CONNECTING THE WORLD AUTONOMOUS PORT

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Information on how to use these game rules in countries:

We deliberately have a mix of simple and more difficult tasks in the game rules. These rules are also used for the WRO International Final, where we expect to see many teams that can solve all missions. At a local, regional, or national level however, there will be many teams that do not have the experience, knowledge or time to solve everything. This is intentional. By offering simple and more complicated tasks all teams will be able to solve parts of the challenge and can keep trying to improve their work. (Also see chapter 6)

1. Introduction

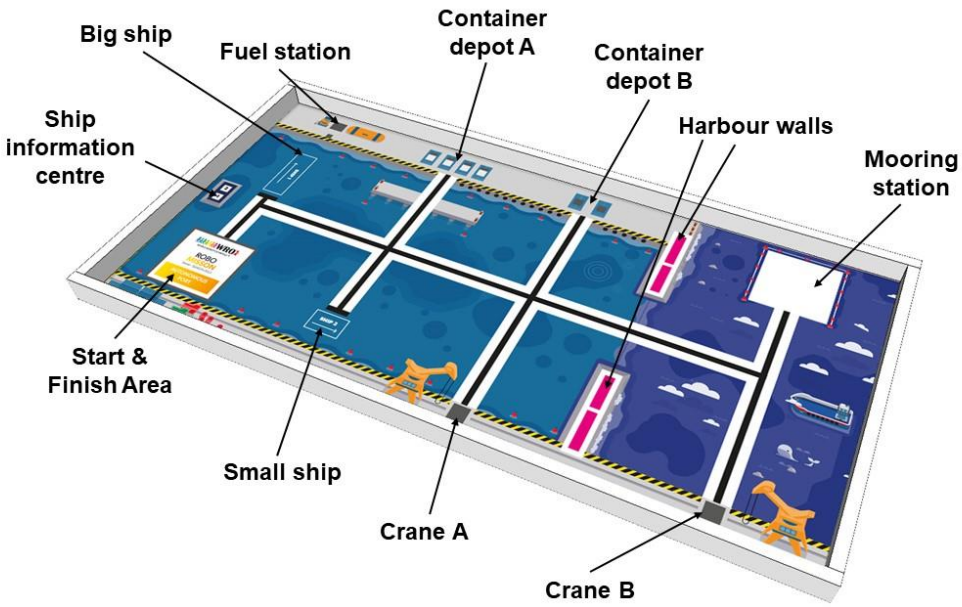
Our modern-day society relies on container shipments that transport all kinds of goods over the oceans. In the past, particular routes would involve ships having to take long, dangerous journeys around the edges of continents, such as around Cape Horn in South America or Cape of Good Hope in Africa. But the construction of the Panama Canal and the Suez Canal have made it possible for ships to reach their destinations much faster and more safely. Many modern transport ships have even been built exactly according to the Panamax or the new Neopanamax standard: the maximum size for crossing the Panama Canal.

Standardization and automation are other aspects that have made international transport over sea more effective. The introduction of standard shipping containers is an example of this standardization. These containers can easily be transferred from a ship to a truck or a train, making transportation faster. In modern ports many processes are automated, for example, unloading of containerships and even piloting of ships. Even autonomous ships are a thing that we can expect to see in the near future.

On the Senior game field, the robot will help to load and unload ships, fuel them and pilot them to open sea.

2. Game Field

The following graphic shows the game field with the different areas.



If the table is larger than the game mat, put the side with the container depots and the ship information centre towards the wall.

For more information about the table and game mat specifications, please take a look at PRO RoboMission General Rules, chapter 6.

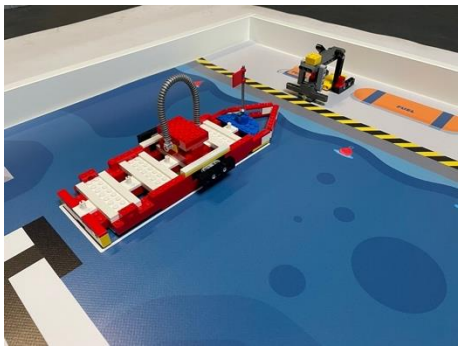
3. Game Objects, Positioning, Randomization

Big ship (1x) and small ship (1x)

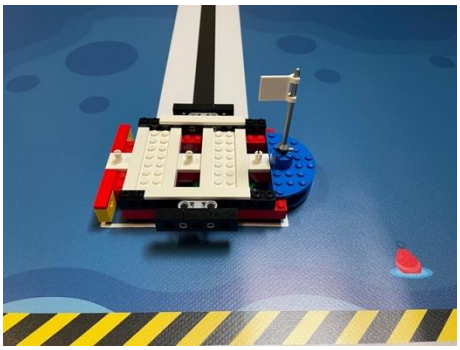
There is one big ship and one small ship on the field. Both ships are always placed at the same position at the beginning of the match, aligning the rectangular part of the ship with the rectangular marking on the game mat.

Big ship

Small ship



Start position of the big ship

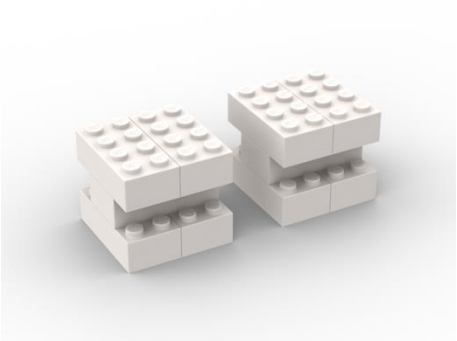


Start position of the small ship

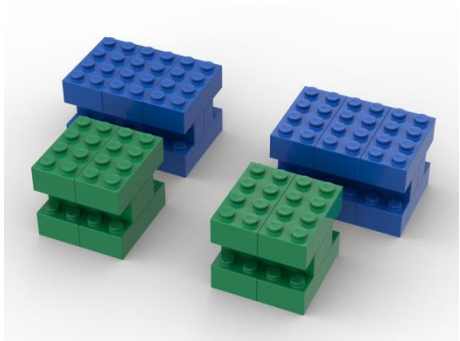
Containers

There are different kind of containers on the field that should be loaded onto the ships:

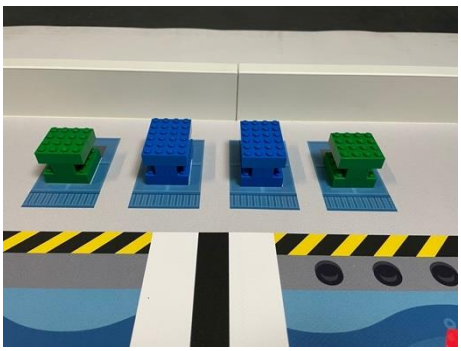
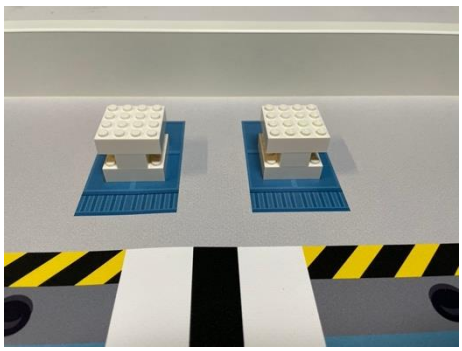
- 2 small white containers that are always placed in container depot B
- 2 small green containers and 2 big blue containers that are randomly placed on the four positions in container depot A



2 small white containers

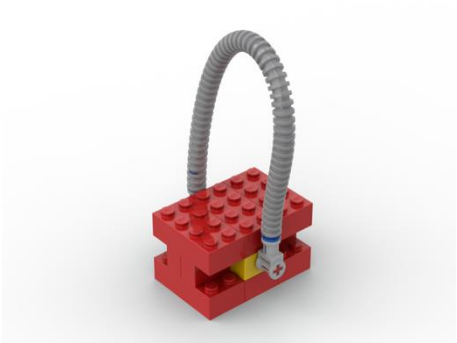
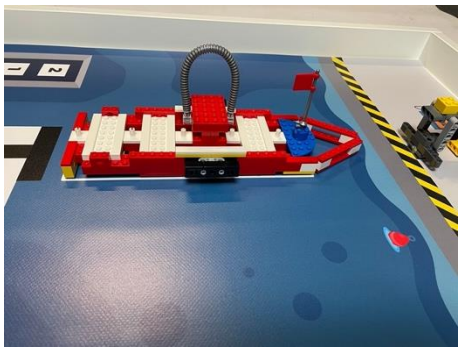


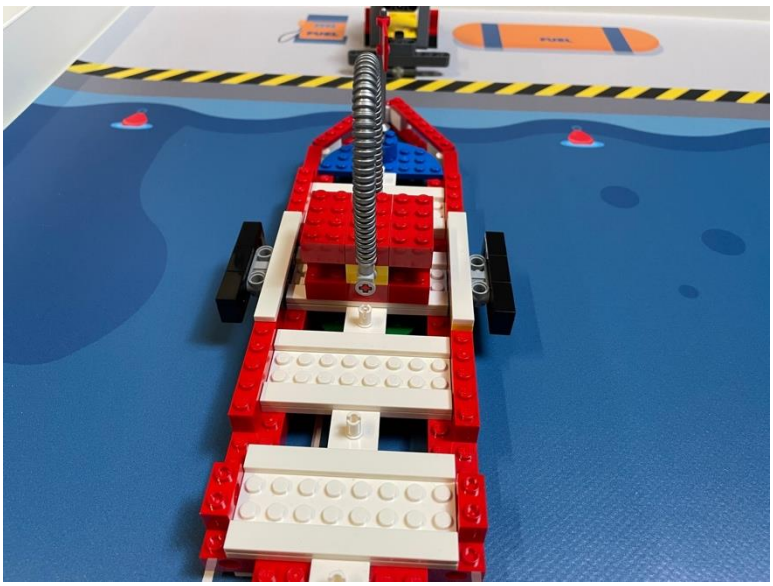
2 small green and 2 big blue containers

 One possible placement of the containers in depot A, containers are always placed in this orientation, green containers always on the light grey marking in front, blue containers on the full light and dark grey area	 Placement of the containers in depot B, containers are always placed in this orientation

Special container

There is one special container with important goods that is always placed on the big ship

 Special container (red)	 The container is always placed in the inner position between the black parts of the ship

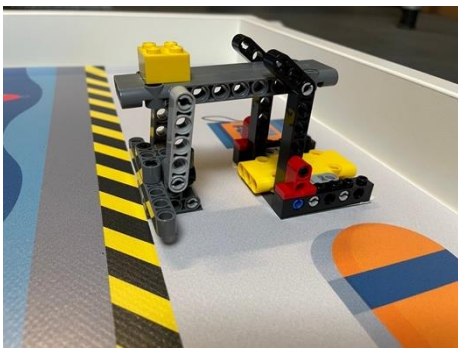


The container is always placed exactly in the middle with the orientation of the loop as shown in the picture.

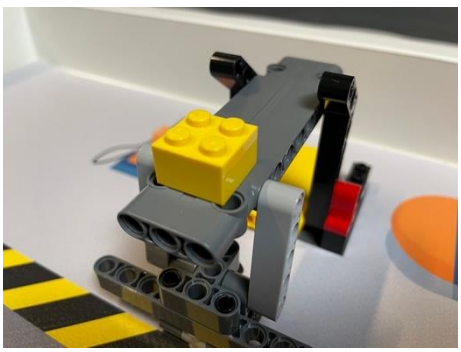
Fuel station

There is one fuel station on the field that includes one 2x2 yellow brick that symbolizes the fuel. Please note, that the base of the fuel station needs to be fixed on the field (see General Rules, chapter 6).

Fuel station



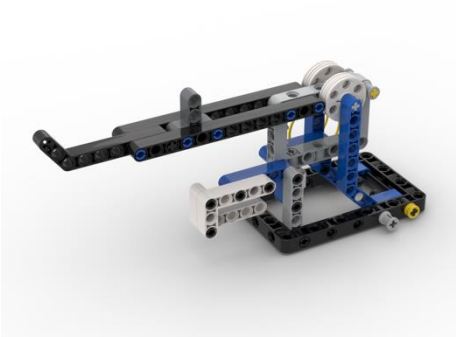
Start position of the fuel station with fuel block (2x2 yellow brick) on top



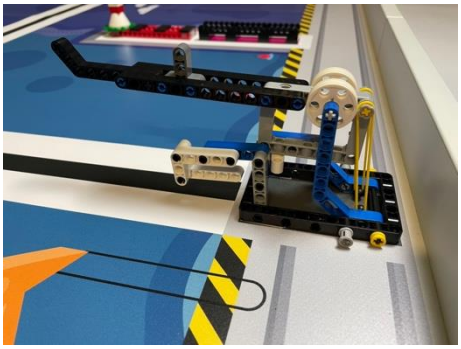
Fuel brick is always placed at this position on top of the fuel station

Crane A and B

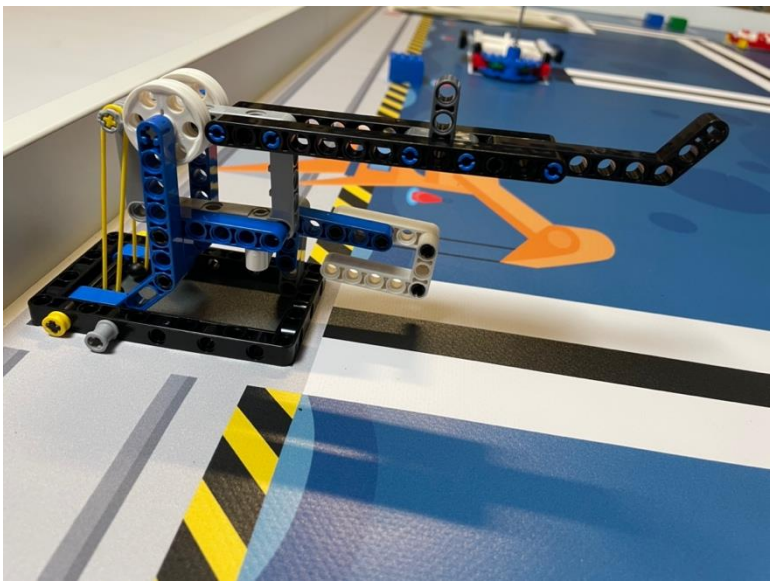
There are two cranes on the field. Both cranes are constructed in the same way and positioned in the same way on the game field. Please note that the cranes need to be fixed on the field (see General Rules, chapter 6). Make sure that, as well as fixing the crane to the mat, you also fix the mat directly to the table underneath the game object for more stability.



Crane
(rubber band is missing in animated 3D, please check the photos and building instruction for that)



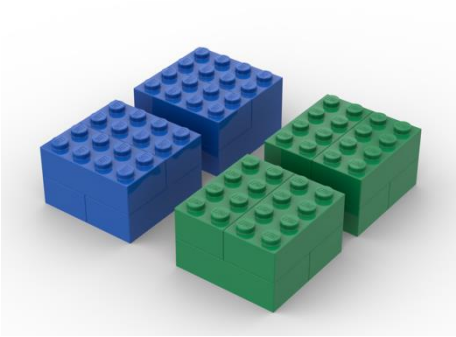
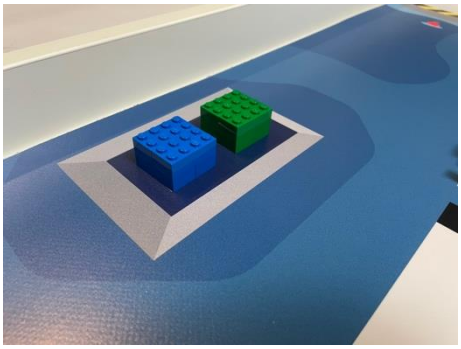
Setup of a crane on a crane position



Larger photo to show the start position of a crane

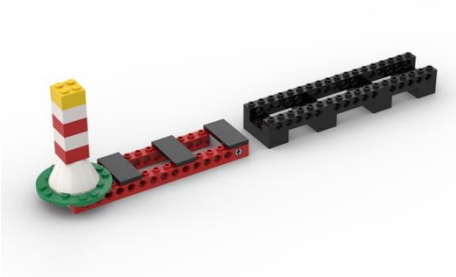
Marking blocks (4x)

There are four marking blocks (2x green, 2x blue). Two marking blocks are randomly selected and then placed on the positions 1 and 2 in the ship information centre. The other ones won't be on the game field. The marking blocks indicate two containers that should be loaded on the big ship.

 All marking blocks	 One possible placement of two marking blocks in the ship information centre

Harbour walls (4x)

There are four harbour walls on the field that divide the field into the harbour and outer sea area, these barriers are not allowed to be moved or damaged. The part with the lighthouse is always placed towards the middle of the game field.

 Harbour walls (2x)	 Placement of the harbour walls at the beginning of each round (one black wall and one lighthouse element should be placed on the marked harbour wall area on each side)

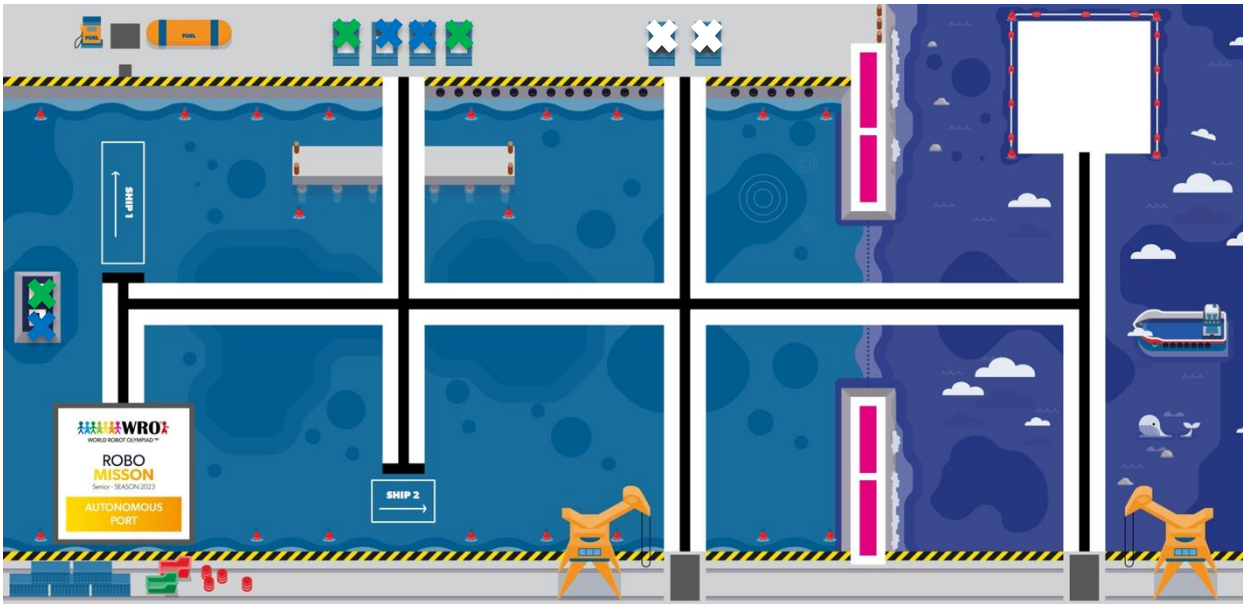
Summary randomization

On this field, the following objects are **randomly placed in each round**:

- Placement of containers in the container depot A
- Placement of marking blocks in the ship information centre

One possible randomization you can see here:

- Green and blue containers are on positions in depot A
- One green and one blue marking block is in the ship information centre
- *(Always: two containers are placed in the depot B)*



4. Robot Missions

For greater clarity, the missions will be explained in multiple sections. The team can decide which parts of the missions they will do and in which order. Final scoring will be based on the situation on the field at the end of the run.

4.1 Load the small ship

The robot should help to load containers on the ships in the harbour. On the small ship the robot can place two containers to get points. It is not important which colour the containers have (green, blue and/or white).

Points are awarded for each container that is loaded onto the ship. Additional points are awarded if the loading is completed (two containers are on the ship). It does not matter where on the ship the containers are placed. It is allowed that the robot moves the ship to make the loading easier or faster. The ship itself should not be damaged, but it is OK if the flag, flagpole and/or blue round brick holding the flagpole are damaged or fall off.

4.2 Fuel the big ship

Robots do not only help with loading containers on the ships, but they can also help with maintaining ship vessels. A task of the autonomous robot vessel in this harbour is to fuel the big ship.

For this, the little fuel brick (2x2 yellow brick) should be added to the ship. It can either be on the ship or in the ship (e.g. in the little triangle at the front touching the mat). To fuel the ship, the robot can activate the fuel station and get the fuel brick itself. The robot can also push the big ship into the fuel station. Then the fuel station is activated and the little fuel brick falls into the ship.

4.3 Load the big ship

Loading the big ship is a bit more complicated than loading the small ship. For a complete loading three containers must be loaded on the big ship:

- Always one white container
- The other two containers of the colour defined by the marking blocks in the ship information centre, example: If a green and blue marking block is placed in the ship information centre, a green and a blue container should be loaded onto the big ship.

Points are awarded for each container that is loaded onto the ship. Additional points are awarded if the loading is completed (all three containers are on the ship). It does not matter where on the ship the containers are placed. It is allowed that the robot moves the ship to make loading easier or faster. The ship itself should not be damaged, but it is OK if the flag, flagpole and/or blue round brick holding the flagpole are damaged or fall off.

For points in this task it does not matter what happens with the special container (see 4.4).

4.4 Unload the special container

At the beginning of each round, there is one special container (the red one) already loaded on the big ship. It is the task of the robot to help unload this container with the help of a crane.

For this, the robot could either fetch the container from the big ship and transport it to a crane or push the ship in front of one of the cranes and unload the container automatically.

Points are awarded for different end situations. You get points if the robot holds the container, more points if the container is at crane A and even more points if the container is at crane B.

Additional points are awarded if the crane with the container is activated, and the container is lifted.

4.5 Escort the ships to open sea

Once containers are loaded onto the ships, the autonomous robot vessel should pilot the ships out of the harbour to the open sea.

For that, the robot should push or pull the ships across the dotted dark blue line between the harbour walls that differentiates the harbour area from the open sea. Points are awarded if the ships have completely crossed the line on top-view but points are only awarded if at least one container is loaded onto each ship.

4.6 Bonus points

Bonus points will be awarded for not moving or damaging the harbour walls on the field.

4.7 Moor the robot vessel

At the end, the autonomous robot vessel should be moored. This, the team can do by either ending in the Start & Finish area or by ending in the mooring station at the open sea.

In both cases, it is OK if the robot is partly within (top-view) one of these areas.

5. Scoring

Definitions for the scoring

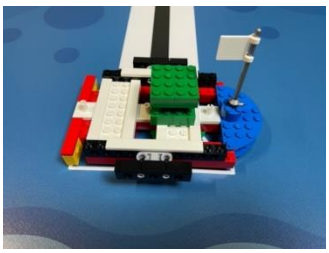
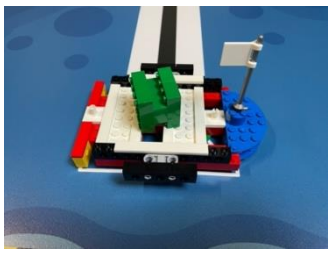
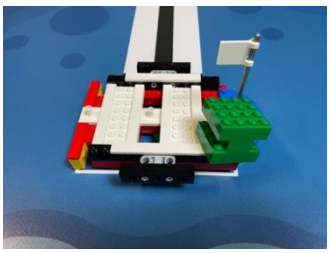
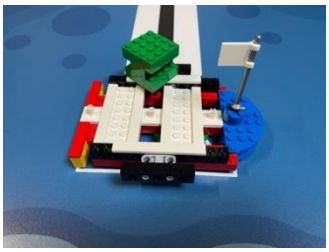
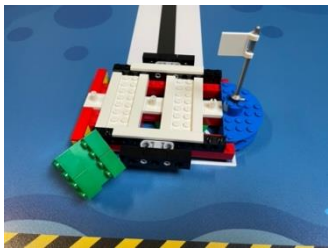
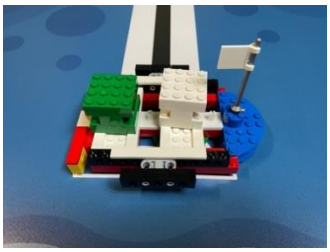
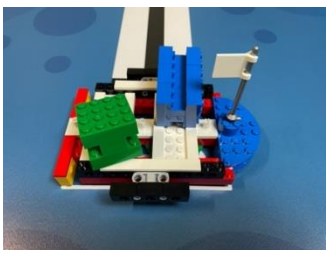
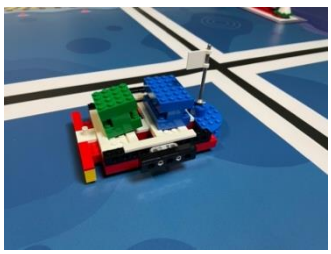
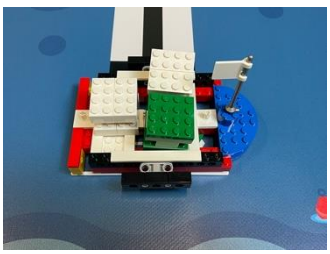
"**On/Onto the ship"** means that a container is only touching the corresponding ship and no other parts of the robot or the game mat. Please note that there is a new rule about damaged game objects in the RoboMission General Rules (Rule 6.8).

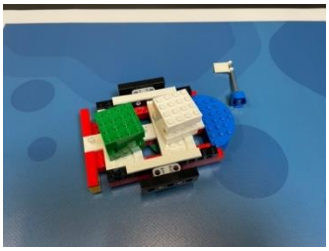
Tasks	Each	Max.
Load the small ship with 2 containers *(no points for this task if more than 2 containers are loaded onto the ship)*		
Any container is successfully loaded onto the small ship	10	**20**
Ship is completely loaded (two containers are on the small ship)		**9**
Fuel the big ship		
Fuel block is in/on the big ship		**11**
Load the big ship with 3 containers *(no points for this task if more than 3 containers are loaded onto the ship, the red container does not count, so with the red container a total of 4 containers could be on the ship)*		
White container successfully loaded onto the big ship		**10**
Other containers of the correct colour successfully loaded onto the big ship	11	**22**
Ship is completely loaded (one white container and two containers of correct colour, red container doesn't count)		**9**
Unload special container		
Robot is holding red container (container is not touching the big ship or the game mat)		10
OR: Tip of crane A is through the loop of the red container (container can still touch the robot, the ship and/or the game mat)		14
OR: Tip of crane B is through the loop of the red container (container can still touch the robot, the ship and/or the game mat)		**20**
Additional: The crane that holds the red container is activated, and the container is lifted (container is not touching the robot, the ship or the game mat)		**11**
Pilot the ships to open sea		
Ship has crossed the dotted dark blue line between harbour and open sea completely and at least one container is loaded onto the ship (not the red container)	12	**24**
Get bonus points		
Harbour walls are not moved or damaged	3	**12**
Moor the robot *(only if other points, not bonus, are assigned)*		
Projection of the robot is at least partly in the start & finish area		10
Projection of the robot is at least partly in the mooring station at open sea.		**17**
Maximum Score		**165**

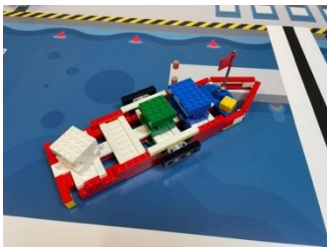
Scoring Interpretation

Definition for all containers in all mission:
"**On/Onto the ship"** means that a container is only touching the corresponding ship and no other parts of the robot or the game mat. To score points it does not matter how or where the container is positioned on the ship. You can see the examples in the first mission for the small ship, the interpretation is the same for the big ship.

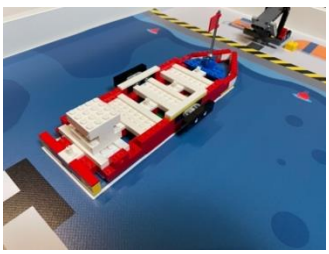
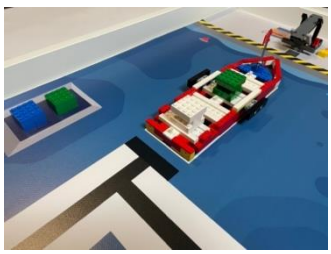
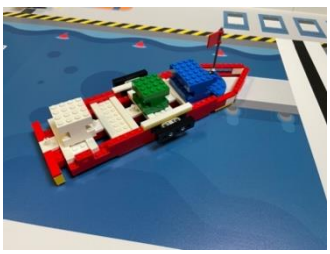
Load the small ship with 2 containers
(no points for this task if more than 2 containers are loaded onto the ship)
Any Container is successfully loaded onto the small ship. ➔ 10 points
Ship is completely loaded (two containers are on the small ship). ➔ 9 points

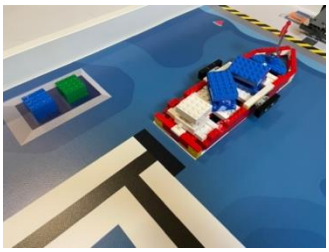
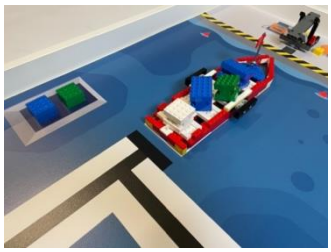
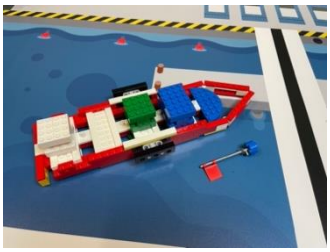
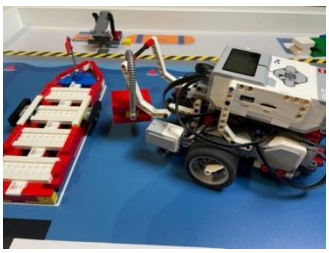
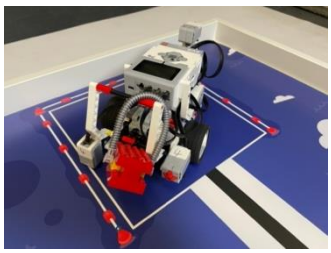
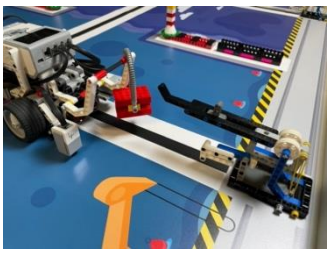
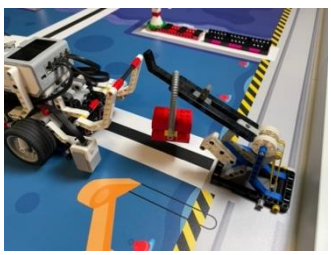
 10 points (onto the ship)	 10 points (onto the ship)	 10 points (onto the ship)
 10 points (onto the ship)	 0 points (touching the mat)	 29 points (two containers loaded + completely loaded)
 29 points (two containers loaded + completely loaded, it does not matter which containers loaded on small ship)	 29 points (two containers loaded + completely loaded, it does not matter where the small ship is on the field)	 0 points (more than 2 containers are on the small ship)

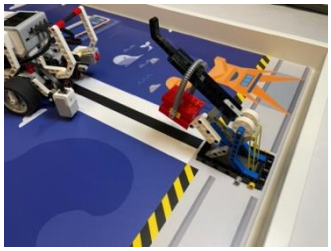
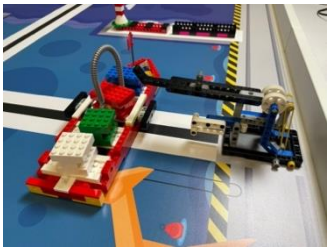
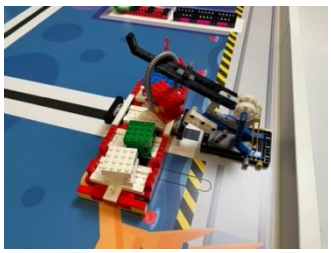
<table>
<tr><td> 
29 points (two containers loaded + completely loaded, OK if flagpole is fallen off)</td><td></td><td></td></tr>
<tr><td colspan="3">Fuel block is in/on the big ship. ➔ 11 points

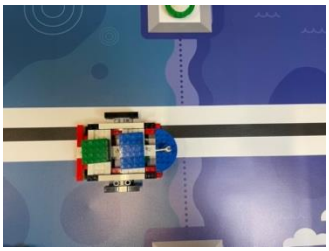
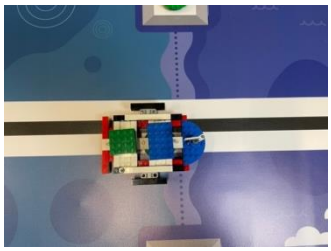
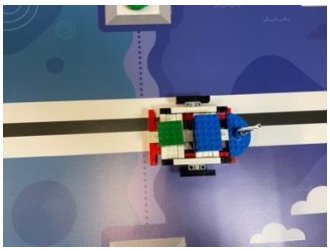
Note: It does not matter how the fuel brick falls or is placed into the ship; it must be in/on the big ship at the end of the match.</td></tr>
<tr><td> 
11 points (ship is pushed forward, fuel fell in ship)</td><td> 
11 points (ship is somewhere else on the field, fuel is in ship)</td><td> 
11 points for fuel brick (ship is somewhere else on the field, fuel on top)</td></tr>
<tr><td colspan="3">Load the big ship with 3 containers
(<u>no points</u> for this task if more than 3 containers are loaded onto the ship, the red container does not count, so with the red container a total of 4 containers could be on the ship)

White container successfully loaded onto the big ship. ➔ 10 points
Other containers of the correct colour successfully loaded onto the big ship. ➔ 11 points
Ship is completely loaded (one white container and two containers of correct colour, red container doesn’t count). ➔ 9 points.

Note: In this example the marking blocks show that a green and blue container should be loaded onto the big ship. Only if then one white (always) + one green + one blue containers are loaded onto the ship, the ship is considered to be completely loaded).</td></tr>
<tr><td> 
10 points (white container on big ship)</td><td> 
21 points (white container + green container on big ship)</td><td> 
41 points (10 for white containers, 22 for green</td></tr>
</table>

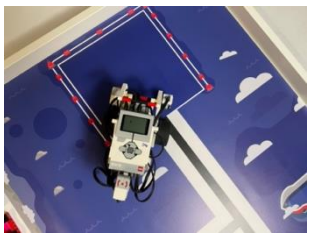
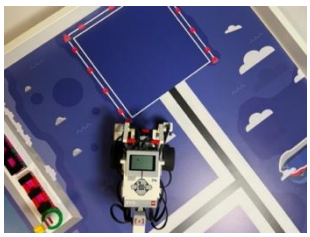
		and blue containers, 9 points for completely loaded)
 21 points (white container + one other correct container on the ship)	 0 points (more than 3 containers loaded onto the big ship)	 41 points (10 for white containers, 22 for green and blue containers, 9 points for completely loaded, OK if flagpole is fallen off)
Robot is holding red container (container is not touching the big ship or the game mat). ➔ 10 points. **OR:** Tip of crane A is inside the loop of the red container (container can still touch robot, the ship and/or the game mat). ➔ 14 points. **OR:** Tip of crane B is inside the loop of the red container (container can still touch robot, the ship and/or the game mat). ➔ 20 points. Additional: The crane that holds the red container is activated, and the container is lifted (container is not touching the robot, the ship or the game mat). ➔ 11 points.		
 10 points (robot holds container)	 10 points (robot holds container somewhere else on the field)	 10 points (robot holds container, crane A is not through the loop)
 14 points (robot holds container, with crane A through the loop, top-view counts for being through)	 25 points (container loop is on crane A without the robot holding it and the crane is activated)	 14 points (container loop is on crane A, it is activated but the robot still touches it)

<table>
<tr>
<td> 
20 points (robot holds container, with crane B through the loop, top-view counts for being through)</td>
<td> 
31 points (container loop is on crane B without the robot holding it and the crane is activated)</td>
<td> 
0 points (red container on the ship but the crane is not through the loop)</td>
</tr>
<tr>
<td> 
14 points (crane A through the loop, top-view counts for being through, container still touching the ship)</td>
<td> 
25 points (container loop is on crane A without the robot holding it and the crane is activated)</td>
<td></td>
</tr>
<tr>
<td colspan="3">Ship has crossed the dotted dark blue line between harbour and open sea completely and at least one container is loaded onto the ship (not the red container). ➔ 12 points.

<u>Note:</u> The same logic applies for both the small and the big ship.</td>
</tr>
<tr>
<td> 
0 points (line not crossed)</td>
<td> 
0 points (line not completely crossed)</td>
<td> 
12 points (line completely crossed)</td>
</tr>
<tr>
<td colspan="3">Harbour walls are not moved or damaged. ➔ 3 points per element.

<u>Note:</u> In total there are 4 wall elements, two per side of the harbour wall. The scoring is done separately for each of the 4 parts (so, for example, if only one of the four has been moved or damaged then they would still get 9 points). An element is considered to be moved if it is outside of the white area.</td>
</tr>
</table>

<table>
<tr><td> 
6 points (all ok)</td><td> 
3 points (one part moved)</td><td> 
0 points (both parts moved)</td></tr>
<tr><td> 
3 points (one part damaged)</td><td></td><td></td></tr>
<tr><td colspan="3">Projection of the robot is at least partly in the start & finish area. ➔ 10 points.
Projection of the robot is at least partly in the mooring station at open sea. ➔ 17 points.

<u>Note:</u> For the mooring station the inner white rectangle counts. For the start & finish area only the white rectangle inside counts. For both areas, cables only do not count for the projection of the robot.</td></tr>
<tr><td> 
17 points (projection of the robot is partly inside the mooring station)</td><td> 
0 points (projection of the robot not inside the inner rectangle of the mooring station)</td><td> 
0 points (projection not partly in the start & finish area)</td></tr>
<tr><td> 
0 points (only cables do not count)</td><td> 
10 points (projection is partly in the start & finish area)</td><td></td></tr>
</table>

Scoring Sheet

Team name: _____ **Round:** _____

Tasks	Each	Max.	#	Total
Load the small ship with 2 containers *(no points for this task if more than 2 containers are loaded onto the ship)*				
Any container is successfully loaded onto the small ship	10	**20**		
Ship is completely loaded (two containers are on the small ship)		**9**		
Fuel the big ship				
Fuel block is in/on the big ship		**11**		
Load the big ship with 3 containers *(no points for this task if more than 3 containers are loaded onto the ship, the red container does not count, so with the red container a total of 4 containers could be on the ship)*				
White container successfully loaded onto the big ship		**10**		
Other containers of the correct colour successfully loaded onto the big ship	11	**22**		
Ship is completely loaded (one white container and two containers of correct colour, red container doesn't count)		**9**		
Unload special container				
Robot is holding red container (container is not touching the big ship or the game mat)		10		
OR: Tip of crane A is through the loop of the red container (container can still touch the robot, the ship and/or the game mat)		14		
OR: Tip of crane B is through the loop of the red container (container can still touch the robot, the ship and/or the game mat)		**20**		
Additional: The crane that holds the red container is activated, and the container is lifted (container is not touching the robot, the ship or the game mat)		**11**		
Pilot the ships to open sea				
Ship has crossed the dotted dark blue line between harbour and open sea completely and at least one container is loaded onto the ship (not the red container)	12	**24**		
Get bonus points				
Harbour wall elements are not moved or damaged	3	**12**		
Moor the robot *(only if other points, not bonus, are assigned)*				
Projection of the robot is at least partly in the start & finish area		10		
Projection of the robot is at least partly in the mooring station at open sea		**17**		
Maximum Score		**165**		
			Surprise Rule	
			Total Score in this run	
			Time in full seconds	

6. Local, regional, and international events

WRO competitions take place in around 90 countries, and we know that teams in each country expect a different level of complexity. The challenge as described in this document will be used for international WRO events. This is the last stage of the competition, where the teams with the best solutions participate. That is why the game rules are challenging.

PRO feels that all participants need to be able to have a good experience in the competition. Teams with less experience should also be able to score points and succeed. This builds confidence in their ability to master technical skills, which is important for their future choices in education.

We deliberately have a mix of simple and more difficult tasks in the game rules. This means that all teams will be able to solve parts of the challenge and can keep trying to improve their work.

PRO Association recommend that our National Organizers consider the situation in their country. They can adapt the rules for events in their country even further. They can decide to make the challenges easier for local, regional, and national events, so that all participants have a positive experience.
All National Organizers can make their own choices, so each competition fits their specific situation and ideas. Here we provide some ideas to make the challenges easier.

Ideas for simplifications:

- No randomization of the containers in container depot A
- Take out one element of both harbour walls (in this case adjust the scoring for bonus points)
- Decide that it is ok that the red container is always brought to crane A (then delete the points for the option to bring it to crane B