Organized by

KHALIFA UNIVERSITY

MBZIRC

مسابقة محمد بن زايد العالمية للروبوت

Mohamed Bin Zayed International Robotics Challenge

Inspiring the future of Robotics صياغة مستقبل الروبوتات

Challenge Description

1. Introduction

The Mohamed Bin Zayed International Robotics Challenge (MBZIRC) is an international robotics competition, held every two years. MBZIRC provides an ambitious and technologically demanding set of challenges, and is open to all teams from all countries. MBZIRC aims to inspire the future of robotics through innovative solutions and technological excellence.

Robotics is poised to have a transformative impact in a variety of new markets and on various human social aspects. These include robot applications in disaster response, oil and gas, manufacturing, construction and household chores. Enabling technologies for such applications include robots working more autonomously in dynamic, unstructured environments, while collaborating and interacting with other robots and humans. We aim to focus on all of these enabling technologies, by providing a demanding set of benchmark robotics challenges to attract the best international teams. Similar to other major competitions, the MBZIRC aims to provide an environment that fosters innovation and technical excellence, while encouraging spectacular performance with robotics technology.

More information about MBZIRC can be found at the website:
http://www.mbzirc.com

The inaugural MBZIRC will take place in February 2017 (subject to minor adjustment based on venue availability).

This document describes the main challenges of MBZIRC 2017, and the call for Proposals. It also includes the Competition Rules, important dates and deadlines, the application process to participate, and the application process for sponsorship.

The MBZIRC Organizers reserves the right to continue to fine tune the challenge Rules, leading up to the Competition in 2017, based on feedback from the robotics community, participants, and the MBZIRC Technical Advisory Committee.

1.1 Competition Overview

MBZIRC 2017 will consist of three challenges and a triathlon type Grand Challenge:

1. **Challenge 1** requires a UAV to locate, track and land on a moving ground vehicle.

2. **Challenge 2** requires a UGV to locate and reach a panel, and physically operate a valve on the panel.

3. **Challenge 3** requires a team of UAVs to collaborate to search for, locate, track, pick up, and place down a set of static and moving objects.

4. **The Grand Challenge** requires a team of robots (UAVs and UGVs) to compete in a triathlon type event that combines Challenges 1, 2 and 3.

MBZIRC 2017 will take place in an outdoor open arena which is approximately the size of a football pitch (Figure 1).

An animated video of the MBZIRC Challenges can be found at:
www.mbzirc.com/Challenge

Competitors may participate in one or more of these challenges.

Competing teams will use untethered robots. A human operator will be allowed to play a supervisory role. The human operator will be sequestered and will not have a direct line of vision to the competition arena.

The communication between the robots and the human supervisors will use a fixed bandwidth communication network provided by the competition organizers, based on IEEE 802.11 standards. For Challenge 3, the robots can communicate with each other using their own communication network complying with UAE regulations. The competition organizers will coordinate with the teams to prevent interference. More details about the communication protocols will be provided in due course.

Teams can attempt any of the three challenges either autonomously or with human supervision. Teams performing the tasks fully autonomously will achieve the maximum scores; teams performing the tasks with human supervision can only achieve at most half of the maximum score. Once a team elects human supervision, that attempt will then be considered supervised, even if the task is later completed in autonomous mode. The score achieved for an attempt with human supervision will depend on the degree of human intervention as evidenced by the volume of information exchange between the robots and the supervisors, and a measure of supervisor key strokes. More details about the scoring scheme will be provided in due course.

If two teams have the same score, then the team with the best task completion time will be ranked higher.

Each team will be allowed 2 trials per challenge and will retain the maximum score from either attempt.

Teams may request a reset during a trial. They will then restart the challenge from the Start Location, for the remaining duration of the Challenge for that particular trial. No extra time will be allocated for resets and this attempt will be counted as one of the two eligible trials for that Challenge.

For safety reasons the speed of the UAV is restricted to a maximum of 30 Km/hour and the speed of the UGV is restricted to a maximum of 15km/hour. The size of the UAVs is restricted to a maximum volume of 1.2m x 1.2m x 0.5m, and the size of the UGVs is restricted to a maximum of 1.7mx1.5m. For safety reasons the operation mode of the UAV must be able to be switched from autonomous to manual at anytime. More details about the safety protocols that must be followed by all participating teams will be provided in due course.

2. The Arena

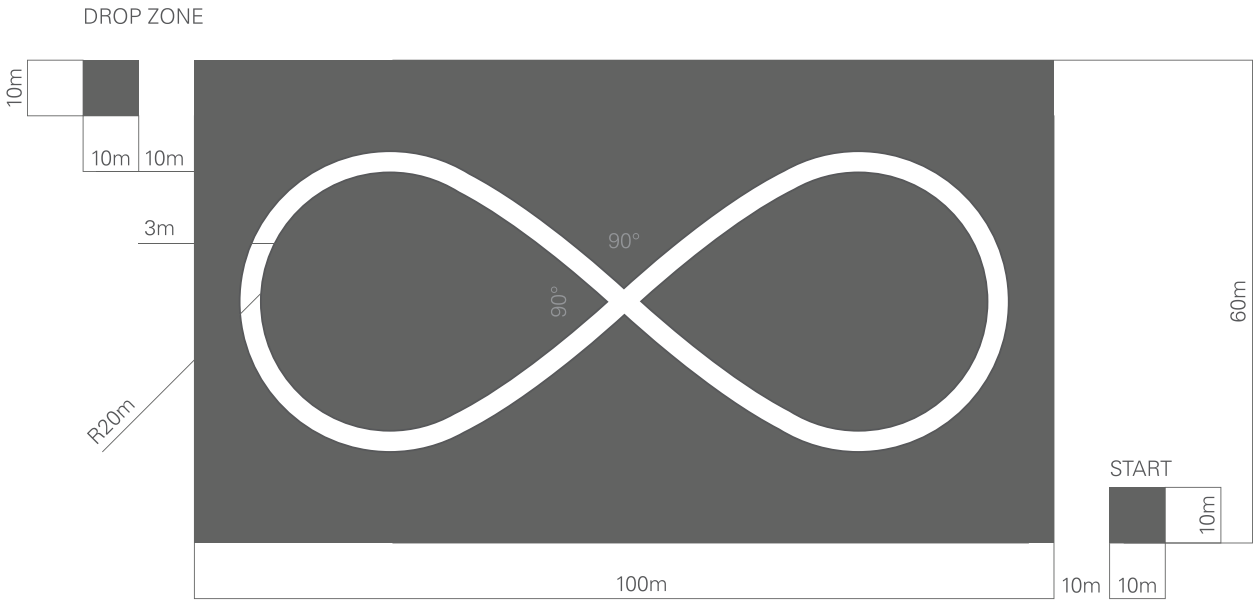
All four challenges will be performed in an outdoor arena with GPS access and the following specifications (see Figure 1):

» Outdoor open arena will be of approximate size 100m x 60m.

The arena will have a predefined track of width 3m, in the shape of a figure 8 (Figure 1). The track boundary will be marked with white paint. The terrain inside the arena will be relatively smooth and relatively level. The dimensions of the arena and the track are shown in Figure 1.

» Initial start location for competing team of approximately, 10m x 10m, will be located 10m away from the arena.

» All teams will have a preparation area outside the arena.



[Figure 1] Arena Dimensions

3. Challenges

3.1. Challenge 1 – UAV Landing on a Moving Vehicle

Challenge 1 requires an UAV to land on a moving ground vehicle. The challenge duration will be 20 minutes.

Task Specification:

» Initial condition:

- The participating team positions the UAV in stationary mode on the ground at the start location.

» UAV to Land on Vehicle

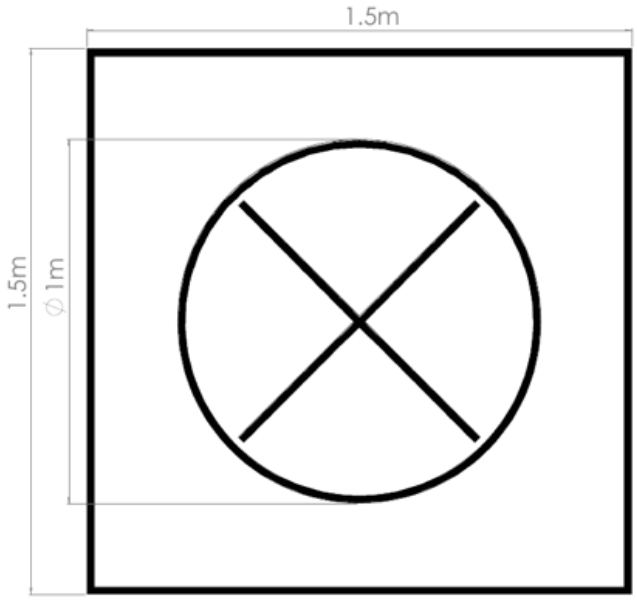
- A ground vehicle of approximate dimensions 2.5m x 1.5m x 1.5m (length, width, height) is driven into the arena and placed at a random location on the track.
- A whistle will then indicate the start of the challenge.
- The ground vehicle will begin moving, and the UAV will monitor the arena to detect the moving vehicle, and will attempt to land at a predefined target location on the moving vehicle (Figure 2).

The landing area will be a square of dimensions 1.5mx1.5m, and approximately 1.5m above ground, positioned on the vehicle. The landing zone inside the landing area is a circle of diameter 1m. The center of the circle is indicated by an X. The landing area, the landing zone and the marker X are shown in Figure 2.

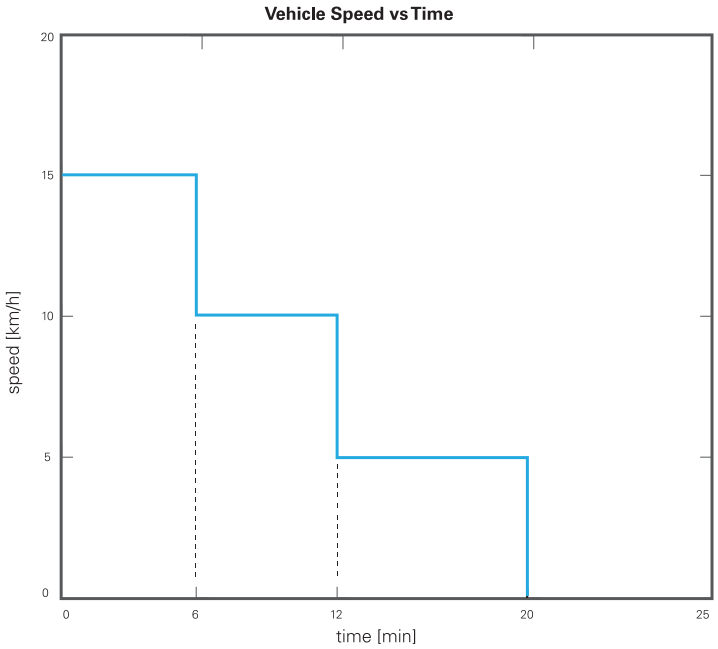
The landing area will be made of a flat ferrous surface to enable docking using magnetic or suction or other means.

- An example speed profile of the vehicle during Challenge 1 is shown in Figure 3; the moving vehicle starts at a constant speed of 15km/h, it reduces the speed to 10km/h after 6 minutes and to 5 Km/h after 12 minutes.

- A successful landing is when a point of contact of the UAV is within the landing circle, with propulsion off and rotors not spinning.



[Figure 2] Landing Zone



[Figure 3] Vehicle Speed Profile during Challenge 1

Scoring:

To complete Challenge 1 and achieve a score, a point of contact of the UAV must be within the landing circle, with propulsion off and rotors not spinning. At most half the maximum score will be given if the task is completed with human supervision.

The maximum score will be given if the UAV lands on target fully autonomously, when the vehicle is moving at maximum speed. If two teams have the same score, then the team with the best task completion time will be ranked higher. More details about the scoring scheme will be provided in due course.

3.2. Challenge 2 – UGV Operating a Valve

Challenge 2 requires an unmanned ground vehicle (UGV) with an onboard manipulator to operate a valve stem placed on a panel (Figure 4). A standard set of valve stems and tools, Figure 4, will be used in Challenge 2. To operate the valve stem the robot must identify the appropriate tool to use, pick it up, and manipulate it to rotate the valve stem one full circle (360 degrees). To operate the valve stem a torque of approximately 5 Nm will be required.

This challenge will last for 30 minutes.

Task Specifications:

» Initial condition:

- The UGV will be in the start location.
- The panel will be placed at a fixed location, with a random orientation, inside the arena.

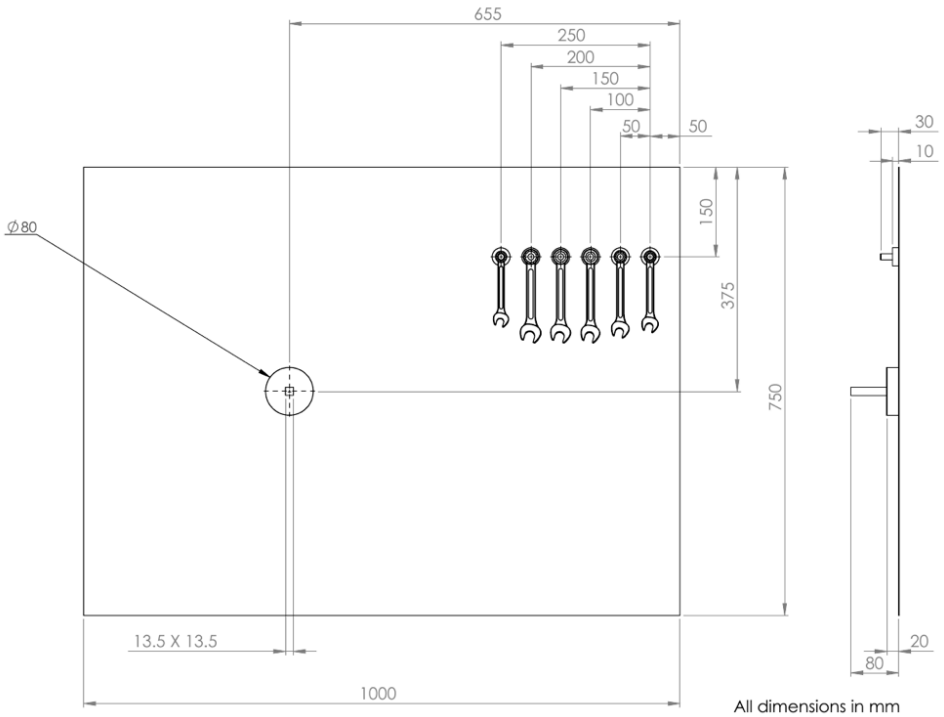
» UGV to locate and close the valve:

- At the start whistle, the UGV will locate the panel, navigate to approach the panel, and then locate and identify the valve stem.
- A set of 6 tools are placed adjacent to the valve stem, as shown in Figure 4. One of these 6 tools is appropriate for operating the valve stem.
- The UGV will analyze the valve stem and select the appropriate tool to close the valve stem from the set of provided tools. These tools are standard wrenches that follow the ISO 7738 standards, and range in size between 10mm and 19mm. The valve stem and the set of tools to be used in this challenge are shown in Figures 4 and 5 respectively.
- The UGV will pick the tool and manipulate the tool to close the valve stem by rotating the valve stem by 360 degrees.

Scoring:

To complete Challenge 2 and achieve a score, the valve stem must be turned a full 360 degrees (or more). The maximum score will be given if the task is completed fully autonomously. At most half the maximum score will be given if the task is completed with human supervision. More details about the scoring scheme will be provided in due course.

[Figure 4] Panel with valve stem and tools



[Figure 5] Size and location of the tools

3.3. Challenge 3 – Treasure Hunt

Challenge 3 requires a team of 3 UAVs, equipped with magnetic, suction or other type of end effectors to search, find, pick and relocate a group of static and moving objects.

This challenge is expected to last for a maximum of 20 minutes.

» Initial condition:

- The three UAVs will be in the start location.

» Search, Locate and Re-Locate Objects:

- Shortly before the start whistle 10 moving and 10 stationary small objects, and 3 stationary large objects will appear in the arena. The objects will be randomly placed inside the arena and the non-stationary objects will be moving at random velocities not exceeding 5 km/h.

- The small objects will be cylindrical or rectangular in shape and made from a ferrous material. The dimensions of the objects will not exceed 30x30x20 cm. The weights of the objects will less than 500g. The objects will be in three different colors, black, blue and red. The objects will have differing scores associated with them and the score will be marked on the top of the object.

- The 3 large objects will have a length not exceeding 200cm, a cross section not exceeding 20x20 cm, and a weight not exceeding 2kg. These objects may require the collaboration between two or more UAVs in order to pick and place them. A higher score will be associated with the large objects.

- The aerial vehicles have to locate, pick and relocate the objects by picking and placing them in a box of dimensions 1.0m x 0.5m x 0.8m (width x depth x height), placed inside the dropping zone outside the arena as shown in Figure 1. The objects can be picked by using a magnetic gripper, a suction gripper or other means.

- Large size objects must be placed outside the box, but inside the dropping zone shown in Figure 1.

Scoring:

The score marked on the object will be given if the object is placed inside the designated box, fully autonomously. At most half the score marked on the object will be given if the object is placed inside the designated box, with human supervision.

The team collecting the maximum points in the designated 20 minutes will be the winner. If two teams have the same score, then the team with the best task completion time will be ranked higher. More details about the scoring scheme will be provided in due course.

3.4. Grand Challenge – Triathlon

The Grand Challenge will require a team of 3 UAVs and 1 UGV to compete in a triathlon event combining the three challenges described above.

This challenge will have a duration of 30 minutes.

- All three challenges outlined above will run simultaneously.

Scoring:

The score for the Grand Challenge shall be the sum of the scores of Challenge 1, Challenge 2, and Challenge 3 weighted so that the three challenges have equal importance. Individual challenges in the Grand Challenge will be scored exactly as in the individual challenges described earlier in this document. More details about the scoring scheme will be provided in due course.

4. APPLICATION PROCESS

Teams can apply to participate in MBZIRC 2017 and for sponsorship by completing an Application Form at: www.mbzirc.com/apply

All teams must complete the following Sections of the Application Form:

Section 1: Administrative Information

Section 2: Proposal

2.1 Key Personnel – Brief CVs of up to 5 key team members.
2.2 Supporting Material – Optional videos, Simulations and/or Other Relevant Material

In addition teams seeking sponsorship should also complete the following sections of the proposal:

2.3 A Statement of Work (SOW) not exceeding 4 pages, including a description of the overall scientific and technical approach, hardware and software to be used, and the implementation of the approach.

2.4 A Budget stating amount of sponsorship money requested with a brief narrative on how the money will be spent, addressing at least (a) the direct costs of labor, capital equipment, and materials, and (b) indirect costs.

The deadline for submitting applications is November 07 2015.

5. PRIZES and SPONSORSHIP

Funding of US $5 million will be allocated for prizes and sponsorship. The current plan is to allocate US $3 million of this for team sponsorship and US $2 million of this as prize money.

MBZIRC will sponsor a selected set of teams up to a maximum value of US $400,000 per team. The exact allocation of team sponsorship funds will depend on the number and quality of the applications received. Teams intending to apply for sponsorship should complete the Application Form as outlined in Section 4.

The prize money will be allocated to the winner of each challenge as follows:

Grand Challenge	US$ 1,000,000
Challenge 1	US$ 350,000
Challenge 2	US$ 350,000
Challenge 3	US$ 350,000

Appendix 1

Table 1 - MBZIRC Important Dates

The following is a list of important dates and deadlines leading up to the main event in February 2017.

September 07, 2015	Call for proposals
November 07, 2015	Deadline for Submission of Proposals
December 14, 2015	Selection of Finalists
June, 2016	Progress Video Submission
November, 2016	Preparation Camp
February, 2017	MBZIRC (subject to minor adjustment based on venue availability).

Appendix 2

Table 2 - List of Challenge Parameters

1. Structure	3 Challenges and 1 Grand Challenge
2. Challenge duration	20 minutes for Challenges 1 & 3 30 minutes for Challenge 2 & Grand Challenge
3. Arena	Outdoor
4. Arena size	100m X 60m
5. Communications Link	Provided by competition organizers
6. Computing power	No restrictions
7. Level of Autonomy	No restrictions, but autonomy is explicitly rewarded in scoring scheme.
8. Maximum size of UAVs	1.2m x 1.2m x 0.5m
9. Maximum speed of UVAs	30km/h
10. Maximum size of UGVs	1.7mx1.5m
11. Maximum speed of UGVs	15km/h
12. Robot Teams	Challenge 1 - 1 UAV Challenge 2 - 1 UGV Challenge 3 - 3 UAVs Grand Challenge - 4 UAVs and 1 UGV
13. Challenge 1 - Vehicle speed	Start high and gradually reduce in discrete steps.
14. Challenge 1 - Landing Zone	Circle of diameter1m
15. Challenge 2 - Valve Type	Valve stem
16. Challenge 2 - Valve access	Open
17. Challenge 2 - Vehicle speed	Stationary
18. Challenge 3 - Type of Objects	The dimensions and weights of the small objects will not exceed 30x30x20cm, and 500g respectively. The dimensions and weights of the large objects will not exceed 200x20x20cm, and 2kg respectively.

Version	Date	Description
V1	July 15, 2015	Initial MBZIRC Challenge Description
V2	September 7, 2015	Updated Challenge Description