ARESROBOTICS

ATOM 2.0

SYSTEM ACCEPTANCE REVIEW

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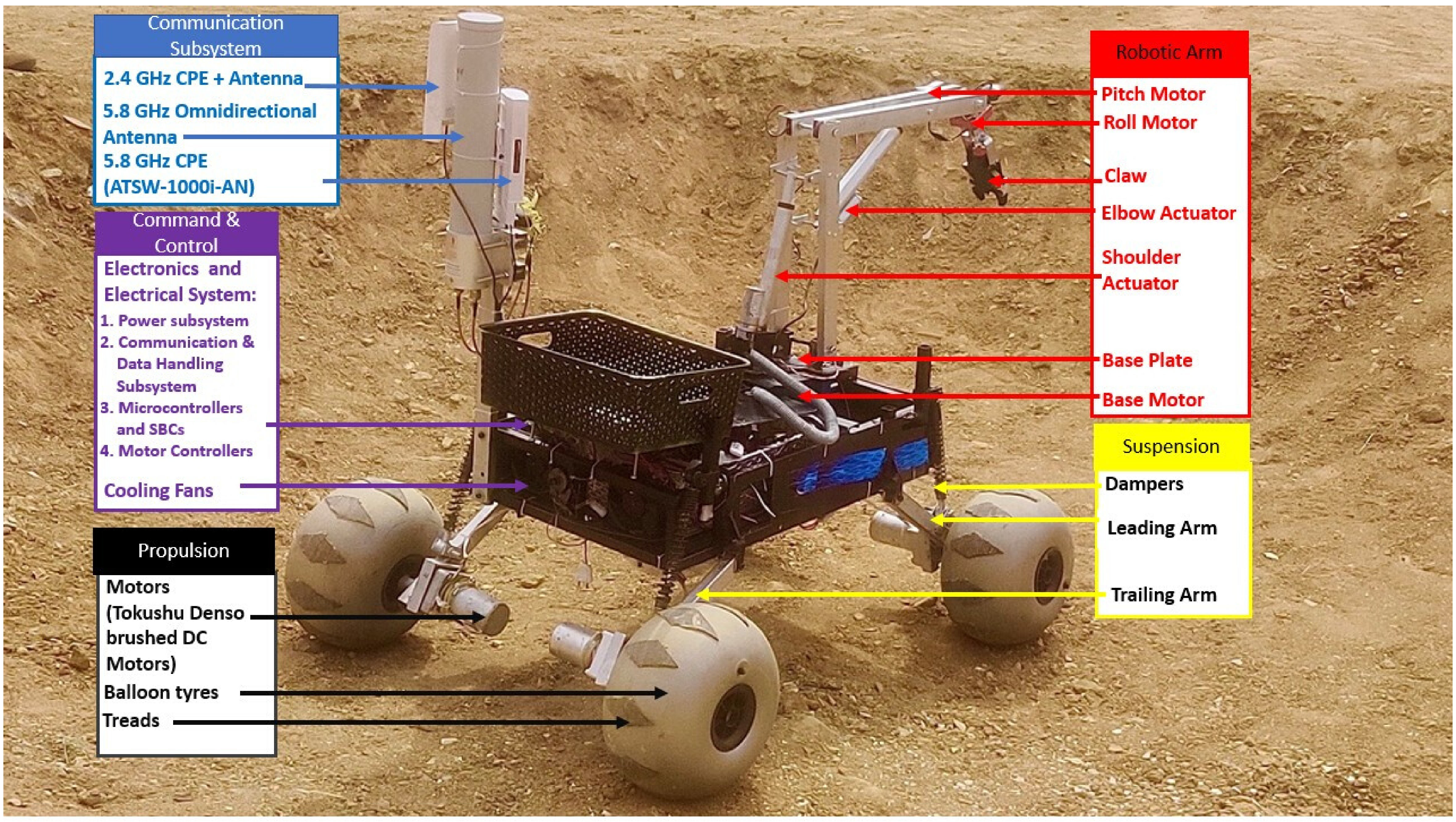
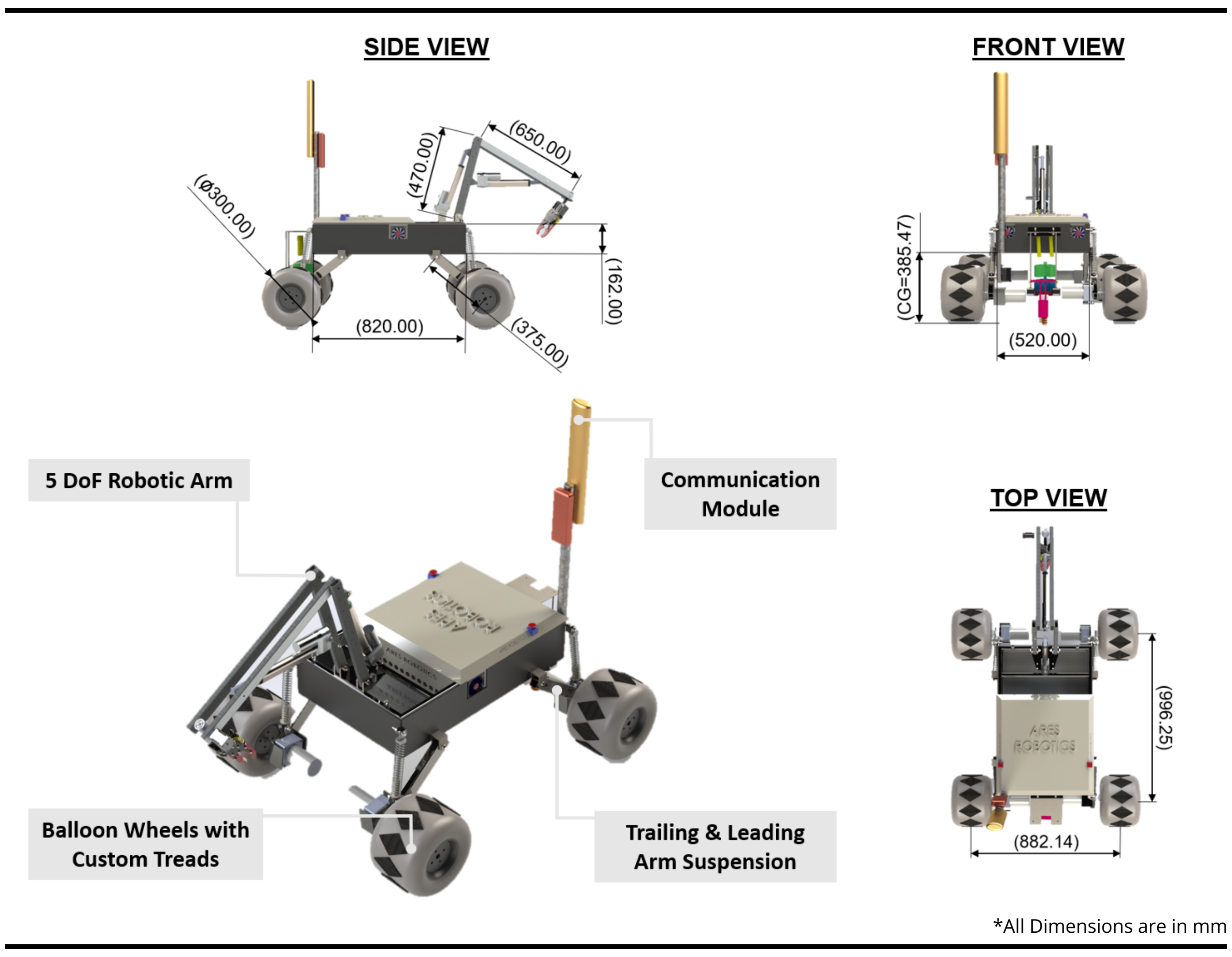
1. OVERVIEW



2. PROPULSION & ROBOTIC ARM

A. FEATURES

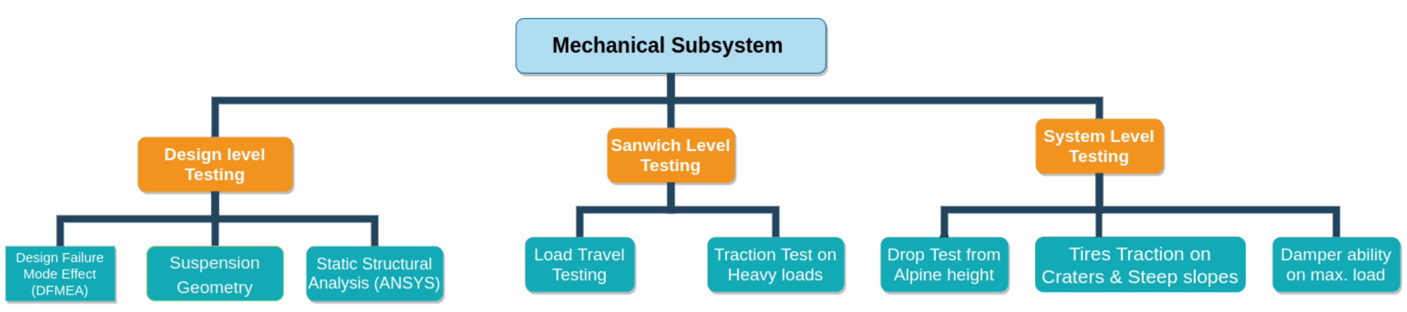


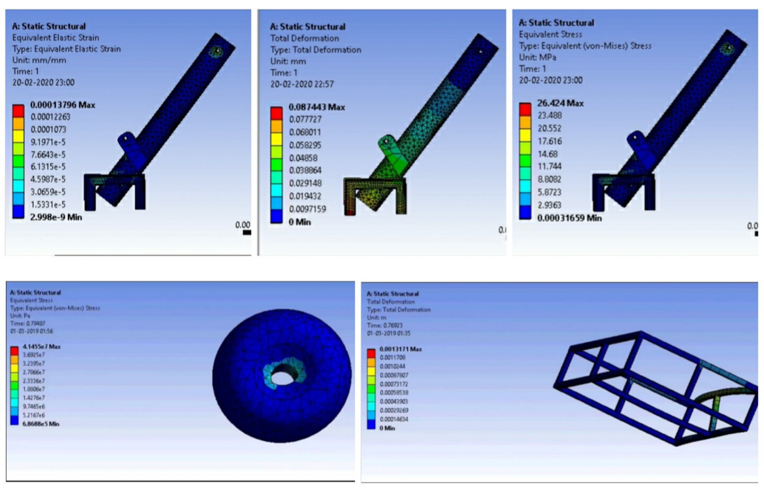
The rover systems are mounted on a space frame chassis outfitted with a four wheel trailing and leading arm suspension system. Aluminium 6061 T-6 was used for fabrication of all structural components considering its strength to weight ratio and required mechanical properties. Low pressure balloon tires are used as the rover propulsion medium. Patterned 3 mm thick vulcanized rubber treads provide high traction to the rover in sandy and rough terrain. The flat body panels are fabricated using Fibre Glass composite.

High torque brushed DC motors (Tokushu Denso 9K24F) have been used for rover propulsion. Independent wheel drivers in skid steering configuration provide better maneuverability owing to the uneven martian terrain. Optical wheel encoders on each motor allow for precise position feedback control.

A 5 DOF manipulator is installed on the rover to perform a variety of tasks like equipment servicing, turning knobs, flipping switches, opening drawers, pressing keys and lifting heavy weights, etc. Worm wheel gearing on brushed DC L-motors provide sufficient wrist actuation torques while two long stroke linear actuators provide precise shoulder and elbow joint movement . An interchangeable two claw gripper provides necessary end effector utility to the robotic arm.

B. TESTING PLAN

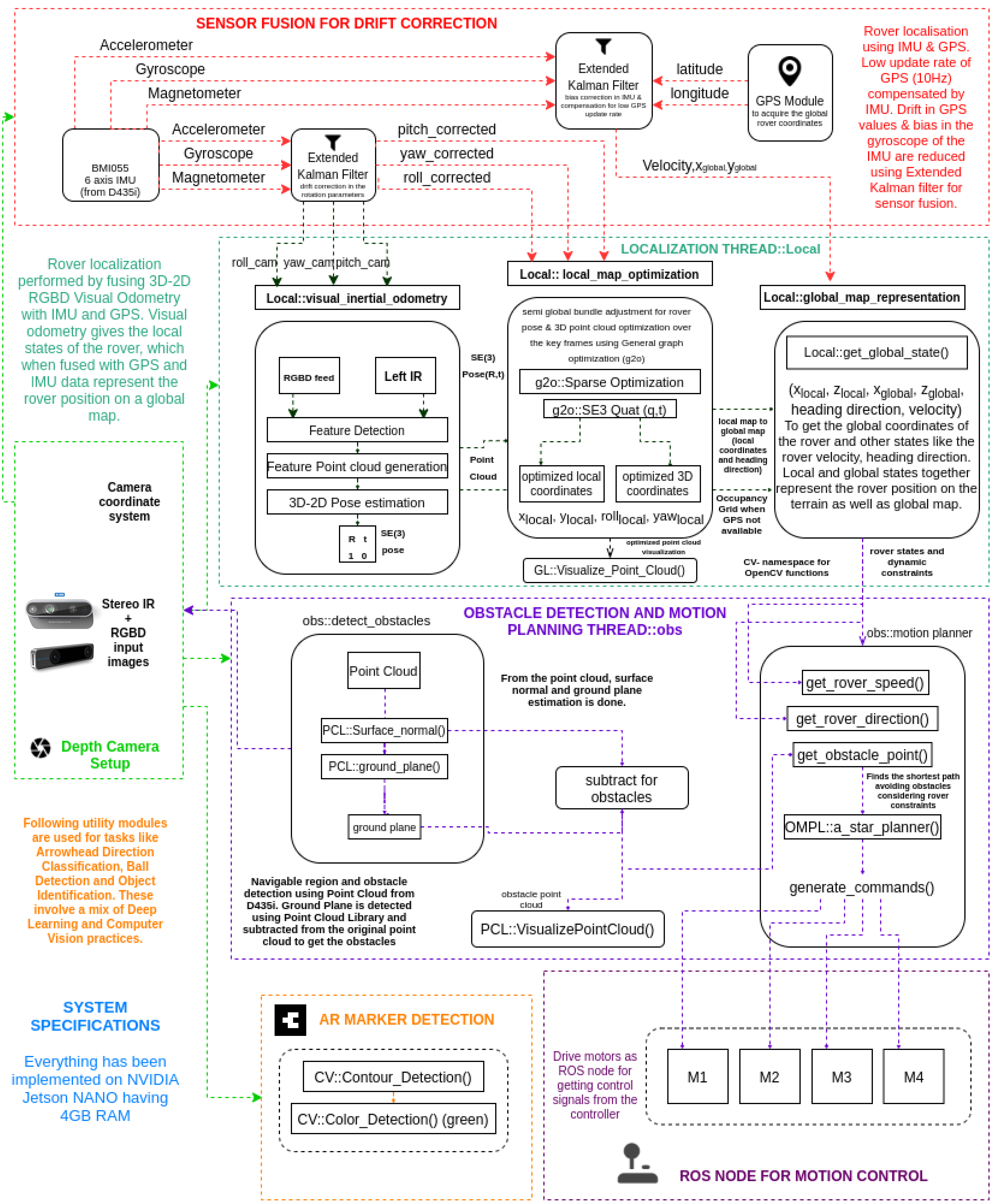




All the mechanical subsystems were rigorously tested on the real terrains for a better understanding of the behavior of the rover. Simulation on the appropriate software was performed to monitor the performance of all subsystems in the extreme conditions. One meter drop test was performed to check the proper functioning of the suspension system and all the other subsystems under the high impact force. The robotic arm was tested thoroughly in all aspects. For traction increment in the balloon wheels, custom treads were attached to the tires and were successfully tested on simulated Martian terrain.

3. AUTONOMOUS

A. FEATURES



B. TESTING PLAN

Unit Testing

- All labelled components were tested and improved individually
- Listed in the Gantt Chart in further Details

System Level Testing

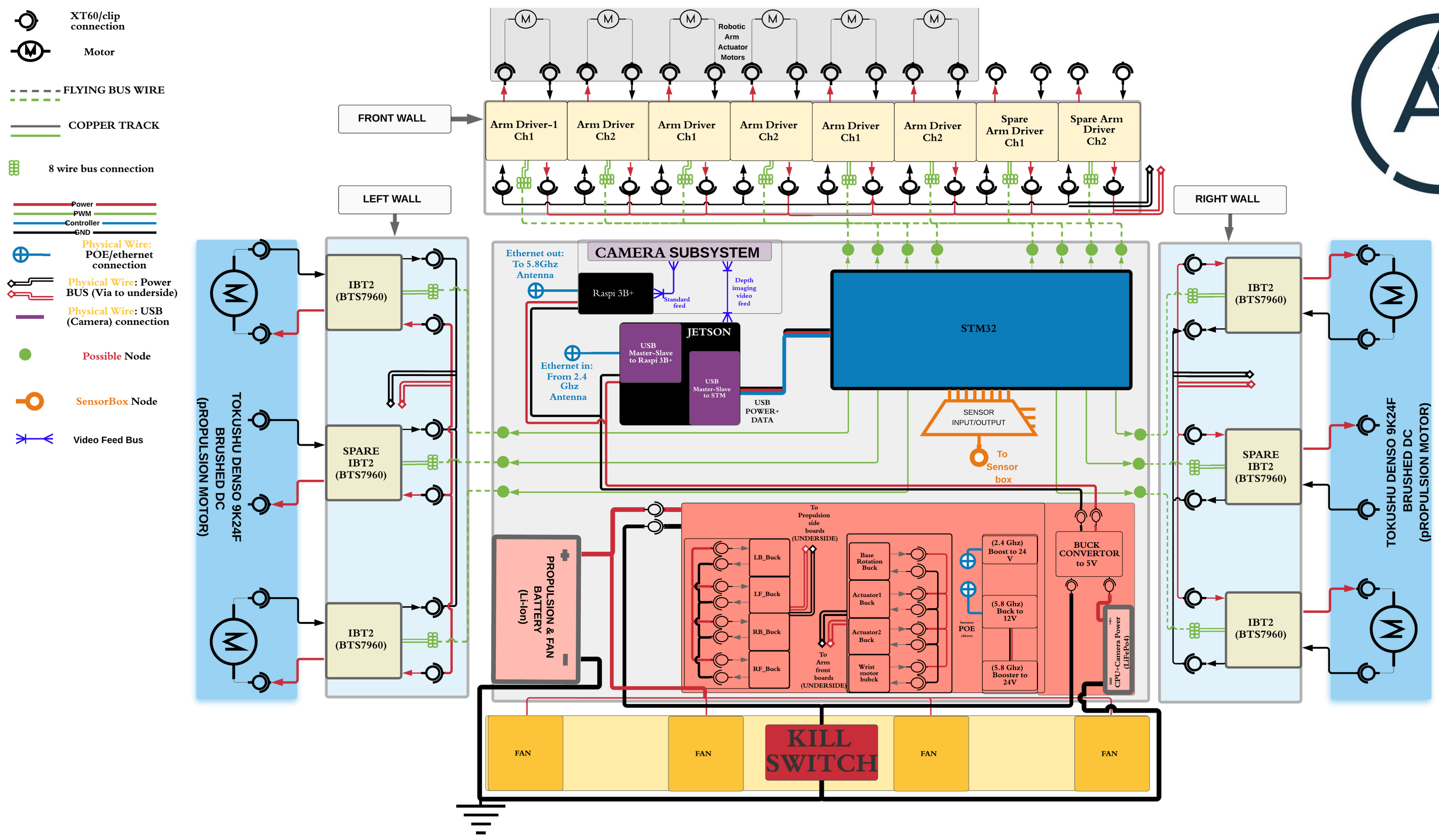
1. **Multiple - Terrain Testing**
   a. Sandy with rocks
   Components tested:
   - Obstacle Avoidance thread
   - Motor Control

   b. Rocky-Bed Terrain
   - Planner Optimization for acclerator
   - Motor Control

2. **Speed Test**
   Objectives: Travel between markers in minimum Time.
   - Perception System
   - Planner Optimisation against accleration change
   - Obstacle Avoidance with Motor Gear
   - High Speed Motor Control

4. COMMAND & CONTROL

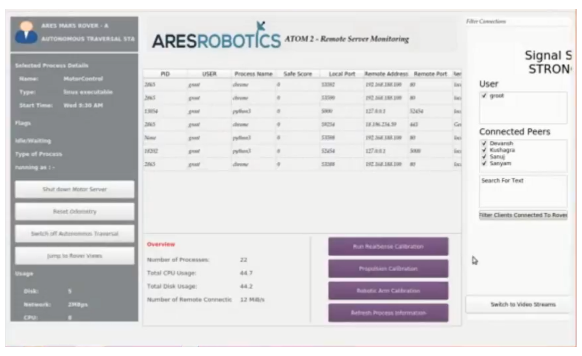
A. FEATURES

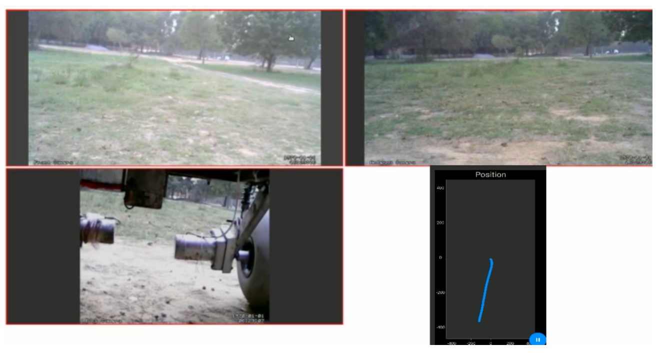


Base station control commands are transmitted to Nvidia Jetson Nano, which is then decoded and communicated to STM32 over a serial interface. STM32 transmits control signals to the motor drivers while also sending back telemetry (IMU information, GPS coordinates, core rover temperature, battery voltages, wheel encoder data) to the ethernet compatible Jetson. This telemetry is transmitted over the 2.4 Ghz band via the Nano to the base station. Voltage measurements across pull-up resistors on the motor driver modules allow for real-time tracking of propulsion current draw. In case of propulsion stalling, or any other event leading to excess current draw (t>5s), the supply is automatically scaled down using a reduced PWM signal from the STM32. This prevents prolonged, if any at all, instances of supply rail shorting which might affect the communication system functioning requiring a threshold power input.

A GUI is developed for

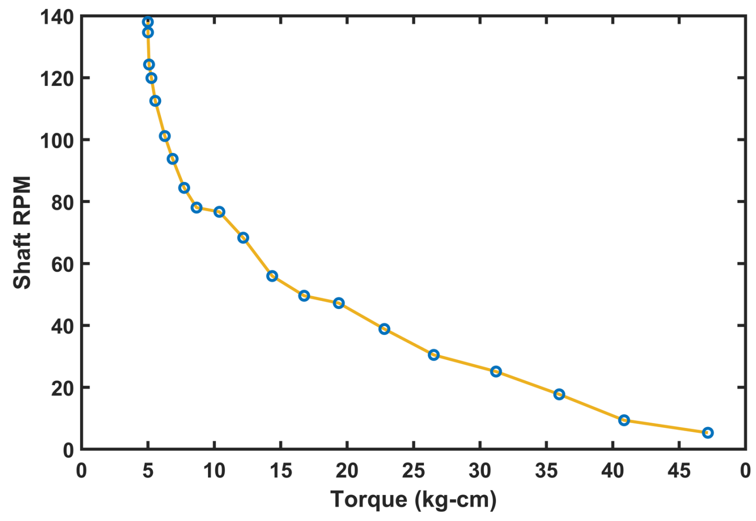
- Live GPS plot
- Wheel odometry
- Live video feeds
- Battery voltages
- System temperature
- System Managment Ut

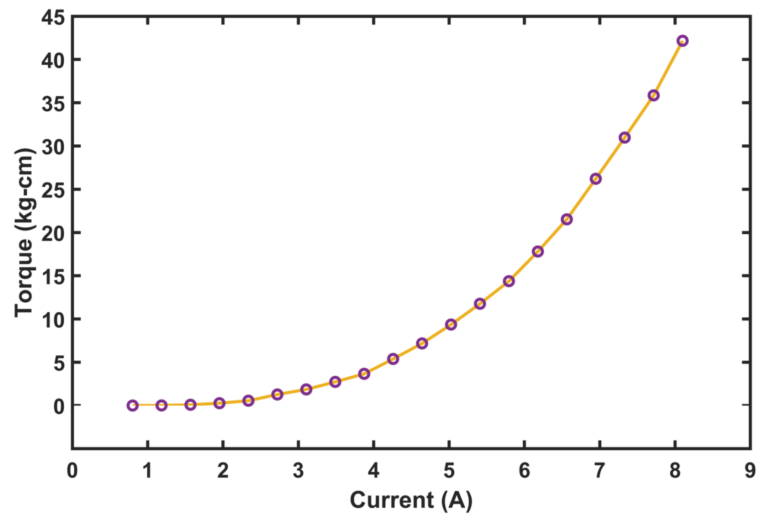


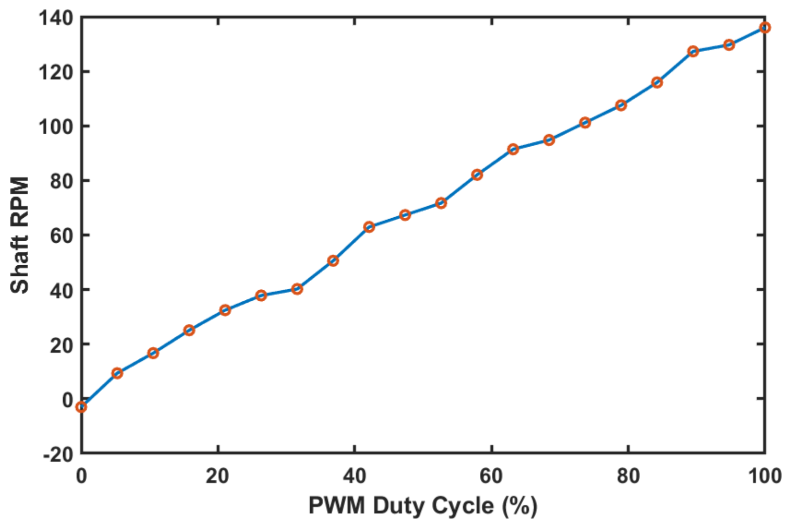


We have installed 3 USB cameras coupled with stepper motors to give a 360° FOV. The cameras are connected to the Raspberry Pi 3B+ which streams the video feeds over the network. The video stream packets are sent via UDP for fast data transmission. We have used high compression video encoding algorithms through which we have reduced our bandwidth requirement by 3 times as well as achieved minimum lag and latency.

B. TESTING PLAN



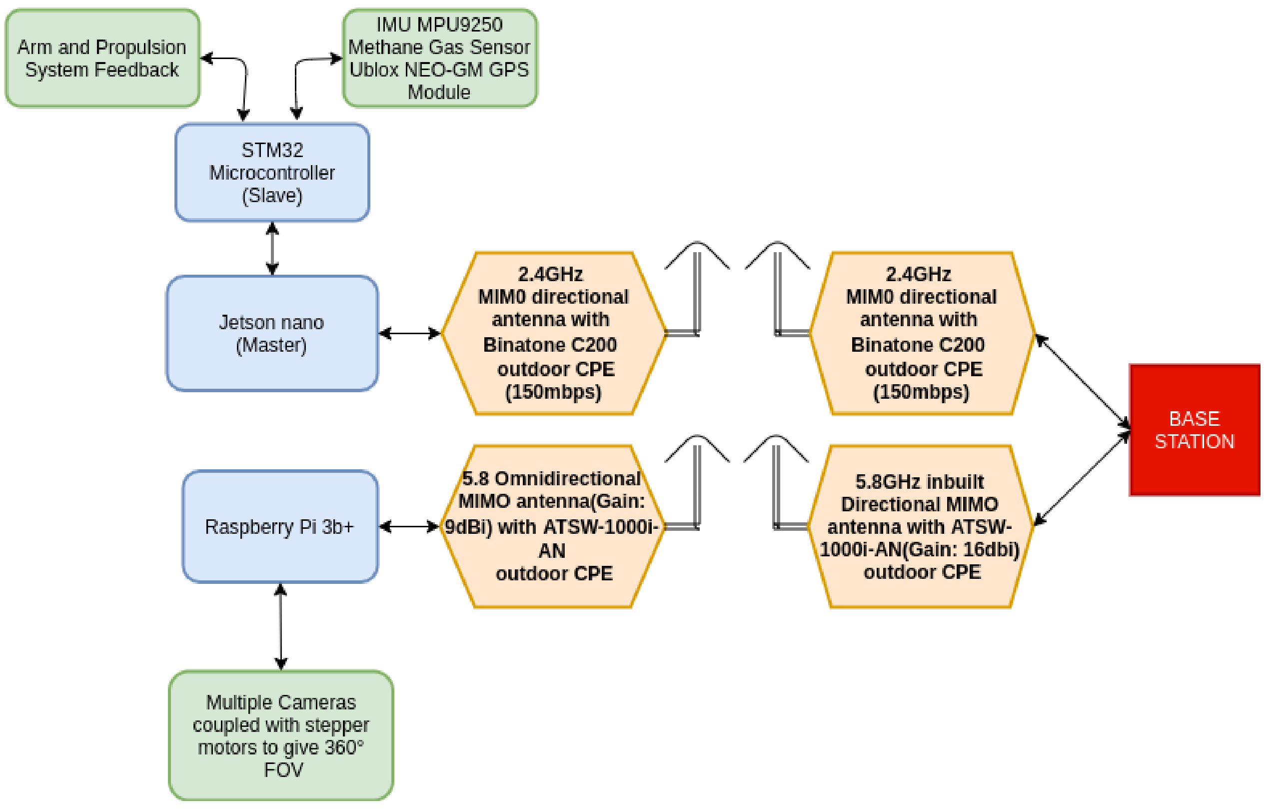




Propulsion system was tested on a maximum input voltage of 20V stepped down from the main battery (nominal voltage 24V) and controlled using PWM. Assuming identical nature of all 4 drive motors, actual runtime characteristics was obtained under standard atmospheric conditions.
Required propulsion torque= 37.96 Kg-cm per wheel
while obtained maximum torque = 42.1 kg-cm per motor
A negative feedback control loop on motor current draw is used to vary driver voltage input. This reduction is scaled using average slope of RPM-PWM curve obtained.

5. COMMUNICATION

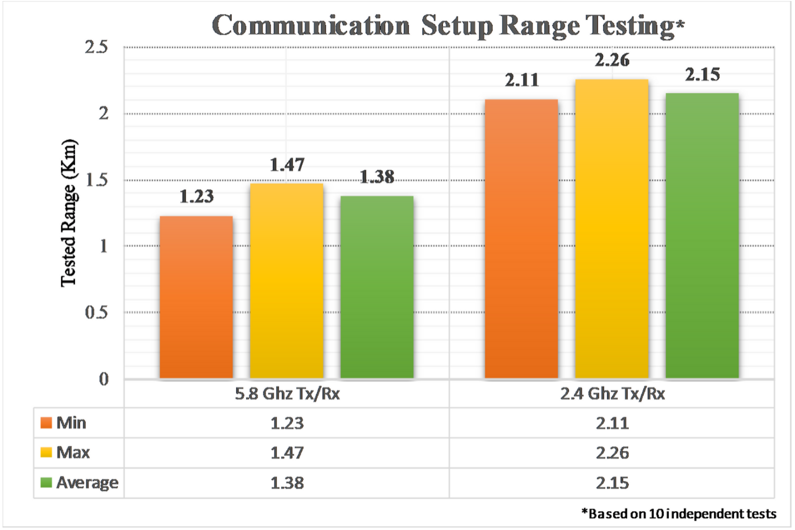
A. FEATURES



The system is designed in such a way to use each spectrum to the best of its ability.

B. TESTING PLAN

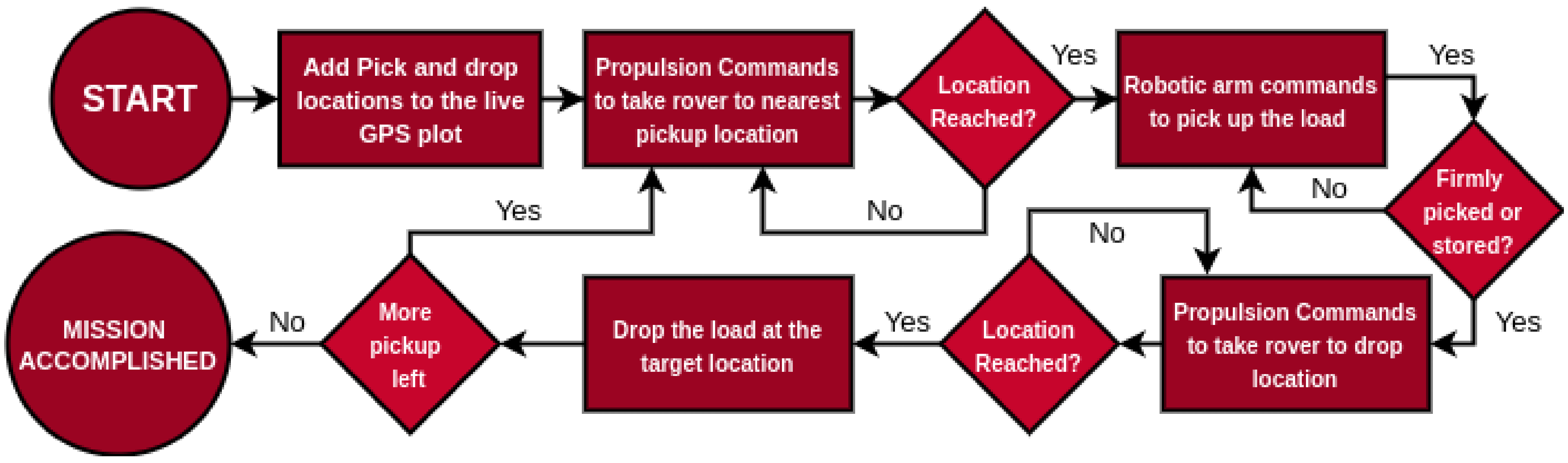
The communication system was tested for its line of sight range of operation and the following results were obtained for both the frequency bands.



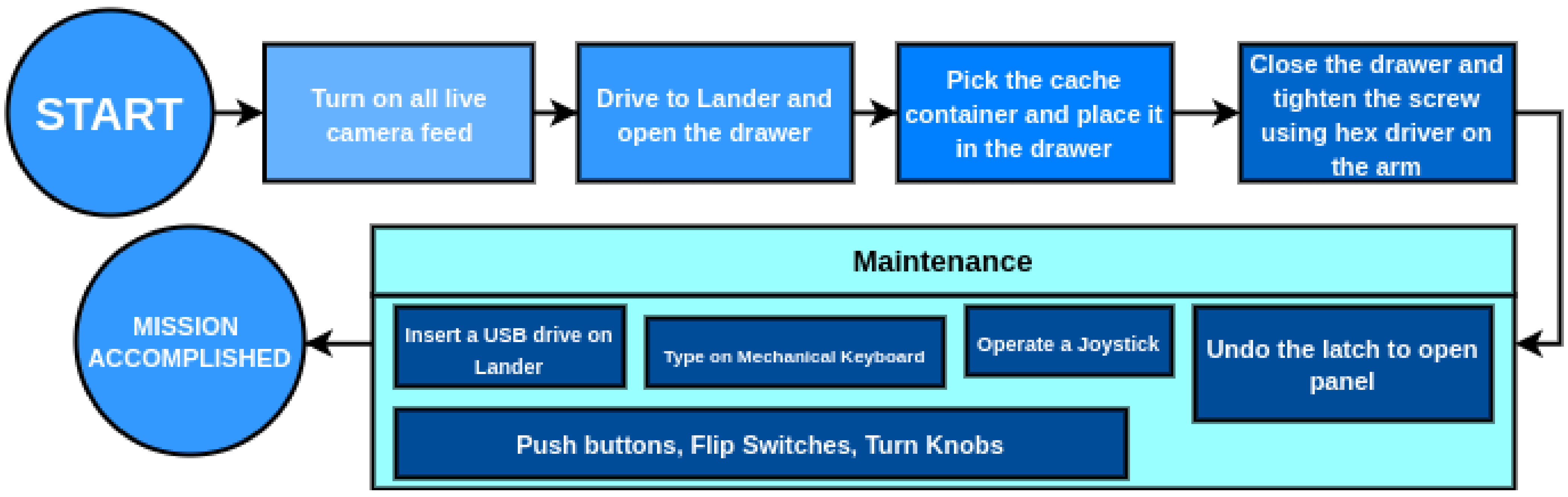
It is clear from the above bar plots that the rover can be controlled over sufficiently long ranges and the communication system is ready for URC 2020.

APPROACH TO MISSIONS

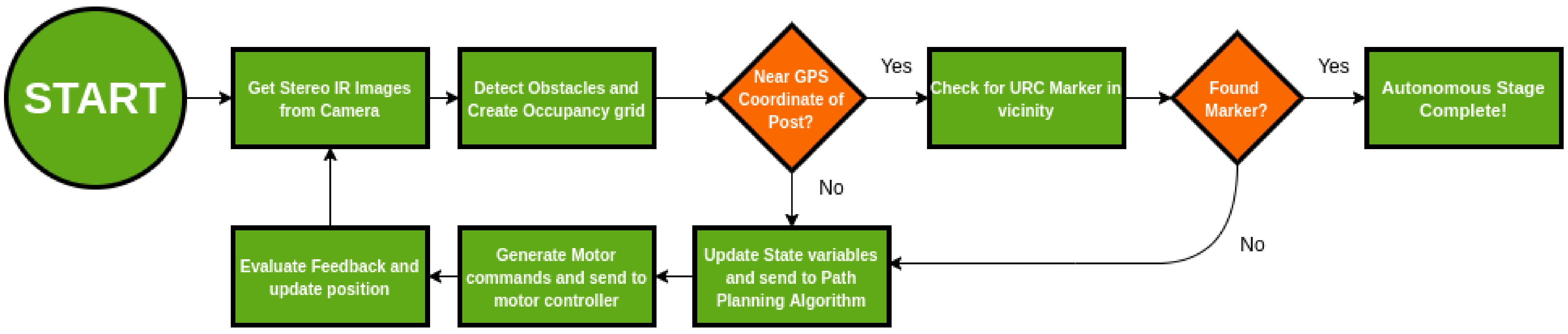
1. EXTREME RETRIEVAL AND DELIVERY TASK



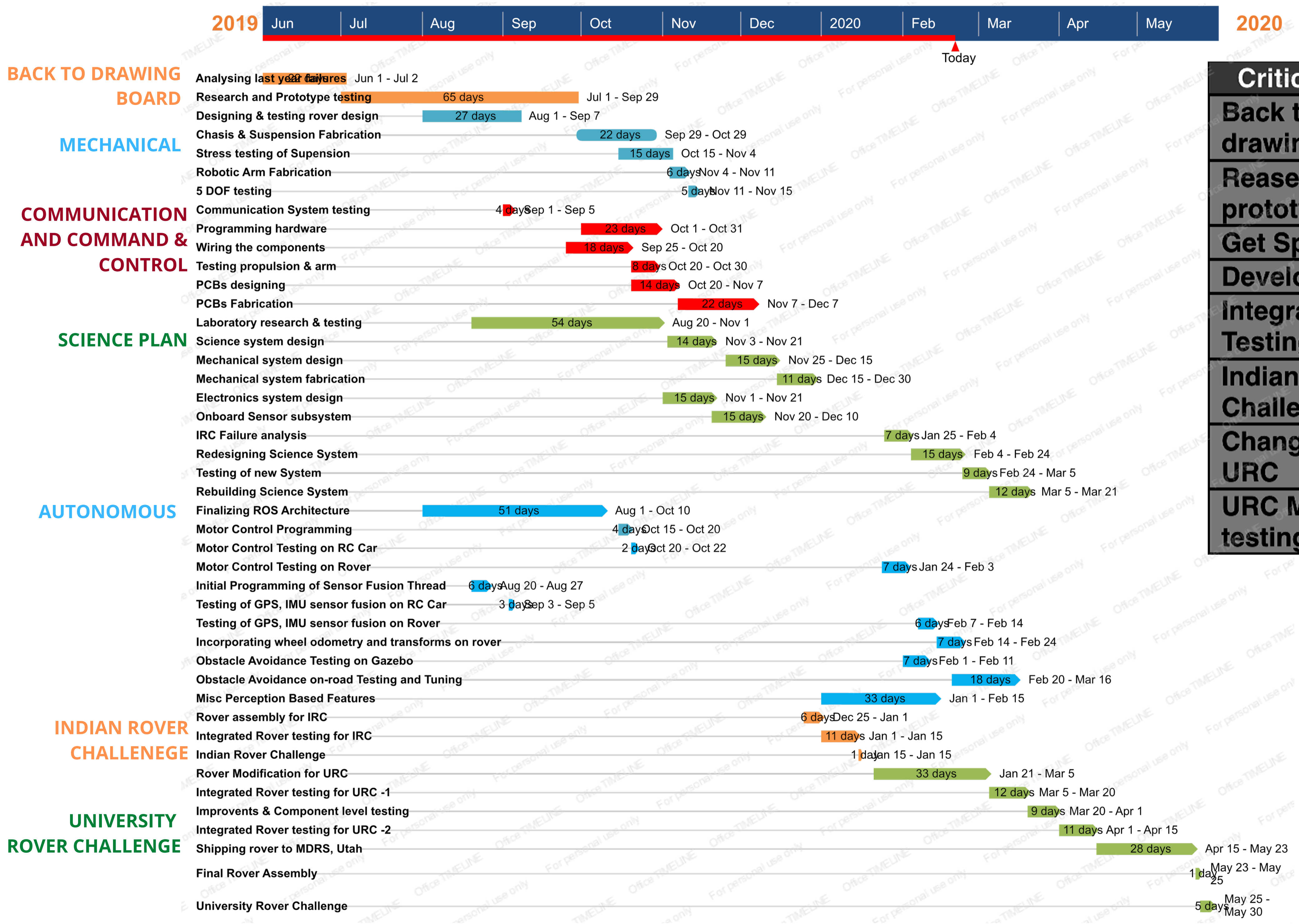
2. EQUIPMENT SERVICING TASK



3. AUTONOMOUS TASK



1. GANTT CHART AND CRITICAL PATH



Critical Path	#
Back to drawing board	1
Reaseach and prototyping	2
Get Sponsors	3
Development	4
Integration & Testing	5
Indian Rover Challenge	6
Changes for URC	7
URC Missions testing	8

2. Team Budget

Science Plan	
CO2 Sensor	$54.22
pH Sensor	$19.33
Gas sensor	$4.16
Temperature sensor	$7
Moisture sensor	$1.70
Ethidium Bromide (5 ml)	$49.08
Agarose (25 GM's)	$17.40
Ninhydrin (5 GM's)	$45.19
Molisch Reagent	$5
UV Lights	$7
Beakers	$15
Auger	$55.61
3D printing	$70
Total	$350.69

Robotic Arm	
Strutural Tubes, Plates	$140
DC 12V Motor	$14
DC 24V Motor	$35
End Effector (Gripper)	$35
Total	$334

Chassis and suspension	
suspension and damper	$392.00
Balloon wheels	$428.00
Chassis	$221.00
Tooling	$246.00
Miscellaneous	$142.00
Total	$1,429.00

Communication	
2 x Binatone 2.4GHz Outdoor CPE	$67.11
12 dbi 5.8 GHz Omni Directional Antenna	$221.49
2 x 5.8 GHz Customisable CPE	$195.46
Miscellaneous	$100
Total	$584.06

Autonomous	
NVIDIA Jetson TX2	$580.42
RealSense D465	$412.68
RealSense T265	$249
Total	$1,242.10

Command & Control	
STM 32 Microcontroller Board	$4.19
Raspberry Pi 3b+	$55.92
6 x IBT-2 Motor Drivers	$102.50
5 x Tokushu Denso Motor	$167.77
Kill Switch	$14.10
Buck and Boost Converters	$29.77
5S LiFePO4 Battery Pack	$85
Li-ion Battery Pack	$377.48
4 x L298n Motor Driver	$6.71
4 x Logitech USB Camera	$95.07
GPS Module	$7
IMU Module	$3
4 x Stepper Motor	$14
Miscellaneous	$200
Total	$1,162.56

Travel to URC	
Flights	$15,000
Accomodation (5 days)	$4,050
Food & Travel	$750
Rover Shipping (Both sides)	$4,000
Total	$23,800

Overall expenses on building Rover = $5,101

Overall expenses including Travel = $28,901.69

3. FUNDING RAISED AND EXPECTED

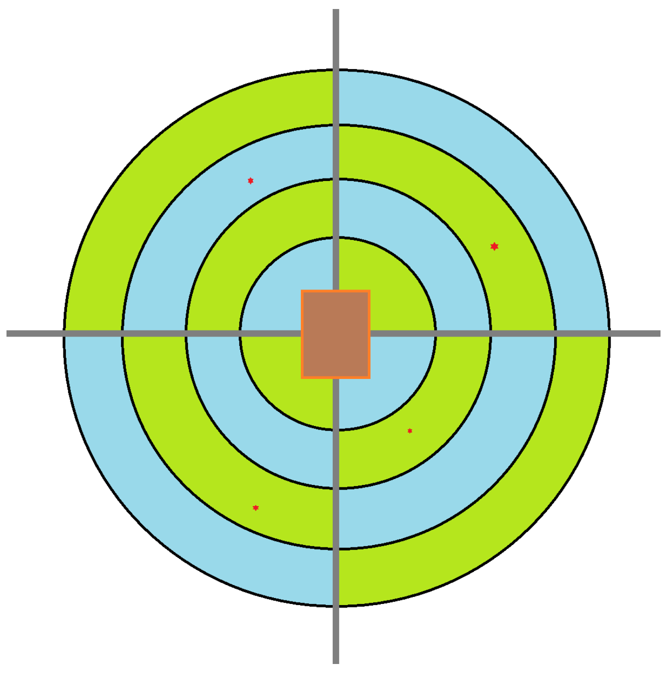
Funding Raised	
Compton Greaves	$2500
Crowdfunding	$2000
University Grant	$2000
Total	$6500

Expected Funding	
More Sponsors	$3000
Crowdfunding	$1000
AICTE	$14,000
Total	$18,000

Yes ,Team ARES has the required funding to participate in the URC 2020 finals if selected. The team shall get $14,000 from the AICTE (**All India Council for Technical Education**) under the scheme, 'Support to students for participating in competitions abroad' in this case.

Some of our Team members have participated in competitions abroad like CanSat competition, USA and iESC LUMEN, Belgium too.

SCIENCE PLAN



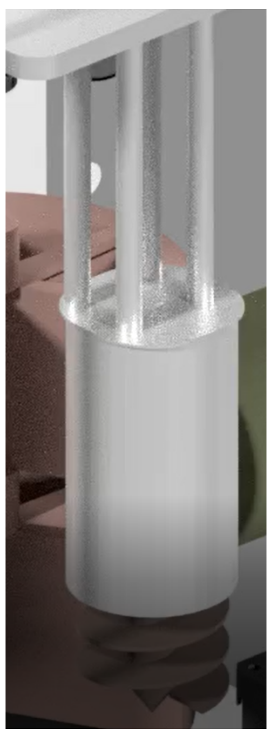
PRELIMINARY ANALYSIS

The rover would be making use of a new technique ARES calls "ROVER CHEMOTAXIS" which is inspired by bacterial movements towards chemical signatures. Here, the rover would have multiple sensors for Gas based biosignatures like methane which would detect the level of gas around the rover, allowing it to move in the direction of the increase of the chemical gradient. This would allow better soil sampling. The changing gradient would allow us to estimate the direction of winds and in the local area of the Rover.
METHANE is chosen as our primary preliminary biosignature since Methane Gas is produced by the most primitive of organisms on earth (methanogens) and the levels of methane are known to periodically change on mars, an effect which could be attributed to life forms.
Other gas based biosignatures we can make use of for ROVER CHEMOTAXIS include CARBON DIOXIDE and WATER VAPOURS.

A schematic of the Rover Chemotaxis plan, with the Rover being in the center (brown rectangle) and the region around it getting labelled based on perpendiculars from the normal of the Rover. The Rover would move towards one of the red stars based on intensity of the differential signal.

A wide range of other sensors are also made use of for preliminary selection of soil.
Once the Rover reaches the location of methane signals the SECONDARY PRELIMINARY ANALYSIS of the Soil shall begin.
IPHYSICAL and CHEMICAL parameters would be tested using on-board sensors to help select drill site.

1. TEMPERATURE & pH
   Selecting soil which has an ideal temperature and pH range; using probe sensors
2. MOISTURE
   Moist soils are much more likely to hold life; using plate based moisture sensors
3. LIGHT & RADIATION INTENSITY
   Measuring regions with least ionising radiation effects on the surface
4. PRESENCE OF IONS AND COMPOUNDS
   Detection of ions using UV-Visible photometry and organic compounds using IR spectroscopy.



An auger based drilling apparatus is used to drill and collect soil from surface and sub-surface locations.

LIFE ANALYSIS
LIGHT ASSISTED INTERPRETATION OF THE PRESENCE OF HALLMARKS OF EXISTENCE (LAIPHE)

Using an auger based system the surface is drilled and soil is collected. Though part of the soil is stored, the other part is put into the LAIPHE system's first Level. Level ONE is a lysis step where a combination of anionic and neutral detergents break away lipid membranes of life-units. The components of within life-units spill into the solution.
Two filters have been applied to remove the debris that may hinder with downstream reactions and the second to allow only the solubilised materials to pass through.
Level TWP of the LAIPHE system employs nanoparticles for detection of biosignatures and for the distinction between extinct and extant life forms. Positively charged, mono-dispersed nanoparticles are used. Gold nanoparticles stabilized with aptamers used for nucleic acid detection, silver stabilized with Ponceau for proteins and copper nanoparticles stabilized with CTAB for lipids. These nanoparticles aggregate in presence of the biosignature being tested and cause of change in colour of solution.
The same colour change can also help infer extinct/extant status as aggregation of nanoparticles would be lesser in extinct units, hence change in wavelength would be smaller. Since death causes biomolecules to break down, markers from extinct units cause lesser aggregation and less change

A schematic of the LAIPHE plan. The plan has two levels, one for soil lysis and one for biosignature detection. A set of membrane filters are used to separate out the dbris to allow for correct colorimetric detection. The LAIPHE system makes use of stabilized nanoparticles which interact with nucleic acids, proetins and lipids and cause a cascading colour change.

Results of the LAIPHE system- Red Au nanopatices give blue aggregates when mixed with nucleic acids from extant sources or green when extinct, red Ag nanoparticles chnage to blue with extant proteins and yellow-green with extinct protein, red Cu nanoparticles give green with extant lipids and yellow colour with extinct lipids. A nanoparticle for carbohydrates can also be tested for using nanoparticles.

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