IEEE International Conference on Robotics and Automation 2018

DJI RoboMaster AI Challenge

ICRA 2018, Brisbane, Australia

Challenge Rules

Version1.2

April 2018

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

Content

Background

DJI initiated RoboMaster in 2015 as an educational robotics competition for talented engineers and scientists. The annual competition requests teams to build ground robots that use shooting mechanisms to battle with other robots and the performance of the robots are monitored by a specially designed Referee System, converting projectile hits into Health Point deduction of robots. The competition balances technology and entertainment. Many game elements in the competition are similar to video games. In August 2017, the final tournament of RoboMaster 2017 attracted over 26 million viewers from over 20 countries around the globe. People can visit https://www.twitch.tv/robomaster to view game replays and introductory videos.

In recent years, deep learning technology greatly has been reshaping the frontier of computer vision and many other AI research areas. In robotics research, deep reinforcement learning allows agents to make decisions based on deep neural networks (DNN) instead of conventional hand-engineered finite state machines and if-else branches. Many excellent research platforms emerged from standard video games such as Doom, DOTA and StarCraft.

RoboMaster also has the potential to become a deep learning platform, with robots that compete on the field fully commanded by DNN based policies. For one thing, robots also need to make complex decisions that cannot be done by conventional methods. For another, RoboMaster is a real game, so algorithms and policies developed on RoboMaster robots are more practical than those developed in virtual environments.

Organizer:

SZ DJI Technology Co., Ltd.

IEEE International Conference on Robotics and Automation 2018

Revision Log

Date	Version	Modifies
Feb 1, 2018	1.1	Updated FAQ with answers based on feedback from teams.
Feb 1, 2018	1.1	Specified more General Technical Requirements, especially Wireless Communication and Optical Element parts.
Feb 1, 2018	1.1	Re-defined Module name of RoboMaster Referee System for clearer purchasing guidance.
Feb 1, 2018	1.1	Stated RMOC official AI Robot User Manuel release date.
Feb 1, 2018	1.1	Updated the newest Challenge Field Map.
Feb 1, 2018	1.1	Clarified Challenge Days arrangement.
Feb 1, 2018	1.1	Released Technical Report Requirements.
Apr 22, 2018	1.2	Updated new prizes based on current DJI products
Apr 22, 2018	1.2	Updated the Robot Inspection Form

Chapter 1 Introduction

1.1 About the Challenge

RoboMaster 2018 offers a platform for researchers and university students to make technological innovations and promotes exchange and dialog among researchers worldwide. In the RoboMaster 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, RoboMaster 2018 includes, as an individual event, the "ICRA 2018 DJI RoboMaster AI Challenge" (hereafter referred to as the "Challenge"). It requires robots to complete specific tasks automatically.

The RoboMaster Organizing Committee's (hereafter referred to as "RMOC") R&D team has developed autonomous robots that can coordinate with each other to fight opponents automatically (hereafter cited as RoboMaster AI Robot). A RoboMaster AI Robot has a built-in neural network to make decisions, especially when encountering ally or opponent robots. At this time, RoboMaster AI Robots cannot defeat robots controlled by human operators, but they serve as an excellent benchmark to test the performance of new AI algorithms.

In ICRA 2018 DJI RoboMaster AI Challenge, a team has to build and program ONE or TWO autonomous robots (hereafter referred as Team Robot) to defeat TWO RoboMaster AI Robots on a 5m × 8m Challenge Field. In each Challenge Round, neither Team Robots nor AI Robots can be controlled by human operators. The winner of the AI Challenge is the team who defeats AI robots in shortest time or less Health Point (hereafter referred to as the "HP") reduction.

Teams should submit the registration form through the official website (https://www.robomaster.com/en-US/robo/know). Along with the registration form, teams must submit Technical Proposals. Qualified Technical Proposals will receive equipment sponsorship as a reward. Teams have to submit their Technical Report before Apr 20, 2018. Teams that submit the highest quality Technical Report will receive travel sponsorship to ICRA in Brisbane.

During the Challenge in Brisbane, each finalist team has **FOUR** Challenge Rounds. During each round, a team needs to set up robots to automatically fight AI robots. A scoring formula evaluates the result of each round. The final score of a team is the highest score achieved over all rounds. Then all final scores of teams are ranked together. According to the final ranking, teams will get certificates, DJI products, and cash prizes as awards.

The robots used in the Challenge must comply with the requirements specified in the challenge rules. Teams can build Team Robots by themselves, or purchase sample robots from the RMOC to shorten the preparation time. The RMOC will release purchasing channel afterward on the official website. Other than sample robots, teams can also purchase Referee System.

1.2 Schedule

Every team should correctly fill in the registration information on the official RoboMaster application system. Please visit https://www.robomaster.com/en-US/robo/know and complete the activity requirements before following deadlines.

Teams can only be qualified to participate in the official Challenge after meeting the requirements of the Technical Report.

The RMOC reserves the rights to change schedule and rules. The RMOC will announce rules update or related information on the official website.

Key date	Activity
Dec 31, 2017, 23:59*	Deadline for Registration
Jan 1, 2017, 23:59*	Deadline for submission of Technical Proposals
Jan 8, 2018, 23:59*	The announcement of qualified teams that receive equipment sponsorship.(RoboMaster Standard robot kit, worth **$8,500)**
Apr 10, 2018, 23:59*	Deadline for submission of Technical Report
Apr 21, 2018, 23:59*	Announcement of finalist teams that receive $1000 travel sponsorship according to the quality of the Technical Report
May 21, 2018 - May 25, 2018	DJI RoboMaster AI Challenge @ ICRA 2018

*The time mentioned above is China Standard Time (CST UTC+8).

1.3 Team Requirements

The challenge is open to undergraduate students and graduate students.

General Requirements

1. Each participant is allowed to join only one team.

2. Each team must have between 1-10 members. The role and responsibility of each member must elaborate on the application form.
3. Each team must have 1 Captain who is responsible for the team's technologies and strategies. The Captain is the main contact point with the RMOC.
4. The team name is the university name or research organization name of team members. If team members come from more than one organizations, the team must decide their primary organization as the team name.

Recommended team structure

1 person (undergraduate or postgraduate) responsible for embedded system programming.

2 persons (undergraduate) responsible for mechanical support and hardware maintenance.

3 persons (undergraduate or postgraduate) responsible for software system architecture, sensor processing.

2 persons (undergraduate or postgraduate) responsible for image processing, computer vision, sensor fusion.

2 persons (postgraduate) responsible for decision making, trajectory generation & execution.

While not mandatory, it is recommended for a team to have a Project Manager who arranges project schedule and utilizes financial resources.

1.4 Award

Award	Prize
1st Prize	Each team member will receive a certificate of recognition and one DJI Mavic Pro. Winning team will receive $20,000 USD (Before Taxes) and one Nvidia Titan XP.
2nd Prize	Each team member will receive a certificate of recognition and one DJI Mavic Air. Winning team will receive $10,000 USD (Before Taxes) and one Nvidia Titan.
3rd Prize	Each team member will receive a certificate of recognition and one DJI Spark. Winning team will receive $5,000 USD (Before Taxes) and a Nvidia Jetson

	TX2.
Finalist	Each team member will receive one certificate of recognition. The team will get travel sponsorships $1,000 USD (Before Taxes).

*All final scores of teams are ranked together. If multiple teams have the same score, the weight of their robots will be used to decide ranking, where lighter robots have a higher ranking.

1.5 Announcement on Intellectual Property

The team owns all the intellectual property developed during the Challenge**.** The RMOC does not claim ownership of any code, system design documents or technical report of teams. The Technical Report submitted to RMOC by teams are only used for progress checking. The RMOC will not modify, distribute to third parties or duplicate any submitted Technical Report and other materials.

The RMOC encourages and advocates technical innovation and open-source. The RMOC will not deal with intellectual property disputes between the members of a team. Team members should handle the ownership of intellectual property among members of the school, companies, and other entities.

In the process of using RoboMaster Referee System and other supporting materials provided by RMOC, teams should respect the ownership of all the intellectual properties. Teams cannot engage to do any behavior that may damage the intellectual property such as reverse engineering on products, copy, translation, etc. Open source codes provided by RMOC are under GPLv3 license.

1.6 Rules FAQ

According to the actual situation before the Challenge, the rules may be updated in following ways:

1. Minor adjustments to the Challenge schedule.
2. Update more detailed description of the Challenge Field and the Challenge Rundown.

Based on feedback from teams, the following rules have been amended:

a. Visit https://github.com/robomaster for RoboRTS platform open sourced codes. The mechanical drawings of the official AI Robot will be released along with RoboMaster AI Robot User Manuel at official website before the end of Feb 2018.

b. Apart from RoboMaster UWB Locating System, other sensors such as LIDAR and Cameras for image processing will not be offered by RMOC;

c. At the beginning of each Round, the official AI Robots start on the RED side, and

the Main Control Module's LED will set to the same color RED. Simultaneously, Team Robots must start on the opposite side opposite to the official and set the LED color BLUE.

If you have any question about the Challenge, please either send an e-mail to RMOC: robomaster@dji.com (Subject: "School/Company/Institution Name + DJI RoboMaster AI Challenge Question"), or leave your questions at GITTER RoboMaster Community: https://gitter.im/RoboMaster/RoboRTS?utm_source=badge&utm_medium=badge&utm_campaign=pr-badge. RoboMaster staff will reply within 1-2 working days.

Chapter 2 Robot Specifications

2.1 Technical Overview

Participating teams can purchase components and modules from the RMOC. All Team Robots must follow the specifications depicted in this chapter.

All Team Robots must operate autonomously during the Challenge Rounds. However, Robot can be operated manually during the Setup Period of each Challenge Round, as long as it has a switching mechanism to switch robot from manual to autonomous operation by the time the Challenge Round starts.

The **RMOC has following advice regarding robot system design:**

- Robots sold by the RMOC are just basic prototypes, the team must have dedicated mechanical and hardware engineers to maintain them.
- To ensure system's stability, use finished components, rather than building them yourself (e.g., an ultrasonic sensor).
- Read and analyze the manual carefully.
- Read Referee System specifications carefully. Referee System modules must be installed correctly before robot inspection.
- A project management plan with highlighting milestones and budgets is recommended before developing robots.
- Test robots thoroughly to make sure robots can endure multiple rounds, transportation, and unforeseen accidents.

2.2 General Technical Requirements

To ensure practical, fair, and safe competition, robots must be designed and engineered in strict accordance with following technical requirements.

Item	Description
Energy requirements	Robots can only be powered by Li-Po batteries manufactured by DJI. Fuel-powered engines, explosive substances, and hazardous chemical materials are prohibited. The power supply must consist only of intelligent batteries manufactured by DJI. The total energy storage of any single robot may not exceed 200Wh.
Remote Controller	Team Robots must be fully autonomous during a Challenge Round, but can be remote-controlled during the Setup Period (two minutes before the start of each Round).

Wireless Communication	A team can also deploy their Wi-Fi devices for wireless communication among different robots and external computing devices. The RMOC will only provide an external power source outside of the Challenge Field at one designated area. Due to environmental factors such as live streaming devices and personal devices in the audience, there will be many unknown Wi-Fi signals on the competition site. The RMOC cannot guarantee the stability of Wi-Fi connection built by teams. Note: 1. During the Setup Period of each round, competition teams can set up their Wi-Fi band. We recommend teams utilize reliable Wi-Fi solutions. 2. There are different Wi-Fi frequencies in different countries or regions. Please plan accordingly. 3. Teams must carry their own Wi-Fi devices during Challenge. 4. To avoid signal interference, team's Wi-Fi devices are allowed to switch on when: a. during their Round; b. hold on the Staging Area.
Optical Elements	The robot is not allowed to use any laser pointers and lighting equipment during the Challenge. Moreover, reflective materials such as glass or mirror are also forbidden.
Surfaces	There are clear visual features on the armor modules of Referee System; teams are suggested to develop imaged based target recognition algorithms to detect armor modules. It is compulsory to place sensors (e.g., LIDAR, camera, ultrasonic) in a way that does not block interface with Armor Modules. The Challenge Field and surrounding environment are complex. Teams should consider this factor when developing vision algorithms to better adapt to the changing lighting condition. The RMOC cannot guarantee that the vision features around the field will not cause any interference to robots' vision system. Decorate stickers on the armor modules are not allowed. Any RED and BLUE (correspondence to the Referee System's LED bar) materials or paint cannot appear on Robot's surface, because that may cause misrecognition.

2.3 Robot Specifications

In each round, teams can use ONE or TWO robots. All robots have to receive official inspection before entering to the Challenge Field.

Team Robots have to comply with following specifications.

Item	Requirement	Penalty
Weight Limit (kg)	20 (Including the battery, but excluding Referee System)	A robot that does not conform to specifications will be rejected during the official inspection.
Initial Size Limit (length, width, height)	600mm × 600mm × 500mm	
Expansion Size Limit (length, width, height) (the maximum size of robots when they fully expand in the challenge)	700mm × 700mm × 600mm	
Projectile Speed Limit	20m/s	HP deduction decided by Referee System.
Projectile Frequency Limit	10Hz	
Chassis Power Consumption	Unlimited	None
The Lower Edge of the Armor Module (measure from the ground)	50mm – 200mm	Fail to Pre-Challenge Inspection. Disqualified to attend the Challenge.

2.4 Referee System

2.4.1 Overview

As an essential part of the Challenge, RoboMaster Referee System must be mounted in each Robot. Therefore, **Teams must purchase a RoboMaster Referee System for each Robot to attend the Challenge**. Critical Modules for ICRA2018 AI Challenge are: a Main Control Module, four packs of Small Armor Module and its Support Frame, a Speed Measurement Module (17mm projectiles) and an RFID Interaction Module. While not mandatory, it is optional to purchase Camera Transmission Module and UWB Locating System depends on each team's requirements. Please visit https://www.robomaster.com/en-US/resource/pages/717?type=announcementSub for purchase instructions. The second batch of RoboMaster products will be available at 1st of March, 2018.

Moreover, teams who submit high-quality Technical Proposals (A list of such teams will be announced after Technical Proposals Assessment) will get an equipment sponsorship as a reward. The team gets ranked A will get one RoboMaster Standard Robot kit for free, and the team ranked B will get one set of Referee System. Those

teams that have not passed the Technical Proposals can purchase the Standard Robot kit and must purchase Referee System. And finalist team who submits high-quality Technical Report (refer to Technical Report Assessment standard) will get US $1000 travel sponsorship.

Robots with Referee System installed can detect projectile hits on armors, which trigger HP deduction. Since Referee System on robots are connected to the Referee Server where all robots upload their HPs and another status, the Referee Server can calculate total HP of each team and decide the winning team instantly when a Round ends. Each robot initially has 2000 HP.

To ensure the Challenge is fair and all robots satisfy robot specifications, the Referee System keeps monitoring robot status during every Challenge Round. If a robot violates certain Challenge rules, the Referee System on the robot will automatically reduce its HP accordingly. If HP drops to zero, its power will be shut off by Referee System.

Please read the *RoboMaster2018 Referee System User Manual* and *ICRA2018 DJI RoboMaster AI Challenge Specification Manual* (*https://www.robomaster.com/en-US/resource/pages/834?type=announcementSub*) for installation instruction and detailed functionality explanations of Referee System.

Referee System consists of following components:

Module	Purpose
Camera Transmission Module	This module concludes VTM Transmitter and VTM Receiver. The VTM Transmitter captures the live video, and send a video stream to VTM Receiver and output as HDMI signal. VTM transmitter is only for monitoring and inspection purpose. Robots cannot read data inside the Camera Transmission Module.
Speed Measurement Module (17mm projectile)	Installed on the barrel of launching mechanism. It can detect the shooting speed of outgoing projectiles. It will deduct robot's Health Point when the shooting speed exceeds the limit. More details state in section 2.4.3.
Small Armor Module	Armor modules have built-in pressure sensors. It can detect projectile hits and convert it to HP deduction signal through Referee System. The lower edge of the Armor Module on the robot should be 50mm to 200mm from the ground.
RFID Interaction Module	RFID Interaction Module can communicate with the function points in the Challenge Field.

UWB Locating System	The system contains Tag and Anchor Module, and they can work together to obtain each robot's position information on the Challenge Field. Parameters of the System: Frequency≈40Hz, Latency≈100ms, Positioning Accuracy≈100mm. Teams can purchase the UWB Locating System Tag and Anchor from RMOC for testing. The UWB products sold for AI Challenge must collocate with the Referee System. During Rounds, RMOC will offer Tags that same as sold ones to teams. For its original point and coordinate system information please see Figure 1 in **section 3.1**
Main Control Module	Main Control Module can monitor the battery power supply and calculate power consumption. The LED light on top of the module indicates the amount of remaining HP. The color of the LED can use to distinguish RED/BLUE side and the status of robots. It will cut the power supply off when the HP drops to 0.

The official AI robots will meet all the specifications stated above. A sample robot is shown as follows. The RoboMaster AI robot's User Manuel and its mechanical drawings will be released at *official website – INFORMATION – Announcement* section before the end of Feb 2018.

2.4.2 Robot Health Point - Deduction Penalty Mechanism

During a Challenge Round, robots HP will be reduced when:

1. Projectile launching speed or frequency exceeds the limit.
2. Armor module being hit by projectiles or accidentally hit by other robots. While violently damaging others are not permitted during Challenge Round.
3. Necessarily modules of Referee System do not properly installed.

2.4.3 Projectile Speed Limit

If the speed of 17mm projectile exceeds 20 m/s, the HP will be deducted accordingly:

Each time the referee system detects a 17mm projectile with speed higher than 20m/s, but lower than 22m/s, HP is reduced by 10% of the maximum HP.

Each time the referee system detects a 17mm projectile with speed higher than (including) 22m/s, but lower than 24m/s, HP is reduced by 20% of the maximum HP.

Each time Referee System detects a 17mm projectile with a speed of 24m/s or above, HP is reduced by 40% of the maximum HP.

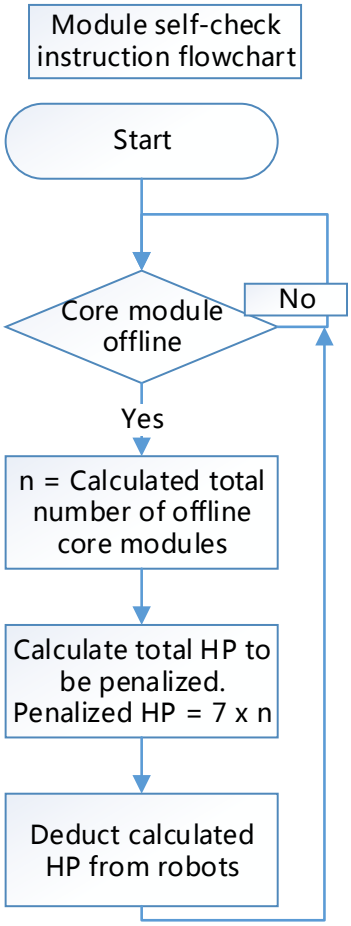
2.4.4 Projectile Frequency Limit

The projectile launching frequency cannot exceed 10Hz (Within one second, at most ten projectiles can go through the Speed Measurement Module). Otherwise, each time Referee System detects a 17mm projectile with exceeding higher than 10Hz will cause HP deduction of 10% of the maximum HP.

2.4.5 Referee System Going Offline

According to the ***ICRA2018 DJI RoboMaster AI Challenge Specification Manual***, Robots should ensure the stability of the connection between Referee System modules and the Server. If critical modules do not correctly connect to the Main Control Module of Referee System, HP will be deducted accordingly.

The critical modules include Main Control Module, RFID Interaction Module, Speed Measurement Module (17mm projectile) and Small Armor Module.



2.5 Safety Guidelines

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

1. During research and contest, safety must always regard as a priority. Captains must take the responsibility to ensure the safety of all team members 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 may cause harm or damage to both operators and robots. Therefore, robots must have an emergency shutdown switch. During Challenge Round, the Referee will also shut down such robots through Server of Referee System.
3. **The RMOC has the right to take the necessary steps to deal with defective robots in case of emergency situations during the challenge (fire, explosion, etc.)**

Chapter 3 Challenge Field

3.1 Overview

The size of the Challenge Field is 8000mm × 5000mm and will be covered by a gray non-slip rubber mat above the wooden floor. The Challenge Field contains Starting Zone, Goal Zone, Obstacle Block Zone, and Bonus Zone. All zones on where they set illustrated in the following figures.

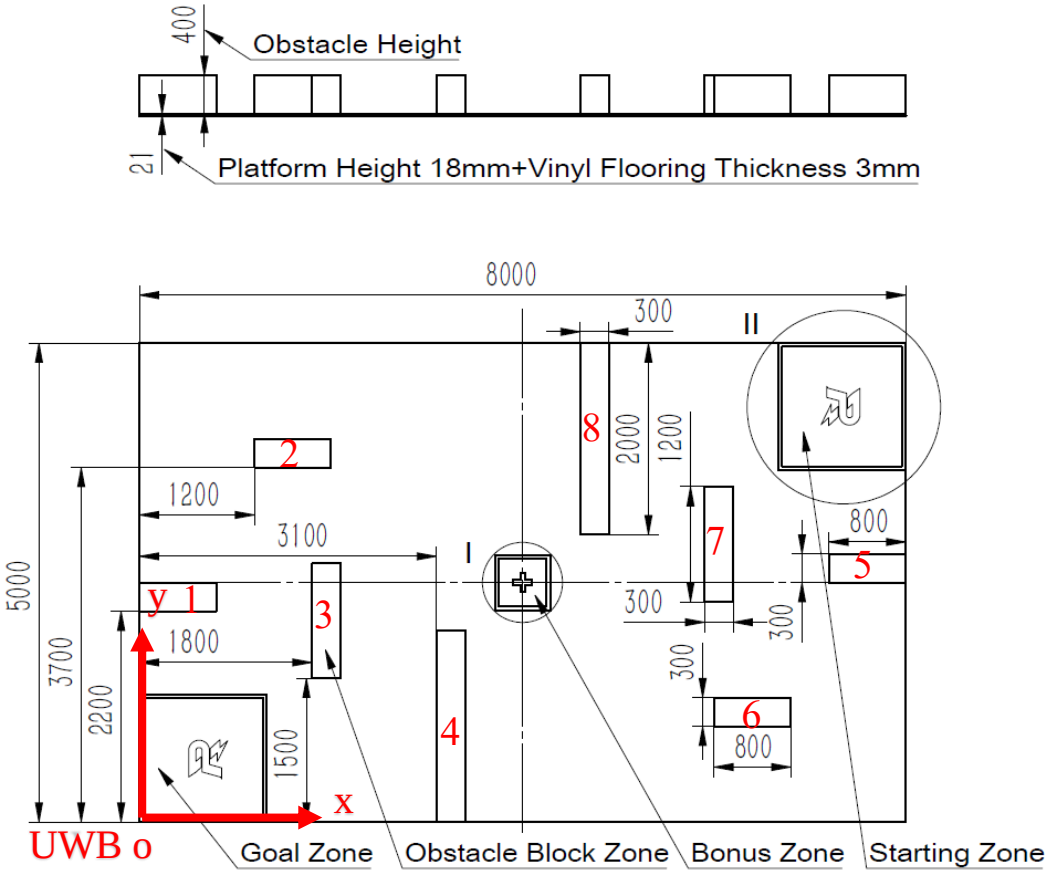


Figure 1. Dimensional Drawings of the Challenge Field

Note: All figures are in millimeters (mm).

3.2 Starting Zone

Starting Zone is the initial location for **Team Robots**. When a Challenge Round starts, Team Robots must be located within Starting Zone. After the challenge round starts, Team Robots can freely move to anywhere on the field. The dimensional drawing of the Starting Zone show as follows.

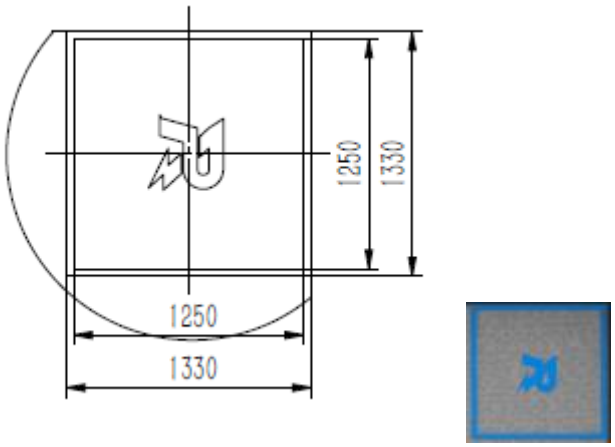


Figure 2. Sizes and Color of the Starting Zone

Note: All figures are in millimeters (mm)

3.3 Goal Zone

Goal Zone is the initial location for **RoboMaster AI Robots**. Similar to Team Robots, RoboMaster AI Robots can also leave the Goal Zone after the Challenge Round starts. The dimensional drawing of the Goal Zone show as follows.

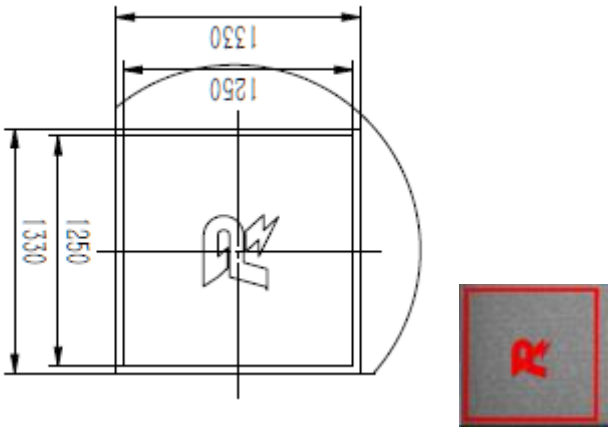


Figure 3. Sizes and Color of the Goal Zone

Note: All figures are in millimeters (mm)

3.4 Bonus Zone

There is one Bonus Zone in the center of the Field. **Both official AI Robots and Team Robots can activate it.** When a Robot resides completely inside Bonus Zone for more than **five** seconds, a Bonus enhancement will be triggered and added to all Robots on the activated side. This enhancement increases damage by 50% for the rest of the Round. For example, if a robot causes 50 HP damage from a single projectile

hit, it will increase to 75. **On each Round, the Bonus Zone can only be activated by ONE robot once. Any other robot cannot re-active it in the same Round.**

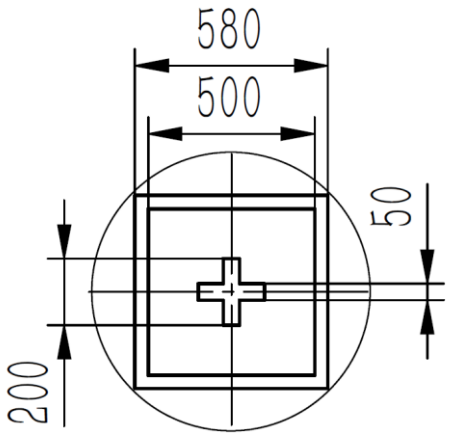


Figure 4. Sizes of the Bonus Zone

Note: All figures are in millimeters (mm).

3.5 Obstacle Block Zone

There are **eight** unmovable obstacles placed at certain designated locations.

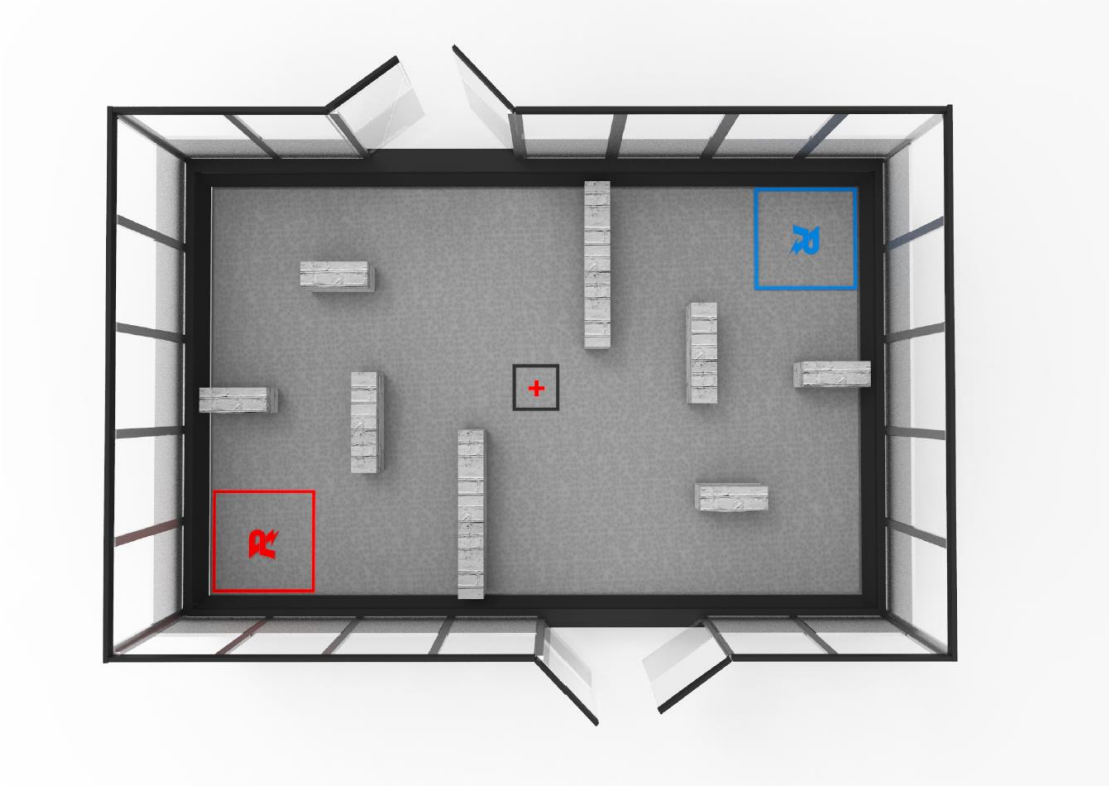


Figure 5. Bird View of the Challenge Field

Note: Units are in millimeters (mm).

Please note that obstacle blocks are attached to the ground and constructed of wood.

Other elements and materials information show as follows.

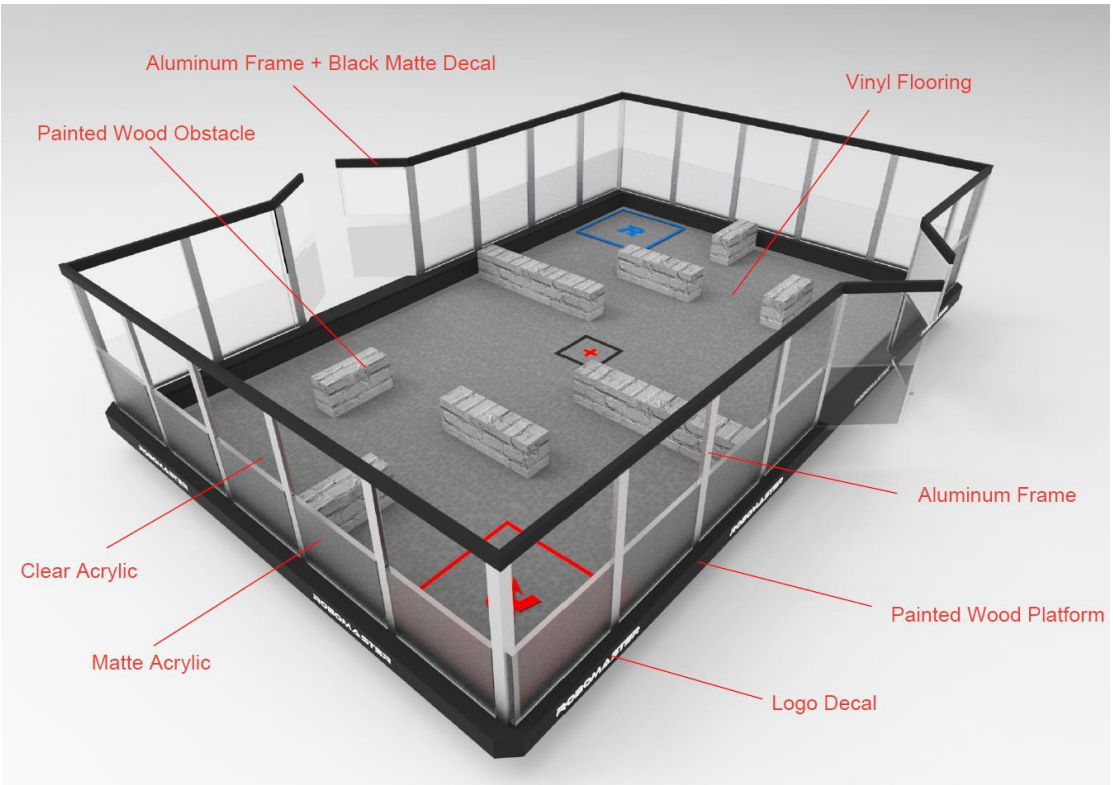


Figure 6. Field Materials

Note: Materials may slightly change in actual Challenge.

3.6 Protection Fence

To ensure that projectiles will not injure audiences, the Challenge Field is surrounded by Protection Fences. The sample fences are illustrated below:

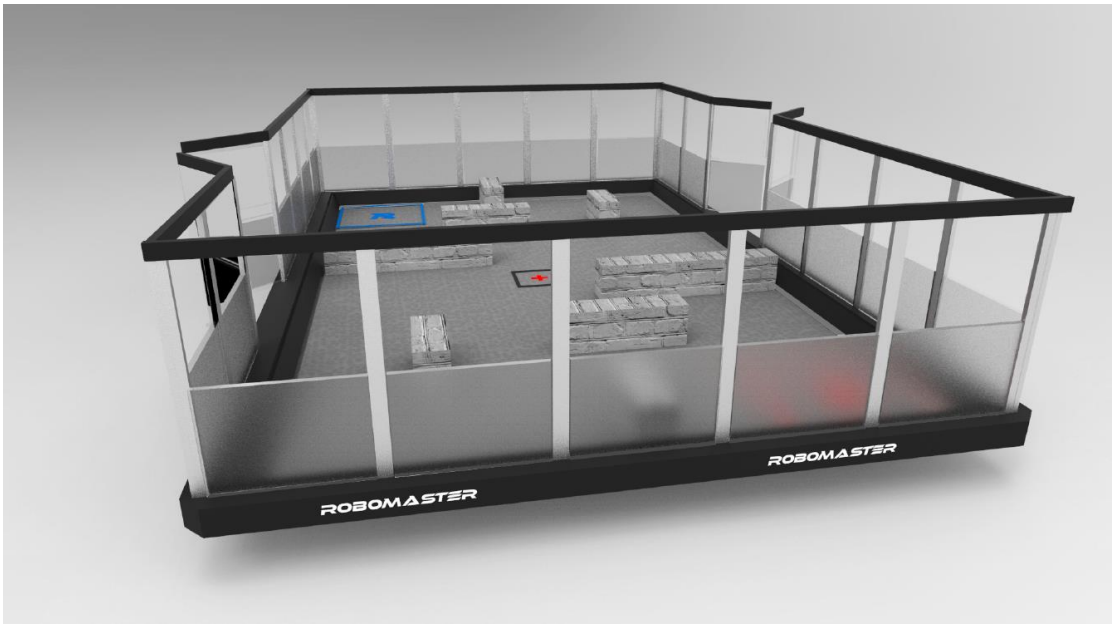


Figure 7. Side View of the Challenge Field

Note: Fences are estimated to be 2 meters height.

The fence's wood platform is attached to the ground and is 400mm height.

However, in the actual Challenge, the color, material, and exact size of the Protection Fences may be different from the figure above. Their appearance and distance to the field should not be utilized in robot localization and decision-making algorithms.

3.7 17mm Standard Projectiles

The only legitimate method to destroy robot is by 17mm projectile hits. Projectile specifications are as follows:

Appearance	Color	Size	Weight	Shore Hardness	Material
Sphere	White	16.9 (±0.1) mm	3.4 (±0.1) g	90A	TPE

Figure 8. Appearance of Projectiles

*All robots must use projectiles provided by RMOC; any others will not be accepted.

Chapter 4 Challenge Procedure

4.1 Overview

The Challenge lasts for several days, including one day for Warm-up and two to three days for the Challenge. Teams are required to arrive and check-in at the venue before Warm-Up, and further to place their robots and devices in Preparation Areas.

On Warm-up Day, each team has about 10 to 20 minutes for testing. The specific time subject to schedule changes.

On the Challenge Days, teams compete in turns, and they can modify, reprogram, and fine-tune their robots between Rounds. Each team has 4 Challenge Rounds in total.

Every Challenge day has multiple Rounds. During the Challenge, each team prepares for the Challenge at the Preparation Areas, reaches the Inspection Areas for official pre-Challenge Inspection of robots, waits for the Challenge starts at the Staging Areas, and finally enters the Challenge Field. Each team is required to leave the field and return to the Preparation Areas upon the end of each Round.

Details of Areas mentioned above and latest schedule will be specified in the official manual, which will be released one week before actual Challenge starts.

4.2 Pre-Challenge Inspection

60 minutes before every Challenge Round, the RMOC will inspect the robots to appear on the Challenge Field, making sure that the weight, voltage, size and Referee System comply with specifications. Only the teams that pass Inspection are eligible to compete in the challenge.

4.3 Challenge Rundown

After the Pre-Challenge Inspection, teams take their robots to the Staging Areas next to the Challenge Field. The referee will notify team members the time when start to move their robots into the field. Once robots enter the field, the Setup Period of the Challenge Round starts.

Each Challenge Round consists of three phases: Setup Period, Referee System Initialization and Challenge Round.

Challenge Rundown Phases	
Setup Period	120 seconds
Referee System Initialization	20 seconds

Challenge Round	180 seconds

Referee System will count the time automatically, linking all phases.

During the Setup Period, team members can power up and set up robots. **No more than 5 team members can enter the Challenge Field. When the Setup Period ends, all team members must leave the Field.**

Each robot (both official AI and Team robot) preloads 200 projectiles before each Round. The Referee will load the projectiles for official AI robots. The referee will also distribute projectiles – 2 bags of 100 if using ONE robot, 4 bags of 100 if using TWO robots to a team member before the Setup Period; then the projectiles can be loaded to robots. **After each Round, the team must take all projectiles out from robots.** The ones left in the feeding tube can be reserved only if removal requires a disassembling procedure.

Referee System Initialization is for Referee System to check the connectivity of robots. During this 20s period, referees can enter the Challenge Field in case of system failure. If a system failure occurs, team members must wait for the orders given by referees to enter the Field and help referees to resolve problems; otherwise, they cannot enter the Field.

A Challenge Round starts immediately after Referee System Initialization finishes. Team members can only remotely trigger Team Robots with a remotely connected laptop or other communication devices. Afterwards, team members shall not control or communicate with Team Robots for any reason. For safety considering, team members are allowed to continue monitoring the status of robots using their video transmission technologies and notify referees when an emergency occurs.

During the Challenge Round, if robots demonstrate abnormal behavior due to program malfunctions, team members can call for an Emergency Termination. The referee will review the situation and then shut down all robots through Referee System interface. When an Emergency Termination occurs, the current Challenge Round ends immediately, and the team who called for Emergency Termination gets a Round score of **0**.

When a Challenge Round starts, each robot has 2000 HP. Each projectile hits will reduce 50 HP from the corresponding robot. Bonus can augment projectile hits (See 3.4).

Challenge Round ends when Round time expires or when all robots of either side are destroyed.

4.4 Score Calculation

After one Challenge Round, the team score is calculated in the following scheme:

$$\text{Score} = \alpha \times X + \beta \times Y - \gamma \times Z$$

Where α, β and γ represent coefficients with the following values:

1. α = 6.0/(4.0+NUMBER OF ROBOTS);
2. β = 75.0/(4.0+NUMBER OF ROBOTS);
3. γ = 2.0/(1.0+NUMBER OF ROBOTS).

NUMBER OF ROBOTS can be 1 or 2, depending on the number of robots that enter the Challenge Round. RMOC will always present Two Robots no matter how many Team Robots stay in the Field.

And X, Y and Z represent the following:

1. X is the HP reduction of RoboMaster AI robots;
2. Y is the remaining time (in seconds) when both RoboMaster AI robots are destroyed. If the challenge time ends before both AI robots are destroyed, Y is 0;
3. Z is the HP reduction of Team Robots.

In this first example, a team uses 2 robots in a Challenge Round. Their robots **destroy** RoboMaster AI Robots within 150 seconds, and after the Round ends, one robot still has 850 HP, while the other has 1000 HP. Their total round score is,

α = 6.0/6.0

β = 75.0/6.0

γ = 2.0/3.0

X = 2000 ×2 = 4000

Y = 180 - 50

Z = (2000 - 850) + (2000 - 1000) = 1150+1000

Score = $\alpha \times X + \beta \times Y - \gamma \times Z$ **= 6.0 / 6.0 ×4000 + 75.0 / 6.0 ×(180 - 150) - 2.0/3.0 × (1150 + 1000) = 2941.6**

In this second example, a team uses 1 robot in a Challenge Round. This robot destroys RoboMaster AI Robots within 150 seconds, and after the round ends, this robot still has 250 HP. Its total round score is,

α = 6.0/5.0

β = 75.0/5.0

γ = 2.0/2.0

X = 2000 ×2 = 4000

Y = 180-150

Z = (2000-250) = 1750

Score = $\alpha \times X + \beta \times Y - \gamma \times Z$ **= 6.0/5.0 ×4000 + 75.0/5.0 ×(180-150) - 2.0/2.0 × (1750) = 3500**

In this third example, a team uses two robots in a Challenge Round. After Challenge Round expires, both RoboMaster AI Robots remain 100 HP. And both Team Robots have 200 HP left. Then the total round score is,

α = 6.0/6.0

β = 75.0/6.0

γ = 2.0/3.0

X = (2000-100) + (2000-100)=1900+1900

Y = 180-180

Z = (2000-200) + (2000-200)=1800+1800

Score = $\alpha \times X + \beta \times Y - \gamma \times Z$ **= 6.0/6.0 ×(1900+1900) + 75.0/6.0 ×(180-180) - 2.0/3.0 ×(1800+1800) = 1400**

It is recommended to use **two** Team Robots for the challenge, since more launching mechanism can generate damage more efficiently, and the score scheme reduces the coefficient for HP reduction of Team Robots if there are more than **one** Team Robot on the Challenge Field.

One team plays **FOUR** Rounds in total. The final score for the team is the highest among all four Rounds.

4.5 Fouls and Penalties

In Challenge Round, Referee System automatically monitors the progress of the Challenge. The referee will monitor the Challenge and issue Foul Penalties. When this penalty is issued, the Challenge Round will be terminated immediately, and a zero score is assigned to the team. The penalty will be issued if following fouls occur during the challenge round:

No.	Type of Foul
1	A robot is about to malfunction or has malfunctioned (quickly moving out of the field or bumping against one side of the competition area, causing damage).
2	One or more team members enter the Challenge Field without approval during the Challenge Round**.**
3	A robot starts to operate before the team members leave the Challenge Field.
4	After the Challenge Round starts, one or more team members manually control a robot or shift from automatic operation to manual operation.
5	Other behaviors that may affect the integrity of the Challenge.

All teams must abide by referee decisions. Otherwise, the score of a team in a Challenge Round will be canceled.

Other behaviors that severely violate the spirit of the Challenge will lead to the disqualification of the team.

Appendix I

ICRA2018 DJI RoboMaster AI Challenge

Technical Proposals Requirement

The Technical Proposals is an optional report for ICRA 2018 DJI RoboMaster AI Challenge. If registered teams choose to submit the Technical Proposals, they must do so by Jan 1, 2018, 23:59 (UTC+8). Registered teams can choose whether or not to submit the proposal up to January 1st (China Standard Time). Teams with well-written and outlined reports will win a RoboMaster robot kit or one set of Referee System for free.

Ⅰ. Submission

Log in to the submission system with captain's account and submit online. Each team is allowed only one submission. The Technical Proposals is due between Dec 1, 00:00 and Jan 1, 2018, 23:59 (UTC+8).

Ⅱ.Requirements

1)Report Format: PDF with file name：School name + team name + ICRA Technical Proposals.

2)Font: 10 point Times New Roman.

3)Length: Max. 5000 words with figures, flow charts, and design drawings. Logic data proof and highlights are also significant.

Ⅲ.Key Sections

The following information should be contained in the main body.

1)Team Introduction

Team Captain's Bio

Each Member's Bio

2)Technical Proposals

a.Proposed perception system

b.Technical Feasibility Analysis

c.Development Schedule

d.Team Members' Responsibilities & Task Assignments

3)References (add any cited literature)

Appendix II

ICRA2018 DJI RoboMaster AI Challenge

Technical Report Requirement

Technical Report submission is a mandatory procedure for ICRA 2018 DJI RoboMaster AI Challenge. Only teams with approved Technical Report will be qualified to participate in the Challenge at Brisbane.

Ⅰ.**Who should submit the report**

Teams with RoboMaster AI Challenge registration number.

Ⅱ. **How to submit**

Log in to the RoboMaster Submission System with captain's account and then submit online. Each team is allowed to submit the Technical Report only once before 23:59 April 10, 2018, China Standard Time (CST UTC+8).

Ⅲ. **What should include in the report**

The Technical Report consists of text description and video demonstration. Hence, a well-edited video and an EN or CN written report should be concluded in the submission.

1. Video Requirements:

a. Format:

- Teams are allowed to upload password protected videos to YouTube or another platform. Remember to specify video links along with passwords in their report.

b. Evaluation Criteria:

- Basic information such as school name, shooting date and location should be firstly presented at the beginning of the video.
- Videos should be shot in places with the good illuminating condition to ensure every movement of the robots is seen.
- Do not demonstrate any meaningless scene in the video, try to keep the video brief and pithy with no more than 5 minutes
- It is recommended to rearrange multiple videos into a single video. But video editing with any fake effects is not allowed.
- On each part, teams can demonstrate their critical technology including but

not limited to mechanical design, detection, localization, planning, decision making, launching projectiles

- Each procedure needs to come with subtitles or notes and explained by the video narration.

2. Report Requirements:

a. Include all texts, images, video links and passwords in a PDF with the file name: school name + team name + ICRA Technical Report. The report should be written in 12 points Times New Roman font and no more than TEN A4 pages.

b. Evaluation Criteria:

- **Hardware**

a) Mechanical Design

1) Brief descriptions of the Mechanical Design.

b) Sensors

1) Analyze the requirements for detection, localization, obstacle avoidance and other algorithms.

2) Point out the detailed sensor parameters. For the camera, it should include shutter, resolution, FOV, max FPS and more. As for LIDAR, it should conclude range radius, max samples per second, FOV and any other feature.

c) Computer

1) The number of computers that have been used and detailed information of each including CPU and GPU.

d) Others

1) Describe the information of other sensors or key devices that have been used in your robots.

- **Software**

In the beginning, use a system diagram to describe the software framework.

a) Detection

1) Describe the process of the detection algorithm in detail. For example, how to measure the distance of robot armor and how to estimate the speed of the enemy robot.

2) Point out the algorithm performance, such as maximum frequency and maximum detection distance. Please specify the network framework and number of layers if you are using deep learning algorithm.

b) Localization

    1) Describe the localization algorithm and its accuracy performance.

c) Planning

    1) Describe global planning algorithm, local planning algorithm, and multi-robot collision avoidance method you implemented.

    2) Specify the performance including but not limited to maximum velocity and maximum acceleration.

d) Launching Projectiles

    1) Analyze key factors that will affect the autonomous launching system. Describe with solutions.

    2) Control Methods.

e) Decision-Making

    1) Describe the framework and algorithms of decision making. Specify the state transfer process if conventional methods such as FSM are used. And describe the learning framework if learning based methods are used.

Appendix III

ICRA2018 RoboMaster AI Challenge Pre-challenge Inspection Form				
Uni： _____ **Team：** _____ **Date：** _____				
Robot number: **1st** **2nd** **Spare 1** **Spare 2**				
No.	**Type**	**Check Item**	**Description/Allowance**	**Eligibility**
1	Size and Weight	Initial Size	630mm/W * 630mm/L * 525mm/H	
2		Expansion size	735mm/W * 735mm/L * 630mm/H	
3		Net Weight	21kg (exclude Referee System 3.4kg)	
4	Referee System	Integrity	1. The modules are complete with no adjustment or self-modified to the RMOC's Referee System.	
		Armor Module	1. The armor modules and its frames should not be modified or damaged. 2. The virtual lines that connect front-rear modules and left-right modules are perpendicular to each other. The cross of two virtual lines is at the geometric center of the robot within the tolerance of ±50mm. So two virtual lines coincide with X and Y axes of robot's body frame. 3. The height difference of any two modules (the difference of distances of the lower edges of modules) must not exceed 50mm. 4. The armor and the frame need rigid coupling with each other, two screws on each frame must be installed. 5. The FOV of the module is 145°. Within a range of 145°, there must not have any mechansim that prevent projectiles from hitting the module's surface. 6. Whether the robot transforms or not, the distance between ground and the lower edge of any module must always within 50mm to 200mm. 8. HP(s) drops 50 on each standard hit to any armor.	
		Upgrading	1. All modules must be upgraded to firmewares with newest version through RoboMaster Assistant.	
		RFID interaction module	1. The **RFID module** can blink with normal frequency when touches RF card.	
		Speed measurement module	1. Speed and frequency data indicates normal (each robot must use the controller to launch projectiles for data checking).	
		UWB locating system (optional)	1. The tag must be installed with bottom side parallel to the horizontal plane. Its front direction (indicates on the tag with a small arrow) must coincide with robot's forward moving direction. 2. Apart from the botton side, the other five sides must not be covered within 10cm of its range. 4. Calibrations must be done within the inspection area. 5. Green LINK Indicating light flashes. Red SYS Indicating light flashes.	

6	Others		1. All batteries must be produced by DJI, the total power of each robot must not exceed 200Wh. 2. Total voltage must not exceed 30V; The external circuit doesn't have any potential risk such as short circuit situation and insecure wire connections. 3. Each robot can be operated by maximumly ONE remote control during testing and preparetion period, this controller must be produced by DJI. 4. Report wireless data link within the bandwidth range of between 2.412 to 2.472GHz or 5.725 to 5.850GHz. 5. No laser pointer allowed. 6. No other external lighting allowed. 7. The robot does not have any component that may damage the field. 8. Any coupling mechanism that may cause a robot to physically connect with other robots is not permitted. 9. No material with color red or blue are allowed to decorate robots; No reflective material or sheet are allowed either.	
7	Wireless data link			
			Sign to comfirm：	

The Organizing Committee@ICRA2018

The RoboMaster Organizing Committee

Challenge Email: robomaster@dji.com

Website@ICRA2018：http://icra2018.org/

RoboMaster Website：https://www.robomaster.com/en-US

Challenge Tel: 0755-36383255（Monday-Friday CST UTC+8 10:00-19:00）

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