**Infantry Supply Station Design for DJI RoboMasters Competition**

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Contents

[Introduction 2](#_Toc495675013)

[DJI RoboMasters 3](#_Toc495675014)

# Introduction

DJI RoboMasters competition, is an annual robotics competition for postsecondary students across the globe that is intended to offer a platform to promote exchange and dialog among researcher and students alike. This global tournament is sponsored by SZ DJI Technology Co. LTD, and hosted by Communist Youth League of China, Secretariat of All-China Students’ Federation, and Shenzhen Municipal Government. To promote a fair and balanced competition platform, a set of annually updated competition rules are provided by the organizers of the contest, i.e. Technology Innovation Committee of Nanshan District Government of Shenzhen Municipality. The competition uses a range of robots, including Aerial, Base, Hero, Standard, and Engineering robots, each of which must satisfy a certain set of requirements. During the competition robots are able to fire bullets of standardized size at a Referee System attached to the sides of robots. Robots are equipped by HD cameras and are controlled wirelessly from another control room. Robots are able to refuel their ammunition anytime during the game at a stationary Supply Station that collects limited bullets distributed to teams at fixed intervals during the game. In total, eight hundred bullets of 2.6 g (±5%), plastic (TPE 90), of diameter 17 mm (-3% to 0%) are released in total during the game; 200 bullets initially, 300 bullets at 2 minutes 30 seconds mark, and 300 bullets at 5 minutes mark. A Base robot may also be refueled by an Engineering or Hero robots, while the Hero robot may be also refueled by Engineering or Arial robots. Engineering robot collects ammunition from the battle ground while Aerial robot gathers ammo from a resource column, tarmac, Hero, or Engineering robot.

University of Alberta’s RoboMasters Student group competed for the first time in 2017 and is planning to compete again in 2018. Previously, they used a mechanically-triggered supply station that was activated while a robot was pushing a mechanical lever. The supply station lacked the control needed to refill robots with accuracy and speed. The team needs to redesign the station to allow for accurate loading of about 50 bullets at a fast pace, while ensuring no bullets gets jammed in the supply station. Various robots are allowed to refuel at the supply station, see table 1, but the team is planning to use the supply station only to refuel 3 infantry robots. The supply station needs to confirm with the RoboMasters organizing committees’ mandated rules. Moreover, the team needs the station to autodetect, auto release ammunition, and refuel two infantry robots simultaneously. A team of mechanical engineering students are designing 3 infantry robots that would be using this supply station. Clear communication with this team would be necessary throughout the year to ensure that the supply station would be fit for use by the infantry robots. Specifically, for our design, we need to know the shape, location, dimensions of robots’ ammunition container. The client’s main goals and constrains could be summarized as follows:

1. Conforms with DJI RoboMasters’ competition rules,
2. Safe to use,
3. Fast ammunition loading rate; the faster the better,
4. Absolutely no jamming of bullets in the station,
5. Fully automatic,
6. Able to refuel two robots simultaneously,
7. Can be easily setup and carried by two personnel,

**Table 1:** DJI RoboMasters allowed robots and refueling mechanism. University of Alberta team is planning to use refueling station only for Standard Infantry Robots.

|  |  |  |  |
| --- | --- | --- | --- |
| Robot | Quantity | Function | Bullet Supply Method |
| Base Robot | 1 | Automatic Self-Defense Robot | >Initial 300 bullet |
| Hero Robot | 1 | Has high offensive power | >Refueling Station  >Engineering Robot  >Resource Island  >Aerial Robot |
| Engineering Robot | 0-1 | Assistant Robot, heals and gathering ammo from battle field | >Tarmac  >Resource Island  >Aerial Robot |
| Standard Infantry Robot | 0-3 | Fight flexibility | >Refueling Station  >Engineering Robot  >Resource Island  >Hero Robot |
| Aerial Robot | 0-1 | Supplies aerial support, may help in refueling, and may occupy healing columns | >Tarmac  >Resource Column  >Engineering Robot  >Hero Robot |
| Refueling Station | 0-1 | Ammunition supply station, collects ammunition, and automatically dispenses ammunition | >Official Supply Mechanism |

# Competition Refueling Station Regulat0ions and Standards

DJI RoboMasters require the station to be satisfy the following constrains:

1. be fully automatic,
2. able to handle 17 mm in diameter ammunition,
3. has maximum dimension of 1000x1000x1000 mm,
4. without an active movement or firing mechanism,
5. self-balancing; i.e. cannot be fixed to the ground using tape or materials that can damage the competition area,
6. maximum supply voltage of 30 volts, and maximum total power of 200 Wh
7. if radio communication is employed, a bandwidth of less than 40 MHz within 2.412 to 2.472 GHz is used

Objectives:

Legend for the Pairwise Comparison Chart:

1: indicate the row element is more important

0: indicate the row element is less important

-: indicate the row element and the column element are the same

Table 2: The Pairwise Comparison Table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Speed of Refueling | Able to fill two robots simultaneously | Able to fill robots with ~50 bullets during each refueling cycle | Able to be maintained & be carried by two members from the team |
| Speed of Refueling | - | 0 | 0 | 0 |
| Able to fill two robots simultaneously | 1 | - | 0 | 0 |
| Able to fill robots with ~50 bullets during each refueling cycle | 1 | 1 | - | 0 |
| Able to be maintained & be carried by two members from the team | 1 | 1 | 1 | - |
| Power Source to last for 30 minutes | 1 | 1 | 1 | 1 |
| Able to detect the docking of robots | 0 | 0 | 0 | 0 |
| Keep track of the # of bullets in the refueling station | 1 | 1 | 1 | 1 |
| A way to avoid the supply station being overfilled | 1 | 1 | 1 | 1 |
| The supply station is adjustable vertically | 1 | 1 | 1 | 1 |
| Total Score | 7 | 6 | 5 | 4 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Power Source to last for 30 minutes | Able to detect the docking of robots | Keep track of the # of bullets in the refueling station | A way to avoid the supply station being overfilled | The supply station is adjustable vertically |
| Speed of Refueling | 0 | 1 | 0 | 0 | 0 |
| Able to fill two robots simultaneously | 0 | 1 | 0 | 0 | 0 |
| Able to fill robots with ~50 bullets during each refueling cycle | 0 | 1 | 0 | 0 | 0 |
| Able to be maintained & be carried by two members from the team | 0 | 1 | 0 | 0 | 0 |
| Power Source to last for 30 minutes | - | 1 | 0 | 0 | 0 |
| Able to detect the docking of robots | 0 | - | 0 | 0 | 0 |
| Keep track of the # of bullets in the refueling station | 1 | 1 | - | 1 | 1 |
| A way to avoid the supply station being overfilled | 1 | 1 | 0 | - | 1 |
| The supply station is adjustable vertically | 1 | 1 | 0 | 0 | - |
| Total Score | 3 | 8 | 0 | 1 | 2 |

**Table 2: The Correlation Matrix with Design Objectives**

**Legend for the Pairwise Comparison Chart:**

* ++: Highly correlated positive
* +: Moderately correlated positive
* -: Moderately correlated negative
* --: Highly correlated negative

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Speed of Refuel | Ability to refuel two robots | Dispense about 50 bullets per refuel | Able to be handled by two people | Battery power Lasting 30 minutes | Able to detect the docking robots | Track the number of bullets | Avoid overfill the supply station | Supply station able to adjust |
| Speed of Refuel |  |  |  |  |  |  |  |  |  |
| Ability to refuel two robots |  |  |  |  |  |  |  |  |  |
| Dispense about 50 bullets per refuel |  |  |  |  |  |  |  |  |  |
| Able to be handled by two people |  |  |  |  |  |  |  |  |  |
| Battery power Lasting 30 minutes |  |  |  |  |  |  |  |  |  |
| Able to detect the docking robots |  |  |  |  |  |  |  |  |  |
| Track the number of bullets |  |  |  |  |  |  |  |  |  |
| Avoid overfill the supply station |  |  |  |  |  |  |  |  |  |
| Supply station able to adjust |  |  |  |  |  |  |  |  |  |

Please note that the bullets that the supply station carries are plastic(TPE90) bullets that are 17mm (-3% - 0%) in diameter and weigh 2.6g(. The level of importance of an objective is based on the total score that each goal is obtained from the pairwise comparison table. Based from the analysis by the pairwise comparison table, the ability to detect the docking of the infantry robots has the highest score of 8 and therefore is the most critical objective. While the goal of keeping track to the number of bullets in the refueling station has the lowest score of 0 and is the least critical objective. This analysis is logically correct because the supply station will not be able to distribute bullets if it will not be able to detect the docking of an infantry robots. This will cause the whole project to be a failure. From the pairwise comparison table, the speed to refuel the infantry robots with bullets and the efficiency to fill bullets to the infantry robots are also two critical objectives that need to be optimized. During the meeting with the Robomaster representative, the client emphasized a lot on the speed to refuel bullets to the infantry station and the ability to refuel two infantry stations simultaneously. Therefore, the design of the supply station needs to optimize the speed of refuel, to be able to dock, and to refuel two infantry robots simultaneously.

|  |  |  |
| --- | --- | --- |
| Function | Specification | Regulatory Information |
| Prevent the bullet stuck in the filling station | Low rpm with high torque motor. |  |
| Controlling the motor and switch | Microcontroller  Voltage: 12V DC  Multifunctional which is able to control all the motor, electromagnetic, load cell and laser sensor | IEEE 802.3 |
| Battery | Support all the electronic device on the refueling station.  Supply 12V DC voltage |  |
| Open or close the gate | Electromagnetic  Able to work on 12V DC  Size limited |  |
| Measure the weight of bullets to calculate the number | Micro Load Cell  Supplied by 12V DC voltage  Measure the weight up to 5KG |  |
| Accurately locate the robot | Laser sensor  12 V DC and small size |  |
| Bullets which is used in the robot | Plastic (TPE 90)  Size: 17 mm (-3% - 0%)  Weight: 2.6 g (±5%)  Damage amount: 50 |  |
| Refueling Station | Size: 1000\*1000\*1000mm |  |

Achievability

From our design, all our design is achievable. The whole system is powered by a 12 V battery and all the parts that we are going to use are consuming 12V DC. To prevent the bullet stuck in the filling station, we choose a small motor with low rpm but high torque. This type of motor are easy to find for a reasonable price. To simplify and make the refueling station more efficient, we use electromagnetic to open and close the gate. The electromagnetic is very small with extremely large magnetic force, and it is very cheap to get (less than $10). To actually calculate the number of bullets within the shortest time, we use micro load cell to measure the weight of all the bullets. To detect the location of the vehicle, we use laser sensor, which is the fastest and accurate way. Both are existing technology and wildly used, and at the same time, he price is also under our budget. To control all of these components, we choose a multifunctional micro which is able to control all the motor, electromagnetic, load cell and laser sensor. This type of controller is also in a reasonable price and under our budget.