Super Squadron technical paper for

International Aerial Robotics Competition 2017

Team Reconnaissance

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ABSTRACT

The Team Reconnaissance is a team from India presents an indigenously developed Super Squadron an autonomous aerial robot as the candidate for the 7th mission of the AUVSI International Aerial Robotics Competition (IARC).This paper describes the technology used in the aerial system for performing the required tasks of the mission. The robot is programmed to track and interact with the ground robot autonomously and this bot programmed to work like a like a sheepherder and thereby it controls and guides the ground robots. Visual navigation method is used as an alternative for the conventional GPS method of navigation. The robotic platforms are equipped with optical flow navigation sensors and LIDAR to navigate efficiently through the arena without hitting the obstacles. Guidance for ground robots is accomplished with effective multiple objects tracking algorithm. The robust design of this copter makes it a tough contender in this event.

I. INTRODUCTION

Statement of the problem

This event provides an opportunity to develop an aerial robot that operates fully autonomously in a sterile non-GPS indoor environment. The present challenge of IARC is to demonstrate three main behaviours viz.

- Interaction between aerial and ground robots,
- Navigation in a sterile environment and,
- Interaction between competing autonomous air vehicles.

The general restrictions on the vehicle are listed below:

- Must be less than 1.25m in any dimension
- Must operate electrically
- Must remain within the arena boundary
- Must have a ground station and termination device

A. Conceptual approach

Team Recon has developed a multi rotor capable of exploring unknown environment and implementing specific operations without the use of any external navigation aids such as GPS. An integrated vision based navigation method is adopted to provide altitude, attitude, velocity and relative position estimation of the quad copter within the indoor environments. Multiple objects are detected by HOG- based SVM running on an ARM processor. Safety is the primary concern, so we have installed the kill switch that does not depend on the on-board computer and works independently. In order to protect the direct collision with obstacles, the propellers are shielded using a foam casing.

B. Air Vehicle

The Parrot AR drone 2.0 is taken as the base robotic platform for this mission. We have modified this model to meet the mission requirements. Ultrasonic sensors along with the installation of LIDAR make the robot to detect and avoid obstacles easily. The autonomous aerial robot uses a vision based navigation method thus guides the ground robots towards the green line, dodging the collision and making the mission successful.

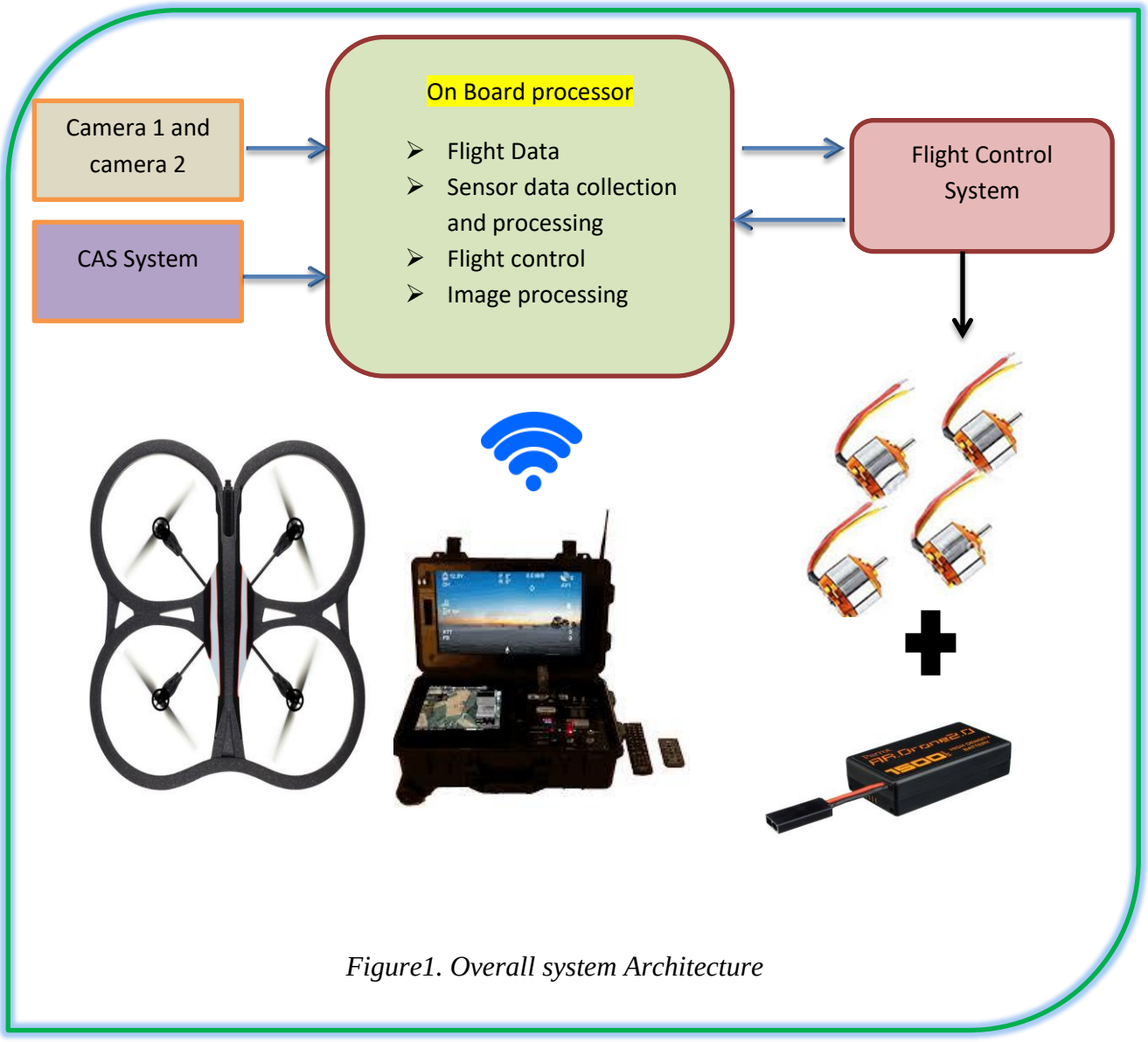


Figure1. Overall system Architecture

C. Yearly milestones

Team Recon is participating in the 7th mission for the third time. The experience from participating in previous years gave us some good knowledge about the advanced technologies which can be implemented in order to rectify the errors that we have committed earlier. Our yearly progress is steady and refinements have been done to the structure to reduce the weight and to have a sustain flight to meet the time requirement.

A. Propulsion and Lift system

The Super Squadron is equipped with four brushless DC motors and four propellers. Two pairs of propellers spin in Clockwise and Counter clockwise directions respectively, such that the sum of the reaction torques is zero during hovering. We change the rotational speed of the four motors in order to create relative thrust offset between the propellers and therefore the attitude control is achieved. The aerial robot has six degrees of freedom and is achieved by varying the motor speeds.

B. Guidance, Navigation and Control

B1) Stability Augmentation System

Stability is an essential thing for any flying machine and the stability for this copter is mainly achieved with the use of inertial measurement system (INS). The system is comprised of 3axis gyros and accelerometer. Apart from these sensors, a magnetometer is placed for maintaining the heading of the aircraft. Orientation of the craft is maintained using this and the INS system is completely responsible for the stability. An ultrasonic sensor is also attached with this system and is used for measuring and maintaining the altitude of the aerial vehicle.

B2) NAVIGATION

Mission 7 requires the robots to navigate without the use of GPS and our team have come up to use a vision based navigation method. The navigation system is equipped with number of sensors to ensure the stability of the copter. The sensors fitted on-board make up the overall feedback from the copter and provides the data on Euler angles. This data is processed and used for stabilizing the aerial vehicle. A forward looking camera and downward facing cameras are placed on the robot. These cameras act like an eye for the super squadron and using the image information, the robots

navigate. The target ground robots are identified and traced by the doing image processing the algorithm developed by the team makes the robot to move efficiently and combining it with the other control systems; the robot herds the ground robots towards the green line

C) Flight Termination System

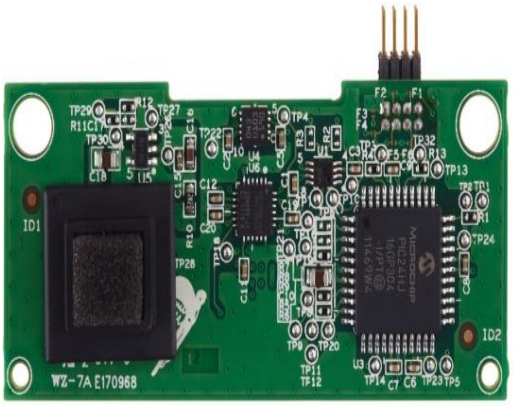
The flight of the aerial vehicle can be terminated in two ways. One method of terminating the system is by using the flight termination switch in the ground station. Pressing the switch will run the termination program and shuts down the motors and lands. Another method is used mainly during emergency situation. This can be actuated by the referee using the kill switch provided to them.

II. PAYLOAD

A) Sensor suite

a1) GNC Sensors

Super Squadron quad copter is designed to be extremely stable, robust and safe platform. The on-board sensors include laser range finder, navigation board, cameras and ultrasonic distance measuring sensor. The Inertial Measurement Unit forms the main part of the navigation board. This unit comprises of 3-axis digital accelerometer, 2-axis gyroscope and a 3-axis magnetometer. The digital accelerometer is used for monitoring the positional movements of the copter and the gyroscope are used for pitch, roll and yaw measurements.



(a) Navigation board

(b) On-board Camera

Figure (a), (b):.Various on board sensors

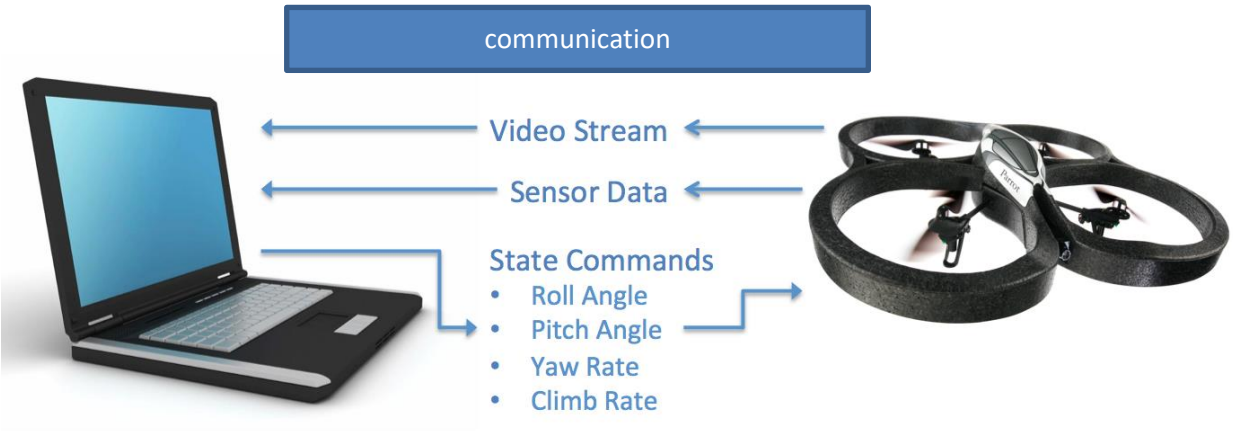
The ultrasonic sensors are equipped to this aerial platform for the purpose of measuring the altitude changes. Measurements are used for increasing the accuracy of altitude corrections. RP LIDAR- LIDAR stands for Light Detection and ranging system and this model LIDAR is a lightweight 360 degree laser scanner. The scanned data is used for avoiding the obstacles and navigate the robot freely.

(c) Ultrasonic sensor

(d)LIDAR

B. Communications

Super Squadron communicates with the GCS using the Wi-Fi module attached to the on board computer as well as to the ground station. The video taken by the on-board camera is also streamed using Wi-Fi. A typical communication link between the ground station and the aerial robot is as shown in the following figure.

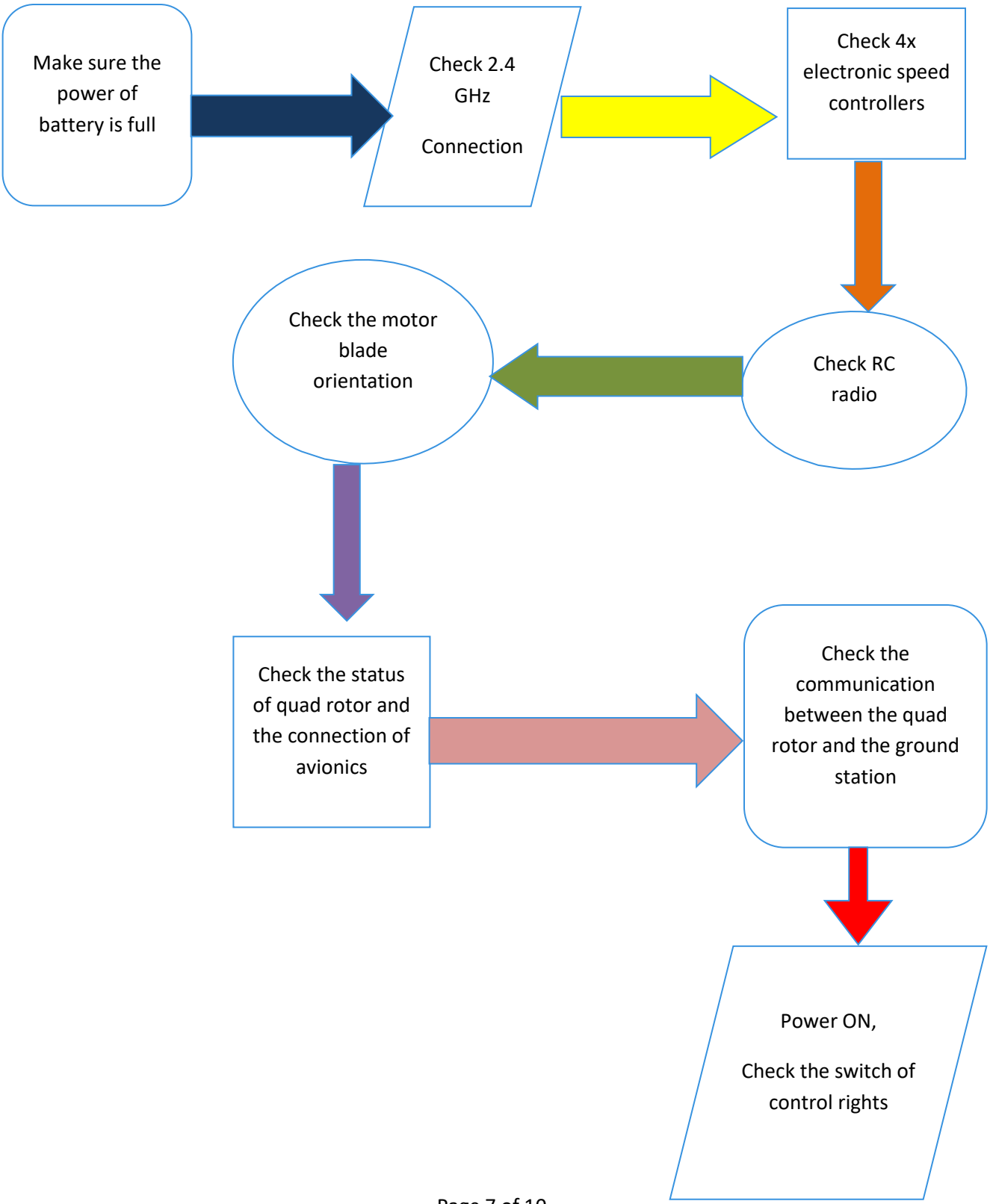


C. Power Management System

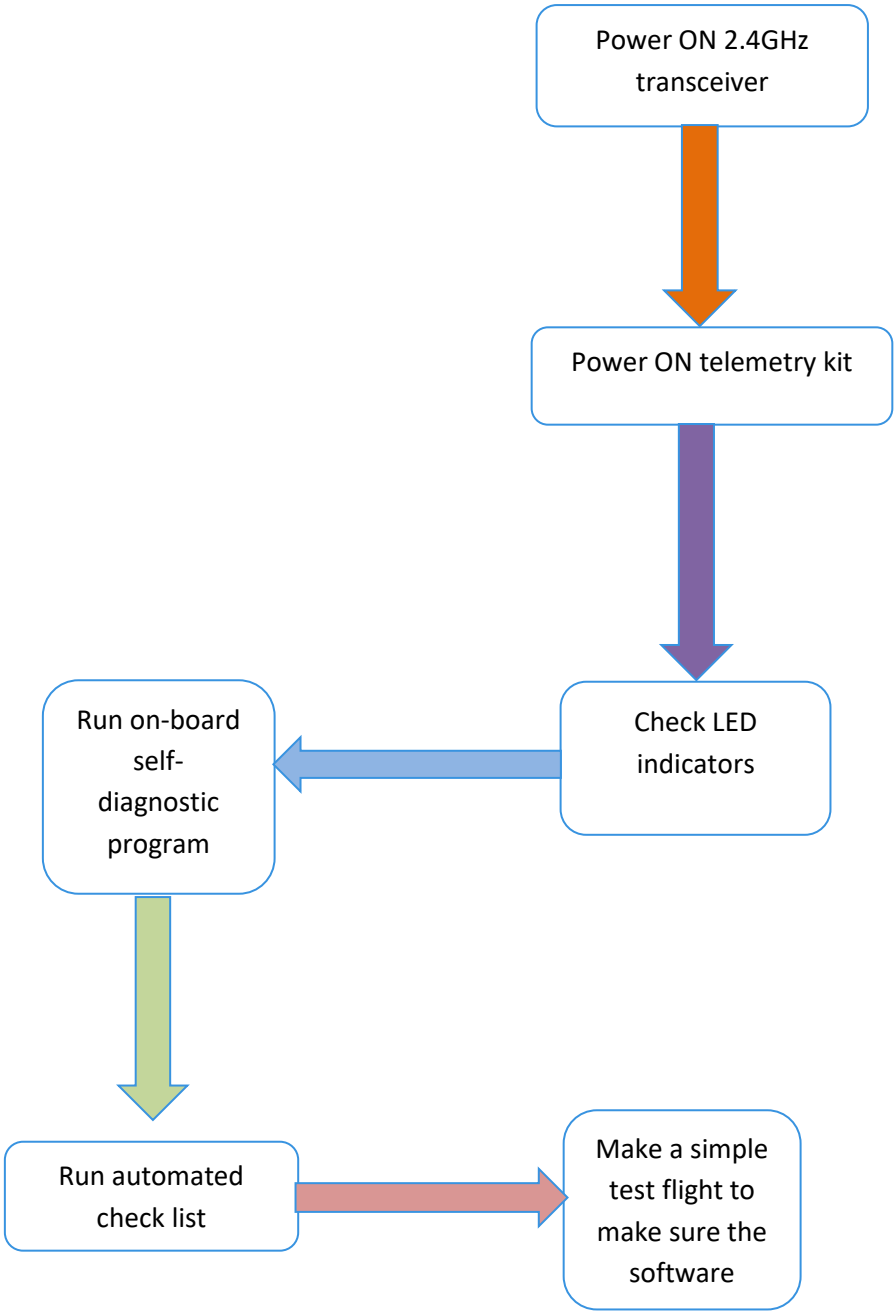
The quad copter is equipped with a 1500 mA-hr. lithium polymer- ion battery. This allows for a flight time of 15 minutes. The battery connected to a power distribution board redistributes to the motors and the controllers. A voltage regulator is used to turn the voltage into 5 V for powering the processors on-board.

OPERATIONS

a1) Check List(s)



The following checklists are carried out after performing the initial setup and visual checks



B. MAN/ MACHINE INTERFACE

Man/machine interface is established by telemetry and on-board camera. The telemetry is connected with the ground station for real-time display of quad rotor flight status, including attitude, position and ambient environment and so on, which is used to judge whether the flight is normal. All the telemetry downlinks and camera images are transferred via Wi-Fi to the ground

control station. Apart from the Wi-Fi link a radio trans-receiver is connected to the aerial platform and his is used for actuating the kill switch.

5. RISK REDUCTION

A. Vehicle status

Super squadron quad rotor will transfer its flight status continuously to the ground control station via Wi-Fi during the flight. All systems are continuously monitored and recorded into the memory card placed in the GCS unit.

B. SAFETY

The total aerial vehicle is made using lightweight materials and as per the safety regulations of the event, we have shielded the propellers of the copter. The propeller shields are made out of foam material. A radio controlled kill switch is added to the copter as measure of safety. This switch can be actuated manually and can switch of the system. The radio transmitter for actuating the kill switch is constructed as per the mission rules and will be provided to the referee.

D.TESTING

The endurance test of the robot was conducted initially and an arena same as the real one was built and the robot was flown autonomously inside it. During the trial, the object tracking and interaction of aerial robot with ground robot was tested. The following figure shows the image of the floor tile been made with similarities to the actual floor tile used in the arena. The robot was flown over it.

Figure: Super squadron over the model arena floor

CONCLUSION

This paper has presented the details of the Super Squadron autonomous vehicle developed by Team Recon for 7th mission of IARC. Our system is in initial stages of testing and we are working hard to give our best. We hope that our attempt will be successful in tracking and creating a physical interface with the ground robots to drive them towards the recognized finish line by avoiding the hindrance caused by the obstacles.