Competitor Information Document

Autonomous Mobile Robotics

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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 Appendix X. 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 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 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 WorldSkills WorldSkills Discussion Forum. Teams must provide a spreadsheet of the required parts to Studica two months prior to the competition (C-2 months) to ensure that they are available on site.

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

Manufacture Design, Prototyping and Testing of the Competitor Robot

e of all permissible Competitor designed components and needed by the team to assemble their robot for the main Test Project;

Manufacture of 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**, and any purchased Autonomous Mobile Robotics Competition components will be provided on C-2 to all Competitors.
- A **Laptop** with the core programming tools installed will be provided on C-2 to all Competitors.

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, 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. For module D, 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 be provided on these laptops.

4.2 Equipment and material not permitted.

- Laptop or portable computers.
- PDA's e.g. Palm, IPAQ etc.
- Memory sticks/MP3 Player/Digital Storage.
- 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.

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.

A) All 3D-Printed elements must be created using ABS, PLA, Nylon, PETG, HIPS, ASA, or Carbon Fiber Filled.
B) All sheet components must be created using any polycarbonate material.
C) 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.
D) 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).
E) Competitors must bring one 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.
F) Competitors will be required to bring any custom components with them to Lyon. They will not be provided on-site.
G) 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.
H) 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 Chief Expert may be removed from or brought into the competition venue. To enter into items in the competition after Familiarization Day, the approval of the Chief Expert is first necessary, and if approved, it must be weighed 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.

5.1 Module A - Work Organization and Management

5.1.1 Completion Time:

Module A – Work Organization and Management 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 and 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 and Management

Robot Assembly Completed on Time.

5.3 Module B – Design

5.3.1 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.

ASPE	
	Base Robot – Structural Elements
	Wiring Installation
	Drive System Installation
	Object Management Design and Wiring
	Driving Performance
	Accuracy
	Maintenance Test
	Safety
	Operation of Object Management System

5.3.2 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.

5.3.3 Module Task:

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

5.4 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.

5.4.1 Completion Time:
Module C – Prototyping is expected to be completed in 3 hours.

5.4.2 Assessment Criteria:
Module C is marked by a three-judge panel made up of Experts.

5.4.3 Equipment:
Appendix C contains an example list of parts that will be provided to the Competitors to complete this module. No Competitors' competition or purchased components may be used for this module.

5.4.4 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.

5.5 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. This code will be shared with all teams.

5.5.1 Completion Time:
Module D – Navigation and Localization is expected to be completed in 3 hours.

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

5.5.3 Equipment:
Competitors will be given a preassembled robot separate from the robot they designed. The robot will be one of three known in advance robots. Appendix D has the list of three possible robots.

Competitors will be given a password to another user on their Competitor provided laptops to program the robot on. The new user on the Competitor provided laptop 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.

5.5.4 Module Task:
Appendix D contains an example task the Competitors can expect to see at the competition.

5.6 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 if they wish. An example task for the vision module is in Appendix E.

5.6.1 Evaluation Time:

Module E – Vision is expected to be completed in 3 hours.

5.6.2 Assessment Criteria:

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

5.6.3 Equipment:

Competitors will be given a pack of ten simulated fruit. This fruit may be purchased ahead of time for practicing from Studica and is part of the Competition Elements Kit.

5.6.4 Module Task:

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

5.7 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.

5.7.1 Evaluation Time:

Module F – Robot Environment Interaction is expected to be completed in 3 hours.

5.7.2 Assessment Criteria:

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

5.7.3 Equipment:

Competitors will be given an unknown item that the Competitors robot must manipulate. The basic size and weight requirements of this item will be provided in advance via the WorldSkills Discussion Forum.

5.7.4 Module Task:

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

5.8 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 must also 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.

5.8.1 Completion Time:

Module G – Testing and Fault Finding is expected to be completed in 3 hours.

5.8.2 Assessment Criteria:

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

5.8.3 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 task will be provided using equipment that is provided in the workshop.

5.8.4 Module Task:

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

5.9 Module H – Performance and Commissioning

Module H is the main task of the Autonomous Mobile Robotics skill competition and based on the sample task known to call Competitors. Core performance tasks and test runs are completed in this module on a court that might have a dimension around 2 m x 4 m, 4 m x 4 m, 4 m x 8 m, or 8 m x 8 m.

5.9.1 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.

5.9.2 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.

5.9.3 Equipment:

Module H is where the Competitors will use 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. Teams are to submit their budget worksheet to Studica on advance so that the additional components will be available on site.

5.9.4 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.

5.10 Mock Schedule

Competitor Schedule						
Time	**C - 2**	**C - 1**	**C1**	**C2**	**C3**	**C4**
Morning	**Competitors Build Robot They Designed at Home** **Familiarization Day**		**Module D/E**	**Module C/G**	**Module H**	**Module H**
Afternoon			**Module D/E**	**Module C/G**	**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

Appendix A - Work Organization and Management

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		
Part	**Part #**	**QTY**
288 mm U-Channel	76013	1
20 mm OD Round Groove Pulley	76235	4
Polyurethane 5 mm Round Belt 3 m length	76400	1
6 mm x 96 mm D-Shaft	76161	2
Rubber Foot	76506	4
32 Tooth Gear	76220	1
48 mm Square Beam	76108	1
14 mm Bronze Bushing	76301	4
Shaft Spacer 2 mm	76306	24
6 mm D Shape Collar Clamp	76320	3
6 mm Shaft Hub	76284	1
M3 x 10 mm Socket Head Cap Screw	76201	4
M3 x 20 mm Socket Head Cap Screw	76209	1

C.2 – Example Task for Module C
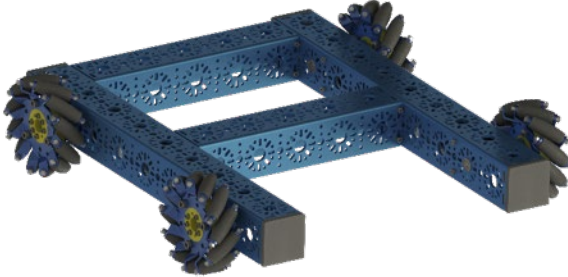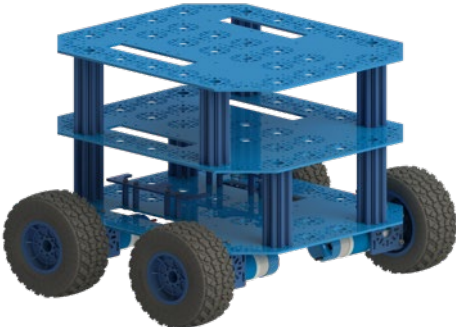
Using the list of parts in C.1, design a conveyor system to get a foam golf ball to travel 240 mm. The conveyor, once built, can be spun by hand to simulate a moving conveyor.

Example Solution for training purposes only.
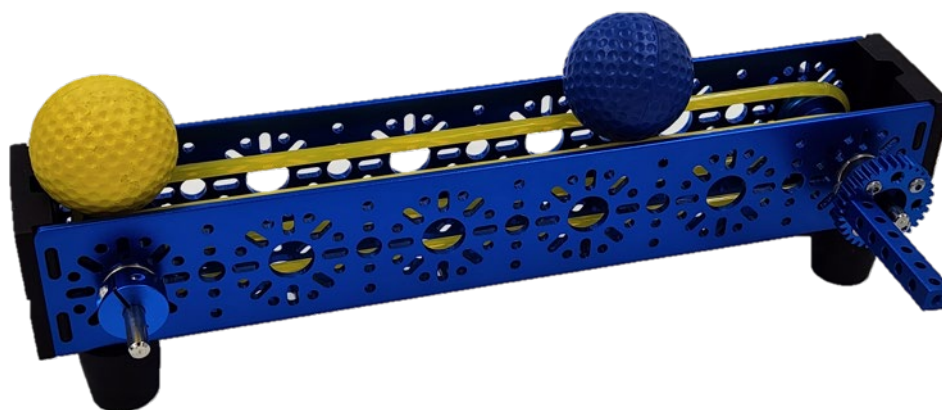
Appendix D - Navigation and Localization

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

Module D List of Robots		
Chassis	**Part #**	**Picture**
Mecanum		
X-Drive		
The Stack		

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, 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. The robot is required to map out the environment of the module D court. After mapping the environment, Experts will place an object in the robot's path. The robot will be required to move around the object by choosing a different path.

Appendix E –Vision

E.1 – Fruit used for Module E (Sample Objects for Training 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.

Competitors are allowed to use code previously made at home; however, they may not use any pre-trained models or cascades. If Competitors wish to use models or cascades, they must be trained at the competition during the Competitor's allotted time for the Vision Module.

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. 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.

The additional details will be provided during the Competition.

Appendix G - Testing and Fault Finding

G.1 – Example Task for Module G Part 1

Competitors will be given some faulty electronics or assemblies normally found inside the Competitor's collection. Competitors are required to diagnose and find all faults in the electronics given to them. The faults might not need to be fixed (only identified), or they might require replacement.

Example Faults and Equipment		
Equipment	Part #	Fault
Servo Power Block	75006	6V Bus is damaged and has no output
Titan Quad Motor Controller	70152	Can't communicate as wrong CAN ID set in Titan EEPROM
		M2 Fuse Blown
Multi-Mode Smart Servo	75002	Servo is set to continuous mode when it should be set to standard mode
Ultrasonic Distance Sensor	70753	Echo and Trigger cables were swapped
12V 3,000 mAh NiMH Battery	70018	Fuse is popped
IR Range Sensor	40117	Signal Cable is cut

G.2 – Example Task for Module G Part 2

Competitors will be given a broken piece of equipment and a datasheet. Using the datasheet and Competitor knowledge, the Competitor will be required to fix the equipment back to working order.

Competitors could be provided a damaged ribbon cable. The Competitor will need to follow a guide such as this: https://docs.wsr.studica.com/en/latest/docs/Vision/installing-the-ribbon-cable.html to uninstall and reinstall a new cable that is not damaged.

Appendix H - Performance Review and Commissioning

H.1 – Task Procedures

In the morning breifing Competitors will be provided a random sample of the required information for the performance task. Prior to starting a run the compeititors 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.

Alternativley, 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 Items

There are a few items in this module the robot might be required to interact with.

1. Seeds (10 mm to 20 mm Round objects, each will weigh between 2 g and 12 g)
2. Weeds
3. Harvest Basket.
4. Seed Dispenser