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

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# 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 Regulations 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 |

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.

In conclusion to the Pairwise Comparison Table, the core goals must be related to the ability to detect the docking of the infantry robots to the refueling station and the efficiency of the bullet distribution system. Therefore, the core goals are: the speed of refueling, the ability to refuel to infantry robots simultaneously, and the ability to dispense about fifty bullets at a time. The stretched goals include: the ability to be maintained and carried by two people, the power source that can last for at least 30 minutes, the tracking system to record the number of bullets in the refueling station, a way to avoid the supply station to become overfilled, and to make the supply station vertically adjustable. The followings are reasonings regarding to assigning of the stretched goals. Since each game takes about seven minutes and a thirty second preparation time before the start of each game, the supply station’s power source can be easily changed. The reason why the client wants the refueling station to be able to be carried by two people is that they want to optimize the use of their team members during the thirty second preparation before a game to start. However, this is not regarding to the efficiency of the bullet refueling system during a game. A mechanism to prevent the refueling station to become overfilled and the vertical adjustability of the supply station are both not related to the efficiency of the distribution of bullets during a game to the infantry robot. Therefore, these two factors are seen as two stretched goals in this project.

**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 vertically |
| 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 |  |  |  |  |  |  |  |  |  |

From the correlation matrix, the three objectives: the speed to refuel, the ability to refuel two robots simultaneously, and the ability to dispense about 50 bullets for each refuel are highly correlated. All these objectives are high relative to the optimization of refueling efficiency, which the client has emphasized highly on. The ability to be handled by two people during the preparation of each game is moderately correlated negative to all objectives for the refueling efficiency. Therefore, the ability to be handled by two people is a stretched goal.

# Function:

* Distributes about fifty bullets each to the two infantry robots simultaneously
* Able to automatically sort out about fifty bullets and store them in a batch in the individual storage unit (possibly a revolving storage unit) that is ready to fill the robots with fifty bullets at anytime after receiving docking signal of the infantry robots at the dumping sites.
* Able to store bullets that are distributed by the Robomaster host during a game

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* The signal for the docking of the infantry robots
* The bullets distributed by the Robomaster host during a game
* Power from the battery
* Adjustment in the height of the dumping opening that dispenses bullets into the infantry robots

# User Interface:

Since the supply station is run by itself with its own power source and all the operations are automatic, therefore the user just needs to turn on a possible switch during the preparation time before each game. After finishing the match, the user just needs to turn it off. The user can also easily change the battery of the supply station and to have a new battery or a newly charged battery as the power source.



From the perspective of the infantry robots, which are the recipients for receiving bullets from the refueling(supply) station, the infantry robots are first docked at the dumping sites where the bullets are distributed to them from the revolving storage tubes. After the docking of the robots, the laser sensors in the middle will detect the infantry robots and then it will trigger the opening on the bottom of the revolving storage tubes. The bullets be automatically distributed into the infantry robots’ top openings for receiving bullets. See image for the final project sketch. This operation happens at the first level of the supply station.