ROBOMASTER 2020
YOUTH TOURNAMENT

ROBOT BUILDING
SPECIFICATION MANUAL

Prepared by the RoboMaster Organizing Committee
Released on April, 2020
Using this Manual

Legend

Prohibition  Important notes  Hints and tips  Definitions and references

Release Notes

<table>
<thead>
<tr>
<th>Date</th>
<th>Version</th>
<th>Changes</th>
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<tr>
<td>2020.04.07</td>
<td>V1.0</td>
<td>1. Adding visual tag specifications;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Revising some technical parameters.</td>
</tr>
<tr>
<td>2019.12.17</td>
<td>Preview</td>
<td>First Release</td>
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1. **Foreword**

Participating robots are required to meet all specifications described in this document, or they will not pass the Pre-Match Inspection. If any safety incident has occurred due to a violation of rules, the RoboMaster Organizing Committee ("RMOC") reserves the right to hold the violating party legally responsible. Any dispute arising from this Specification Manual will be settled based on interpretations provided by the RMOC.

The information of the basic parts, modules, educational products, sponsorship, discounts and other details relating to robots shall be subject to the announcements released on the official RoboMaster website.
2. Technical Specifications

2.1 General Technical Specifications

2.1.1 Energy Source

- The use of combustion engines, explosives, hazardous chemicals, etc. is forbidden
- Connection to mains electricity is prohibited in the Competition Area.

S1 Robots can be powered only by electricity.

S2 The battery product designated for use in this competition season is the RoboMaster S1 Intelligent Battery manufactured by SZ DJI Technology Co., Ltd.

In order to ensure the safety of the competition, the Referee System used in this competition season can only be used after communicating with the RoboMaster S1 Intelligent Battery. Therefore, this battery has been selected as the designated battery product.

S3 Robots must use the battery product designated by the RMOC (apart from Aerial Robots).

S4 The battery capacity of robots must satisfy the requirements of the building parameters for each robot.

2.1.2 Wireless Equipment

S5 Robots must not be equipped with wireless equipment other than the Referee System Module.

2.1.3 Optical Equipment

S6 Robots can be installed with a laser sight for aiming when launching crystal projectiles. The laser beam from the laser sight must be red and the optical power consumption of the laser beam must be less than 35 mW. The projection angle of the laser sight must not exceed 5° (i.e. the diameter of the laser spot enclosing circle perpendicularly projected by the laser sight on a vertical wall at a horizontal distance of one meter must be less than 9 cm).

S7 Apart from laser sights, an Engineer may also be equipped with visible light launching installation, to provide supplemental light to enhance visual recognition features when procuring projectiles. Other Ground Robots are not allowed to be mounted with any other obvious visible light launching equipment (apart from Referee Systems).
2.1.4 Computer Vision Features

On both sides of the Referee System Armor Module there must be clear LED lighting effects to enable robots to develop automatic recognition and sighting algorithms. The environment in and around the Competition Area is relatively complex. The RMOC cannot guarantee that the Computer Vision features of the Battlefield will not cause visual interference. The Computer Vision algorithm should adapt to the changes of the lighting of the venue and other possible interferences around the venue.

The following specifications must be followed when designing a robot’s computer vision features:

S8 The Armor Module cannot be blocked.

S9 No light can be projected on the Armor module, and no device may be mounted on the robot that reflects or refracts the LED lights from the Armor Module. The robot’s design should not include paint having effects similar to the LED lights of the Armor Module, to avoid interfering with the function of the visual recognition equipment on the opposing team’s Armor Modules.

S10 The robot must not be painted with patterns that are the same or similar to the visual tags on the Referee System.

2.1.5 Visual Tags

S11 The effective size of any visual tag carried by a robot must not exceed 75mm*75mm.

S12 Visual tags must be made of hard and non-reflective materials, to avoid robots not being able to recognize the visual tags due to deformity or reflection.

2.1.6 Robot Numbering

During the Pre-match Inspection and competition, the RMOC staff will provide robots with their corresponding number stickers according to the robot numbering rules. For details on robot numbering, please refer to Chapter 1 of the RoboMaster 2020 Youth Tournament Competition Rules Manual. Please see Appendix 1 for the sticker diagram.

The following specifications must be followed when attaching a number sticker on a robot:

S13 The number sticker must correspond to the robot’s number according to the rules, and the digits and symbols must be pointing in the correct direction with no visible air pockets. The locations for attaching the stickers are yet to be determined.

S14 Apart from the special number stickers provided by the RMOC, no robot may carry any pattern similar to the special numbering stickers on its Armor Module or other external structures.
At least one number sticker must be clearly visible when the robot is viewed in a direct line of sight from any angle at a height of 350 mm from the ground.

2.1.7 Aesthetic Design

To ensure the external armors of robots do not affect the shootout battles in the Competition Area and the match-viewing experience, the following specifications must be followed when designing and creating a robot’s exterior:

Basic Requirements:

S16 The lines of the robot must be neat and not exposed. Exposure that is unavoidable requires line protection using materials such as drag chains and cable managers.

S17 Do not use materials that will have an obvious impact on the aesthetics of the robot, such as washbasins, plastic bottles, corrugated paper, bed sheets, white foam boards, bubble wrap, etc.

S18 Fish nets should not be used as external design materials, unless absolutely necessary for functional reasons.

S19 Avoid sharp structures that may damage the site or harm any person.

Gloss:

S20 The gloss for where the robot’s exterior armor surface is at a distance of no more than 50 mm from the edge of the Armor Module’s LED lights must not exceed 20 Gs.

Paint Color:

All the robots of a team should preferably have a consistent aesthetic style.

S21 The proportion of the red or blue area on the exterior of a robot must not exceed 10%, with any single area unit smaller than 6 cm².

S22 A robot must display two school badges or team badges, each facing a different side. The size of a single school badge or team badge must not be larger than 40mm*40mm. The school badges or team badges must be displayed prominently on a robot, and their distance to the Armor Module lights must not be less than 50 mm. In the case of non-compliance with the specifications, the pre-match inspector will require the team to correct the positions or sizes of the school or team badges.

S23 Reverse type can be applied on a school badge or team badge, or its original colors can be retained.

Mounting of Exterior Armor:

It is recommended that teams use tough materials that are not easily damaged for the exterior armor and conduct reliability tests, to avoid any violation of rules caused by breakage of the exterior armor from battles in the Competition Area.
2.1.8 Launching Mechanism

S24 The Launching Mechanism constitutes a part of the Referee System. Teams must use the official Launching Mechanism.

Launching Mechanism: A mechanism capable of launching a projectile from a robot on a fixed trajectory to inflict damage on another robot.

S25 The modification of Launching Mechanisms is strictly prohibited.

2.1.9 Miscellaneous

S26 Fragile materials must not be used in the design and creation of robots.

S27 Robots must not cause any bodily harm to any person.

S28 For a motor that can be controlled by the Referee System, the Referee System will control the robot’s speed through rotating speed limits, and the diameter of robot wheels must be smaller than 100 mm.

S29 For a motor that cannot be controlled by the Referee System, the robot’s wheels must not be restricted in size, but the linear speed of the wheels must be less than 2.0 m/s.

2.2 Robot Technical Specifications

2.2.1 Standard Robots

The building parameters for Standard Robots are as follows:

Table 2-1 Standard Robot Building Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Total Power Supply</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Capacity (Wh)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Power Supply Voltage</td>
<td>12.6</td>
<td></td>
</tr>
<tr>
<td>(V)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Moving Speed (m/s)</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Launching Mechanism</td>
<td>No more than one Launching Mechanism can be installed.</td>
<td></td>
</tr>
<tr>
<td>Projectile Supply Capability</td>
<td>Can only receive projectiles</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Weight (kg)</td>
<td>8</td>
<td>Including the Referee System’s weight</td>
</tr>
<tr>
<td>Maximum Initial Size (mm, L<em>W</em>H)</td>
<td>350<em>350</em>330</td>
<td>Its orthographic projection on the ground should not exceed a 350*350 rectangular area.</td>
</tr>
<tr>
<td>Maximum Expansion Size (mm, L<em>W</em>H)</td>
<td>420<em>420</em>400</td>
<td>Its orthographic projection on the ground should not exceed a 420*420 rectangular area.</td>
</tr>
<tr>
<td>Referee System</td>
<td>Front Armor Module, Left Armor Module, Right Armor Module, Rear Armor Module, Video Transmitter Module, Motion Control Module, and Speed Monitor Module (already included in the Launching Mechanism)</td>
<td>-</td>
</tr>
</tbody>
</table>

- Maximum Expansion Size: The maximum size of a robot during its transformation.
- L*W*H: Length*Width*Height

### 2.2.2 Engineer Robots

The building parameters for Engineer Robots are as follows:

Table 2-2 Engineer Robot Building Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Total Power Supply Capacity (Wh)</td>
<td>26</td>
<td>-</td>
</tr>
<tr>
<td>Maximum Power Supply Voltage (V)</td>
<td>12.6</td>
<td>-</td>
</tr>
<tr>
<td>Maximum Moving Speed (m/s)</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td>Parameter</td>
<td>Limit</td>
<td>Notes</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Launching Mechanism</td>
<td>No Launching Mechanism can be installed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The Grabbing Mechanism cannot damage Battlefield Components. In particular, it cannot use serrated or sharp-edged structures to interact with projectile containers, which will cause irreversible deformation to the projectile containers.</td>
</tr>
<tr>
<td>Grabbing Mechanism</td>
<td>Only one mechanism for grabbing projectile containers can be installed.</td>
<td></td>
</tr>
<tr>
<td>Maximum Weight (kg)</td>
<td>10</td>
<td>Including the Referee System’s weight</td>
</tr>
<tr>
<td>Maximum Initial Size (mm, L<em>W</em>H)</td>
<td>450<em>450</em>450</td>
<td>Its orthographic projection on the ground should not exceed a 450*450 square area</td>
</tr>
<tr>
<td>Maximum Expansion Size (mm, L<em>W</em>H)</td>
<td>650<em>650</em>650</td>
<td>Its orthographic projection on the ground should not exceed a 650*650 square area</td>
</tr>
<tr>
<td>Referee System</td>
<td>Front Armor Module, Left Armor Module, Right Armor Module, Rear Armor Module, Video Transmitter Module, and Motion Control Module</td>
<td></td>
</tr>
</tbody>
</table>

### 2.2.3 Aerial Robots

The building parameters for Aerial Robots are as follows:

Table 2-3 Aerial Robot Building Parameters
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Total Power Supply Capacity (Wh)</td>
<td>4.2</td>
<td>Teams should reasonably evaluate and fully test whether the propulsion system and power supply system of an Aerial can meet the requirements of loading and combat, to prevent safety incidents or accidents during the competition.</td>
</tr>
<tr>
<td>Maximum Power Supply Voltage (V)</td>
<td>4.35</td>
<td>-</td>
</tr>
<tr>
<td>Protective Cover</td>
<td>Rotor blades must not be exposed.</td>
<td>-</td>
</tr>
<tr>
<td>Positioning</td>
<td>Must possess a positioning function</td>
<td>Able to position location and height indoors</td>
</tr>
<tr>
<td>Maximum Weight (kg)</td>
<td>0.2</td>
<td>-</td>
</tr>
<tr>
<td>Maximum Size (mm) L<em>W</em>H</td>
<td>180<em>180</em>150</td>
<td>Its orthographic projection on the ground should not exceed a 180*180 square area</td>
</tr>
<tr>
<td>Referee System</td>
<td>No Referee System installed</td>
<td>-</td>
</tr>
</tbody>
</table>
| Motor                                    | • Type: Coreless motor  
• Qty.: Maximum 4 | -                                                                     |
| Maximum Rotor Blade Size                | 4.4"       | -                                                                     |
3. Referee System Mounting Specifications

3.1 Overview

A Referee System is a fully automatic electronic system that can monitor the state of a robot and make a determination. During the competition, the Referee System monitors the information of each participating robot such as its HP level, and transmits the real-time information to the corresponding computer in the Operator Room and the competition’s engine server. It also automatically determines the outcome of the competition, ensuring the fairness of the competition.

The robots designed by each team must have a mechanical and electrical port built in, and each module of the Referee System must be correctly mounted according to the requirements in this chapter.

A Referee System consists of the following modules:

Table 3-1 Referee System Component Modules

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video Transmitter Module</td>
<td>The Video Transmitter Module consists of a Smart Central Control and a camera, and is connected to the client in the Operator Room via a wireless network. Its function is to capture the view in front of the robot through the camera, and transmit the first-person view image back to the monitor in the Operator Room.</td>
</tr>
<tr>
<td>Speed Monitor Module</td>
<td>The Speed Monitor Module is used to detect the initial firing speed and frequency of projectiles. The Speed Monitor Module is already built into the Launching Mechanism, and need not be mounted separately by teams.</td>
</tr>
<tr>
<td>Armor Module</td>
<td>The Armor Module is a robot’s damage sensor system for detecting the projectile attacks received by the robot.</td>
</tr>
<tr>
<td>Motion Control Module</td>
<td>The Motion Control Module connects the Armor Module, power source, and Video Transmitter Module hub, and is able to transmit the Operator’s commands to the robot through the UART interface.</td>
</tr>
</tbody>
</table>
3.2 Configuration of Robot Referee System

The configuration of Referee System Modules for each robot is as follows:

Table 3-2 Configuration of Robot Referee System Modules

<table>
<thead>
<tr>
<th>Type</th>
<th>Qty.</th>
<th>Motion Control Module</th>
<th>Armor Module</th>
<th>Video Transmitter Module</th>
<th>Speed Monitor Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Robot</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Engineer Robot</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Aerial Robot</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

3.3 Installation of Motion Control Module

Refer to the size of the Motion Control Module, and pre-allocate a mounting area on the robot.

![Motion Control Module Diagram]

- [1] M BUS interface
- [2] CAN BUS interface, for connecting the Smart Central Control
- [3] UART interface
- [4] CAN BUS interface, for connecting the Armor Module
- [5] POWER interface
- [6] CAN BUS interface, for connecting the Launching Mechanism

Figure 3-1 Motion Control Module
3.3.1 Installation Steps

1. Fix the Motion Control Module in place on the specific position on the robot.

![Motion Control Module Installation Diagram]

[1] Motion Sensor Module

Figure 3-2 Motion Control Module Installation Diagram

2. Use the power adapter from the package and connect the Motion Control Module to the battery.

![Motion Control Module Cabling Diagram]

[1] Power adapter cable

Figure 3-3 Motion Control Module Cabling Diagram

3.3.2 Installation Requirements

The installation requirements for the Motion Control Module are as follows:

S30 Ensure the upper surface of the Motion Control Module is level and facing upwards when the robot is in normal
S31 Ensure the Motion Control Module is fixed securely inside the robot, with no relative movement when in motion.

### 3.4 Armor Module Mounting Specifications

The Armor Module consists of the Front, Right, Left and Rear Armor Modules, as shown below:

![Armor Module Diagram](image)

**Figure 3-4 Front Armor Module Diagram**
Figure 3-5 Right Armor Module Diagram

Figure 3-6 Left Armor Module Diagram
3.4.1 Installation Steps
Use the data cable provided in the package to connect each Armor Module to the CAN BUS interface of the Motion Control Module.

Figure 3-9 Armor Module Cabling Diagram

3.4.2 Installation Requirements

The mounting of an Armor Module must meet the following requirements:

S32 The areas within 90° from the left, right, top and bottom edges of the attack surfaces on the Front and Rear Armor Modules of a Standard Robot cannot be blocked. The areas within 50° from the left and right edges of the attack surfaces on its Left and Right Armor Modules cannot be blocked.

S33 The areas within 90° from the left, right, top and bottom edges of the attack surfaces on the Front and Rear Armor Modules of an Engineer Robot cannot be blocked. The areas within 50° from the left and right edges and 75° from the top and bottom edges of the attack surfaces on its Left and Right Armor Modules cannot be blocked.

S34 When designing the structure of a robot, sufficient consideration must be given to the level of impact received by the Rear Armor. If impact on the Rear Armor causes the buckle to fall off and block the Armor, penalties will be imposed by the referee as per the competition rules.
3.4.3 ID Number Configuration

The Armor Module must be configured with the correct ID number before the Pre-Match Inspection. The specific requirements are as follows:

Based on the robots’ Armor Module mounting requirements, the coordinates of a robot are established using the positive front-facing direction of the robot’s Video Transmitter Module at the start of the match as the X-axis positive direction, and the positive direction pointing towards the earth’s center as the Z-axis positive direction. After entering the Module Armor ID configuration mode, tap the X-axis positive direction, Y-axis negative direction, X-axis negative direction and Y-axis positive direction, to complete all the Armor Module ID configurations for the robot. The ID configuration for Armor Modules is shown below:

Figure 3-10 Armor Module Mounting Diagram
Table 3-1 Robot Armor Module ID Configuration

<table>
<thead>
<tr>
<th>Axis</th>
<th>Module ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Positive direction: Front</td>
</tr>
<tr>
<td></td>
<td>Negative direction: Rear</td>
</tr>
<tr>
<td>Y</td>
<td>Positive direction: Right</td>
</tr>
<tr>
<td></td>
<td>Negative direction: Left</td>
</tr>
</tbody>
</table>

### 3.4.4 Mounting Specifications

In the following section, the robot’s body coordinate system is a standard Cartesian coordinate system with X-, Y- and Z-axes, and the coordinate origin is the robot's center of mass, as shown in the following figure:
The kinematic equations of the robot should be based on the Cartesian coordinate system. If a robot’s kinematic model is established using a non-Cartesian coordinate system, the body coordinate system is defined as follows: The direction vector of a projectile launched by the robot’s Launching Mechanism in its initial state projected onto the XY plane is the X-axis. Based on the X-axis and the Z-axis pointing towards the earth’s center, the Y-axis is generated according to the right-hand rule, and the origin is the robot’s center of mass.

### Mounting the Armor Module

**S35** When an Armor Module is mounted on a robot, the Armor Module must be connected firmly. The LED plane of the Armor Module must be perpendicular to the XY plane, so that the normal vector line of the impact surface plane of the Armor Module is perpendicular to the negative Z-axis line. The two lines of the LED on the Armor Module must be kept parallel to the XY plane. Define the projection of the normal vector of the impact surface plane of the mounted Armor Module on the XY plane as the direction vector of the mounted Armor Module. The direction vectors of the four Armor Modules must be in a one-to-one correspondence to the positive X-axis, negative X-axis, positive Y-axis, and negative Y-axis of the robot’s body coordinate system, and the angular error between a direction vector and its corresponding coordinate axis cannot exceed 5°.

**S36** The kinematic equations of the robot should also be based on the above reference coordinate system. The mounting procedures for the Armor Modules must use the same reference coordinate system as the robot’s own structural or kinematic characteristics. The geometric central point line of the Armor Modules mounted on the X-axis and the geometric central point line of the Armor Modules mounted on the Y-axis should be perpendicular to each other. The offset of the Armor Modules from the geometric center of the robot must
not exceed 50 mm on the X or Y-axis.

**Rigid Connection**

S37 A mounted Armor Module must be rigidly connected to the chassis to form a whole body. During the competition, the Armor Module and the chassis must not shift relative to each other.

**Robot Transformation**

In principle, after a competition has started, any Armor Module must not actively move relative to the robot body's center of mass. If a robot's shape is transformable due to its structural design, the requirements for Armor Modules are as follows:

S38 At no time can any Armor Module move continuously and reciprocally with respect to the robot's center of mass as a whole, and the short-term movement speed must not exceed 0.5 m/s.

S39 Before and after the transformation of any Ground Robot, the distance between the lower edges of its Armor Modules and the ground must be within 30 mm – 50 mm.

### 3.5 Video Transmitter Module Mounting Specifications

The Video Transmitter Module consists of a Smart Central Control, camera cable, and camera, as shown below:

Drill preformed mounting holes at the necessary positions according to the size and mounting interface of the Video Transmitter Module.
3.5.1  Installation Steps

1. Fasten the Smart Central Control at the appropriate position using four M3 screws.
2. Connect the Smart Central Control and camera using the camera cable.

3. Connect the Smart Central Control and the Motion Control Module using the data cable from the package.

3.5.2 Installation Requirements

The installation of the Smart Central Control must comply with the following requirements. Any installation that fails to follow the requirements may result in reduced image quality of the video transmitter, or even operational malfunction.

S40 The air inlet and outlet of the Smart Central Control cannot be blocked.

S41 As the Smart Central Control’s antenna is located at the top of the Module, the top should not be blocked by
any metal.

S42 As shown on the mounting diagram for the Smart Central Control, no motor or other device that may cause electromagnetic interference is allowed within a 90mm hemisphere from the central point of the Smart Central Control, to avoid any interference with the camera’s video transmission signals.

The specific mounting position and angles can be confirmed by checking the quality of receiver images.

![Antenna Diagram](image)

[1] Antenna

Figure 3-18 Smart Central Control Mounting Positions Diagram
### 3.6 Speed Monitor Module Mounting Specifications

The Speed Monitor Module is already built into the Launching Mechanism, as shown below:

1. Fasten the Launching Mechanism at the appropriate position using four M3 screws.

![Launching Mechanism Diagram](image1)


Figure 3-19 Launching Mechanism Diagram

2. Connect the Launching Mechanism to the CAN BUS interface of the Smart Central Control.

![Launching Mechanism Cabling Diagram](image2)

[1] Launching Mechanism data cable

Figure 3-20 Launching Mechanism Cabling Diagram
Appendix 1 Number Sticker Diagram