# DJI RoboMasters

# Mobile Manipulation Challenge

ICRA 2017, Singapore

# Competition Rules


**Nov 2016**

The RoboMasters Organizing Committee reserves the right to revise and interpret the rules.
If you have any questions, please email us: robomasters@dji.com.

# Contents

# Background

DJI initiated RoboMasters in 2015 as an educational robotics competition for students around the globe. The annual competition attracted teams who competed on building ground robots that used shooting mechanisms to hit opponents. The performance of the robots were monitored by a specially designed judging system. The competition is designed not only to entertain, but also to draw more attention from the general public to robotics. A recent media report from the Verge gives a detailed introduction to the competition :**<Rise of the RoboMasters>**

At first glimpse, RoboMasters is a robot fighting game, but it has great potential to foster robotics research. Its competitive nature pushes students to develop autonomous systems that have fast speed and reaction ability. The organizing committee of RoboMasters, which consists of the best DJI engineers and consulting professors from various world-class universities, carefully selects active research areas in robotics and adds valuable technical inputs to the RoboMasters competition rules. For RoboMasters 2017, the committee allows participants to add an "engineering robot" to their team of robots in the competition in order to encourage mobile manipulation technologies to enter the RoboMasters competition.

The ICRA 2017 DJI RoboMasters Mobile Manipulation Challenge runs in a similar setting as RoboMasters 2017. We also require contestants to develop an "engineering robot" that can manipulate "obstacles". However, since ICRA is a research conference, we designed the challenge topic to focus on mobile manipulation and human robot interaction research. We also hope that this challenge topic can shed light on some research papers.

# Purpose

## Expanding our influence

RoboMasters is one of the most popular and influential robot competitions in China, making use of the best resources from the community to make it an amazing showcase of technology. The RoboMasters 2017 Robotics Competition for College Students (hereinafter referred to as “RM2017”) draws society’s attention to robotics with its innovative competition format and emphasis on good science and engineering.

## Promote the development of practical teaching

RoboMasters will collaborate with universities to promote the development of practical teaching combined with cutting-edge technology through competitions, groom and retain talented teaching faculty, build teaching practice centers and laboratories, cultivate a group of outstanding scientists and engineers, and promote the transformation of scientific and technological achievements.

## Improve social participation

RoboMasters will carry out various kinds of activities during the course of the event to show the interactive experience, the most cutting-edge scientific and technological achievements in the most intuitive way to the general public through in-depth cooperation with relevant enterprises.

## Summarizing academic achievements

Besides the competition itself, the event will also focus on summarizing academic and technical achievements in the field. Through academic lectures and exchange, we hope to present the latest accomplishments in robot research and development achieved by participating teams, and promote in-depth exchanges in related research.

# 1 Introduction to the Challenge

## 1.1 Overview

RoboMasters 2017 offers a platform for researchers and university students to make technological innovations and promotes exchange and dialog among researchers worldwide. In the RoboMasters arena, teams have the opportunity to showcase and push the limits of their technical capabilities within a fun and challenging environment. For the general public audience, it can be an eye-opening experience into the world of robotics and its close relationship with humans.

To encourage more participation in shaping the future of robotics, RoboMasters 2017 includes, as a special event, the “ICRA 2017 DJI RoboMasters Mobile Manipulation Challenge”, hereafter referred to as the “Challenge”. It is based on a different environment and set of rules from the main competition, and requires robots to complete certain tasks automatically.

The ICRA 2017 DJI RoboMasters Mobile Manipulation Challenge is a ground robot challenge, which examines the application and competence of technologies that include positioning, object grasping, force control and target identification, and also the stability of the entire system. The competition is suitable for researchers and students with interest and background in the stability of autonomous robotic platforms, as well as intelligent navigation and manipulation technologies.

Teams are to first register by email. Along with the registration email, teams must submit a technical proposal. Qualified technical proposals will receive equipment sponsorship. After the qualified teams receive sponsorship, they can work on the challenge, and have to submit their progress reports before Apr 20, 2017. Based on the progress reports, the finalists and possible travel sponsorship will be decided.

During the event, finalist teams have three competition runs. During each run, a team needs to complete the commissioning of robots and enable them to automatically complete the required tasks within 10 minutes. The scores of a team are calculated on the basis of time consumed to complete the required task and the quality of the accomplished task. The final score of a team is the highest one achieved over all runs.

The robots used in the Challenge must comply with the requirements specified in this document.

# 1.2 Schedule

The RoboMasters Organizing Committee reserves the rights to change competition schedule and rules. Specific rules and other things related are subject to the information announced by the committee on **the official website.**

| Key date | Activity |
|---|---|
| Jan 13, 2017 | Deadline for Registration |
| Jan 13, 2017 | Deadline for submission of technical proposals* |
| Jan 15, 2017 | Announcement of qualified teams that receive equipment sponsorship.( Standard RoboMasters robot platform ,$1,500) |
| Apr 20, 2017 | Deadline for submission of progress reports |
| Apr 30, 2017 | Announcement of finalist teams (may provide travel sponsorship according to quality of progress report) |
| May 29, 2017- May 31, 2017 | RoboMasters Mobile Manipulation Challenge @ ICRA 2017 |

*Requirements for technical proposal and progress report will be released later.

# 1.3 Competition Requirements

The competition is open to everyone around the world regardless of age, nationality and academic qualifications. As long as you are a robot enthusiast or interested in Robomasters Mobile Manipulation Challenge, you are welcome to set up a team of 1-5 persons to register for the competition. The application form in **Annex I** should be filled and sent to the email of RoboMasters Organizing Committee before Jan 13, 2017.

**Notes:**

1. Each participant is allowed to join only one team in the same competition.

2. Each team should have at least 1 member and at most 5 members. The role and responsibility of each member should be elaborated in the application form.

3. Each team must have 1 captain who is responsible for the team's technologies and strategies. The captain is also responsible for schedule management, contact with the Organizing Committee and the competition report submission.

# 2 Robot Specifications

## 2.1 Technical Overview

**Participating teams can purchase components and modules necessary for robot making on their own.** All of these robots must follow the specifications depicted in this chapter.

All the robots must be completely automatic to ensure that the result of Robotics Challenge is decided by the referees.

**The RoboMasters Organizing Committee advises teams to follow these guidelines:**

1. Analyze and plan the structure design carefully before manufacturing robots. Try to choose mature industrial products and modules to improve the reliability of the structure.

2. Evaluate man hour and financial needs in advance. Make budgets and plans to avoid too much cost for iteration of robots in the early stages of preparation.

## 2.2 Safety Guidelines

Safety is a basic principle of RoboMasters. All participating teams must pay attention to and take necessary actions to ensure safety when making robots.

1. During research and contest, safety should always be regarded as top priority. Captains should take the responsibility to ensure the safety of the people involved.

2. Error in operation, software, and control, as well as malfunction of components and equipment, may lead to dangerous and unpredictable robot behaviors that cause harm or damage to both operators and robots. Therefore, measures must be taken to mitigate such risks.

3. The RoboMasters Organizing Committee has the right to take the necessary steps to deal with defective robots in emergency situations (fire or explosion, etc.)

## 2.3 Robot Requirements

| Item | Requirement | Penalty |
|---|---|---|
| Weight limit | 25kg | A robot that does not conform to the requirement specifications will be rejected during the check-in process. |
| Initial size limit | 800mm x 800mm x 800mm (length, width, height) | |
| Expansion size limit (the maximum size of robots when they fully stretch in the challenge) | 1500mm x 800mm x 800mm (length, width, height) | |
| Voltage limit | 6S Li-Po battery | |
| Control method | Full autonomous | |
| Start conditions | A standard robot is allowed to move only after the formal start of a game | A standard robot that moves before the formal start of a game will be considered to violate competition rules. |

# 3 Competition Field

The competition field of the Challenge has the entrance, the starting area and the working area. Their locations are indicated in the following diagram.

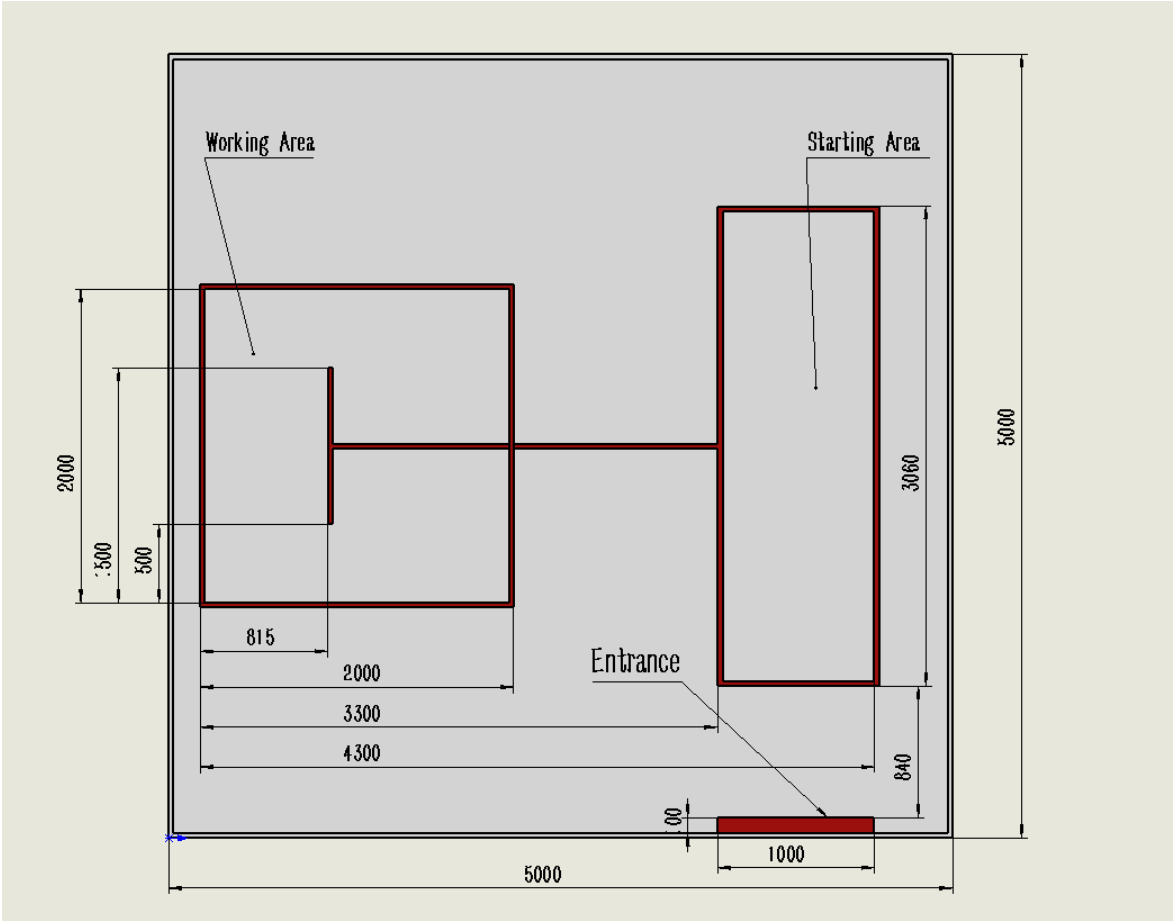



**Figure 1**

**Note:** Units are in millimeters (mm).

**Building block:**

The size of a building block is: 200*200*200mm. The material is EVA foam and hardness is 45 degrees. There is a hole with a diameter of 115mm and depth of 130-150mm on one side of each building block. As shown below:

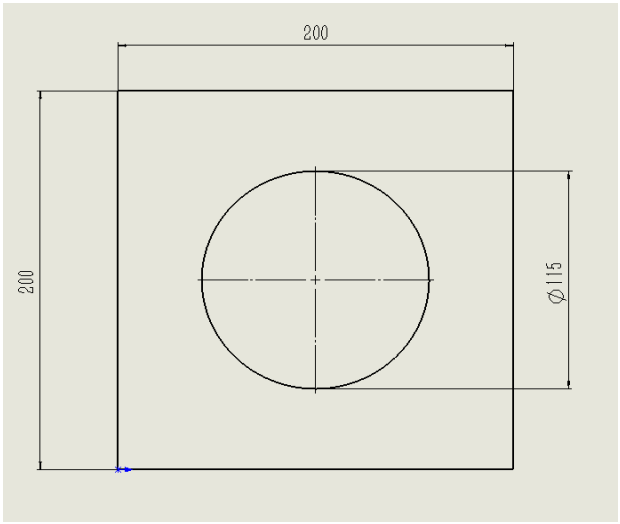
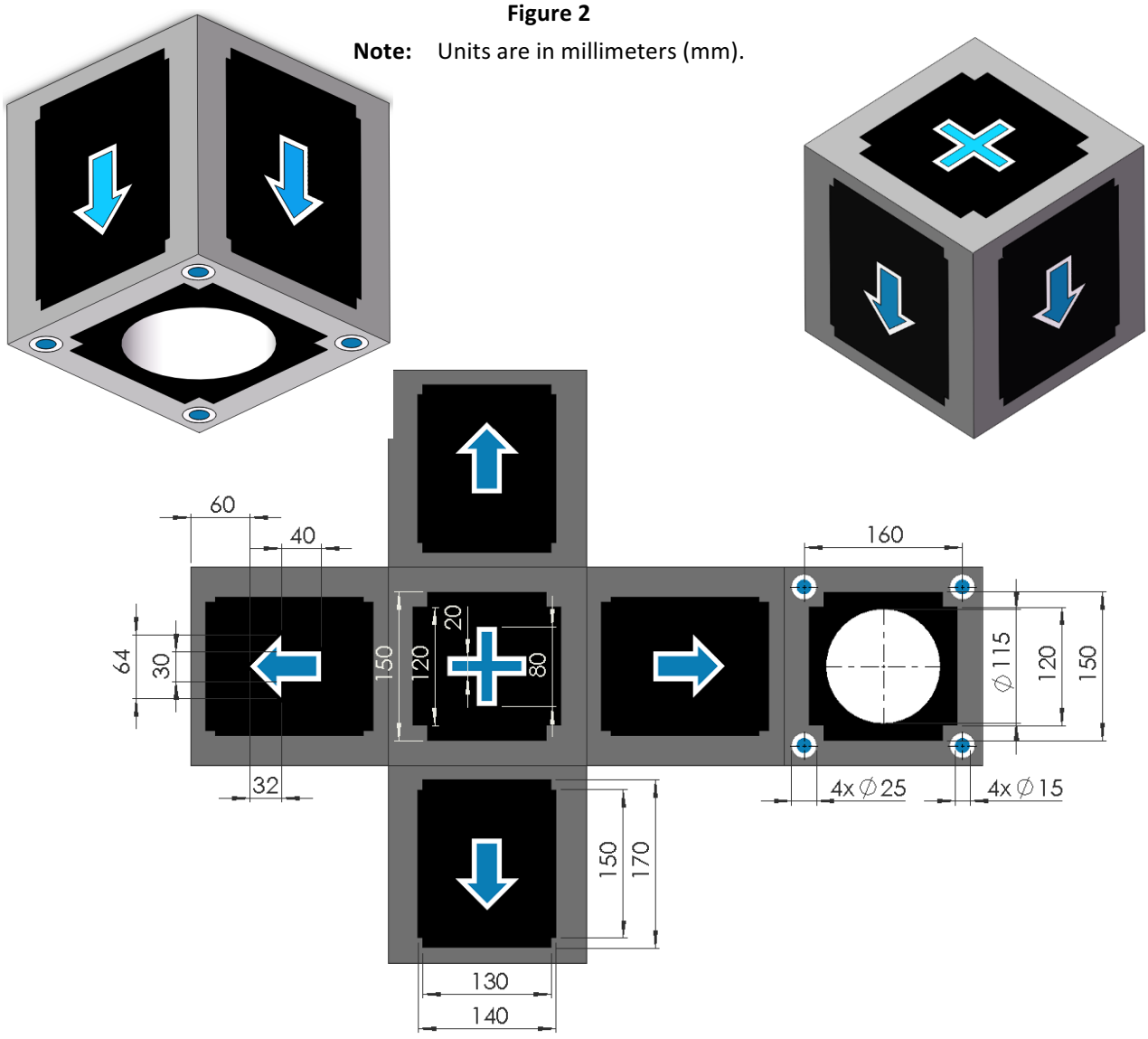



**Figure 2**

**Note:** Units are in millimeters (mm).



# 4 Competition Process

## 4.1 Pre-Competition Check

The Challenge lasts for several days. Teams are required to arrive at the designated venue within the time specified by the RoboMasters Organizing Committee to check in, and place their robots and devices in designated areas.
After the check-in, the Organizing Committee will check the robots for weight, voltage, and size, and only the teams that pass the check are eligible to compete in the competition.

## 4.2 The Challenge

Before each challenge run, robots must go through the pre-competition check again. During the competition, robots are required to complete the task fully automatically after completing the commissioning. Inside and outside the field, teams are not allowed to place equipment and devices that help their robots with positioning. A robot can only be connected to 1 to 3 PCs, laptops or other computing devices outside the field through wireless connection. Before the start of a challenge run, a team must report to the referee the locations and usage of these devices. The referee will monitor the operating status of these devices during the game.

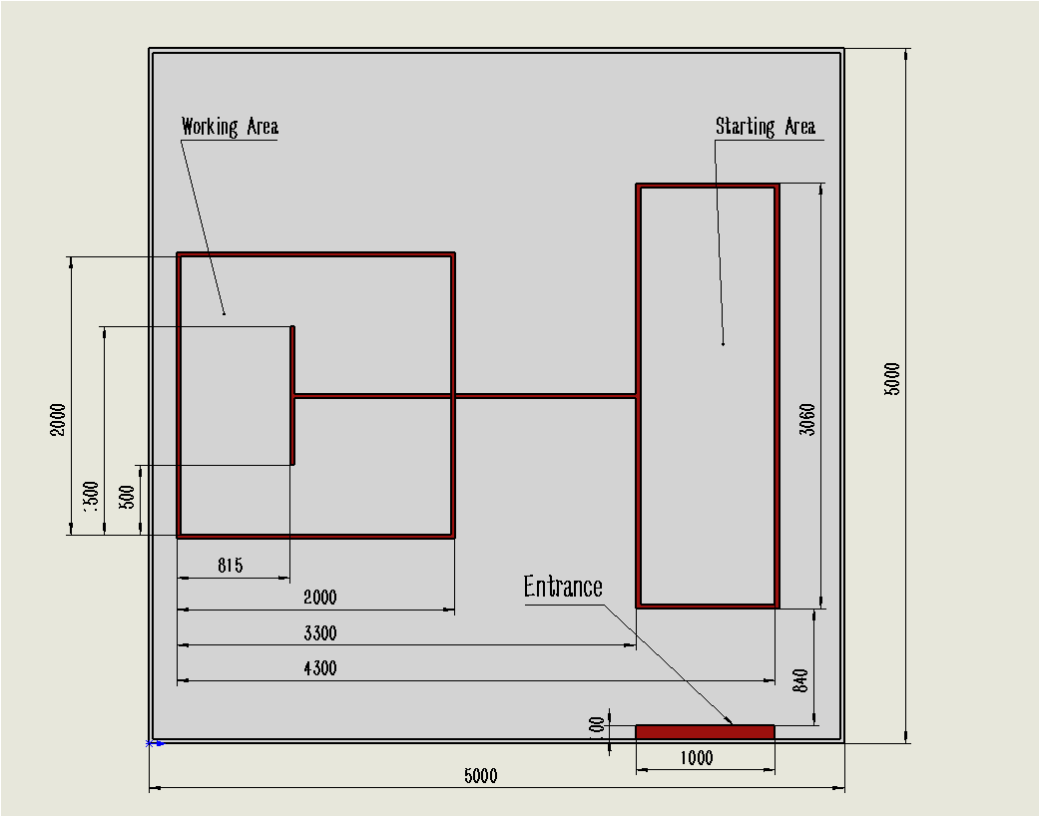
If a team needs to shift the operating mode of its robot from automatic control to manual control, team members must report to the referee the change of operating modes, and acknowledge that this will cause their game to be terminated immediately.

As the illumination and electromagnetic environment of the competition area may be different from the commissioning conditions in a laboratory, teams should test their robots in different places, scenarios and illumination conditions as much as possible, and try to design fully embedded autonomous systems so as to avoid controlling the robots remotely through wireless connection.

| Robotics Challenge Competition Procedure | |
|---|---|
| **Procedure** | **Description** |
| **Preparation** | Before the start of a challenge run, team members and their robot should prepare at the entrance of the competition area. |
| **Entry** | When the team is ready, the referee will give the instruction of |

| | |
|---|---|
| | entering the competition area, and start the 10-minute countdown. |
| **Commissioning** | Team members can move their robot into the competition area, place it at the designated area, and begin the commissioning. No more than 5 team members are allowed to enter the competition area. When the commissioning is completed, the team members must leave the competition area. |
| **Robot Operation** | Only after team members leave the competition area can the robot start operation. |
| **Timekeeping** | After the robot starts, a referee will begin the timekeeping. |
| **Competition Start** | The robot moves building blocks from the starting area to the working area in the remaining time. |

## 4.2.1 Competition Rules




In the Challenge, there are 16 building blocks in the starting area. The positions of these building blocks in the starting area can be freely arranged by teams themselves. However, before a robot starts, building blocks and the robot must be within the boundaries of the starting area.

A robot can only start to operate from the starting area. After starting, the robot must collect building blocks on its own and then place them into the working area. Each building block that is successfully placed into the working area scores 10 points. A robot cannot carry and move with more than 2 building blocks within the starting area and the working area, or it will be considered as cheating, and this will lead to immediate termination of the competition.

The required task for a robot is to successfully move all building blocks into the working area. After the robot completes the required task, the team scores 300 points.

If there is no building block in the starting area, the time when the robot returns to the starting area and stops moving indicates the end of the run. The referee will announce the end of the run and stop the timekeeping. The time remaining (from the time limit of 10min) will be used to calculate the time reward points.

If a challenge run is terminated in advance by a referee (when there is an unexpected problem with a robot) or upon the request by a team (when a robot cannot complete the required task, or there is an unexpected problem with a robot and it has to be controlled manually), then the run ends and the time remaining will not be used to calculate the time reward points.

## 4.2.2 Calculation of Points

A team's points scored in a challenge comprise three parts:

1. The first part: The points scored from putting building blocks into the working area;

2. The second part: The points scored from the highest height of the structure created by building blocks in the working area;

3. The third part: The points rewarded on the basis of time remaining (from the time limit of 10min). The less time a robot spends on the required task (moving all building blocks from the starting area into the working area), the more points the team gets. The time reward points equal twice the number of seconds remaining.

**The highest height of the structure created by building blocks in the working area:** Let *D* be the farthest distance between the corner, edge or face of a building block and the ground of the working area when all building blocks are still. The units of *D* re in centimeters (cm) and the measurement resolution is 5cm. The final value is rounded down, and we denote this value by *D*'. For example, if *D* is 88.5cm, it is rounded to 85cm; if *D* is 91cm, it is rounded to 90cm. The points scored for the height equal 20*(*D*'-20).

**The scenarios in which a team scores points in a challenge run are illustrated by the following examples:**

**Example 1：**

A robot puts all 16 building blocks into the working area, returns to the starting area and stops. The referee immediately stops the timekeeping and confirms that the ground robot spends 100 seconds to complete the required task.
All building blocks are placed horizontally on the bottom surface of the working area, and the highest height of the structure created by the building blocks is 20cm (every building block is a cube of 20cm).
**The final points of the team are:**
1. The first part: 16x10+300=460
2. The second part: 20x(20-20)=0
3. The third part: 2x(600-100)=1000

**Subtotal:** 16x10+300+2x(600-100)+20x(20-20) = 1460

**Example 2：**

A robot puts 12 building blocks into the working area, and then arranges the structure of building blocks until the given time runs out. The referee stops the timekeeping and confirms that the robot spends 600 seconds to complete the required task.
The building blocks are placed into a cube column of six layers, and its highest height is 120cm.
**The final points of the team are:**
1. The first part: 12x10=120
2. The second part: 20x(120-20)=2000
3. The third part: 2x(600-600)=0

**Subtotal:** 12x10+2x(600-600)+20x(120-20) = 2120

**Example 3:**
A robot puts all 16 building blocks into the working area, returns to the starting area and stops. The referee immediately stops the timekeeping and confirms that the ground robot spends 320 seconds to complete the required task.
If the highest height of the structure created by the barriers is 90cm.
**The final points of the team are:**
1. The first part: 16x10+300=460
2. The second part: 20x(90-20)=1400
3. The third part: 2x(600-320)=560

**Subtotal:** 16x10+300+2x(600-320)+20x(90-20) = 2420.

**Example 4：**

A robot puts all 16 building blocks into the working area, and it suddenly loses control. It runs towards one side of the field, crosses the starting area and bumps against a wall with its wheels spinning. The team shifts the operation mode to manual control. In this situation, the referee immediately terminates the competition and confirms that the ground robot spends 85 seconds to complete the required task.
All building blocks are placed horizontally on the bottom surface of the working area, and the highest height of the structure created by the barriers is 20cm.
**The final points of the team are:**
1. The first part: 16x10+300=460
2. The second part: 0
3. The third part: 20x(20-20)=0

**Subtotal:** 16x10+300+20x(20-20) = 460

A team's highest score in the **three challenge runs** are taken as its final score. If two

teams score the same points, the Organizing Committee will compare the weights of the two robots according to the pre-competition check records to rank the two teams (The lighter one gets a higher rank.)

According to the four examples above, the guidelines for achieving a high score in the Challenge are:

| No. | Key Points |
|---|---|
| 1 | Shorten the preparation time (The time to complete the required task includes the time for commissioning. Therefore, the less the commissioning time, the less time is spent on the required task). |
| 2 | Try to place all building blocks into the working area. |
| 3 | Improve the stability of picking, carrying and placing the building blocks through visual servo and sensor technologies. |
| 4 | Design the stacking structure of the building blocks to maximize the height. |
| 5 | Improve the stability and accuracy of a moving robot through autonomous positioning technology. |

# 4.3 Prizes

| Award | Qty. | Prize |
|---|---|---|
| **1st Prize** | 1 | Each team member can get one certificate and one DJI Phantom 4 Pro |
| **2nd Prize** | 1 | Each team member can get one certificate and one DJI Mavic Pro |
| **3rd Prize** | 1 | Each team member can get one certificate and one DJI Osmo Mobile |
| **Outstanding Performance Prize** | 1 | Winning team can get $20,000 |
| **Participation Prize** | Some | Honorable mention certificates and souvenirs |

**Note:**

1. A team is eligible for the Outstanding Performance Prize if it uses no more than 10 building blocks to create a structure in the working area whose highest height is above 1.2 meters.

   If more than one team complete the task, the team that gets the highest final score is the winner. If two teams score the same points, the Organizing Committee will compare the weights of the two robots according to the pre-competition check records to rank the two teams (The lighter one gets a higher rank).

   If all teams fail to complete the task, there will be no Outstanding Performance Prize of the Challenge.

2. The 1st, 2nd and 3rd Prize are given according to the final scores of participating teams. If two teams score the same points, the Organizing Committee will compare the weights of the two robots according to the pre-competition check records to rank the two teams. (The lighter one gets a higher rank).

3. For teams that do not win the 1st Prize, 2nd Prize and 3rd Prize, they will get the Participation Prize.

# 4.4 Fouls and Penalties

In the Challenge, a referee only issues “Game Terminated Penalty”. The penalty will be issued if:

| No. | Type of fouls |
|---|---|
| 1 | A robot is about to malfunction or has malfunctioned (quickly flying out of the field or bumping against one side of the competition area, and causing damage to the area) |
| 2 | One or more team members enter the competition area without approval |
| 3 | A robot starts to operate before the team members have left the competition area |
| 4 | After timekeeping starts, one or more team members manually control a robot, or shift from automatic operation to manual operation |
| 5 | Robots or team members cheat |

In addition, the time to end a game (a robot returns to the starting zone) shall be subject to the judgment of referees. The Organizing Committee will record the Challenge with video recorders to ensure the accuracy of the timekeeping.

Teams must abide by decisions made by a referee. Otherwise, the scores of teams in a single challenge will be canceled. Other acts that severely violate the spirit of the competition will have penalties according to the degree of violation.

# 5 Rules FAQ

If you have any question about RoboMasters Mobile Manipulation Challenge, please send your questions to the email of RoboMasters Organizing Committee: robomasters@dji.com (Subject: “School/Company/Institution Name + Team Name + RM Robotics Challenge Question”), the staff will reply within 1-2 working days.

# Annex I：

《ICRA2017 DJI RoboMasters Mobile Manipulation Challenge Application Form》

| **ICRA2017 DJI RoboMasters Mobile Manipulation Challenge Application Form** | | | |
|---|---|---|---|
| **Team Information** | | | |
| School/Company/Institution | | Country | |
| Team Name | | | |
| Address | | | |
| **Captain Information** | | | |
| School/Company/Institution | | | |
| Name | | Country | |
| Occupation | | Expertise | |
| Phone | | Email | |
| Address | | | |
| Responsibility | | | |
| **Team Member 1 Information** | | | |
| School/Company/Institution | | | |
| Name | | Country | |
| Occupation | | Expertise | |
| Phone | | Email | |
| Address | | | |
| Responsibility | | | |
| **Team Member 2 Information** | | | |
| School/Company/Institution | | | |
| Name | | Country | |
| Occupation | | Expertise | |
| Phone | | Email | |
| Address | | | |

| | | | |
|---|---|---|---|
| Responsibility | | | |
| **Team Member 3 Information** | | | |
| School/Company/Institution | | | |
| Name | | Country | |
| Occupation | | Expertise | |
| Phone | | Email | |
| Address | | | |
| Responsibility | | | |
| **Team Member 4 Information** | | | |
| School/Company/Institution | | | |
| Name | | Country | |
| Occupation | | Expertise | |
| Phone | | Email | |
| Address | | | |
| Responsibility | | | |

The RoboMasters Organizing Committee
Email: robomasters@dji.com
Official forum: http://bbs.robomasters.com
Official Website: http://www.robomasters.com

Tel: 0755-36383255（Monday-Friday 10:00-19:00）

Address: Room 202, Floor 2, 1089 Chaguang Road, Xili, Nanshan District, Shenzhen, Guangdong Province

**WeChat**

**Weibo**