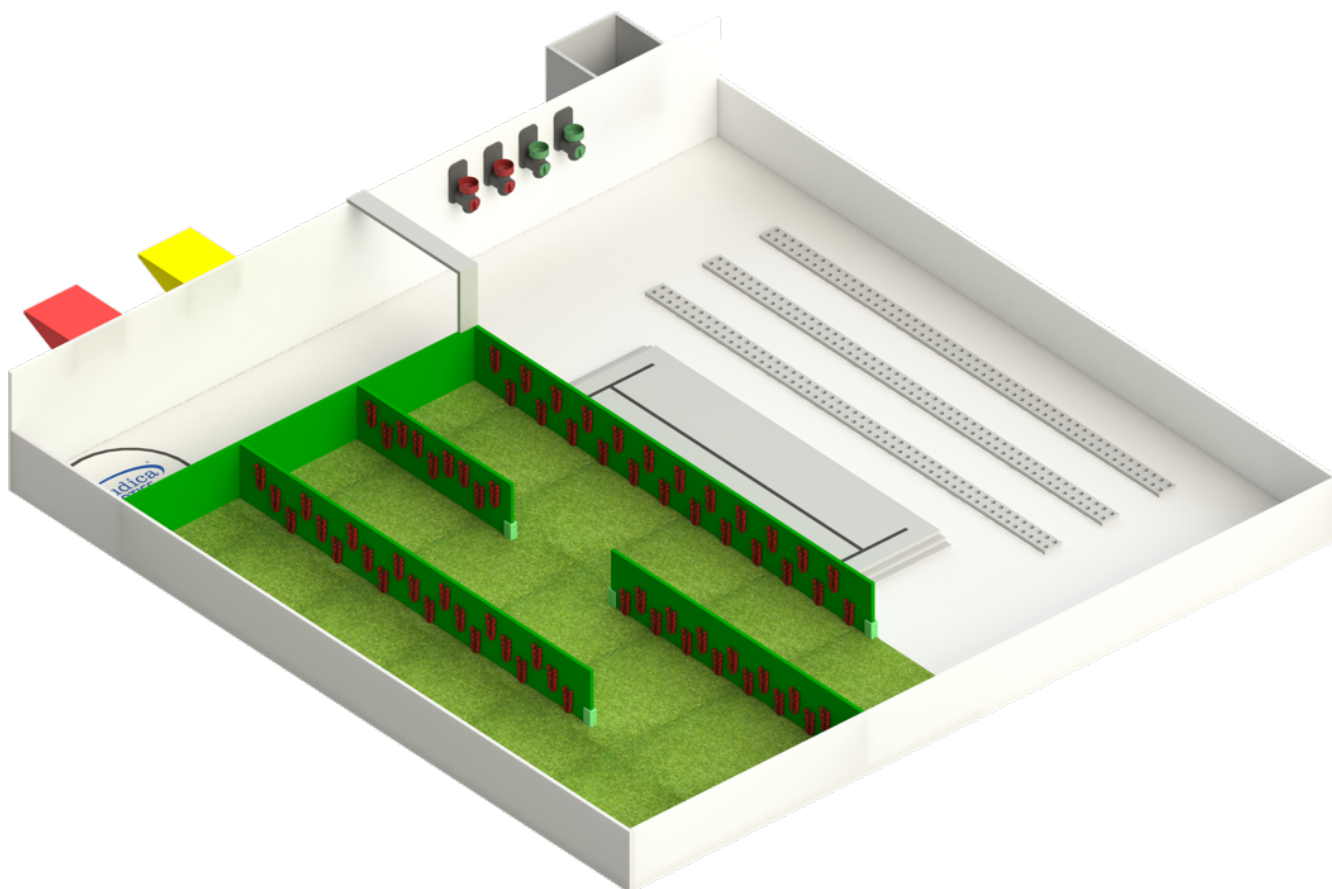
In the morning briefing Competitors will be provided a random sample of the required information for the performance task. Prior to starting a run the competitors will input the order in which the robot must complete their tasks directly on their computers at the beginning of the performance run.

If a robot becomes stuck during a performance run, Competitors have two options to resolve the situation and resume the autonomous operation. Firstly, they may physically enter the court, relocate the robot to a predetermined position, and reactivate its autonomous mode.

Alternatively, Competitors can remotely control the robot to move it to a known location and then switch it back to autonomous mode. It should be noted that if remote control is employed, the run will be evaluated with a penalty, whereas if a Competitor enters the court, the penalty would be higher.

H.2 – Sample Module ItemsPerformance Review

There are three runs to be completed on the example court. Runs 1 and 2 are the same, however the order is different, and the layout of the grapes is different. Run 3 is completely different from runs 1 and 2.



H.2.1 Sample Sequence for Runs 1 and 2

1. Robot is placed on the court on the charging pad.
2. Competitor sends the order to the robot.
3. Grapes are placed on the grape vines according to the roll of the dice.
4. Competitor starts the robot by hitting the start button on the robots control panel.
5. Robot takes a basket from the red station.
6. Robot goes out and gets the first batch of the order.
7. Robot places the basket on the yellow / green station.
8. Robot repeats 5 – 7 until order is complete
9. Robot goes back to the charging pad.
10. Robot flashes the red stopped LED on the control panel to indicate run complete. (Experts will not stop the time until this is displayed.)

H.2.2 Sample Sequence for Runs 3

1. Robot is placed on the court, on the charging pad.
2. Competitor sends the order to the robot.

3. Seed Dispensers are randomized based on a roll of the dice.
4. Competitor starts the robot by hitting the start button on the control panel.
5. Robot travels to the seed dispensers and collects the seeds.
6. Robot plants the seeds based on the order.
7. Robot repeats 5-6 as needed.
8. Robot travels to the charging pad.
11. Robot flashes the red stopped LED on the control panel to indicate run complete. (Experts will not stop the time until this is displayed.)

H.2.3 – Example Order Run 1 or 2

Order:

- First Batch
 - 5 x Red Grapes
- Second Batch
 - 2 x Yellow Grapes
- Third Batch
 - 2 x Green Grapes

Grape Placement on court (roll of dice selects placement)

- Vine 1: Red Grapes
 - Grapes on row 1 and 3
- Vine 2: Green Grapes
 - Grapes on row 2
- Vine 3: Yellow Grapes
 - Grapes on row 1 and 2

A complete order would have the following baskets on the yellow / green station:

- Basket with 5 x Red Grapes
- Basket with 2 x Yellow Grapes
- Basket with 2 x Green Grapes

H.2.4 – Example Order Run 3

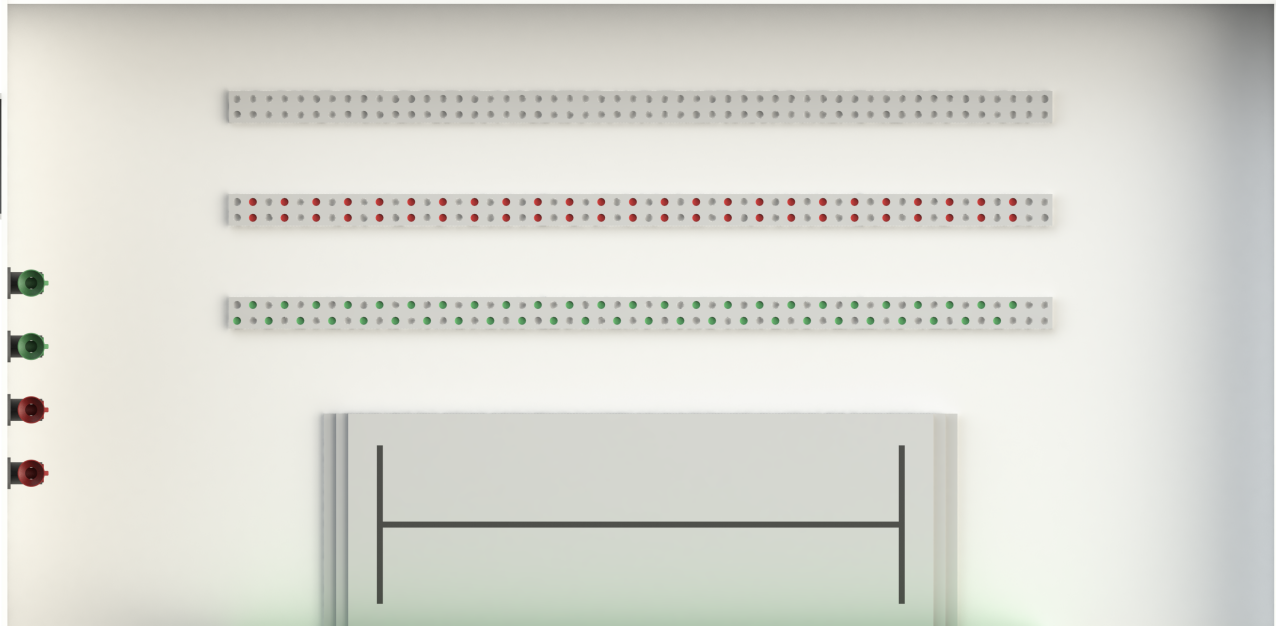
Order:

- Green Seeds
 - Planted in row 1 as a zigzag.
- Red Seeds
 - Planted in row 2 spaced evenly.

Dispenser Placement on court (roll of dice selects placement)

- Green Dispensers
 - Dispenser 3 and 4
- Red Dispensers
 - Dispenser 1 and 2

A complete order would look like below:



H.3 –Module Items

Within this document, there are objects which will be part of the final Test Project for WorldSkills Lyon 2024, and others which are just examples.

The Competitor Designed Basket will stay without changes (as it depends on the competitor's preparation), the Seed Pod Dispenser will have minor changes on the inside, and will have different colours (but same action mechanism), while the Seeds will suffer changes on the specifications (size/weight). The Grapes are only examples and will be replaced by a different object.

H.3.1 – Competitor Designed Basket



Competitors are required to design at least three baskets for their robots to deliver the test objects in (Sample module uses grapes). The baskets can be made from anything but must be manufactured by the competitors.

Specs for the basket:

- No size restrictions
 - Max number of objects the basket should hold is 6.
- No weight restrictions (Does not count towards the robots manufactured parts weight limit).
- Three minimum baskets must be made. Spares are encouraged.
- Basket starts location is the red station.
- Basket end location is defined on the run (e.g. the green or yellow station).

H.3.2 – Seed Pod Dispenser

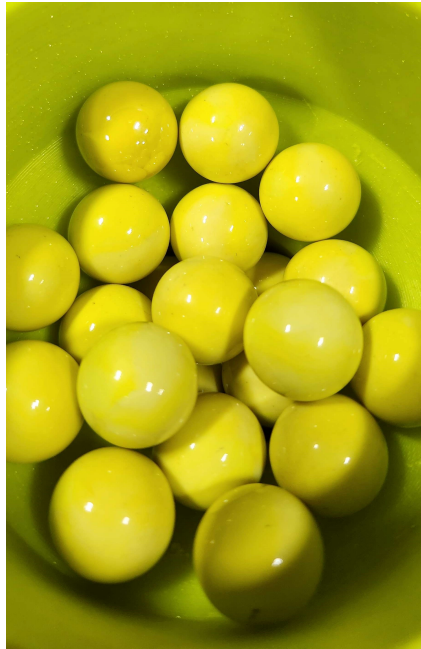


The seed dispenser is a 3D printed object that is attached to the wall of the court.

- **Four dispensers per court**
 - 2 x Red (sample)
 - 2 x Green (sample)
- **Holds 25 seed pods.**
- **Robot must turn the dispenser handle to allow the seeds to be dispensed into the robot.**
 - If the robot can't turn the dispenser the competitor may spin the handle (having a penalty).

At the competition the hopper and handle of the dispenser may have a different colour. In this training example Red and Green are used. The colour is chosen at the start of the run with a roll of the dice.

H.3.3 – Sample Seed Pods



Specs:

- **Size: 16mm**
- **Colour: Red, Green**
- **Weight: ~5.44g**
- **Normal 16mm Marble**

H.3.4 – Sample Object: Grapes



Specs:

- Measure: 12cm – 14cm
- # per stem: 20 – 23
- Weight: 24g – 26g
- Colour: Green, Red, Yellow